PALEOLIMNOLOGY OF NORTHERN EURASIA

Proceedings of the International Conference

Northern Water Problems Institute
Karelian Research Centre
Russian Academy of Sciences
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The «Paleolimnology of Northern Eurasia» conference is the first conference in Russia to deal with the reconstruction of North Eurasian paleogeographical and paleoclimatic environments relying on interdisciplinary studies of bottom sediment cores from lakes of different types. The conference aims to analyze the state-of-the-art in paleolimnological research in Russia and abroad, to share latest expertise and experiences in paleolimnology, to offer training workshops to young scientists, PhD, BSc and MSc students, to determine the prospects for paleolimnological research, and to work out plans for further studies. In the 1960s-1980s, conferences on lake history used to be regular (triennially) in Russia. One of the challenges for this conference is to reinvigorate paleolimnological studies in Russia as a promising scientific speciality addressing a wide range of issues in paleogeography, paleoclimatology, evolution of aquatic ecosystems, geoecology and some other fields.

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PROSPECTS OF PALEOLIMNOLOGICAL STUDIES

Dmitry A. Subetto

Interest in palaeolimnological studies in the Northern hemisphere has been boosted lately, first of all by the problem of global climate warming, especially in high latitudes. Circumpolar regions of the Northern hemisphere have a plethora of lakes of different genesis and morphometry, which bottom sediments are archives of detailed information about changes in the climate, landscapes and hydrology in the Pleistocene and Holocene. The combined area of northern lakes can be estimated at >80 x 10^3 km^2. Lakes of glacial and thermokarst genesis prevail among them (Ryanzhin et al., 2010). Because of their geographical location, polar lakes had long remained little studied, and it is only in the past few decades that active research into the stratigraphy of lake bottom sediments and reconstruction of palaeogeographical and palaeoclimatic environments has been underway. One should mention international projects such as 'Lake El'gygytgyn', 'Lakes of Siberia' and others, in which palaeolimnological studies of the Lake El'gygytgyn, lakes of Yakutia are carried out. Sediments of the meteoritic Lake El'gygytgyn have been drilled, and their layer-by-layer study will enable a reconstruction of climate changes over 3.6 million years (e.g. Melles et al., 2012). New original data have been obtained in collaboration with colleagues from Yakutia within the 'Lakes of Siberia' project, focusing on the study of the history of Yakutian lakes, such as Billyakh, Satagai, etc., which covers a time interval of up to 30-40 thousands years. It has been found, for instance, that bottom sediments in Lake Billyakh, at the Verkhoyansk mountain ridge, have been accumulating continuously for at least 40 kyr, indicating there were no large ice caps in the study area during the last glacial maximum (e.g. Müller et al, 2009). However, as before, there are many gaps in our knowledge of climate fluctuations at high latitudes. In recent years, researchers from different countries carried out the collection and analysis of data palaeolimnological northern regions, to get a more complete picture of the environmental changes of the past (e.g. Sundqvist et al., 2014).

Active palaeolimnological research in the European North is underway, including reconstructions of post-glacial natural-climatic environments, water level changes in large basins along the Baltic shield periphery, identification of the causes and mechanisms of abrupt climate changes at the Pleistocene-Holocene boundary (Subetto, 2009). E.g., bottom sediments in Solovetsky Archipelago lakes located at different elevations were studied, and post-glacial changes in the White Sea level were mapped as the result (Subetto et al., 2012). Similar studies have previously been carried out in the eastern Baltic Sea and Lake Ladoga.

Detailed lithological, geochemical and micropalaeontological studies of bottom sediments in small lakes of Northwest Russia helped detect unique natural events that happened at the Late Pleistocene-Holocene transition (13-10 ka B.P.). A sharp climate change in the Late Pleistocene (Older Dryas cooling event) is attributed to a dramatic dampening of thermohaline circulation due to massive influx of fresh water from large periglacial basins of North America and Europe into the North Atlantic. Another hypothesis explains the Older Dryas cooling event by a meteor impact. According to this hypothesis, shortly before the cooling began some 12.9 ka B.P., a large fireball (up to 4 km in diameter) had exploded over the Laurentide ice sheet. This catastrophic event could have triggered an abrupt climate change. If we assume that the meteorite exploded over North America, the prevalent west-east air transport could carry the micro-particles generated by the explosion over vast distances, all the way to Western and Eastern Europe. Some studies have shown Late Pleistocene sediments in Western Europe to contain the material potentially associated with a meteor impact. To find the geochemical traits of the meteor impact, Late Pleistocene sediments from the deepest part of Lake Medvedevskoye, situated in the Central upland of the Karelian Isthmus, were analyzed. Geochemical analysis of the bottom sediments has shown that the content and distribution patterns of trace elements in the Late Pleistocene core are indicative of the presence of materials originating from sources not typical of lake sediments in the region. Sediments in Lake Medvedevskoye can be assumed to contain micro-particles generated by a meteor impact ca. 12,900 years ago. Since key trace element enrichment of Lake Medvedevskoye sediments is minor, one can assume Northwest Russia has been the most remote eastern region for air-borne transport of the material generated by the Late Pleistocene meteor impact (Andronikov et al., 2014).

A new research project has been worked out and adopted for the coming years at the Northern Water Problems Institute of the Karelian Research Centre RAS, focusing on the investigation of patterns in the development of aquatic ecosystems as related to changing natural-climatic and human impacts in the geological past through palaeolimnological studies. The project is to gather, analyze and summarize published data on the palaeolimnology and ecology of lakes in North Russia, assemble them into a common database, as well as to carry out new original palaeolimnological and palaeoecological studies based on examination of bottom sediment sections in lakes of different genesis and located in different northern geographical zones (tundra, forest-tundra, taiga). Contemporary litho-, bio- and chrono-stratigraphic methods will be applied. The project will be implemented in collaboration with colleagues from other institutes of the Karelian Research Centre, the Institute of the North Industrial Ecology Problems and the Geological Institute (both Kola Science Centre RAS), Institute for Ecological Problems of the North of the RAS Ural Branch, Institute of Limnology of RAS, North-eastern Federal University in Yakutsk, Kazan (Privolzhsky) Federal University, St. Petersburg State University, Herzen State Pedagogical University of Russia, Petrozavodsk State University and others.

The "Paleolimnology of Northern Eurasia" conference is the first conference to deal with the reconstruction of North Eurasian paleogeographical and paleoclimatic environments relying on interdisciplinary studies of bottom sediment cores from lakes of different types. The conference aims to analyze the state-of-the-art in palaeolimnological research in Russia and abroad, to share latest expertise and experiences in paleolimnology, to offer training workshops to young scientists, PhD, BSc and MSc students, determine the prospects for paleolimnological research, and work out plans for further studies. In the 1960s-1980s, conferences on lake history used to be regular (triennially) in Russia. One of the challenges for this conference is to reinvigorate paleolimnological studies in the country as a promising scientific specialty addressing a wide range of issues in paleogeography, paleoclimatology, evolution of aquatic ecosystems, geoecology and some other fields.

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NATALIA N. DAVYDOVA (6.07.1931-23.07.2014)

Natalia Naumovna Davydova, Soviet and Russian palaeolimnoogist, palaeogeographer and algologist, a prominent specialist in diatom analysis, Leading Research Associate of the Russian Academy of Sciences' Institute of Limnology, DSc in Biology, died on July 23, 2014.

Natalia Davydova was born on July 6, 1931 in Leningrad into a serviceman's family. In 1954 she graduated from the Geography Faculty of the Leningrad State University and took a job at the Academy of Sciences' Limnology Laboratory, which was later transformed into the USSR Academy of Sciences' Institute of Limnology. In 1963 she defended the PhD thesis on 'Diatom assemblages in contemporary sediments in Lake Ladoga', and in 1984 – the post-doctorate thesis on 'Diatoms as indicators of change in lake ecosystems in the Holocene'.

The entire scientific career of Natalia Davydova, from PhD student to Leading Research Associate, was bound to the RAS Institute of Limnology, where she carried out palaeolimnological studies based on the diatom analysis of lake-bottom sediments. She developed methods for reconstructing the main stages of lake evolution and for assessing the natural and anthropogenic controls of the rate and directivity of lake geosystem evolution relying on diatom analysis. Natalia Davydova worked out a method for geo-ecological monitoring of lakes and human impact assessment based on integrated indices of diatom complex saprobity. She is the author of the monograph "Diatoms as Indicators of Holocene Lake Environments" (1985), which has turned into a benchmark in diatom analysis, palaeolimnology and palaeoecology. The study objects for Natalia Davydova were large lakes in the humid zone – Ladoga, Onega, Peipus, and small lakes in the Vologda-Arkhangelsk region, Baltic States, Kola Peninsula, Northwest Russia, South Urals, West Siberia, as well as arid zone lakes – Balkhash, Zaysan, Ysyk, some lakes in Kazakhstan.

Natalia Davydova was a leading expert in algology, palaeolimnology, and palaeogeography both within and outside Russia. She supervised a number of successful doctoral and post-doctoral theses. Natalia Davydova participated in and organized numerous palaeolimnological expeditions. She was the first to carry out the diatom analysis of bottom sediment cores from the Baltic Sea, lakes Ladoga, Onega, Balkhash, Ysyk-Kul, etc. She took part in a great number of national and international research projects, was a member of the Journal of Paleolimnology editorial board, organized and participated in international conferences on the history of lakes. She carried out research and lectured at universities of Paris, Lund, Stockholm and London. Natalia Davydova wrote over 300 scientific papers in Russian and English on diatom analysis, palaeolimnology and palaeogeography, including especially the monograph "Diatoms as Indicators of Lake Ecosystem Evolution" (1985) and the book series "The History of Lakes" (1988-1998), for which she prepared numerous feature articles and edited some of the volumes. Natalia Davydova was an active member of the Russian Geographical Society, for many years chairing its Palaeolimnological Commission. For the book series "The History of Lakes" Natalia Davydova was awarded Honorary Diplomas of the Russian Geographical Society (1991, 1999).

Natalia Naumovna Davydova will forever remain in the hearts and minds of her family, friends and colleagues.

Scientific Committee

Session 1.
Evolution of lake ecosystems of the Northern Eurasia in the Past

Oral session

POLLEN, STABLE ISOTOPE, LOI AND CHARCOAL PROXIES FROM LAKE'S SEDIMENTS IN CENTRAL KHAKASSIA AS EVIDENCE OF VEGETATION/CLIMATE CHANGE AND HUMAN ACTIVITY

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For palaeogeographic purposes sediments of small lake Dikoe located on low Batenevsky Range (north of Altai-Sayan Mts. Russia) were investigated by multi-proxy methods including: pollen analysis, LOI, stable isotope (δ^{13} C and δ^{18} O) and charcoal analyses. Five AMS radiocarbon dates have been obtained. At present time vegetation cover of Batenevsky Range is formed by larch-pine-birch forests with rich herb and fern under storey vegetation. Real and meadow steppes are spread north of Batenevsky Range and dry steppe in the south from range. Stepper zone exists here only in intermontane depressions and it is surrounded from all sides by mountain forests growing on slopes of low to middle height mountains. This area is known by development of ancient prehistoric cultures of southern Siberia, signs of which can be find in landscape as numerous graves and stone mengires. Small Dikoe Lake is located at height 800 m.s.l. in glacial circus hollow. In the middle of lake sediment core of thickness 412 cm have been excavated. Pollen diagram of Dikoe Lake demonstrates change of vegetation and landscapes from 7900 ka BP till present. Dark coniferous forests with *Picea obovata* and *Pinus sibirica* were spread on Batenevsky range from 7900 ka BP till 5000 ka BP. The area of steppe was restricted. Archaeological evidence (van Geel et al., 2004) showed that in the *Neolithic time*, the plains of the Hollow were not colonized by people until 6000 BP. *Afanasievo culture*, formed in the 6th to 5rd millennium BP by tribes of Indo-Europeans that migrated from southwest to study area and thrived on the background of reach mountain forests and meadow stepper in hollow (Slavnin and Sherstova, 1999). Dry and warm climate at 5-th millennium PB stimulated development of Okunevo archeological culture (Blyakharchuk and Chernova, 2013). The following *Andronovo culture*, dated to the middle Bronze Age, developed in landscapes were birch forest-steppe and real steppe predominated. At the end of 4-th millennium BP a new aridization of climate caused shellowing of lake, bich forests changed to pine-birch forests and nomadic Karasuk culture developed in area of research. *Tagar culture* (Dinlin tribes, part of the *Scythians*, in Khakassia), dated to the early Iron Age, 3th century BP. The economy of Tagar tribes was complex. Both cattle breeding and agriculture were employed, with a slight predominance of agriculture. During Scythian time dark coniferous forests with *Pinus sibirica* spread on mountains with pine-birch forests – on low mountains and steppe – in hollow.*Tashtyk culture and Yenisey-Kirgiz culture*, dated to the late Iron Age, the end of the 3rd and beginning of the 2nd millennium BP were based on a settled and semi-nomadic agricultural and cattle breeding economy. During this time birch forests and birch forest-steppe predominated in landscapes. Area of dark coniferous taiga decreased. During *Tataro–Mongolian invasion* in 13th–14th century A.D. and following Russian colonization a new change in landscape took place. Beginning of this time was marked by new episode of increased role of dark coniferous *Pinus sibirica* forests, which finally changed to predominance of birch forests and birch forest-steppe. Additional proxies analyzed in Dikoe Lake demonstated 3 clear warm and dry time intervals marked by increased organic productivity of lake (4220, 3190 and 2220 cal yr BP). Interestingly, that this organic maximums coincides well with 3 isotope δ^{13} C minima and with 3 birch pollen maxima. This data conforms that climate was really dry and warm during this time intervals and supplemented by spreading of birch-forest-steppe. On the contrary during humid intervals more minerals have been washed to lake. An increased amount of carbonated deposited in lake sediments during thriving of agricultural human cultures (Andronovo, Scythian). And finally, Dikoe Lake multi-proxy palaeoecological data demonstrated that during thriving of predominantly agriculture archeological cultures (Andronovo, Scythians) were found pollen of *Cannabis* and *Urtica*, and during predominantly nomadic cattle-breeding archeological cultures (Karasuk, Mongol) – only *Urtica* pollen formed maximums. Additional proxy – aglae *Pediastrum* were extremely abundant in lake's sediments during Karasuk culture saying about eutrophication of lake by nomadic cattle-breeding culture. At the same time charcoal particles were not informative about human activities. Charcoal maximums in Dikoe Lake marks only forests fires during rapid landscape changes from forested areas of middle Holocene to birch forest-steppe of Subboreal time.

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COMPLEX PALEOLIMNOLOGICAL AND HYDROMETEOROLOGICAL INVESTIGATION OF KRASOLOVSKOE LAKE

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For interpretation of palaeolimnological data a great help can give modern monitoring observations of limnological systems. For this aim a complex palaeolymnological and hydrometeorological investigations were initiated in Krasilovskoe Lake of Altai region. This lake is located in ancient valley of water flow on right bank of Ob' River on height 220 m.s.l. in 60 km upstream of Barnaul town. Formation of lake is connected with blocking of small water stream by eolian sands, which moved from south-west to north-east. At present time pine and pine-birch forests grow on ancient dunes, which cover alluvium of river terrace. In the past area of lake was bigger than now, which is marked by few terraces around lake. Soil investigation detected, that at present time the first terrace of lake have signs of soil formation on lacustrine sediments. Repeated bathymetric measurements demonstrated that during last 40 years maximal depth of lake decreased from 12 m to 6 m. By opinion of local people decrease of lake's level accelerated especially strong after earthquake in September 2003 yr.

For complex monitoring of Krasilovskoe Lake and adjacent dry land a multi-channel meteorological complex "APIC" was constructed, which allows to receive in automatic regime data about meteorological conditions of atmosphere, sun radiation, levels of lake's and ground waters, temperature and Ph of lake's water. Complex consists of three blocks: stationary, bank and lacustrine. Stationary block includes one mast of 4 m height with recorders of humidity and temperature of air on heights 2 and 4 meters and two masts of 2 m height with meters of snow level and amount of precipitation. It was found that ground waters in place of construction of complex are located deeper than 4 m. Second block of complex (bank) includes hydrostatic meter of lake's waters fixed on the bottom of lake at the depth 2 m. Third block of "APIC" was set on raft in 300 m from lake's bank where depth of water is 5,5 m. Triangular mast of 2 m height with meteorological meters was set on raft. A loop of sensors of temperature and electro conductivity of water fixed on cable on definite distances was passed with use of polypropylene tube on distance 1,5 m from raft to avoid of it's influence on measurements. Controller of data collecting with battery was located in hermetic box fixed on surface of raft.

An unique device - temperature profile-meter MTR-5 have been used during summer field works of 2013 yr, which allows to carry hour temperature observation of temperature regime of first km of atmosphere with vertical resolution from 10 to 50 m. The first results of complex hydrometeorological observations on Krasilovskoe Lake in July 2013 yr. demonstrated that hydrological regime of lake is considerably controlled by atmosphere, mostly by precipitations and in less degree by internal sources. In case of absence of precipitations the automatic complex "APIC" registered quick decrease of lake's level up to 76 mm during 5 days. It means daily amplitude of fluctuation of lake's level (decrease in day time due to evaporation and increase at night due to spring income) consist of 22 mm and does not compensate the evaporation. Thus it was found that internal hydrological resources of Krasilovskoe Lake are considerably impaired.

If the observed decrease of lake's level is exceptionally contemporary event caused by recent global warming and anthropogenic influence, we can understand tracing it's dynamic during longer period using palaeolimnological investigation of lake's sediments and some other "natural archives" such as peat sediments. For this aim a coring of lake's sediments was performed from raft with use of piston corer. A core of soft lake's sediments by thickness 150 cm was extracted from the depth of water 3m for biological and geochemical investigations. The upper half liquid part of lake's sediments was extracted by transparent plastic tube and divided in 1 cm thick samples while vertical. The last part of core was divided in 1 cm samples in laboratory. Noteworthy, that in structure of lake's sediments was found very clear layer of mire moss *Drepanocladus*, which evidences about strong drying of lake to mire condition somewhere in the past. The layer of mire moss is overlapped by lacustrine sediments when lake's level again raised. When took place this episode of drying of lake, what was it's reason and what has happened during it in surrounding landscapes – to answer these questions will help pollen and geochemical analyses of collected samples. Thus preliminary paleolymnological and soil investigations of Krasilovskoe Lake demonstrated that in the past history of lake took place periods of dryness similar or even stronger than contemporary.

To find more complete "natural archive" as well to get additional independent from lake evidences of past climate change we took peat core of thickness 3 m from eutrophic mire located in 5 km from Krasilovskoe Lake. Peat was underlied by 1 m of laminated lake's sediments. This mire was marked as open treeless mire on topographic maps made 50 years ago. But at present time it was grown up by toll birch forest with reach herb under layer. The upper 10 cm of peat were transformed in dark humus soil. Under this layer the thickness of peat has clear structure of numerous alternating dark brown and light brown layers. This structure possibly demonstrates unstable water supply of mire during all period of peat accumulation. Moreover a thin lamination of 60 cm of lake's sediments under peat says about unstable environments before mire formation. Only basal part of lake's sediments had homogeneous blue-gray color.

Thus, in climatically sensitive forest-steppe zone of west Siberia on adjacent to Altay Mts. plain have been initiated long-time hydro-meteorological monitoring of water area of Krasilovskoe Lake and performed field works for detailed paleolymnological investigations. This will allow not only to decode past climatic rhythmic, but to connect it with data of instrumental observations.

LATE QUATERNARY LAKE ELGYGYTGYN LEVEL FLUCTUATIONS IN COMPARISON WITH OTHER LARGE SIBERIAN ARCTIC LAKES

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Lake El'gygytgyn is located in Central Chukotka, Far East Russian Arctic (67°30′ N and 172°5′ E), approximately 100 km north of the Arctic Circle. The lake is almost square in shape with a diameter of about 12 km in filling a portion of a meteorite impact crater, today marked at 18 km in diameter. The crater formed 3.6 million yr ago (Layer, 2000). In the winter season of 2008–2009, deep drilling of Lake El'gygytgyn recovered long cores embracing both the entire lacustrine sediment sequence from the center of the basin (318 m) and a companion core into permafrost from outside the talik surrounding the lake (141.5 m, Melles et al., 2011). These cores now provide the science community with the longest terrestrial paleoenvironmental record from the Arctic, starting in the warm mid-Pliocene (Melles et al., 2012; Brigham-Grette et al., 2013).

The knowledge about past lake level fluctuations plays very important role for interpretation of long sedimentary record.

Existing reconstructions of past lake level fluctuations based mostly on studying of lake terraces. Lake has 40m terrace, 10m terrace, 5m terrace and 10m below modern level terrace (Glushkova et al, 2007, 2009, Fedorov et al., 2008, Schwamborn, G., et.al., 2006, 2008, Juschus, O., et.al. 2011). More evidences for previous high and low stands comes from stratigraphy of the Lake shelf sediment core LZ1028 (Juschus, O., et.al. 2011) and long permafrost ICDP core 5011-3 (Schwamborn, G., et.al., 2012).

Here we present the revised reconstruction of Late Quaternary Lake Elgygytgyn level fluctuations based on new pollen record from Lake shelf sediment cores LZ1027 and LZ1028 and OSL-dating of the 10m above modern level terrace. We also compare Lake Elgygytgyn level fluctuations with available data for other large Siberian Arctic lakes (Taymyr and Pyasino).

The revision of all available data allows us to make following conclusions:

1. Lake Elgygytgyn level changes are climate driven with tendency to abrupt rising in very beginning of warm stages and gradual lowering after climatic optimum with peak of low stand in cold and dry stages.
2. The Lake is sensitive to both precipitation, controlling water income and temperature, controlling ice cover and wave's activity. Warm and moist – highest level, cold and dry – lowest level, warm and dry and cold and moist – gradual lowering or insignificant fluctuating.

3. The low most level position associated with MIS 6 when level dropped down at least for 50 m. This is most likely associated with formation of outflow to Enmyvaam River during MIS7 high stand and subsequent deep erosion.

4. The modern morphology of the crater with preserved terraces in southern part formatted since Middle Pleistocene after opening of outflow. The modern shelf in Lake bathymetry formatted during low stands in MIS 6, 4 and 2.

5. The Holocene sedimentation on modern shelf prevented by strong lake currents

6. The level fluctuations of large Siberian Arctic lakes are climate driven with high stands in warm stages and low stands in cold stages unless ice damming.

7. For all three lakes shown high stands during MIS3 and beginning of Holocene. For lakes Taymyr and Elgygytgyn shown very low stands at least by end of MIS2, very abrupt level rising in Pleistocene-Holocene transition and persistence of high lake levels stand into Holocene climate optimum (up to 8 kyr BP).

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THE PERSPECTIVES OF PALEOLIMNOLOGICAL AND GEOMORPHOLOGICAL RESEARCHES OF VOLCANIC LAKES OF THE KURILE ISLAND ARC

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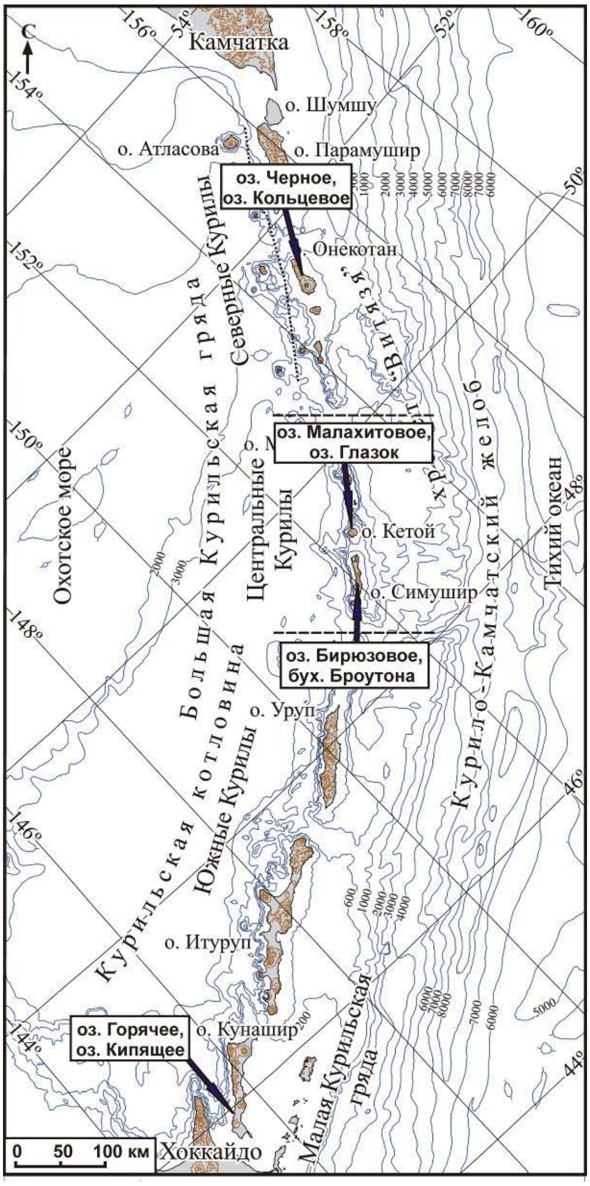

Fig. 1. The location of investigated lakes in the system of the Kurile Island arc.

During last decade the work on research of morphology particularities and genesis of almost inaccessible and at present time not practically studied objects such as the volcanic lakes of the Kurile Island arc is conducted by IMGG FEB RAS (Fig. 1). The investigations is fulfilled with use of modern methods of digital echo-sounding profiling with synchronic satellite fixing on profile and computer processing of echograms (Kozlov, Belousov, 2007; Kozlov, Zharkov, 2010; Kozlov et. al, 2012), at this during the cameral works the results were wide discussed and analyzed in close collaboration with the colleagues of A.I. Gertsen RSPU (Saint Petersburg) and NWPI KarRC RAS (Petrozavodsk) (Kozlov, 2013). So, the work on generalization of information about the specific of morphometrics and genesis of the unique objects – volcanic reservoirs is conducted by the common efforts of the researches from several scientific centers.

At present time the profiles is obtained, the bathymetrical schemes and models of some objects were made: Kipyashchee and Goryachee (Golovnin caldera, Kunashir Isl.), Biryuzovoe (Zavaritsky caldera, Simushir Isl.), Brouton (Brouton caldera, Simushir Isl.), Malakhitovoe and Glazok (Ketoi volcano, Ketoi Isl.), Chyornoe (Nemo caldera, Onekotan Isl.) and L'vinaya Past' Bay (L'vinaya Past'caldera, Iturup Isl.). Underwater extrusive domes, explosive cones and hydrothermal outputs forming the variety of the volcanic lakes basins were revealed and described in details in the bounds of above mentioned volcanic reservoirs (Fig.2) (Kozlov, 2013).

Besides that it is necessary to enlarge considerably the complex of conducted researches and to amplify them with data about the history of lake system formation and specific of sedimentary genesis in their boundaries. We must do tephrochronological studies, radiocarbon dating and geomorphological modeling of the basins, the research of matter composition of bottom deposits including determination of mineral, granulometrical and chemical compositions, after this it will be possible to create complex models of the volcanic lakes. Without doubts such work demands to conduct annual expensive expeditions in almost inaccessible areas, however it will allow to define data about the character of nature-climate conditions in the Kurile Islands in Late Pleistocene and Holocene.

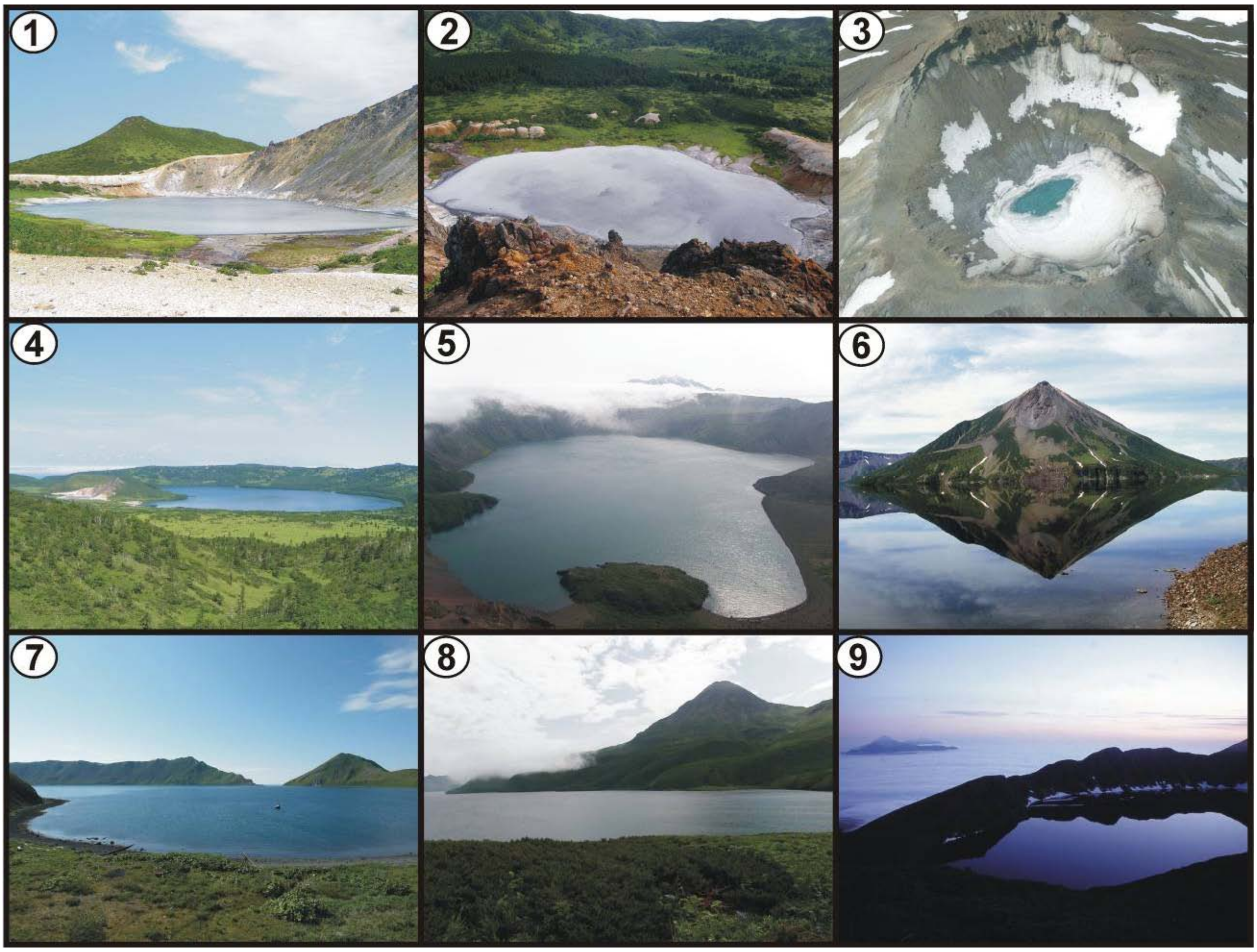

Fig.2. Crater lakes of the Kurile Islands. 1, 2 - Kipyashchee; 3- Glazok; 4- Goryachee; 5- Biryuzovoe; 6-Kol'tsevoe; 7 - Brouton; 8 - Chyornoe ; 9 - Malakhitovoe.

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2.8 MILLION YEARS OF ARCTIC CLIMATE CHANGE FROM LAKE EL'GYGYTGYN, NE RUSSIA

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Here we present the first time-continuous and high-resolution record of environmental history in the Arctic spanning the past 2.8 Ma. The record originates from Lake El´gygytgyn, which was formed 3.6 Ma ago by a meteorite impact event and today is located ~100 km to the north of the Arctic Circle in northeastern Russia (67.5 °N, 172 °E, Fig. 1). Scientific deep drilling at Lake El´gygtygyn in winter 2008/09 revealed a limnic sediment succession of 318 m thickness above impact breccia (Melles et al. 2011). According to the age model, which is based on magnetostratigraphy and tuning of proxy data to the regional insolation and global marine isotope stratigraphy, the upper 135.2 m of the record represent the past 2.8 Ma continuously (Melles et al. 2012). The pelagic sediments, excluding event layers from volcanic ashes and mass movements, are highly variable in nature, but consist of three dominant lithofacies, two of which reflect end-member glacial and interglacial climatic conditions.

Facies A represents peak glacial conditions, when perennial lake ice persisted, requiring mean annual air temperatures at least 4 (± 0.5) °C lower than today (Nolan 2012). This resulted in a stagnant water column with oxygen-depleted bottom waters. Facies A first appeared 2.602 - 2.598 Ma ago, during marine isotope stage (MIS) 104, corresponding with pollen assemblages that indicate a significant cooling at the Pliocene/Pleistocene boundary. From the long-term succession of Facies A pervasive glacial episodes at Lake El´gygytgyn gradually increase in frequency from ~2.3 to ~1.8 Ma, eventually concurring with all glacials and several stadials reflected globally in stacked marine isotope records.

Facies B represents an interglacial climate similar to that of today, with ice-free conditions and full mixing of the water column in summer times, leading to oxic, bioturbated sediments. Particularly warm interglacials are reflected by Facies C. The elevated temperatures lead

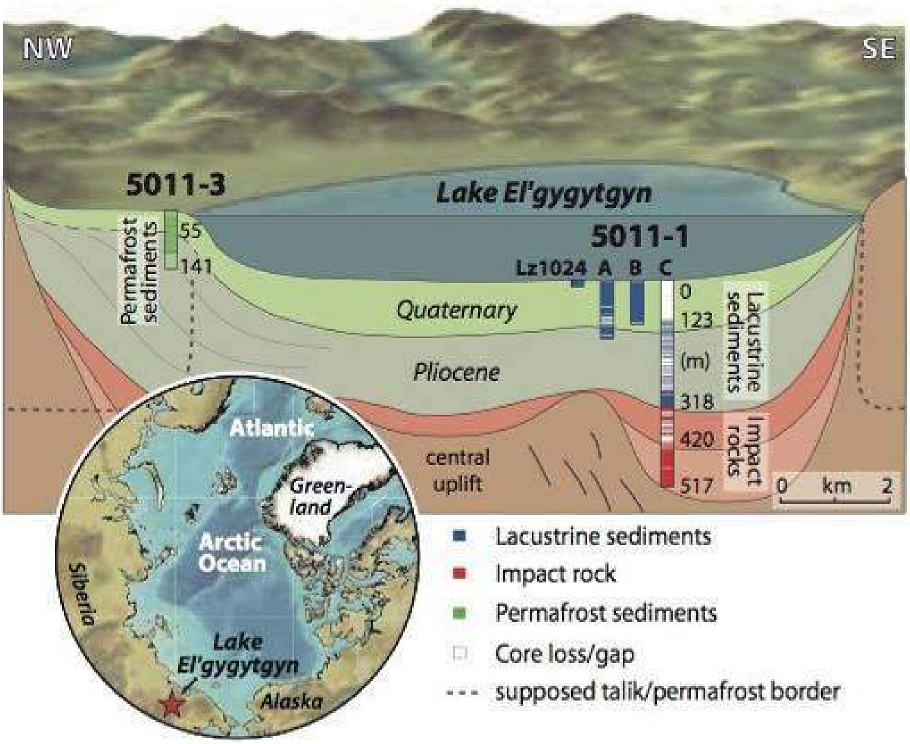

Fig. 1: Location of Lake El´gygytgyn in northeastern Russia (inserted map) and schematic cross-section of the El´gygytgyn basin stratigraphy showing the sediment cores drilled.

to longer ice-free seasons and clearly enhanced nutrient supply from the catchment, thus allowing for a particularly high primary production in spring and summer and a well-mixed water column with oxygenated bottom waters for most of the year.

These peak interglacial settings are most pronounced for MIS 11c, 31, 49, 55, 77, 87, 91, and 93. Their exceptional character becomes evident based upon a comparison of MIS 1 and 5e ("normal" interglacials of Facies B) with MIS 11c and 31 ("super" interglacials of Facies C), using pollen-based climate reconstructions. During the thermal maxima of MIS 1 and 5e the mean temperature of the warmest month (MTWM; i.e., July) and the annual precipitation (PANN) were only ~1-2 °C and ~50 mm higher than today, respectively. During the super interglacials MIS 11c and 31, in contrast, maximum MTWM and PANN were up to 4-5 °C and ~300 mm higher than those of MIS 1 and 5e, respectively.

According to climate simulations using the current version of the GENESIS v. 3.0 Global Circulation Model interactively coupled to the BIOME4 equilibrium vegetation model, the exceptional warm and moist climate at least during MIS 11c cannot be explained by the natural variability in Earth´s orbital parameters and greenhouse gas concentrations alone. This suggests additional climate impacts from outside, which may have become amplified due to feedback mechanisms in the Arctic climate system.

The super interglacials at Lake El´gygytgyn coincide remarkably with diatomite layers in the Antarctic ANDRILL 1B record, which reflect periods of a diminished West Antarctic Ice Sheet (Pollard and DeConto 2009). A higher number of events at Lake El´gygytgyn does not necessarily reflect a higher frequency, but could also be due to the discontinuity of the ANDRILL 1B record. One possible explanation for the obvious intra-hemispheric climate coupling during times of ice retreat in Antarctica could be a reduction of Antarctic Bottom Water (AABW) formation, which may have reduced upwelling in the northern North Pacific, thus leading to warmer surface waters, higher temperatures, and increased precipitation on nearby land. Alternatively, or in addition, a significant global sea-level rise due to WAIS decay may have allowed more warm surface water to penetrate into the Arctic Ocean through the Bering Strait.

In conclusion, the upper 135 m of the limnic sediment record from Lake Elggygytgyn have provided a detailed view of natural climatic and environmental variability in the terrestrial Arctic since 2.8 Ma, a better understanding of the representative nature of the last climate cycle for the Quaternary, and how sensitive the terrestrial Arctic reacts to a range of forcing mechanisms.

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ORIGIN AND EVOLUTION OF A LARGE THERMOKARSTIC LAKE IN ULTRA-CONTINENTAL SUBARID ENVIRONMENT: LAKE TERE-KHOL (SAYAN-TUVA HIGHLAND, SOUTHERN SIBERIA)

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Tere-Khol (50.6150°N, 97.3853°E) is an open lake located in a small tectonic basin in the south-western edge of the Baikal rift zone. Lake area is 33 km², average depth 0.5 m, maximum depth 1.9 m. Lake is drained by a small Saldam River that tributes to the Balyktyg-Khem River, one of the Yenisei River sources. Permafrost >100 m deep is found everywhere in the bottom of the basin, but there is a through talik under the lake. Sedimentary cores from the lake banks, bottom and islands were radiocarbon dated and studied using a set of lithological and palaeobiological methods. The results provided the following conclusions.

1. Lake formation and planform had been predetermined by uneven accumulation of coarse alluvia in the bottom of the basin occurred during the high runoff epoch in the Late Glacial. Alluvial fans of local and transit rivers advanced into the basin and separated its relatively low-elevated south-western edge. Flood activity decreased by the middle of the Younger Dryas (12200 cal yrs BP). During 12200-11000 cal yrs BP the gravely fans were covered by a 2-3-m thick layer of overbank fines.

2. Lake has thermokarstic origin. It appeared initially as a small water body around 11000 cal yrs BP as a result of permafrost thawing due to accumulation of river flood waters in the relatively low south-western edge of the basin. Area occupied by the lake had extended considerably at around 9500 cal yrs BP and probably at 7300 cal yrs BP when it had acquired approximately its present planform. These events resulted from permafrost thawing due to increase of surface water yield by river floods.

3. Lithological and algological study of lacustrine sediments provided designation of five epochs of increased surface water yield into the lake (increased river runoff): 11000-10500 (it promoted initial formation of the lake), 9500-9300 (major expansion of the lake), 7300-6200 (the longest and the Holocene most humid epoch), 3800-2500 and 2700-2300 cal yrs BP. The last two short episodes were designated only at the background of general aridity characteristic for the second half of the Holocene. Lake expansion during humid epochs occurred due to high seasonal rise of the lake water level which promoted permafrost thawing at the lake banks, their subsidence and integration into the lake.

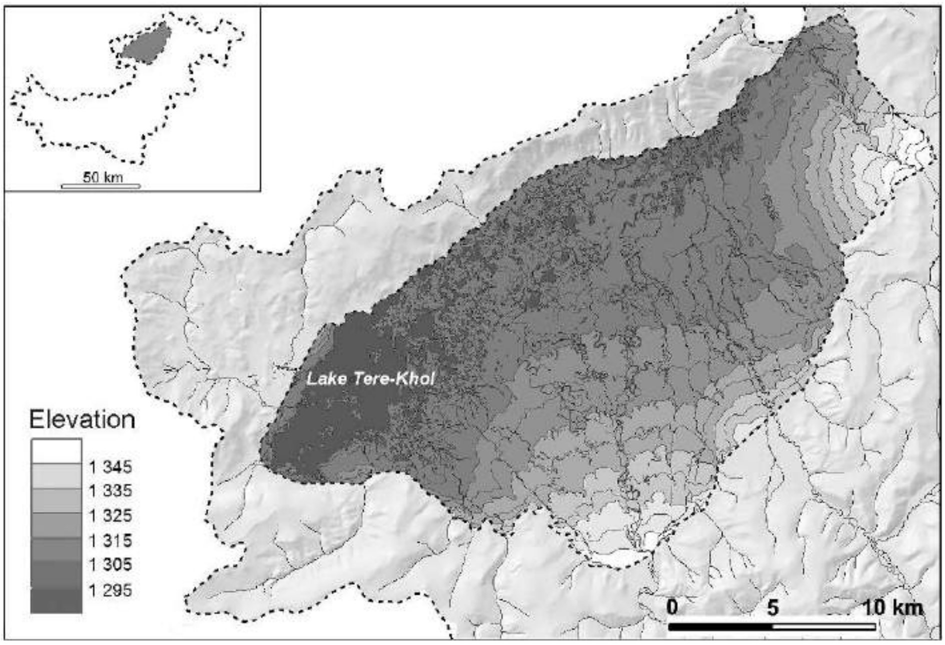

Fig. Terekhol Basin and Lake Tere-Khol. Inset demonstrates the asymmetry of the basin catchment (dashed line). It predetermined uneven alluvia accumulation in the bottom of the basin, which favored formation of the lake in the SW edge of the basin.

4. The first half of the Holocene till 6200 cal yr BP was characterized by unstable humidity, high variability of river water input into the lake. The second half of the Holocene exhibits general trend for climate aridization interrupted by short intervals of higher moisture. During the driest epochs 6200-3800 and 2000 – 100 cal yrs BP, the lake had lower depth and was frozen to the bottom in winters. Freezing of bottom sediments led to frost heaving and formation of in-lake palsas, which have survived by now and make two age generations of lake islands composed of lacustrine sediments. In islands permafrost regenerated and reaches now 20-25 m in thickness. Period 3800-2000 yrs BP was characterized by some higher water input into the lake but it was provided rather by underground than by runoff water yield. Strongest aridization occurred in the last 2000 years. Against this background, the XXth century exhibits relatively humid conditions and higher water yield.

This study contributes to RFBR projects 09-05-0351 and 13-04-01829.

PALEOLIMNOLOGICAL RESEARCH IN CENTRAL YAKUTIA

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Paleolimnological studies conducted on the territory of Yakutia, since the 90s of the last century. The first objects of study are lakes of Central Yakutia. In order to obtain records of Holocene lake dynamics, sediment cores were collected from three different lake-genesis types, i.e. from Lake Satagay which is a Western-Lena-discharge depression thermokarst lake, from Lake Boguda which is a fluvial-erosion thermokarst lake, and from Lake Ulakhan Chabyda which is a dune lake (Figure 1). Sediment core was collected through the lake-ice cover using a Russian (ITAN) hand-operated corer. Radiocarbon data from Lake Satagay have been published by Pestryakova et al. (2008), and age determinations on cores from Lake Boguda and Lake Ulakhan Chabyda have been published by Tarasov et al. (1994), Andreev & Klimanov (2005), and Pestryakova et al. (2008, 2012).

Lake Ulakhan Chabyda (61°59'N; 129°22'E) lies at 290 m a.s.l. on the ancient Lena River erosion-accumulation plain, within the central Yakutian Depression. The plain consists of Quaternary loams overlying Cambrian limestones (Kachurin, 1965). Because the lake basin was formed on ancient tukulans (i.e. on fixed and partly-fixed aeolian sands) the lake belongs to the dune lake category. Lake Ulakhan Chabyda has an area of 2.1 km^2, with an average depth of 0.5 m and a maximum depth of 2.0 m; it has no surface inflow. In July 2005 the lake typically had a pH of 7.58, a Secchi depth of 0.3 m, and a conductivity of 653 µS/cm. There is no direct human influence within the lake catchment area. A core of 10.6 m length collected in 1991 consists of sandy silt and silt with plant remains in the lower part, and of gyttya with numerous plant remains in the upper 9.2 m. To obtain an age-depth model, linear interpolation was based on two radiocarbon dates from the lower part of the core, correlation of a increase in *Pinus* at 500 cm core depth with a mid-Holocene increase that is known to have occurred at 6000 ^{14}C years in central Yakutia (Andreev et al., 2002), and a setting of 0 cal kyr BP for the uppermost centimeter.

Lake Boguda (63°40'N; 123°15'E) lies at 119 m a.s.l. on an early Pleistocene terrace, about 100 m above the present-day Vilyui River. The 100 m terrace consists of about 20-40 m of Quaternary sand and clay, underlain by Upper Cretaceous sandstones (Alekseev, 1978). Lake Boguda is the largest of all the investigated lakes, with an area of 45 km^2, a length of 15 km, and a maximum width of 3.5 km. The lake is fed by several small streams and overflows via a small river into the Vilyui River, and it has been classified by Zhirkov (2000) as a fluvial-erosion thermokarst lake. In July 2003 the lake had a neutral pH (7.51), and was relatively shallow with a maximum depth of 1.4 m (average: 0.7 m); it had a Secchi depth of 0.5 m and a conductivity of 100µS/cm. Lake Boguda is situated about 15 km southeast of Champa village and is not directly affected by any human impact or use. Two cores (5.8 m and 4.5 m length) were collected in 1985 and 1998, and have been correlated with each other on the basis of the sediment descriptions (Pestryakova, 2009). The studied deposits are mostly composed of algae-rich sandy gyttya. Our study utilized diatom analyses from the second (1998) core, together with radiocarbon data from the correlated (by sediment description) first (1985) core.

Lake Satagay (64°10'N; 122°15'E) is situated at 175 m a.s.l. in the lower reaches of the Vilyui River and covers an area of 2.9 km^2. The lake is located about 0.7 km south of the Satagay village but is little used by the inhabitants. It is composed of a three-lake chain within a closed thermokarst depression. The shape of the depression and distribution of wetlands between the three lakes suggests the former presence of a single, large lake. We investigated the largest (southernmost) of the three lakes. In July 2003 it was alkaline (pH 9.0) and shallow (maximum depth 1.6 m; average depth 0.7 m), with a Secchi depth of 0.6 m and a conductivity of 270 µS/cm. A 14.5 m long core was collected, consisting mainly of gyttya with several plant or moss layers. The gyttya is underlain by a peat layer and sandy deposits. An age-depth model was obtained by linear interpolation of dating results from neighboring samples. The sample from 1015 cm depth was excluded from the construction of the age-depth model reconstruction because the age obtained was clearly incorrect, being too young relative to neighboring dating results.

Table

Sample depth, radiocarbon age, calibrated age, and laboratory reference for dated samples from the studied lake sediment cores

Sample depth (cm)	Radiocarbon age (yr BP)	Calibrated ages (cal yr BP)	Lab reference
Lake Satagay (Pestryakova et al., 2008, Popp, 2007), (1015 cm – excluded from the construction of the age-depth-model)			
360	670 ± 25	560 - 669	KIA 20704
685	2040 ± 30	1923 - 2068	KIA 24040
880	3170 ± 45	3322 - 3473	KIA 20703
1015	1745 ± 25	1566 -1712	KIA 24039
1155	3865 ± 30	4225 - 4410	KIA 24038
1280	4495 ± 40	5036 - 5299	KIA 24037
1345	4850 ± 80	5449 - 5746	KIA 24036
1426	5610 ± 35	6306 - 6450	KIA 24035
1447	6420 ± 45	7271 - 7422	KIA 20702
Lake Boguda (Andreev, 1989)			
40-60	2110 ± 70	2010 - 2243	GIN-4500
80-90	2650 ± 90	2605 - 2856	GIN-4501
90-100	2530 ±100	2451 - 2722	GIN-4502
150-170	4000 ±100	4326 - 4668	GIN-4504
190-210	5570 ± 80	6308 - 6444	GIN-4505
280-300	6398 ± 50	7287 - 7399	GIN-4507
430-450	7780 ± 100	8475 - 8747	GIN-4510
520-540	9130 ± 120	10200 - 10473	GIN-4512
Lake Ulakhan Chabyda (Andreev, 2000)			
977.5-987.5	9630 ± 70	108330 - 11129	TO-5402
1047.5-1057.5	11,550 ± 120	13290 - 13586	TO-5401

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NEW INSIGHTS FROM THE LATE PLEISTOCENE PALEOCLIMATE RECORD OF LAKE BAIKAL, SE SIBERIA: RADIOCARBON CHRONOLOGIES, MILLENNIAL OSCILLATIONS, BIOGENIC FLUXES AND QUANTITATIVE RECONSTRUCTIONS

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Two decades of research on the Lake Baikal sediment record sampled by gravity, piston coring and deep drilling from an ice-based platform have shown the responsiveness of this lake system to past changes in regional climate and helped develop an understanding of the key proxies. With average sedimentation rates varying from 4 cm/kyr to ca. 20 cm/kyr for the late Pleistocene, Baikal sediments provided a number of paleoclimate records from centennial resolution during MIS 3 and the Holocene millennial-resolution records of the Plio-Pleistocene.

