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PALEOLIMNOLOGY
OF NORTHERN EURASIA

EXPERIENCE, METHODOLOGY, CURRENT STATUS
AND YOUNG SCIENTISTS SCHOOL IN MICROSCOPY
SKILLS IN PALEOLIMNOLOGY

PALEOLIMNOLOGY OF NORTHERN EURASIA:
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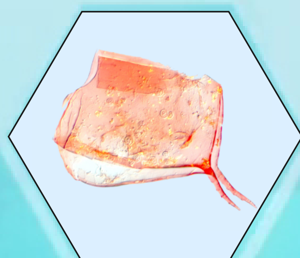
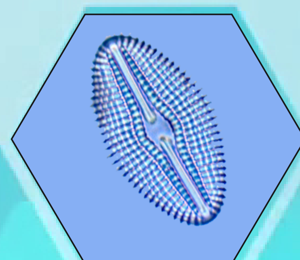
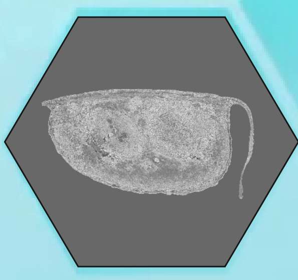
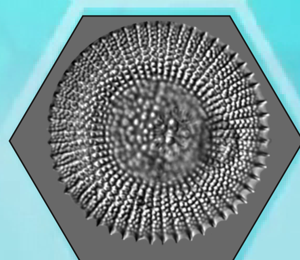
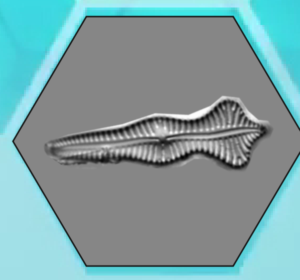
Proceedings of the 3rd International Conference

Kazan, Republic of Tatarstan, Russia, 1- 4th of October 2018

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P17 **Paleolimnology of Northern Eurasia: experience, methodology, current status and young scientists school in microscopy skills in paleolimnology:** proceedings of the 3rd International Conference (Kazan, Republic of Tatarstan, Russia, 1–4th of October 2018). – Kazan: Publishing House of Kazan University, 2018. – P. 148.

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Proceedings of the 3rd International conference “Paleolimnology of Northern Eurasia: experience, methodology, current status and young scientists school in microscopy skills in paleolimnology” are presented in the author's edition. On the meeting actual paleolimnology problems and recent scientific achievement in paleolimnological studies of the North Eurasia were discussed. Colleagues from various russian and foreign scientific centers exchanged their knowledge and experience of the last decades in the field of paleolimnology. Workshops for young scientists, postgraduates and students were conducted. Future opportunities and plans for joint future research are determined.

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RELATIONSHIP BETWEEN POLLEN AND FLORISTIC DIVERSITY IN THE RECENT LAKE SEDIMENTS AND MOSS POLSTERS IN CENTRAL EUROPE

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Palynological reconstruction of Holocene vegetation changes requires understanding of cross-scale relationships between floristic and pollen diversities. We explored the relationships in two regions differing in dominant vegetation and diversity patterns. The White Carpatians are a biodiversity hotspot of thermophilous vegetation comprising dry-mesic grasslands and broadleaved forests, while the Bohemian-Moravian Highland is dominated by species-poor coniferous forests, meadows and wetlands. In each region, 40 sites covering the major habitats were sampled for plant and pollen diversity. A detailed floristic survey in radii of 10 and 100 m and in two transects of 1,000 m was conducted at each site. Recent pollen diversity was sampled by gravity corer in ponds and quarries in the Bohemian-Moravian Highland at 20 sites. The rest of sites were moss polsters taken in the centre of each site. Altogether, 1260 plant species were recorded and more than 219 pollen taxa were identified. The total number of plant species was similar in both regions (942 species-poor region and 965 species-rich region), but number from Bohemian-Moravian Highland is biased large area surveyed around water deposits. When selecting 20 terrestrial sites with equal vegetation sampling effort and rarefied pollen sum to 827 pollen grains, we obtained expected pattern.

Palynological diversity follows floristic diversity according to habitats and regions. Interestingly, palynological diversity in ponds and quarries is significantly higher than terrestrial habitats in Bohemian-Moravian Highland, similarly as a floristic diversity due to larger sampling area. It indicates, that whole area of the lake shore and lake watershed contributes to the pollen assemblage in the lake.

Higher proportion of *Abies* in the recent lake sediments also links to better flotation capacity of the saccate pollen grains (Albert & Pokorný 2012). Another dispersal-depositional bias was identified at forested sites in both regions. They had a higher proportion of the regional pollen component (*Ambrosia, Artemisia*, Chenopodiaceae family) than the open sites, in spite of the fact that those taxa occupy open habitats. Pollen is trapped on the larger leaf/needle area of the trees and subsequently washed to a moss polster.

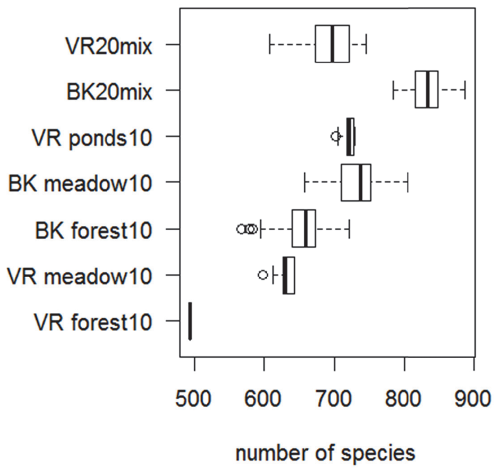

Fig. 1. Boxplot showing number of species (floristic) recorded in different regions/habitats (BK - White Carpathians, VR - Bohemian-Moravian Highland). Two upper graphs show floristic diversity at 20 terrestrial sites randomly selected independently on habitat. Five lower graphs floristic diversity at 10 sites randomly selected in each habitat

Regression analysis between floristic and palynological diversity showed similar R squared in both regions (0.5-0.6). Following Odgaard (1999) we tested whether the pollen productivity is a main bias influencing the palynological diversity. We calculated relative pollen productivity from the same pollen-vegetation dataset and found substantial differences in relative pollen productivity (eg. Poaceae 1, *Quercus* 1.5, *Picea* 2.1, *Betula* 2.5, *Alnus* 3.1). We divided pollen counts of the main dominants by those values and also rarefied pollen counts to equal pollen sum. We found that pollen productivity calculated from the same pollen-vegetation dataset did not improve the diversity relationship.

Work was supported by Czech Science Foundation (project no. 16-10100S).

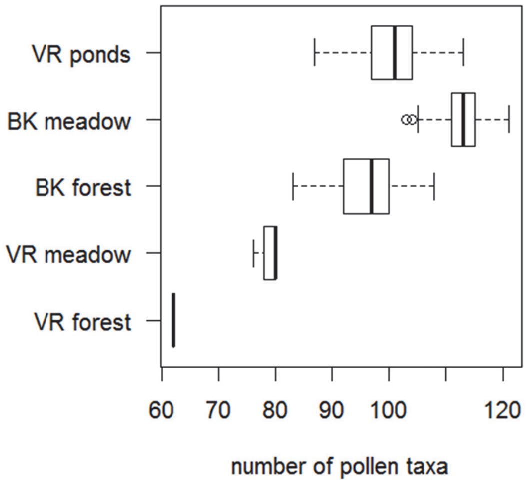

Fig. 2. Boxplot showing number of pollen taxa recorded in different regions/habitats (BK - White Carpathians, VR - Bohemian-Moravian Highland). Graphs show pollen diversity at 10 sites randomly selected in each habitat

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NEW DATA ON THE QUATERNARY SEDIMENTS' STRUCTURE OF THE PETROZAVODSKAYA BAY OBTAINED WITH RESULTS OF THE SEISMIC PROFILING

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The data about quaternary deposits of the Petrozavodskay bay was recieved during the expedition on the Onega lake in 2016. These researches were provided by Marine Research Center of Moscow State University, Saint-Petersburg State University and Northern Water Problems Institute of Karelian Research Center of RAS. The works included: seismic profiling, geological sampling and side-scan sonar. High-frequency electrodynamic source of radiation "Boomer" and low-frequency electrosparking source of radiation "Sparker" were used in seismic profiling. At last, 70 km of seismic profiles were recieved. The profiles form the polygon, 8 km at length and 2,5 km at width. For this report longitudinal profile NS_GP_S_09 and transverse GP_P_03 were chosen (fig.1). They were analyzed and interpreted in software Kingdom IHS.

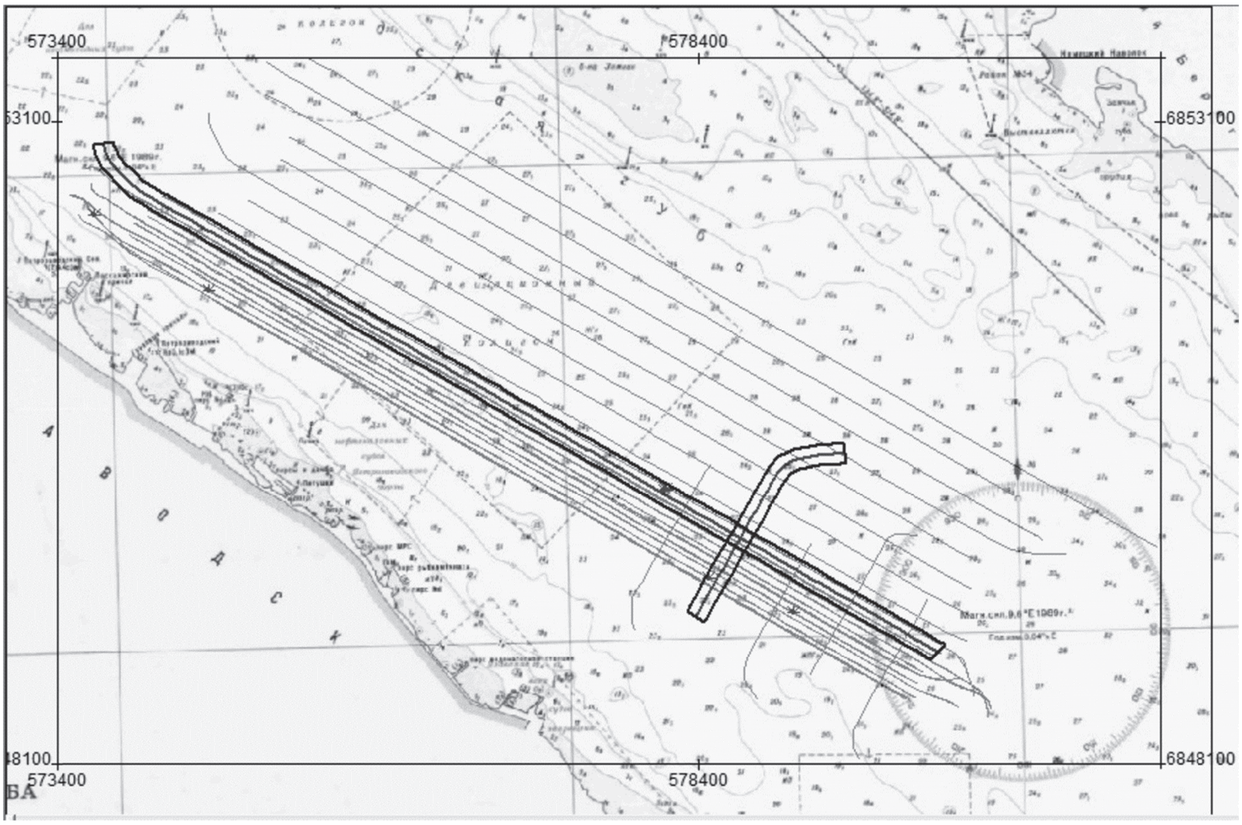

Fig. 1. The scheme of the polygon with chosen profiles

Profile NS_GP_S_09 extends in north-east direction, has length about 7,7 km. On the base of previous researches (Demidov, Lavrova, 2010; Saarnisto, Saarinen 2001; Semenovich, 1973; Subetto, 1990) and results of the geological sampling from the expedition, described above, a few layers were marked.

At the base of the section stratum with chaotic recording is layed. At some places, mild lamination can be observed. The contact with layer above is rough and well-marked. This could tell us about glacial origination of these sediments and so, they can be interpreted as late Pleistocene moraine (gIIIost).

The next layer has subhorizontal lamination. Its thickness is about 5,5-10 metres. The lays have different thickness. According to the previous researches, the deposits could be suggested as lymnoglacial varved clays of the late Pleistocene ($lgIII_1$). The lamination disappears sometimes. That could be explained with existence of fluvioglacial sediments there (fgIII). The boundary with the layers above is clear, well-marked.

Then layer with subhorizontal lamination can be observed. According to record features, these sediments have more homogenic structure than sediments below. Specific point of the layer is lamination details' decrease to the top of deposits. This one can tell about transgressive accumulation of the stratum. Somewhere, the layer disappears. The thickness can reach the point of 4,5-5 metres. These sediments are also the late Pleistocene lymnoglacial varved clays ($lgIII_2$). The contact with higher sediments is badly determined.

The next stratum has low-observed laminated subhorizontal structure. With increase of the thickness, the lamination is getting more determined. This is the thickest layer of the profile with the maximum thickness about 15 m. These deposites are presented as aleurites of the early-middle Holocene (lnH_1). The stratum is dicordantly bedded on the varved clays. The contact with next layer is well-marked, but with growth of thickness, it becomes more gradual.

The last stratum is presented as modern silt (lnH_2). The texture is homogenic, but at the top lamination can be spotted. Record features can tell about more clastic grain-size distribution. The maximal thickness of these sediments is about 8 m.

To describe the profile, it was divided into 4 parts. The first one is sector of modern accumulation. The second part is characterized with minimal accumulation of sediments. On the third part the most expressive form of topography can be watched – the esker formed with fluvioglacial sediments. In fact, it consists of two parallel ridges, connected with each other. It has north-north-west direction, its length is about 1,2 km, width – about 0,6 km. Height above the bottom is about 10 m, thickness of deposits is about 35 m. The last part is also characterized with modern accumulation. All these parts contain sights of gas formations. Some of them show on the surface, forming pok-marks. There are also a lot of neotectonic movements' signs. We can observe plenty of disjunctive dislocations, which presented as faults of deposits.