The recent effort to resample and increase the resolution of the best radiocarbon-dated archive records across the basin made it possible for the first time to reliably correlate postglacial records with a high degree of accuracy using the shared repetitive signature of stable isotopes of carbon in bulk sediment organic matter. This effort for the first time resolved the long-standing controversy of 'reservoir'-type corrections suggested by bulk sediment radiocarbon dates and thereby made it possible to compare not site-specific but basinwide patterns of proxy responses of the late glacial and the Holocene. The emerging pattern is that of strong and coherent millennial oscillations during the past 14 kyr, and a strong changes in biogenic fluxes during the Holocene. Extended across the past 80 kyr in the new complete composite sediment record, the carbon stable isotope signal was discovered to record individual Dansgaard-Oeschger warming events, most prominent during the MIS 3 interval.

Parallel studies of the more recent record from Lake Hovsgol, NW Mongolia, provide proxy records for the past hydrologic balance from carbonate mineralogy and geochemistry and thus help understanding the significance of proxy signals in the Baikal records. In particular, the significance of the late glacial shift in precipitation/evapotranspiration balance, which was previously underestimated in pollen-based quantitative reconstructions.

ALPINE LAKES - CUMULATIVE INFORMATION SYSTEMS AND INDICATORS OF CLIMATE CHANGES

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As it is well known, the lakes, as slow water exchange systems, are excellent geological archives of past environmental information. Lake bottom sediments are the important component of lacustrine ecosystems and protects the full information about its history (Sevastyanov & Subetto, 2003; Subetto, 2009).

Hydrochemical properties of lake water give us the information about the modern ecological lake ecosystem status (limnosystems) and geochemical background, reflecting the composition of rocks or lakes catchment. Coastal forms, lakes terraces contain the information about the past lake levels fluctuations and past erosion and accumulation cycles.

In contrast, the lake sediments (allochthonous and autochthonous) have been annually accumulated in the kettle-hole depressions. The composition and structure of the lake sediment give a complex information. They are saving the information about the dynamic of environmental conditions and their changes appearing throughout the period of history and limnosystems. The structure of the lake sediments reflects changes in climate, precipitation and vegetation changes on the lake catchment.

Lake depressions are sediment natural traps on the way of sediment transport from the catchment. An accumulation of lake sediments occurs in continuous interaction with the water mass of the lake catchment by aeolian, water and terrigenous transport of and energy. In this process manifests ecological unity lake and its catchment as a natural system (Drabkova & Sorokin, 1979).

Especially processes of sedimentation in the lakes occur in mountainous areas, bearing traces of ancient or modern glaciers. Specific natural conditions of highland areas close to the cold polar latitudes, necessity a joint investigation of the lake and glacial- nival morpholithogenesis. This approach allows us to identify the common regularities of formation of glacial, limno - glacial and lake sediments, inherent alpine and polar regions, to determine the rate of sediments accumulation in lakes and increase the reliability of paleolimnological reconstructions.

For many years the authors are studying of mountain lakes in the Tian – Shan', Pamir, Altay, Khangai and the Caucasus, as well as in the polar regions of Russia (the territories of Valday Glaciation). This allowed identifying common regularities in processes of lake sedimentation and to determine the degree of informative limno-glacial sediments for paleogeographic reconstructions. In the study of the lake and glacial morpholithogenesis in mountain and lowland areas is advisable to allocate geomorphological system such as limno-glacial complex (LGC). They represent a set of genetic elements of relief and limno-glacial deposits (Sevastyanov & Seliverstov, 1995; Sevastyanov Subetto et al, 1996; Subetto, Sevastyanov et al, 2002).

Alpine lakes are good objects for studying the processes of sedimentation. Usually they are relatively isolated from direct human impacts. Therefore, their sediments are a reliable source of information in the study of climate change, glaciers and vegetation dynamics in the mountains. Furthermore, such lakes are very sensitive to climate change and air pollution. In the context of the current phase of climate change with a warming trend indicator to study the properties of lake ecosystems becomes actual direction paleolimnological and paleoclimatic studies.

Caucasus lakes located at altitudes of over 3000 m above sea level are excellent subjects for climatic and anthropogenic changes investigations. These lakes are located, for example, Aragats and Geghama volcanic massive: Kari, Umroy, Birjuzovoye, Akna, Azhdahak and others lakes. Generally they have lava barrier or moraine genesis with depths to the 15 meters.

The authors proposed a methodic of reconstructing the alpine lakes history, based on the study of the material composition of sediments, relief forms and limno-glacial complexes.

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CENOZOIC PLATE TECTONIC CONTROLS OF THE SIBERIAN FRESH WATER DRAINAGE TO THE ARCTIC OCEAN

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Looking at the geography of Eastern Siberia one has to realize that the modern rivers of the entire Siberian platform virtually all drain to the North into the Arctic Ocean (Fig. 1), but the history and evolution of this drainage pattern is only poorly known.

The ACEX 2004 drill cores from Lomonosov Ridge demonstrated that a clear sedimentary impact of an Arctic sea ice cover started to appear in Eocene sediments, approx. 48 Ma, much earlier than known hitherto. It is an unresolved question if it existed the entire time span because the ACEX stratigraphic record is interrupted by 2 long lasting hiatusses.

The onset of IRD (coarse Ice Rafted terrigeneous Debris) sedimentation was preceded by the *Azolla*-fresh water event (lower to middle Eocene sediments flooded with spores of *Azolla*) which seems to mark the onset of the drainage of large quantities of fresh water to the Arctic Ocean leading to the formation of the Arctic sea ice cover and a general cooling of the climate over the Northern Hemisphere. The unresolved question remains how this development was triggered.

We believe that it may be linked to the plate tectonic collision of the Indian plate with with the southern Eurasian continental margin, resulting in the initial built-up of morphologic barriers to the South of the Siberian platform and a Siberian platform morphology with the drainage pattern of the rivers to the North. The large amounts of fresh water entering the Arctic Ocean then generated an environment conducive for the initiation of a permanent sea ice cover in the Arctic much earlier than the formation of the Antarctic ice cover.

During the Neogene and Quaternary the Arctic Ocean sediment record formed frequently under the influence of intensive melt water events from the NW Eurasian glacial ice sheets. The events of the past 200 000 years are known in considerable detail, but it is difficult to link them to the history of the large rivers draining

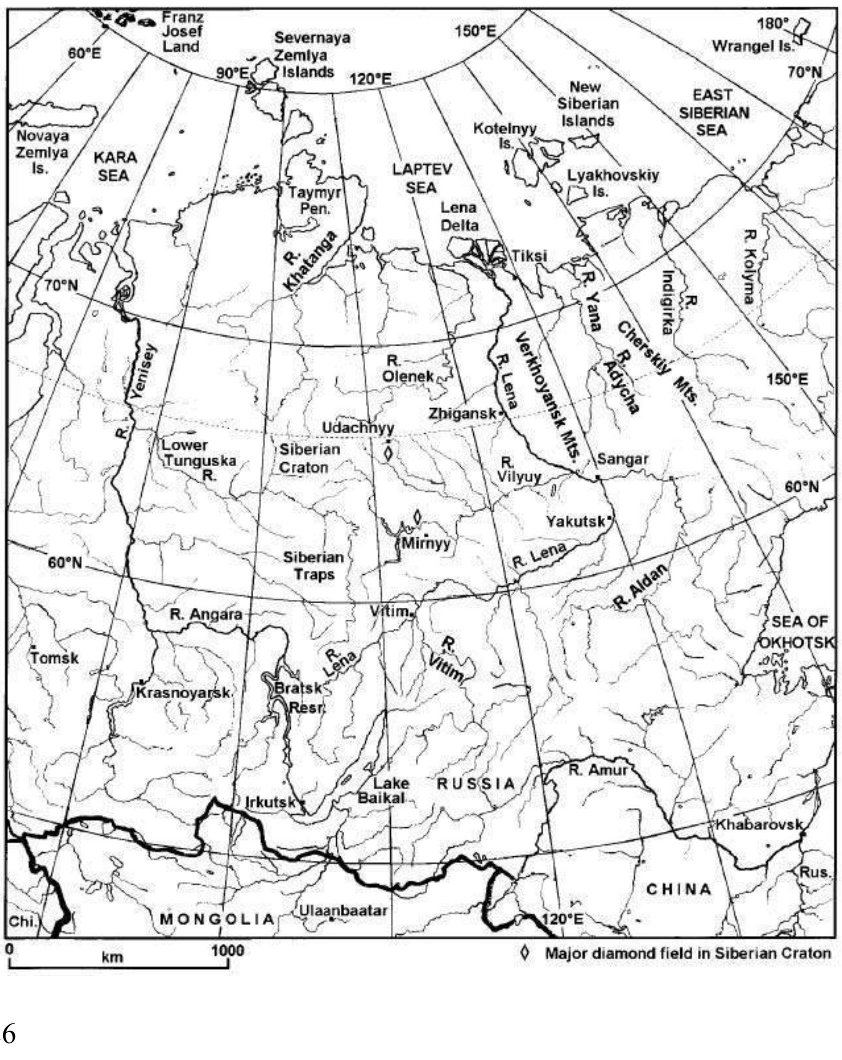

Fig. 1. Modern drainage pattern of the Siberian platform with most of the rivers flowing northward into the Arctic Ocean (from Alekseev and Drouchits, 2004, Proc. Geol. Assoc., 115 (4): 339-346).

the Siberian hinterland. As part of a major study of the paleomorphology of Northernmost Eurasia we have therefor initiated a project aiming at resolving the history of the Lena River from its upper to the lowermost reaches. During 3 expeditions in (2011, 2012 and 2013) we have sampled a substantial number of sections from a large variety of sedimentary environments. Beside dating the collected sample materials we are also attempting to define the extent of selected river terrace complexes by means of Digital Elevation Models derived from satellite data.

AN LGM PROGLACIAL LAKE WITHIN THE NORTH DVINA - VYCHEGDA FLUVIAL SYSTEM: DIMENSION, SEDIMENTS AND CHRONOLOGY

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Ice-dammed lakes occurrence is one of “hot” problems of European North Late Quaternary geology, geochronology and paleoenvironmental history because of their direct relationship with Scandinavian and Barents Sea Ice Sheets evolution and degradation. Vychegda and North Dvina river basins (Arkhangelsk region and south Komi republic) within the European North-East represent an area of controversial hypotheses concerning Late Weichselian proglacial lakes.

A huge proglacial lake already has been reconstructed for the Early Weichselian in the European North-East, within the Pechora lowland (Mangerud et al., 2004). This lake which has been called the Lake Komi, has been formed due to block of Pechora outflow by Barents – Kara sea ice sheet and existed 90-80 ka BP filling the river valleys of Pechora basin, with lake level 110-90 m a.s.l. and area of 76000 km^2 (Mangerud et al., 2004).

For the LGM, existence of an immense lake in the European North-East first has been proposed in 1970s (Kvasov, 1975) and now is supported by a number of scientists (Lavrov, Potapenko, 2005; Lysa et al., 2011; Larsen et al., 2013). This idea is based upon the hypothesis that the SE lobe of last Scandinavian ice sheet entered the Sukhona and Vychegda valleys via North Dvina river (Larsen et al., 2013). The level of this lake was supposed to have risen up to 130-135 m a.s.l. and then it drained out into the Kama-Volga basins through the spillway between North and South Keltma valleys. In that case, the area of this lake could reach dimensions of the Lake Agassiz, though its real limits, size and age are still unknown. The opposite view exists of only limited extent of this lake (Sidorchuk et al., 2001), based upon the studies of alluvial terraces in the lower Vychegda valley. Lavrov and Potapenko (2005) proposed another lake existing in the Early Holocene, mostly related to the ice sheet melting and degradation. Such discrepancy in scientific hypotheses, from our point of view, appeared due to a lack of geological and chronological data on these phenomena.

In our study, we focused on the LGM-lake spatial and temporal framework: this could clarify a nature of relationship between SE flank of the LGM glacial extension and related basins.

We studied a series of sections within the Vychegda river valley, comprising deposits synchronous to LGM and adjacent time. These were sections of Vychegda river terraces, with radiocarbon dated horizons underlying LGM deposits. Radiocarbon dates fall into the interval of 26 – 25 ^{14}C kyr BP and mark the last period of pre-LGM warming. The LGM-associated deposits are represented by alluvial sands in all studied sections (Zaretskaya et al., 2013).

The section closest to the Vychegda outflow comprising the LGM-lake deposits is Tolokonka (100 km downstream from Kotlas). Tolokonka is located in the middle course on the North Dvina river, at its right bank. This is a complex 30–m section; its main part is ~4 km long and has been studied and dated (Maksimov et al., 2011; Shebotinov et al., 2011; Larsen et al., 2013). Its middle part is represented by ~1 m layer earlier considered as diamicton (Shebotinov et al., 2011; Larsen et al., 2013). During our studies in 2012 we found varved clays within this "diamicton" horizon (Zaretskaya et al., 2013). The entire stratum is composed of several varved layers interbedding with alluvial sands: a deeper-water facies is gradually alternating with shallower-water from bottom to top of the stratum, and shrinkage traces are well seen at its top. Boulders and pebbles in the layer could occur from ice rafting in the proglacial lake and may therefore indicate the proximity of the glaciation margin.

At the top of the section there is a ~1-m horizon of layered silty loam interbedded with fine sands and enclosing dropstones. Probably this horizon marks a second, short Late Glacial phase of proglacial lake formation within the North Dvina river valley, during the initial stages of the Scandinavian Ice Sheet degradation. OSL-dates of this horizon could confirm this proposal (Shebotinov et al., 2011).

15 km upstream from the main section there is a sandy outcrop of 28 m height (Upper Tolokonka). This section is composed mostly of alluvium layers. The whole section is underlain by a thin silty layer containing organic matter. The radiocarbon date is 24.570±140 (GIN-14874). In the middle part of the section (within the alluvium), there is 1-m varved layer; varves are composed of silty sand, and can indicate a distal (shallow) part of proglacial lake.

The low terrace in the Vychegda valley which provides both pre- and post-LGM ^{14}C dates demonstrates clear features of fluvial morphology and leaves no space for occurrence of lacustrine environments during LGM. Based on the elevation of this terrace at the Vychegda mouth, the level of proglacial lake may be thought to have not exceeded 60 m a.s.l., which is far below the 135 m a.s.l. level of the Kel'tma sill where the hypothetical outflow into the Kama River basin could have occurred. We consider that the LGM proglacial lake did not exceed the Vychegda river mouth, but the accumulation of its terrace had probably been promoted by the backwater effect from the lake. The extension of the LGM proglacial lake was not more than ~200-250 km spreading upstream from the SE margin of the last glaciation (boundaries according to Demidov et al., 2006 etc.).

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Poster session

LAKE LADOGA´S POSTGLACIAL-GLACIAL-PREGLACIAL SEDIMENT RECORD: FIRST PALYNOLOGICAL RESULTS FROM THE RUSSIAN-GERMAN PROJECT „PLOT“

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The new German-Russian project PLOT (**P**aleolimno**LO**gical **T**ransect) aims to investigate the Late Quaternary climatic and environmental history along a transect crossing Northern Eurasia. Within the scope of a pilot phase for the PLOT project, funded by the German Federal Ministry of Education and Research, we were able to investigate Lake Ladoga, the largest lake in Europe (ca 18.000 km^2), located close to St. Petersburg at the western end of the transect. Although the late glacial and Holocene history of the lake and its vicinity was already studied over the past decades (e.g. Subetto et al., 1998 and references therein), the older, preglacial lake history remained unknown. It is assumed that during the Last Interglacial (Eemian) Lake Ladoga was part of a precursor of the Baltic Sea, which had a connection via Ladoga and Onega Lakes to the White Sea.

A seismic survey in September 2013 revealed acoustically well stratified Holocene muds overlaying rather transparent postglacial varves, which can reach more than 10 m in thickness. The varves usually are bordered by a hard reflector underneath that may represent hardrock, coarse-grained sediments, or a till, which in most areas is not penetrated by the acoustic waves. Sediment coring at two sites in western Ladoga Lake confirmed the seismic interpretation of the postglacial sediment succession. At one of these sites, the basal reflector at about 13 m depth was penetrated another ca. 10 m into preglacial sediments. The core catcher samples from a 22 m sediment core were palynologically investigated. In addition to traditional pollen analysis, non-pollen palynomorphs (NPP), such as cysts of dinoflagelates and algae remains, are recorded, which provides additional palaeoenvironmental information about the lake and its catchment.

According to the pollen results, the lowermost sediments (ca. 22-15 m), which contain pollen of broad-leaved taxa (*Carpinus*, *Quercus*, *Corylus*, *Ulmus*, and *Tilia*), might be formed during an interglacial with a climate warmer than that of the Holocene. The sediments also contain numerous fresh-water green algae remains of *Pediastrum* and few *Botryococcus* as well as cysts of marine dinoflagelates and brackish-water acritarchs (prasinophytes *Cymatiosphaera* and *Micrhystridium*). Dinocyst assemblages are very poor in species, presented by *Spiniferites ramosus* s.l. and *Lingulodinium machaerophorum*. Very short processes of the latter species indicate rather low salinity

(Mertens et al. 2012). The occurrence of these NPPs documents that Lake Ladoga was part of a brackish-water corridor between the Baltic and the White Seas during an interglacial (Eemian?).

It is important to note that we have used two methods of treatment of samples for pollen analysis: one method according Faegri and Iversen (1989) using hydrofluoric acid and the other in accordance with Grichuk and Zaklinskaya (1948) using heavy liquid. Many found microfossils were of poor preservation, but the largest number of well-preserved taxa was found in the samples prepared using heavy liquid separation method.

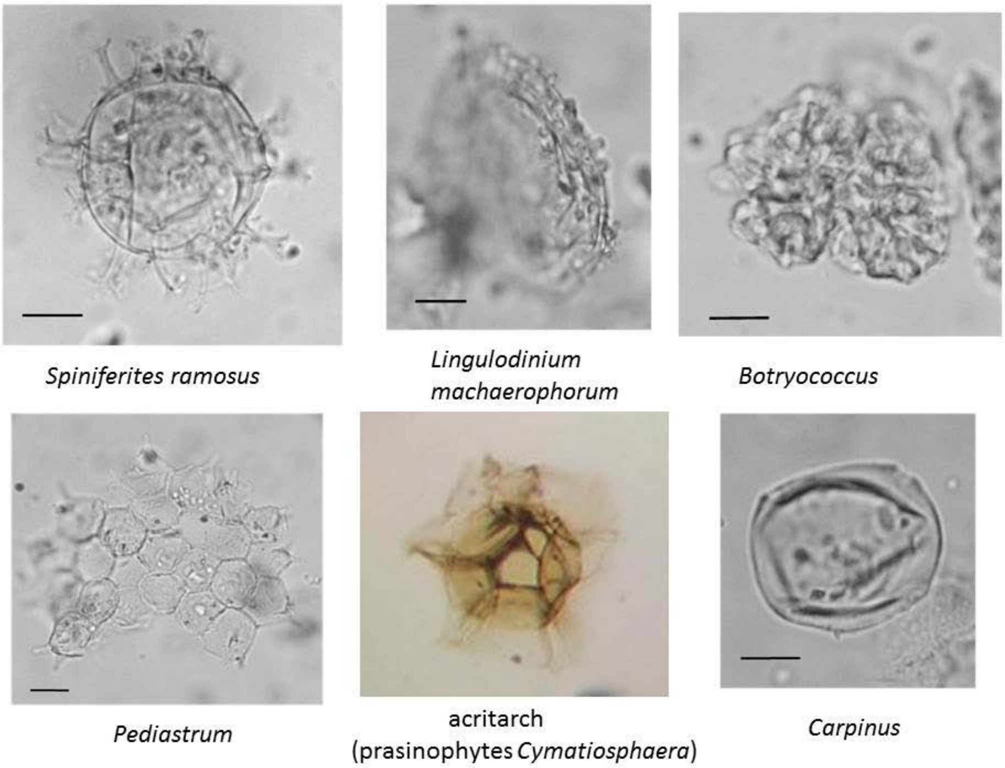

Fig 1. Pollen and NPPs from the interglacial sediments (Photos by L. Shumilovskikh).

RECONSTRUCTION OF LAKE SHIRA LEVEL DURING THE LAST 1500 YEARS ACCORDING TO MICROSTRATIGRAPHIC STUDIES BOTTOM SEDIMENTS

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We have previously shown that the layered sediments of the salt lake Shira (Khakassia) contain annual layers (varves) suitable to assess the rate of sedimentation in different sections of the core [1]. Thermodynamic calculations showed that the presence of specific white layers in the sediment is determined by higher contents of carbonates and may be associated with an increase in salinity of the lake due to a sharp decrease in the water level [2]. Available data allowed us to go for the construction of a lake level quantitative reconstruction with high temporal resolution.

Time model for the analyzed core Shira-2009 is built on isotope studies (^{137}Cs and AMS ^{14}C) and thickness estimates of annual layers for over 9 sections of this core. (fig.1)

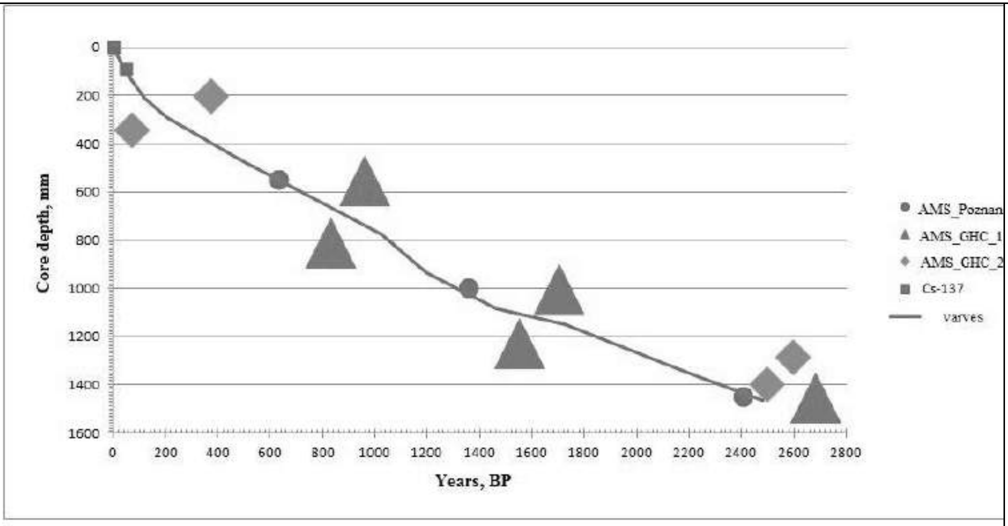

Fig.1. Time model of Shira Lake bottom sediments core, constructed on varvochronology and isotope analyses ^{137}Cs and AMS ^{14}C.

Solid samples of core Shira-2009 were investigated by scanning XRF analysis with annual step [3]. Lake level data were compared with the geochemical indicators and transfer function was built.(fig.2.)

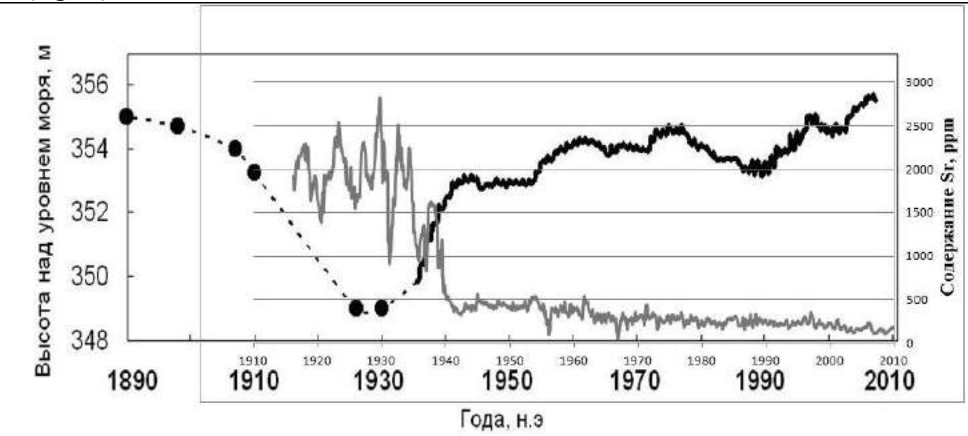

Fig.2. Comparison of instrumental and historical data about the Shira Lake level with profile of strontium content in the interval core sediments corresponding to 1910-2010 AD.

To construct the transfer function linking the level of the lake and geochemical indicators we have selected those that had a significant correlation with the reconstructed parameter in the training interval (1910-1985). Training interval was limited by 1985 due to the sharp increase of anthropogenic influence on the lake state at that date. During this transfer function construction, we wanted the variation scale in the training interval not to be less than 80% of the same in the reconstruction interval. Compliance of this criterion let us reasonably talk about the similarity of modern and reconstructed conditions of sedimentation.

The reconstruction of Shira Lake level with annual temporal resolution for interval 500-2000 years is built from multiple regression.(fig.3.)

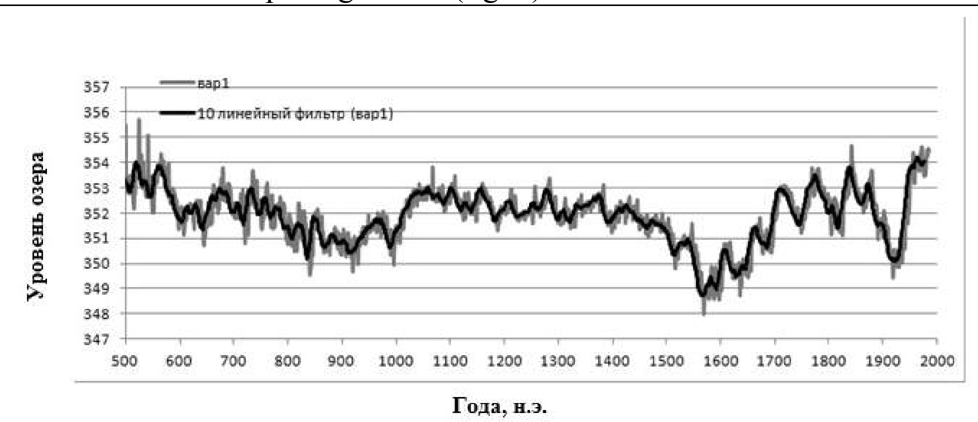

Fig.3. Reconstruction of Shira Lake level for last 1500 years, calculated using multi-regression method for geochemical parameters (LOI, XRD, Zn, Br, Sr concentrations).

The obtained results allow us to construct the quantitative estimates of tendencies and trends of aridization for southern Siberia region during the late holocene.

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PALAEOLOMNOLOGICAL STUDIES IN KALININGRAD REGION RF: RESULTS OF 2012-2013

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In 2013 the major part of the field and laboratory studies in the frame of the scientific project RFBR 12-05-33013 "Evolution of the environment of the South-Eastern Baltic Region and the stages of early settling of the territory on the Pleistocene – Holocene border" finished. The most of obtained data are in processing now, although it is already possible to discuss some preliminary results. One of the most interesting are related with palaeolimnological studies of the lake Kamyshovoe (Vishtynetskaya hill, Kaliningrad region RF).

In 2012-2013 sediments cores of 10, 75 m , presented both by Late Glacial and Holocene deposits (high organic brown sapropel, gray-brown clay sapropel and dark gray claish silt) were obtained. Approximately 200 samples are processing. Study of samples included radiometric dating (AMS and C14), palynological , geochemical , diatom analysis, analysis of isotopes (δ18O, δ13C) and magnetic susceptibility and other kinds of work. Preliminary results are following.

- Analysis of the magnetic susceptibility of sediments - revealed significant changes of the parameter -5x10- 9 m3 kg- 1 to 194 x10- 9 m3 kg- 1 , associated with the different cycles of sedimentation and indirectly confirming the presence of the Late Glacial Stage in this process; analysis was carried out in Nature Research Centre, Institute of Geology and Geography, Vilnius.
- Radiometric dating (C14) of samples - the earliest dating (Lu - 6980 , 8740 ± 160) was obtained from the depth of 8.3-8.4 m from the surface of the water. Samples were analyzed from the higher, the Holocene part of the column; analysis was performed at the Laboratory of Geochronology, St. Petersburg State University (prof. Kh. A. Arslanov).
- Analysis of total organic carbon (TOC) – revealed the dynamics of this indicator of bioefficiency over time, the analysis conducted in Herzen State Pedagogical University (prof. D.A. Subetto, Y. Kublitsky).

- Palynological analyzes – allowed to get essential results, showing the relation of the sediments from the bottom of the column with the end of Pleistocene; analysis conducted by dr. M. Stanchikaite, Nature Research Centre, Institute of Geology and Geography, Vilnius.

- Diatom analysis - highlighted various environmental groups of diatoms with the characteristic of the habitat groups; analysis conducted by dr. G. Vaikutiene , Vilnius University.

- Results of AMS dating, performed at the Poznan Radiocarbon Laboratory, revealed older dates of the samples than it was expected due to previous biostratigraphical analysis, this points needs further discussion and interpretation.

The results confirmed the assumption of the Late Glacial genesis of the reservoir. The final stage of research will allow to describe the dynamics of various natural processes in this part of the South-Eastern Baltics, including climate change, evolution of the vegetation, dynamics of the hydrological and geomorphologic processes etc. , gradually over the past ~ 12 thousand years .

Acknowledgements

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THE PALAEOLIMNOLOGICAL EVIDENCE OF THE LARGE BASINS LEVEL CHANGES DURING THE HOLOCENE – A REVIEW OF THE SITES IN THE KARELIAN ISTMUS AND AROUND LAKE LADOGA

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The palaeolimnological studies in the Karelian Istmus have a 50-years-long tradition. One of the many implications of the palaeolimnological approach is the reconstructions of the large basins shoreline dynamics caused by transgressive or regressive processes.

Sediment cores from more than 40 lakes in the Karelian Isthmus have been studied during the last 5 decades, and sediments of the Baltic Ice Lake and/or other Baltic palaeo-basins, as well as of Lake Ladoga trasgressive stages were described and dated in the most sections. The presentation focuses on thereview of all the sections studied by now.

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A HOLOCENE POLLEN RECORD FROM LAKE SEDIMENTS OF SUBARCTIC ZONE OF YAKUTIYA

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A 432 cm core PG2022 ($69^0$37,7'N; 123^0 39,0'E) recovered by the Russian corer from central part (290 cm depth water) of the Kyutyunda Lake. The lake is located ca 300 km south from Tiksi and lies in north taiga zone. The Kyutunda lake is situated on the second terrace of the Molodo River, which is a left tributary of the River Lena. The joint Russian-German research team investigated lake and took sediment cores in 2010. The lacustrine sediment samples (each 10-20 cm) have been studied for pollen, spores and freshwater green algae.

The different climatic periods of the Holocene are reflected in the section. Seven pollen zones were determined based on visual inspection of the pollen diagram. We consider that transition from the Pleistocene to the Holocene is found in the lower part of the core (approximately 350 cm depth) and expressed in a sharp change in pollen spectra from the dominance of grass pollen to pollen spectra with shrubs domination while Picea pollen appears and Larix pollen increases. The amount of freshwater green algae *Pediastrum* sharply reduces at a depth of about 325 cm. It can be associated with an increase in the lake level. A high percentage (up to 30%) of redeposited pre-Quaternary pollen and spores were noted. This is due to the fact that the catchment area bedrock is presented by Jurassic sandstones and overlain by the thin cover of Quaternary sediments. As a result of the erosion activity old microfossils could come in the modern lake.

THE RESEARCH OF UNDERWATER TERRACES OF LAKE BAIKAL USING MANNED SUBMERSIBLES "MIR" FOR PALEOLIMNOLOGICAL RECONSTRUCTIONS

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The large scale expedition with the deep-water manned submersibles “Mir” was carried out on Lake Baikal from 2008 to 2010. Primarily, it should be noted that it was one of the first experiences of using the private capital to solve fundamental scientific problems with the help of the Fund for Protection of Lake Baikal. During this period, 178 dives on the two submersibles "Mir", which belong to the Institute of Oceanology RAS, were made on all areas and depths of the lake waters. More than 200 hydronauts from 12 countries participated in these submersions.

As a result of this underwater research they collected unique data about new organisms living at the bottom of the lake and processes of chemosynthesis, and found new discharges of hydrotherms and fields of gas hydrates, underwater sources of gas and oil. Another important outcome of the expedition was the visual mapping of underwater abrasion and accumulative terraces on slopes of a lake bed made by the author.

As known, the main paleolimnological reconstructions are carried out on the basis of survey of coastal terrace levels, considering that the highest levels are the oldest. For that reason most researchers think that the oldest Miocene-Pliocene and Eopleistocene lacustrine deposits are located on the high terrace levels of Southern Baikal, near the Ushkan Islands and on the other several places.

However, the research of Lake Baikal underwater terraces conducted by the author suggests a completely new picture of the evolution of the lake bed of the world’s largest freshwater reservoir. This new pattern is very closely connected to the paleogeographical reconstructions of the late Cenozoic of Northern Asia.

During the first season of the expedition, a well-rounded boulder-pebble deposits were discovered at depths about 820-840 m along the east coast of Olkhon Island. Old-aged coastlines processed by wave-cut activity are observed on the steep rocky slopes. Opposite to Aya bay and near the village Goloustnoye accumulative terraces were found at depths of 640m, and in Baikalsk area boulder-pebble deposits were found at depths of 450 and 220 m which stand out against a background of the gently sloping sandy slope as a broad band. At the same time, there are no any notable rock massifs on the adjacent waters.

Thus, there are the accumulative and abrasion old-aged coastlines on the different sites of an underwater slope of the Baikal lake bed, these coastlines were formed as a result of long wave-cut activity of water mass in the conditions of lower level of the lake. At the same time the lowest levels are most old-aged. Under that logic the evolution of the lake basin had a fluctuating character while taking place a regime for filling the reservoir. If we assume that lake level had been decreasing at certain stages, ancient lake deposits and coastlines would be destroyed.

This data suggests that lake level was 800-900 m lower than a modern mark at the initial stage of formation of the lake bed. Under that logic the next stages of the evolution of the Baikal lake bed and its coast were caused with glacial eras of surrounding mountain chains and their further ablation.

Classical Quaternary chronology of Northern Asia includes four stages of continental glaciation, which have formed the main features of the modern landscape of the territory. Each stage of glaciation was caused with arid climate and conservation of water systems contours. Accordingly, each warming was the reason mountain glaciers of the Pribaikalye melted and it determined the filling phase of the Baikal lake bed that explains the emergence of a huge volume of fresh water in the center of the Asian continent.

Such paleoreconstructions help to explain the origin of the four levels of underwater well-rounded boulder-pebble material and the existence of rock slopes processed by wave-cut activities at great depths of the lake. It is known from textbooks on hydrodynamics that the active processing of the coastline and the accumulation of the accumulative deposits occurs at depths not exceed 3-5 m in conditions of the constant level of the reservoir. With a sharp increase in water mass these limnological markers switch to conservation mode, and with a fall in water level they usually get destroyed by exogenous processes.

This research draws attention to the usage of manned submersibles to research depths near the coast and on the shelf, located beyond the reach for divers. Exactly here at depths of the first hundreds meters traces of ancient fluctuations of level of the World Ocean, as well as the remains of economic and cultural activity of the lost civilizations have to be found. Who knows the past, has the right to judge the future.

The usage of manned submersibles in study of marine and ocean underwater slopes is the only way to conduct paleolimnological reconstructions and to understand the evolution of mankind that is inextricably linked to the aquatic environment. Unfortunately, nowadays scientists explore outer space more intensively than the ocean. However, the ocean is the home for the human, and such essential interests as supplies of food and energy, the forecast of climate and the cheapest sea transport, defense and medicine are connected with the ocean.

CONDITIONS OF DEVELOPMENT OF MARINE PALEORESERVOIR IN PETROZAVODSK (RUSSIA, KARELIAN ISTHMUS)

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Geological sections in Petrozavodsk sity (N. 1 and 2), in 500 m to the north-northwest from the isue of the Neglinka river have opened (under the description I.M. Ekman in 1983) deposit of marine paleoreservoir, which one existed during Moscow Lateglacial, Mikulino intrglaciation and Valdai glaciation, in the conditions of permanently varying climatic situation (Yelovicheva, Lak, Ekman, 1989 – in russian; Funder, Demidova, Yelovicheva, 2002).

In the basis of the section 2 of the thickness about 22 m on the moraine of the Moscow glaciation the strata of clays (belt, sulfur, dark-grey, laminated, massive, with vegetative oddments) and loam occurs, accumulating in a severe climate Moscow Lateglaciation. Palynocompleses 1-10 mirror a succession of the vegetation (*Betula*+*Pinus*+NAP)→

(*Pinus*+NAP+*Abies*)→(*Picea*+*Pinus*+NAP)→(*Betula*+NAP)→(*Betula*+*Pinus*+*Picea*+NAP)→(*Pinus*+*Betula*+*Abies*+NAP)→.

Above on a section the palynocompleses 11-21 characterize the formations of loamy sand, clays, aleurites with vegetative oddments and conchas of marine molluscums in moderately-warm and warm climatic conditions of a beginning, first optimum, interoptimum cooling-down and second optimum of the Mikulino (Eem) interglaciation. The succession of the vegetation is submitted (*Pinus*+Spores)→(*Pinus*+*Ulmus*+*Quercus*)→(*Pinus*+*Alnus*+*Quercus*+*Tilia*+*Ulmus*)→(*Pinus*+*Alnus*+*Corylus*+*Quercus*+*Tilia*+*Ulmus*+*Carpinus*+*Larix*)→(*Picea*+*Alnus*+*Corylus*+*Carpinus*)→(*Pinus*+Q.m.)→(*Pinus*+*Betula*+*Alnus*+Q.m.+ *Corylus*). The lower optimum was more warmly upper under the high contents of broad-leaved breeds (10-12%), hazel (130%), alder (70%) and presence of exotics *Osmunda cinnamomea, Salvinia natans.* The interval, sectioning them, does not characterize the periglacial situation and can be estimated as a cooling-down between two optimum. The rank last can be comparable with the Holocene optimum (Atlantic period) at comparison with the palynological data on a section of a moor Chiilicuo in the same region (Елина, 1981). As a whole in a section is submitted the fullest climato-stratygraphycal rhythm of the Mikulino interglaciation with the two optimum keeping for this age interval general regularity in the sequence of occurrence and culmination of the main woodmake breeds in a climatic optimum and specificity of a structure of spectra, flora and vegetation for the northwest of Russia.

The section 2 completes the formation of the 27--m Late Pleistocene strata in the cold and moderately-cold climatic situation with the redeposition of the vegetative microfossiles. The given strata is representatived by the loamy, high-gravity, bouldery moraine of the Early Valdaj (glQ_3vd^1 – palynocomplex 1 – the blossom pollen of *Pinus, Picea, Betula, Alnus, Quercus, Artemisia* of poor safety, oddments of macrosporas of Mesozoic) is individual; belt and sulfur, dark grey, laminated clay, interbedding of sand and aleurite of Middle Valdaj (l, $lglQ_3vd^2$ – palynocomplexes 2-9); then clay belt and loam, moraine of the Late Valdaj (glQ_3vd^3 – palynocomplexes 10-22); and at last – sands with gravel lQ_4-hl (palynocomplexes 23-24). The succession of the vegetation is expressed (*Betula*+*Pinus*+*Picea*+NAP)→(*Pinus*+*Picea*+NAP)→(*Pinus*+NAP)→(*Pinus*+*Picea*+NAP)→(Betula+NAP)→(*Pinus*+*Abies*+*Larix*)→(*Pinus*+Spores)→(*Pinus*+*Betula*+ Spores)→(*Betula*+Spores)→(*Pinus*+*Picea*). In a structure of flora are constant the shrubbery form of the birches, ***Selaginella selaginoides, Larix, Abies, Eurotia ceratoides, Ephedra.***

Thus, both introduced sections 1 and 2 in Petrozavodsk sity contain a marine strata of precipitations continuously accumulating at the end of the Moscow (Warta) glaciation (MIS-6), during Mikulino (Eem) interglaciation (MIS-5) and Valdai (Visla) glaciation (MIS-2-4). The secured on the palynological diagrams the phase of the development of the vegetation represent the detail stratigraphy of the three horizons Upper Pleistocene and in this respect have the relevant value for the mining of the climate-stratygraphycal scale of the northwest of the East Europe flatness.

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Session 2.
Paleontological, geological, geochemical and isotopic methods in paleolimnology

Oral session

BIOGENIC ELEMENTS IN SURFACE BOTTOM SEDIMENTS OF LAKE LADOGA

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Any external impact on an aquatic ecosystem triggers the compensatory response mechanism meant to preserve it. Intensive human activities in Lake Ladoga catchment and utilization of its water resources in the second half of the 20th century have sharply changed the lake's nutrient status from ultra-oligotrophic to mesotrophic. The economic decline that followed in the 1990s significantly reduced the human pressure on the lake, and the ecosystem was somewhat stabilized. Progressing eutrophication results in intensified exchange processes at the water-bottom interface. These processes have been investigated for half a century already (Mortimer, 1942; Burns, 1976; Bostrom, 1982; Manning, 1983; Ahlgren, 1989; Zhukova, 2002; Martynova, 2008, 2014, etc.). For Lake Ladoga, Ignatieva (1996, 1998, 2002) has reveled three periods of change in internal phosphorus load on the ecosystem between the 1950s to the late 1990s.

The aim of the study was to find patterns in the formation of nutrient fluxes in the top layer of bottom sediments in Lake Ladoga depending on the scope of human impact.

Nutrient fluxes (C, P, N, Fe, Mn) at the water-bottom interface depend on the rate of organic matter transformation in bottom sediments, and the qualitative and quantitative composition of the matter depends on production processes and sedimentation conditions. Organic matter of the bottom sediments in the Sortavala, Hiidenselkä and Jakimvaara Bays of Lake Ladoga contained high amounts of reduction-oriented substances (Eh < 100 mV, C:N= 20 C:P=40). Atomic C:N and C:P ratios of profundal sediments were 9 and 80, respectively. The ratios for sediments in the dynamic zone were C:N =13, C:P =80. Organic matter transformation in the top layer of bottom sediments in pelagic Lake Ladoga proceeds under oxic conditions. The oxidized layer is up to 5 cm thick, oxygen demand ranges from 0.08 to 1 $gO_2 \cdot m^{-2}\ day^{-1}$, the rate of organic matter decomposition – from 0.02 to 0.6 $gC \cdot m^{-2}\ day^{-1}$. Sediments in bays had higher oxygen demand values and organic matter destruction rates.

Research into the spatial and vertical distribution of nutrients across bottom sediments in the northern part of Lake Ladoga in 1997-2004 showed the content of C (0.4 to 6%), P (0.05 to 0.7%), N (0.05 to 4%), Fe (1 to 8%), Mn (0.05 to 2%) in the solid-phase top layer of the bottom sediments was higher than the Clark degree, usually increasing with depth and the degree of dispersion of the sediment. Nutrient content in the top layer was the highest in sediments of high-productivity bays in the northern skerried part of Lake Ladoga. Ore bands rich in phosphorus, iron and manganese were found to form in the 5-10 cm sediment layer at the redox boundary throughout the central parts of the lake. Phosphorus accumulation in bottom sediments in the pelagic region is mainly due to an increase in the proportion of iron-bound phosphorus (up to 40% of the total). The vertical distribution of nutrients across the bottom sediments and interstitial water can be plotted by curves of several types – from those uniformly declining or rising with the sediment depth to those with distinct minimums or maximums at certain depths. The sharpest changes in the content of these nutrients were observed at the redox barrier.

In the bays exposed to human impact the position of the redox boundary coincided with the water-bottom boundary, so that redox-sensitive elements were immobilized and concentrated in the top layer of bottom sediments, wherefore their release to the water from such sediments was 2 – 100 times greater than their influx from bottom sediments in central parts of the lake.

The comparison of data on profundal bottom sediments from the northern part of Lake Ladoga obtained in the 2000s with results on the vertical distribution of nutrients across sediment columns sampled in 2013 (PLOT project – Palaeolimnological Transect) demonstrated that a tendency has appeared in the top layer of bottom sediments in Lake Ladoga for a reduction in the oxygen demand and nutrient concentration, and hence for a reduction in material fluxes from the bottom sediments back to the water. Such changes in the composition of the sedimentary material accumulated on the bottom are due to a decrease in production processes in the lake. Higher rates of organic matter sedimentation during anthropogenic eutrophication (1980s) intensified the processes of iron and manganese reduction and their vertical redistribution across the 15 cm sediment layer. The active impact lasted for 20 years only, but the diagenetic transformations have affected the bottom sediment layer deposited over a thousand years. Local maximums for iron (at 3-5 cm depth) and phosphorus (at 8-10 cm depth) correspond to the maximums of their concentration at a depth of 30 cm, which are dated to the 'Neva breakthrough' event 3100 yrs. B.P. Manganese content in the top layer is 5 times greater than its concentration at the 30 cm depth. The formation of ore bands retaining phosphorus in the bottom sediments appears to be a natural mechanism preventing eutrophication of the lake ecosystem.

One can say in conclusion that the resistance of the lake ecosystem to the external impact can be determined by the rate of cycling of the organic matter, which excessive amounts are deposited in the bottom sediments. Changes in the distribution of nutrients across Lake Ladoga bottom sediments suggest that human activities in the catchment, even if short-term, are comparable in effect with the impact of natural-climatic and tectonic factors. The Lake Ladoga ecosystem is now gradually returning to its original oligotrophic status.

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A NEW APPROACH FOR TIME-RESOLVED RECONSTRUCTIONS OF INPUTS OF DIFFERENT TYPES OF TERRIGENOUS MATTER INTO AQUATIC SYSTEMS: A RESPONSE OF GLACIAL AND INTERGLACIAL TYPES OF TERRIGENOUS MATTER INPUTS INTO THE OKHOTSK SEA SEDIMENTS TO GLOBAL CLIMATE CHANGES DURING THE LAST 350 KYR AT THE ORBITAL AND MILLENNIAL SCALES

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A new approach for time-resolved reconstruction of weight fractions of different types of terrigenous matter entering to aquatic systems was proposed. This approach is based on high-resolution multi-elemental analyses of a sediment core, followed by specially elaborated mathematical tools for treatment of the obtained elemental profiles. The method was applied to previously dated central Okhotsk Sea (OS) sediments covering the last 350 kyr. The studied core MR06-04 PC-7R (51°16.87'N, 149°12.57'E; water depth 1256 m; core length 1723 cm) was analyzed for biogenic compounds ($CaCO_3$, SiO_2_bio and C_org) and for 63 chemical elements (using the ICP-MS method) with a high resolution (1 cm; ~ 200 years).

For natural systems, whose sedimentation is driven by two main types of terrigenous sources, a mathematical model for the reconstruction of their inputs (at each fixed moment of time) was developed and thoroughly tested. This model was applied to reconstruct the weight fractions of interglacial (with modern elemental composition) and glacial (with elemental composition characteristic for the Last Glacial Maximum) terrigenous matter in the OS sediments with high resolution (Fig.1).

The weight fraction of the interglacial terrigenous matter in OS sediments increased during warm Marin Isotope Stages (MISs) and substages and decreased during cold MISs and substages, and the weight fraction of the glacial terrigenous matter varied with reversal regularity. Reconstructed inputs of these two types of terrigenous matter simultaneously change with lithophysical sediment properties and with biogenic productivity in the OS, depending on global climate changes on both orbital and millennial oscillation scales. This result indicates that the terrigenous accumulation of Okhotsk Sea sediments is strictly modulated by global climate changes in the Northern Hemisphere,

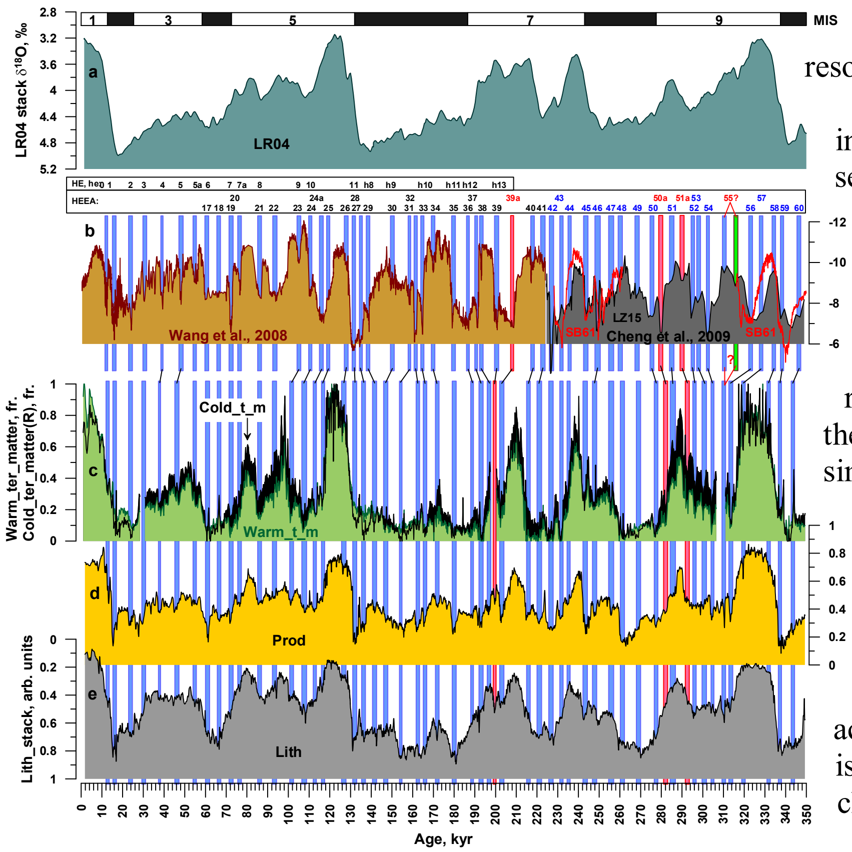

Fig. 1. Orbital and millennial scale changes in paleoenvironmental proxies in OS sediments (core PC-7R) over the last 350 kyr. (**a**) global stack of $\delta^{18}O$ in benthic foraminifera (Lisiecki and Raymo, 2005); (**b**) East Asian monsoons oscillations recorded as $\delta^{18}O$ in Chinese cave speleothems (Wang et al., 2008; Cheng et al., 2009); (**c**) reconstructed weight fractions of glacial* (*Cold_ter_matter(R)*) and interglacial (*Warm_ter_matter*) terrigenous matter in the terrigenous part of OS sediments (tephra layers and adjacent horizons with high values of volcanogenic indicators are cut off); (**d**) stack of productivity proxies in OS sediments (Ba_bio, C_org, $CaCO_3$, SiO_2_bio and chlorine); (**e**) stack of lythophysical proxies of OS sediments (humidity, density, magnetic susceptibility and % of fraction >63 µm). Blue bars mark 52 abrupt climate cooling events in the OS (called Heinrich equivalent event anomalies or HEEAs, (Gorbarenko et al., 2012)) numbered after McManus et al. (1994). HEEAs are correlated with Heinrich events of Heinrich (1988) during MIS 2 and 3, with cold events in the North Atlantic measured by McManus et al. (1994) during MIS 4 and 5 and with North Atlantic IRD peaks during MIS 6 and 7. Pink bars mark three probable HEEAs additionally obtained by a comparison of OS proxies with EA monsoon activity records.
* Shown as reversal profile of the *Cold_ter_matter* profile.

which impacted dominating sources of terrigenous matter (intensity of riverine runoff and of coastal wave and ice abrasion processes) and its supply into the open sea (changes in the volume of sea ice formation and currents and wind patterns). Tight correlations of element distributions in the terrigenous part of the OS sediments (reflecting variations in main terrigenous matter source inputs) with variations in sediment lithophysical properties and in basin productivity suggest that the OS environment, its ecosystem and the preparation and accumulation processes of terrigenous matter in the OS responded to global climate changes as one whole system.

Additionally, a new method for cryptotephras detection in OS sediments based on the mathematical analysis of their elemental composition was proposed and successfully tested.

METHOD OF QUANTITATIVE RECONSTRUCTION PALEOCLIMATE HOLOCENE BASED ON HIGH-RESOLUTION LITHOLOGICAL-GEOCHEMICAL STUDIES OF LAKE SEDIMENTS

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Reconstruction of past climates is necessary for an understanding of future changes. Length of meteorological observations time series is typically less than 100-150 years, which is insufficient for detecting climate variations with long periods. Therefore it is very important to do the reconstruction of long climatic parameters time series on quality comparable with those of instrumental meteorological: 1 year time resolution for the millennial scale; calibration using instrumental meteorological data; quantitative evaluation of possible errors (IPCC-2007, IPCC-2013).

Lithologic-geochemical approach based on the fact that the composition of lake sediments depends on: 1) the terrigenous material; 2) the salinity of the lake water, which determines the possibility of authigenic mineralisation; 3) the organic material as allochthonous and autochthonous; 4) the aerosols. Each component of lake sediment has a specific set of trace elements. Natural variations in the intensity of incoming different components lead to the formation of the sediment fine structure, which contains information about the state of the environment at the time of formation of each layer of sediment. The authors have developed a technique for solution the following research tasks:

- coring core sediments overlying last millennia time interval;
- construction time model, based on isotope studies (^{137}Cs, ^{210}Pb, ^{14}C) and varvohronology;
- obtaining data on the distribution about 20-25 trace elements in the depth of core with annual time resolution using the developed microstratigraphy analytical techniques;
- establishing correlation of composition, properties and structure of lakes bottom sediments with major regional climatic parameters for the period of instrumental meteorological observations (usually - the last 70-120 years);
- identify the climatic response of sediment major components - terrigenous, biogenic, aeolian and authigenic;
- the formation of a time series of climate change for the period of the last millennium based on the obtained data;
- comparison of regional chronologies with global climate change;
- identify trends and periodicity of regional climate variations;
- preparation of quantitative regional climate changes prediction in the coming decades depending on natural causes.

Microstratigraphy analytical techniques developed authors in the last 10 years, especially for tasks high resolution study lake bottom sediments.

In our studies we used X-ray scanner with synchrotron radiation was created Institute of Nuclear Physics SB RAS (Novosibirsk) based on storage ring VEPP-3 [1].

The current facility allows us to scan core samples with steps of 0.1-1 mm, simultaneously analyze 25-30 trace elements (from Cl to U) with detection limits of 0.1-1 ppm.

We have developed a method of manufacturing a solid samples from the wet core, which includes three stages: imposition of aluminum foil box on the surface of the sediment and extracting it from the core; freezing in liquid nitrogen and drying in a vacuum chamber; polymeric saturation by the mixture of epoxy resin and acetone [2]. The result samples are useful for long-term storage, manufacture of thin sections for the study of optical microscope, X-ray and other modern methods of microanalysis.

Obtained analytical data allows us to build the series of lithological and geochemical indicators on the scale of last millennia with annual time resolution. Calibration using meteorological data allows to transform received signals into the records of retrieved fundamental climatic parameters: temperature and precepitation. Climatic time series are analyzed with methods of mathematical statistics to identify periodicities of different lengths and assess the role of these oscillations in regional climate change. To identify the frequency we use traditional methods of Fourier and wavelet analysis, and less known empirical mode decomposition using the Hilbert-Huang transform [3].

On the basis of the identified patterns and different time scale periodicities we can go for quantitative prediction of regional climate changes due to natural causes in the coming decades. For this purpose we use:

- search of analogues of climate processes in the past and their extrapolation into the future;
- numerical simulation and optimization processes of quasiharmonic function;
- calibration and synchronization of identified natural cycles with instrumental meteorological data.

The presented approach has been implemented in recent years at the facilities of the Central Asian region.

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CURRENT STATE OF THE LAKE LADOGA ENVIRONMENT ACCORDING TO DATES OF THE GEOENVIRONMENTAL-MONITORING

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Lake Ladoga is the largest reservoir of drinking water for the water supply of St. Petersburg and Ladoga area total, and also has important meaning Fishery and Shipping. The state level legislative documents of Ladoga and Onega lakes, just adopted of Russia Government indicate them as a strategic resource for Russia. So, the preservation of the natural environment of these lakes is a priority of the various environmental organizations. The report discusses the results of the monitoring of the geological environment of Lake Ladoga, including the study of the geochemistry of sediments and near-bottom waters, held for several years the Centre for Monitoring the geological environment and engineering research of JSC "Sevmorgeo" on government programs funded by the Department "Rosnedra" Ministry of Natural Resources.

The drainage basin of Lake Ladoga is about 258,000 km^2. A low salinity, bicarbonate-calcium composition, high content of human substances is typical for rivers in the basin of the Lake Ladoga. Such as river Volkhov and Vuoksa are translators of pollutants of industrial enterprises located on their shores. In fact, several paper mills on the shores of Lake Ladoga previously polluting the waters currently almost stopped. The main contaminant serves large agricultural enterprises and shipping.

The main pollutants of Lake Ladoga, gets into it with wastewater (and precipitation) are organochlorine compounds (OCPs), polycyclic aromatic hydrocarbons (PAHs), petroleum products (HC), heavy metals (HM), synthetic surfactants (detergents). But the main role in the pollution of Lake Ladoga plays biogenic components: organic matter, nitrogen and phosphorus, which were a source of waste pulp and paper mills in the form of lignin.

Distribution and accumulation of anthropogenic products in the bottom layer in Lake Ladoga is in accordance with natural sedimentation processes. The main factors of these processes is the separation of the lake basin into two parts: the northern, deep-sea, where can accumulate predominantly lacustrine nepheloid silty-pelitic sediments, and the southern, shallow, where the bottom surface lies a layer of sandy sediments of various thickness, overlapped of series of glacial- lacustrine clay.

The features of the contamination by heavy metals, hydrocarbons, radioactive elements can also be clearly divided also into two parts, northern and southern. Sediments in the southern part of the lake, which is dominated sandy and coarse clastic sediments, usually are characterized by low concentrations of trace elements. The contaminating components put to great depths in the north side. The most intense accumulation of pollutants associated with zones of nepheloid sedimentation in the northern part of the lake, where the main factor is the low hydrodynamic activity. Pelitic sediments of the northern sedimentary basins are enriched in organic matter (TOC up to 2-4 %) and are characterized by high background concentrations of heavy metals, hydrocarbons and increased content of ^{137}Cs.

The main sedimentary basins are Priozersky, Lahdenopohsky, North and South Valaamy. Another sedimentary basin, which receives runoff chemical components of river Volkhov, Svir and Sjas, selected the central part of the lake at its Eastern shore. He spatially confined to the buried valley, which is a continuation of the river Sjas.

In the southern Lake Ladoga are located mainly erosion zones or "zero sedimentation", which are located on the bottom surface of the glacial- lacustrine and lacustrine deposits, covered with a thin layer of medium- coarse, poorly sorted sand, with a thickness of not more than 5 - 15cm. Accumulation of both natural and anthropogenic chemical components, primarily in the form of moving the slurry is absent here.

Special technogenic fancies are highlighted at the bottom of the Lake Ladoga, along with natural facial areas. It is bottom areas completely or largely modified due to anthropogenic impact (underwater careers, harbors, underwater dumps, etc.).Geochemical characteristics and composition of near-bottom and pore waters and sediments in these fancies are very different from natural as a set of elements and their concentrations. Techno genic facies are located mainly in the northern bays of the Lake Ladoga, near the former or even to some extent the existing industrial centers, including pulp and paper mills. Examples are man Technogenic sediment in the Bay “Shutchiy” (entering the bay Lehmalahti) can serve as an example.They was formed as a result of the former mill (Priozersky ZBK) and are represented by black mud, with a distinct odor of hydrogen sulfide silt with high content of lignin and heavy metals. Technogenic facies near the village Läskelä composed of gel-like mud formed by semi-decomposed scree, with putrid smell. Low pH values in places less than 5.9 are associated with the processes of hydrolysis of cellulose with the release of free carbonic acid. The chemical composition of bottom waters of Lake Ladoga in these areas characterized by the appearance of hydrogen sulfide and changes the prevailing hydro-calcium composition on calcium sulfate. The problem is that this system is autochthonous and trace migration continues even in the absence of rain water for these new portions of pollutants.

So, all ecosystem of the Lake Ladoga in results this feeling the effects of heavy metals in small doses. Such effects of low doses of pollutants called low-intensity exposure factors is extremely dangerous due to their permanent nature. This leads to the accumulation of toxic substances in the environment and the components, primarily in animal organisms. Local complex HM anomalies occur in sediments near specific sources they are formed exclusively in clay sediments. So the bottom sediments of the Gulf of Sortavala characterized by high contents of vanadium up to 86 g / t), copper (up to 53 g / t), zinc (up to 237 g / t), and in the southern part of his set higher accumulation of lead (up to 1000 g / t). Increasing content of mercury in bottom sediments contain directly near Sortavala. Definite influence on the level of heavy metal concentrations in sediments has metallogenic features bedrock substrate.

The bottom sediments of the southern bays of Lake Ladoga covered sands and do not contain high concentrations of contaminants. However, in spring, when the mouth of bays worth thermobaric, sands are covered with a thin layer of fluidic silt, which is already a hub of some heavy metals. In summer, the liquid silt brought to the north-east and accumulates in Eastern sedimentary basin.

Thus, the HM anomaly in sediments and bottom water is largely caused by natural sedimentation processes. Local sources of pollution lead to the formation of zones with a high content of the trace elements that are characteristic of specific production cycles. However, and their formation is subject to the laws sedimentogenesis.

LACUSTRINE RECORDS OF THE HOLOCENE PALAEOCLIMATE IN IRAN

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Fig. 1.The map of sampled sites in Iran. Most of the selected sites are along Zagros heights and eastern playas and interdune basins.

Iranian plateau lies in arid zone between 25°N to 40° N where three major climatic systems of the NAO, Siberian High pressure and Indian Ocean Monsoon (IOM) meet each other and the interaction of the systems shapes the climate of Iran. The tectonic setting of Iran and the consequent orography of the region provides the possibility of frequent inland basin development such as lakes, wetlands, peat bugs, playas and inter-dune basins. These basins as a cross section of the mentioned climatic systems, recorded the history of climatic changes and their shifting over the plateau. To investigate the changes, a comprehensive research campaign has been conducted in 2013 and 2014 for sampling in the basins. Totally,11 basins including lakes (Urumia

Lake, Hamun, Maharlou, Neor, Almalou, GhuriGol), wetlands (Ruzian, Asepas, Hashilan) and interdune basins (Shourgaz, ChaleMalek Mohammad in Lut desert) were selected for sediment sampling. Maximum core penetration varies from 0.5 m down to 30 m.

Magnetic susceptibility applied for raveled cores. The cores opened for description, and sub-sampled for sedimentology, palynology, paleontology and geochemical analysis. Newly retrieved cores are under processes and here we present the first achievements.

A QUANTITATIVE VARVE SEQUENCE CROSS-CORRELATION AND MAGNETOSTRATIGRAPHY FROM TWO CLAY VARVE BASINS IN WESTERN ESTONIA

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Concern about current climate change has raised the number of publications dealing with varved sediments giving rise to the term 'recent varves' for those forming today, and 'paleovarves' for those from earlier in the Holocene and Pleistocene (Francus et al. 2013).

Work on paleovarves has advanced in the use of the varve sequences to constrain chronologies and to further our understanding of Pleistocene climate as well as non-climatic events associated with deglaciation. Currently a Late Weichselian local varve chronologies, varve thickness variations and palaeomagnetic secular variation will be discussed for coastal Estonia, eastern Baltic.

The decay of Late Weichselian ice from Estonian territory between 14.7 – 12.7 ka yrs BP was followed by extensive proglacial bodies of water, which developed in accordance to the receding ice margin and opening of new drainage roots. This is reflected in a wide distribution of varved clays with their characteristic summer (silty) and winter (clayey) layers which are interpreted to reflect seasonal variations in sedimentary environment in proglacial lake. Varved clays in western Estonia forming two large basins, namely Pärnu and Vigala have been deposited in the Baltic Ice Lake. Up to 30 m thick cover of clay is characterised by distinct lamination with visually distinguishable seasonal layers. The lower contact of silty summer layers are sharp, but as the silt grades normally into clay the contact between summer and winter layers is gradational. Varves are usually thick and clayey with silty microlayers in some intervals. Recently a new local varve chronology comprising 584 yrs was constructed for Pärnu area (Hang & Kohv, 2013). There are clear trends in varve thickness variations and in the relation of seasonal layer thickness which can be readily followed from the mean varve thickness graph (Fig. 1). Local varve chronology for Vigala basin comprises 532 consecutive varve years (Fig. 2). As two basins are separated by c 15 km till terrain no good visual correlation between above chronologies was possible. It is why we exploited numerical techniques to assist in finding possible correlation. Raw varve thickness series were normalized in order to remove sedimentary signal assumed mostly to reflect the proximity to melting glacier. This signal (general trend) was calculated using Empirical Mode Decompositon (package EMD in R software) and extracted from raw series. Residual series were log-transformed in order to stabilize variance. Log-transformed series were smoothed with 21 year window median filter (package robfilter in R). Cross-correlation function suggested the best fit if normalized Vigala series is lagged +140 years (Fig. 3). This under the hand the earlier magnetostratigraphic data (Hang et al. 2011) from two clay sections from Pärnu and one from Vigala basin were connected. As NRM results differ between the core sections due to poor orientation of a sampler during the coring only relative changes in magnetization was derived. Strong eastern shift in declination is correlated with similar data from regional declination curves (Bakhmutov & Zagniy 1990; Saarnisto & Saarinen 2001) between 13.9-13.3 ka BP. This correlation places the stagnation of ice margin at Pandivere-Neva line to ca 13.9-13.7 ka BP being thus ca 600 yrs earlier than proposed from NE Estonia and Lake Onega in NW Russia and supports the recent AMS dates from northern Estonia suggesting the age of Pandivere-Neva formations there to be 14.0-13.8 ka cal yrs BP (Vassiljev & Saarse 2013).

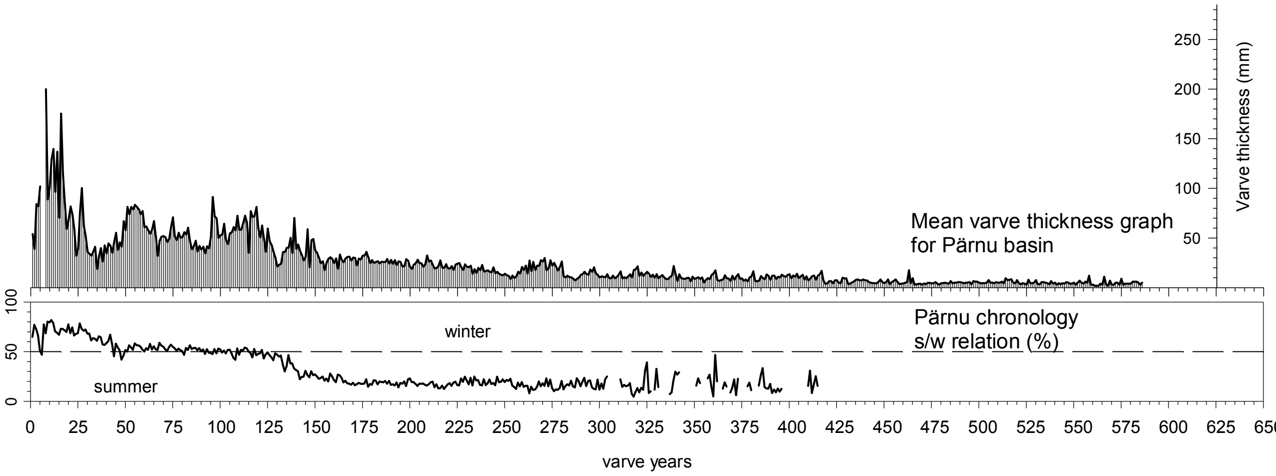

Fig. 1. Mean varve thickness curve for Pärnu chronology based on all studied sequences. The lower diagram summarizes the relation of winter and summer layer thickness within the varve

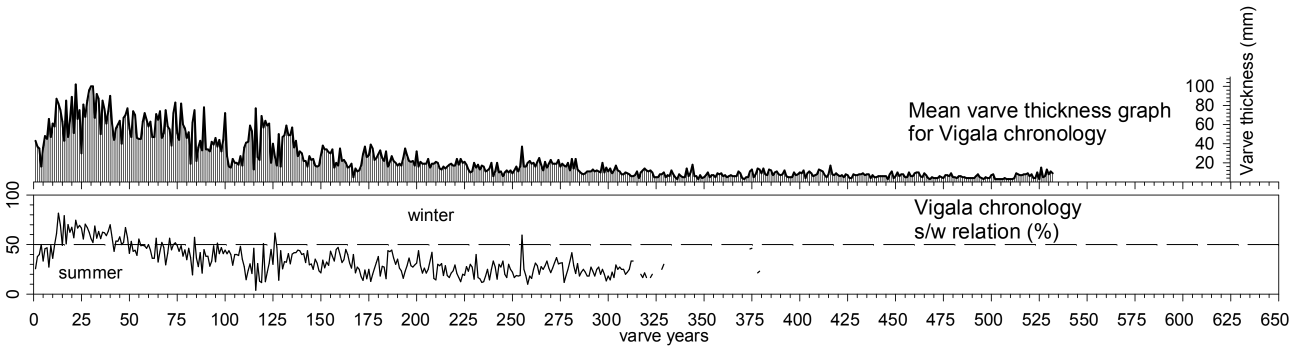

Fig. 2. Mean varve thickness curve for Vigala chronology based on all studied sequences. The lower diagram summarizes the relation of winter and summer layer thickness within the varve

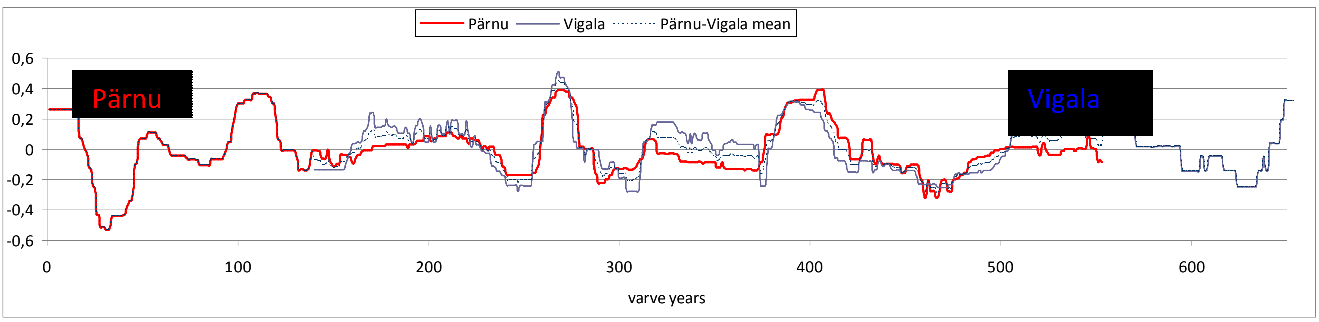

Fig. 3. Cross-correlation function suggested the best fit between normalized Pärnu and Vigala series if Vigala series is lagged +140 years

GEOCHEMICAL RECORD FROM LAKE BAIKAL SEDIMENTS AS A HISTORY OF ENVIRONMENTAL CHANGES IN THE LATE-PLIOCENE-PLEISTOCENE

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Despite the Baikal Drilling Project whose main target was to reconstruct the environment and climate was accomplished the sedimentary records obtained from the project are still of interest. With new data obtained recently there is a possibility for more profound conclusions and interpretations. During the project run five clusters of boreholes were drilled in various geomorphic structures of the lake. Borehole on the Academic Ridge (BDP-98) that separates the Central and Northern basins penetrated to a depth of 600 m. and thus yielded the most continuous record. We discuss the detailed geochemical features of the Late Pliocene and Pleistocene bottom sediments obtained from studies of major and trace element composition. We concentrated our studies on the core interval marking the transition from the Pliocene to Pleistocene (2.8-2.5 Ma) that correlates with the glaciation in the Northern Hemisphere. In Lake Baikal Area this time span correlates with the stage of active continental movements that resulted in mountain growth to the height marking the snow line that gave rise to mountain glaciers on surrounding ridges. For obtaining a more complete element distribution we studied the adjacent core intervals which characterize the Late Pliocene and Pleistocene as a whole.

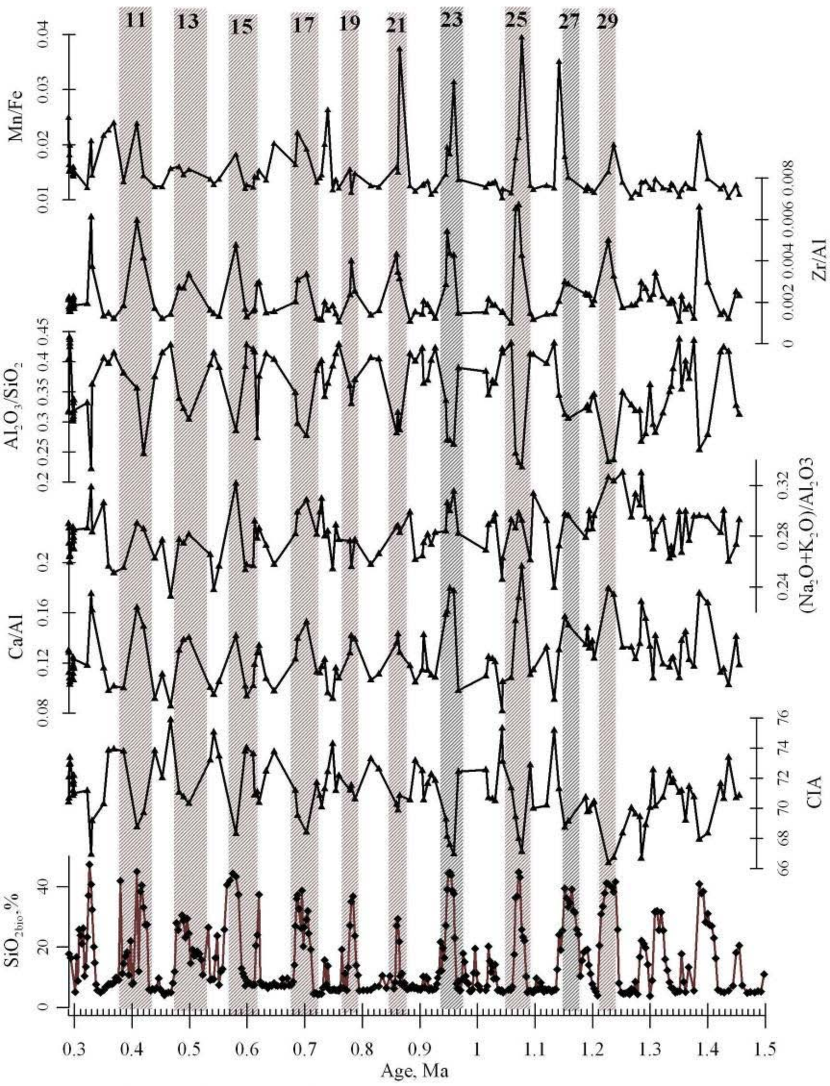

Fig 1. Pleistocene major components record 0.3-1.5 Ma (BDP98)

When studying the major components the most informative were the following indicators: chemical weathering index CIA as well as (CaO/Al_2O_3) и ($(K_2O+Na_2O)/Al_2O_3$) modules. As the sediments penetrated by BDP-98 borehole show the variations in particle-size composition, the alumo-silicate module (Al_2O_3/SiO_2) and Zr/Al values were used to estimate the influence of physical rock destruction and the size of deposited particles.

Thus, the correlation of CIA, Ca/Al, $(K_2O+Na_2O)/Al_2O_3$, Zr/Al, Mn/Fe in Lake Baikal sediments marks both the active orogenic phase dated as 3.2-2.2 Ma and the glacial-interglacial transition in the Middle-Upper Pleistocene.

Despite the general chemical weathering decreased from the Late Pliocene to Pleistocene (Fig. 1), the chemical weathering was more intense in the Pleistocene cold periods as compared to warm ones. It suggests the contribution of glaciers to destruction of rocks on the snow line, permafrost processes leading to exposure of the older Quaternary deposits and increase of the eolian transfer of different-age fine fraction in cold periods. In turn it resulted in a greater contribution of weathering crust (clay component) into Baikal sediments in the glacial.

In span of time (from Pliocene-to Pleistocene ranging from 2.8 to 2.5 Ma) the trace elements were more intensively accumulated in colder periods that also suggests the response to climatic changes.

Thus, the results will help to shed light on the important "Neobaikalian" stage in the evolution of the Baikal Rift zone from the viewpoint of environmental and climatic changes using the geochemical records from Lake Baikal sediments.

The obtained results are the continuation of studies to reconstruct the Cenozoic environment in Baikal region started by the Baikal Drilling Project.

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GEOCHEMICAL SIGNALS OF PALEOCLIMATE RECORDED IN THE VARVED CLASTIC AND CARBONATE LAKE SEDIMENTS

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As it well known, recent quantitative estimations of high-resolution environmental variability are based on geochemical records in lake sediments. Necessary requests for study origin of rhythmic paleoclimatic signal in bottom sediments are following: 1) accurate sampling /coring and preparing of solid preparates /, 2) high resolution submillimeter analytics, 3) absolute dating and 4) calibration of geochemical time series by instrumental data.

The basic request to sediment records is primary succession of deposition without next disturbances of matter. Naturally, annually laminated sediments (varves) are the best objects for paleoclimatic study, because they allow to investigate seasonal variability for understanding long-term environmental pattern. Also, varved sediments seem to be applied as the model for identification of element-indicators for non-laminated sediments.

The XRF scanner on Synchrotron Radiation provides big geochemical dataset for next mathematic treatment, including time series construction. XRF scanning realizes rapid and non-destructive determinations more than 30 trace elements in a range of concentration from 1 up to 10000 ppm in annual layers, that makes sedimentary cores comparable with tree-rings. Geochemical and physicochemical investigation of lake sediments provides basic information to identify geochemical signals with paleoclimate.

In general, sediment consists of mineral component, organics and carbonates. The proportions between these components are affected by environmental parameters, because measured element content or their combinations show correlation with meteodata on instrumental time interval. That allows applying geochemical variability to reconstruct the environmental parameters in the form of time series.

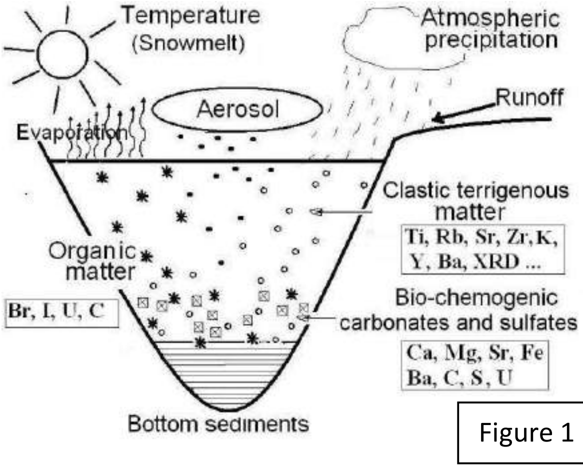


Figure 1

Bottom sediments is the result of structural ordering, averaging and secondary transformation of the terrigenous, organic and bio-chemogenic source matter (fig. 1).

The proportions between main components are controlled by environmental parameters - temperature, atmospheric precipitation, water salinity, wind direction and other external forcings. So, layered structure of lake bottom sediments and detectable elements content variability both represent a continuous record of environmental history.

Element composition and it's climatic response. Bottom sediments represent conditions of physical weathering, temperate bioproductivity and aridity, which concerns to mountain lakes within extra tropical zone.

Mineral matter responses to runoff. Mineral clastic part is correlated with x-ray density. It includes "clastic" rock-forming - Si, Al , Ti, Fe, Mg, Ca, K and trace elements such as Sr, Rb, Y, Zr, REE etc. The most reliable components having climatic response are Sr/Rb ratio, XRD, K and Ti because they are main arguments in calculated transfer function after minimization options of its' number. Organic component of sediment more reflects temperature by means of productivity in the catchment and waterbody. Organophillic elements are Br, I, U and others soluble elements correlated with organic Carbon or LOI<500^{o}C. Bio-chemogenic component is more characteristic for saline lakes, where Ca-, Mg- and Sr- carbonates precipitated in dependence of temperature, aridity and water salinity.

Separate geochemical indices are directly used for paleo- environmental evaluation. For example, elements with changing valency may be a special indicators of outer conditions. Fe is strictly connected with sulfur in sulphide under anoxic conditions. And also Fe forms siderite in carbonate ion saturated but calcium poor water in the sedimentation system. Mn-enriched layers, crusts and nodules mark usually a long – term pauses of sedimentation in oxic systems. Mo/Mn ratio is good correlated with anoxic atmosphere. And so on.

Grouping of elements by correlation. In natural sedimentation system elements are statistically joining by correlation in compliance with physicochemical reasons (like concentration, solubility, absorption etc) and water dynamics, which are depended on environment.

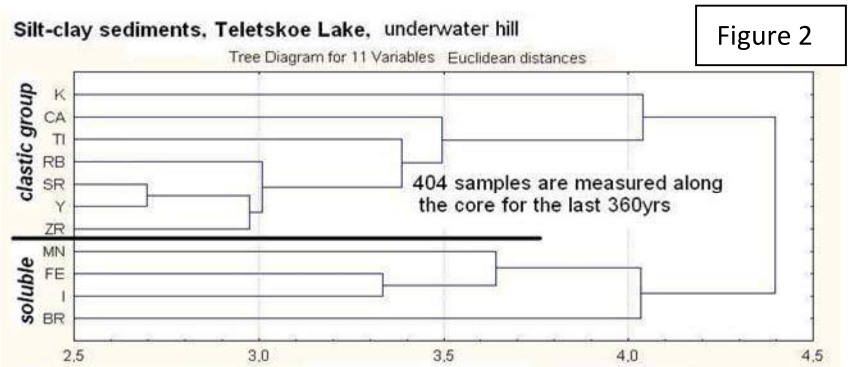


Figure 2

Clastic varves are well-known in glacial and in non glacial lakes all over the world. Sediments from lakes Lehmilampi, Donguz-Oron, Teletskoe (fig. 2), Kucherla have typical structure within individual layer showed gradation from bottom mid-grained material (silt) to fine-grained top (clay with a touch of organics). Correspondingly **Rb** and **Br** content increase, but **XRD, Ti, Sr, Zr** and other "clastic" components decrease upward. So, **Sr/Rb** ratio reflects portion of clay fraction and marks stable sedimentation periods. Each annual rhythm demonstrates graded sequence corresponded to seasonal change from spring-summer turbulence to autumn-winter period of stable water. Carbonate varves are presented in continental semi-arid areas. Sediments from saline lakes, Telmen (Mongolia), Van (Turkey) and Shira (South Siberia, fig.3) were analysed. They have strong seasonal Sr-signal (fig. 4), due to the different solubility of Ca- and Sr- carbonates under salinity and temperature gradients.

Figure 3

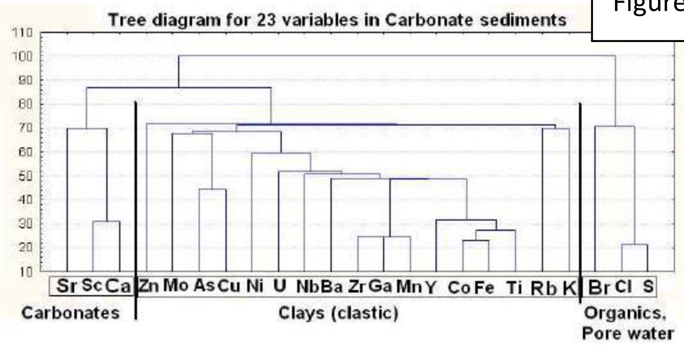
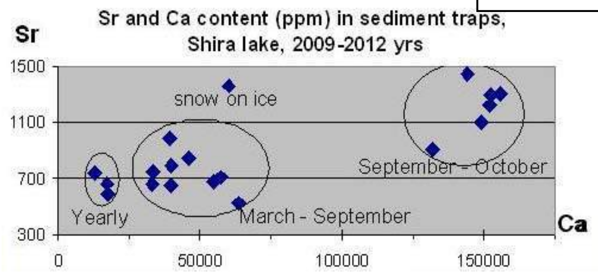


Figure 4



The work is supported by grants SB RAS 52-34, 52-56, RFBR 13-05-00621, Earth Sci. Division RAS № 12.8.

METHODS OF QUATERNARY RADIOCHRONOLOGY: MODERN APPROACHES, DATING RESULTS, PROSPECTS OF APPLICATION

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Reconstruction of palaeogeographical and geological events, recovery of history of environmental changes such as landscape climatic and vegetation variations, sea level changes, etc. during Middle and Late Pleistocene and Holocene is based on comprehensive environmental studies including radioisotope dating results obtained for natural materials. We provide radioisotope geochronological research of Quaternary oceanic and terrestrial sediments applying U-series dating methods jointly with radiocarbon method. The solution of the tasks connected with expediency of application of one or other radioisotope methods means carrying out comprehensive radiochemical, geochemical and micropalaeontological investigations of varying sediment types.

The results of the critical analysis of the theoretical framework and the improvement of the geochronology methods based on U-series radioisotopes in dating Quaternary oceanic and terrestrial deposits are reported. Our studies support both the ^{230}Th- and ^{231}Pa-methods of determining the age of pelagic sediments (including foraminiferal and metalliferous deposits) as well as ferromanganese nodules and crusts [1, 2]. The case studies of foraminiferal and metalliferous sedimentary cores by ^{230}Th- and ^{231}Pa-dating in combination with ^{14}C, ^{18}O/^{16}O, geochemical and micropalaeontological analyses are also reported. Growth rates of ferromanganese nodules and crusts from the Pacific Ocean determined by both methods of ^{230}Th- and alpha-radiographic (alpha-track) dating [1-4].

Our analytical studies of mollusk shells showed that reliable ^{230}Th/U-age can be obtained if the requirements of sampling and of radiochemical analysis are fulfilled. According to these recommendations we dated Eemian (Tyrrhenian) mollusk shells from the Black and Mediterranean seas [1, 5].

Possibilities and limitations of the ^{230}Th/U-dating of seafloor massive sulfide (SMS) deposits at the Mid-Atlantic Ridge (MAR) were substantiated experimentally and the first geochronological results were obtained [1, 2, 6, 7].

In recent two decades, the uranium-thorium (^{230}Th/U) radioisotope method is used for dating terrestrial Interglacial (Interstadial) organic-rich deposits with age up to 300-350 ka [1, 2, 8-10]. Up to now a strict approach to practical application of this method has not been devised and the ^{230}Th/U dating of these deposits has not become a widely applied method. We initiated comprehensive radiochemical, radiochronological and biostratigraphical studies of organic-rich sediments to substantiate the capabilities and limitations of the ^{230}Th/U-method for their dating. Up to now we have obtained a number of age data for the Late and Middle Interglacial/Interstadial buried deposits from the East European Plain and Siberia [1, 2, 10-13]. Case study of paired ^{14}C and ^{230}Th/U methods in dating organic-rich sediments from the North-Western Russia supports the reliability of the ages obtained [14].

First ages and prospects of ^{230}Th/U dating of travertine and fossil wood remnants are discussed in the report [15-16].

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DIATOM EVIDENCES FOR THE MID-HOLOCENE LADOGA TRANSGRESSION, A KEY EVENT IN THE LAKE LADOGA HOLOCENE HISTORY

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The mid-Holocene Lake Ladoga transgression resulted from the increased water inflow via the new-born River Vouksi and uneven glacioisostatic uplift of the northern and southern parts of the lake basin, and lasted over 2000 years. During this high-level stage, the Lake Ladoga level is believed to have raised over 15-18 m above the sea level (a.s.l.). More precise estimate of the transgression maximum level is still debatable though, and varies from the north to the south of the Ladoga basin due to the different rates of uplift. Progressive inundation of vast areas of the coastal lowlands by the Ladoga waters caused early human migrations, and new settlings appeared along the transgression shoreline. The formation of the new Ladoga outlet, the River Neva, put an end to the transgression, and the lake level dropped rapidly up to the present 5 m a.s.l. As a result of this remarkable regression event, the lake’s shoreline displaced, the whole drainage pattern in the Lake Ladoga region was reorganized, and many early human settlings ceased to exist.

Presently, Ladoga transgression sediments are thought to be widespread, and can be found both in small-lake basins at lower elevations and terrestrial sequences. Once accumulated under the large-lake conditions, they preserved invaluable evidences to reconstruct temporal and spatial (areal and altitude) extent of the mid-Holocene Lake Ladoga high-level stage, and the diatom analysis has recently been proven one of the most powerful tools in Ladoga transgression studies.

This study deals with the diatom records from a number of sites around Lake Ladoga once inundated (or thought to be) by transgression waters, given their present elevation. About 20 lacustrine and terrestrial sections are revisited to define most important features related to the Ladoga transgression start and termination, and various direct and indirect evidences for transgression are recognized. The discussion focuses in the indicator value of such signals as a presence of the so-called “large-lake” diatoms, diversity of the “large-lake” taxa, planktonic to benthic ratio, diatom-inferred trophic and pH changes, etc., and their site-specificity, and further applications in palaeoreconstructions are outlined.

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REGIONAL STATISTIC MODELS AS A TOOL FOR PALAEOCLIMATIC INFERENCES

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The study of Arctic palaeoenvironmental records enables qualitative and quantitative estimations of past climate changes and provides a basis for prediction of future changes in the region (Andreev et al. 2004). The timing of Holocene climate events in the North Atlantic region is relatively well studied (Bond et al. 2001; Solignac et al. 2006). In contrast, there are few quantitative palaeoclimatic data for eastern Siberia, such that hypotheses regarding the timing and spatial coverage of important climate events, like Holocene Thermal Maximum remain untested. In addition, proxy records from northern Eurasia mostly document environmental changes at low temporal resolution and are derived from pollen studies (Anderson et al. 2002; Andreev et al. 2004). Due to the relatively small magnitude of temperature changes throughout the Holocene, reconstructions based on a single proxy must be interpreted with caution. Furthermore, current global climate warming can be challenging for the lakes and aquatic fauna of eastern Siberia since this region is among the most sensitive areas affected by extreme changes in climate (Smol et al. 2005).

Many studies have explored the potential of aquatic organisms, including chironomids (Order: Diptera, Family: Chironomidae), as Quaternary palaeoclimate indicators (Porinchu and Cwynar 2002; Dieffenbacher-Krall et al. 2007). Chironomid calibration data sets and inference models for reconstructing mean July temperature (Larocque et al. 2001), lake depth (Korhola et al. 2000), salinity (Eggermont et al. 2007) and lake production (Woodward and Shulmeister 2006), have been developed successfully for Western Europe (Olander et al. 1999; Brooks and Birks 2001), North America (Walker et al. 1997; Barley et al. 2006), Africa (Eggermont et al. 2007), New Zealand (Woodward and Shulmeister 2006) and Tasmania (Rees et al. 2008). But still no calibration data sets and inference models have been established for the Russian high latitudes, including Arctic Siberia.

It is known that most of the models have limited application outside of the regions where they have been developed. Differences in faunal composition between sites included in the calibration set and the studied site make data difficult to interpret and results are sometimes unreliable (Lotter et al. 1999). Attempts to apply a transfer function based on a northern Sweden calibration data set (Laroque et al. 2001) to chironomid records from the northern Russia: Nikolay Lake, northern Yakutia (Andreev et al. 2004) and Lake Lyadhej-To, northern Ural (Andreev et al. 2005), have shown that only 50-59.5% of the taxa from fossil lake sediment assemblages appear in the modern calibration data set. The application also shows that reconstruction of the mean air temperature of the warmest month (T_{July}) before 10,650 cal. yr BP and after 7000 cal. yr BP during the Holocene is problematic because of existing taxonomic incompatibility between the fossil and the training set assemblages (Andreev et al. 2005). Therefore, the necessity of a regional data set containing information on the composition, distribution and ecological preferences of the modern chironomid fauna of russian north remains very high.

Until now, only two studies of chironomid ecology quantifying the influence of modern environmental conditions on midge distributions in northern Russia are known (Porinchu and Cwynar 2000; Nazarova et al. 2008). Both of them covered only short climatic gradients: $\Delta T_{air} = 1.6$ °C and Δ WD = 10 m in Central Yakutian lakes (Nazarova et al. 2008); $\Delta T_{air} = 8.5$ °C and Δ WD = 9.85 m in lower Lena Delta data set (Porinchu and Cwynar 2000). That was not sufficient for generating inference models for reconstructing temperature or other ecological parameters in Holocene.

We investigated subfossil chironomids from lakes and other periglacial waters of the permafrost zone in Yakutia, northeastern Russia. The region that spreads over 2500 km from east to west and 2000 km from north to south over different geographical zones: tundra at the Arctic Ocean coast, mountains in the east and south (up to 2000–3000 m a.s.l.) and taiga forests in the west (Tahtadzhan 1978). Nearly the whole territory of Yakutia is underlain by permafrost (Geocriology of USSR 1989). Due to a harsh environment and extreme difficulty in getting access to the lakes, only limited chironomid studies have been undertaken in this region. The existing studies focused on estimation of productivity of benthic communities (Karationis et al. 1956; Strelezkaja 1972; Ogay 1979; Salova 1993; Tjaptirgjanov et al. 1992) or solely on taxonomy or karyotaxonomy of chironomids (Zelentsov and Shilova 1996; Kiknadze et al. 1996; Shobanov et al. 2002).

The environmental data and sediment samples for chironomid analysis were collected in 5 consecutive years, 2003–2007, from several regions of Yakutia. The lakes spanned wide latitudinal and longitudinal ranges and were distributed through several environmental zones (arctic tundra, typical tundra, steppe-tundra, boreal coniferous forest), but all were situated within the zone of continuous permafrost. Mean July temperature (T_{July}) varied from 3.4 °C in the Laptev Sea region to 18.8 °C in central Yakutia near Yakutsk. Water depth (WD) varied from 0.1 to 17.1 m. T_{July} and WD were identified as the strongest predictor variables explaining the chironomid communitiy composition and distribution of the taxa in our data set. Quantitative transfer functions were developed using two unimodal regression calibration techniques: simple weighted averaging (WA) and weighted averaging partial least squares (WA-PLS). The two-component T_{July} WA-PLS model had the best performance. It produced a strong coefficient of determination (r^2_{boot} = 0.87), root mean square error of prediction (RMSEP = 1.93), and max bias (max bias $_{boot}$ = 2.17). For WD, the one-component WA-PLS model had the best performance (r^2_{boot} = 0.62, RMSEP = 0.35, max bias $_{boot}$ = 0.47).

GIS-BASED PALAEOGEOGRAPHIC RECONSTRUCTIONS

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The use of digital terrain models (DTM) and GIS-based spatial calculations has substantially raised the effectiveness and reconstruction quality of the palaeo-coastlines in formerly glaciated areas with possibilities to process large data sets and make analyses of higher accuracy. Such palaeoreconstructions are based on spatial calculations in which glacioisostatically deformed water-level surfaces, derived from the shore displacement curve data and/or palaeoshoreline elevations, are subtracted from the DTM. The regional reconstructions have been provided new information about drainage history and volumetric changes of the past Baltic Sea, while the local scale reconstructions are relevant for a better understanding of environmental conditions around the Stone Age settlements. In current paper case-studies from Estonia area are presented showing the potential of GIS-based reconstructions to model past lake and sea shoreline positions.

POLLEN RECONSTRUCTIONS OF LAKES SEDIMENTS AND REGIONAL CORRELATIONS.

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Pollen records are important data for paleolimnological reconstruction. The pollen grains are well mixed in the air; therefore the pollen from a lake is an integration of the pollen from the all catchment area. The reconstruction of the vegetation is a complex function of many factors including sediment type, lake size and genesis, vegetation zone. We have pollen data from small and large lakes from the Kola Peninsula in the north to of the Crimean Peninsula in the south. Pollen and radiocarbon data have allowed to reconstruct the vegetation and climate changes during the Holocene period. In the north regions main reason of vegetation change is temperature variations. In the south regions - is strongly influenced by humidity changes.

Detailed reconstructions based on the pollen data collected for all the study lakes were then confirmed by the results of other analyses, which, in turn, allowed us to reveal main environmental changes throughout the Holocene, and more specifically, major natural trends in the development of the vegetation cover at the regional level. Reconstructed vegetation history according to the pollen analysis of lake sediments was correlated in regional and zonal level. We correlated pollen data from the lakes Kanozero, Vodlozero, Kenozero, lakes of Karelian Isthmus, lakes of Central European Russia, lakes of Crimean Peninsula and other. Also there were analyzed surface samples of all the studied lakes. For each region we received data on the beginning of human impact on lake ecosystems.

The results of pollen analyses with radiocarbon datings, covering the all Holocene, give an improved temporal picture of the development of study region history.

QUANTITATIVE CLIMATE RECONSTRUCTIONS FROM PROXY DATA: WILL THE METHODOLOGICAL REVOLUTION DEVOUR ITS CHILDREN?

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The emergence of quantitative environmental reconstructions from biological proxy data has affected palaeoecology, palaeolimnology and palaeoclimatology to the extent that it is reasonable to talk about a new paradigm or a revolution in these fields of science. The use of various types of transfer functions have become a routine in quantitative reconstructions of many environmental factors, and their use is often justified by simple cross-validation performance tests with modern data. However, it has also become clear that these reconstructions contain problems, biases and pitfalls not revealed by simple performance tests. Some of these problems, such as the poor level of analogue between the modern assemblages and fossil assemblages and the confounding role of human impact on ecosystems, have been recognized from the beginning of the quantitative reconstructions. Recently, it has been shown that additional and often serious problems in the reconstructions are caused by spatial autocorrelation between the modern samples used in the transfer functions, by the collinearity between many environmental variables, by the presence of non-causal variables that act as surrogates for underlying causal factors, and by the low predictive power of the models when used under environmental conditions different from their modern settings. These pitfalls are highlighted here with some recent examples. To make the reconstructions more realistic, palaeoecologists and palaeolimnologists must identify the factors that can be robustly reconstructed in a given region and setting and to acknowledge that the reconstruction of many collinear or non-causal factors can lead to pseudoaccurate and spurious results.

DIATOM ASSEMBLAGES OF POLYGONAL TUNDRA WATER RESERVOIRS FROM THE ARCTIC SECTOR OF YAKUTIA

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As monitoring sites, we selected small ponds from polygonal tundra of "Pokhodsk" (Nizhekolymskiy district), "Kytaluk" (Allaikhovskiy district), "Peninsula Fadeevsky" (New Siberian Islands) of Republic of Sakha (Yakutia) and the section "Khatanga" (Krasnoyarsk Territory).

The material for this work was the results of the analysis of surface sediments from reservoirs by diatom method performed with the standard technique [1,2].