Combining all information above we can tell that observed deposits exist on the whole profile except the location of esker. Somewhere the holocene sediments almost disappear. Generally, they are laid subhorizontally on the late Pleistocene formations. The varved clays have disordant bedding, they folded into many dislocations. The surface line is flat, the depth is fluctuating about 25-28 m. The sights of erosion are insignificant. Specific feature of the surface is increase of depth to the south-east direction.

Profile GP_P_03 is high frequency profile, which has less depth of the signal, that's why the glacial deposits can't be observed. The rest of layers are presented here. Minimal thickness of sediments is above 12-13 m, maximal – 16-17 m. Depth amplitudes are about 7 metres. Depth is increasing to the north-east with flat terraces. At all, there are 3 such terraces, which can be connected with increasing of water level. There are also signs of neotectonic movements shown as plicative and disjunctive movements. Some pok-marks are displayed, by the way gas formations are located throughout the profile.

So, observing these profiles, there were some results recieved. The polygon is presented as wavy lake plain with some low ridges, formed with late-Holocene lacustrine silts. At the base of quaternary deposits late-Pleistocene moraine of last glaciation is located. The rest of section is formed with late-Pleistocene lymnoglacial varved clays and Holocene lacustrine aleurites. Also fluvioglacial esker can be observed. Generally there is accumulation on the polygon, although signs of erosion are also watched. Concerning endogennic processes, in the late Pleistocene this territory was affected by intensive neotectonic movements of upward direction, which connected with glacio-isostasy effect. Between Pleistocene and Holocene there was a break of accumulation. In Holocene tectonic movements became downward with less intensity.

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RECONSTRUCTION OF PALEOBASINS OF LARGE LAKE SYSTEMS OF THE SOUTHEASTERN PERIPHERY OF THE CANDINAVIAN ICE SHEET IN THE LATE PLEISTOCENE

Anisimov N.V., Minina M.V., Subetto D.A.

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Abstract. The work is based on GIS-technology includes the systematization of spatio-temporal data and studies transformation of the paleogeographic situation within Ladoga and Onega lakes basins; reconstruction of the changes in the boundaries of large periglacial water bodies as a result of deglaciation, glacioisostatic and neotectonic movements and, in a result changes in the direction of river flow systems.

Material and methods. GIS-modeling was accomplished using ArcGIS software on the base of original digital elevation model of the lakebed and its watershed. A digital relief model (DEM) of the research area was developed and based on open sources. The reconstructions for all periods were unified, had spatial resolution 90 m and a strict geographic conjunction. Paleo-levels of reservoirs were constructed in different historical periods, taking into account isostatic and peat deposits. Reconstructions were originated from the ideas of the deglaciation model proposed by A. Hughes and the data of M. Eckman concerning Lake Ladoga depression isostatic uplift in the Holocene. The work is focused on the crucial moments in the history of the territory development which is associated with the change in the direction of the watercourses: the runoff from Onega Lake to Ladoga Lake on the Oyat River, from Onega Lake to Ladoga Lake on the Svir River, from Ladoga Lake to the Baltic sea along the Vuoksa River and the formation of the Neva River and catching area was analyzed. Ten paleogeographic maps were developed as a result.

Results. As a result of the reconstruction we identified 3 main stages of the Ladoga-Onega lake system: deglaciation, drainage and modern state.

The main factor of the first stage(Fig.1) is the contact between the boundaries of the lake and the glacier and its rapid retreat which had an impact on formation Lake Onega (16ka) and Lake Ladoga (12 ka). Initially Lake Onega was connected with The Caspian Basin. 15ka was occurred the formation of the southern shore of Lake Onega. At that time river runoff was carried out through the Onega River or Ojat River. 14ka - The breakthrough of Lake Onega across the Svir River into the Ladoga Lake.

Factor unites the second stage(Fig.2) is a decrease of lake levels. Preboreal and the Boreal the level of Lake Ladoga rosed to 18-25 m and for a long time there was a strait in northern part of the Karelian Isthmus, connecting Lake Ladoga and the Baltic Sea. In Atlantic period the level of Lake Ladoga fell below the current level.

Stage 3 (Fig.3) shows the recent changes in the level of lakes, Neva River formation and the direction of the runoff which leads to the current state.

Conclusions. GIS-based reconstructions of Onego Lake and Ladoga Lake development in the Holocene and the Late Pleistocene are presented on the poster. During the development of the lakes systems, the main stages were identified, showing either a change in the flow direction occurred, or a sharp change in the water levels at the reservoirs. The next step in this research will be calculating of the main morphometric characteristics of lakes - volume and the average depth for each of the considered historical periods. The results of the work will be used in the paleolandscapes reconstruction and development modeling of natural processes in Northern Europe.

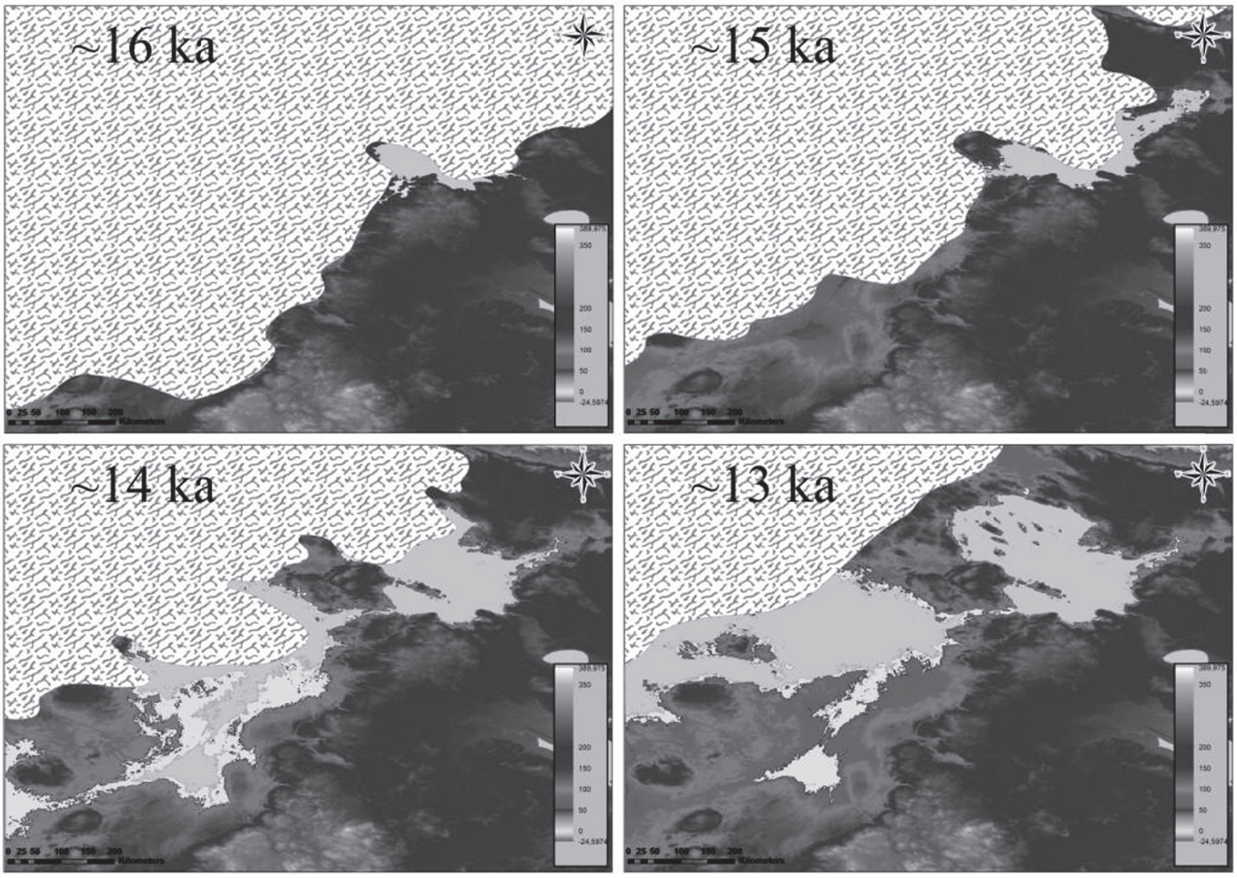

Fig. 1. Stage 1 The deglaciation of lakes

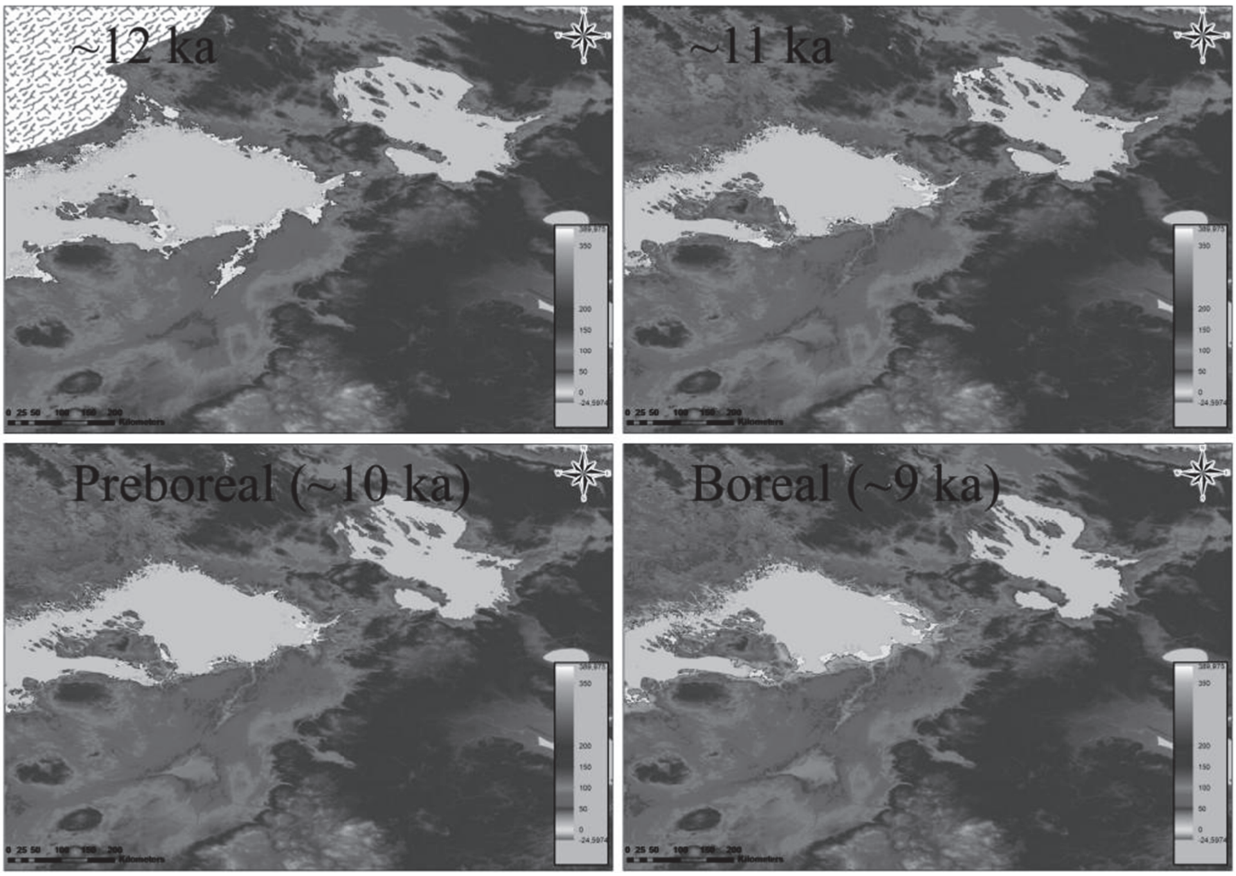

Fig. 2. Stage 2 Drainage

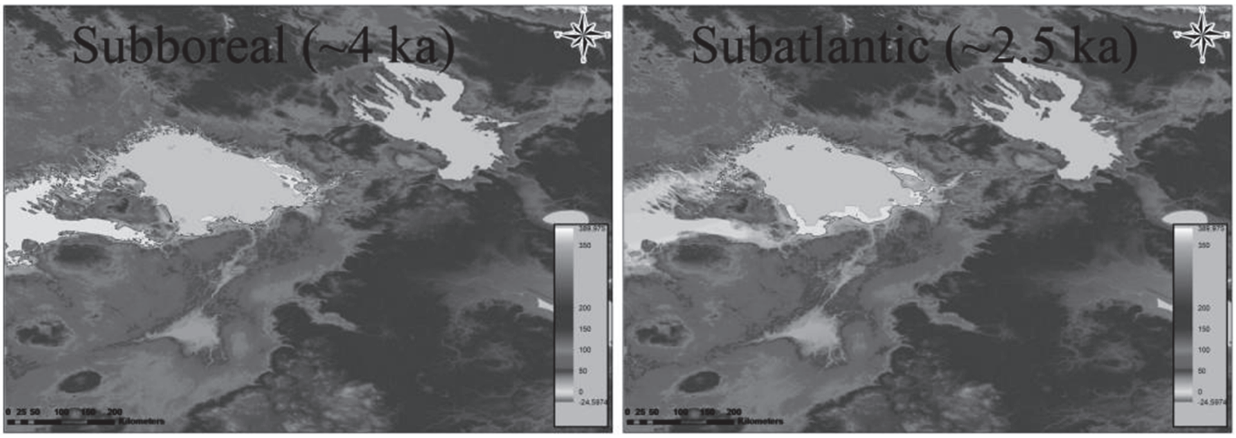

Fig. 3. Stage 3 Modern condition

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PALEOLIMNOLOGICAL TRANSECT (PLOT) PROJECT: THE PREGLACIAL TO POSTGLACIAL HISTORY OF THE RUSSIAN ARCTIC BASED ON THE PRELIMINARY POLLEN RESULTS

Andreev A.[1]***, Savelieva L.***[2]***, Baumer M.***[1]***, Fedorov G.***[2]***, Gromig R.***[1]***, Krastel S.***[3]***, Lebas E.***[3]***, Shumilovskikh L.***[4]***, Wagner B.***[1]***, Wennrich V.***[1]***, Melles M.***[1]

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The joint Russian-German project "PLOT - Paleolimnological Transect" aims to investigate the Late Quaternary climatic and environmental history along a >6000 km-long longitudinal transect across the Eurasian Arctic. For this purpose, seismic surveys and sediment coring were conducted on five lakes, which are located along transect and have the potential to host preglacial sediments. Following a pilot expedition on Lake Ladoga close to St. Petersburg in summer 2013, the full PLOT project commenced in Nov. 2015. Since then, sediment coring was conducted at Lake Bolshoye Shuchye (Polar Urals) in spring 2016, followed by a seismic survey and a coring campaign on Lakes Levinson-Lessing and Taymyr (both Taymyr Peninsula) in summer 2016 and spring 2017, respectively. A joint seismic and coring campaign was also achieved on Lake Emanda (Verkhoyansk Range) in summer 2017. Here, we provide an overview of the interpretations made on the basis of the initial studies of the sediment cores.