In samples of "Pokhodsk" we recorded 151 species of diatoms belonging to 22 genera, 18 families, 11 orders and 3 classes. The largest class is the class Bacillariophyceae, including 7 orders, 15 families and 139 species consisting of diatoms. Most algae found in waters with a key area of the polygonal tundra terrain Pohodsk are epiphytic forms. Also benthic forms were presented, preferring soil substrates. Planktonic forms were insignificant. In relation to salinity galofoby and indifferent species were dominated. With respect to pH, acidophiles (species prefer an acidic environment) were dominated. In the geographical distribution the largest numbers of taxa were north-alpine species. Boreal and cosmopolitan group conceded them. The main parts (more than 5% of the total flaps) consisted of 6 genera: Eunotia (10), Navicula (5), Achnanthes (2), Cymbella (2), Nitzschia (1) and Tabellaria (1). Dominant complex in all waters was almost identical. The exception is 12ROK03 pond, where the dominant complex consisted solely of a kind Eunotia. Overall diatom flora of Pokhodsk's water reservoirs consisted of benthic forms, indifferent to changes in water salinity and prefers neutral acidic environment.

Comparison analysis of diatom assemblages of reservoirs "Kytaluk" and "Pokhodsk." General list of flora of diatoms had 183 species belonging to 24 genera, 19 families, 11 orders and 3 classes. Leading genera for number of species were Eunotia (39), Cymbella (27), Navicula (22), Achnanthes (15) and Pinnularia (14). More than half of genera (54%) were represented by one or two species. Taxonomic structure of two polygons reservoirs differs significantly. In particular, 79 species (43%) were found only in the waters "Pokhodsk." List of flora, which is charactered only for ponds area "Kytaluk" consisted of only 29 species. However, the Serensen's index of similarity was quite high (0.64). In the samples of studied reservoirs of Pokhodsk's plot 12 (8% of the total list of diatoms) new species for the flora of Yakutia were found. Rare species were 8 (6 - to "Pohodsk" and 2 kinds of "Kytaluk").

Analysis of changes in biotic diversity groups performed using different indices, which determine the degree of species richness, diversity and dominance of aquatic communities (Shannon-Weaver, Pielou evenness, Simpson's dominance, Simpson's species richness, Margalef, Zhivotovsky). Species diversity of diatoms waterbody rather high and varies from 7 (KUT7) to 51 (12ROK10) with an average of up to 24. Thus, diatom flora of studied water bodies in their characteristics is moderate continental type flora characteristic of the Palearctic. It consists essentially of benthos prefers neutral acidic environment.

The qualitative composition of diatoms from the section "Faddeevsky peninsula" showed that in the studied reservoirs 175 species of diatoms from 25 genera were identified to date, which, in accordance with the classification become to 20 families, nine orders and three classes. Diversity of this group of algae in these water bodies was formed mainly by Naviculaceae (genus Navicula with 23 species), Eunotiaceae (genus Eunotia - 21), Cymbellaceae (genus Cymbella - 20), Pinnulariaceae (genus Pinnularia - 17), Achnanthaceae and Neidiaceae (12).

Environmental analysis of the flora showed that all found diatom species were benthic forms (as well as in "Kytaluk"), including the bottom species (down 53%) and epiphytes (47%). Planktonic forms were missing. Information in relation to salinity is available for 73% of the taxon. In conditions of low salinity water almost half species composition were indifferent (to 58%), galofobs were considerably inferior (up 23%), little halophiles were noted (up to 5%). Information about pH prefers is known for 67% taxons among which acidophiles, alkalifily and neutrophils (20%) take an equal share. Information on the geographic distribution of taxa is known for 69% algae. All three biogeographic groups have almost equal share of participation: arctic-alpine - 22%, cosmopolitan - 23% and boreal species - 24%. When on the "Pohodsk" site the north-alpine group has the distinct advantage.

In 15 samples of "Khatanga" 89 species, varieties (10) and forms (1) of diatoms belonging to 18 genera, 13 families, 3 orders of 3 classes were registered: Bacillariophyceae, Fragilariophyceae and Coscinodiscophyceae.

Most found algae were benthic forms, including an equal share of epiphytes and bottom. Planktonic forms were minor. Information with respect to salinity is available for 59 (66.3%) taxon. Predominant group are indifferent (to 45%), they are considerably inferior galofoby (up 23%), halophiles - characterized by small (up to 5%). Information with respect to pH are available for 49% of the taxon, which are dominated by acidophilic species (31%), neutrophils - 17% and atsidofil - 12% are less numerous. Information about the geographic distribution of taxa known for 68% algae. The greatest number of taxa (30% or 24) are widespread or cosmopolitan species. Boreal group consists of 19 species (22%), arctic-alpine group represented by 16 species (16%).

Thus, the diatom flora of the studied reservoirs consisted essentially of benthos prefers ultrafresh, neutral oxygen, slightly alkaline environment.

We recorded a new and rare species of Yakutia. New species have been recorded in the amount of 72 species of diatoms, the largest number were noted for the genus Eunotia-16 species, Navicula-14, Achnanthes-8. Rare species were met in the amount of 39 species. Here is already the genus Achnanthes-9 diatom species, Eunotia-8 are dominated. There are also taxa that need further clarification and identification at the species level.

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AUTIGENNY MINERALOGENESIS IN BOTTOM SEDIMENTS OF TAZHERANSKY LAKES (PRIBAIKALYE)

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The lakes located compactly in the territory which is characterized by identical landscape and climatic, geological and geochemical conditions and are connected by a uniform superficial waterway, form the lake system which studying allows to estimate correctly influence of various factors on a chemical composition of waters and on neogenic minerals of the top part of bottom sediments.

The purpose of this work is studying of multicomponent structure of the top part of bottom sediments of small lakes of Tazheransky system (Priolkhonye) and identification of interrelations of the organic and inorganic composition which are shown in sedimentation of carbonates by means of bioassimilation, formations of colloids, biosorptions and destructions of organic substance (mortmass).

Relating the springs and fresh lakes Priolkhonya to the Cainozoic breaks inheriting ancient blastomilonitovy seams, created at an ordovician conflict tectogenesis, and salty lakes - to "pull-apart" to the systems formed in the course of left shift moves at early stages of evolution of the Baikal rift system it is proved in Sklyarova O. A. work. [1]. Sklyarova O. A. it is shown that the major factors defining a variety and geochemical specifics of lake waters of Tazheransky lakes are the composition of feeding underground waters, concentration and freeze concentration processes. Makarkina N. V. studied the trophic status of these lakes, organic substance in water, etc. [2].

Sampling of components of a biogeocenosis of lakes is executed during the period from 2008 to 2013. In field conditions visual survey and the operational analysis of unstable parameters of solutions has made. Macro - (Al, Fe, Ca, Mg, K, Na) and the microelement composition (Cd, Pb, Cu, Zn, Mn, Cr, Ni, Co, V, Hg, Be, Ba, Sr, Li) lake waters and muds was defined by a nuclear and absorbing method, anion composition of waters - a method of a highly effective liquid chromatography. The component of hydrocarbonates - a method of electrometric titration. The mineral structure and component was investigated by means of the X-ray diffraction analysis and a scanning electronic microscope.

Lacustrine depressions have the tectonic nature. Catchment basin of lake systems is put by magmatic and metamorphic rocks [3]. Lack of snow cover because of strong winds leads to a freezed of soils and waters of lakes that defines receipts of a significant amount of a detrital sediments with temporary rain streams and eolian transfer from the reservoir areas. The geochemical and mineral components of detrital sediments agree with the original composition of indistinct soils and rocks catchment basin of lake systems [4]. Author's data of a chemical composition of waters of lakes during 2008 - 2013 will well be agreed with analytical results of the previous researchers. At lake waters there are two anions (HCO_3^-hydrocarbonate, SO_4^{2-}sulfate) and two cations (Mg^{2+} magnesium, Na^+ sodium), in the subordinated quantity are revealed (Cl^-chlorine and Ca^{2+} calcium, K^+ potassium). Ca^{2+} prevails among cations only in waters of springs. But already in the lake, created at a spring, the maintenance of Mg^{2+} exceeds concentration of Ca^{2+}. With increase in the general mineralization of waters of lakes of Tazheransky system in them accurate dependence of increase of concentration of the main components in identical ratios is observed: sulfate and chlorine of ions in relation to a hydrocarbonate and in the relation between Na and Mg (figure 1). Therefore, various ratios of ionic composition of waters of lakes are defined by level of their metamorfization.

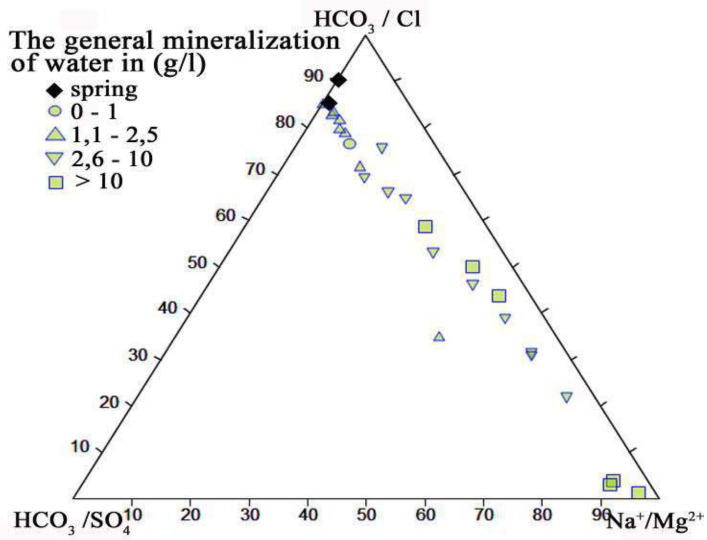

Figure 1. Ratio of the main ions in waters of lakes of Tazheransky system. On mineralizations (g/l) of waters of the lake are divided into groups: fresh (0-1); saltish (1,1-2,5); salty (2,6-10); strongly salty (higher than 10).

In the top part of ground deposits of lakes education the authigenic minerals is established: calcite, different degree of a magnesia components, pyrites, chlorite and illit-smektita, sometimes monohydrocalcite, aragonite, Ca-dolomite. Apparently from the Ca/Mg ratio in water practically in all lakes is inherited in bottom sediments (figure 2). Outside area of construction there were Ca/Mg relations in the lake at a spring, where it is maximum (equally 28) and the calcite without impurities is formed in deposit.

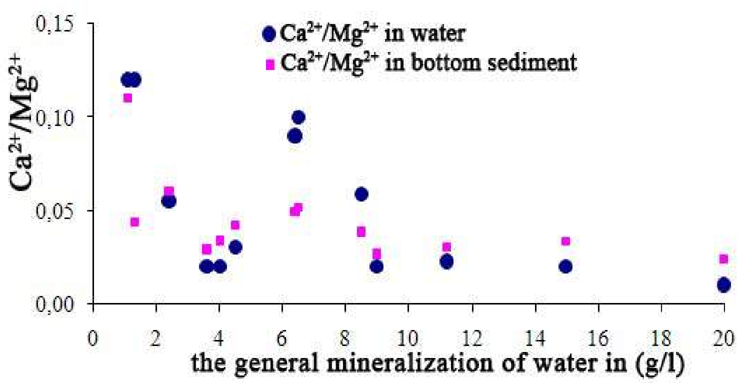

Figure 2. The relation of concentration (%) of calcium to magnesium in water and in bottom sediment of lakes of Tazheransky system depending on the general mineralization of water in (g/l).

Degree of a magnesia`s of calcite depends on level of a metamorfization of waters. At high degree of a metamorfization of waters there are Ca-dolomite and high level of Mg substitutional impurity of calcite in bottom sediments. At the low and average level of a metamorfization of waters almost pure calcite (Mg impurity no more than 0,3%) and medium-sized magnesian calcite (Mg impurity from 1-3%) are formed. But at joint crystallization of calcite with chlorite or illit-smektity as a part of which Mg is the main cation, the content of magnesium in calcite to become low even at average degree of a metamorfization of waters.

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ABOUT A NEW COMPLEX METHOD OF RECONSTRUCTION OF PAST CLIMATES AND FORECAST OF FUTURE CLIMATE CHANGES

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The forecast of climatic changes in the future – in the near and in the far – is one of the most significant scientific issues of today. This issue is directly connected with the issue of reconstruction of climates, since a reliable forecast of any phenomenon or event can be made only in case if there are an idea how these or that phenomenon and events had developed in the past and in which state there are today. The new complex method of reconstruction of past climates and forecasting of climatic changes based on: (1) the pollen-spore data, (2) the radiocarbon data, (3) the recent meteorological data, and (4) the Sun's activity data expressed in Wolf's number (Max, Min W). Pollen-spore analysis method is based on the zonal principle, the main idea of which is the use of the Similarity Indices (SI) for the zonal level and for dominant and co-dominant plant taxa in the pollen-spore spectra of sediments of any genesis and age [2]. The SI enable us to establish a connection which exists between the components of fossil pollen-spore spectra and the components of recent pollen-spore spectra, and, consequently, a connection between today's vegetation and the vegetation and climate of the past. It is advisable to use the SI for the reconstruction of the main elements of climates of the past, introducing it into the formula developed by the author [3]. The suggested new method does not only allow to reconstruct the elements of climates but also allows making a forecast of climatic changes in the future on the regional level, as well as using the obtained data for a forecast of climatic changes on the global level. Based on the data of the pollen-spore and radiocarbon methods during our research of a high peat bog in the south-eastern part of the Taymyr Peninsula (71°42 ' N, 108° 03' E), we discovered the natural dynamic of the vegetation cover and climate changes for this region during the last 10 500 years (Figure 1) and made a forecast of climatic changes both for the Taymyr Peninsula and other Arctic regions (Table 1).

Table 1.
Forecast of changes in the main climatic elements
in the forthcoming 50 years for the high-latitude regions of the Arctic

Kupetsky, 1998	Ukraintseva, Pospelov 2012 a,b					
Cycle Year Max W	Years (AD/BP)	Elements of Climate				
		T_{VII}	T_{I}	▲ T for year	Precipitation, мм	SI
27 2048 100	2048	(–0,6)	(–1,7)	(–0,7)	(–36)	0,95
26 2036 130	2036	12,3	–33,8	– 13,4	348	1,0
25 2024 110	2024	(– 0,6)	(– 1,7)	(– 0,7)	(– 36)	0,95
24 2012 100	2012	(– 0,6)	(–1,7)	(– 0,7)	(–36)	0,95
23 2000 140	**2000**	**12,3**	**–33,8**	**–13,4**	**348**	**1,0**
	500±60	11,7(–0,6)	–32, 1(–1,7)	–12,7(–0,7)	312 (– 36)	0,95
	3660±60	13,5(+1,2)	–37,2 (+3,4)	–14,7 (+1,3)	383(+ 35)	1,1
	5720±60	11,1(–1,2)	–30,4(–3,4)	–12,0(–1,4)	313(–35)	0,9
	7040±60	10,2(–1,2)	–28,0(–5,8)	–11,2(–2,2)	289(–69)	0,83
	7530±70	6,4(–5,9)	–17,6(–6,2)	–7,1(–6,4)	181(–167)	0,52
	8150±60	9,8(–2,5)	–27,0(–6,8)	–10,7(–2,7)	278(–70)	0,80
	10500±60	9,8(–2,5)	–27,0(–6,8)	–10,7(–2,7)	278(–70)	0,80

Note: In the brackets there are deviations of climatic elements from values of the 1950–2003 years.

Taking into an account the data of reconstruction of climate only as a basis, we can talk about of a trend of climatic changes in the future. However, when we compared the Sun activity forecast expressed in Wolf's units made by V.N. Kupetsky [1], with the climatic characteristics which have been reconstructed by us (Table 1), we could make then a more precise forecast of climatic changes for the Taymyr Peninsula and for the Russian part of the Arctic.

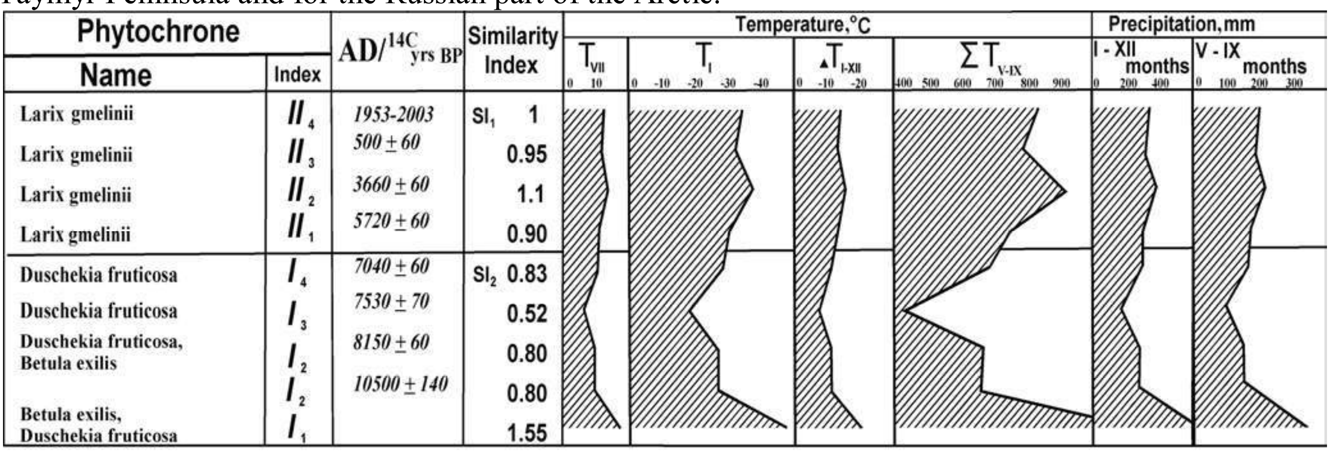

Figure 1. The character of warmth and precipitation availability
in the Fomich River Basin during the last 10,500 years

All above data lets us to make the following basically important conclusions: (1) the climate's warming, which is currently being observed on the Earth (the 23rd cycle of the Sun's activity) will last till 2013 or so; (2) during the following two cycles (24th and 25th) the Sun's activity will decrease to 100–110 Wolf units, which will cause a cooling of the climate on the Earth; (3) in the following, the 26th cycle, the Sun's activity will increase up to 130 Wolf units, which will cause a warming of the climate again; (4) in the 27th cycle (2037-2048 years) the Sun's activity will decrease to 100 Wolf units, causing a cooling on the Earth again. Thus, the forecast of climatic changes in the Arctic, which we have worked up and based on the Sun's-Earth's connections, is an objective natural reality. It is safe to say, the climate fluctuations in the Arctic, which we have identified for the last 12-10 thousand years, will continue in the forthcoming 50 -100 years. Consequently, only the synthesis of solar-telescopic, palaeoclimatic and modern meteorological data will allow making a valid long-term global forecast of climatic changes in the future. Regional and local forecasts developed on the basis of a global forecast will be then of a primary value. The level of contemporary scientific knowledge does not show us any other way yet.

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PALINOLOGICAL CHARACTERIZATION OF THE SEDIMENT CORE FROM THE LAKE 12FAD03 OF FADDEYEVSKY PENINSULA, NEW SIBERIAN ISLANDS

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18 cm sediment core was selected from small lake 12FAD03 (75⁰51'N, 143⁰28'W) of Faddeyevsky Peninsula with maximum water depth 1,5 m for spore-pollen analysis in 2012 (Fig. 1). Sediment corer UWITEC was used for the sampling (Fig. 2).

The lake is located in zone of continuous permafrost. Peninsula is composed mainly sandy and clay rocks, riddled with underground ice cores. Depth of seasonal thawing reaches 0.5 m Flora is dominated by moss-lichen tundra. Shrub and tree forms are missing (Ushnitskaya, et al, 2013).

Samples (18 pieces of 2 g) was processed according with modified procedure Faegri & Iversen (1989). One tablet of Lycopodium spores calibrated to calculate the concentration added to each sample. To remove carbonates samples poured 10% hydrochloric acid and washed with distilled water and the procedure repeated twice. Then, for removing humic acid was poured 10% KOH, the procedure was repeated twice, washing each time with distilled water. Silicates eliminated from the samples using hydrofluoric acid (40% HF), and left for a day, washed, and centrifuged. Then added a 10% solution of hydrochloric acid and left for 10 min. in a water bath at a temperature of 900C. Then washed twice with distilled water and centrifuged. Filled with glycerol.

Fig.1 Map of the New Siberian Islands

Counting of pollen grains and spores (NPPs) were performed using a light microscope Premio Star (Zeiss) with a magnification of 400 times. Taxonomic affiliation of pollen grains and spores was determined by determinants and atlases (Savelieva, LA, et al, 2013, Reille M., 1992). In each sample, there were at least 300 grains. Results of the palynological analysis are presented in spore-pollen diagram (Fig. 2). The diagram is constructed using software Tilia 1.7.16. Zoning was conducted with using of cluster analysis in the program CONISS.

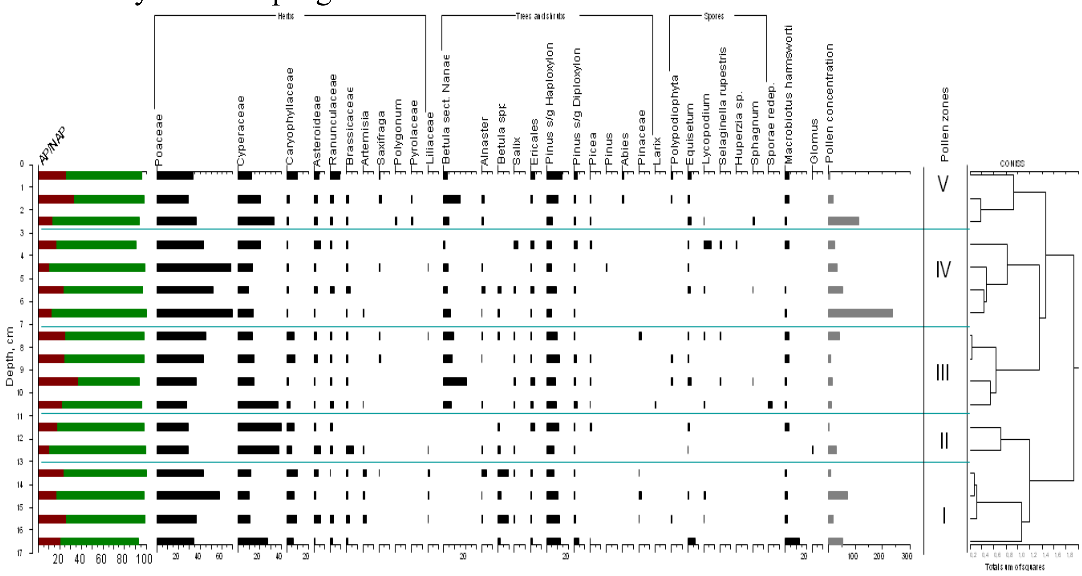

Fig. 2 Spore-pollen diagram of palynological studies of lake cores 12FAD03

Description of spore-pollen diagrams was performed by palinozones (PZ). According to cluster analysis five palinozones were identified which were presented in Fig. 2.

Palinozone I (17-13 cm). Four samples are included in this zone. Palinozone is characterized by pollen domination of herbaceous plants (grasses, sedges), there is a relatively high content of pollen

Caryophyllaceae. This palinozone is characterized by domination of pollen grains (60%), also by high concentrations of pollen *Artemisia.*

Pollen of trees and shrubs were represented mainly *Betula* spp. and *Pinus s/g Haploxylon.* Also, there was alder pollen *Alnaster, Ericales.*

Palinozone II (13-10 cm). Second palinozone is also characterized by prevailiation of pollen grasses and sedges (70% of total grains in the samples). As compared with the first area, pollen Cyperaceae (40%) is dominated here. Grass pollen is also presented by Asteraceae, Ranunculaceae, Cruciferae. Tree and shrub pollen palinotaksons are presented by birch and pine *(Pinus s/g Haploxylon).*

Palinozone III (10-7 cm). If the second pollen palinozone is described by sedges (20%), the third – by the pollen grains of cereals (50%). Herbaceous plants also presented Caryophyllaceae, Asteroideae, Brassicaceae, *Saxifraga.* In this zone, the maximum number of recorded pollen belongs to *Betula* spp. (25%). Also *Salix, Alnaster, Picea, Pinus were* found in samples.

Palinozone IV (7-4 cm). Zone is characterized by an absolute predominance of cereals pollen grains (60-80%) and the highest concentration of pollen. Share of sedge pollen reaches 15%. It should also be noted that herbaceous taxa were depleted. We marked seven families, variety of some samples reduced to five. Tree and shrub pollen taxa were dominated by *Betula* spp. and *Pinus s/g Haploxylon*.

Palinozone V (4-0 cm). The ratio of pollen grasses and sedges (45 to 35%, respectively) changes dramatically in this palinozone. Maximum number of pollen Ranunculaceae was noted in observed samples. Among gymnosperms the most abundant pollen was presented by *Pinus s/g Haploxylon, Pinus s/g Diploxylon and Picea.* The main background for angiosperms was created by deciduous breeds *Betula* spp., *Alnaster, Ericales*. Together with *Pinus s/g Haploxylon., Pinus s/g Diploxylon and Picea* they were subdominant pollen assemblages. Different spore plants had significant biodiversity as spores of *Equisetum, Polypodiophyta, Lycopodium, Selaginella, Huperzia sp.* and *Sphagnum* were met in all samples.

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Poster session

GEOCHEMICAL SIGNATURES OF A POSSIBLE LATE PLEISTOCENE EXTRATERRESTRIAL EVENT IN PALEOLIMNOLOGICAL "RECORDS" OF EUROPE

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The Late Pleistocene climate oscillation (Younger Dryas, or YD, cooling) is connected predominantly to a sharp decrease of thermohaline circulation in the Atlantic Ocean, affecting the salinity in the areas where north Atlantic deep water is formed [1-3]. Recently, however, a hypothesis was proposed relating the YD cooling to an extraterrestrial (ET) bolide impact [4]. This hypothesis suggested that just before the onset of the YD cooling (12.9 ka), a large bolide (~4 km in the diameter)

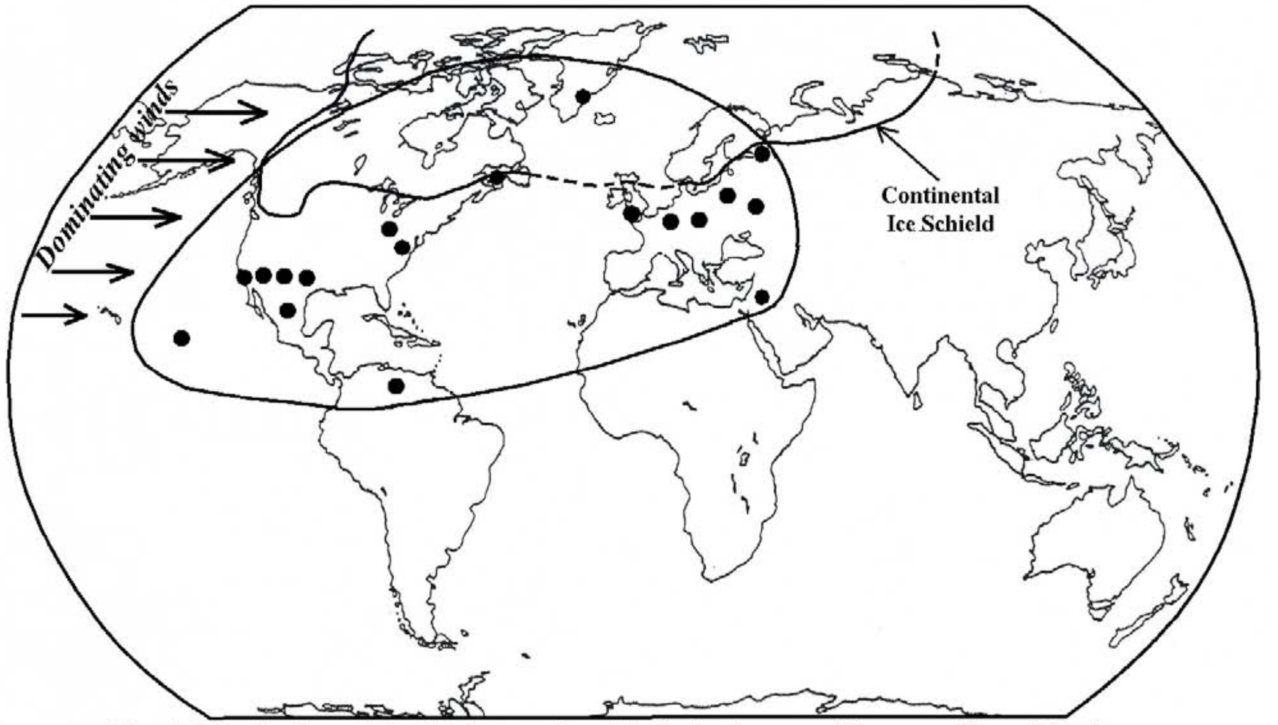

Fig. 1. Distribution of the ET fingerprints (black dots), a possible area affecetd by the suggested pre-YD ET event, and an outline of the continental Ice Schield in the Northern Hemisphere ca. 12.9 ka (see [5] for references).

exploded over the North American Laurentide Ice Sheet. The consequences of such an event ("impact winter") led to an abrupt climate change. If the impact occurred over North America, transportation of the impact cloud eastward by the dominating movement of the air masses could have delivered impact-related material as far to the east as Europe (Fig. 1) [6]. Lake sediments, where undisturbed, proved to preserve reliable paleorecords on environmental, geochemical, and biotic changes [e.g., 7]. Continuing sedimentation in lakes of North-Central Europe started in Allerød and continued during the YD [3,8], covering a period of the suggested ET impact [4]. Therefore, geochemical fingerprints of the ET event can be preserved in paleolimnological records. There is not much data existing on the geochemistry of lake sediments in Europe in terms of the possible presence of the ET fingerprints. It is likely due to the fact that the event was very short and the layers carrying such fingerprints are very thin and, secondly, that nobody really searched for such geochemical anomalies.

An increase of the concentration of elements which are in much higher abundances in meteorites than in terrestrial materials ("meteoritic" elements), especially in the platinum group elements (PGE), is accepted to be a clear indicator of a contribution of a meteoritic component to the terrestrial environment [9]. For the present study, the authors applied inductively coupled plasma-mass spectrometry (ICP-MS) in order to check the presence of geochemical anomalies (including the ET-related anomalies) in Late Glacial sediments from a few lakes in Belgium, the Netherlands, Lithuania and NW Russia. All studied sedimentary sequences are dated either by radiocarbon, or thermo-luminescence, or pollen methods, providing the time frames for a search for geochemical anomalies.

Our study revealed that in spite of different local lithologies, some samples of Late Glacial lake sediments collected from the horizons corresponding to the age of ca. 12.9 ka display simultaneous enrichment in at least a few "meteoritic" elements (some PGE, Ni, Co, Cr). If enrichment in any of the "meteoritic" elements alone could be due to the influence of some terrestrial processes (e.g., changes in a source of sedimentary material; influence of biotic activity), simultaneous enrichment in a few "meteoritic" elements should raise suspicion about the potential presence of the ET material. Enrichment in "meteoritic" elements was observed only for very thin sedimentary layers in lakes of different parts of Europe. That points out that the event responsible for the enrichment was very short, which is consistent with the influence of the ET impact. Therefore, we suggest that elevated concentrations of "meteoritic" elements in the Late Pleistocene lake sediments are due to the presence of microparticles related to the ET event. Interestingly enough, some sedimentary horizons (ca. 12.9 ka) enriched in "meteoritic" elements also display enrichment in "volcanic" (such as REE, Zr, Hf, Sr, and Ti, i.e., elements common in products of volcanic eruptions) elements. We connect such a "double" enrichment with the presence of material from both the eruption of the Laacher See volcano (ca. 12.9 ka) [10] and a possible pre-YD ET event.

Because of only patchy and weakly-pronounced occurrences of suggestively ET geochemical fingerprints in paleolimnological records of Europe, we hypothesize that the post-impact cloud did not completely blanket the sky over Europe; instead, the majority of the impact-related material deposited in North America, Greenland and North Atlantic. Therefore the influence of the pre-YD impact-related processes on the climate, if pronounced, should be restricted mostly by the Western Hemisphere, and be very limited in the Eastern Hemisphere.

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ISOTOPE COMPOSITION OF KARELIAN GROUNDWATER AND ITS USE IN CLIMATE PALEORECONSTRUCTIONS

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Groundwater is one of the archives, which allows to study the climatic variations of the past on the basis of data on their isotopic composition ($\delta^{18}O$ and $\delta^{2}H$) and age (residence time in the subsurface hydrosphere). Extremely important is the fact that only the isotope data can uniquely identify the presence of permafrost and cryopegs on the study areas in the past. Such information is useful for correct geographical and climatic paleoreconstructions. Also important is the ability to assess changes in the chemical composition of groundwater during the formation and subsequent degradation of the permafrost in the Holocene.

The close correlation found between the isotopic composition of precipitation and air temperature. The atmospheric precipitations with lightweight isotopic composition (i.e. having the most negative values δ^2H and $\delta^{18}O$) fall out in the Polar Regions, in the highlands and in winter. This relationship can be used for climate reconstruction. It should be noted one feature of the isotopic composition of groundwater for paleoreconstructions. Namely, the isotopic composition of precipitation of the winter season in the humid regions of northern Eurasia affects strongly on the isotopic composition of groundwater because the major restocking groundwater occurs during spring snowmelt. From the analysis of the IAEA database is known that isotopic composition of groundwater characterized as $\delta^2H < -130$ and $\delta^{18}O < -15\%$ for cold climate with an average temperature below 0°C.

Monitoring of the isotopic composition and other parameters of atmospheric precipitation in Petrozavodsk carried out in 2009-2014. The calculated local meteoric water line (LLMW, the equation is showed in the figure) does not differ from the global meteoric water line (GMWL, described by the equation $\delta^2H = 8 \times \delta^{18}O + 10$). The groundwater sampling also was made in southern and central Karelia (133 wells and springs) during this period. Monitoring since 2005 performed for mineral water "Marcial Waters".

Average isotopic composition of groundwater in the studied area is $\delta^{18}O = -13,3$ and $\delta^2H = -98$ ‰, which is significantly lighter than weighted average isotopic composition of precipitation $\delta^{18}O \approx -11,6$ and $\delta^2H \approx -85$ ‰. Average composition of the snow (March 2012) is $\delta^{18}O \approx -17,8$ $\delta^2H \approx -137$ ‰, which implies that groundwater replenished not only melted water, but summer precipitation .

Forming of brackish sodium chloride groundwater and groundwater with specific composition (for example ferrous mineral waters) causes the particular interest from the standpoint paleoreconstructions of climate. In most cases these groundwater have likely considerable age. This is indicated by their light isotopic composition (Figure) and a significant deviation from LLMW in some cases. The displacement of the points of the isotopic composition of water right from LLMW indicates the formation of groundwater due to melting permafrost, because the partial freezing of water lead to metamorphization its chemical and isotopic composition, particularly deuterium and oxygen-18 accumulate in the ice. As a result, the isotopic composition of the ice should be "weighted" in the newly formed frozen zone, and isotopic composition of water in front part of the freezing - should be "lighter" on the starting of groundwater composition.

In brackish waters are found the high concentrations of radiogenic accumulated helium (2-4 orders higher than the helium concentration in equilibrium with the atmosphere), low or zero tritium concentrations, enriched isotopic composition of dissolved uranium (up 234U/238U = 6,6, while for modern water characteristic ratio $^{234}U/^{238}U \approx 1$), which further confirms the presence of relict meltwater (Tokarev et al., 2005). You can calculate the average paleotemperature at the time of formation of these groundwater: $\delta^{18}O = 0,69 \times t - 13,6$ ‰, $\delta^2H = 5,6 \times t - 100$ ‰, where t - the average air temperature at the observation point, ^oC (Dansgaard, 1964). The upper limit of the estimated average annual paleotemperature is -3 ... -5°C, which corresponds to the current climate of the north of Western Siberia.

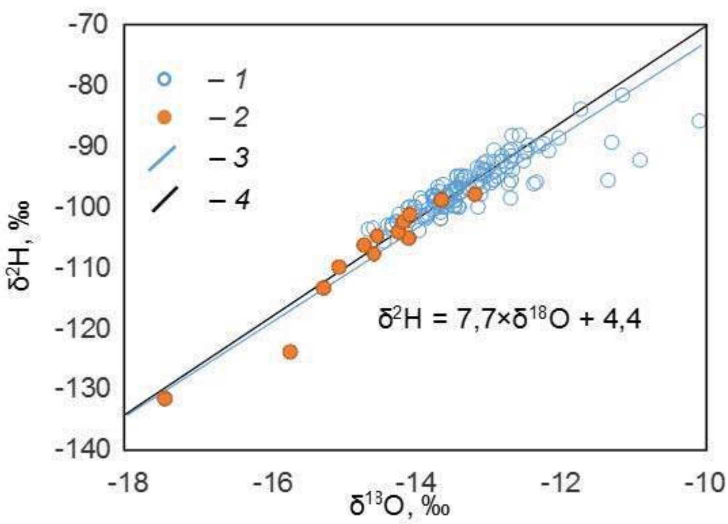

Fig. The isotopic composition of groundwater in South and Central Karelia: 1 - fresh groundwater; 2 - brackish groundwater; 3 - local meteoric water line (LLMW, equation on the graph); 4 - global meteoric water line GMWL.

The study of mineral "Marcial Waters" showed that in 1979-80 groundwater were characterized by fractionated isotopic composition, elevated concentrations of helium, “light” isotopic composition of carbon, enriched in uranium- 234. All this indicates that groundwater formation was only possible in colder climates than currently (Resources…, 1987). Observations of the isotopic composition of mineral water in 2005-2012 found a sharp increase in the share of modern water. It is interesting that chemical composition of mineral waters changed little. The latter is possible only if the iron content increased due to the dissolution of its readily available compounds. Thus, the isotopic composition is a sensitive indicator of paleoclimatic and modern groundwater formation processes.

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TESTATE AMOEBAE FROM SMALL POLYGONAL TUNDRA PONDS AND LAKES AS A PALEOENVIRONMENTAL PROXY

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Testate amoebae (Protozoa: *Testacealobosea* and *Testaceafilosea*; testaceans) are a group of free-living protozoans that have an organic shell (testa). Testaceans inhabit practically all water and land habitats, but prefer bogs and litter of coarse humus soils. Environmental conditions determine the development of communities definite to a given habitat. Testate amoebae, being inherently aquatic, respond by restructuring their coenoses to environmental changes such as ground water table, soil moisture, pH, content of biophilic elements (N, P, K, Ca, Mg), and organic matter (Gilbert et al. 1998; Wilkinson and Mitchell 2010). Due to their indicator potential, rhizopods have been already applied in palaeoecological research (e.g. Charman 2001; Charman et al. 2007; Mitchell et al. 2007). Sphagnobiontic species serve as reliable model organisms which distinctly react to changes in light, soil temperature, soil moisture, and oxygen concentration (Mitchell and Gilbert 2004). Testacean coenoses preserved in permafrost are increasingly employed for the reconstruction of local soil conditions during the late Quaternary past (Andreev et al. 2009; Bobrov et al.2004, 2009; Meyer et al. 2010; Müller et al. 2009; Schirrmeister et al. 2011; Wetterich et al., 2012), while modern testate amoebae research in tundra environments focus on their indication of ongoing climate warming processes in the terrestrial Arctic (Beyens et al. 2009; Tsyganov et al. 2010, 2011).

Patterned ground elements of the polygonal tundra are sensitive indicators of environmental and climate changes. Polygon ponds, mires and cryosols are typical components of arctic Siberian wetlands underlain by permafrost. Recently, testaceans of modern tundra habitats have been described from several arctic and subarctic regions in Greenland, Canada and Sweden (Beyens et al. 1986a, 1986b, 1992, 2000; Beyens and Chardez 1995, Mattheeussen et al. 2005; Payne et al. 2006; Trappeniers et al. 1999).

The study area site Kytalyk was located in the floodplain and the adjacent thermokarst affected lowland along the Berelekh River, a tributary of the Indigirka River, near the WWF station Kytalyk (70°83´12.1 N, 147°48´29.9 E). Nikolay Lake (73°20'N, 124°12'E) is the largest water body in the Lena Delta region, situated in the northwest, on the Arga Island. The sediments were analyzed for testate amoebae. Dry samples weighing 2 grams were placed in 50 mm of water. The large organic and mineral particles were removed with a 500 µm sieve. A drop of suspension was placed on a slide and, glycerol was added. Normally, 5 subsamples per level were examined at X200-400 magnification using a light microscope.

27 samples were from polygonal ponds (Kytalyk) with depths ranging from 15 cm to 80 cm. 81 species of testate amoebae, belonging to 14 genera were totally found. Species diversity in the samples ranged from 1 to 23 taxa. Community rhizopod was divided into several ecological groups. In the hygro-hydrophilic group includes species of the genuses *Arcella, Difflugia, Lagenodifflugia, Lesquereusia*, in sphagnofilous from genuses *Bullinularia, Heleopera, Assulina, Sphenoderia, Paraquadrulla, Difflugiella* in the soil and evribiontic from genuses *Centropyxis, Schoenbornia, Corythion, Trinema*.

Generally, the sediments contained few rhizopod shells in Lake Nikolay. They belonged to 57 species, varieties, and forms of testate amoebae. The rhizopods can be grouped into the assemblages. Only two species: *Centropyxis constricta* and *C. aerophyla* are eurobiotic, while the others are hydrobiotic. Oligotrophic *Centropyxis* and *Difflugia* species dominate all samples, reflecting oligotrophic character of the lake environment since the initial lake was formed. Rhizopod zone I (RZ-I, 83-26 cm) is characterized by the rather low density of shells. It is possible to subdivide the zone into RZ-Ia (83-69 cm) characterized by the presence of *Cyclopyxis*, *Arcella* and *Centropyxis ecornis* v. *megastoma* and RZ-Ib (69-26 cm) characterized by a relatively high content of *Centropyxis ecornis. C. sylvatica*, and *Difflugia* species. Environmental conditions were favorable for rhizopods (or for preservation of their remains) during that interval, as indicated by the high density of rhizopod shells. RZ-II (26-0 cm) is notable for a relatively high shell density and may indicate better condition for the shells preservation. An alternative explanation can be better environmental conditions for the rhizopod communities. Nevertheless, an abrupt decrease of shell density and species diversity in the sediments at the 23-17 cm depth may reflect climate deterioration. Likewise, the increase of shell density and species diversity at the 13 cm may reflect a climate (or local environmental) amelioration. The alternative explanation for the high shell density and species diversity might be better conditions (e.g. pH) for the shell preservation.

Thus, large diversity of testate amoebae in the studied samples defines their role in the trophic webs of benthic communities of the polygonal tundra, and the ability to share rhizopod to environmental groups is the basis for their use as paleoecological method.

MULTI-ELEMENTAL COMPOSITION OF THE SEDIMENT CORE FROM LAKE KITEZH (KING GEORGE ISLAND, THE ANTARCTICA): A RESPONSE TO GLOBAL CLIMATE CHANGES IN THE HOLOCENE

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Using ICP-MS method, we studied elemental composition of the core Kit-10-1 (98 cm) with bottom sediments of Lake Kitezh, which is situated not far from the Russian Antarctic station “Bellingshausen” (King George Island). The content of 61 elements (Li, Be, B, Na, Al, Si, P, S, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, I, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Au, Tl, Pb, Bi, Th and U) is determined with a high resolution (1 cm). The tentative age of the core was accepted as ca. 2000 years by compare with the length of another dated core from that lake (Martinez-Macchiavello, et al., 1996) assuming that the sedimentation rates are equal.

Statistical methods used have revealed two main groups of the elements principally differing by the character of their distribution along the core depth.

The first group includes 31 elements (Li, Be, Na, P, Ca, Ti, Mn, Zn, Ga, Y, REE, Zr, Nb, Hf, Ta, W, Si, K), most of them are typically terrigenous. The relative elements content (“Element/Al” ratio) is considerably elevated at five core intervals (Fig. 1), which, within the accepted age model, are situated near the boundary of climatic phases change (warming/cooling) in the Antarctic Peninsula region. These elements probably mark active phases of on-land glaciers growth/ablation (intensive rocks abrasion in the basin and their discharge into the lake).

The second group includes conventionally biogenic (Mg, S, Mo, As, Se, Br, I, Cu, Co, U) and some terrigenous (Ni, Rb, Cs Ag, Bi, Th) elements (Fig. 1). Oscillation of these elements occurred 2-3 times more frequently than in case of typical terrigenous elements of the first group. At the same time, at the profiles of some conventionally biogenic elements (Mg, Br, I, S, As, Mo), low-frequency trends are clearly observed (Fig. 1); they coincide (within the accepted age model) with cold climatic phases of the Antarctic Peninsula (Sun et al. 2004) and suggest a higher productivity of Lake Kitezh during cold periods.

Reasons of high-frequency variations both of conventionally biogenic and of typically terrigenous elements of the second group are for a while unclear. Probably, short-time spikes in lake bioproductivity increase occur at climatic conditions improvement on the background of stable current climatic phases (both warm and cold ones). Enrichment of sediments with some terrigenous elements may be due to intensification of rocks drainage in the lake basin resulting in wash-out of more fine-grained mineral phases having specific elemental composition from the rocks and/or from mobilization of organo-mineral colloids which are able to selectively extract some of the hardly soluble elements.

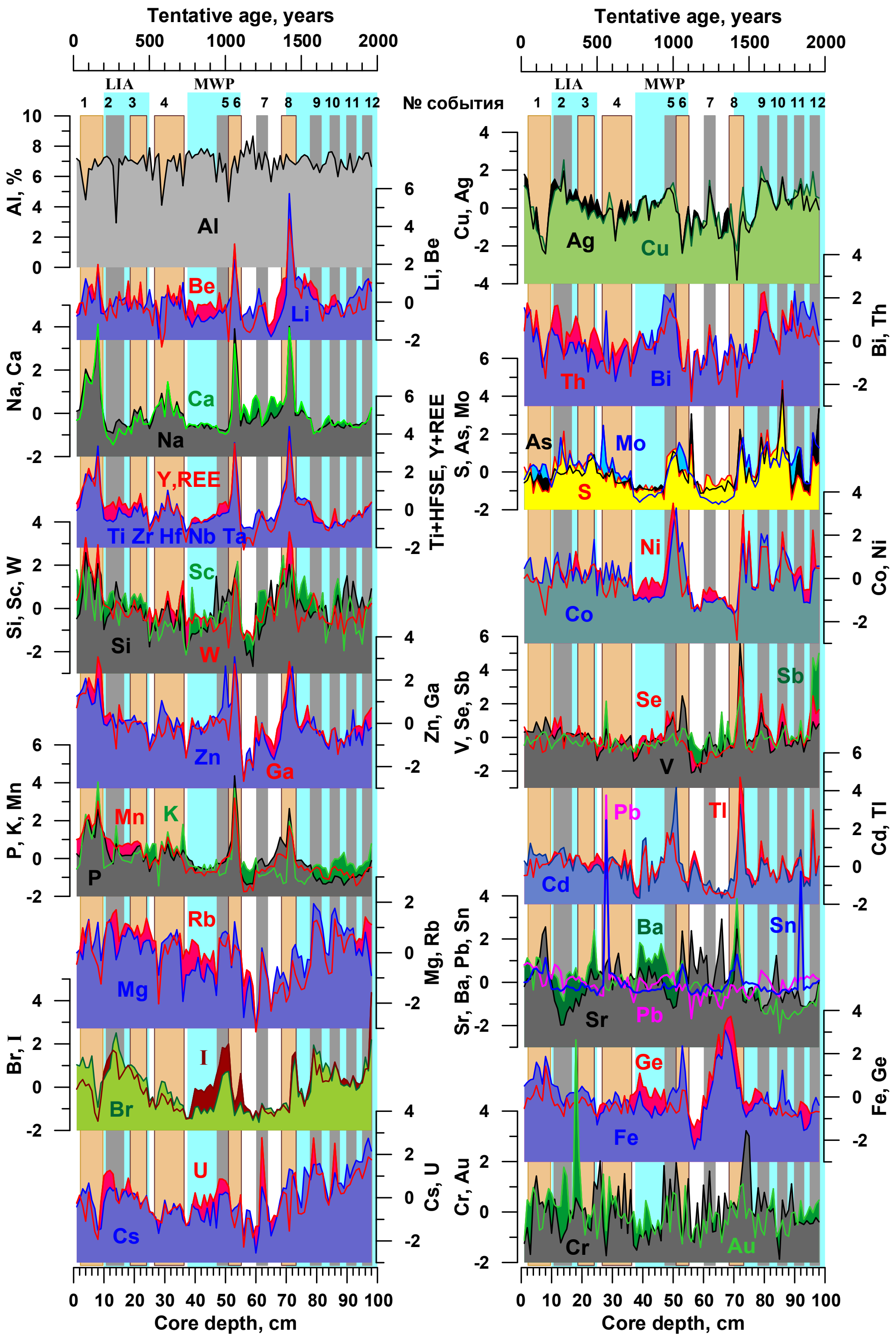

Fig. 1. Profiles of chemical elements distribution normalized by Al depthward of the core Kit-10-1. The value of ratios Element/Al is shown in arbitrary units. Sand-colored bars mark events of a considerable increase of the fraction of terrigenous elements of the first factor group (Li, Be, Na, P, Ca, Ti, Mn, Zn, Ga, Y, REE, Zr, Nb, Hf, Ta, W, Si and K), gray bars – conventionally biogenic (Mg, S, Mo, As, Se, Br, I, Cu, Co, U) and terrigenous (Ni, Rb, Cs Ag, Bi, Th) elements of the second factor group. Light blue long bars mark cold climatic phases in the Holocene in the Antarctic Peninsula region (according to Sun et al. 2004). LIA – Little Ice Age (cold in Europe and Antarctic), MWP –Medieval Warm Period (this period was warm in Europe, but in the Antarctic Peninsula region, on the contrary, it was even colder than LIA period in the Antarctic).