Lake Ladoga is the largest lake in Europe. Although the postglacial history of the lake was studied over the last decades, the preglacial history remained unknown. It is assumed that during the Last Interglacial Lake Ladoga was part of a precursor of the Baltic Sea, which had a connection via Ladoga and Onega Lakes to the White Sea. Subsequent coring provided a new 22.75 m sediment record. Its upper 13.30 m comprise Holocene and Late Glacial sediments separated from the lower 11.45 m of preglacial sediments by a hiatus. The preglacial sediments were investigated for lithology, chronostratigraphy, and palynology (Andreev et al. submittted). They consist of highly terrigenous sediments and according to OSL datings were deposited 118-80 ka ago. Between 118 and 113 ka (MIS 5e) birch and alder forests with broad-leaved taxa dominated in the area, suggesting climate conditions more favourable compared to the Holocene. A high contents of well-sorted sands and poor-preserved palynomorphs indicate a shallow-water environment at least temporarily. More fine-grained sediments and better preserved organic remains suggest deeper waters between *c.* 113 and 88 ka. Pine and spruce became dominant during this interval, while broad-leaved taxa started to disappear especially after *c.* 90 ka, pointing to a gradual climate cooling at the beginning of the Early Weichselian. An increase of open herb-dominated habitats *c.* 88-86 ka (beginning of MIS 5b) reflects colder and dryer climate conditions. However, later (*c.* 86-82 ka) pine and spruce again became more common in the area. Birch and alder forests dominated in the area *c.* 82-80 ka. Although open treeless habitats also became more common at this time, a slight increase of hazel may point to slightly warmer climate conditions coinciding with the beginning of MIS 5a. The studied sediments also contain numerous remains of fresh-water algae (*Pediastrum*, *Botryococcus*) and cysts of marine and brackish-water dinoflagellates and acritarchs documenting that the present lake basin was part of a brackish-water basin 118-80 ka ago, likely a gulf of the Pre-Baltic Sea.

The pollen record from the upper 13.3 m documents regional vegetation and climate changes in northwestern Russia in high temporal resolution over the last 13.9 cal ka BP (Savelieva et al. submit.) The late Glacial chronostratigraphy is based on varve chronology, while the Holocene stratigraphy is based on AMS ^{14}C and OSL dates, supported by the comparison with regional pollen records. The shrub-grass communities dominated between 13.9 and 13.2 cal ka BP. The increase of *Picea* in pollen spectra at ca 13.2 cal ka BP probably reflects the appearance of spruce in the Ladoga area in Allerød.

Younger Dryas cooling led to a significant decrease in spruce and increase of tundra- and steppe-like vegetation after 12.6 cal ka BP. The Younger Dryas/Holocene boundary (*c*. 11.2 cal ka BP) is characterized by a sharp transition from the tundra-steppe communities to birch dominated forests. Pine forests dominated 9.0-8.1 cal ka BP. The most favourable climatic conditions for thermophilic taxa existed between 8.1 and 5.5 cal ka BP. The decrease of tree pollen taxa (especially *Picea*) and the increase of herbs after last 2.2 cal ka BP probably connects with anthropogenic activity. The presence of Cerealia and ruderal herb pollen is permanently recorded since ca 0.8 cal ka BP.

The thickness of the lacustrine sediments in Lake Bol'shoe Shuch'e (Polar Urals) was 54 m. According to the previous studies, most of the study area has remained ice-free over the last 50-60 ka. However, the configuration and timing of the preceding glaciations has remained unclear, because of lack continuous, long-term paleoenvironmental records in the area. Preliminary pollen studies (Fig. 1) show that the sediments between 25 and 54 m were accumulated during the MIS 3, when treeless tundra- and steppe-like communities with some dwarf birches dominated the area; sediments between 11 and 25 m - in MIS 2, when only tundra- and steppe-like grew in the lake vicinity; sediments between 11 and 9 m - in Allerød warming which is characterized by drastic increase in shrubby birch and willow communities; sediments between 11 and 9 m - in Younger Dryas, when birch communities decreased; the uppermost 9 m were accumulated in the Holocene, which pollen spectra reflecting the gradual forestation of the area.

The thickness of the lacustrine sediments in Lake Levinson-Lessing (Taymyr) was ca 44 m. Preliminary pollen studies show that the sediments between 44 and 31.5 m were accumulated during the MIS 3, when treeless tundra- and steppe-like communities with few dwarf birches dominated the area; sediments between 31.5 and 15 m - in MIS 2, when only tundra- and steppe-like grew in the lake vicinity. Numerous coprophilous fungi spores indicate the presence of grazing animals. Pollen assemblages in sediments accumulated in Allerød (15-8.5 m) reflect some increase in shrubby birch and, especially, in willow communities. Younger Dryas pollen assemblages (8.5-6.5 m) show that birch communities decreased. The uppermost 6.5 m were accumulated in the Holocene, their pollen spectra demonstrate gradual increase of shrubby vegetation in the area.

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LATE VALDAI PROGLACIAL LAKES OF THE UPPER VOLGA: GEOLOGICAL AND GEOMORPHOLOGICAL DATA

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Proglacial lakes are water bodies formed in periglacial zones. Two ways of proglacial lakes' possible origin are widely recognized in literature (Bylinskij, 1996; Kvasov, 1975). The first one was suggested by Kvasov (1975) who stated that the formation of these lakes was made possible because of river damming. When ice-sheets extended further onto the Russian mainland, north-flowing rivers were blocked, which resulted in appearing of ice-dammed lakes. On the other hand, according to Bylinskij (1996), factor that played the most important role in formation of proglacial lakes was the glacio-isostatic effect. It has long been recognized that horizontal mass transfer in the low viscosity asthenosphere due to glacial loading would have induced uplift and the formation of a peripheral bulge with its axis parallel to the ice sheet boundary. Glacio-isostatic forebulge affected existing fluvial systems which resulted in appearing of proglacial lakes.

Upper Volga basin supposedly could have been one of the regions where proglacial lakes emerged during the Late Valdai, as it was largely affected by the last glaciation event (Astakhov et. al., 2016). The idea of Upper Volga proglacial lake system was first introduced in 1975 by Kvasov. According to his calculations and predictions, the majority of Upper Volga territory has been covered by large lake system. The river itself was to appear only after lake system stopped existing. Presumably, it happened due to formation of a breakthrough valley near the town of Plyos, about 14,5k y.a. (Fig. 1) (Kvasov, 1975).

GIS modelling of Upper Volga proglacial lake system resulted in discovering that some of Kvasov's calculations are not to be considered completely trustworthy. Stated modelling was conducted according to Kvasov's data, such as change in lake system levels during different events of deglaciation. During Last Glacial Maximum (LGM) the Upper Volga proglacial lake system admittedly had two main outlets, both headed to the south. The first one was leading the waters of the system through river Klyazma, the second one – through river Teza. If we are to consider lake levels that were stated by Kvasov (1975), modelling shows that there was no possible way of the waters of the lake system to flow through river Klyazma. Yet river Teza still was confirmed as a possible outlet, according to GIS modelling. To examine this possible outlet more thoroughly, regional geologic and geomorphologic data were studied. The results of this study detected the complete absence of geomorphological and sedimentary evidence of lake waterflow through Teza outlet. Since river Teza valley is located lower than its surroundings, waterflow could not have occurred here only during one possible scenario: this passage was blocked by dead-ice. As the ice-sheet during the last glacial event did not reach this territory, Teza could have only been blocked during previous glacial event (170-125k y.a.). Considering everything stated earlier, we can assume that breakthrough valley of Volga near the town of Plyos was formed by the glacial meltwater outflow of degrading ice sheet.

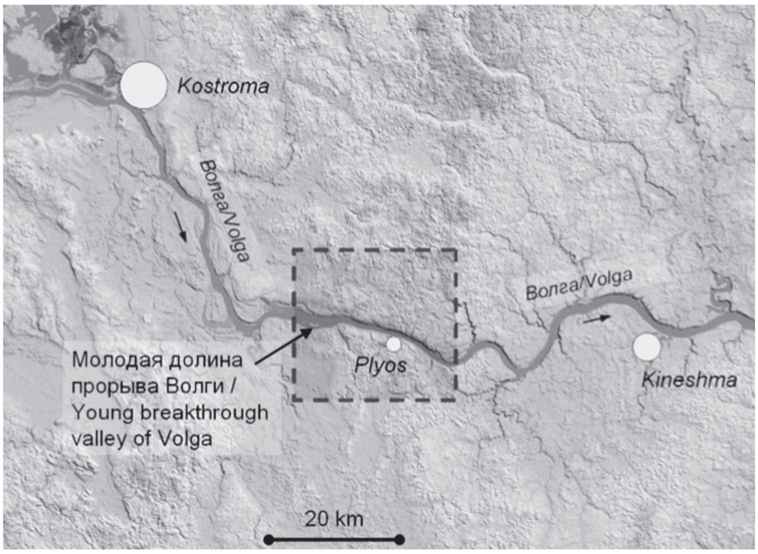

Fig. 1. Location of the breakthrough valley of Volga

The most important factor that could not have been considered by Kvasov and therefore was also neglected in previous study is glacio-isostatic adjustments. The role in valley development of crustal warping related to glacio-isostatic effects appeared through forebulge formation, as stated above. The reason we presume that forebulge could have affected Upper Volga is its close position to Valdai ice-sheet. The first one to indicate the possible effect of glacioisostasy on periglacial zone was Bylinskij (1996). Supposedly, glacio-isostatic adjustments could have been determinant in proglacial lakes' evolution of the Upper Volga region (Panin et al, 2015; Panin, Baranov, 2015). A new model of the last deglaciation event of the Late Quaternary ice age denoted as ICE-6G_C (VM5a) model was used to determine the glacio-isostatic effect on river Volga basin (Peltier, 2015). One of the predictions obtained from the model is topography difference from present. Using stated data allowed us to calculate the paleo topography of LGM. River Volga lengthwise section (Fig. 2) was used to visualize the changes in its structure. According to the given sections, glacio-isostatic adjustments did not affect the Volga valley as originally presumed. Forebulge was thought to distort the topography of the Upper Volga region in a way that it should have become tilted in the direction of the ice-sheet. The sections illustrate that instead glacial isostasy resulted in forming the parts of river Volga with an incline opposite to the current one, or even almost flat parts. The results indicate that both stated parts could have been covered with lakes.

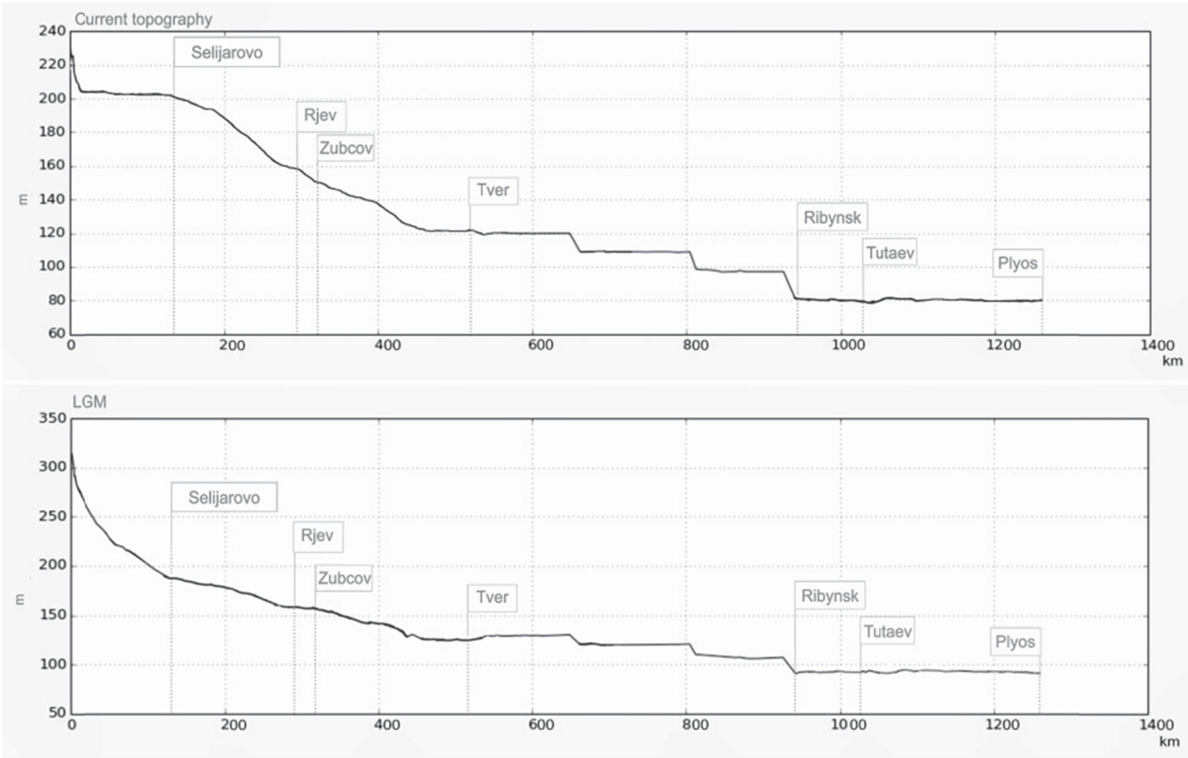

Fig. 2. River Volga lengthwise sections

Geological evidence of the proglacial lake existence is considered to be the widespread sandy-loam and loam deposits which are found near to the surface. These deposits have been indicated as in Yaroslavskoye Povoljie region (Rusakov, 2011), as in Tver oblast region (Kjamjarja, 2012). According to stratigraphic position, these deposits are commonly considered as Late Valdai deposits, however, there is no established opinion formed on their origin. Rusakov (2011) states that these Late Valdai deposits correspond to lacustrine deposits. Particle size distribution analysis was conducted using the multi-fractional scale of Baturin V.P. Analysed deposits were collected near the Bolshaya Kosha river in Tver oblast region. Starting from the surface and lower, until the 2 meters mark, studied section consists mostly of fine-grained sand and silt (fractions 0,1 – 0,05 and 0,05 – 0,005 mm) (80% of the whole mass). In the upper 0,5-0,7 meters the sediments are mixed, loose and unstratified, also the addition of medium-grained and fine-grained sand (up to 30% of the mass) is observed. From 0,7 to 2 meters deposits consist (up to 80% of the mass) of fine-grained sand and silt, while the fraction 0,05 – 0,01 mm (coarse-grained silt) makes up 50% of the mass. These deposits are well sorted and have thin stratification. The results show that described sediments should be classified as lacustrine deposits. Deposits of the upper 0,5-0,7 meters of the section are probably wind-borne after the lake stopped existing.