MODEL OF FORMATION SEASONAL GEOCHEMICAL SIGNAL IN LAKE DONGUZ-ORUN (CAUCASUS) ANNUALLY LAMINATED SEDIMENTS ACCORDING TO MICRO SCANNING XRFA USING FOCUSES X-RAY OPTICS

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Lake Donguz-Orun sediments was coring in August 2012. A 28-cm long core was retrieved from a water depth of around 7 m. The sediments consist of regularly laminated, fine beige clay, with several interlayers of sand. The coring process appeared to be challenging due to the stiffness of clay, which led to extreme bending of the sediment layers in the basal part of the core. The original thickness of the sediments was obviously higher than observed in the core.

A detailed lithological and geochemical study of the internal structure of the layers, allowing to understand the annual cycle of sedimentation and select geochemical signals, marking seasonal processes, was carried out. To undertake such research requires special equipment and methods of sample preparation. It is necessary to prepare an optical thin section, allows to obtain a detailed picture of the internal structure of individual annual layers, but having a thickness of not less than 20 microns. Another important factor is the precise focus of the exciting X-ray radiation on the sample surface to reduce the influence of the substrate on the quality of X-ray spectra.

We used equipment "Elemental analysis station" of "Siberian Center for Synchrotron Radiation" with poly capillary lens with X-ray spot diameter of 10 microns [1, 2].

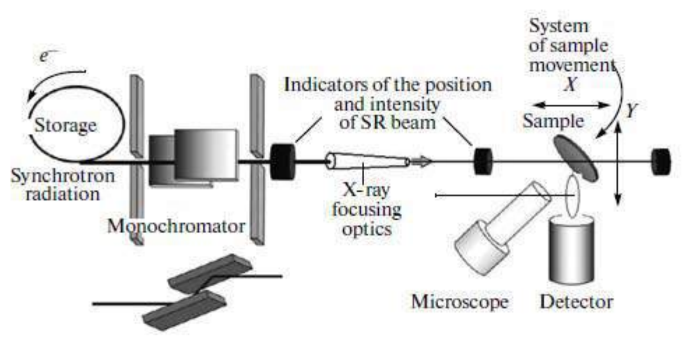

Fig. 1. Scheme of the scanning X-ray fluorescence microanalysis station, which includes the following basic blocs:
(1) A monochromator that provides radiation in the energy range of 10–25 keV;
(2) X-ray focusing polycapillary optics The beam from the source is focused to a spot with a diameter of 10 µm;
(3) A scanning device.

Optical thin section from the top 60 mm of the core was investigated with step scan 30 microns. The upper part of the core (0-170 mm) was scanned with step 100 microns and sampled for dating using ^{137}Cs and ^{210}Pb. Recorded simultaneously analytical peaks of the following elements: K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr, Nb.

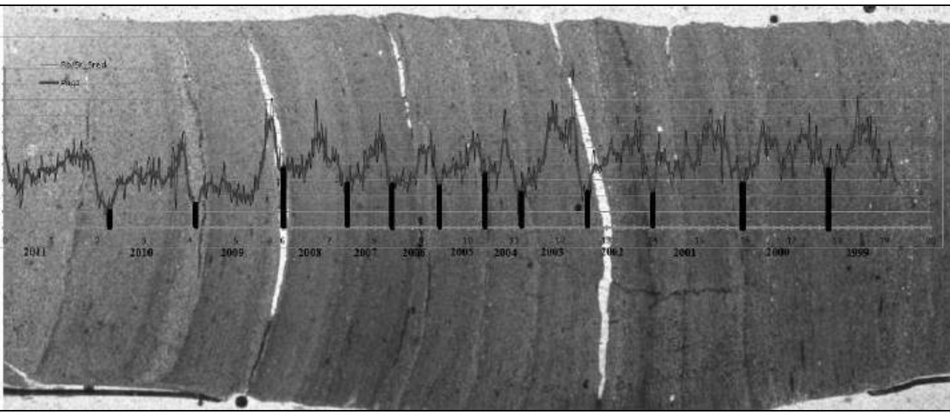

Fig. 2. Variations in the scan Rb / Sr ratio along the core sample sediments. Maximum Rb / Sr ratio marks the beginning of the annual cycle of sedimentation.

Effective geochemical indicator of annual layers was the Rb/Sr ratio marking spring flooding. Geochemical signal is connected to the gravitational differentiation of terrigenous material, which fell into the lake as a result of spring floods. When flooding ends in the lake comes dynamic equilibrium and differentiation of sediment particle size is no observed.

The assumption that the sediment stratification represents annual layering (spring flood) is generally confirmed with correlation of the Rb/Sr-ratio (that supposedly marks grain-size variations in the sediments) curve and the image of the sediment core. Calculations of Rb/Sr peaks or visual layers yield an accumulation rate of around 2 mm/yr. Analogous results (1.73 mm/yr) are derived from ^{137}Cs-dating. With this high accumulation rate, the sediment core of lake Donguz-Orun represents an important source of information for high-resolution reconstructions of climatic parameters and glacier variations of the region.

This work was supported by RFBR projects №13-05-00871, №14-02-00631.

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RECONSTRUCTION OF PALEOTEMPERATURES OF THE LAST MILLENNIUM BY MICROSTRATIGRAPHIC ANALYSIS OF SEDIMENT CORES FROM SOUTHERN BAIKAL

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The studies were conducted on samples of bottom sediments of Southern Baikal (core BAIK09-1). To construct a time model data of sedimentation rates obtained for core BAIK00-1 were used. Core BAIK00-1 was recovered about 1 km from the core BAIK09-1. The results of ^{32}Si dating method of the core BAIK00-1 allowed to construct a model of temporary sedimentation and to date three last turbidite layers [1]. Two turbidite layers were distinguished in core BAIK09-1. Apparently they correspond to the first and second turbidites in core BAIK00-1, which were formed in 1670 and 1310 AD. So we have possibility to do a time model for the core BAIK09-1. For precise time series of geochemical parameters is very important to assess the boundaries of each turbidite layers.

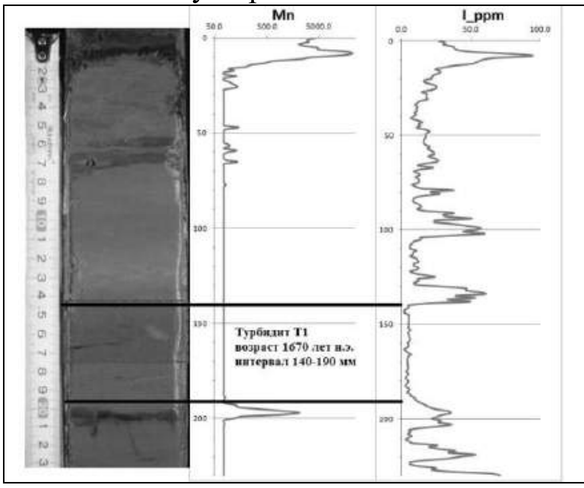

Fig. 1. Turbidite layer T1 (dated 1670 AD) is highlighted in the core BAIK09-1 according to lithological and geochemical data. Previously the turbidite was isolated in interval 140-175 mm of the core. However, the presence of so-called “buried” peak of manganese at a depth of 190 mm, gives grounds for extending the interval of turbidite layers (T1) to 190 mm, which also coincides with the interval of low iodine content in the sediment. Iodine is considered as an indicator of organogenic sediment components.

By the same criteria second turbidite layer T2 (dated 1310 AD) was selected in the interval 285-335 mm. To construct a time series data for turbidite layers were deleted from the geochemical data. To the points corresponding to the layers were assigned timestamps 1670 and 1310 AD on depth scale.

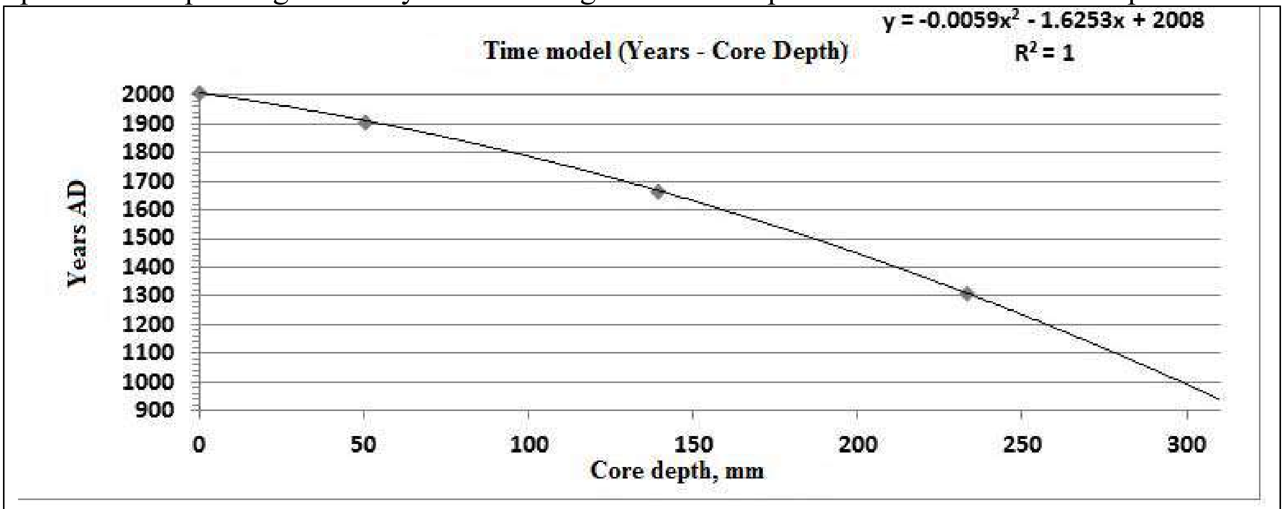

Fig. 2. Time model for core BAIK09-1

The procedure of correlation between climatic oscillations and geochemical series for the search of paleoclimate geochemical indicators and construction transfer functions (meteoparameters = function of sediment composition) was carried out. Time series of temperature changes according to Irkutsk weather station for the period 1873-2000 used as the weather parameter. To construct the transfer functions were identified 4 geochemical indicators – contents of Zn, Br, I and Rb/Sr ratio. The coefficients of correlation of the indicators with temperature are shown in table.

Table.

Coefficients correlation geochemical indicators with an average temperature according to Irkutsk weather station for timeslot 1880-1990.

Indicator	Zn	Br	I	Rb/Sr
Coefficients correlation	0.54	0.47	0.58	-0.36

Transfer function for the reconstruction of paleotemperatures of the region in the range of the last millennium was built by multiple regression method. Figure 3 shows the resulting of reconstruction of mean annual temperatures of the Baikal region during last millennium, superimposed on the reconstructions of the Asian part of the Northern Hemisphere according to the report Climate Change

2013 Intergovernmental Panel IPCC. Major trends and climatic events in the whole match, except the time interval 1300-1370. This discrepancy may be due to regional characteristics, given that most of the data used for the Asian part of IPCC refers to the territory of China.

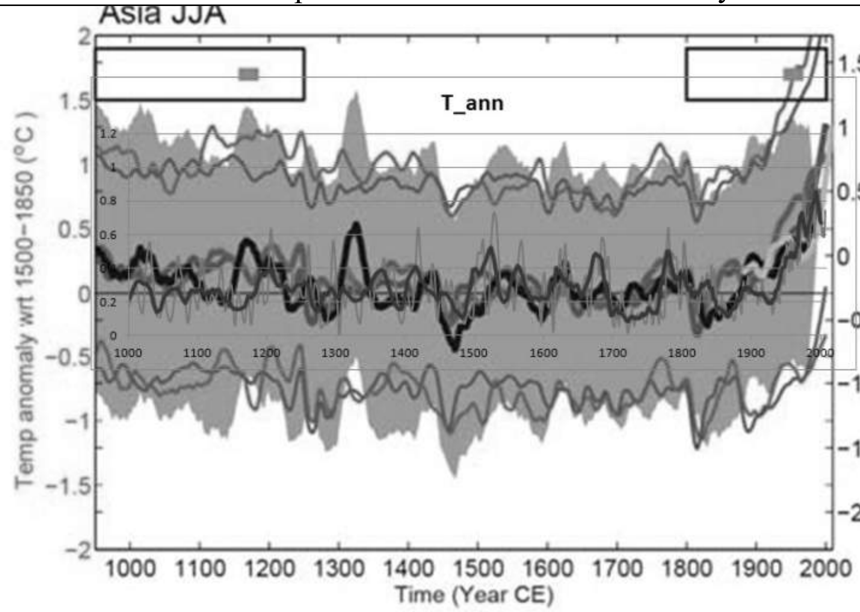

Fig. 3. Reconstruction of annual temperature range of the Baikal region of the last millennium (blue line – Year-data, the red line – smoothed 5 years), superimposed on the reconstructions of the Asian part of the Northern Hemisphere according ICPP-2013.

A regional climate model of the last millennium with an annual temporal resolution was created. Obtained results were compared with other data on Central Asia and the global reconstructions on a comparable time scale.

The researches were supported by a partnership project of SB RAS № 34.

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TRENDS IN CHEMICAL COMPOSITION OF LAKE SEDIMENTS OF THE NORTH FENNOSCANDIA IN THE LAST CENTURIES

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During the last 25 years, since the time of the organization of the Institute of the North Industrial Ecology Problems (1989), the chemical composition of sediments of reservoirs of the Murmansk region and the border area between Russia, Norway and Finland are studied. Studies are carried out to assess the accumulation and distribution of heavy metals in the lakes.

Sediment samples, taken from the deepest layers of the sediment cores (usually more than 20 cm), allow to obtain background concentrations of heavy metals in the study of the intensity of anthropogenic load on the lake watersheds. Average sedimentation rate in lakes of northwestern part of Murmansk region and the northern regions of Norway and Finland over the past half century are fairly constant and range from 0.3 to 0.6 mm/year. Increase of Ni, Cu and Co concentrations in the lake dated sediments generally found in layers, which age is estimated 1920-1930 as a result of the beginning of mining and metallurgical activities in the region (Figure). With increasing distance from the plant

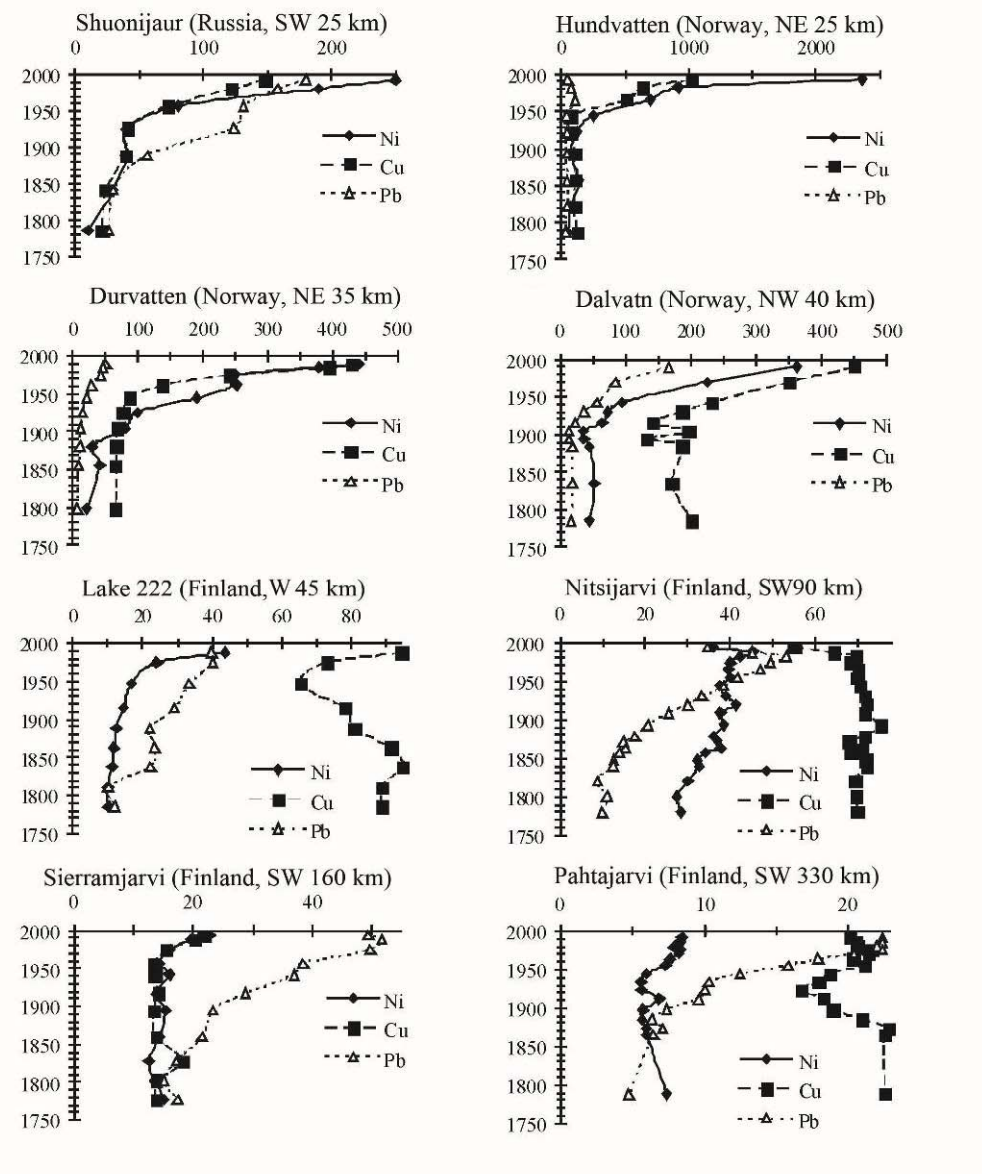

Fig. Concentrations of Ni, Cu, Pb (μg/g dry weight) in dated lake sediments at different distances from the Copper-Nickel Plant "Pechenganikel."

"Pechenganikel" the concentrations of Cu and Ni in the surface layers of sediments reduce and the contents scatter in the whole column decreases. Significant increase in the concentrations of Pb dates from the late XIX - early XX century. Lead becomes one of the main pollutants with increasing distance from the smelter. This is particularly typical for Finnish lakes. Contamination markers of watersheds serve as well as As and Cd, beginning pollution of which dates from the middle of XIX century.

Dust emissions of smelters "Pechenganickel" are the main source of elevated concentrations of Ni, Cu and Co (10-180 times more in the background values) in the surface layers of sediments at a distance up to 30-40 km. The highest concentrations of Ni and Cu, exceeded background values up to 10-25 times were noticed in the lakes at a distance of 10 km from the plant. Significant reduction in concentrations up to 3-7 background values observed at a distance of 20-30 km from the contamination source. The similar pattern was observed in the distribution of Co and Cd. The most intensely polluted area situates up to 10 km . There has been excess metal concentrations above background values from 2 to 5 times. When moving off the plant by 20-30 km, a decrease of metal concentrations to background values of 2-3 was observed. The similar pattern is noticed in the distribution of As and Hg.

Atmospheric deposition of aerosols are the main cause of pollution, including heavy metals, terrestrial and aquatic ecosystems, surface and ground water. In the background areas, where the significant role in the balance of atmospheric fallout belongs to soluble forms of the metals, a surface runoff takes away up to 5% of Pb influx and 30% Zn and Cd influx. In conditions of air pollution, when the role of solid-phase deposition increases significantly, surface removal is reduced to 1-3% of influx of Pb and 10% Zn and Cu. The remainder of the metal accumulates in the soil. Migration of metals in the soil profile occurs at a rate of 0.1-0.4 cm/year and is characterized by a rapid decrease with the depth increasing. The possibility of self-purification of soil from anthropogenic metal accumulation is assessed to be very limited. The total removal of metals (surface runoff , soil solutions , biological processes , etc.) in conditions of moderate climate and subject to the termination of new flux from anthropogenic sources provide of self-purification of contaminated soils from Pb for the period from 150 to 500 years, from Zn and Cd from 100 to 200 years. This period increases significantly in subarctic conditions of the Fennoscandia region. Therefore, the period of natural cleaning of soils, terrestrial and water ecosystems from contaminating metals is estimated to be by the value of the order $n \cdot 10^2$ years (i.e. hundreds years) .

DIATOM COMPLEXES OF THE LAKE SEDIMENTS IN KOLA NORTH

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Investigations of the nuclear power plants «thermal pollution» of the natural cooling lakes of is one of the most important research directions in World and national practice since the development of nuclear energy. The chronology of the aquatic ecosystems development study is allow to reconstruct the historical events of termofication that can be done by diatom analysis of the lakes sediments core.

Diatom assemblages of the Lake Imandra sediments core from the influence zone of heated waters of Kola nuclear power plant (KNPP) have been investigated. Sampling was conducted in deepwater part of the Babinskaya Imandra Lake by the open gravity sampler in 2011. Diatom analysis performed in the laboratory of aquatic ecosystems INEP KSC RAS using the procedure described previously (Denisov, 2007). Sediment capacity was 18cm. Diatoms taxonomic identification was made in accordance with modern taxonomic classification (Guiry, 2014).

The dramatic changes in the diatoms assemblages' structure and quantitative characteristics from the deep sediment layers to the surface have been revealed. In the lower layers (18 – 16 cm) typical planktonic centric diatoms were dominated, as well as in large reservoirs of the European subarctic: *Aulacoseira alpigena* (Grun.) Krammer, *Cyclotella radiosa* (Grun.) Lemm., *C. ocellata* Pant. Interesting finds of the benthic *Ellerbeckia arenaria* (Moore ex Ralfs) Crawford. in the deepest layers of sediment core – the typical feature for so-called "pre-industrial" period of the Imandra Lake history (Kagan, 2001). Toward the upper sediments layers the periphyton species share (Fragilariaceae) to be increasing in the diatom assemblages as well as general increase in taxonomic variety. There are typical situation of the eutrophic reservoirs. Obviously, the main reasons of this transformation are the influence of heated water KNPP, as well as the hydrodynamic conditions changes. The dam, which was constructed across the Strait between two flatwaters of the Imandra Lake, leads to a flow patterns violation, and natural water exchange reducing.

The surface sediments are to reflect modern ecosystem conditions; the planktonic species: *Cyclotella schumannii* (Grun.) Håk. and *C. rossii* Håk. are dominated. It is the oligotrophic conditions indicator, so the Imandra Lake ecosystem seems to be not so eutrophycated by heated waters. The percentage of periphyton species increasing in diatom complexes, including typical of mesotrophic and eutrophic waters taxa, may be the consequence of intensive development of the modern littoral communities of diatoms, as well as the formation of abundant algocenoses in heated water discharge channel.

Thus, the structure of the diatom assemblage's changes caused not only by the influence of heated water KNPP, but also global environmental change and climate Euro-Arctic Region. Long-term exploitation of water resources of Lake Imandra with multivariate industrial pollution has led to a significant transformation of the water quality and changes in the functioning of the ecosystem as a whole.

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DIATOM ASSEMBLAGES OF THE LAKES OF LESSER KURIL ISLANDS

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Diatom flora was studied in 14 lakes of Shikotan, 7 lakes - Zeleniy, 6 - Tanfiliev, 4 - Polonsky and 3 – Yuri islands. All lakes are small and shallow and located in the coastal zone. Aim of this work is to elucidate the ecological and taxonomic composition of diatom flora and specificity of formation of diatom assemblages in relation to habitat conditions. The highest species diversity of diatoms typical for lakes of Shikotan (146), Polonsky (130) and Tanfiliev (115) islands, less rich lakes of Zeleniy Island (91) and in lakes of Yuri Island met only 14 taxa. The marine and brackish species met among diatoms of most lakes.

Diatom flora of Shikotan Island lakes includes 8 taxa of centrales species (*Aulacoseira* - 5 and *Cyclotella* - 3) and 138 pennales. The number of diatoms ranges from 19-64 taxa, and in some pools of coastal zone of Dimitrov and Tserkovnaya bays, often ephemeral, met 2-5 species. The most diverse types of epiphytes (76) and bottom (58), which is characteristic of shallow lakes, usually overgrown by aquatic vegetation. 12 taxa of plankton and meroplanktonic species were met - *Tabellaria flocculosa* (Roth.) Kütz. present in all pools, but in the mass is found only in two. Also *Aulacoseira alpigena* (Grun.) Sim. and *Fragilaria nanana* L.-Bert were met. Representatives of plankton that present in some lakes are *Cyclotella stelligera* (Cl. et Grun.) VH, *C. meneghiniana* Kütz., *Asterionella formosa* Hass., *Aulacoseira distans* (Ehr.) Sim., *A. granulata* (Ehr.) Sim., *A. italica* (Ehr.) Sim., *Diatoma tenuis* Ag. List of bottom and epiphytes species is wider. In most lakes *Staurosira venter* (Ehr.) Cl. et Möll. dominates, in three lakes - *Stauroforma exiguiformis* (L.-Bert.) Flower, Jones et Round and *Achnanthidium minutissimum* (Kütz.) Czarn. Only in one lake *Cymbella gracilis* (Rabenh.) Cl., *Fragilaria subsalina* (Grun.) L.-B., *Achnanthidium affine* (Grun.) Czarn., *Navicula cryptocephala* Kütz, *Anomoeoneis styriaca* (Grun.) Hust. are among the dominant species. The common species for diatom flora of the majority lakes are *Fragilaria vaucheriae* (Kütz.) Peters., *Nitzschia perminuta* (Grun.) Perag., *N. linearis* (Ag.ex W. Sm.) W. Sm., *Eunotia bilunaris* (Ehr.) Mills, *E. incisa* Greg., *Pinnularia viridis* (Nitz.) Ehr. The peculiar composition of diatoms was found in drying small pool located between the ridges on the coast of Snezhkova Bay. Dominants in the complex are *Luticola mutica* (Kütz.) D. Mann, *Hantzschia amphioxys* (Ehr.) Grun. and *Diadesmis contenta* (Grun.) D. Mann.

On Polonskiy Island the lakes are situated in the southern and western parts. Diatom flora includes freshwater, marine and brackish species. The highest number of marine and brackish diatoms (up to 69%) found in the Dlinnoe Lake and in small barrier lake (17%) on the coast of the Yuzhnaya Bay. In Dlinnoe lake *Chaetoceros* (spores), *Cocconeis scutellum* Ehr., *Melosira nummuloides* Ag., *Tabularia tabulata* (Ag.) Snoeijs dominate. In the barrier lake dominants are brackish *Navicula salinarum* Grun., *Planothidium hauckianum* (Grun.) Round et Burkht., *Melosira lineata* (Dillw.) Ag., *Melosira moniliformis*, *Tabularia tabulata*. The presence of marine and brackish is small (up to 4.5 %)

in the lakes separated from the sea by wide pebble ridge on the island western side. Among freshwater of diatoms 6 taxa of centrales forms were found (*Aulacoseira* - 2, *Cyclotella* - 4) and 127 – of pennales. Planktonic diatoms and meroplanktonic are represented by 8 taxa, only meroplanktonic *Tabellaria flocculosa* (Roth.) Kütz has mass development in one lake. It was met 69 taxa of benthic diatom. The most typical are *Amphora veneta* Kütz., *Craticula halophila* (Grun. ex VH) Mann, *Navicula peregrina* (Ehr.) Kütz., *N. rhynchocephala* Kütz. There are 58 epiphytes species. The dominants are *Pseudostaurosira brevistriata* (Grun.) W. et Round, *Martyana martyi* (Herib.) Round., *Staurosira venter, S. subsalina* (Hust.) L.-B., *S. elliptica* (Schum.) Will. et Round, *Fragilaria capucina* var. *gracilis* (Østr.) Hust.

Diatoms of Zeleniy Island lakes inlude 7 taxa of centrales forms (*Aulacoseira* - 2, *Cyclotella* - 3, *Cyclostephanos* - 1 and *Stephanodiscus* - 1) and 84 pennales. The highest species diversity of diatoms is observed in Kamenskoe Lake (40) and Srednee Lake (52). Up to 4-25 species were found in other lakes. The number of planktonic and meroplanktonic diatoms is small (up to 10). Large amount of *Cyclotella atomus* Hust., *C. meneghiniana* were met and absolute dominance has *Fragilaria nanana* in the lake on the island southern part. *Aulacoseira granulata*, *A. italica*, *Diatoma tenuis*, *Stephanodiscus minutulus* (Kütz.) Cl. et Möller are present too. List of bottom diatom has 36 taxa, and don't reach large amount, except *Nitzschia palea* (Kütz.) W. Sm., that was met in mass in shallow lake on the island eastern coast. In diatom assemblages *Nitzschia nana* Grun., *N. amphibia* Grun., *Navicula rhynchocephala*, *Sellaphora pupula* (Ehr.) Meresch. are frequently met, in lakes near the coast - *Navicula peregrina* and *Craticula halophila*. There are 45 taxa of epiphytes. *Staurosira venter* is dominant in all lakes, in one lake *Staurosira subsalina*, *Cocconeis placentula* Ehr., *Fragilaria capucina* var. *gracilis* and *Martyana martyi* have development in mass. Such diatoms as *Cocconeis placentula* var. *lineata* (Ehr.) V.H., *C. placentula* var. *euglypta* Ehr., *Pseudostaurosira brevistriata*, *Staurosirella pinnata* (Ehr.) Grun. et Will. are common species in most lakes.

Diatom flora of Tanfiliev lakes includes 7 taxa of centrales species (*Aulacoseira* - 3, *Cyclotella* - 3 and *Stephanodiscus* - 1) and 108 taxa of pennales. Diatom species diversity in most lakes is low (22-27 taxa) and more than 50 taxa were found only in two lakes within the swamps on the coast of Tanfiliev Bay. 11 taxa of planktonic and meroplanktonic diatoms were found, *Asterionella formosa*, *Cyclotella meneghiniana* and *Aulacoseira granulata* developed in mass. The *Diatoma tenuis*, *Aulacoseira alpigena* and *Tabellaria flocculosa* are present in some lakes. Among bottom diatom 38 taxa were met. The most typical are *Sellaphora pupula*, *Nitzschia dissipata* (Kütz.) Grun., *N. palea*, *N. perminuta*, *Brachysira brebissonii* Ross. The richest in number (66) and amount of species (6) is group of fouling. As the dominant *Gomphonema acuminatum* Ehr. (in 4 lakes) and *Lemnicola hungarica* (Grun.) Round et Bukht. (in 2 lakes) are occur most often. *Cymbella cistula* (Ehr.) Kirchn., *Staurosira subsalina*, *Gomphonema parvulum* (Kütz.) Kütz have extensive development only in one lake. Common to most lakes are *Karayevia clevei* (Grun.) Round et Bukht., *Planothidium oestrupii* (Cl.) Edlund, *Stauroforma exiguiformis*, *Staurosira venter*, *Gomphonema angustatum* (Kütz.) Rabenh.

On Yuri Island lakes diatoms have low species diversity and content. There are 14 species, the most frequent types are epiphytes *Cocconeis placentula, C. placentula* var. *euglypta*, *Gomphonema gracile* Ehr., *Rhopalodia gibba* (Ehr.) O. Müll., *Staurosira venter* and bottom *Epithemia adnata* (Kütz.) Breb., *E. turgida* (Ehr.) Kütz., *Diploneis ovalis* (Hilse) Cl. Planktonic *Cyclotella meneghiniana* was met in one lake.

The analysis of the diatom flora of the Lesser Kuril lakes showed that more than half of the species list consist of cosmopolitans. Boreal species and significantly less arctic is occupied second place. The indifferent species occupy leading position in relation to salinity of water in most lakes. Participation of halophobous more typical for lakes of Shikotan Island. The halophilos species most widely represented in the lakes of other islands. The most abundant of mesohalobous were found here. The alkaliphilous constitute almost half of diatom species in relation to the pH of environments. Especially their high value is in the large lakes of Tanfiliev, Polonskiy and Zeleniy islands. In small lakes circumneutral diatoms dominate. Acidophilous are not typical for the lakes. There are exceptions - two lakes on the Shikotan and one lake on the Polonsky Island, where *Tabellaria flocculosa* and

Anomoeoneis styriaca dominate. In general, the tendency to swamping of lakes is most pronounced on the Shikotan Island, that indicated by species of *Eunotia* and *Pinnularia* genera.

The work was performed with financial support of RFBR grant 12-05-00017.

ANALISES OF FOSSILISED CLADOCERA REMAINS (BRANCHIOPODA, CRUSTACEA) FROM LAKE GOLOVKA, SYSTEM OF THE HARBEY LAKES (NORTHERN URAL, RUSSIA)

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Bolshezemelskaya tundra is situated in the northern part of the Republic of Komi, and is a part of the richest Timan-Pechora oil and gas province of north-eastern part of European Russia. The climate of the region is subarctic and continental. Average annual temperature is -7°C, but during the last decades the difference between the warmest and the coldest months increased for 1.4°C.The progressive development of the fields of hydrocarbon production was a reason of the ecological problems in that region. In addition, the presence of the permafrost determines the formation of fragile and vulnerable ecosystem [1]. Harbey lakes system is situated in the eastern part of Bolshezemelskaya tundra, 100 km west of Vorkuta city. The system consists of three connected water : Golovka, Bolshoi Harbey and Malyi Harbei and lots of smaller lakes, connected with the channels. Harbey lakes have glacier origin. The lakes are well oxygen saturated and highly transparent [2].

The sediments for our study were sampled in 2011 during the joint expedition of KFU and The Institute of Biology SC URS RAS. The sampling was made by tube-like benthic sampler Uwitec in the central and the deepest part of the lake. The dating of the short sediment column from the lake Bolshoi Harbei was made by the ^{210}Pb in the laboratory of St. Petersburg State University. Since the sedimentation rate in the lakes situated in the same region is equal, we used the observed data to determine the age of our sediment core. The age of our core is aproximately 80 years.

Between 4 and 8 g of surface sediment sub-samples were heated in 10% KOH at 75°C for approximately 30 min. The sediments were then rinsed through 125 and 63 µm sieves. The material retained on the sieves was transferred to small vials containing distilled water and a few drops of ethanol to prevent fungal growth. Two to three drops of a safranin solution was added to stain any cladoceran remains. Sub-samples were analysed using a light microscope at 40–400x magnification. From 100 to 302 remains were identified from every sample. The chitinous remains of cladoceran (post-abdomens, claws, mandibles, sections of antennae, ephippia and remains of carapaces) were identified with reference modern identification literature [3]. The forms with more than 10 % of the total number of Cladocera in the sample were considered to be dominant, taxa that compose 5-10% of the total number of Cladocera in the sample were considered to be subdominants

In total 17 taxa were identified in the Cladocera community of the lake Golovka. Specific diversity of the lake is determined by littoral taxa. The taxa inhabiting the lake are universally common. *Chydorus sphaericus* is dominant in the lake sediments. Taxa from the genera *Bosmina,* and *Alona affinis, Alona quadrangularis, Eurycercus sp.* play secondary role in the lake. Stratigraphic analysis, made in C2 program, demonstrates decrease of the moderately cold water inhabitant *Bosmina longispina* in the samples of the last 5 years and *Eurycercus sp* for the last 60 years. Increasing number of *Alona affinis* could be the consequence of the presence of macrophytes in the lake.

Jakkar and Serensen-Chekanovsky indices (0.7 and 0.8 respectively) demonstrated high degree of similarity between the modern and fossil Cladocera communities of the Golovka lake. Not all Cladocera taxa found in the zooplankton were found in fossilized remains, mainly because of the poor preservation of some groups: Chydoridae and Bosminidae preserve better than others. In subfossil Cladocera we found *Camptocercus rectirostris Schoelder*, 1862, species, that has never been observed in previous investigations. The species is typical inhabitant of southern overgrown lakes and river backwaters.

Zooplankton, pollen and chironomid data analysis support our results and register some signs of the eutrophication growth in the lake and increasing temperature in the region.

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LITHOFACIES ANALYSIS OF HOLOCENE SEDIMENTS OF THE LAKE TERE-KHOL (SOUTHEASTERN TUVA)

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The Tere-Khol shallow lake (fig. 1) located at height 1300 m asl in the bottom of the intermountain rift basin in southeastern Tuva. At one of the small islands placed ancient fortress Por-Bajin - a unique monument of culture the middle of VIII century. When studying the monument appeared a few questions related to the history of the lake: How old the lake exists; what are the main stages of the history of the lake; what was the environment near the fortress at the time of its construction? To solution of the problem we studied a number of drilling cores at the bottom of the lake, on the shores of the lake and the islands. Field data were obtained by the author in collaboration with colleagues in the expedition of the Department of Geomorphology and Paleogeography

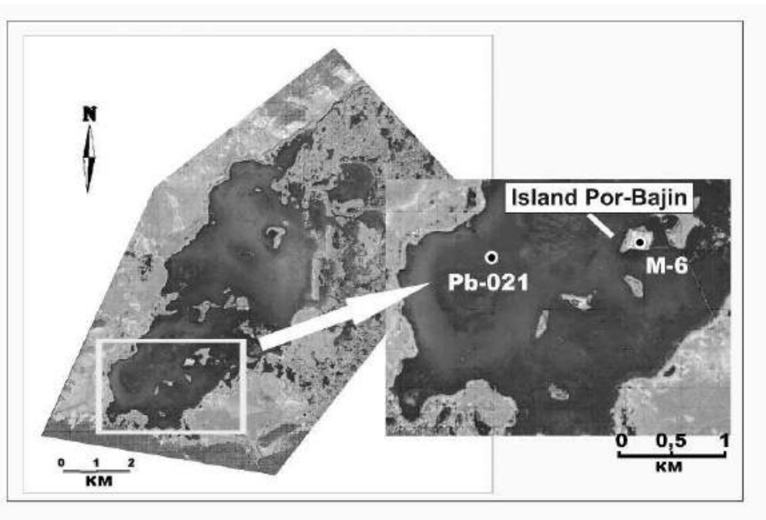

Figure 1. Lake Tere-Khol on the satellite image and the location of key boreholes.

(Faculty of Geography MSU) in 2007-2008. Analytical work was carried out in the laboratory of the department. Results of a comprehensive study of the environment in the Tere-Khol Basin were previously published in several papers: Koshurnikov et al., 2008; Panin et al., 2012; Bronnikova et al., 2013.

In detail, using a set of analytical techniques were studied two main drilling cores: Pb-021 - a borehole in the deepest part of the lake (~ 1.2 m depth); M-6 - a borehole in the central part of the island Por-Bajin. For samples from the core, we determined the content of the main sediment components - carbonates, organic matter and terrigenic mineral matter. Analysis spent by a method re-determination of loss on ignition at 550° C and 950° C (Oliver et al., 2001). Grain-size analysis was performed only for the mineral component of the sediment, which was separated from the sample by sequential treatment with 3% HCI (to remove carbonate) and 15% hydrogen peroxide (to remove the organic matter). Grain-size analysis was performed by the combined procedure: the separation of sand particles (0.05-2.0 mm) was performed by sieve analysis and for fine particles (smaller than 0.05 mm) was used laser diffraction analyzer Fritsch Analysette 22.

From the borehole Pb-021 (fig. 2) was obtained the three-meter core of lake sediments. The upper 2.5 m of the core are organic mud (sapropel). The lower 0.5 m of core Pb-021 are presented by mineral loam (dominated by clasts of rock). At a depth of 2.4-2.6 m we fixed the border of a type of sedimentation from mineragenic (mineral matter more than 80%) to the biogenic-chemogenic (organic matter with carbonates exceeds 60%). This boundary fixes formation time of the Lake Tere-Khol in shape approximate to the modern. According to radiocarbon AMS-dating of the core samples found that this border corresponds to the beginning of the Holocene (about 11000 cal BP). In the depth interval 2,5-0,0 m in the sediment composition we trace a slight tendency to increase the proportion of biogenic (organic matter) and chemogenic (carbonates) components. This shows the eutrophication of the lake and a reduction of its depth with the time. Depth reduction could be associated with increased levels of the lake bottom due to sediment accumulation.

Key borehole M-6 (fig. 2) is located on the island of Por-Bajin, which is on the permafrost basis and consists from the lake sediments. A.V. Panin et al. (2012) have shown that the island Por-Bajin, like most of the other islands of the lake, was formed due to the frost heaving lake bottom. The studying of the core of borehole M-6 (7 m depth) allowed us to determine the environmental conditions near the island until the formation of lakes in the area. In the diagram M-6 we can see a clear boundary (depth 340-350 cm) from mineragenic to chemogenic-biogenic type of sedimentation, which marks the step of forming the lake. This step correlates to the same phase, which was defined in the core of Pb-021. Below this border it was determined the aquatic sediments by mineragenic type. To the bottom of the core there is a significant increase in grain size. Radiocarbon dates indicate a

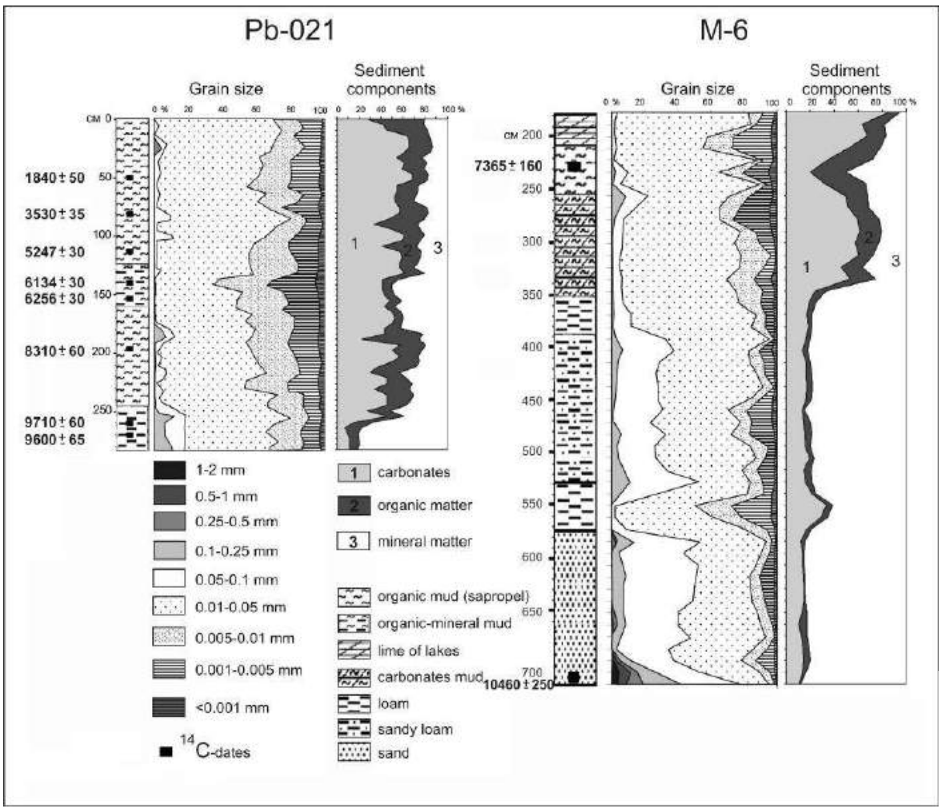

Figure 2. Results of laboratory analyzes of samples from drilling cores

significantly higher rate of sedimentation at this stage compared to the rate in the conditions of the lake. Rhythmic changes in the content of sand, silt and clay in this interval indicates an unstable flood (proluvial) type of sedimentation. Before the formation of the Lake Tere-Khol, the bottom of depression was in the zone of influence of temporary streams. Probably already at that time there were numerous scattered lakes. Since the beginning of the Holocene the activity of temporary streams decreased and there was a gradual flooding of areas - the Lake Tere-Khol was formed.

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ARSENIC IN NATURAL WATERS AND SEDIMENTS OF ZAONEZHJA LAKES

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Arsenic has high biological activity and pronounced capacity for accumulation in the body. With the accumulation in the body of animals and humans, arsenic compounds are characterized by a variety of toxic effects - effects on the central and peripheral nervous system and on chromosome lesion vessels, liver, kidneys, upper respiratory tract, etc. (Walsh, Keeney, 1975; Kabata-Pendias, 1989; Kovda, 1990; Gamayurova, 1993 Karpov Potatueva 1991; Kovalevsky, 1991; Arshad, 1991). The high toxicity of the element (contaminant hazard class 1) determines the need for environmental assessment of areas containing arsenic. The most common forms of inorganic As (V) in oxygenated waters are near neutral anions $H_2AsO_4^-$ and $HAsO_4^{2-}$. Reduced forms of As (III) exist at lower Eh. In natural waters, arsenic migrates in an anionically active form, and can be deposited on the geochemical barriers (Kowalski, 1974; Walsh, Keeney, 1975; Geochemistry, 1990; Burceva, 1991; Bortnikova, Ayriyants, 1996; Pokatilov, 1993; Barselo, Bech, 1997).

The Zaonezhsky Peninsula is located on the eastern outskirts of the Pheno - Scandinavian Shield. Pre-Quaternary formations are represented by carbonate rocks of Proterozoic age, various schists, including schungite. Quaternary sediment thickness varies from 0.5 to 20 m and the geochemical characteristics of the area is heavily influenced by structural zone rupture dislocations, where Cu-U-Mo-V ores are confined to, which exhibit elevated to anomalous trace element contents, including arsenic. The soil cover is characterized by its diversity and the complexity of widespread dark-colored brown earth developed on shungite moraine and glacial sediments. Alleged mining ores in the area will inevitably lead to the contamination of the site, where micronutrients change their migration characteristics and accumulate in reservoirs.

The aim of this work is the environmental assessment of natural waters within the Zaonezhskoe Peninsula and its subsequent arsenic content. To determine the total content of arsenic the method employed was ICP-MS.

In the area of Zaonezhja extending 1900 km^2 there is located 251 lakes with a total area of 212 km^2 (Freyndling and Polyakov, 1965). The largest 7 lakes presented in this study (Table 1) are of tectonic origin, resulting in a depression, and Yandomozera Myagrozera has glacial origin. In the water balance of the lakes studied, a large number share an underground water supply.

In various types of groundwater aquifers, background concentrations of arsenic can reach up 0.3-2.5 mg/l, and in oxygenated groundwater significant (above the detection limit) concentrations were observed in only 8% of the samples. Background arsenic is slightly increased in the waters interglacial horizon. Concentrations of greater than 5 g/l are found in only 5% of the samples when Eh < 300 mV and pH> 7. Maximum concentrations recorded in "Marcial" sources (up to 48.4 mg/l), wells on Maksovskom shungites field (up to 30 mg/l), in wells in p.N.Vilga (68 mg / l). Usually sources of As in groundwater are sulfides of iron, copper, as well as its own sulfides. But extracts from shungites As concentration did not exceed 3.6 mg/l. Arsenic may concentrate in wetland soils, as well as other groups ferruginous horizon soils. As anionic element, As can pass from sulphides to alkaline groundwater.

The peculiarity of the chemical composition of surface waters in Zaonezhja shows increased mineralization, low organic matter content, low concentrations of iron, good saturation of oxygen, the reaction is within a slightly alkaline environment. Most objects are characterized by high quality of natural waters. Arsenic concentrations in lake waters are small and do not exceed 1 mg/l (Table 1). Element concentration in small streams in the Zaonezhskoe Peninsula vary from 0.3 to 0.6 mg/l

The arsenic content in the sediments has been studied in the lake Padmozera. Arsenic concentrations varied from 5 to 11 ug/g dry weight, which exceeds the Clarke values of 2-5 and is located at the MPC soil (8 ug/g). Vertical distribution of elements in the sediments shows its accumulation in the surface oxidized layer of sediments that may be due to high arsenic exposure in sediments during field development "Average Padma" in the 80s , which is located in the upper river Padma , which flows into the lake.

In conclusion, it should be noted that in the surface waters of the Zaonezhskoe peninsula high levels of arsenic were not observed. The maximum concentration of the element found in groundwater was in wells in shungites. Arsenic accumulates in sediments, where its content is much higher than Clarke values.

Table 1. Characteristics of ion composition and concentration of arsenic in water bodies in the Zaonezhskoe Peninsula.