In conclusion, previously stated geological and geomorphological data can be described as a positive evidence of proglacial lakes existence in the Upper Volga region. The research was supported by RSF (project No. 17-17-01289).

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LATE PLEISTOCENE-HOLOCENE ENVIRONMENTAL AND CLIMATIC CHANGES IN THE BAIKAL REGION INFERRED FROM MULTI-PROXY LACUSTRINE RECORDS

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Humanity today lives in an unusual time. It is proved that greenhouse gas concentrations are increasing rapidly and are now much higher than they have been for at least 420,000 years. Global average temperatures exceed anything seen in the last thousand years. In general, climate on Earth naturally undergoes changes driven by external factors and internal causes. Natural forcing mechanisms will continue to operate and will play a role in future climate variations. By studying the records of climate variability and forcing mechanisms in the relatively recent past, it is possible to understand how the climate system varied under "natural" conditions, before anthropogenic forcing became significant. Lakes are one of the best objects for studying the climate of the past since they act as excellent "sentinels of change" (Williamson et al., 2009) by providing signals that reflect the influence of climate change in their much broader catchments. Their sediments provide natural archives for past environmental change. In many cases, the study of lake's bottom sediments (i.e., paleolimnology), and the biotic and abiotic components in particular, that combine information from the water column, catchment area, atmosphere, can help assess baseline conditions for different physical, chemical, and biological systems (e.g., climate, ecosystem development), as well as the recovery times after disturbances of ecosystems (Pienitz, Lotter, 2009).

A large share of paleolimnological research in Baikal Region has focused on climate records from lakes located in the vast areas of boreal taiga-forest and semi-arid areas of western Baikal Lake shore and in Trans-Baikal region. These environmental and climate records are concerned with changes in temperature, precipitation or effective moisture. Most of these lakes are fresh or brackish with various depths. The most commonly used proxies are pollen, diatoms, stables isotopes ($\delta^{13}C$, $\delta^{18}O$), grain size and various geochemical variables.

Among the lacustrine records, proglacial and moraine lakes, lava-dammed lakes as well as lakes of tectonic origin, are often considered to be especially well suited for paleoenvironmental studies. Reconstructions of the Baikal Region environment and climate history using multi-proxy lacustrine records testify to the global teleconnection of climate variability at glacial-interglacial, orbital and shorter time scales but also reveal distinct regional climate processes.

The most recent studies have made an important contribution to the detailed reconstruction of the natural environment, climate and vegetation of the Baikal region in the last glacial-interglacial cycle and, especially, to the understanding of the post-glacial history of regional.

For example, results of drilling in Lake Kotokel (southeastern coast of Lake Baikal), Lake Baunt (northeastern wing of the Baikal Rift Zone hollows), several glacial and lava-dammed lake in the Zhom-Bolok River valley (the Eastern Sayan Mountains, the area of the largest manifestations of Holocene eruptions in the Central Asia) contribute to the continuous debate concerning the degree of climate amelioration and the chronological framework of the MIS3 interstadial and the Holocene climatic optimum in Siberia.

The discontinuous pollen, diatom, diatom-inferred oxygen isotope, geochemical data from the abovementioned lakes were used to infer a drier/colder-than present late Pleistocene climate in the southern part of eastern Siberia even during the interstadial episodes of climatic amelioration that are visible in the taiga (maxima) and steppe (minima) biome scores. The reconstructed pattern of changes in the regional environments demonstrates that the late Pleistocene climate dynamics in southern Siberia were more complex than previously thought, and resemble the temperature variations (e.g. Greenland interstadials and Heinrich events) expressed in the δ18O record from Greenland ice and the East Asian Monsoon intensity signal in the δ18O record from Chinese stalagmites. Minor inconsistencies could be explained by the lower accuracy of regional age models, the lower resolution of the regional records in comparison to the above δ18O records.

The full glacial occurs in the regional pollen, diatom, XRA records at ~30/28–17 kyr BP and is marked by an increase in herbaceous taxa percentages, the highest scores for steppe and the lowest scores for taiga biome, suggesting an increased aridity/continentality of the regional climate and the predominance of open herbaceous communities in the landscape. The noticeable decrease in diatom concentrations followed by the virtual disappearance of diatoms from the KTK2 sediment (laminated grey silty clay) at ~31.5–17 kyr BP might be another indicator of the dry and cold climate with strongly pronounced seasonality. A similar dramatic reduction in diatom abundance occurred in Lake Baikal during periods of climate deterioration during the MIS3 interstadial (Mackay, 2007). The highest percentages of Ranunculaceae pollen at ~30–23 kyr BP support a shift of meadow/wetland communities closer to the coring point, suggesting that regional lakes was much smaller in size than today during this probably the dry interval.

The reappearance of diatoms in small quantities might be a sign of a slight amelioration of the regional climate at ~24–22 kyr BP, which might have influenced the aquatic ecosystem of small lakes. Both herb/grass-dominated pollen assemblages, the absence of aquatic macrophytes at ~22–17 (21-18) kyr BP point to a second phase of climate deterioration, conventionally associated with the Last Glacial Maximum.

A gradual increase in tree/shrub pollen percentages after ~18 kyr BP and changes in the diatom, lithology and geochemical records after ~17 kyr BP indicate the late-glacial climate amelioration in the region. The multi-proxy records from different lakes (e.g. decrease in woody cover, increase in tundra biome scores, marked changes in the diatom assemblages, geochemical indices, elemental ratios) clearly identify the YD stadial in the Lake Baikal region, allocating it within ~13–11.5 kyr BP.

The Holocene vegetation and climate dynamics in the region under study was reconstructed from the Kotokel Lake and Lake Baikal pollen records (Tarasov et al., 2009). The chronological sequence of environmental change reconstructed from several lacustrine records shows great similarity with the previous study. The maximal spread of the boreal forest (taiga) communities is associated with higher-than-present July and January temperatures and precipitation, reconstructed at ~10.5–7 kyr BP (Tarasov et al., 2009). A noticeable increase in *Pinus sylvestris* pollen recorded after ~7 kyr BP reflects the spread of Scots pine in the Lake Baikal region (Demske et. al., 2005; Bezrukova et al., 2011), in line with the onset of drier and colder (similar to present) climate.

The relatively high temporal resolution and reliable AMS-based age models of several lacustrine pollen, diatom, geochemical records enable their comparison with the reference palaeoclimatic archives representing North Atlantic (e.g. Svensson et al., 2008) and North Pacific regions (Yuan et al., 2004). This comparison suggests that the reconstructed shifts in late Pleistocene–Holocene vegetation and environments in the Lake Baikal Region could have been controlled by the major factors controlling NH climate.

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THE CHEMICAL COMPOSITION OF SEDIMENTS AS A CRITERION FOR ASSESSING THE STATE OF LAKES IN THE HUMID ZONE (ON THE EXAMPLE OF THE KARELIAN LAKES)

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An assessment of the condition of the reservoir is a difficult task. Most often it is solved on the basis of a multidisciplinary approach, which includes a set of physical, hydrological, chemical, and biological criteria. Bottom sediments are natural archives, storing information about the evolution of the lake throughout its history. The possibilities of using the characteristics of sediment as criteria for assessing the state of the lakes to date remain insufficiently studied.

Karelian Lakes in the course of their existence passed a number of successive stages of development: from accumulators of mineral terrigenous material during the Pleistocene period (conditions of the nival climate), to the development of Holocene aquatic ecosystems producing organic matter (humid climate conditions).The speed of development of lake ecosystems depends both on the local features of the watersheds (geomorphology, rock composition, soils, vegetation, economic activities, etc.) and the reservoirs themselves (morphology of the basin, hydrological regime, chemical composition of water, biological characteristics). It should be noted that the bottom sediments of the deep zone, where the accumulation of matter occurred continuously, most fully reflect the global and local changes in the natural and climatic conditions, the geological features of the catchment area and the impact of human economic activity.

The complex of criterial characteristics of bottom sediments proposed by the authors is based on taking into account the main factors influencing the formation of precipitation. The chemical characteristics of precipitation (type of lacustrine accumulation) common to all lakes in the region are determined by the controlling influence of the climate and the composition of the rocks of the eastern slope of the Baltic Shield. Local catchment conditions and differences in anthropogenic load are responsible for the individual chemical characteristics of bottom sediments in each reservoir. Under humid climate conditions in the lakes of Karelia, silicon, humus (organic matter) and iron make up the bulk of the matter of present bottom sediments, which is a sufficient basis for incorporating the accumulation of silicon, organic matter and iron in the system of general estimation of sedimentation and as criteria determining the state of the lake. On the basis of these three characteristics of the chemical composition, the modern sedimentogenesis of the lakes in the region has been typified. Basically in the lakes of Karelia a mixed type of sedimentation is observed: Fe-Si-humus, Fe-humus-Si, or humus-Fe-Si. Sometimes there are small lakes, which can be attributed to a monotype: a humus, Si and Fe type of accumulation. Carbonate sediments, lying under the Holocene layer, are found in small lakes in the northern part of Karelia. Their accumulation was associated with the arid climate of the arctic desert. At present, in the conditions of humid climate, silicon and Si-humus sediments are deposited in these lakes.

Bottom sediments are a complex open nonequilibrium colloid-dispersed system into which the suspended matter of water continuously enters and in which various processes (physical, chemical, biological) take place. The physical and physicochemical parameters of the sediments, such as density, moisture, specific weight, porosity, pH, Eh, describe the state of the medium in which the sedimented matter is transformed. Geochemical characteristics of the environment are considered as criteria for assessing the state of the reservoir by bottom sediments, as it allows to judge the conditions, the general tendency and intensity of diagenetic processes. (Belkina, 2003, 2005, 2011, 2015, 2017).

An important characteristic of the general background of sedimentation, which makes it possible to divide lakes according to the principle of accumulation of matter, is the ratio of the mineral and organic parts in the bottom sediments. This indicator allows us to judge with some approximation the degree of influence of terrigenous and biological factors in the total pool of material arriving to the bottom. Classical indicators giving this information are loss on ignition (550 ° C) (LOI), and ash content (900 ° C) (A). Lakes where the LOI: A <0.45 refers to the mineral type of accumulation. In lakes where the ratio LOI: A> 0.65 in bottom sediments is observed accumulation of organic matter. Lakes, where the ratio of the ratio of LOI: A varies from 0.45 to 0.65 refer to water bodies with a mixed type of accumulation.

The composition of the organic matter of the bottom sediments is extremely diverse (proteins, simple and complex carbohydrates, amino acids, ethers, phenols, aldehydes, ketones, etc.), which makes it difficult to study these systems. Most of the organic matter is made up of natural polymers of irregular composition (humic substances), which justifies the use of generalized characteristics for describing the entire aggregate of organic substances. The most important of these are the elemental composition (C, N, O, P, H, S) of the organic substance and the various ratios of these elements, the oxygen equivalent (the amount of oxygen required to oxidize the unit mass of dry ashless organic matter), COD and BOD, the degree of oxidation and the electrochemical valence of carbon, humic and fulvic acids. The trophic status of the reservoir can be estimated by the pigment composition of the bottom sediments.

The study of the geochemical history of the reservoir is carried out on the basis of a chemostratigraphic analysis of the bottom sediment sections. The dynamics of the main components and the physicochemical characteristics of the medium are studied. To the above characteristics, proposed for use in the system of criterial assessment of the state of the reservoir along the bottom sediments, it is necessary to add trace elements that play an important role in the life of organisms: elements of the electrolyte background (Na, K, Ca, Mg, Cl), as well as other biometals (Zn , Cu, Mn, Ni, Mo, Co). The analysis of the distribution of elements in the section (morphology and synchronism of variations) provides information on the process of sedimentogenesis in the past and its changes in the catchment area and in the lake.

Over the past 100 years of civilization development, the influence of the anthropogenic factor on processes occurring in lakes has increased many times. Geochemical indicators of economic activity in bottom sediments are the chemical elements actively used by man and synthesized compounds. Observations of contamination of bottom sediments are an integral part of monitoring of water bodies in the developed countries of the world. The choice of pollutants primarily depends on the characteristics of the industrial and agricultural complex of the territory.

The main industries in the structure of the economy of Karelia are forestry, pulp and paper and mining. Pollutants, degree and mechanism of influence on water bodies of various types of economic activity are different. Consider the possible environmental risks of each of the industries.

The development of the forestry sector (deforestation) causes erosion of the soil cover as a result of weathering, which increases the eolian and terrigenous streams of matter entering the reservoirs. Deforestation also affects the water balance of the catchment area: evaporation increases and, accordingly, the volume of water flow to the lake decreases. As a result, the inflow into the pool of substances in a dissolved form decreases. Increasing the turbidity of water and reducing the level of the lake can contribute to the development of eutrophication processes, for example, overgrowing of a reservoir. The consequences of the changes will be traced in changes in the micro- and macro-composition of the terrigenous material.

Mining, namely quarrying (mining of non-metallic materials) significantly increases the flow of terrigenous matter into water systems, as a result of which the turbidity of the water rises, and mineral sediments accumulate in the bottom sediments. High rates of sedimentation contribute to burial of detritus in bottom sediments, which can have a positive effect on the lake ecosystem (slowing of eutrophication). But at the same time, the burial of unoxidized organic matter favors the development of anaerobic processes, changes in the mineral part of the sediments and the introduction of toxic gases (methane, hydrogen sulphide, etc.) and soluble mineral elements forms back into the water.

One of the consequences of the development of agriculture is the increase in terrigenous demolition in the reservoir, as well as in the case of deforestation and mining by the quarry method. It should be specially noted that the introduction of fertilizers coming into the lake from the fields causes an increase in the productivity of the lake, which consequently accelerates the accumulation of matter in the bottom sediments (especially N and P) and, in general, the degradation of the lake as an element of the landscape. The intake of pesticides used in agriculture can be dangerous for hydrobionts.

It should be noted that any populated areas, and especially large cities - are powerful sources of pollutants, accumulation of which occurs in bottom sediments (oil products, heavy metals).

Bottom sediments are inextricably linked with other components of the aquatic ecosystem (water, higher aquatic vegetation, benthos, periphyton). An increase in the flow of matter into the reservoir leads to changes in the chemical composition of the water, the biological and hydrological characteristics of the lake, the physicochemical conditions of sedimentation, the chemical composition of the bottom sediments, and the diagenesis of the sediment. The result of the changes is an increase in the risk of secondary pollution of the reservoir, the danger of migration of pollutants along food chains of living organisms, the end point of which can be a human.

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DIATOMS IN THE THANATOCOENOSIS OF THE LAKE ZAPOVEDNOYE (EVENKIYA)

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Diatoms are one of the main proxies of the lake condition in the past. In this work we present the first data on the composition and quantitative distribution of diatoms species from the bottom sediments of the lake Zapovednoe (Evenkiya).

Lake Zapovednoe (60° 31'N, 101° 43'E) is a freshwater lake located at the Verkhnyaya Lakura River in the Tunguska Nature Reserve, about 60 km from the settlement Vanavara. The lake is about 500 m in diameter, a round form and a depth about 47 m. Sampling was carried out in March 2015 from the ice in the central part of the lake with a gravity corer with removable plastic pipes with a diameter of 90 mm (UWITEC, Austria). Data on the distribution of ^{137}Cs and ^{210}Pb isotopes at the depth of the cores were used for preliminary dating of the upper layers (Darin, Kalugin, unpublished. Sub-samples were processed using 30% hydrogen peroxide and analyzed for diatoms by light microscopy (Bolobanschikova et al., 2015).

The results showed that the thanatocenosis of the lake Zapovednoye has a rich species composition of the diatoms. More than 40 genera of diatoms were found in the core. We emphasized several genera that play a major role in the quantitative and qualitative results of the analysis. The core has a several zones, in which abundance of these genera changed. Planktonic species correlated with other planktonic species: *Aulacoseira* sp. - *Lindavia* sp. - *Discotella* sp., and benthic species correlating with other benthic species: *Cocconeis* sp. correlated with *Cymbella* sp., and *Fragilaria* sp. correlated with *Epithemia* sp. (fig.1).

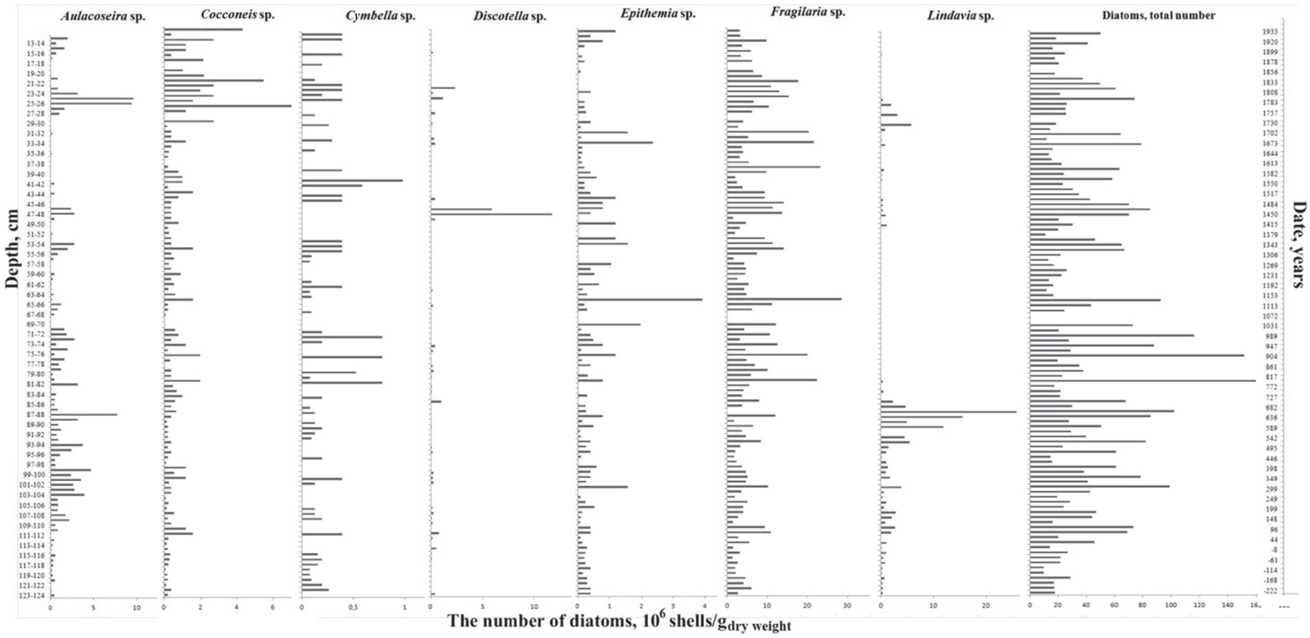

Fig. 1. Distribution of the diatoms in the bottom sediments of the Lake Zapovednoye

Also a periodic explosion of diatoms *Lindavia lemanensis* (Chodat) T.Nakov et al. and *Discostella stelligera* Cleve and Grunow) Houk and Kle are interesting. These species are known to be dependent on the ratio of nutrients - nitrogen (N) and phosphorus (P) (Saros, Anderson, 2015): the high concentration of these elements contributes to increasing of the number *Cyclotella sensu lato* species. Also the abundance of these species is influenced by the availability of light.

In all cases the maximum values of *L. lemanensis* and *D. stelligera* species were preceded by an increase of the number *Epithemia* sp., which has an endosymbiotic N-fixing cyanobacteria. It can be assumed that the change in the number of shells *Cyclotella sensu lato* is probably due to change in level of N-concentration in the lake. Also an increase in planktonic species was preceded by an increase in benthic species *Cymbella* sp., *Cocconeis* sp. and *Fragilaria* sp., except for the lower core layers. Perhaps this indicates the favorable conditions for benthic diatoms and probably entails an increasing of the eutrophication level and sedimentation rate for that moment. We suggest that the changes in the water level of the lake were a main cause of these changes.

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LAKE GALICH DURING THE LATE VALDAI (WEICHSELIAN) GLACIATION

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Lake Galich is located in the central part of the East European Plain, in the region where glacial relief of the Moscow stage of the Dnieper glaciation is widespread (the Warthe stage of the Saale glaciation). This territory lies outside the area of the Late Valdai (Late Weichselian) glaciation, but its northern part was partly occupied by the large proglacial lakes during the Last Glacial Maximum (LGM) and during the subsequent main stages of this glaciation. After melting of the glacier, these vast lakes did not preserve for long, and as the river valleys incised, most of them were drained. Only the lakes located in more favorable tectonic environment persisted, in particular, those within the wide Yaroslavl' tectonic trough, such as Lake Galich and other largest lakes of this region – Pleshcheyevo, Nero, and Chukhloma (Rumyantsev et al., 2015).

Lake Galich (58° 24' N, 42° 17' E, 101.2 m a.s.l.), the largest natural lake in the region, is located in the northeast of the Kostroma lowland, which is bounded by the Uglich-Danilov Upland from the northwest and by the Galich-Chukhloma Upland from the southeast. The lake is 17 km long and up to 6.4 km wide and stretches from west-south-west to east-north-east. The area of the lake is 71.1 km^2, the average depth is 1.3 m, and the maximum depth is 3.5 m. The lake is weakly flowing, strongly overgrown with macrophytes, and at the present stage hypertrophic. Most part of its bottom is covered with a layer of gyttja of 3-8 m thick (the maximum thickness is about 12 m).

Sedimentation in the Lake Galich occurred continuously since the end of the Middle Pleistocene. Over this time, more than 100 m of lacustrine sediments accumulated with undisturbed bedding of layers. After the retreat of the Moscow ice-sheet, which left moraines and fluvioglacial deposits both in the bottom of the basin and on the surrounding interfluves, the accumulation of clays in Lake Galich has begun (Moscow glacial cover …, 1982). In the Mikulino (Eemian) interglacial they were overlain by lacustrine sediments, which are preserved in the deepest parts of the basin (Evseenkov et al., 1967; Pisareva, 1971). Accumulation of lacustrine sediments continued during the Early and Middle Valdai. Based on the analysis of topographic maps, aerial photographs and geological materials available at that time, D.D. Kvasov (1975) suggested that, at the maximum stage of the last glaciation, when the ice-sheet obstructed the flow of rivers towards the north, a chain of extensive lakes formed along its margin. Lake Galich became part of the proglacial Kostroma Lake, which occupied the Kostroma lowland and connected with the Sukhona Lake in the north and the Rostov Lake in the southwest. It is assumed that the shoreline of this vast lake was at about 145 m above sea level during the LGM, at 130 m a.s.l. in the Vepsian stage of the Last glaciation, and at 120 m a.s.l. in the Luga stage (Kvasov, 1975). Analysis of the maps constructed by D.D. Kvasov (1975, figure 7) shows that during all these stages the basin of the present-day Lake Galich occupied the apex of a deep and narrow ingression bay, in spite of significant changes in the levels.

The most comprehensive data on the landscape and climatic conditions and the nature of sedimentation in the Lake Galich during the last glacial epoch were obtained in 1997-2000 within the framework of the projects of the German Science Foundation FKZ 03F13GUS and the Russian Foundation for Basic Research (project No. 98-05-64534) (Velichko et al., 2001a, 2001b). The coring of the deep borehole Galich-2 was carried out near the eastern coast of the lake. It penetrated the Valdai (Weichselian) deposits to a depth of 69 m. Another borehole (Galich-1) was drilled in the central part of the lake; it penetrated lacustrine mud and gyttja to the depth of 11.9 m below the lake floor. A series of AMS radiocarbon dates obtained by Prof. P.M. Grootes in the Isotope Laboratory of the University of Kiel indicates that the 70m thickness of lake deposits accumulated for more than 50 thousand years (Velichko et al., 2001a, 2001 b), beginning from the Early Valdai (= Marine Isotope Stage 4). Accumulation continued during the Middle Valdai iterstadial (MIS 3), the Late Valdai (MIS 2), and in the Holocene up to app. 5 ka BP (calibrated), when this part of the lake basin became filled in, and peat accumulation started on the lake shores. Calibration of the ^{14}C dates using the IntCal13 and Marine13 calibration curves (Reimer et al., 2013) and the construction of the depth-age model on their basis make it possible to determine the positions of the boundaries of isotope stages in the core and calculate the apparent sedimentation rates of lake sediments.

The granulometric analyses of lake sediments (Velichko et al., 2001a) indicate very stable sedimentation conditions that persisted throughout MIS 3 with a steady trend toward an increase in particle size. In the section from bottom to top, clay, heavy loam and medium loam occur with an average accumulation rate of 1.4 mm per year. At the beginning of the Late Valdai (at the boundary of MIS 3 and 2), the sediment accumulation rate does not change, but the fraction of coarse silt (0.05-0.01 mm – the main component of loess deposits) reaches a maximum content (about 60%) in the granulometric composition. Perhaps this reflects the participation of eolian material in the composition of the lake sediments of this age. Simultaneously, the content of the fine particles (<0.005 mm) is reduced by almost 20%, which can be explained by a decrease in the activity of chemical weathering processes due to a considerable cooling. In the second half of the Late Valdai, after LGM, the mean accumulation rate decreases to 0.8 mm per year, although the particle size of the sediments increases: the medium loam is overlain by a light one, then by a layer of strongly silted mixed-grained sand and again by light loam (Velichko et al., 2001a). Apparently, these changes were associated with a less stable (intermittent) accumulation of sediments in conditions of greater unevenness of rainfall and water flow due to the general aridization of climate. The formation of a sand layer in the deposits of Lake Galich can be presumably compared with the stage of the Younger Dryas at the end of the Last glacial epoch. Sedimentation in the lake sharply accelerated in the Middle Holocene, about 7 ka BP, when in the conditions of significant warming the productivity of the lake increased, and the accumulation of mineral deposits was replaced by the formation of gyttja.

The results of pollen analysis (Velichko et al., 2001a, 2001b) make it possible to reconstruct the changes in vegetation and climate on the territory surrounding the lake during much of the Valdai glacial epoch. During the last interstadial warming of the Middle Valdai (estimated age 32-24 ka BP) the vegetation was of a periglacial forest-steppe type; open forests and woodlands were then formed by spruce, pine and tree birch. In the maximum stage of the Last glaciation (24-17 ka BP) the proportion of woody vegetation, especially of spruce forests, was reduced, primarily due to the arid climate. The periglacial-steppe communities with *Artemisia* prevailed, with limited participation of pine forests. The more intensive sedimentation not only of coarse silt, but also of sandy fractions at this time indicates the development of erosion on the slopes surrounding the lake, poorly protected by disturbed vegetation. This is also indicated by an increase in the proportion of Mesozoic spores, reworked from the terrigenous deposits of the Early Cretaceous and Jurassic age widely spread in the area (Velichko et al., 2001b).

At the beginning of the Lateglacial warming (about 17 ka BP), the role of forest communities with the participation of birch, and later also spruce, increased, while the composition of herbaceous communities remained close to that of the maximum stage of the Last glaciation. In the landscapes around Lake Galich, open forest, shrub, periglacial-steppe, and meadow communities occurred. Spruce played an important role in the forest communities. In the Younger Dryas, the processes of slope erosion sharply intensified and sediment yield from the area surrounding the lake increased, resulting in the accumulation of sandy material in the lake. The Younger Dryas was the last stage when in this region in the conditions of cold, continental, and relatively arid climate, periglacial-steppe vegetation spread.