Water	pH	∑ion		Ionic composition, %-eq.	As mkg/l
		mg/l	mol-eq/l		
Kosmozero	6,87-7,56	50,3	0.73	Ca44 Mg33 Na20 K3 / $HCO_3$67 Cl12$SO_4$11 A_{opr}10	0,4
Putkozero	7,05-7,80	87,8	1.25	Ca47 Mg40 Na10 K3 / $HCO_3$64 $SO_4$22 A_{opr}7 Cl7	0,6
Padmozero	7,05-8,03	150,8	1.99	Ca58 Mg34 Na6 K2 / $HCO_3$82 $SO_4$8 A_{opr}7 Cl3	0,3
Ladmozero	7,23-7,80	46,3	0.66	Ca59 Mg28 Na11 K3 / $HCO_3$71 $SO_4$14A_{opr}9 Cl6	0,6
Turastomozero	6,70-8,10	46,7	0.67	Ca60 Mg27 Na11 K2 / $HCO_3$73 $SO_4$12A_{opr}10 Cl5	0,7
V.Myagrozero	7,25-8,03	108,0	1.51	Ca76 Mg19 Na4 K1 / $HCO_3$81 A_{opr}12 $SO_4$5 Cl2	0,1
Vangozero	6,85-7,80	58,6	0.78	Ca63 Mg25 Na10 K2 / $HCO_3$80 $SO_4$11 $A_{o\ pr}$5 Cl4	0,1
Valgomozero	7,15-8,15	124,3	1.80	Ca59 Mg28 Na8 K5 / $HCO_3$78 $SO_4$10 A_{opr}6Cl6	<0,1
Yandomozero	6,86-7,55	42.2	0.62	Ca45 Mg38 Na14 K3 / $HCO_3$64 $SO_4$17A_{opr}12 Cl7	0,6

PALINOLOGICAL STUDY OF BOTTOM SEDIMENTS FROM PONDS ON THE POMOR WHITE SEA COAST

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The goal of our project was to estimate the relative translocation of the White Sea shoreline on the basis of the lithological and micropaleontological study of bottom sediments from the pond basins of the Pomor White Sea coast that occur at various hypsometric levels near Sumsky Posad Town. The water bodies with absolute water edge marks of 45.0 and 40.9 m a. s. l. are located on the lower storey of the Sumozero Insular Upland, while others lie at its flanks or on the Pribelomorian Lowland. Buried peat, formed in the Late Dryas, was revealed by drilling in the lake basin at an altitude of 49.0 m a.s.l. At that time the shallow-water zones of the prabodies of water were overgrowing with coastal-aquatic species in the Sumsky Posad area. After active ice melting at the end of the Younger Dryas and in the early Preboreal the water content of Onega Bay increased through the rapid inflow of meltwater and the coast was flooded, as indicated by layered and indistinctly layered clay that rest on the peat in the sedimentary sequence of the lake located at the highest latitude. In the late half of the Preboreal the Onega Bay shoreline began to regress and the lake basins studied separated.

The bottom sediments of the lakes are thin, suggesting the low productivity of the water bodies or the oxidation of the organic matter. The 2 m thick sedimentary sequence of Lake Levisgorskoe, located at an altitude of 45.0 m a.s.l., is most representative. Eleven palinozones, consistent with the climatic periods and phases of the Late Glacial Period and the Holocene from the Late Dryas to the present, were identified in the SPD obtained for the sediments from this lake. The periodization of other diagrams was performed in less detail because the corresponding sedimentary sequences were thin. The distinctive feature of the spore-and-pollen spectra is the absence of the halophyte (*Salicornia herbacea, Atriplex nudicalis*, *Aster-type, Plantago)* pollen produced by obligate halophytes that grow in the littoral; zone. Their pollen is almost always present in marine sediments and in sediments from the transition zone between the marine and lake sediments of the Karelian coast of the White Sea. This evidence supports the earlier assumption (Kolka et al., 2012) that the Onega Bay depression was separated by a glacier front from the White Sea basin upon cooling in the Late Dryas and that there was a periglacial freshwater body in it. It seems that as shallow Onega Bay was also largely desalinated in Preboreal time, there were no habitats for the settling of obligate halophytes in the coastal zone.

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LITHOLOGICAL AND DIATOM EVIDENCES FOR LAKE ONEGA POST-GLACIAL LEVEL CHANGES: NEW DATA FROM BOLSHOY KLIMENETSKIY ISLAND

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The basin of Lake Onega, the second largest lake in the European Russia, have experienced a considerable glacioisostatic rebound after the retreat of the Scandinavian Ice Sheet. The neotectonic activity, however, largely complicates estimating the rate of the uplift and corresponding relative lake-level changes, amplifying or obscuring the effect of the isostasy. As a result, synchronous palaeo-shorelines are presently found at different elevations in the northern (emerging) and southern (submerging) parts of the basin, which is still more complicated by locally restricted tectonic movements.

In this study, we examined a sediment sequence from Bolshoy Klimenetskiy Island, north-central Lake Onega. Five lithological units and four local diatom assemblage zones were clearly distinguished enabling the reconstruction of the large basin level changes and related evolution of the study site. The varved clays in the bottommost part of the sequence accumulated in the proglacial basin, and are almost bare of diatoms. An abrupt transition to gravely sand and silt indicates a significant water-level drop resulted from the proglacial lake drainage, and establishing shallow-water conditions at the site. The diatom assemblages are dominated by the so-called "large-lake species" also typical of Lake Onega, suggesting the near-shore sedimentation within the large oligotrophic basin. The subsequent transition to gyttja with the predominance of the "small-lake" taxa, and subsequently to peat in the topmost part of the sequence, points at further regression of Lake Onega and the isolation from the large basin followed by the paludification of the site. The time of the isolation agrees well with the results by Demidov et al. (2006) obtained from the Zaonezhskiy Peninsula, north of the study site. Comparison with other reconstructions of the shoreline displacement along the Lake Onega shore is attempted as well.

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THE USE OF SILICEOUS MICROFOSSILS FORM THE BURIED ARCHAEOLOGICAL SITE IN RECONSTRUCTING THE LAKE LADOGA TRANSGRESSION

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Although the mid-Holocene Ladoga transgression has been first hypothesized more than a century ago, the exact temporal and spatial limits of the event remain debatable until present. It explains the increasing use of archaeological sites located along the palaeo-shorelines as an additional source of information in reconstructing Ladoga level changes (Gerasimov et Subetto 2009). Given the elevation of a site and stratigraphic position of a cultural layer (below or above Lake Ladoga sediments) an independent evidence for the transgressive/regressive events can be obtained, while a combined use of archaeological, micropalaeontological, geochemical analyses and absolute dating provides more accurate palaeoenvironmental reconstructions.

In this study, siliceous microfossils of aquatic (diatoms, Chrysophyte cysts, sponge spicula), and terrestrial origin (phytoliths), from the Neolithic archaeological site Ust'-Rybezhna 1 were analyzed to infer Ladoga transgression signals in relation to the evolution of the site.

The lowermost fine sands almost lack any siliceous microfossils but phytoliths increasing by the top of the unit, and pointing at subaerial or nearly subaerial conditions. In the overlaying organic-rich sediments containing archaeological artifacts, phytolith concentrations further increase, and a number of benthic (including terrestrial) diatoms is observed. Noteworthy, the upper part of the unit is dominated by aquatic microfossils (primarily, Chrysophyte cysts). The diatom concentrations and species diversity assemblages increase as well with gradually declining phytolith abundances, suggesting permanently waterlogged conditions resulted from the Lake Ladoga level rise, and cessation of early human activity at the site. The predominance of characteristic Lake Ladoga species in the diatom assemblages of the topmost sedimentary unit clearly indicates the site inundation by the Ladoga waters resulted in burying the cultural layer under the transgression sediments.

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PALYNOLOGICAL CHARACTERISTICS OF THE HOLOCENE LAKE SEDIMENTS IN THE KOMI REPUBLIC

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The Holocene lacustrine deposits are widespread in the Komi Republic. They are represented by silts, clays, loams and fine and medium sands, mainly dark gray in color, with the plant remains, sometimes peaty. Pollen and spores, minerals, plant remaines, diatoms, sponge spicules and other particles are preserved sufficiently well in the lake sediments. The palynological materials sometimes dated by radiocarbon allowed to specify the main stages of development of environments in the republic during the Holocene.

During Lateglacial there were two cold (Middle and Yonger Dryas) and two warm (Bölling and Alleröd) periods. The Bölling deposits (BÖ, 12300–12700 years ago) are found in the basin of Luza river. Spore-pollen assemblages comprise large portion of wood forms, with predominance of *Betula* sect. *Albae* and *Pinus sylvestris* occured sporadically. The assemblage reflects the development of birch forests with pine. A variety of shrubs were formed by birch *Betula* sect. *Fruticosae, Betula nanae* which played an important role in the vegetation. Dryas deposits (DR–2, 11800-12300 years ago) were exposed in the section of the Vychegda river. Spectra composition indicates the dominance of periglacial landscape with sagebrush-goosefoots and grass groups with tundra communities of dwarf birches, also the occurence of very sparse areas of birch and spruce forests. The greatest number of steppe xerophytes allowed to bind these stadial periods. Alleröd deposits (AL, 11000-11800 years ago) in the same section are characterized by the increase of spruce pollen and the reduction of birch pollen (both tree and shrub).

Postglacial vegetation history was revealed from the Preboreal period (9300 10300 years ago). In the first half of the period (PB 1) forest formations were distributed, first in middle taiga subzone (the basin of the Vychegda river), and then in the northern areas (the basin of the Pechora river). Pine forests with spruce and birch dominated in the Vychegda river valley. Woodlands of spruce, birch, *Larix sibirica* were distributed in the vegetation of the Middle Timan. The spruce and birch woodlands developed in the Pechora valley. The vegetation still retained here the features of periglacial complex with a predominance of tundra and also communities of grasses, *Artemisia* sp. and Chenopodiaceae. In the second half of the period (PB 2) periglacial vegetation partially re-developed and the role of forest formations were reduced. The shrub thickets of birch trees and sagebrush-goosefoot groups were spread. The birch with common shrub and herbaceous associations of *Artemisia*, Chenopodiaceae and grasses were developed in the southern regions (Kalya section in the basin of the Vychegda river).

The Boreal period (8000-9300 years ago) was studied in some sections of the lake-marsh sediments Sindorskoye and Kalya lakes. In the beginning of the period south taiga spruce forests grew in the basin of Vychegda river, including broad-leaved species (elm, linden, hazel). In northern district (the basin of the Vym river) northern taiga spruce and birch forests dominated. The Early Boreal warming influenced the vegetation. The second half of the period is characterized by the development of northern and middle taiga spruce-birch forests with pine. The watershed between the Mezen, and

Pechora – Pizma rivers was occupied by assemblages in which the role of birch tree was growing, and the pine's one was reducing, the broad-leaved trees disappeared as a result of climate cooling.

The Atlantic period (4600-8000 years ago) is highlighted in many sections of the investigated area. In the beginning of the period, spruce forests with pine, birch and broad-leaved species were extensively developed in the south of the region. To the north, in the watershed of Mezen river and Pechora–Pizma rivers birch forests were replaced by spruce forests with birch and rare broad-leaved species. In the middle of the Atlantic period in the basin of Vychegda river the role of birch increased and the spruce reduced; the participation of broad-leaved trees decreased. This indicates a climate cooling . At the end of the period the spruce forests were replaced by the southern taiga (pine, spruce, fir with birch). The broad-leaved trees widespread (oak, elm, hazel). In the basin of the Luza river subtaiga broadleaved-coniferous forests developed. The quantity of the broad-leaved species pollen in the spore-pollen spectra reached 14%. In the northern areas (the basin of the Izhma river) birch and pine forests with alder, fir and broad-leaved species dominated.

The Subboreal period (2500-4600 years ago) is characterized by a three-phase development of vegetation. At the early interval of the period the birch- spruce forests grew and the broad-leaved species gradually disappeared from the vegetation in the southern regions of the republic (the basins of the Sysola, Vychegda rivers, Sindorskoye lake). The spruce forests decreased. Northern (the basin of the Izhma river) vegetation is characterized by the development of birch and spruce forests. Tundra groups became dominant in the north. In the middle of the Subboreal period in the basin of Vychegda river spruce forests with a significant portion of pine and birch dominated. Fir, alder, broad-leaved trees occured in the stand (basswood, elm, oak and hazel, the pollen, which in total reached 6 %). The pollen of broadleaved trees (lime, hazel, oak and elm) in the spectra from the deposits in the basins of the Izhma and Mezen rivers may indicate a location in the northern border the southern taiga subzone. At the end of the Subboreal the role of broad-leaved trees, cedar and fir diminished.

The Subatlantic period (2500 years ago - present) was studied in some sections in the basins of the Vychegda, Sysola, Vym rivers, Sindorskoye lake. In the early part (SA- 1) the share of spruce has decreased and pine forests and birch has increased. In the middle part of the period (SA- 2) coniferous forests were developed. In the lower Vychegda river southern taiga coniferous forests along with the mid-and southern taiga pine forests distributed. Climate was almost modern-like. The role of birch in the composition was increased that was caused by cooling at the end of the period (SA- 3). In the southern region the northern taiga forests dominated. In the north of the territory groups with forest-tundra communities of alder, ferns and moss tundra species were developed.

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DENDROCHRONOLOGICAL STUDIES OF THERMOKARST DEPRESSIONS DEVELOPMENT IN CENTRAL YAKUTIA

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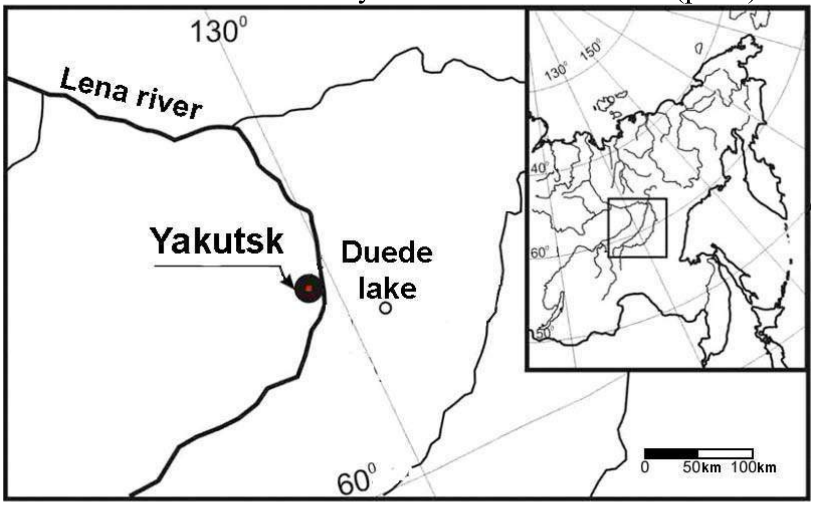
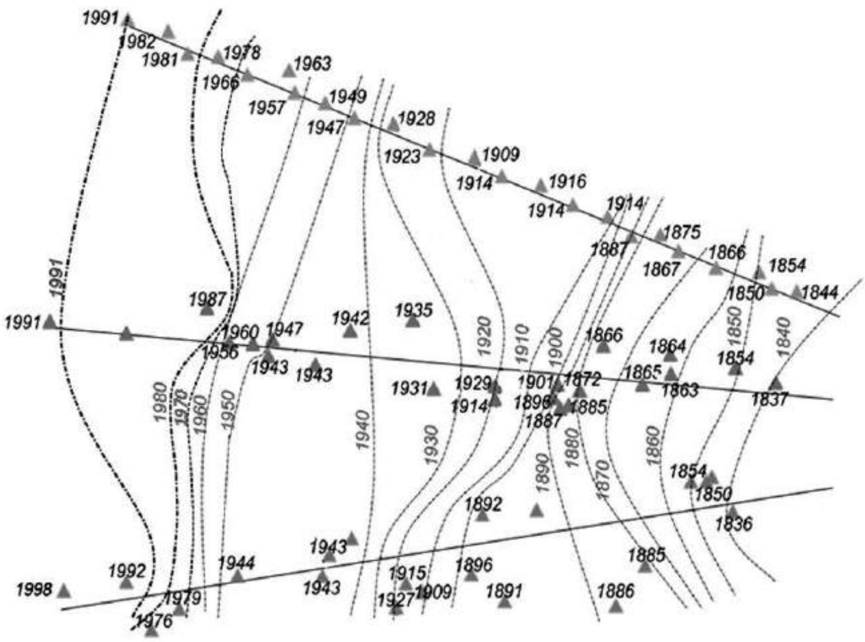
Studies concerning thermokarst influence on tree growth in Central Yakutia have been carried out. Study region is characterized by alas landscape and ground ice distribution presence. Forest disturbance due to fires, forest cut etc. can result thermokarst activization in Central Yakutia. In interfluve area of Lena and Amga rivers where ground ice occurs in any landscape element these landforms prevail. Ice wedge width may reach 6 m, and ice complex thickness at interalas area may vary from 20 to 25 m. Denrochronological research of dynamics in initial thermokarst forms in Central Yakutia has showed activization of theses processes during last several decades. These processes are correlated with more significant temperature increase. We have conducted studies of the dynamics of development of thermokarst lakes on the territory of the Central Yakutia (pic.1).



Picture 1. Map of Central Yakutia and area studies of the dynamics of the development of thermokarst lakes

Temporality of thermokarst and its influence on tree growth varied depending on period's climatic conditions (pic.2). The analysis showed that thermokarst borders extent varies in different periods that results in demise of forest species growing adjacent to thermokarst depression. Increase of mean summer air temperatures results in more significant thawing of ground ice and, consequently, deeper thermokarst depression occurrence. Thermokarst lake area in such seasons increases. Due to ice wedge thawing goes lakeside retreat as a results tree stems inclination towards the depression occurs. This moment is clearly fixed by tree-ring growth. At this time radial increment process changing. According to our analysis tree stems under the influence of thermokarst depression and wind heels and forms sway wood; further lake area increase leads to tree demise.



Picture 2. The reconstruction of thermokarst lake borders by the date of compression tree ring formation

Periods of thermokarst activity at permafrost landscapes of Central Yakutia have been determined due to dendrochronological study results. Sample timing showed that studied trees growth has begun in the end of 18th – the beginning of 19th centuries and the middle of 19th century. Probably in the mid-to-late 19th century thermokarst processes most likely began at disturbed sites. They are now represented by thermokarst lakes (duede). The deepest pits formed in 1879-85, 1892-1897, 1909-1919, 1927-1937, 1942-1949, 1973-1977, and 1987-1993. In theses periods tree growth is characterized by tree-rings width decrease and sway wood formation.

POST-GLACIAL AND HOLOCENE EVOLUTION STAGES OF THE WATER BODIES ON THE POMOR WHITE SEA COAST, BASED ON DIATOM ANALYSIS OF BOTTOM SEDIMENTS (SUMSKY POSAD AREA, KARELIA, RUSSIA)

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Bottom sediments from six lakes, located on the Pomor Coast near Sumsky Posad Town at an absolute altitude of 24.4 to 49 m above sea level, were studied. Stratigraphic subdivision of the sediments was first performed in the field on the lithological basis and then by analysis of the composition of diatom complexes. Periglacial, marine, transitional and freshwater facies were identified [4]. The bottom sedimentary sequences in the Sumsky Posad area differ considerably in sediment stratigraphy and the composition of diatom complexes from those in the Kuzema [1, 2], Engozero [3] and Chupa [5] areas. Their major lithological and stratigraphic difference is the presence of peat interbeds that rest on sand-silt deposits and are overlain by lake gyttja or silty bedded clay and gyttja in bottom sediments from lakes located at high absolute marks (in excess of 38 m a.s.l.). There are practically no marine species of diatoms in lake bottom sediments in the study area. They are present in all sequences either as abundant unidentifiable fragments or scarce valves that make up 2-5% of the total flora. The low degree of preservation of the valves and a high percentage of fragments suggest the redeposition of the sediments. The scarcity or even the complete absence of valves from some layers indicate the shortage of nutrients for the development of diatoms. The greatest number of marine and brackish-water forms has been revealed in lake bottom sediments from an absolute water edge mark of 49 m (depth 950-920 cm). The planktonic brackish-water species *Hyalodiscus radiatus, Melosira moniliformis* and *Paralia sulcata*, the littoral brackish-water species *Campilodiscus hibernicus, Campilodiscus noricus* and *Navicula comoides* and the bottom species *Gyrosygma acuminatum* (10%), *Navicula comoides, N.laterostrata* and *N.peregrina* (about 6% of the entire complex) are noteworthy. Marine species are either absent from the bottom sediments of the lakes located at lower absolute marks (45-24.4 m) or occur as scarce poorly preserved valves and fragments. The mesohalophobes *Diploneis smithi, D. parma, D.interrupta, Navicula peregrine* and *Mastogloia smithi var. lacustris* from the sediments of all the lakes studied make up only 10%. The percentage of halophils, dominated by *Gyrosigma acuminatum, Navicula radiosa, N. pupula var. rectangularis, Anomoeoneis sphaerophora, Navicula halophila* and *N.laterostrata,* varies from 5 to 90%. The latter, together with *Gyrosigma acuminatum*, prevails in the sediments of the lakes located at higher absolute altitudes (49-46 m a.s.l.), while *Anomoeoneis sphaerophora* and *Navicula peregrine* dominate in lakes with lower water edge marks (40.9-24.4 m). Freshwater complexes from Holocene sediments are most diverse. The planktonic species, common to all the lakes, are *Aulacoseira distans, A. lyrata, A. italica, A. lacustris, Cyclotella stelligera* and *Ellerbeckia arenaria.* The species of the genera *Cymbella, Eunotia, Fragilaria, Staurosira* are the most diverse encrusting forms. The bottom community consists of the species of the genus *Diploneis*, dominated by *Diploneis elliptica, D. finnica, D. smithi* and *D. parma,* and many species of the genera *Navicula, Pinnularia* and *Stauroneis.* The presence of the green algae Pediastrum: *P.angulosum v.angulosum, P.boryanum v.boryanum, P.boryanum v.cornutum, P. boryanum v.longicorne, P. duplex, P.duplex v.rugulosum* and *P. integrum* in the lower layers of the sequences studied is particularly noteworthy. Most of them are typical of Late Glacial periglacial water bodies, where diatoms did not evolve because of the cold climate, the turbidity of the glacial meltwater supplied into the water bodies and the lack of silicic acid and light. The absence of relict diatom flora from some of the sedimentary horizons also suggests that periglacial conditions in the Late Glacial and early Holocene periods persisted for a long period of time.

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CARBONATE MINERALOGY AND CLIMATE SIGNALS FROM THE HOLOCENE SEDIMENTS OF SHALLOW SALINE LAKES IN BAIKAL REGION

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The hotly debatable problem of global warming and the uncertainty of climate forecast have led to appreciable growth of paleoclimatic researches. Foreign researchers who deal with paleoclimatic reconstructions pay enhanced attention to the modern systems of small saline lakes of arid and semiarid zones [1]. The bottom sediments of these lakes are high-resolution paleoclimatic archives due to the fact that the small dimensions of the reservoirs predetermine their unique sensitivity to climatic changes.

The goal of this work was to study assemblages of endogenic carbonate minerals from the bottom sediments of closed shallow mineral lakes, situated in drylands of the Baikal region, the crystallochemical and structural features of carbonate phases, the regularities of their formation, and the sequence of their deposition depending on the environmental and climatic changes. The methods of investigations are: X-ray diffraction analysis (ARL X’TRA, Cu K_α radiation), IR-spectroscopy, scanning electron microscopy, SR XFA, analysis of stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) and atomic

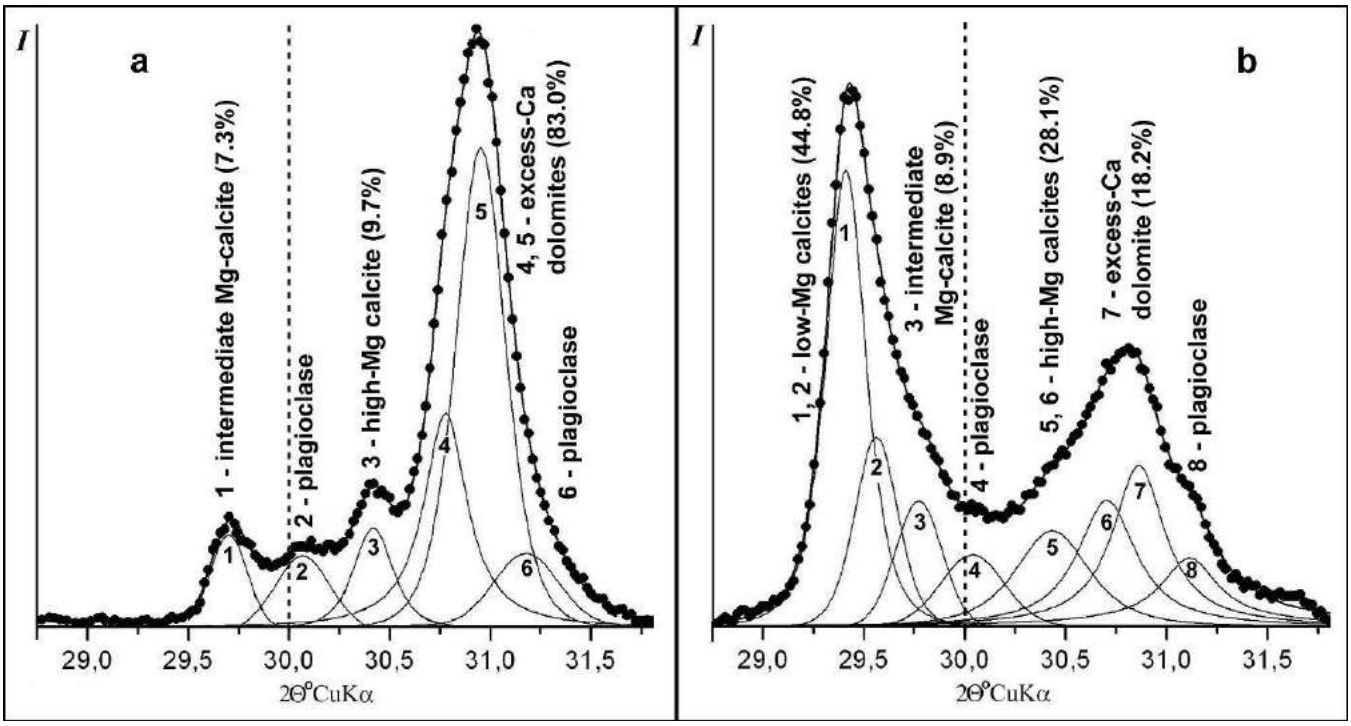

Fig. 1. Results of modeling of experimental XRD profiles of carbonates in the range of d_{104} peaks. The total modeled profiles (solid line) are in agreement with the experimental ones (dotted line).

absorption spectroscopy. The age of sediments was determined on carbonates material by AMS ^{14}C dating. A whole new level of researches was provided using modern methods of mathematical processing of XRD patterns [2]

The assemblage of endogenic carbonate minerals of the Holocene lacustrine sediments consists of calcite, Mg-calcites with different Mg contents, excess-Ca dolomites, less frequently aragonite, monohydrocalcite and rhodochrosite. The most widespread minerals are Mg-calcites possessing unusual and yet not completely studied properties. By the chemical composition and the position of main analytical peaks on X-ray patterns as well as position of absorption bands on IR spectra Mg-calcites and excess-Ca dolomites are situated between calcite $CaCO_3$ and stoichiometric dolomite ($CaMg[CO_3]_2$). Since the ionic radii Mg^{2+} and Ca^{2+} are strongly different, the solid solutions of the system $CaCO_3$–$MgCO_3$ must exist only in a limited range of Mg contents. This means that Mg-calcites containing with more than a few mol.% $MgCO_3$ in the structure are metastable. Nevertheless, they occur widely in nature and content of $MgCO_3$ in the Mg-calcites may amount to 43 mol.%, right up to excess-Ca dolomite.

At present, Mg-calcites are regarded as mixed crystals varying from real solid solutions to mixed-layered structures in the series calcite–dolomite and characterized by different stability. These structures are sequences of calcite and magnesite layers alternating with different degrees of ordering and forming nanosized domains [3]. In contrast to Mg-calcites, excess-Ca dolomites have more intricate structural ordering. They have a complex mixed-layered structure, in which layers of nonstoichiometric dolomite with different contents of excess Ca alternate with stoichiometric-dolomite and calcite-like layers in different proportions and with different degrees of ordering [4]. This mixed crystal is an end-member of the series of anhydrous Ca–Mg carbonates and has genesis different from dolomite *sensu stricto* [3].

According to the content of $MgCO_3$ in the structure, Mg-calcites are divided into three groups: (1) low-Mg calcites (LMC) with $MgCO_3$ < 4–5 mol.%; (2) intermediate Mg-calcites (IMC) with 5–18 mol.% $MgCO_3$; and (3) high-Mg calcites (HMC) with 30–43 mol.% $MgCO_3$. The excess-Ca dolomites (CaD) are characterized by an excess of $CaCO_3$ to 7 mol.%. On the high-resolution X-ray patterns of the studied samples (Fig. 1), the peaks corresponding to d_{104} of Mg-Ca carbonate minerals look like two broad maxima of varying intensity: (1) LMC and IMC and (2) HMC and CaD. The conventional boundary between them is located at 30º 2Θ CuK_{α}. The gap between the maxima is due to the transition of Mg-calcites structures from true solid solutions to mixed "domain" crystals.

To identify all carbonate minerals present in the samples, we decomposed their complex XRD patterns into individual peaks by Pearson VII function. The content of $MgCO_3$ in structure was determined from the d_{104} vs. $MgCO_3$ content (mol.%) calibration plots [3]. The model approach allowed us to identify carbonate phases in calcite-dolomite series and to obtain their quantitative ratios.

The total content of carbonates in the sample is taken equal to 100%.

Climate aridization, which accompanied by a drop in the water level leads to precipitation of high-Mg calcite and excess-Ca dolomite (Fig. 1a) and vice versa – a warm and wet climate is conducive to the formation of intermediate and low-Mg calcites (Fig. 1b). A high-resolution carbonate record has been obtained for the first time for the lacustrine sediments. It bears the information about the stratigraphic distribution of carbonates from calcite-dolomite series, in which the amount and proportions of phases with different Mg contents are controlled by Mg/Ca, salinity, and total alkalinity of the lake water changing depending on the climatic cycles and lake level fluctuations.

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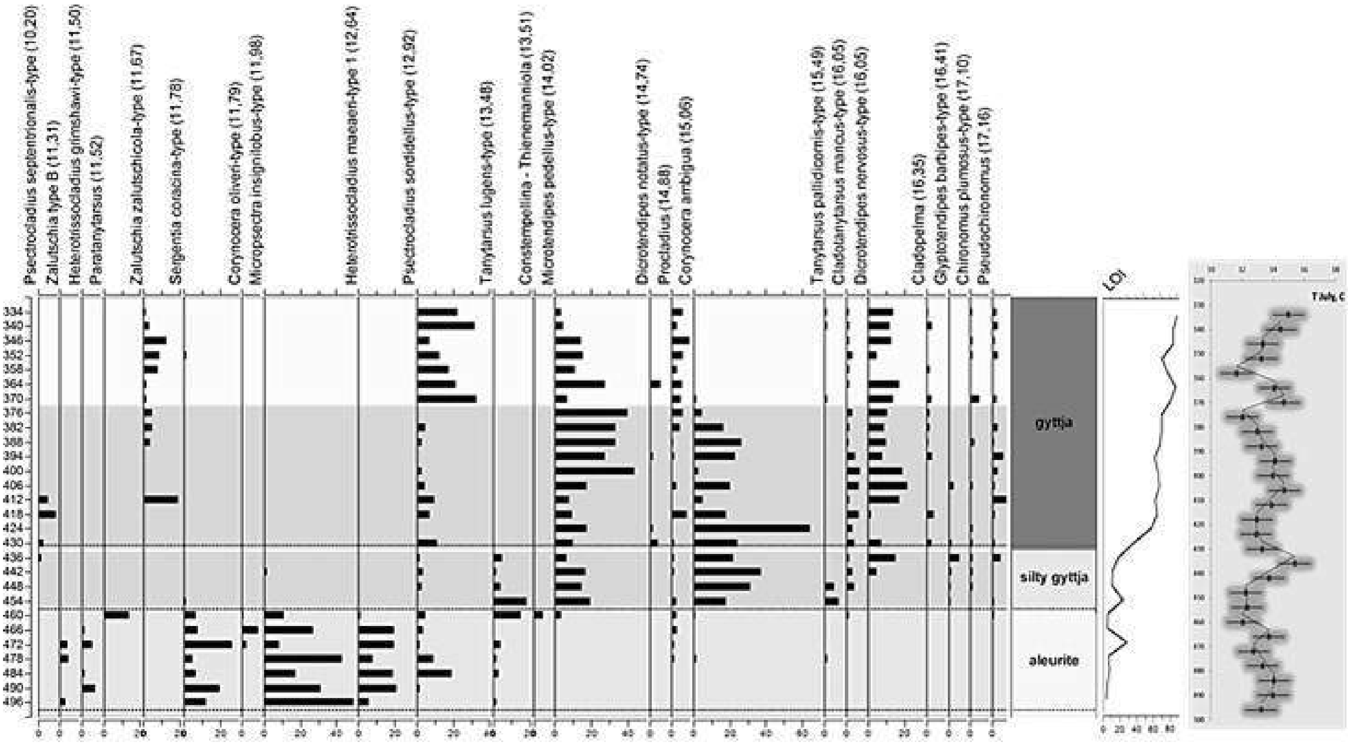
RECONSTRUCTION OF PALEOCLIMATE OF THE KARELIAN ISTHMUS IN THE LATE GLACIAL AND HOLOCENE (EVIDENCE FROM CHIRONOMID ANALYSIS LAKE MEDVEDEVSKOE)

Syrykh, L., Nazarova, L., Subetto, D.

The Karelian Isthmus is the approximately 45–110 km wide stretch of land, situated between the Gulf of Finland and Lake Ladoga in northwestern Russia, to the north of the River Neva (between 61°21'N, 59°46'N and 27°42'E, 31°08'E). Its northwestern boundary is the relatively narrow area between the Bay of Vyborg and Lake Ladoga. The region has a maritime climate, with mean January temperatures of -9°C, mean July temperatures of +16°C and a mean annual temperature of +3°C. Precipitation is around 600 mm yr^{-1}.

The studied lake basin formed before 12650 cal. yrs BP, possibly due to melting of stagnant glacier ice. Although the chronology of this early part of the record is too uncertain to attribute an exact age to the beginning of minerogenic sedimentation in the basins, it is likely that the sediments accumulated fairly rapidly. Shrub, herb and grass communities ('steppe-tundra') and cold and dry climatic conditions dominated in the area until about 11 000 cal. yrs BP. The rapid environmental response to warming at the Pleistocene/Holocene boundary, which is evident in many North Atlantic



Pic. 1. Chironomid Stratigraphy

records at c. 11 500 cal. yrs BP, is not very prominent in our two data sets from the Karelian Isthmus about 10000 cal. Yrs BP when climate became distinctly warmer and more humid. High organic productivity in the lakes indicates that soils around the lakes were stable. The delayed response of the lakes and the vegetation to the distinct temperature rise at the Pleistocene/Holocene transition may be explained by a different circulation pattern in this part of Europe compared to that around the North Atlantic. The extreme continentality shown in GCMs and strong anticyclonic circulation due to strengthened easterlies south of the Scandinavian ice sheet could have preserved extensive stagnant ice and permafrost in western Russia.

For the study was chosen one of the lakes of the Karelian Isthmus - Lake Medvedevskoe(60°13'N; 29°54'E). Advantages of this site: high hypsometric position promoted the continuous development of the lake basin and catchment area since deglaciation ca 15000 Yr BP.

We studied a 2,5 m long lake sediments core. It was investigated for lithological analysis, Loss of Ignition and chironomid analysis. Material is sent for C14 radiocarbon dating. Cluster analysis allowed to identify three main Stratigraphic zones. There was a shift in taxonomic composition of chironomids from the lower to surface sediments : (1.) Lowermost zone is marked by dominance of cold-profundal chironomid taxa: Micropsectra insignilobus-type, Sergentia coracina-type and Heterotrissocladius maeaeri-type 1. (2.) The dominant taxa of the middle zone are Corynocera ambigua, Microtendipes pedellus-type et. al. These are more warm-water taxa. (3.) Dominant taxa of the upper zone are Microtendipes pedellus-type, Dicrotendipes nervosus-type, Corynocera ambigua. Taxa are predominantly warm-water inhabitants of the littoral zone of the lake.

Obtained data are also reflected by similar trends in the analysis of lithology, LOI and partly July air T. (as reconstructed by North-Russian chironomid-based inference model, Nazarova et al., in press).

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Session 3.
Paleolimnological reconstructions of environmental and climate changes in the Past

Oral session

ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES OF HAMRIN RESERVOIR (IRAQ)

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This paper presents the assessment of the impact of climate change on the water resources of Hamrin Reservoir. Rainfall, reservoir inflow and temperature data obtained from Hamrin station were analyses using, Mann-Kendall, Regression, and reduction pattern methods. The statistical analysis was carried out to determine the measures of central tendencies, dispersion and skewness. The regression and Mann-Kendall analyses were carried out to determine the nature of the trend and their level of significance. The reduction pattern analysis was used to study the fluctuation of each variable over the period of record. The results showed that reservoir inflow and temperature have significant positive trends, which indicated that the parameters have tendency to increase. Rainfall was observed to have insignificant negative trends. This implies that there is tendency for the rainfall to reduce slightly over time and the reduction might not be noticeable.

REGIONAL FEATURES IN THE EVOLUTION OF NATURAL ECOSYSTEMS OF THE CIS-BAIKAL AREA OF THE NORTHERN ASIA IN RESPONSE TO GLOBAL CLIMATIC CHANGES IN THE LATE QUATERNARY

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Worldwide terrestrial and marine sedimentary archives demonstrate that the late Quaternary interval in the Earth's history experienced a number of long- and short-term climatic oscillations. High-resolution and accurately dated pollen and sedimentary records of the Pleistocene-Holocene time exist for several regions of Europe and East Asia, providing important insight into the environmental dynamics in the North Pacific and North Atlantic regions. However, a recent global-scale synthesis of the late Quaternary palaeoenvironmental data demonstrates a lack of palaeorecords of comparable dating quality and resolution from the vast areas of Eurasia, including Siberia. The dating problem becomes even more obvious, when the pre-Holocene interval of the late Quaternary is considered. The Cis-Baikal region (Russia, between ~80–120°E and ~50–60°N) consists of numerous sub-latitudinal mountain ranges and lakes, including Lake Baikal in the east. The lake sediments are one of the most promising sources of detailed palaeoenvironmental information, which provide an opportunity for bridging the European and Asian palaeoclimate archives and addressing critical questions concerning late Quaternary climatology and palaeoecology. Numerous publications on the Lake Baikal region presented coarse-resolution (millennial- or multi-century-scale) qualitative reconstructions of the Quaternary environments. Although the long cores from Lake Baikal span millions of years research was mainly focused on the Holocene. However, little is known about glacial/interglacial intervals due to the problems associated with very low pollen concentrations, poor organic content, low sedimentation rates and poor dating. Until recently, even the YD cooling was not unequivocally identified and dated in the Baikal records.

This study presents new multiproxy palaeoenvironmental records from regional great and small lakes as well as from peatlands, and aims to reconstruct regional features in evolution of natural ecosystems and environmental history in the Cis-Baiakl region since 5 Ma; to compare it with the oxygen isotope records from the North Atlantic and North Pacific regions; and to discuss the underlying mechanisms of the environmental change in the region.

The study was partly supported by the Russian Foundation for Basic Research (RFBR) project 12-05-00476, Integration project of the SB RAS No53.

LANDSCAPE AND CLIMATIC CHANGES IN THE CENTRAL RUSSIAN PLAIN DURING THE LATEGLACIAL AND THE HOLOCENE: RECONSTRUCTION IMPROVEMENT WITH THE USE OF PALYNOLOGICAL DATA FROM A SMALL LAKE

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The main stages of the vegetation and climate evolution in the Central Russian Plain (CRP) in the Lateglacial, beginning from the Allerød, and in the Holocene were reconstructed on the basis of pollen analysis of peat deposits (Neustadt, 1957; Khotinsky, 1977; and many others). Palynological data, accumulated since then, make possible a more detailed reconstruction of the landscape and climatic changes in CRP for the last ~15,000 yr BP. In the cold stages of the Lateglacial periglacial steppe communities were prevalent in the vegetation cover. A rapid warming which began at the Oldest Dryas/Bølling boundary and continued in the Allerød after a short interruption in the Older Dryas, favoured dissemination of trees in CRP. Originally, open woodlands and forest patches were formed by the hardy species (birch, spruce, and pine), which survived within the region through the entire Late Valdai (Late Weichselian). The lateglacial flora also included tree species that at present grow in the areas with cold continental climate, mainly in Siberia, such as *Pinus sibirica, Abies sibirica, Larix,* and *Alnaster fruticosus.* The Younger Dryas cooling brought about a new reduction of woodlands and spread of the periglacial steppe.

A resumption of the warming at the beginning of the Holocene brought about a rapid spread of woodlands, dominated primarily by birch and pine, and promoted the spread of more thermophilous arboreal species from glacial-time refugia. During the Preboreal, vegetation in CRP still retained some of the features inherited from the Lateglacial: dry slopes were occupied by periglacial steppe communities, Siberian pine and microthermal shrubs (*Betula humilis* and *B. nana*) occurred in the woodlands. Beginning from the middle Boreal, the broadleaved trees (*Ulmus, Quercus, Tilia*, and *Fraxinus*) penetrated the forests in CRP. Further warming and reduction of the continentality of climate in the Atlantic forwarded their increasing role in landscape, so that in the late Atlantic the broadleaved forests with *Corylus* and other mesophilous shrubs in the understory became the zonal vegetation type in CRP. An increase in humidity in the second half of the climatic optimum was favorable for the spread of alder in the area. The Subboreal cooling was accompanied with a decrease in climate continentality. It forwarded spread of spruce in the forests, which reached its maximum in the early Subatlantic. Substantial changes in the vegetation in CRP in the late Subatlantic, especially in the last 1000 years (the decrease in the broadleaved trees, and later also of spruce participation, increase in birch and pine role, spread of herbaceous vegetation), were probably caused not only by climatic changes, but also by anthropogenic influence.

Palynological studies of small, relatively deep and long-living lakes with stable accumulation conditions and sufficiently high sedimentation rates provide an opportunity for more detailed reconstructions of vegetation changes. In the CRP, the detailed pollen record from the Dolgoye Lake (56°04' N, 37°20' E) enables such a reconstruction. The first research results obtained from this site were published by Kremenetski *et al*. (2000). Taking into account pollen concentrations (number of grains *n* per cm^3) and accumulation rates (n cm^{-2} yr^{-2}) of various taxa, in addition to the calculations of pollen percentages in spectra, further facilitate the reconstructions based on palynological data. For example, in the Dolgoye Lake record, within "the lower maximum of spruce", corresponding to the Allerød, *Picea* pollen content is 30-40% of the tree pollen sum, which is almost equal to its content in "the upper maximum of spruce", corresponding to the early Subatlantic (2-2.5 ^{14}C kyr B.P.), whereas its concentration in the Allerød layers is lower than in the early Subatlantic by an order of magnitude. It indicates that the conditions for spruce growth in CRP during the late Holocene were much more favorable than during the Allerød interstadial. Nevertheless, besides pollen, *Picea* stomata were also found in the Allerød layer, thus indicating a presence of spruce trees near the Dolgoye lake shore.

Pollen abundance and good preservation along with other non-pollen palynomorphs typical for lake sediments make possible to compare the vegetation changes within the area surrounding the lake with those in the lake itself. Within the lateglacial part of the pollen profile from the Dolgoye Lake, of the aquatic plants, *Myriophyllum* (water milfoil) pollen has been recognized most frequently. According to Hoek (1997), the presence of *Myriophyllum spicatum* and *M. verticillatum* indicates carbonate reach conditions in the lake. Pollen of *Potamogeton* (pondweed) also has been registered in the same layers. In the sediments corresponding to the Bølling interstadial, rare pollen grains of riparian species *Sparganium* (bur-reed) and *Typha latifolia* (great reed-mace), were found. *T. latifolia* is tolerant of different substrates and water level conditions, but its presence on the Dolgoye lake margins indicates that already in the Bølling the mean July temperature in CRP was not lower than 13°C. During the Allerød, *Sagittaria sagittifolia* (arrowhead) and *Alisma plantago-aquatica* (common water-plantain) also grew around the lake. In the same layers, coenobia of *Pediastrum*, including those of *P. kawraiskyi*, highly typical for the lateglacial deposits in Europe, are found in abundance. *P. kawraiskyi* prefers cool water with alkaline reaction and low nutrient contents. Later, in the Holocene part of the section, *Pediastrum* coenobia seldom occur and belong almost entirely to various subspecies of *P. boryanum*.

With the temperature rise at the beginning of the Holocene various riparian species (*T. latifolia*, *Sparganium* sp., *and Phragmites communis*) flourished at the lake margins. Among open water taxa, *Potamogeton* and *Ceratophyllum* (hornwort) occurred at that time: spiny teeth of *Ceratophyllum* leaves are often found in this layer. Further warming and an increase in the lake productivity in the Atlantic are indicated by finds of water-lilies pollen (*Nymphaea alba*, *N. candida*) and that of spatterdocks (*Nuphar lutea*). Although rare pollen grains of these insect-pollinated plants are registered in the Dolgoye lake sediments only after app. 8 ^{14}C kyr B.P., their appearance in the lake already at the beginning of the Boreal is evidenced by finds of distinct stellate-branched sclereids from Nymphaeaceae tissues. At the end of the Subboreal, a single pollen grain of water chestnut (*Trapa natans*) was found. This relict species grows in relatively warm water together with *Nuphar lutea* and other aquatic plants and has a disjunctive modern geographic range. In the Subatlantic layer the group of aquatic plants is represented only by scarce pollen of *Menyanthes trifoliata* (bogbean) and *Sparganium*. Probably, the impoverishment of the hydro- and hygrophytes was caused by cooling, changes of trophic conditions and chemical composition of lake water under the influence of both natural and anthropogenic factors.

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COOL EVENT ABOUT 8.2 KA AGO IN THE NORTHERN EUROPE: LESSONS PAST FOR FUTURE

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"The 8.2 ka cold event" was first identified from pollen-spore data of the lake and continental sediments and oxygen-isotope composition of the ice cores from different sites from Greenland ice sheet (Alley, Ágústsdóttir, 2005; Heikkilä , Seppä, 2010; Kobashi et al., 2007; Thomas et al., 2007; Seppä et al., 2007, 2008; Snowball et al, 2007; Zubakov, Borzenkova, 1990). Kobashi et al. (2007) from the GISP2 ice core data, with a time resolution of ~10 year, shows a complex time evolution of this event. The duration of the entire cold event was about 160.5 ± 5.5 years, the coldest phase occurring at 69 ± 2 years (Thomas et al., 2007). An air temperature drop of 3 ± 1.1°C occurred within less than 20 years. Independent estimates of changes in air temperature during this cooling event have been obtained from isotope data from four Greenland ice-cores: NGRIP, GRIP, GISP2, and Dye-3 (Thomas et al., 2007). According to data from GISP2 core revealed two comparatively warm stages: ca. 8,220 and ca. 8,160 ice years ago. The initial stage of cooling is more explicitly recorded in the NGRIP core data.

Independent empirical data, such as marine cores with high time resolution, lake sediments, clay varves, speleothems isotope data, indicate that this cool spell was widespread in the entire Baltic Sea Basin, except for the most northern regions, northern of 70°N (Seppä et al., 2007, 2008; Zubakov, Borzenkova, 1990).

Pollen diagrams from lake and continental sediments provide independent evidence of this cooling. Lake sediments from four sites - the Rõuge lake in Estonia; the Flarken lake in Sweden; the Arapisto and Laihalampi lakes in Finland, all located south of 61°N - indicate that pollen percentage of thermophilous deciduous tree taxa, *Corylus* and *Ulmus*, decreased from 10-15% in the Early Holocene to 5% between 8,250 and 8,050 cal yr BP (Seppä et al., 2007), cool event lasted about 200-300 years and ended by a sudden temperature rise. In Estonia, this cool event lasted longer as indicated by a longer period of vegetation re-establishment after a decrease in annual air temperature by at least 1.5-2.0°C (Seppä, Poska, 2004; Veski et al., 2004). "The 8.2 ka cold event" has been identified in pollen diagrams from lake sediments from eastern Latvia and Gulf of Riga displaying a decrease of *Alnus, Corylus* and also *Ulmus*, and some increase of grass pollen. According the Heikkilä and Seppä (2010) a relatively warm and stable climate was interrupted by cooling at about c. 8,350-8,150 cal yr BP when mean annual air temperatures dropped by 0.9-1.8°C. This was reflected in a change in vegetation composition, characterized by a decrease in broad-leaved tree productivity and pollen increase of boreal species (Heikkilä, Seppä, 2010). Almost all data indicate that the decrease in air temperature was significantly larger in winter than in summer. This promoted an earlier freezing and later thawing of sea and lake surfaces.

The causes of the cooling during "the 8.2 ka" event and other cold episodes in the Lateglacial/Early Holocene drew the early interest of researchers (Alley et al., 1997; Alley, Áqústsdóttir, 2005; Clark, 2001;Clarke et al., 2004 Kobashi et al., 2007; Marotzke, 2000; Thomas et al., 2007; Yu et al., 2010). Although some scientists attribute "the 8.2 ka" cold event to changes in the incoming solar radiation (Bos et al., 2007), most of the studies relate this cooling and other cooling events in the past 13,000 years to changes in the circulation of surface and deep water in the North Atlantic driven by melt water from the continental ice sheets disintegration.

About 20 years ago the hypothesis has been speculated that freshening of the sea surface layer of the North Atlantic due to melt of the continental ice sheets (mainly, the Greenland ice cover) not only disturbed the circulation in the surface layer but also hindered the formation of deep water, thus affecting the intensity and position of the Atlantic "conveyor belt" itself. Drainage of glacial lakes Agassiz and Ojibway as a result of the Laurentide ice sheet melting ca. 8,470 cal yr BP (~ 7,700 14C yr BP), during which a high volume of the fresh lake water could have been released within less than 100 years, could have exerted a serious impact on the formation of sea ice, and thus significantly changing the time of their formation in autumn and melting in spring. Sea ice has a higher albedo than open water, and a longer period of sea ice causes an additional cooling (Clark, 2001; Clarke et al., 2004; Fisher et al., 2002; Ganopolski, Rahmstorf, 2001).

The cool episode about "the 8.2 ka" ago provides some guidance in assessing the possible effects of future shutdown in the North Atlantic overturning circulation due to increasing discharge fresh water as a consequence of the preset global warming. Future freshening of the North Atlantic is projected by almost all global – warming models as a result of increasing evaporation of the ocean due to increasing of the global temperature. Now, the value of the global temperature is higher to 0.8 ± 0.2°C (IPCC, 2013) compare the end of the 19th century. The mountain glaciers melting and precipitation increasing (especially in high latitudes) may be caused cooling in the future in light of the global warming.