The results of comprehensive studies of the deposits of Lake Galich, however, do not yet make it possible to unequivocally solve the question of whether Lake Galich was part of the huge Kostroma proglacial lake during the Late Valdai maximum. According to the hypothesis of D.D. Kvasov (1975), during the LGM the water level in the Kostroma lake reached 145 m a.s.l., while the deposits of the same age in Lake Galich, according to our studies, lie at the height about 80 m a.s.l. Consequently, the water depth at the top of the gulf of the Kostroma Lake corresponding to the present Lake Galich basin, at a distance of no more than 15 km from the shore, was to reach 65 m. During the Middle Valdai interstadial, this ice-dammed lake has not yet existed, and the depths in the Lake Galich then probably did not exceed 10 m (similar to the early Holocene conditions). In connection with this, it seems unlikely that such a dramatic change in the depth of the lake did not cause any appreciable changes in the textures of the bottom sediments. However, due to the "marginal" location of the basin of Lake Galich within the Kostroma proglacial basin, the area from which sediments would have been transported into this basin by incoming rivers even at its highest stage would be close to the modern one, since the drainage basins of the main rivers flowing into Lake Galich lie to the east and south of it. The texture of the bottom sediments accumulated during the post-maximum half of the Late Valdai glaciation indicate the development of erosion in the catchment area, and perhaps even some catastrophic washout episodes in the sparse vegetation conditions, but there is no pointers to the existence of a vast and deep (more than 30m) proglacial lake in place of a modern Lake Galich. For a reliable solution to this problem, further research is necessary, in particular, the study and dating of sediments on high terraces presumably of lake origin in the Lake Galich basin.

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LITHOLOGY AND SEDIMENTARY GEOCHEMISTRY OF CORE CO1410 FROM LAKE IMANDRA (KOLA PENINSULA, NW RUSSIA)

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The Late Quaternary climatic and environmental history of the Kola Peninsula, which is one of the key areas for study of glacial-preglacial-postglacial environments in the European Arctic, has been the focus of many palaeoenvironmental studies since the end of 19th century. However, Lake Imandra – the largest lake in the European Arctic – has not yet been properly studied, and even no one long core containing the whole Holocene record was recovered from this lake. With the aim to obtain new deeper insight into the development of climatic and environmental history of the Kola Peninsula during the present interglacial period and to improve the understanding of previous findings, we employed lithological and geochemical analyzes (XRF scanning, CNS, TOC/TIC) as well as measurement of magnetic susceptibility (MSCL logging) on an 8.5 m long sediment core (Co1410, N67°42.946', E33°05.107') recovered from Lake Imandra in September 2017. The results provide detailed information concerning changes in lake productivity, water and sediment loads into the lake basin, as well variations of lake level and lake-ice-cover conditions during and since the last deglaciation. The coarse-grained sub-angular moderately sorted sediments at the core base suggest fluvio-glacial processes and a short distance transport of these sediments. They are overlaid by organic-poor varved sediments of a proglacial lake, deposited under perennial ice cover and near anoxic bottom-water conditions likely during the first half of the Pleistocene-Holocene transition. Throughout the second half of the terminal Pleistocene and the Early Holocene an accumulation of organic-rich sediments was initiated, pointing to increasing lake productivity and related to well-oxygenated bottom waters suggesting prolonged ice-free periods. The elemental composition of the Holocene sediments speaks of low lithogenic input into the lake basin and increasing chemical weathering within the lake catchment, indicating a rise in air temperature and establishing of extensive vegetation cover stabilizing slopes and preventing erosion. The uppermost sediments indicate again the extreme local erosion linked to the beginning of apatite-nepheline and Cu-Ni mining close to Lake Imandra, which is resulted in a slight deterioration of conditions for producing autochthonous organic matter.

The sediment core is currently under investigation at the collaborating institutions in Germany and Russia. Here, we provide an overview about the fieldwork at Lake Imandra and highlight some of the initial interpretations made on the basis of existing analytical data.

This research including logistics for the expedition and all analytical works was funded by the DFG–SPbU project "Last and current interglacial environments of Kola Peninsula, as reflected in the sediment record of Lake Imandra" (No. 18.65.39.2017).

VARIATIONS IN SOLAR ACTIVITY AND CHANGES IN THE LEVEL OF KHAKASSIA SALT LAKES IN THE LAST MILLENNIUM

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Core samples of bottom sediments of salt lake Shira and Bele, located in the steppe zone of Southern Siberia (the Republic of Khakassia and the southern part of the Krasnoyarsk Territory) were investigated. The sediments have the thinly laminated structure with the annual stratification (varves), which makes it possible to build reliable time models of core depth vs sediment age with an accuracy of ~ 2% over a time interval of the last centuries. The scanning X-ray fluorescence microanalysis was carried out at the experimental station "Element Microanalysis" of the Siberian Synchrotron Radiation Center. The possibility of varying the spatial resolution of the analysis (scanning step) from 1 mm to 15 μm made it possible to study both the inter-annual and intra-annual variations in the chemical composition of the bottom sediments. Analysis of the distribution of microelements over the depth of the cores resulted in detection of a set of microelements (geochemical indicators) that react to changes in sedimentation conditions due to regional climatic conditions changes. Transfer functions based on geochemical time series have been calibrated in the interval of 1925 - 1985 AD according to regional instrumental meteorological observations. That enabled building quantitative paleoreconstructions of the lake level (salinity) change over the past 2000 years with a step of one year. Analysis of the paleoreconstructions revealed presence of natural cycles with periods of ~ 100, ~200, ~ 460, and ~ 990 years. Comparison of the of Lake Shira level reconstruction with the low-frequency component of solar activity (Sun spots number) shows a significant correlation (the correlation coefficient is +0.64) over a time interval of the last three centuries (1670–1980).

PALAEOENVIRONMENTAL MESSAGES FROM MOUNTAIN LAKES OF EASTERN SIBERIA

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Sedimentary records from mountain lakes of eastern Siberia provide insight into palaeo-environmental changes over the late Pleistocene to Holocene, as revealed by palaeolimnological multiproxy approaches on the basis of sedimentological, geochemical, and micropalaeontological data series (diatoms, chironomids, pollen, palynomorphs).

Lake Billyakh in the central Verkhoyansk Mountains existed during the last 50 ka and was formed by tectonic and deglacial processes. Our lake record suggests final deglaciation around 35 ka BP in association with a high lake-level stage during the Karginian interstadial. Geomorpho-logical findings, however, point to earlier deglaciation already sometime after 85 ka BP. Karginian warming with muted signs of millennial climate variability is documented by short-term lake-level fluctuations and vegetation dynamics (40-31 ka BP). The Sartanian glacial stage was characterized by low lake level and colder and dryer conditions, followed by Holocene climate amelioration and lake-level rise after 11.5 ka BP.

Another palaeolimnological record comes from Lake Bolshoe Toko in southeastern Yakutia, Russia. The lake occupies a basin at the foot of the northern slope of the eastern Stanovoi mountain range. At its north-eastern margins the lake is bordered by moraines of three different glacial sub-periods. First findings from sediment cores reveal a glacial advance during the last glacial maxi-mum, which likely did not affect the whole lake, as former glaciations did. Postglacial development was characterized by a lake-level lowering during the mid-Holocene by at least six metres.

The overall climate history of eastern Siberia is consistent with trends across the higher northern hemisphere, while the sequence of mountain glaciation is out of phase with the global ice-volume pattern, possibly because of complex atmospheric moisture routing effects, which so far are poorly understood for eastern Siberia.

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CONTINUOUS PALEOENVIRONMENTAL SEDIMENT RECORD FROM TWO LAKES ON VALDAY ICE MARGINAL ZONE STARTED SHORTLY AFTER THE ICE RETREAT

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This work presents the results of multi-proxy studies of the sediments from two lakes in the eastern part of the Valdai Highlands, which is the marginal zone of the last ice sheet. At the Zvan and Piros lakes, a ground-penetrating radar profiling was carried out and several lake sediment cores up to 5 m long were retrieved with the Russian peat corer. The cores were subject to visual analysis of lithological facies, the analysis of the organic carbon and nitrogen content, pollen and diatom analyzes. To determine the age of the sediments, a number of radiocarbon dates were obtained. As a result, we performed detailed reconstruction of vegetation evolution since the ice sheet retreat and found that significant mass of dead ice had degraded about 14 cal. ka BP. For the first time in this region, the first peak of spruce has been clearly dated and referred to the period 14-13 cal. ka BP. Oscillations of the level of small lakes in the Holocene were controlled by climate. Karst processes played an important role in the formation of modern lake basins. The clear traces of the agricultural activity shortly before 2000 cal. a BP were discovered.

FIRST RECORD OF PHREATALONA PROTZI (HARTWIG, 1900) (CLADOCERA, CHYDORIDAE) IN PECHORA DELTA, NENETS AUTONOMOUS REGION, RUSSIA

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Cladocera (Branchiopoda: Crustacea) is the key component of aquatic ecosystems. They are commonly used in paleoecological reconstructions of climatic and environmental change. Cladocerans indicate changes in the effect of various abiotic and biotic environmental factors on the condition of lakes (trophic status, acidity, depth, lake-level changes, ionic structure of water etc.). The studies of cladoceran assemblages in lakes have demonstrated and suggested that this group of hydrobionts can be successfully used as an indicator of the changes caused by climate change occurring in the ecosystem [1].

The study area is located in the Polar Circle, within the Pechora River delta, at the territory of the Nenets State Nature Reserve. Subfossil cladocerans of the Nenets autonomous okrug are poorly known. However, the data available currently on subfossil cladocerans in the region under investigation are insufficient.

The sediment samples from 17-Pe-03 lake (68°11′30.8″N, 53°47′36.2″E) were used for analysis of subfossil cladoceran remains. *Phreatalona protzi* was discovered for the first time in this region of Russia and this is the most eastern point of findings of this species. *Ph. protzi* can be distinguished by its characteristic shape of headshield with a short rounded rostrum and a notched posterior margin of carapax. We found head shields, carapaxes and postabdomens in the sediment samples (Fig 1).

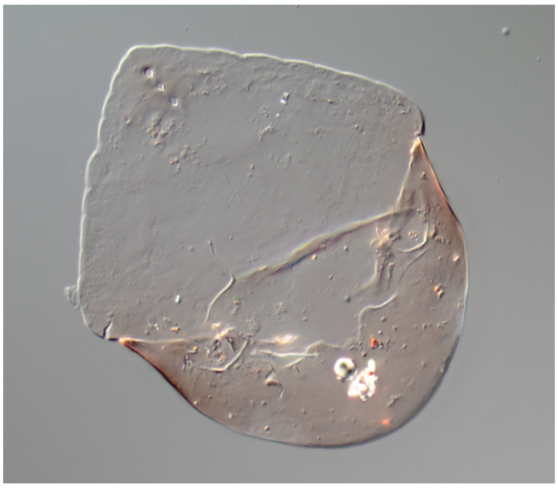

Fig. 1. Photos of headshield (200 µm) and postabdoment (140 µm) of *Phreatalona protzi* (Hartwig, 1900) from lake 17-Pe-03 (Pechora Delta, Nenets Autonomous Region, Russia)

According to Kotov, *Ph. protzi* is distributed in Central and North-East Europe, in streams and rivers on river sand [2]. The species has been found in Finland, Ireland, England, Belgium, Germany, Poland, Czech Republic, Slovakia, Hungary, Romania [3], Turkey, France [4]. The ecology of *Ph. protzi* is poorly known. The species is adapted to permanent riverine conditions and may have lost the ability to withstand desiccation or temperature fluctuations [3]. The environmental spectrum of the finding sites is wide and ranges from relatively nutrient poor clear water lakes to eutrophic turbid water lakes, thereby indicating that *Ph. protzi* is not narrowly restricted to particular habitats. Rare species reported from lakes, springs, river adges, in channels, in small streams mostly in hyporheic zone [3]. *Ph. protzi* occurs under various environmental conditions and has no clear preference to, for instance, lake area or depth. [5]. The findings of this species indicate a periodic flow of river water into the water area of lakes.

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CHANGES IN CLADOCERAN ASSEMBLAGES FROM A SMALL ARCTIC LAKE (NENETS AUTONOMOUS OKRUG, RUSSIA)

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Arctic and subarctic regions have been of considerable interest to researchers during the recent years. It is widely accepted that high-latitude regions play an essential role in climate forcing and may be particularly sensitive to climate change. Climate change and active development of the Far North territories have already lead to negative consequences by disturbing a fragile balance of northern ecosystems, which are known as the systems with a low degree of resistance to anthropogenic influence and an extremely low rate of restoration.

Cladocera (Branchiopoda: Crustacea) is the key component of aquatic ecosystems.They are commonly used in paleoecological reconstructions of climatic and environmental change. Their chitinous exoskeletal components (shell, head shield, postabdomen, postabdominal claws, antennal segments, and mandibles) are usually well preserved after death in lake sediments. Furthermore, most of them are identifiable to the species level. Ecological data have been obtained for most cladoceran species. It has been proved that they are sensitive to changes in climate and environmental variables, such as trophic state, electric conductivity, salinity disturbances, and predation intensity (Jeppesen et al, 2003; Frolova et al. 2016). The aim of the present investigation was to analyze the taxonomic and ecological diversity of cladoceran microfossil assemblages from a lake in the catchment area of the Pechora delta (Northeast Europe, Russia).

The lake 11-Pe-03 (68°11′30.8″N, 53°47′36.2″E) has a thermokarst origin. The lake is characterized by low electric conductivity, pH 7.2, and prevalence of bicarbonate-calcium water composition. The greatest depth (2.0 m) was recorded in the southern part of the lake, but the average depth is 1-1.5 m. One core (11-Pe-03A, 48-cm long) was used for analysis of subfossil cladoceran remains. The sediment samples for cladoceran analysis were studied using the standard techniques described in Szeroczyńska and Sarmaja-Korjonen (2007).

A 0.5 g subsample was placed in a ceramic crucible and heated at 1100˚C for 2 h to determine the loss on ignition (LOI).The structure of bottom sediments is characterized by an increase in the proportion of organic material (LOI). The LOI varies between 0.9 and 2.9% at the beginning of the stratigraphy and increases constantly to approximately 30.2-32.8% towards the surface sediment.

The species distribution of cladoceran remains in recent sediment layers was similar to that observed in contemporary water samples. The cladoceran assemblages were quite rich and diverse in speciesfor all studied lakes, including the lake 11-Pe-03, with relatively stable structures. A total of 27 cladoceran taxa, of which 21 taxa are in the family Chydoridae, were identified from the core 17-Pe-03. The most common cladoceran taxa were as follows: *Chydorus sphaericus*, *Alona guttata / Coronatella rectangula,* and *Bosmina (Eubosmina) longispina* (all had the occurrence frequency of 100%). The bottom part of the core is characterized by the dominance of cold-water pelagic taxa (*Bosmina (Eubosmina) longispina*, and *Chydorus sphaericus*s.l.) and small taxa of the genus *Alona*. The obtained data show considerable changes in cladoceran assemblages along the studied core. The most common taxa at the top of the core are *Chydorus sphaericus*s.l., *Pleuroxus uncinatus,* and *Alonella nana*, all increased significantly in number towards the top of the core. The observed changes in the cladoceran fauna reflect an increase in the trophicity of the lake 17-Pe-03. The dominance of the cladoceran *Chydorus sphaericuss.l.*, the species associated with high nutrient status, suggests that the lake had elevated productivity. This is also indicated by the presence of *Pleuroxus uncinatus*, *Alonella nana,* and *Disparalona rostrata*, because these taxa occur mostly in mesoeutrophic localities, as well as by the high number of cladocerans and the high organic content of the sediment.

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RECONSTRUCTION OF THE POST-GLACIAL ENVIRONMENTAL VARIATIONS BASED ON THE MULTI-PROXY APPROACH: DŪKŠTELIS LAKE, EASTERN LITHUANIA

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Though numerous lithological, palaeobotanical and chronological investigations were carried out across the territory of Lithuania revealing environmental variations during the Lateglacial and Holocene, not so much is known about the changes of the sedimentological regime of the basins that has been directly determinate by the climatic fluctuations, surface dynamic, anthropogenic impact and etc. Deglaciated during the earliest stages of the Lateglacial, the Eastern part of the Lithuania serves as a promising area for the evaluation of the above mentioned fluctuations.

Here we briefly present results of the detailed interdisciplinary approach, involving geological techniques, applied to investigate post-glacial sedimentological changes of the Dūkštelis basin situated in the Eastern Lithuania (54° 50’ 10”N, 25° 9’ 59”E). The investigated site is located in the marginal area of the Last Glacial Maximum, surrounded by the formations of the South Lithuanian Phase, within the hummocky moraine zone. From the North boggy area borders with end moraine and glaciolimnic sediments are located southwards. In order to reconstruct the post-glacial geological-geomorphological development of the surroundings of Dūkštelis site, a set of black-white stereoscopic aerial photos (scale 1:17 000; 1952) has been interpreted. Alongside with this, the area was also digitalized applying the digital reconstruction model LIDAR (Guobytė and Rimkute, 2013). Obtained data suggested that Dūkštelis Lake was one of a few in the lake system that existed in area during the Lateglacial. Since the onset of the Holocene the size of the water bodies decreased by around 85%.

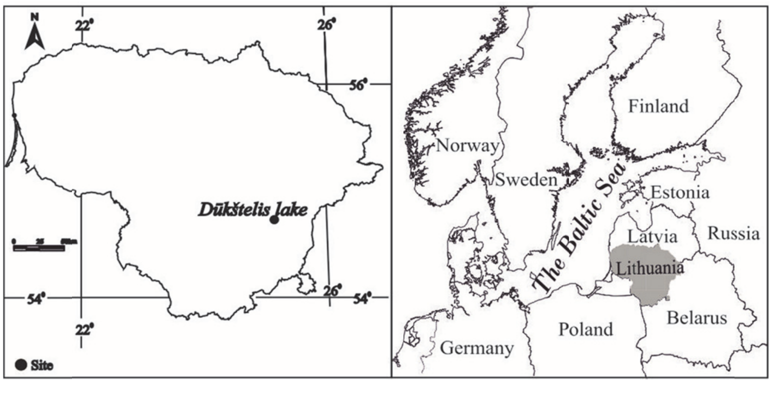

Fig. 1. Location of the study area

Post-glacial history of the local catchment and surrounding morphology have been analyzed taking in to account the results of the multiproxy studies of the Dūkštelis Lake sediment sequences. All together 7 cores have been taken and analyzed, records synchronized through lithological boundaries as well as magnetic susceptibility data. According to that, cross sections of the paleolake were modeled. The complex investigations of the deepest sediment core (1300 cm) consisted of palaeobotanical (spore-pollen analysis), lithological (grain-size and loss-on-ignition survey (LOI)), measurements of magnetic susceptibility (MSus), isotopic (^{14}C, AMS, $\delta^{18}O$ and $\delta^{13}C$) studies and geochemical analysis. In total, 127 pollen samples, 110 samples for grain-size, 636 samples for MSus, 44 samples for isotopes, 133 for LOI and 86 - for geochemical elements were investigated. More than 500 terrestrial pollen grains were counted per sample and taxa are presented as percentages of sums of arboreal and non-arboreal pollen grains. Age/depth model was constructed according to the age/depth plot median values; sediment accumulation rate was calculated for each centimeter of the core. Besides pollen and spores, green algae such as Pediastrum (e.g. P. simplex, P. duplex) and testate *amoebae* (*Amphitrema flavum*) taxa, were calculated. Alongside notes were taken for bigger mineral pyrite crystals.

Based on characteristic taxa and results of cluster analysis investigated sediment sequences were sub-divided into seven sedimentological stages (Fig. 2.).

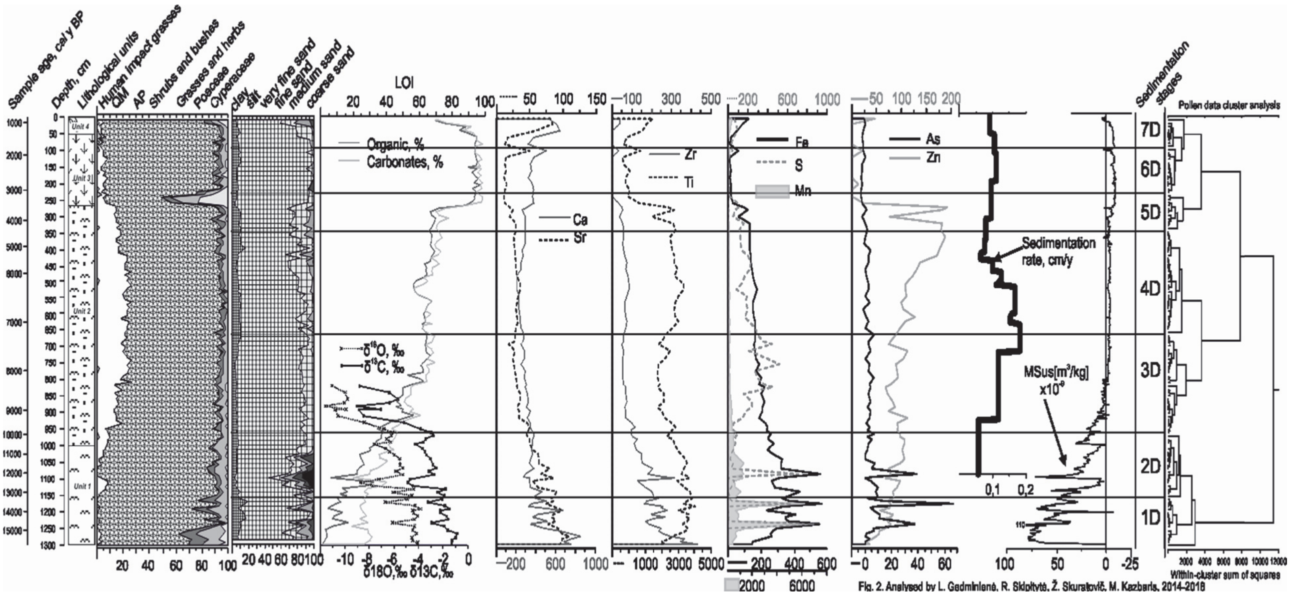

Fig. 2. Summarizing diagram of multi-proxy approach of the deepest sediment core taken from Dūkšteliai Lake

Stage 1D (before 13,200 cal BP). During stage 1D Dūkšteliai Lake was an open water basin. The lowermost lithological unit (Unit 1) contains richly calcareous gyttja, laminated, light bluish-greyish, sandy-silty, with clay lenses and with very low input of organic matter. MSus values are high within this interval. The geochemical investigations proves high instability of this record with high peaks of S, Fe, Mn, As. Enrichment of the sediments by Ti and Zr as well as high concentration of Ca and Sr proves terrigenous origin of investigated strata. *Juniperus – Betula* – Cyperaceae - *Hippophae rhamnoides* found in the bottom part of the sediments (LPAZ 1P) responses to Early Bølling pollen zone, the first thermal episode in Lateglacial (Fig. 2.). At the time, the natural environmental conditions were unstable, poor vegetation predominated and the soil was in the process of formation in most places. Simultaneously, the environment (in surface sediments) was filled with fine terrigenous substance which could easily get to the bottom of the lake sediments due to intensive erosion.

Stage 2D (13,200 – 9,900 cal BP). Multi-proxy records reflect high palaeoenvironmental instability in stage 2D. Firstly, in the beginning of this sedimentation interval broadleaved trees pollen appears in the pollen spectrum (approximately at about 13,000 cal BP). At the same time remarkable peak of organic matter and drop of MSus curve is visible, as well as extremely low isotopic $\delta^{18}O$ and $\delta^{13}C$ values, significantly lower Fe, S, Mn, Zr, Sr is determined. All data point to a climatic amelioration, with higher bioproductivity, which initiated migration of the elements to which the organisms are capable of adapting themselves, simultaneously providing a removal of the excess elements. A warm period with a decreased of some elements sedimentation was comparably short. According to the modeled data, if the sedimentation at that time could have been about 0,06 cm/year, 0,5 m warm interval representing sedimentation interval could have lasted about 800 years and which probably was interrupted with some cold event, that could have lasted no longer than 300 years. This is suggested by appearance of dryer and colder climate tolerant vegetation pollen such as Ericaceae, *Artemisia*, *Juniperus* in the pollen diagram. Simultaneously, a remarkable input of coarse grained sand is seen, which nicely correlates with higher concentrations of Zr and Ti, Sr and the increase of MSus. At the upper part of 1D sedimentation stage obtained data suggest the instability of the environment gradually decrease as i.e. predominance of thin layer of soil on the lake shore, remarkable fluctuations of the water table, changes in redox conditions and etc. calms down.

Stage 3D and 4D (9,900 – 7,300 cal BP and 7,300 – 4,500 cal BP). Multi-proxy data in lithological Unit 2 suggest an amelioration of the general climatic situation. Broadleaved tree pollen dominates in the spectrum. Accumulation rate fluctuate from 0,1 to 0,2 cm/year. The highest accumulation rate is determined in the Middle Holocene, at about 6,500-7,500 cal BP at possible Holocene thermal maximum. Described bed is covered by gyttja, consisting of 40 - 70% of organic matter. Here, sediments have a decreasing trend of MSus, with increased sulfur curve in the *Stage 3D* and high concentration of Zn approaching the upper limit, *Stage 4D*, of the interval. Recorded composition of the sediment bed points to the predominance of high water level and intensive mineralization, but also fast deposition processes and very high bioproduction. A lake contains excess dissolved nutrients, it becomes eutrophic. Green algae increased curve indicate lake trophic stage maximum and hydrological condition change accordingly. Highest pyrite accumulation correlates with green algae maximum and probably could be caused by the lack of oxygen in the deeper water bed.

The highest representation of the organic matter was recorded in the third lithological unit, which consists of more or less decomposed peat. Describing the environmental dynamics, 3 sedimentation stages (5D-7D) have been identified within this unit.

Stage 5D (4,500 – 3,100 cal BP). This stage is represented with very high pollen and spore concentration, increasing curve of organic matter, Ca, Zn element concentration, the flourishing of the aquatic (*Typha, Menyanthes, Nymphaea*) taxa, grasses and herbs. Simultaneously, the gradual decrease is noted in Sr, Ti, Zr, Fe, S and MSus representation. In the beginning of this stage very fine and fine grained sand has higher values. Recorded changes both in geochemical and biological proxies could point to constant reproduction and decomposition of the large amount of biomass in a eutrophic system.

Stage 6D (3,100 – 1,800 cal BP). Abrupt appearance and flourishing of Sphagnum, maxima exhibited by Ericaceae. At this sedimentation stage closed basin and shallow shores, nutrient-enriched water initiated bogging processes that started in the basin.

Stage 7D (after 1,800 cal BP). The top of the sediments consists of disintegrated peat with very fine to coarse sand and an increased MSus values. Sediment slightly enriched with heavy metals, more carbonaceous. High flammability at the latest stage of the sediment formation is observed.

Conclusions: A detail radiocarbon dating of the section revealed that the area deglaciated much earlier than it was thought before. At the beginning of the Early Holocene the climate stabilized coursing formation of the rich soil layer. Formation of the entire plant cover prevented erosional processes. Alongside with the closing of the basin more and more nutrition concentrated in the lake which led to its eutrophication while the decrease of oxygen content slowed down the mineralization of organic substance. At the end of the Middle Holocene the investigated part of the lake bogged up.

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PALAEOGEOGRAPHY OF THE LOWER KUYA VALLEY (EUROPEAN ARCTIC RUSSIA) OF THE LATE HOLOCENE

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Previous study of the Quaternary palaegeography of the Kuya River valley (Lavrov, Potapenko, 2012; Andreicheva, 2002; Isakov et al., 2017) does not concern the Holocene environmental history. Our preliminary conclusions from investigation of lithological composition and palynological study of Holocene alluvium have been presented earlier (Marchenko-Vagapova, Buravskaya, 2017). The results are supported by new palynological data.

The alluvial sediments in the Lower Kuya valley in the European part of the Russian Arctic were studied in section K12 (67°37′N, 53°24′E) which is a left bank cutting 4 m high (Fig. 1).