PALAEOENVIRONMENTS IN EASTERN SIBERIA:INSIGHTS FROM LAKE RECORDS

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The availibility of terrestrial records of Holocene palaeoenvironmental changes in eastern Siberia is quite limited. Compared to other places on the northern hemisphere, this climate-sensitive region is very underrepresented. Situated at the border of northeastern Eurasia, it offers the potential to pinpoint connections of Arctic to sub-Arctic palaeoenvironmental changes between the periglacial and highly continental landmasses of Yakutia and the maritime-influenced setting of Kamchatka. In order to widen our understanding of palaeoclimate dynamics in eastern Siberia, sediment records from different lake systems were studied on north-south and west-east transects during the last decade in the framework of the SibLake initiative. The studies followed a multi-proxy approach, using sedimentological and geochemical data as well as fossil bioindicators, such as diatoms, pollen and chironomids. Chronostratigraphy of the studied records was achieved through radiocarbon dating and tephrostratigraphy.

The possibly oldest lakes of Yakutia were formed in proglacial settings in the Verkhoyansk Mountains and the Stanovoy Mountains foreland during the mid-Weichselian ice age. As in other worldwide regions, this time was punctuated by warmer interstadials at millennial time scales, as documented by short-term changes in hydrological lake status and surrounding vegetation. The last glacial maximum was characterized by dry conditions and low lake level. High-resolution records of Holocene climate variability are preserved in lakes on Kamchatka Peninsula and are included in the widespread thermokarst lakes of the Yakutian lowlands. They document a regional climate optimum between 7.0 and 4.5 ka BP. Superimposed on the long-term climatic trend are short-term climate punctuations and cyclic changes in lake level at centennial time scales, which demonstrate a high impact of internal climate variability on the palaeoenvironment, likely related to atmospheric oscillation patterns. Many of the thermokarst lakes, however, reveal changes in the lacustrine depositional environment that were driven by permafrost dynamics, only mediately related to climate changes.

THE SCANDINAVIAN ICE SHEET RETREAT AT THE LATE GLACIAL AND THE PERIGLACIAL LANDSCAPE DEVELOPMENT DURING THE LATE GLACIAL

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The climate warming after 14.5^{14}C ka BP brought about noticeable shifts in the glacier budget in the Northern Hemisphere. As a result, the structural plan of the Scandinavian ice sheet underwent essential changes, and since then its deglaciation proceeded according to transgressive-regressive type (instead of the formerly prevalent regressive one), with high-frequency oscillations in the marginal zone. All the subsequent coolings and warmings (from Dryas 1 to Dryas 3 inclusive) were accompanied by the ice margin fluctuations varying in range and duration.

The climatic changes and glacial phases (advances, retreats, and temporary stagnation phases), along with ocean level changes resulting from the ice sheet decay, controlled the periglacial landscape patterns and had a noticeable impact on vegetation. Authors considered changes in the plant formations within short-term intervals against the background of the recessing Scandinavian ice sheet at its southwestern (Atlantic sector), southern (Baltic sector) and southeastern slopes within the limits of the periglacial zone. The outer limit of the latter may be drawn approximately at the boundary of the maximum ice expansion at the LGM. At present the area is occupied with forest zone. A comprehensive analysis of radiometrically-dated sections made it possible to trace spatial and temporal changes in plant communities and gave a better understanding of the existing disagreement about duration, boundaries and other characteristics of individual intervals within the late glacial time.

The first post-pleniglacial – Pre-Bølling – relatively small warming occurred about 14^{14}C ka BP. Studied in lake deposit sections, it revealed a typical glacial xerophyte flora with halophytes and may be assigned an interphasial rank. The Raunis section in Latvia had been suggested as a stratotype of this unit (Savvaitov et al., 1964), but further investigations cast doubt on it (Raukas, 2009). Equally unconvincing was the attribution of swamp deposits studied in the north of Germany to that warming (Meiendorf Interstadial, see Litt et al., 2001); the paleobotanical characteristics of the deposits are almost undistinguishable from those of the subsequent late glacial warming – Bølling.

The Bølling warming lasted a little longer than 600 yrs and covered an interval from 12 450 to 11 920 ^{14}C yrs BP (by the ^{14}C date known at present). Most specialists relate it to G1-1e interval of the Greenland ice core curve. The ice sheet retreated by about 30 km in the Atlantic sector, with ice-free zone occupied by dwarf shrub tundra. In the west of the Baltic sector, where the ice retreated by more than 50 km, tundra was replaced by open woodland of birch with an admixture of pine. Pine gained in importance eastwards in the Baltic region. Spruce appeared off the southeastern slope of the ice sheet and became forest-forming species farther east. There the warm phase gave way soon to colder one, which is recorded in pollen assemblages by the Dryas flora appearance. In Karelia, plant communities of dwarf birch, Alnaster, Ericalis, green moss and those of Artemisia and Chenopodiaceae spread over the areas formerly occupied by dead ice. South of it, there were pine and birch open woodlands. On the whole, the considered interval was cool, July temperatures rarely exceeding 10° C. Most of thermophilic species could not move far enough to the north from the refugia due to the short duration of the warming. Farther east the warming was occasionally delayed.

During the next, most pronounced warming – Allerød– the ice retreated by more than 130 km to the north everywhere in the Atlantic sector except for Kattegat Strait; the latter remained blocked with ice till the end of Allerød, which resulted in the formation of the Baltic ice-dammed lake. The warming began immediately after the Pandivere (Nevskaya) marginal zone had been formed (13 750–13 300 cal yr BP) and lasted for more than 1000 yrs (from ^{14}C ~11 900 14C yr BP). The 1st half of Allerød was the warmest. Then the climatic conditions changed several times: a cooling marked by ice edge oscillations (Gerzensee, Kilarny 11 130–10 790 14C yr BP and almost synchronous Palivere advance 11 000–10 600 14C yr BP) was succeeded by a short relatively warm phase beginning ~10 800 14C yr BP and changed to a cooling at the end of the interval.

The climatic fluctuations reflected on the vegetation. At the Allerød optimum the July temperature was close to modern one, and that of January was lower by 8° C (Klimanov, 1994). In the ice-free zone of the Atlantic sector there existed open woodlands of birch, replaced eastwards by birch forests, locally with pine. Spruce appeared in the forests in the NW of Russia; it spread northwards up to the Helsinki latitude and became the forest-forming component. To the south and southeast the spruce forests gave way to birch-pine ones, with some larch.

Among important paleogeographic factors that exerted control over the vegetation in the northern region should be named a prolonged existence of a cold freshwater basin in the White Sea depression (the Late Glacial marine transgression began at 11 230±300 14C yr BP) along with some ice-dammed lakes; that may account for tundra landscape persistence in the region. Tundra was spread in the SE Karelia giving way to open birch woodlands farther the south. Locally, however, the environments were suitable for coniferous (pine and spruce) forests that could be found occasionally even in the north of the Kola Peninsula. The climate deterioration towards the end of Allerød resulted in increasing areas of open landscapes with dwarf birch and grasses.

Late glacial cool intervals (Dr-1 and Dr-2) were distinct for development of periglacial landscapes of cold forest-steppes, with a noticeable participation of the Dryas flora. In some regions the cold wave between Bølling and Allerød was but slightly pronounced and did not exert a noticeable influence on the vegetation.

At the Allerød/Younger Dryas boundary there occurred a very quick change in environments. At the end of Allerød deglaciation rate came up to a few hundreds of meters per year. At the Younger Dryas maximum the ice advanced. Later on, with deglaciation resuming, the Baltic ice lake was drained and the connection with ocean restored when the ice edge shifted to the north as far as Billingen end moraine ridge in Sweden and Salpausselkä II in Finland at 11.8–11.6 cal ka BP. The Younger Dryas cooling was global in occurrence. In NW Eurasia the January temperatures were 14°C below those of today. The cooling proceeded along with ice edge oscillations and development of end moraine belt around Fennoskandia. In the Atlantic and Baltic sectors of the ice sheet the moraine ridges did not developed simultaneously everywhere – they could be formed locally at the beginning or in the middle part of the Dryas interval, or developed through the entire Younger Dryas (Mangerud, 1980). That may be attributed to the increasingly autonomous dynamics of the ice edge in its different parts. The differences in the deglaciation rate resulted in regional variations in development of plant communities on the newly deglaciated areas. Abundance of NAP pollen (particularly Artemisia, along with increase in Chenopodiaceae proportion) characterized a cooling in the NW of the periglacial zone; farther towards SE the plant communities include dwarf birch, Alnaster, Salix. In the NE and N of the periglacial zone (in Karelia) the ice edge retreated at greater rate as compared with adjacent regions in Finland, which was reflected in difference of periglacial landscape appearance. The Younger Dryas duration was about one thousand years, its upper boundary may be asynchronous.

MODERN STATE AND CHANGES OF RUSSIAN LAKES UNDER CLIMATE CHANGES

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This report is devoted to the analysis of modern state and changes of Russian Lakes under climate changes. The necessity to minimise the impact of anthropogenic eutrophication and water pollution, which have reached global scope and jeopardize the quality of the already limited freshwater resources, has triggered quite a number of various studies in limnology, mathematical modeling, economics, with view to conservation, restoration, and efficient use of the resources of large stratified lakes. Special attention will be addresses to the contemporary state of the lakes of Russia especially largest lakes of Europe (lake Ladoga & Lake Onego) and their watershed under anthropogenic and climate changes, with special emphasis placed on feedforward and feedback interactions between aquatic ecosystems, watershed hydrology and economy of the region. To investigate the responsiveness of both environments to the respective counter impacts, as well as regional and global climate change, data analysis of multi-year field observations, numerical modeling are exploited.

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CLIMATE AND ENVIRONMENT CHANGES DURING THE LATE GLACIAL AND HOLOCENE IN THE ONEGA LAKE DRAINAGE BASIN (KARELIA, NW RUSSIA)

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Palaeogeographic data for 8 model areas located in the mid-taiga subzone of Karelia in the Onega Lake drainage basin were obtained. Detailed reconstructions of the vegetation dynamics from the Allerød (11635±225 yrs BP, Ua-14013) until present were carried out with regard to changes in the climate and hydrology, as well as the geomorphology and human impacts. They are based on 16 pollen diagrams of lake-mire deposits, determination of plant macrofossil remains from 82 sections and on 75 radiocarbon datings.

To make palaeovegetation reconstructions more reliable, evidence for the composition of 179 surface pollen spectra from the study area and the pollen concentration in sediments calculated by the “marker” spore method were used. It was found that the Late Glacial pollen was present in deposits in very small quantities, and a large part of it (primarily wind-pollinated woody plant pollen) was adventitious, and part of it was redeposited (including the pollen of thermophilic species). The influx of birch pollen increased in the Preboreal (9640±205 yrs BP, Ua-14807). A significant increase in the number of micro- and macrofossil remains began in the Boreal (9260±170 yrs BP, ГИН-12150), during the active spread of pine forests and overgrowing of shallowed palaeolakes by wetland vegetation.

Updated palaeoclimatic curves of July, January, annual temperatures and total annual precipitation over the past 11500 years were constructed using 4 pollen diagrams from the Kivach Nature Reserve (62°18'N, 33°55'E). Warming and cooling extrema, related to the time scale by 23 ^{14}C datings, are in good agreement with those determined earlier for 4 model areas from the Onega Lake basin, but some of them were revealed for Karelia for the first time (Филимонова, Климанов, 2005). As a result, a climatic-chronological scheme of vegetation dynamics from the Allerød until present was produced for the mid-taiga subzone of Karelia.

To characterize the paleohydrology of the study area evidence for the chronostratigraphy of lake-mire sediments, changes in relative water level of the studied palaeolakes, overgrowing and paludification rates, variations in the humidity index of mire palaeocommunities was used. Correlation of the available data with the transgressions and regression activity of Lake Onega (Девятова, 1986) and palaeoclimatic curves on the same time scale has provided a better understanding of changes in the palaeogeographic environment during the Late Glacial and Holocene (Филимонова, 2005, 2010, 2011, etc.).

Analysis of the data obtained and the literature has shown that in the late Allerød time (11500–11000 yrs BP) the study area was free of the ice sheet. Most of the area was occupied by periglacial Lake Onega, where varved and then massive clay accumulation had been especially intense up to 10300 yrs BP. A subsequent expansion of the mineral soil area in the Late Glacial and Holocene time was caused by compensatory glacioisostatic uplift of the Baltic Shield and a decline in the water level of periglacial Lake Onega.

A significant decrease of the water level in the Younger Dryas (11000–10300 yrs BP) and Preboreal (10300–9300 yrs BP) has led to the separation and isolation of small and medium-sized water bodies in existing depressions. Further decline in their water level and improvement of climatic conditions contributed to the vigorous development of plankton, benthos and hydrophytes. This in turn contributed to gyttja accumulation, overgrowing and peat deposition. These processes occurred in shallow water-filled depressions in the Preboreal period (9950±70 yrs BP, SU-3585; 9890±70 yrs BP, SU-3587). Gyttja deposition in deep palaeolakes began mostly in the Boreal time (8680±60 yrs BP, TA-1506; 8670±80 yrs BP, TA-1185; 8570±130 yrs BP, LU-2228) and only in Pichozero (61°46' N, 37°25' E, 118 m a.s.l.) and Tolvosuo (62°16' N, 31°27' E, 185 m a.s.l.) it started earlier (9640±205 yrs BP, Ua-14807 and 9260±170 yrs BP, ГИН-12150, respectively).

Overgrowing and paludification of the coastal parts of some palaeolakes started in BO-3 (8250±80 yrs BP, TA-890; 8130±120 yrs BP, TA-1942). Peat deposition in most sections from the central part of the investigated mires was recorded only from the Atlantic (7880±40 yrs BP, ГИН-10755; 6890±50 yrs BP, ГИН-1249; 6580±80 yrs BP, ЛУ-3422) or Subboreal (4180±60 yrs BP, ЛУ-2162; 2930±90, ЛУ-2154; 2740±50 yrs BP, TA-1184) periods. The facts of peat accumulation beginning at the end of the Boreal period correlate with some cooling of the climate and decrease in total annual precipitation in BO-3 (Filimonova, Klimanov, 2005), neotectonic movements of the crystalline basement (Елина и др., 1994), significant decline of the water level in Lake Onega (Девятова, 1986) and the investigated overgrowing palaeolakes (Filimonova et al., 1996a, 1996b; Филимонова, 2005, 2010), as well as a maximum spread of mid-taiga pine forests (Филимонова, 1995, 2010, etc.).

Since the beginning of the Atlantic period (~ 8000 yrs BP) the water level of the studied palaeolakes has been rising. Some decline of the water level was recorded at ca. 6500 and 5900–5800 yrs BP and an increase at 6200 and 5750 yrs BP. A significant decrease in the water level after 5600 yrs BP and in the Subboreal period (4700–2500 yrs BP) caused further shallowing and complete paludification of the water bodies. Reconstructions of wetland vegetation successions and spatial-temporal growth dynamics of some mires were made. Neotectonic movements of the crystalline basement that caused changes in the shape of some depressions and shifts of sediment layers were considered. Data on variations in the humidity indices of the reconstructed wetland palaeocommnites are used to characterize variation in the groundwater level of the investigated mires and the hydrological regime of the area.

Detailed mineral soil vegetation successions in Late Glacial and Holocene have been reconstructed for 8 model areas. The dominant vegetation in the Onega Lake basin from the Allerød until present consisted of: **periglacial steppe-like** *(Artemisia, Chenopodiaceae, Poaceae,* etc.) and **tundra** (*Betula nana, Salix, Ericales, Dryas, Saxifraga, Carex, Bryales*) **palaeocommunities** (PC) with sparse trees and shrubs [AL: 11800–11000 yrs BP] → dwarf shrub moss **tundra** combined with periglacial steppe-like PC and sparse trees and shrubs [DR_3: 11000–10300 yrs BP] → **forest-tundra:** open birch woodlands combined with dwarf shrub moss tundra and with present of *Artemisia-Chenopodiaceae-Varia* PC [PB-1,2: 10300–9800 yrs BP] → **northern taiga:** light birch and pine-birch forests [PB-2: 9800–9300 yrs BP] → light birch-pine and pine-birch forests [BO-1: 9300–8900 yrs BP] → **mid taiga:** pine and birch-pine forests [BO-2,3: 8900–8000 yrs BP] → **south taiga:** pine, pine-birch and black alder forests with spruce, broad-leaved species *(Acear, Quercus, Tilia, Ulmus)*, hazel [AT-1,2: 8000–6000 yrs BP] → spruce-pine, pine-spruce and pine-birch forests with broad-leaved species and hazel, spruce-black alder (with elm) forests [AT-3: 6000–4700 yrs BP] → **mid taiga (southern variant):** spruce, pine-spruce and spruce-pine forests with birch and presence of broad-leaved species, black alder and hazel [SB: 4700–2500 yrs BP] → **mid-taiga:** spruce-pine and pine-spruce forests with birch and alder [SA-1,2: 2500–1400 yrs BP] → pine, spruce-pine and pine-spruce forests with birch and alder [SA-2,3: 1400 yrs BP – 0 yrs].

Palaeovegetation maps (time slices: 10500, 8500, 7500, 5500, 3000 and 1000 yrs BP) of the Zaonezhje Peninsula model area (12 000 km^2, 62°11–62°48' N, 34°20'–35°37' E) and large-scale (detailed) maps (time slices: 8500, 6700, 4800, 4000, 2500 and 700 yrs BP) of a small area on Zaonezhje Peninsula shore and Kizhi Island (10 000 ha) were drawn (Елина и др., 1999, 2000; Elina et al., 2010).

SOME PHYSICAL AND CHEMICAL PARAMETERS OF WATER FROM WATER OBJECTS OF FADDEYEVSKY PENINSULA (NEW SIBERIAN ISLANDS)

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North-Eastern Federal University named after M.K. Ammosov

Since 22nd to 30th of August 2012 the scientific expedition “New Siberian Islands 2012” was conducted by the Expedition’s Center of Russian Geographical Society. Field team of North-Eastern Federal University (Gorodnichev R.M., Ushnitskaya L.A., Shelokhovskaya L.V.) explored surface water objects on Faddeyevsky peninsula (Kotel’niy island, New Siberian Islands) (fig. 1).

It were observed 2 polygonal ponds, 7 lakes, Alyn River and Gedenshtrom’s Bay which are located between 75°22′—75°53′ N и 142°22′—143°28′ E. Elevation was ranged from 11 to 42 m above sea level.

Natrium was dominant among major cations for water objects 12FAD01, 12FAD02, 12FAD04, 12FAD05, 12FAD06, 12FAD11; magnesium was leader for 12FAD07 and 12FAD08; calcium – for 12FAD03 and 12FAD09; 12FAD10 was characterized by leading of calcium and magnesium in same range. Hydrocarbons were the dominant anions for the most part of water objects (except Gedenshtrom’s Bay, Where chlorides are dominants).

Concentration of dissolved oxygen in water was high (from 8.9 mg/l to 12 mg/l).

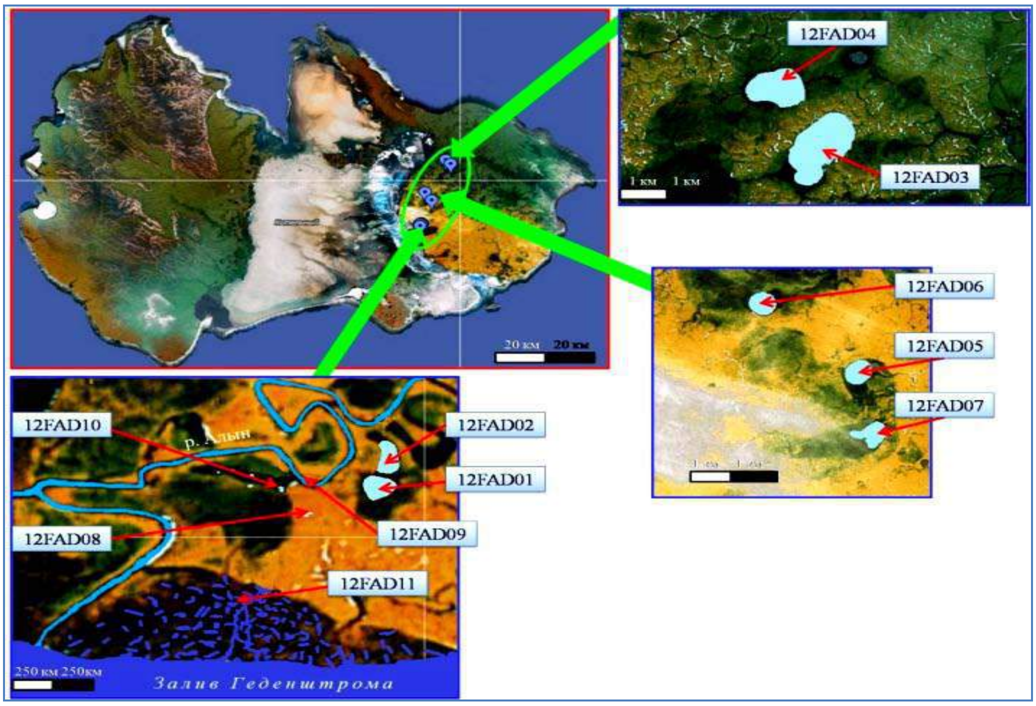

Fig. 1. Map of investigated area (Faddeyevskiy peninsula)

pH was varied from neutral to weak-alkaline (7.27 – 8.27) that could be an indirect indicator of high concentration organic substations absence which can change that balance. All investigated water objects (12FAD01 - 12FAD10, except Gedenshtrom's Bay) can be define like objects with ultramineralization (mineralization < 200 mg/l).

This scientific investigation realized in a framework of the project № 13-05-00327 «Paleoecology and paleogeography of lakes from New Siberian Islands» which is occured with the support of Russian Foundation for Basic Research.

ENVIROMENTAL VARIABILITY IN THE SOUTH-EASTERN PART OF BALTIC REGION

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1. Introducing

Within the frame of the research project, which aims at a high-resolution reconstruction of environmental and climatic changes in SE Baltic region since the Last Glacial Maximum, lake sediment sequences have been investigated on the Vishtynets highland by applying a high-resolution sampling strategy. Our paleogeographical investigations started in 2009 and include the analyses of the sediment cores from peat-bogs and lakes. In 2009 we investigated the peat-bog Velikoe (N 54º 57' 06'', E 22º 20' 28''; 34 m a.s.l.; area ca 2000 ha), it is located in the eastern part of the Kaliningrad region and belongs to the watershed of the River Sheshupe. Some of the results have been published (Arslanov Kh.A et. al., 2010). At the 2011-2012 we have cored the lake Kamyshovoye (54º22'531''N, 22º42'750''E, 189 m a.s.l.) located on the Vishtynets highland. At the 2013 we have drilled Protochnoe lake (N 52°59`38'', E 23°55`50'', 135 m a.s.l.) and now we have the first results of LOI and radiocarbon dating analyses.

2. Methods

Investigations consist of 2 steps. First step is a field work, which began at the March 2013. This includes measurement of depth, finding optimal place for working, and coring. All deposits were retrieved by Russian corer (diameter of sampler 7 cm and 5 cm, 1 meter length). In total we took 27 cores with 1 meter length each. The sediment lithology was described in the field. 9 cores were sampled in the laboratory in 10 cm samples for radiocarbon analysis, 9 cores were sampled in 4cm samples for LOI, and last 9 cores were saved for other analysis. LOI analysis was performed by standard methodic at 500 and 1000 degrees to assess the dynamic of total organic carbon and dynamic of carbonate carbon. LOI analysis and radiocarbon dating were investigated in the laboratory of Environmental Geochemistry in Herzen University.

3. Results

The Protochnoe lake is a small and shallow lake with a maximum length ca 631m., width – 455 m., maximum depth – 1.75 m, at the point of coring - 1.16 m.(fig. 1). As a result of coring it was taken 8.64 meters of bottom deposits presented from top to bottom by high organic gyttja, brown-grey clay gyttja, layer of peat and sand.

All result and LOI data will be presented at the presentation.

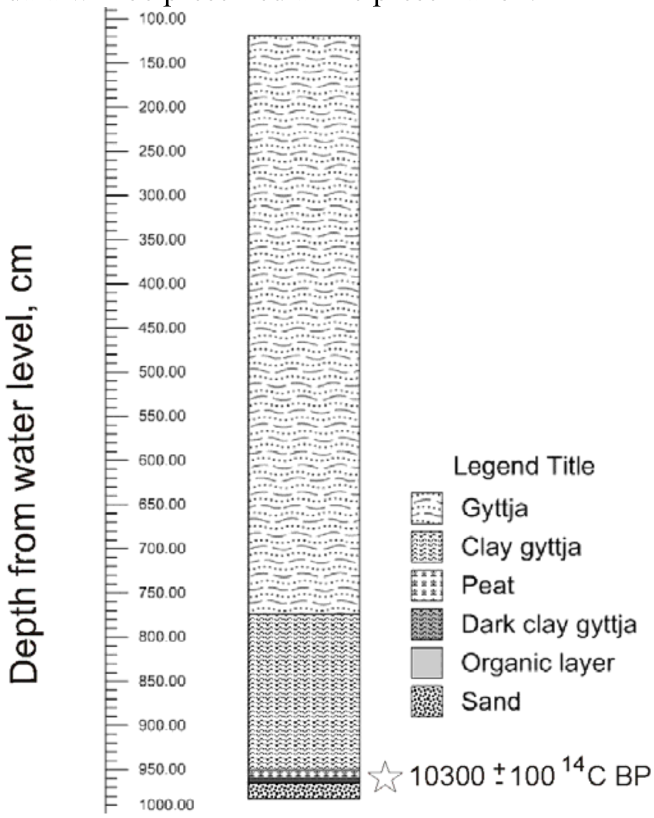

Fig. 1 Lithology of Protochnoe lake

The research is supported by Strategic development program of the RFBR projects (№ 12-05-33013; 13-05-01039; 13-05-41457).

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HOLOCENE ENVIRONMENT DYNAMICS AND HUMAN ACTIVITY IN THE FOREST ZONE OF EUROPEAN RUSSIA: A CASE STUDY FROM THE GALICH LAKE

Novenko, E.

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The Holocene vegetation dynamics in the taiga forest zone of European Russia were assessed using analogue-based methods of quantity reconstructions using modern and fossil pollen data and MODIS satellite images. The main steps of our study are (1) creation of the reference dataset consisting of 965 surface pollen spectra and associated satellite (MODIS)-based estimates of woody cover density, (2) checking the accuracy of regional woody cover reconstructions using the “Best Modern Analog” approach applied to the reference modern dataset, and (3) application the method for reconstruction of vegetation disturbance by the pollen data of Galich Lake (Velichko et al., 2001), located in the Kostroma region in the north-western part of European Russia.

The accuracy of reconstructions was tested by leave-one-out cross-validation. The results of tests was well but imperfect (R^2=0.57 and SEE= 10.8%), however it is sufficient for reconstruction of major changes in forest vegetation.

The Galich Lake is located 100 km northeast of the Kostroma city (58°24' N, 42°17' E, 101.2 m above sea level), in the southern taiga subzone. The site for deep drilling (the Galich-1 borehole) was chosen at the lake basin’s axis off the eastern coast of the lake near the Serednyaya River mouth.

The results of pollen analysis demonstrate that pollen assemblages of Preboreal and Boreal periods of the Holocene are characterised by the AP content of about 40%, birch and spruce pollen prevails (depth 950-1200 cm. Fig.1). In the NAP group *Artemisia* and Chenopodiaceae occur, the pollen of Poaceae is present. In pollen spectra corresponded to the Atlantic period of the Holocene (depth 750-950 cm) the amount of arboreal pollen increased up to 90%. In its composition broad-leaved species are

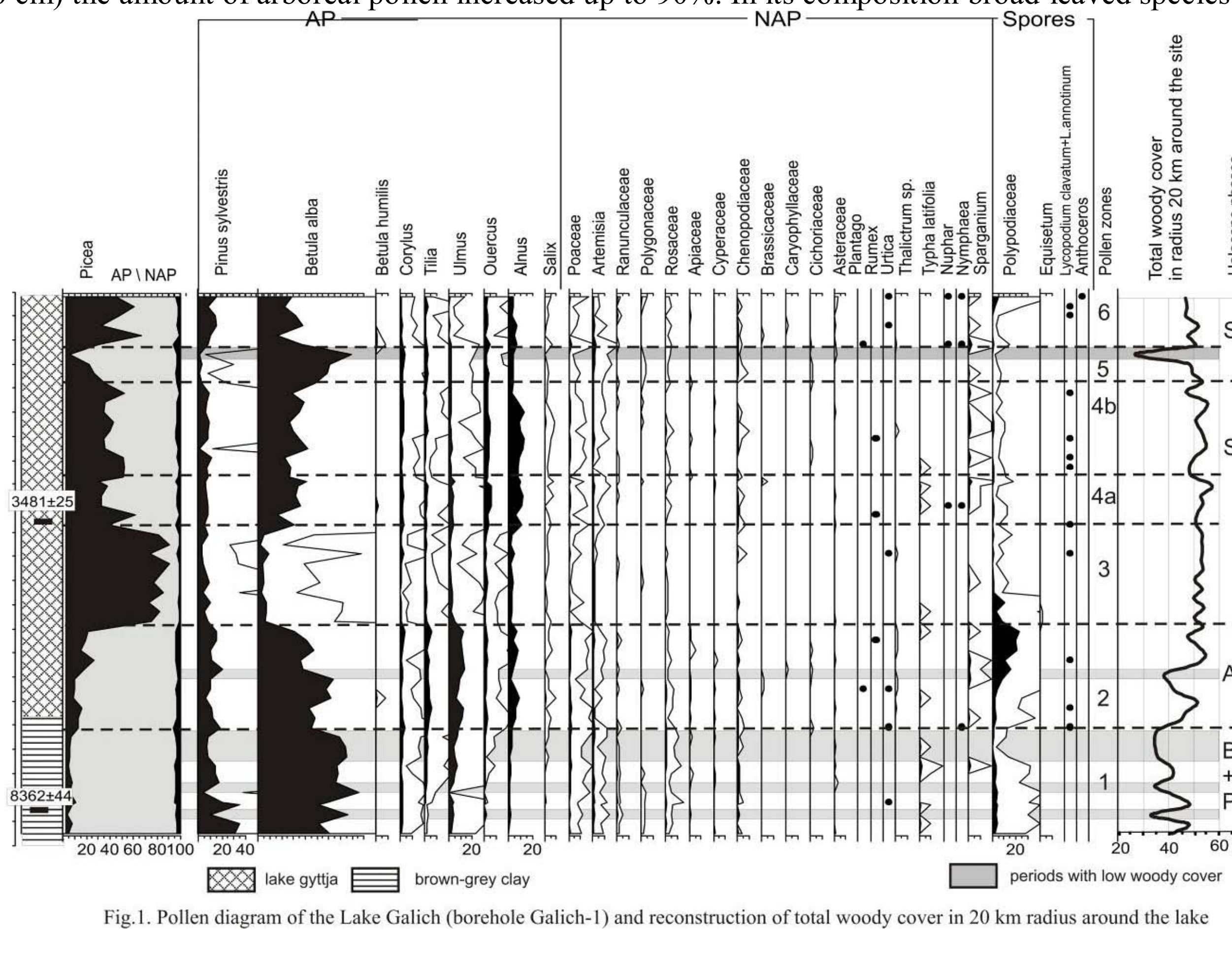

Fig.1. Pollen diagram of the Lake Galich (borehole Galich-1) and reconstruction of total woody cover in 20 km radius around the lake

well represented. It indicates that the territory adjacent to the lake was occupied by coniferous-broad-leaved forests with a significant participation of tree birch. Among the broad-leaved trees various species of *Ulmus* abundant, *Quercus* and *Tilia* occurred relatively rarely. The climatic optimum of the Holocene corresponds to the time interval from 7.0 to 5.5 Kyr B.P.

The lower boundary of the Subboreal (depth 250-750 cm) is marked by a sharp raise of the spruce pollen content. In the second half of the Subboreal birch forests also occupied considerable areas. Pollen spectra of the Subatlantic period (depth 0-250 cm) feature an increasing content of birch pollen, particularly the middle part of the zone, and decreasing contents of spruce and pine pollen, and that of the broad-leaved species in the final part of the interval.

The obtained results of woody cover reconstruction show that signals of anthropogenic changes in the vegetation in the forest-steppe zone and human-induced fires are clearly pronounced in the Neolithic and Bronze Ages, however human impact on plant cover was not significant until 2.5 Kyr B.P. (the beginning of Subatlantic period). Reconstructions of total woody cover show a good agreement with land-use history of the territory. An extensive agriculture during the periods of human occupation (obviously, in the Medieval time) resulted in decrease in forest coverage (depth 150 cm on pollen diagram: Fig.1), when the territory was abandoned forests recovered their areas. Large-scale landscape changes and the degradation of natural vegetation become conspicuous over the last two centuries.

This work was supported by RFBR grant 14-05-00550.

RECONSTRUCTION OF PALEOENVIRONMENT AT THE SITE SELLIACH, YANO-INDIGIRKA LOWLAND, YAKUTIA

Plotnikov, V., Protopopov, A., Klimovskiy, A.

Site "Selliach" is located on the right bank the river Selliach (its upstream), which is 57 km to the east of the settlement Tumat, Ust-Yana Ulus 70°45'65N and 140°45'79E.

On the site we found 62 units of bone material belonging to *Mammuthus primigenius* (Blumenbach, 1799). Research results of osteological material and taphonomy of the site show that bone accumulation was of single or multiple-season character in comparison with Berelekhskaya mammoths' "graveyard", where the accumulation of bone material took place for many years (Vereshchagin, 1977). All fossil remains were found in a radius of 10x5 m and at a depth of 5-6 m, which is just above the level of the river water in the same horizon. Apparently burial was subjected to redeposition. Judging from the ratio of the right and left sides of limb bones, tusks, as well as fragments of mammoth skulls number of the diseased mammoths could be about 20 individuals. The study showed that the deceased group of mammoths on the bank of the Selliach river consisted mainly of mature young individuals: 20-30 years old - 50%, 6-16 years old - 28.3% 40-45 years old - 11.6% and 10% - 1-6 years old calves.

Height of coastal cliff on the site is about 9-10 m, its length is 40-50 m. Outcrop was formed about a year ago, at first its dimensions were much less. Later, the site expanded as a result of thermoabrasive processes.

Geological section was laid on the place of discovery. Section is represented by three horizons of different density and color (Table 1). Multi-year ice in the form of thin layers (20-30 cm) penetrates vertically the outcrop in several places. Furthermore, the bottom portion of the second geological horizon has a buried vegetation.

Table 1.

Geological section at the site "Selliach"

Layers	Description	Power (cm)	Depth (cm)
	Sod layer	10-15	0-15
SL-0	Loam containing vegetable (roots). Soil color is light gray. Soil composition is loose, silty and moist.	50-60	15-60
SL-1	Sand soil is dark gray with a brown tint, fine-grained. The layers of light sand soil and dark more loamy sediments are penetrated by thin grass roots. Horizontal layering maybe traced in some places. Thin ice core vertically penetrates all horizons. Local small lenses of transparent ice can be seen. There are the remains of the buried vegetation at a depth of 5.2 m. The soil is moist, its density is average. There are red spots showing the process of ferrugination.	530	60-590
SL-2	Loam is dark gray with threadlike roots. Soil is dense, and it's frozen at the bottom. It represents bone-bearing layer.	∞	590 - ∞

Vegetation development phase of bone-horizon SL-2 corresponds to the period of accumulation of dark gray loam with threadlike roots, in its lower part the interval is 590 - ∞. Concentration of pollen and spores in the sample is average, 291 grains were collected in a single preparation.

A characteristic feature of the spectrum is the absolute dominance in the overall composition of the pollen spectrum of herbaceous plants (94.5%) with subordinate significance of pollen of trees and shrubs (3.3%) and spore (2.2%) plants.

Cereal pollen (*Poaceae*) (46,8%) plays an important role as part of grass pollen, which is represented by five morphological varieties. The species composition of grasses pollen is quite rich. It is represented by appreciable quantities of pollen found in xerophytic communities common to dry habitats - in the steppes, dry meadows, scree, alkaline meadows, gravelly-stony slopes, etc. These include diverse pollen of *Artemisia* (18,3%), which includes *A.tilesii, A.jacutica, A. dracunculus, A.spp.*; pollen of pink family *Caryophyllaceae* (10,0%): *Lychnis sibirica L., Minuartia arctica (Stev.) Asch., Stellaria sp., Silena repens*, pollen of representatives of aster family *Asteraceae* (2,4%), chicory *Cichoriaceae*, and also single pollens of the goosefoot pollen *Chenopodiaceae, legumes Leguminosae*. Pollen from meadow-steppe plants present buttercup *Ranunculaceae,* as well as *Polygonaceae (Rumex sp.),Rosaceae (Potentilla sp., Sanguisorba officinalis),Umbelliferae, Valerianaceae (V. capitata), Polemoniaceae (P.boreale)*. In significant quantities there is pollen of moderately moist and wet habitats - sedge *Cyperaceae* (7,3%).

Poor in quality and quantity tree and shrub group is represented by single pollen grains of larch *Larix*, *Pinus pumila Pinus pumila*, alder *Alnaster*, birch *Middendorf B.* and skinny birch *Betula exilis*.

In a small group of spore-bearing plants, along with a single dispute hepatic *Hepaticae + Riccia*, sphagnum *Sphagnum* mosses, plants more or less moist habitats

spores of the fern family *Polypodiaceae* and plaunkov Siberian *Sellaginella sibirica* - plants prefer more xerophytic habitats.

The preparation is covered with small and large plant remains, rare carbonaceous and mineral particles. We can see green algae of the genus *Spirogira*, which is usually found in freshwater ponds, and various fungal spores.

The data suggests that during the formation of thick loam, vegetation landscapes were widely open. The floristic composition of herbaceous vegetation was very varied. It shows a kind of mosaic of xerophytic, mesophytic, gigrofitnyh conditions in which plants grew. The role of woody vegetation in this period of time was small. Such a composition of vegetation is a characteristic of cold and arid phases of the Late Pleistocene, perhaps for one of the coldest phases of the Kargin interglacial.

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RECONSTRUCTION OF GLACIER FLUCTUATIONS IN THE EAST SAYAN, BAYKALSKY AND KODAR RIDGES (EAST SIBERIA, RUSSIA) DURING THE LAST 200 YEARS BASED ON HIGH-RESOLUTION GEOCHEMICAL PROXIES FROM PROGLACIAL LAKE BOTTOM SEDIMENTS

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Small mountain glaciers exist in a sensitive state of equilibrium with climate and are therefore good indicators of climate change, The slightest change in climate (precipitation and temperature) can affect the overall mass balance of the glacier (Haeberli et al., 2004; Solomina et al., 2008). At the same time, glaciers located in the continental areas far from the main sources of moisture are the most sensitive to climate changes (Dyurgerov, Meier, 2000). This study was conducted in the south-eastern part of East Siberia (Russia). We present results of study of bottom sediments of the proglacial lakes enriched by meltwater of Glacier Peretolchin (the East Sayan Ridge), Glacier Chersky (the Baykalsky Ridges) and glaciers of the Kodar Ridges. Bottom sediments sequence formed from the end of the Little Ice Age to 2013 were investigated with time resolution in year-season using X-ray fluorescence with synchrotron radiation, inductively coupled plasma mass spectrometry and the Fourier-transform infrared analysis. The depth-age models of the cores were based on to count of years laminate layers with controlling by ^{210}Pb and ^{137}Cs chronology. Intense glacier thawing was calculated from the level clastic matter supplied by meltwater of the glaciers into proglacial lakes. High content of Rb, Sr, Zr, Nb, Y and Th in bottom sediments can describe the intensity of restrict of glacier front edge. Glacier in the East Sayan and Baykalsky Ridges began intensively thawing since the 1910s, however, Kodar glaciers did not. Glaciers rapidly retreated approximately 1947-1970 with increasing during ca. 1953-1970. The second episode of glacier retreat everywhere in East Siberia occurred during 1980-2000 and this episode is in agreement with the significant temperature anomaly that occurred in the Northern Hemisphere. The melting rates of glaciers have slowed since 2000.

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GEAOARCHAEOLOGY OF ONEGA LAKE: CURRENT STATE OF RESEARCH AND PROSPECTIONS FOR FUTURE WORK

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The connections between geological processes and history of human habitation on the coasts of Onega Lake have been studied for almost 100 years, beginning with the works of K. Markov and B. Zemlyakov in the 1930-th. Karelian archaeologists A. Bryusov, N. Gurina, and especially G. Pankrushev paid close attention to this line of investigation, though their conclusions are not always supported by the current evidence. The most profound research was conducted by E. Devyatova in the 1970-s and 1980-s in collaboration with Karelian archaeologists. In the beginning of XXI century, geoarchaeological investigations up to the moment were not very active. Minor investigations were conducted in the vicinity of Kizhi island (mainly I. Demidov) and close to Orovnavolok cape on the eastern coast (M. Saarnisto and I. Vuorela).

Correlation of results obtained by different researchers is complicated by the fact that Holocene tectonic movements had different directions in the northern and southern parts of the lake. Because of this coastal formations of the same age can be found at different heights above the sea level. At the moment detailed reconstruction of the shoreline displacement in connection to human habitation of the area has been made only for several microregions, while reconstruction of the paleogegraphical situation along the whole coast is lacking.

E. Devyatova proposed such reconstructions for a number of locations with important agglomerations of archaeological sites: the area between outfalls of Vodla and Chernaya Rivers on the mid-eastern coast, capes Orovnavolok and Chernaya Guba on the north-eastern coast, Pindushi on the northern coast, area of Pegrema and Palajguba in Zaonezh'e Peninsula, and Sheltozero on the south-western coast. Dozens of archaeological sites have been found in each of these localities, as well as in the area close to Kizhi island. The available reconstructions definitely help to clarify the question of interconnection between geological processes and human habitation, but their extrapolation to wider areas is not possible. A very important agglomeration of archaeological sites in the outfall of Shuya River close to Petrozavodsk on the mid-western coast still awaits geomorphological and geoarchaeological investigation. The agglomeration contains at the moment nearly one hundred sites, the majority of which were found and partly excavated during the last twenty years.

Holocene water levels and corresponding shorelines have been defined in the abovementioned micro-regions, including shorelines of the Preboreal period. Despite a big series of sites with late Preboreal – early Boreal datings that have been discovered in the Ladoga Lake area and in Finland, especially in the recent decades, none site that can be certainly dated to such an early period is known from the Onega Lake. Because of growing evidence of late Preboreal habitation of Eastern Fennoscandia, finding sites belonging to the earliest stage of human colonization of the coasts of Onega Lake is on the agenda of current research. Thorough surveying at Preboreal levels in the coastal zone may help to solve this problem.

The study is financially supported by the Russian Scientific Foundation (14-17-00766)

MODERN GEODYNAMIC MOVEMENT IN INLAND SEAS ON THE PERIPHERY OF THE BALTIC CRISTALLINE SHIELD (THE LAKE LADOGA , WHITE SEA , GULF OF FINLAND) ACCORDING SEISMO-ACOUSTIC AND SONAR PROFILING.

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The accounting of geological hazards in the construction of engineering objects directly on the seabed is one of the problems lively discussing in the scientific and industrial circles. Among them, the greatest importance has modern geodynamic endogenous processes and closely related gravitational effects or discontinuities soils. Moreover, this problem becomes relevant not only for areas with known active neotectonic regime, but also for the platform or inland seas of the European part of Russia. Engineering surveys along the tracks of linear engineering constructions indicate on disturbed sediment, of the meso-and microrelief characteristic forms. It is the influence of neotectonic factor.

The sonar and seismic profiling is effective method of identification areas with same processes. The use of high frequencies at seismoacoustic profiling and the use of different sources (piezoceramics, Sparker, Bummer) allows totally study the structure of the upper layer of bottom sediments, including sharing at seabed undisturbed and disturbed deposits. Sonar profiling allows to receive acoustic performance seafloor in a certain area or corridor and allows not only spatially orient the selected objects (the shape of the geological body is often the main diagnostic feature of them genesis), but also allocate submerged objects in the side of the profile. The most valuable feature of this side-scan sonar acquires necessary follow- linear objects (including trending fault structures) and the allocation of area objects violations primary occurrence (landslides, downfalls, density sedimentary flower.).

Engineering-geological surveys, seismoacoustic and sonar profiling in the north-western seas of the Russian Federation (the White Sea, the Barents Sea, and the Baltic Sea) and the Lake Ladoga conducted in frame of gynecological monitoring. There are showed that along with the mosaic distribution of the Quaternary, especially Holocene sediments, related to features of sedimentogenesis there is a large number of distributions of the sedimentary cover, reflecting the influence of the seismogenic or gravitational factors. All these marine and lake basins and the Lake Onega have similar story. They are confined to the eastern and southern periphery of the Baltic Shield and the contact zone with the platform deposits. Major depression appeared here as a result of glacial scouring. There depressions were later occupied periglacial lakes, after the retreat of the glacier. Deep-depression the White Sea and Lake Ladoga can serve as an example. Depth is greater than 200 m, slope angles up to 15 degrees and more. Glacier opened here Late Proterozoic clastic sediments. So, deep-sea graben in the Kandalaksha Bay has depths of 150 -200m and slope angles up to 20-25 º. Numerous landslide bodies fixed on these slopes. They form a continuous train of declivial deposits along the south side of the Kandalakshsky graben. Their thickness of according to OGT-methods more than 150 m. Deep, narrow troughs with depths up to 80-90 m were established n the innermost part of the bay, near Kandalaksha and oil terminal "Mitino". Here developed intensively dissected skerry relief with depths 0 -50 m (average about 20m). They can be traced towards the islands, where they find a continuation in the form of long-lined rocky shores, or traced in the form of narrow depressions within the islands. These valleys, in our opinion, are the legacy of ancient structures and modern geodynamic zones. Confirmations are periodic seismic shocks that were recorded seismic station "Khibiny". Numerous seismic dislocations, including fresh crushed rubble, have been identified on the shores of the Kola Peninsula and Karelia. Additional factors were the discovery of desalinated water at the bottom of the section of the water column in the Kandalaksha Bay. Seismic acoustic data allowed establishing a close correlation modern geodynamics and exogenous gravitational processes. Numerous landslides were having been fixed on the slopes of the narrow valleys. Tectonic push is causing movements of rock masses.

Even more amassing picture was obtained in the Great Salma Strait, which separates the islands from the mainland. The depths are from 0 to 120 m. along the northern coast (southern coast of the Great Island) stretches narrow subhorizontal surface underwater coastal platform, giving way to a steep slope. It is expressed very well on seismograms. Steps have a width of up to 100 -200m and a height of up to 20m, at least 30m. Analysis of the data obtained, no correlation with depth, the occurrence of sharp angular unconformities, transition «layered» texture pattern in the diffuser, and a sometimes thin corrugated folding at the base of the scarps indicate to gravitational nature of the blocks. The surface slopes at depths of 10-50m are usually the sliding surface formed either by a moraine, or even in crystalline rocks.

Additional information was obtained using high-frequency profilograph. On geoehogramms clearly seen that all leveled platforms is covered layer of postglacial (probably mostly Holocene) sediments. Their thickness is up to 10 meters or more. Lamination is a clear subhorizontal. Mode of occurrence of sediments suggests that their accumulation occurred after the formation of the leveled surfaces. It was formed, probably, as a result of the deposition of suspended materials rollinged during slumping of big blocks of a hard sediments or rocks. At the same time layer of Holocene sediments practically absent in thalweg of central hollows. Here are fixed one or two ridges formed landsliding deposits with differently-layered. We believe that this is the result of a delapsing landslide.

Similar pictures were obtained by us during the geological mapping of the bottom and geo-environmental monitoring in the Lake Ladoga and the Gulf of Finland. Part of layers allocated to seismograms currently already dated. This allows determining the time when the horizontal-layered sediments cover disturbed sliding deposits. If we assume that the distribution of bedding occurred as a result of landslides and landslides is result of geodynamic movements, these geological events took place in the Holocene and even Middle Holocene time. So, a zone of tectonic displacement of bottom sediments, a series of landslide formations of different ages followed by release of juvenile gases were installed during the seismoacoustic profiling on the track of the North European gas pipeline in the Gulf of Finland.

These data indicate that at the present time when carrying out any engineering works accounting geodynamic factors are necessary. Seismoacoustic profiling in the same or different versions is the most reliable method for mapping areas of geodynamic (endogenous and exogenous) movements. Particularly effective implementation of such works in Lake Ladoga, where the crowning section of thin-pack allows you to clearly distinguish between the different position on the genesis and layers.

Poster session

CHANGING ENVIRONMENTS IN THE EASTERN ARCTIC 364-787 THOUSAND YEARS AGO, INVESTIGATIONS AT LAKE EL'GYGYTGYN

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An interdisciplinary investigation of a 317-m thick sediment core from Lake El'gygytgyn provides the most complete chronicle of continuous paleoenvironmental changes in the Arctic over the past 3.6 million years. The lake, which is located 100 km north of the Arctic Circle (67° 30' N, 172° 05' E), has a diameter of 12 km and a water depth of 173 m in the central basin. The site originated as a meteorite impact crater. Core chronology has been determined using radiocarbon, optical luminescence, and paleomagnetic analyses supplemented by the tuning of proxy data to regional insolation curves and marine isotope stratigraphy. The new palynological data reported here are from 364-787 thousand years ago (kyr) and span marine isotope stages (MIS) 11-19. Palynological analyses at the Northeastern Interdisciplinary Scientific Research Institute have focused on warm intervals within the El'gygytgyn record. Currently, additional levels are being analyzed in core sections where sampling intervals are broad, particularly to add information to portions of the record associated with glaciations. Glacial age samples usually have low pollen concentrations. This low pollen input has been noted in other lakes of northeastern Siberia and at Lake Baikal. In contrast, samples of interstadial or interglacial age typically have moderate to high concentrations of pollen and spores.

Interpreting fossil pollen spectra relies on knowledge of modern vegetation-pollen relationships. This is especially true for the El'gygytgyn record, because of the lake's great size and the anomalous nature of the local vegetation as compared to that more typical of the Anadyr Upland. The Upland is characterized by a mosaic of low-shrub *Salix-Betula* and graminoid-forb tundra that includes scattered populations of *Pinus pumila* and *Duschekia fruticosa*. The vegetation in the lake catchment is dominated by lichens and graminoids, and the landscape often has a discontinuous vegetation cover, especially at higher elevations. Low shrubs of *Salix krylovii* and *S. alaxensis* occupy protected areas within the open mountain draws, along stream valleys, and in seepages near the lake. *Betula exilis* is also present in the catchment but is limited to river terraces and mountain saddles where there is sufficient accumulation of organic matter.

Analysis of samples taken from the sediment-water interface from locations throughout Lake El'gygytgyn indicates that the modern pollen rain primarily reflects the regional and not the local vegetation. For example, the modern pollen spectra are dominated by *Duschekia fruticosa* (35%), *Betula* (20%), and *Pinus pumila* (15%), with total shrub pollen comprising up to 45% of all pollen and spores. Pollen from *Duschekia* and *Pinus* represents wind transport into the basin, and given the limited occurrence of shrub *Betula* in the lake crater much of the *Betula* pollen likely represents extra-local vegetation. The fact that the El'gygytgyn spectra reflect the regional vegetation is of importance because: 1) it indicates the paleorecord is not overly influenced by the local vegetation, which primarily reflects anomalous soil conditions associated with the meteor impact; and 2) the regional vegetation is a better indicator of broad-scale climatic conditions.

MIS 11 (termination 424 kyr) is the warmest period between 364-787 kyr. This interval falls within the early middle Pleistocene or the middle of the Ionian stage. The pollen spectra indicate the regional development of *Picea obovata* forests with gallery forests composed of *Larix cajanderi, Populus suaveolens, Chosenia arbutifolia,* and *Alnus hirsuta*. Vegetation was similar to the relict forests found today along the Maymandzha River, which flows to the Shelikhov Gulf (Sea of Okhotsk). MIS 31 (the lower boundary of the Jaramillo episode, 0.99-1.07 million years ago) is the only other interval during the Quaternary period (including the Gelasian stage) when climatic parameters approximate those of MIS 11. Mean estimates for MIS 11 are: July temperatures +12º to 16º C, January -20º to -24º C, summer rainfall 300 to 400 mm, and winter precipitation 100 to 150 mm.

The interval from 427-787 kyr includes MIS 12-19 of the early Neo-Pleistocene. Lower MIS 19 corresponds to the boundary of the Neo-Pleistocene and Eopleistocene or Ionian and Calabrian Stages. The landscapes of MIS 12 (427-474 kyr) supported a barren vegetation that probably approximated the vegetation of modern Wrangel Island, which is located 600 km north of Lake El'gygytgyn. This tundra was dominated by Cyperaceae and Poaceae and formed a discontinuous vegetation cover. *Artemisia* and Papaveraceae grew on the neighboring rocky slopes and low elevation hills. *Salix* was the only shrub species present, probably growing in prostrate or low growth forms (<1 m height) and restricted to sheltered valley settings. Mean July temperatures apparently did not exceed +2º C.

Palynological spectra similar to those of MIS 12 were noted for glacial MIS 14, 16, and 18. These assemblages are dominated by pollen of Poaceae and Cyperaceae with a variety of herbaceous taxa also represented. The significant percentages of *Artemisia* pollen and *Selaginella rupestris* spores indicate that rocky and scree-covered slopes were common. MIS 14 deposits also contained relatively high percentages of shrub *Betula* pollen. Taking into account that this taxon is easily transported some distances by wind, it is likely that thickets of shrub *Betula* were common in the Anadyr Upland but probably absent or very limited in the lake basin. An increase in taxa associated with scrub communities during MIS 14 suggests a greater presence of this vegetation type as compared with MIS 12, 16, and 18. Mean summer temperatures were up to +4-8º C.

Palynological data relating to MIS 13, 15, 17, and 19 reflect the features of both glacial and interglacial assemblages. Spectra from these zones are characterized by high percentages of Poaceae and Cyperaceae pollen and peaks in *Sphagnum* and *S. rupestris* spores. *Larix* pollen is found consistently in these assemblages, suggesting the presence of *Larix* forest in the valleys of the Anadyr Upland. A widespread occurrence of *Betula-Alnus* communities is indicated by the high pollen percentages of these taxa. Two substages have been defined within MIS 13. Substage 13a reflects interglacial conditions. At this time, *Larix* forest with a dense undergrowth of shrub *Betula*, *Alnus*, and *Pinus pumila* established near the lake. Substage 13b spectra reflect the dominance of Poaceae-shrub tundra in the vegetation.

MIS 15 is divided into 5 substages. Pollen spectra of substages 15a, 15c and 15d indicate that the regional vegetation was dominated by closed *Larix* forest with shrub thickets of *Betula* and *Alnus*. *Pinus pumila* was also an important component of the forest understory and likely formed a shrub zone above altitudinal treeline. *Larix* forests were present during substages15c and 15d, but the pollen data suggest substage 15a was the warmest. However, the occurrence of *Larix* forests indicates that mean July temperature in each substage was at least +12º C. Two cooler intervals (substages 15b and 15d) are marked by high pollen percentages of herbaceous taxa, particularly Poaceae. Comparison of warm spectra from MIS 15 to MIS 17 shows higher values of *Betula* pollen and a reduced role of *Alnus* and *Pinus* pollen in the earlier interval. However, *Larix* forests also were well developed in MIS 17. Spectra of MIS 19 indicate the presence of Poaceae and shrub *Salix-Betula-Alnus* tundra. MIS 19 displays pollen characteristics more typical of interstadial than interglacial conditions. MIS 20 represents the uppermost Eopleistocene. The dominance of Poaceae and *Artemisia* pollen and *S. rupestris* spores indicate that dry tundra with sparsely vegetated slopes characterized this glacial interval. *Salix* is the most common woody taxon. Climatic reconstruction of glacial, interglacial, and interstadial intervals show that low summer temperature and precipitation had a greater impact on the development of shrub tundra communities than did the extremely low winter temperatures

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NEW DATA ON THE HOLOCENE SEA LEVEL CHANGES IN THE SOUTH-EASTERN AREA OF BUNGE LAND (NEW SIBERIAN ISLANDS)

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Arctic sea-level changes during the post-glacial period are an interesting theme for paleogeographic research, which has not so far been fully explored. In this respect, the New Siberian Islands are no exception. In 2000-2005, the authors of this paper had extensively studied - as part of the

Zhokhov 2000 project - terrace regions of much of the islands belonging to the archipelago and the deposits of the northern lagoon of Zhokhov Island (Anisimov, Tumskoy, Savatyugin, 2002; Anisimov et al., 2010). Based on the results of this research, the dynamics of the Holocene sea-level changes in the area of the North Siberian Islands was reconstructed. In particular, it was suggested that recent tectonics possibly contributed to the development of certain areas of the New Siberian Archipelago (Anisimov et al., 2009).

Bunge Land, connecting Kotel'ny Island and Fadeevsky Island, is a low flat land with some elevated areas of up to 10-12 m. The southeastern part, where Lake Karakhastakh is located, is gently inclined towards the south and has the elevation of +4 m in the area around the lake. The mechanism of Bunge Land formation remains unclear; some researchers speculated about the role of geotectonic processes in it (Trufanov, 1982; Fartyshev, 1993). The contribution of neotectonic processes to the formation of Bunge Land is also recognized by other authors (Schirrmeister et al., 2010); however, the most significant factor, according to them, was the degradation of permafrost sediments followed by inundation of surfaces lying in the area of lower hypsometric levels. The studied bottom sediments of Lake Karakhastakh make it possible for us to better define our understanding of coastline position changes in this area during the Holocene.

The present reconstruction is based on the results of the analysis performed on diatom assemblages identified in the core sample from bottom sediments of Lake Karakhastakh recovered at the depth of 6 m. The thickness of the sampled sediments was 82 cm. The sediments are represented by grey sandy loam in the lower part of the core sample up to 46 cm; higher up they are represented by dark-grey, almost black, sandy loam that grades to almost black-coloured clay loam up the section. In the lower part of the core sample, there are five levels with marked organic-rich interlayers. From two of the organic interlayers, samples were selected for dating (*see* Table). A high C13/C12 ratio suggests terrestrial origin of the organics dated.

Table

Sample number	Radiocarbon ages	C13/C12 ‰	2 Sigma calibrated results (95% probability)
Beta 271409	1720 +/- 40 BP	-25.0	Cal AD 230 to 410 (Cal BP 1720 to 1540)
Beta 223419	8530 +/- 60 BP	-26.0	Cal BC 7600 to 7490 (Cal BP 9550 to 9440)

In order to perform paleo-environmental analysis of diatom distribution patterns in the lake sediments on Bunge Land, diatom species composition and abundance were studied. Ten samples were collected from the core of 82 cm long. Standard bottom sediment sample preparation methods were used to treat the samples (Diatom Analysis, 1974).

The variations in diatom assemblages are determined, first of all, by the changes in paleo-salinity of the lake. Brackish-marine and marine conditions changed to freshwater (Fig.1). At the same time, no abrupt changes in the water depth of the lake were found. Benthic and epiphytic diatoms are completely dominant through the core. The maximum of freshwater diatoms identified for the period when the upper part of the core had been formed can serve as evidence of a relative lowering of the sea level and the development of the lake basin.

The results of the study suggest that relative sea level in the southern part of Bunge Land at the beginning of the Holocene (before 8530 +/- 60 BP) exceeded the current level of +4 m. Exposure of the southeastern part of Bunge Land took place approximately 1700 years ago. At the initial stage, the modern lake was a lagoon that gradually lost its connection to the sea. We do not rule out the tectonic influence on the process that formed the modern character of the studied area.

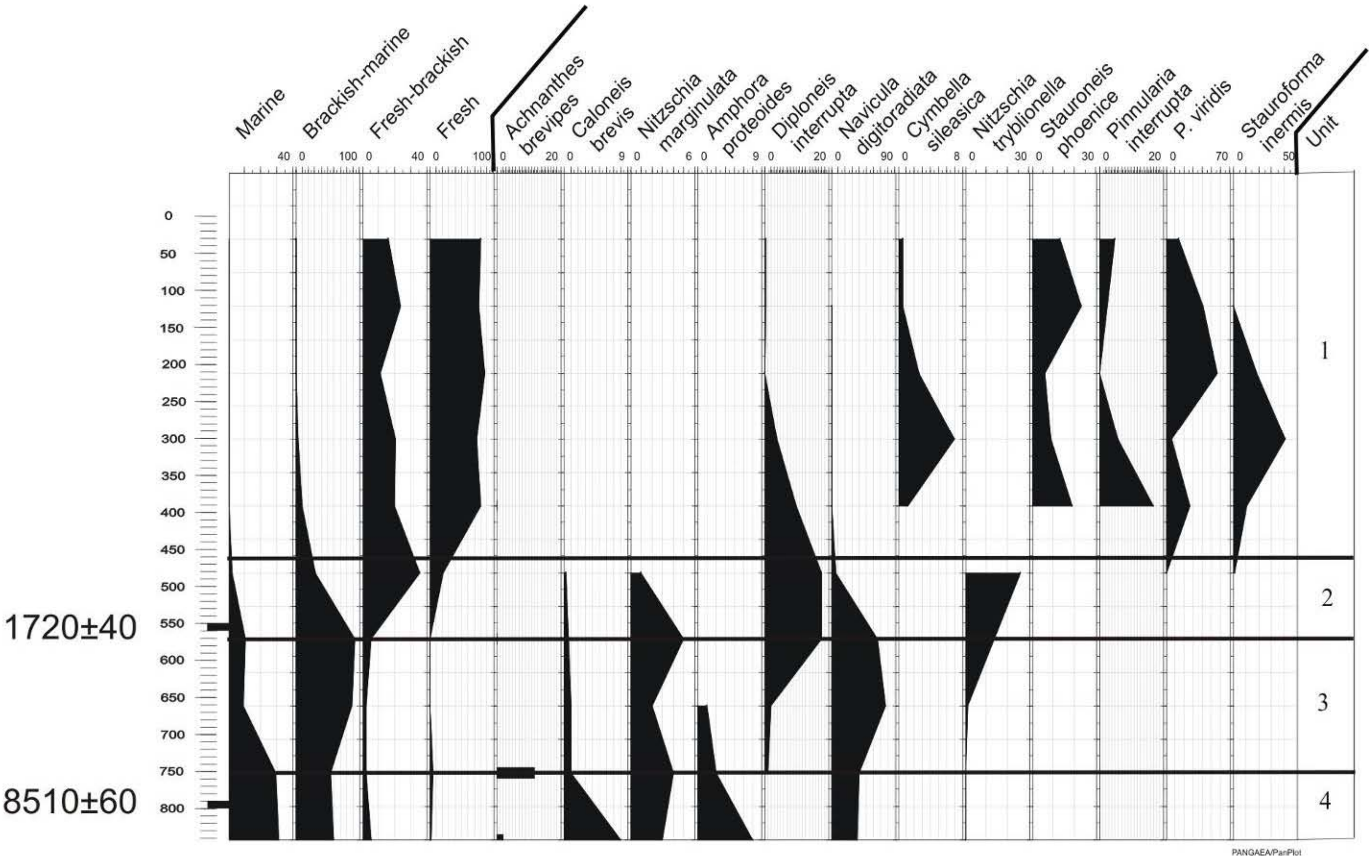

Fig. 1. Distribution of ecological groups and dominant diatoms (%)through the section of the core sampled from Lake Karakhastakh on Bunge Land

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DATABASE PALEOGEOGRAPHIC KOLA PENINSULA «Q-KOLA»

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Study paleogeographic environments and the Late Holocene Fennoscandia in general, and the Kola region in particular is key to understanding climate and landscape changes in the North Atlantic. The main sources of such information are the Quaternary: the bottom sediments of lakes, peat deposits and marine sediments.

Quaternary deposits on the Kola Peninsula are studied more than 100 years, and at present, there are many different data paleogeographic character. The most commonly used data for three time slices: the Late Glacial (12-10 ^{14}C kiloyears ago), the early Holocene (10-8 ^{14}C kiloyears ago) and the time of the climatic optimum (8-5 ^{14}C kiloyears ago).

In order to restore the development environment of the Kola Peninsula held paleogeographic gathering information on which was compiled database «Q-KOLA». Particular attention is paid to materials having a reasonable series of radioisotope dates and detailed description section.

Database «Q-KOLA» is created in the MS Excel, which is convenient for further processing and display in various GIS shells. Currently GIS shell serves as an online service CartoDB (cartodb.com).

The database currently contains 78 objects that have information on the age of formation of Quaternary sediments in the region of the study (Figure 1). The eastern part of the Murmansk coast, Ponoyskaya Basin and the eastern coast of the Kola Peninsula are difficult and poorly known areas, which at this time reliable information in the literature available.

According to reports, using SQL-queries, you can create sample data characterizing the stages and features of organic quaternary deposits on the Kola Peninsula, since the Late Glacial and pre-modern. Sample information can be organized by age, altitude, geographical coordinates and other parameters of objects embedded within the database.

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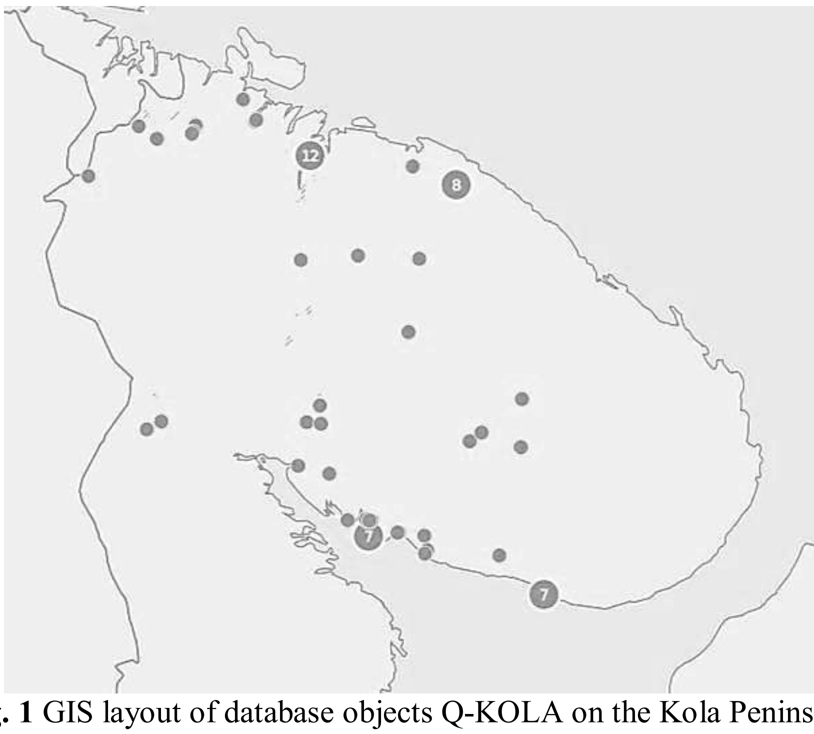

Fig. 1 GIS layout of database objects Q-KOLA on the Kola Peninsula.

PALEOCLIMATE JOINT RECONSTRUCTION FROM DENDROCHRONOLOGY AND SEDIMENT GEOCHEMICAL TIME-SERIES

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Our knowledge of climate change with associated forcing during the last thousand-years remains limited because that cannot be studied thoroughly by instrumental data. So it is an actual task to find high resolution paleoclimate records and to compare it with recent patterns of short-period oscillations. Combination of lake sediments and tree rings appears to be effective for understanding of regional climate forcings.

The Altai mountain range in Central Asia has a climate divide between Siberian forests in the North and arid areas of Central Asia in the South. This region is characterized by the highest degree of continentality. In winter, due to the prevailing stable Siberian High, cold and dry arctic air masses are predominant. In summer, humid air masses from the Atlantic Ocean as well as recycled moisture are the main sources of precipitation.

There are several dendrochronologies (up to 1700 years long) and comparable annual reconstructions by Teletskoye Lake sediments (3000 years) in Altai region. They are calibrated by data from 14 local weather stations (time series up to 80 years) and Barnaul station (170 years) as well. Typical mountains lakes - Teletskoye and Kucherla - with accumulation rate of fine-grained sediments 0,5-2 mm/year and free of human impact are selected to take sediment cores.

A new generation of X-Ray Fluorescence instruments – the XRF scanner on Synchrotron Radiation – allows providing extraordinary high-resolution (up to 0.1 mm) records of elemental composition due to low threshold of detectability of many elements from Al to U. XRF scanning realizes rapid and non-destructive determinations, making sedimentary cores comparable with tree-rings. Also thin-sections, EM photos and image analysis are studied to examine the nature of laminas in order to better understand signals extracted. Traditional lithological, biogeochemical, isotopic and other methods and approaches are also applied to explain variability of geochemical time-series.

Time series of lithological-geochemical indicators of climate change based on dating by ^{14}C, ^{137}Cs, and ^{210}Pb are calibrated by instrumental hydrometeorological data to obtain the functions by way of climate evolution history with annual (seasonal) to decadal resolution.

About 10 elements determined in sediments remain valid as climatic proxies after preliminary testing of analytical accuracy and variability. Set of elements depends on sediment composition, which is differing in sampled lakes. Organophillic elements have larger coefficients in equations for temperature reconstructions, but clastophillic ones are greater in formulas of multiple regression for precipitation. Good correlation between sedimentary-geochemical reconstructions and local dendrochronologies is revealed.

Availability of several basic series of geochemical indices extends the scope for quantitative reconstructions of sought quantity. That becomes in the line of extrapolation, interpolation (detailed elaboration) and combination. Geochemical time series allow estimating regression equations for tree ring width and extrapolating these short chronologies. Specifically, aridization trend is revealed in Transbaikalia for the last 2000 yrs (Arachlei Lake, fig. 1) by tree ring growth index, reflecting alternation of cold-wet warm-dry conditions. Discovered centennial and multidecadal arid periods are not conflict with palinological data. Multi-elemental geochemical matrix principally allows prolongation of any instrumental time-series such as lake level, runoff, tree rings, atmospheric pressure, wind direction, solar activity etc.

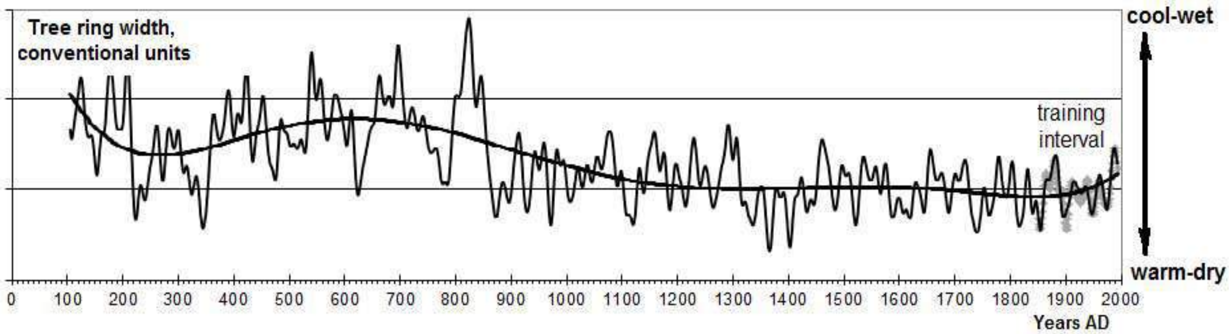

Figure 1. Tree ring width reconstruction (prolongation) by geochemistry of lake sediments.

Another direction for use is detailed elaboration for sparse pollen or diatoms sequences. For example rare sampled palinological series, transferred to biomes, are *worked out in detail* to annual chronologies by training transfer function on element content in the same samples (Teletskoe Lake, Altai, fig. 2). As it was found out, taiga and step biomes have negative correlation there, but both verify aridization trend for the last millennia, enhanced during XX century.

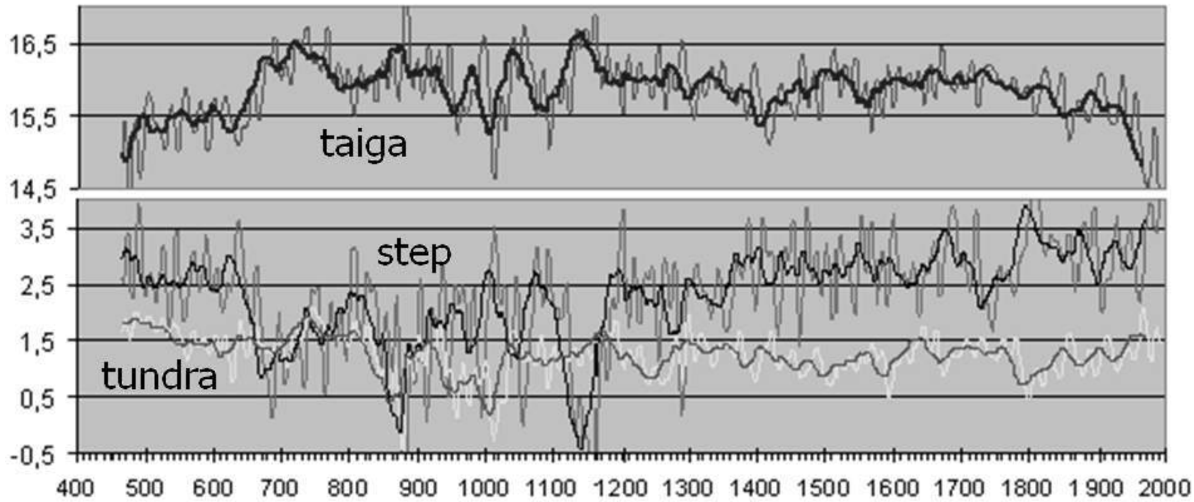

Figure 2. Bioms reconstructed (detailed) by sediment geochemistry on annual scale (solid line - smoothed 25)

Combined reconstruction of summer temperature is made for Altai mountain region using several geochemical parameters of lake sediments together with independent biological series in multiple regression estimations. So we used tree-ring series together with element contents as an additional proxy for calculation of transfer function, considering that tree-ring series are responsed to summer temperature in this climatic zone. Such combined version allows taking one more independent environmental indication for reliable reconstructions. The result is more universal than separate reconstructions by sediment geochemistry and tree rings, although the total length is limited by tree ring chronology (1200 yrs). Actually climate response of tree ring series and lake sediments depends on both air temperature and precipitation, at least for Siberian mountain areas.

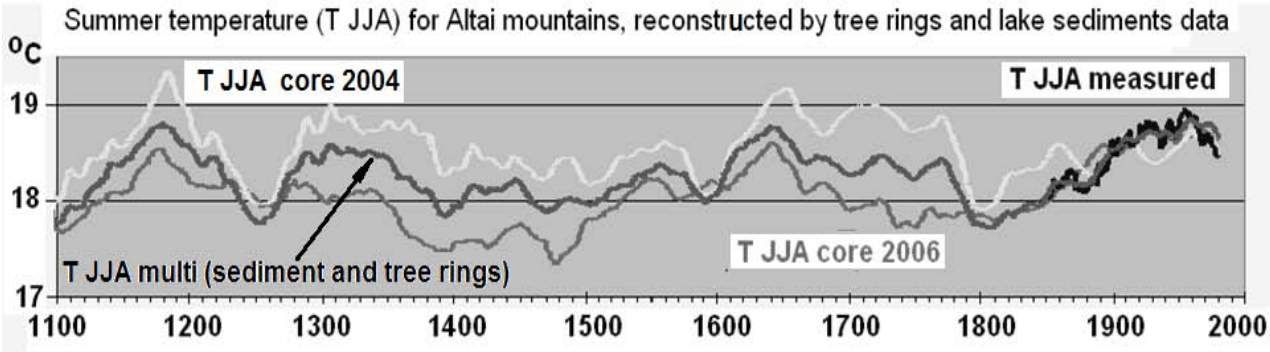

Figure 3. Combined reconstruction

The work was supported by grants SB RAS 52-34, RFBR 13-05-00621.

NEW DATA ON EFFECTS OF STRONG CATASTROPHIC EVENTS IN LAKE SEDIMENTS IN EUROPEAN SUBARCTIC (KOLA PENINSULA)

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Lake sediments, as well as other genetic types of unconcolidated sediments, record past environmental and climatic settings, including such strong catastrophic events as earthquakes, tsunami, earth slides, etc. Data on traces of catastrophic events in small inland lakes lodged on platforms, outside such seismically active areas as seashores, oceanfronts, and subduction zones are limited. This is accounted for by no mere low seismic activity, but also rare occurrence, and absence of special investigations.

New data on effects of catastrophic events in lake sediments were obtained in result of the comprehensive geological and geomorphological research executed in 2013 on the Kola Peninsula (NE Fennoscandian Shield), with the key site located in the southwestern coast of the largest regional water reservoir, Lake Imandra. The research aimed at studying the palaeoseismology and provided the excavation of test pits and trenches, georadar profiling, and palaeolimnological research including bottom lake sediment cores located in the active lineament zones.

In result of the lithological study of the cores in four lake basins disconnected from the Imandra basin during the glacioisostatic rise of the area, the stratigraphic and lithological disturbances were revealed. The most representative disturbances were obtained from the cores of a no-name lake (N 67°31'59.1"; E 31°45'11.9") located 4 km to the west of the Upolokshskaya Bay of the Babinskaya Imandra Lake. The 0.4 km-wide and 3.2 km-deep lake is elongated from the northwest to the southeast for a distance of 1.2 km, and tends to the intersection node of shear lineaments. The lake basin is filled with sand and overlaying silt with a thickness of up to 0.17 m. The silt are overlain by biogenic sediments, predominantly lacustrine gyttja with a thickness of 1.8 to 2.73 m. All cores show anomalous horizon with a thickness of 22 to 49 cm, which markedly differ from underlying and overlaying sediments. The anomalous horizon, which we call the breccia horizon (BH), is represented by mixed gyttja and silt fragments of various shape, colour, and size, organic matter, peat, plant residues, and sand contained in a sapropelic matrix. A large fragment of wood with a length of 5 cm and diameter of 1.2 cm was found in one of the cores taken up.

The presence of BH in the cross-sections indicates catastrophic variations in the sedimentation conditions in the beginning of the quiescent sedimentation period. The pattern of disturbances (mixing of various layers, pieces of wood and branches) indicates fast, single-moment sedimentation, which was only possible in results of a heavy shake, or seismic pulse with a force able to break silt, sand and gyttja layers. Excluded possibility of the BH generation due to the gravitational sliding, arrangement of lake basins in the Holocene palaeoseismic deformations of rocks, similar dislocations in lake sediments resulted from known historical and modern earthquakes in other world areas (Doig, 1991, Nomade et al., 2005; Bondevik et al.,1997) argue for a seismic trigger. It is worth emphasizing that this area records post-glacial differentiated tectonic motions displaced parts of the postglacial Lake Imandra basin bottom relative to each other.

One of the most possible BH generation mechanisms may be the catastrophic material having dischargeed from the basin walls as a result of a heavy shaking caused by the seismic pulse. The report also discusses other possible mechanisms of the BH generation.

The stratigraphic correlation of these anomalous deposits is based on radiocarbon ages, spore-pollen and diatom analyses. The analytic data indicate an strong seismic event that occurred about 5620±300 BP (LU 7365) ^{14}C (6440±340kyr BP calibrated) on the Kola Peninsula.

The possibility to date the lake sediments with the radiocarbon analysis provides great opportunities of defining the time of catastrophic events, and revival of newest faults in the Holocene, thus favouring the search for main stages of the modern geodynamic activity of the intraplatform territories lately eliminated from glacial load.

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PALEOTSUNAMI RECORDS IN LACUSTRINE SEQUENCES OF LESSER KURILS

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The coastal lakes and peat bogs, located behind barrier forms, are peculiar sedimentological traps and are most informative for searches of tsunami traces. The majority of these lakes were formed in Middle Holocene at the peak of Holocene transgression when the sea level reached highest position. Such lakes are widespread in a coastal zone of Lesser Kuril Ridge. Depending on construction of the coastal zone and a lithodynamic situation in different phases of transgressive-regressive cycles of the Middle-Late Holocene these lakes passed some stages of development and along with rather big lakes there are lakes which were transformed to peat bogs. Sometimes on the place of the lake only small relict pools surrounded by swamps remained. In some cases lakes completely disappeared. Also on the coast there are small shallow lakes which during some seasons dry up. Deposits of such lakes and a paleolakes are convenient objects for search of paleotsunami traces, layers of sand of marine origin are easily allocated in lacustrine thin organogenic deposits. On such places profiles with series of corres were put exhausting from coastal line inland with carrying out leveling for determination of tsunami runup height and inundation zone wide. The age of deposits was determined by radiocarbon dating and tephrostratigraphy. Study of paleotsunami deposits in lacustrine deposits was carried out on Shikotan, Tanfilyev, Yury and Zeleniy islands.

On the Pacific coast of the Shikotan Island the most detailed records of paleotsunami traces in the Middle-Late Holocene was received for the Aerodromnaya Bay coast where behind ancient coastal ridge (height 3 m) there is the peatland formed on a place of a barrier paleolake. In peat bog section and the lacustrine deposits presented by gyttija, layers of sand (up to 8 cm) are found. The maximum quantity of sand layers is revealed in low places behind the ancient barrier form at the distance of 230-320 m from the coastline, the majority of them are well traced inland, some – up to 620 m from the coastline and up to the height of 4-5 m above sea level. Some sand layers have the shift bedding, some, most likely, lie as spots and meet not in all sections.

The zone of sedimentation of the most of Late Holocene tsunami situated not far then 260 m from the coast. Middle Holocene sand layers are, as a rule, traced deep into land on bigger distance. Sands have various grain size compositions and contain some silt and gravel. Characteristics the tsunami deposits are well traced in the layer accumulated during passing of the same event. With a distance from the coast only the small redistribution of fractions is noted with preservation of the general form of curve; the part of small fractions, including silt increases and the contents of gravel decreases. As a whole, the deposits of Middle Holocene tsunami contain more content of coarser fractions. Tsunami sands are differ from sand of tidal flat and matrix of ancient barrier form by lower sorting, more diverse material and several modal fractions. Tsunami took material from different sources, including offshore zone. In all layers of the tsunami deposits the rich diatom flora including and marine forms (up to 8%) is found. Sublittoral forms prevail. The high content of brackish *Navicula peregrina* (to 10%) is noted in the upper layers, which most likely, was taken by tsunami wave from mouth pool. In some layers neritic and oceanic types are noted. Three diatom assemblages reflecting to different stages of the shallow lake development are allocated in the section by structure of fresh-water diatom species.

On the coast of northern part of Bezimyannaya Bay 6 layers of the fine well sorted sand which have been allegedly left by Late Holocene tsunami were found among diatomites of small pool in 200 m from the coastline. This part of bay flooded during a tsunami of 1994. Sand layers formed by the strongest tsunami were met in the peat bog located in 700 m from the coast. Deposits include marine diatoms, presented, generally by sublittoral forms, rare neritic and oceanic types are met too. Above layer of volcanic ash Ta-c of Tarumai Volcano (2.4 ka) located on the Hokkaido Island 8 layers the tsunamigenic sands are met.

Traces of more then 7-8 Late Holocene tsunami were found in sections of the small fresh-water pools located between anciet storm on the coast of the Tserkovnaya Bay. The peaty silts with layers of diatomites were accumulated in the pools. Tsunami sands (up to 3 cm) are traced at the distance up to 200 m from the coastline at the height of 1.5-2 m above sea level. All layers contain marine diatoms among fresh-water lacustrine assemblage. Species widespread in coastal waters prevail, and also rare neritic and oceanic species are met. From the basis of section ^{14}C-dates 1210±40 yr. BP, GIN-13031 and 1220±120 yr. BP, GIN-13032 are received. The wave here passed through wide sandy beach and, generally, the beach and low marine terrace material redeposited, grain size composition of tsunami sands are very similar to beach and terrace sands.

Small paleolake existed on the Malokurilskaya Bay coast in the Middle Holocene. Lacustrine deposits are presented by a dark brown gyttija, the base is situated on 3 m below modern sea level. The lake had connected with the sea, that confirmed by the presence of marine diatoms. Environments were similar to the lagoon during the some periods. Expansion of marine waters to the lake is reflected in the presence of marine diatom species, which receipt is connected both with sea level fluctuations, and with paleotsunami. In the lower part of a section thin layers of sand are allocated. In the section above gyttija two thick layers (up to 55 cm) of marine sands divided by a peat layer are present. The marine genesis of sand is confirmed by diatom data. Below layer of ash of Tyatya volcano (1973 AD eruption) sand lenses with well rounded gravel are found which could be left by tsunami of the Chilean earthquake of

1960 or large tsunami of 1958, at which this part of the coast could flood (runup more than 3.5-4 m) (Solovyov, 1978).

On small islands of Lesser Kuril Ridge search of paleotsunami deposits was carried out on the lakes coasts which in Middle Holocene had the bigger sizes. The marine sands which were found in sections, fix passing of only large tsunami. Completely overgrown paleolake was found on east coast of Tanfilyev Island. In the section from paleolake frame which accumulation took place in the Late Holocene (^{14}C-date 3860±160 yr BP, GIN-13452) below a layer volcanic ash Ta-c is found 4-5 layers of sand. The 4-5 sand layers were met between layers of volcanic ashes Ta-c and Ta-a (1739).

As a whole, in the second half the Middle-Late Holocene, including historical time, the frequency of manifestation of strong paleotsunami near Lesser Kuriles was about 300-400 years that well correlated with data on Nemuro Peninsula (200–379 years) (Nanayama et al., 2011).

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DEPOSTIS OF PALEOLAKES OF KURILE ISLANDS AS ARCHIVE OF PLEISTOCENE-HOLOCENE PALEOCLIMATIC AND PALEOLANDSCAPE DATA

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In studying of the natural environment development of the Kuril Islands in the Pleistocene - Holocene great attention paid for deposits of paleolakes, which, together with peat bogs are one of the most informative among continental facies for paleoclimatic and paleolandscape reconstructions. Modern lakes of different types are widespread on the islands. There are lakes of different origin in the inner parts of the large islands. The caldera and crater lakes are the largest and most deep, their development is largely controlled by volcanic factor. Some lakes are formed in areas of large landslides, also associated with volcanism. The most common type of lakes is coastal lakes of barrier type. Some of these lakes were formed in the Middle Holocene, when the sea level reached its present position. The largest coastal lakes are lagoon or passed the lagoon stage of development. At the peak of Holocene transgression the small lakes formed during blocking the mouths of small rivers and streams by barrier forms, which severe storms on the ocean shore arose quickly, these lakes have not passed the stage of the lagoon. At the end of the Middle-Late Holocene on the large islands small lakes arose in depressions between ridges during progradation of sediments at the coast and formation of the coastal lowlands. Small lakes are also located in deflation depressions between dunes. Paleogeographical reconstructions based on the study of lacustrine deposits made for Kunashir, Iturup, Urup, Harimkotan and Paramushir islands (Anderson et al., 2009; Lozhkin et al., 2010). Objects of our research were deposits of different age and origin paleolakes of the Lesser Kuril Ridge islands (Shikotan, Tanfiliev), Kunashir, Iturup, Urup, Rasshua (Korotky et al., 2000; Razjigaeva et al., 2004; 2013).

On the southeast of Kunashir Island deposits of large paleolake were found at the top of the Golovnin cliff, within continental sequences overlying marine sediments of the Middle Pleistocene. Deposits presented by diatomite (thickness of lens up to 10 m) with predominance of planktonic species, accumulation of deposits occurred in the lake with a well defined littoral (Cherepanova, Grebennikova, 1991).

Deposits of lakes that existed in the Late Pleistocene are widespread in the south of Kunashir Island. In Belozerskiy Cliff deposits of paleolakes represented by peat, peaty silt and redeposited tephra. Deposits of the largest lakes were found in the coastal cliff on Okhotsk Sea side of the island to the south from Ivanovskiy Cape. Here four depositional cycles are allocated, each of which begins with the formation of interbedded silts and silty sands formed in the flooding phase and ends with the formation of peat layer formed during shallowing and overgrown of the lake. The lake probably ceased to exist after great eruption of Golovin Volcano and associated with these sharp changes in the catchment area. Pollen assemblages from lake deposits reflect the development of coniferous forests with birch, the climatic conditions were close to modern. Radiocarbon dates are more or close to the limit of the method. Paleolakes could exist in the final stage of the Last Interglacial warming or at the warming of the second half of the Late Pleistocene. For a more precise age binding of deposits more research is needed. Deposits of relatively large paleolake which formed at the end of the Last Interglacial, existed within the land bridge connected Lesser Kuril Islands with Hokkaido and Kunashir islands during sea level lower than the present. Two warm and one cold episode, respondent to the first glacial epoch of Late Pleistocene recorded in the deposits. Lacustrine deposits corresponding to cold conditions probably existed in the Last Glacial age found on the coast of Kosmodemyanskaya Bay on Kunashir (Korotky et al., 2000).

On the south east Kunashir Island paleolake deposits whose formation began in the early Holocene were found in sections of the cliffs. At the base of lacustrine deposits volcanic ash Ma-l of Mashu Volcano which eruption occurred on the boundary of the Late Pleistocene-Holocene. Some small lakes existed for a long time. At the top of the Golovnin cliff deposits of such paleolake were found, the lake existed before two thousand years, when the process of soil formation began. Volcanic ash falls with minimal input of terrigenous material led to the rapid development of diatoms and formation of diatomites.

Several coastal paleolake sections were studied that formed at maximum transgression in the Middle Holocene or early Late Holocene. Such sections are studied in detail on Shikotan, Kunashir, Iturup, and Urup islands. The development of such lakes is closely associated with sea-level fluctuations in the Middle-Late Holocene. In lakes of this type of thin-bedded silts and peaty silts were accumulated. In some lakes diatomites of different composition were accumulated. In the Lesnaya River mouth paleolake deposits presented by clay with fine rhythmic layering - the alternation of light and dark thin layers probably of seasonal origin. According to the diatom analysis several phases of flooding and swamping recorded in barrier lakes deposits, alternation of phases was due to the climatic changes and sea level fluctuations, as well as to lithodynamic processes in the coastal zone. Pollen assemblages from the deposits of lakes that existed at the Middle Holocene or at the beginning of Late Holocene show greater participation and greater diversity of broad-leaved trees in vegetation and warmer climatic conditions compared to modern.

Lakes development studied in ancient caldera on the Rasshua Island in the Central Kuril Islands. The main factors causing the changes of lake-swamp environments and paleolandscape changes were climate changes, and volcanogenic impact. Lacustrine deposits fixed two warmings in the Middle and Late Holocene and well pronounced cooling about ^{14}C 4.2-4.6 ky. Volcanic activity and its influence on different landscape components increased in the Late Holocene. Ash falls of volcanic eruptions of Matua and Ushishir islands volcanoes had the greatest impact on the environments development, causing changes of conditions and type of sedimentation and the landscapes changing.

Thus, on the Kuril Islands deposits of paleolakes of different types were found, which are key objects for paleoreconstructions of environmental development.

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NEW EVIDENCE OF IMPACT ORIGIN OF SMERDYACHEE LAKE (RUSSIA, MOSCOW REGION)

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The heartland of Russia has many enigmatic deep lakes. Shallow lakes have a more obvious origin, perhaps as kettle lakes, oxbow lakes or subsidence features. Deep lakes, particularly round lakes with partial or complete rims are more problematic. Traditionally, round or nearly round lakes with rims are candidates for Holocene age impact structures. The problem is that there are too many such lakes in a relatively small area - Russia has a minimum of 15 deep, round lakes with diameters between 0.2 and 3 km. Even with a possibly increased impact rate during the Holocene, these deep lakes would represent the entire budget of Holocene impacts concentrated in only one region of the Earth.

One proposed impact lake is Smerdyachee near the town of Roshal in the Moscow region. This lake is perfectly round with a raised rim. It is situated on a Holocene fluvioglacial terrace between the Polya and Voimega rivers (Klyazma, Oka, Volga basin) (fig. 1).

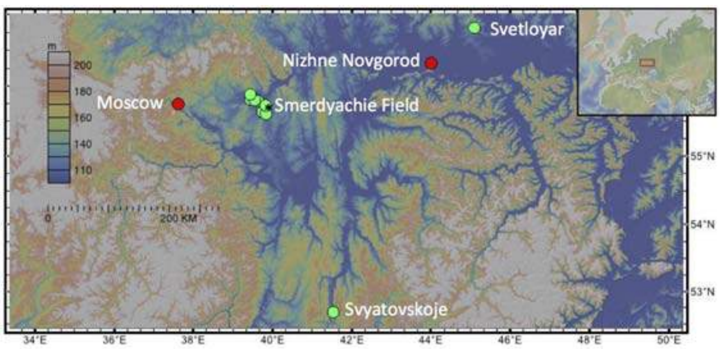

Figure 1. Smerdyachee location map. Red circles: major cities. Green circles: lake-filled crater candidates. Black spot left of S in Smerdyachie: location of Ni rich material on Smerdyachie rim. Smerdyachie is part of a field of deep, circular lakes of possible related origin.

It has a diameter of about 350 meters and a maximum depth of 38 m. Several Russian scientific groups previously explored this lake [1-2]. Because Smerdyachee is not a big impact crater, where the maximum shock pressure during the impact is enough to create obvious impact features, e.g. shatter cones or shocked minerals, it is not included in the Earth impact database [3]. Expeditions of the Holocene impact working group (HIWG) to Smerdyachee in 2013-2014 collected some new data that further suggest an impact origin.

The HIWG expeditions found that the lake had a raised rim that was highest SE of the lake. Because of wild fires in 2010, the

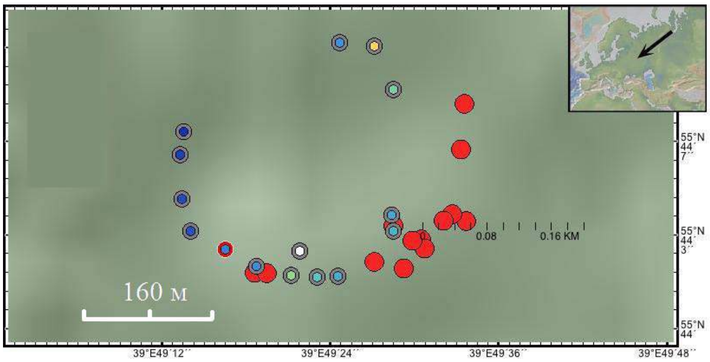

Figure. 2. Location of investigated samples on the Smerdyachee lake rim. Red dots are fossil locations. Other dots are locations of measurements of magnetic susceptibility. The white dot has the highest value of magnetic susceptibility. Dark blue dots have negative values of magnetic susceptibility.

soil was deeply trenched around the lake. The trenches exposed many fragments of basement limestone. The overlying material consists of unconsolidated, sand and silt-sized, quartz-rich sediments. We found clasts of brachiopod, crinoid and gastropod-bearing Carboniferous carbonate rock up to 32 cm in diameter on the SE rim of Smerdyachee. These clasts are present over about 1/3 of the total circumference of the lake. There are no limestone fragments in soil exposed more than about 200 meters from the edge of the lake. If Smerdyachee is a Holocene-age impact crater, this excavation of deeper horizons is expected. The maximum depth of excavation in an impact crater of 300-350 m in diameter is nearly 100 m. Local geological data verify of this hypothesis - the basement at Smerdyachee is at ~40 meters depth. It consists of Carboniferous age carbonate rock with fossils of brachiopods, crinoids and gastropods.

The HIWG expeditions found many recently fallen trees along the rim. Unlike the dark organic rich soil at the surface, the soil in the root balls of the fallen trees was white and contained limestone fragments. Because the soil was exposed on a vertical surface, it was not susceptible to contamination from atmospheric deposition. We used an Nb super-magnet to sample this soil. Magnetic material from the soil in the root ball of a fallen tree on the SE rim contains Fe rich particles and spherules with visible Ni in an X-ray analysis. This fact is not enough to prove impact origin because there is a small probability we could find cosmic particles anywhere on the Earths' surface. We must first know typical concentration of cosmic particles near Smerdyachee. If our samples have a significantly larger concentration of Ni rich particles this would strongly suggest an impact origin.

In May 2014, a HIWG expedition made panned concentrates of the sediment on the rim. To the NW, the concentrated sediment has a negative magnetic susceptibility (-0.07 to -0.03 cgs units), consistent with a higher concentration of pulverized limestone. To the SE, the sediment has a positive magnetic susceptibility (0.06 to 0.35 cgs units). The areas of positive magnetic susceptibility lie on the SE two-thirds of the rim of the lake (fig.2).

The highest susceptibility value is from the sample taken closest to the lake shoreline on the SE rim (fig. 2). This spatial distribution of susceptibility could mean that there is a higher concentration of iron rich material on the SE side of the lake. To test this hypothesis, we plan to remove the calcium carbonate from our previously measured samples and then to remeasure their magnetic susceptibility. We will then examine the material with the highest magnetic susceptibility for possible impactor fragments.

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GEOCHRONOLOGY OF LAKE CARBONATE FORMATION IN THE IZHORA RIVER BASIN ON THE BASE OF URANIUM-THORIUM DATING OF TRAVERTINE LAYER FROM THE PUDOST' DEPOSIT

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The travertines are carbonate objects of carbonate-bearing ground waters which are formed as a rule continuously during decades, hundreds and thousands of years. Therefore, these objects may contain valuable records of palaeonvirontal changes. From this point of view, the chronological study of travertine formation is a needed part of such palaeoreconstructions. One of the known travertine deposit in the territory of Russia is the Izhora Plateau (Leningrad Province).

The first palynological study of the best known section located near the Pudost' Settlement (Gatchina district, Leningrad Province) was carried out in 70-th last century [1]. It was found that the travertine layer formation took place in the time frame of Holocene. The results of the malacofaunas analysis suggested the lake origin of these carbonates [2]. Intensive travertine accumulation was due to its spring-water nutrition whereas the termination of travertine formation could be due to a catastrophic lake water discharge [1, 3]. The youngest isochronously corrected ^{230}Th/U age of 6.8 ± 0.4 kyr obtained earlier for the top part of the travertine layer indicated the termination of the carbonate formation and reflected, probably, the time of lake discharge [3]. Question of the time of lake formation as well as the beginning of travertine formation remained open.

For this purpose, we conducted a radiochemical analysis of samples taken from the 60-cm bottom sub-layer of the 2-meter travertine layer from the Pudost' Section. The radiochemical technique applied is described earlier [4]. The ^{230}Th/U age 8.8 ± 0.6 kyr of the bottom sub-layer was calculated according to the isochronous approximation [4 – 7]. All the ^{230}Th/U ages obtained along the 2-meter profile allowed us to calculate average accumulation rate about 60-70 cm/kyr, as well as time range of carbonate formation and the existence of an ancient lake from ca. 9.4 kyr to ca. 6.3 kyr ago.

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