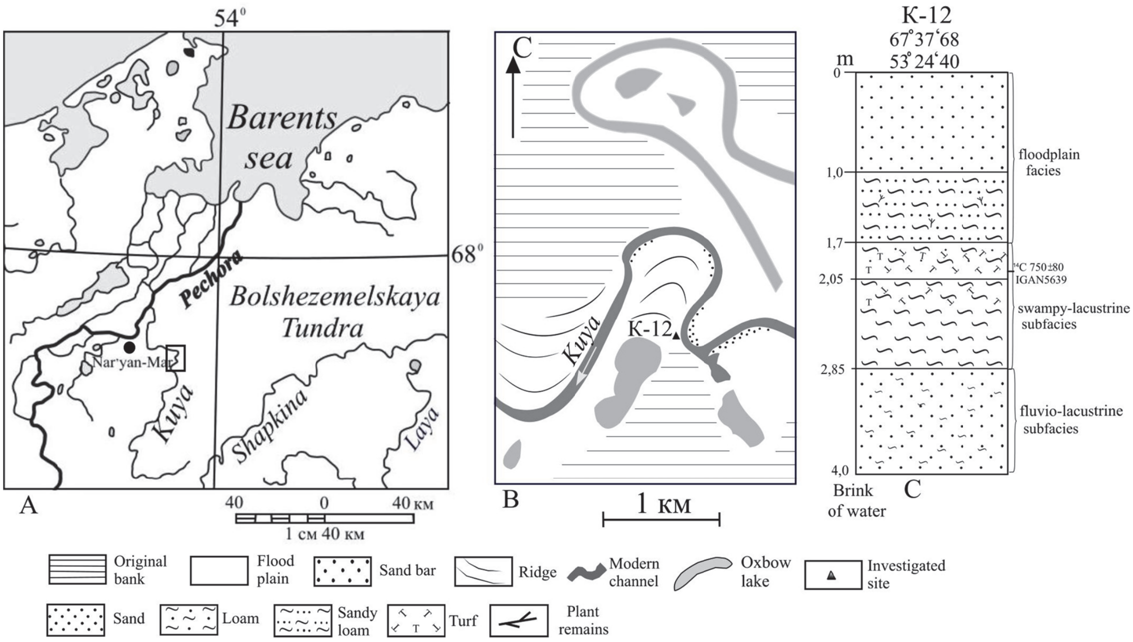

Fig. 1. The Kuya 12 site
A. Location of the investigation site. The study area is shown with square
B. Geomorphological scheme of the site
C. Lithological composition of the Kuya 12 section

The sediments are composed of flood plain and oxbow-lake facies (fluvio-lacustrine and swampy-lacustrine subfacies). The fluvio-lacustrine subfacies is the bottom of sedimentary beds (depth 2.85 – 4 m) and composed of grey fine-grained clayey sand. These deposits formed in flowing water reservoir, when an initial lake was connected with a channel. The lowermost sediments contain spectra (pollen zone K12-I, 4-2,65 m; Fig. 2) showing the coldest climate during the studied interval. The spectra are dominated by *Betula* sect. *Nanae* and Poaceae pollen. High amount of Bryales spores is also characteristic. The spectra composition indicates the development of a dwarf-birch tundra at the beginning of the Subatlantic period.

The overlying swampy-lacustrine subfacies (depth 1.7 – 2.85 m) is composed of blue-grey clay and clayey peat and is correspond to deposits accumulating in closed lake and bog lake during the middle - late Subatlantic. Pollen zone K12-II (2,65-2,05 m) is notable for a dramatic increase in *Picea* and *Pinus sylvestris* (in the lower part of pollen zone K12-II) and *Betula* sect. *Albae* (in the upper part of pollen zone K12-II) indicate the stands of forest-tundra character development during the middle Subatlantic. The presence of an aquatic environment supported by *Menyanthes, Potamogeton* and *Nymphaea* pollen. The occurrence of *Nymphaea* confirms that temperatures were higher than present. The late Subatlantic (LIA cooling) is identifiable by spore-pollen spectra (pollen zone K12-III, 2,05-1,7 m), supported by radiocarbon date 750±80 BP (IGAN-5639). The cooling enabled the spread of shrub vegetation (dwarf birch, alder and willow). Grasses were also very common. Species from Cyperaceae, Poaceae, Ericaceae, Primulaceae, Onagraceae, Ranunculaceae, Rosaceae, Caryiphylaceae, *Filipendula,* Fabaceae, *Valeriana*, Asteraceae, *Thalictrum, Chamaepericlymenum* grew in the area.

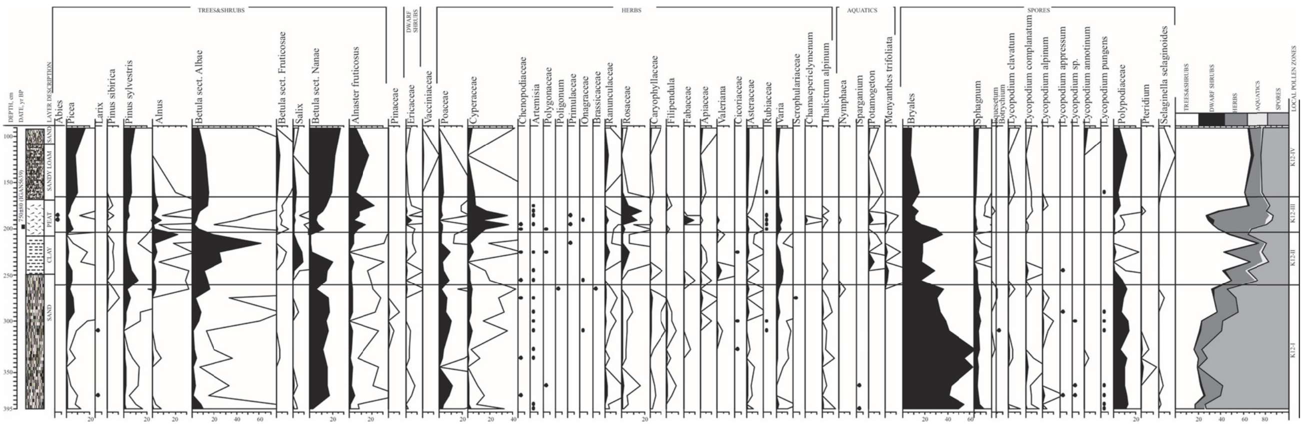

Fig. 2. Pollen percentage diagram of the Kuya 12 section

The clay and peat deposits are overlying by brown sandy loam with plant remains of the flood plain facies (depth 0 – 1.7 m). Pollen zone K12-IV (1,7-0,9 m) reflects a gradual development into the present forest-tundra and southern tundra mosaics of open woodlands, dwarf-shrubs and grasslands. The dominant vegetation of the wider surroundings consists of dwarf-shrub heaths (with e.g. *Betula nana,* Ericaceae). Sparse spruce and birch forests grow along the riverbed. The pollen zone K12-IV is notable for an increase *Picea* and Poaceae pollen contents. Increases in *Sphagnum* and Polypodiaceae percentages are also characteristic, while Bryales is decresed.

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APPLICATION PALEOGEOGRAPHIC DATABASE OF «Q–KOLA» IN THE STUDY OF THE PLEISTOCENE–HOLOCENE BOUNDARY

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The Kola Peninsula is situated entirely on the area of the Fennoscandian Shield on the NW Russia. In a small area there are immediately natural zones: tundra, forest tundra and taiga, what is due of features of geology and development of the area in particular the close location from the center of glaciation, the influence of the Barents and White Seas. The study of the Pleistocene - Holocene events on the peninsula is still in progress.

Lakes of the Kola Peninsula were formed from periglacial lakes or lakes from the sea, which were reflected directly in the bottom sediments as information storage.

A database „Q-Kola“ (Fig.1) [Grekov & Subetto, 2014a,b; Grekov et al., 2014, Grekov & Subetto, 2015] was created to systematize and structure various information on the paleogeography of the region. In modern geoinformation systems, it becomes possible to interactively work with information sources and process the data itself. Particular attention is paid to the lake sediments in the database, but there is also information on peat sediments, paleosoils and outcrops along river valleys. The database „Q-Kola“ contains information on the location of the studied objects, the results of analyzes and references to original publications.

Structuring and cartographic representation of information about region allows for spatial analysis of the territory for different time sections and under specified conditions [Syrykh et al., 2017; Myasnikova et al., 2017; Grekov et al., 2018].

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LATE GLACIAL EROSION AND PEDOGENESIS DYNAMICS: EVIDENCE FROM HIGH-RESOLUTION LACUSTRINE ARCHIVES AND PALEOSOLS IN CENTRAL EUROPE

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Sediments from three paleolakes and two paleosol horizons in south Bohemia, Czech Republic, provide evidence of climate change and landscape evolution in central-eastern Europe on millennial to centennial timescales over the Late Glacial (~16–11.5 ky). Based on a combination of geochemical, sedimentological and geophysical proxy indicators, along with the pollen record and soil micromorphology, we propose a relationship between vegetation cover, soil development, and erosional processes. Four major and two minor environmental stages, identified in all investigated paleo-lakes, were broadly correlated with the Late Glacial climatostratigraphy. Short-term (decadal to centennial) climatic deteriorations between the Bølling and Allerød, and within the Allerød, have been correlated with the Older Dryas and the Intra-Allerød Cold Period (IACP) respectively. B horizons of two (gleyic) podzols discovered under aeolian sand dunes in the lake catchments were dated to the Allerød interstadial and were parallelized with Usselo soils – pedostratigraphical marker horizons of west- and northern-central Europe. The upper parts of these soils have signs of colluvial processes. According to the radiocarbon dating, the erosion occurred at 13,155 ± 150 cal. yr BP and can be associated with the IACP event, which is marked by a significant input of allogenic material into the lake basins. We attribute the significant increase in the iron and consequent phosphorus content in the lake sediments during the Allerød to the podzolization that occurred with the humid interstadial conditions.

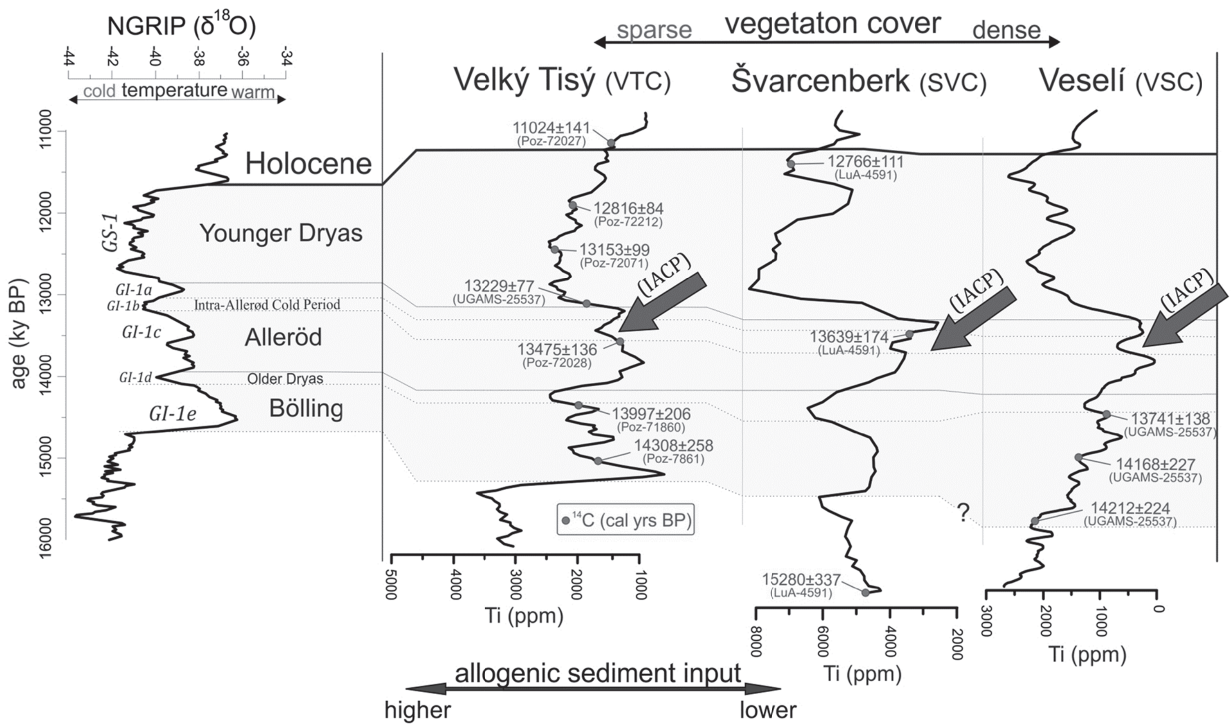

Fig. 1. Correlation of Ti-records from palelakes Velký Tisý, Švarcenberk and Veselý with δ18O record from NGRIP

TRACES OF THE LATE WEICHSELIAN THERMOKARST LANDSCAPE ALONG THE SOUTHERN MARGIN OF THE FORMER EUROPEAN PERMAFROST ZONE

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Thermokarst is the geomorphologic/genetic designation for areas where thaw of permafrost leads to local or widespread collapse, subsidence, erosion, and instability of the ground surface. Although thermokarst processes are recently peculiar to regions underlain by permafrost, i.e. in particular to lowlands of high latitudes Arctic areas (Alaska, Canada, northern and eastern Siberia), geomorphology and sediments reflecting former thermokarst presence can be found also in middle latitudes, far from the recent permafrost areas. So-called "fossil thermokarst" features, including thermokarst gullies, lakes and other kind of depressions, have been documented from many areas of northern and northwestern Europe as well as from Northern America. In contrast to those areas,

the knowledge on the thermokarst processes and landscapes along the southern margin of the Last Glacial permafrost zone (i.e. ~44–47°N) is still relatively fragmental.

Presented research deals with the Late Pleistocene geomorphological and sedimentological evolution of the Třeboň region in South Bohemia, Czech Republic, (49.1°N, 14.7°E; 400–430 m asl) located during the Last Glacial Maximum ~110 km north of the Alpine piedmont glaciers and ~ 420 km from the southern edge of the North European Ice Sheet.

Periglacial features like fossil polygons, nets or ice-wedge pseudomorphs documented in the study area prove the presence of permafrost in the region during the Late Pleistocene. We have also observed involution features (ball-and-pillow structures, injection tongues, and festoons) formed in unpaved sandy sediment, which testify permafrost degradation processes, probably during the Late Weichselian.

Moreover, besides these periglacial features, we have discovered overall 27 depressions filled by lacustrine sediments and peat. Most of them are covered by artificial fishponds of Medieval and Modern origin and thus hardly recognized in the landscape. These basins vary in size (tens up to hundreds of meters in diameter) in the depth of their infill (1–12 m), nevertheless, they share several common features such as their location on Miocene sedimentary bedrock, elongated shape, and the presence of tectonic faults that often run along their major axis. According to radiocarbon and relative palynostratigraphical dating, the largest basins (Fig. 1) were formed along the Pleniglacial/Late Glacial transition (~ 16–15 ka), whereas the smaller depressions during the Late Glacial/Early Holocene. Based on detail geomorphological investigations (approx. 300 hand drilling) and comparison of the geological and hydrogeological setting of the study area with the classical thermokarst landscape of Central Yakutia, we assume that these basins are the result of the complex of thermokarst processes, including formation and collapse of *alases* and consequent surface degradation of the permafrost, which occurred here during periglacial conditions of the Late Weichselian.

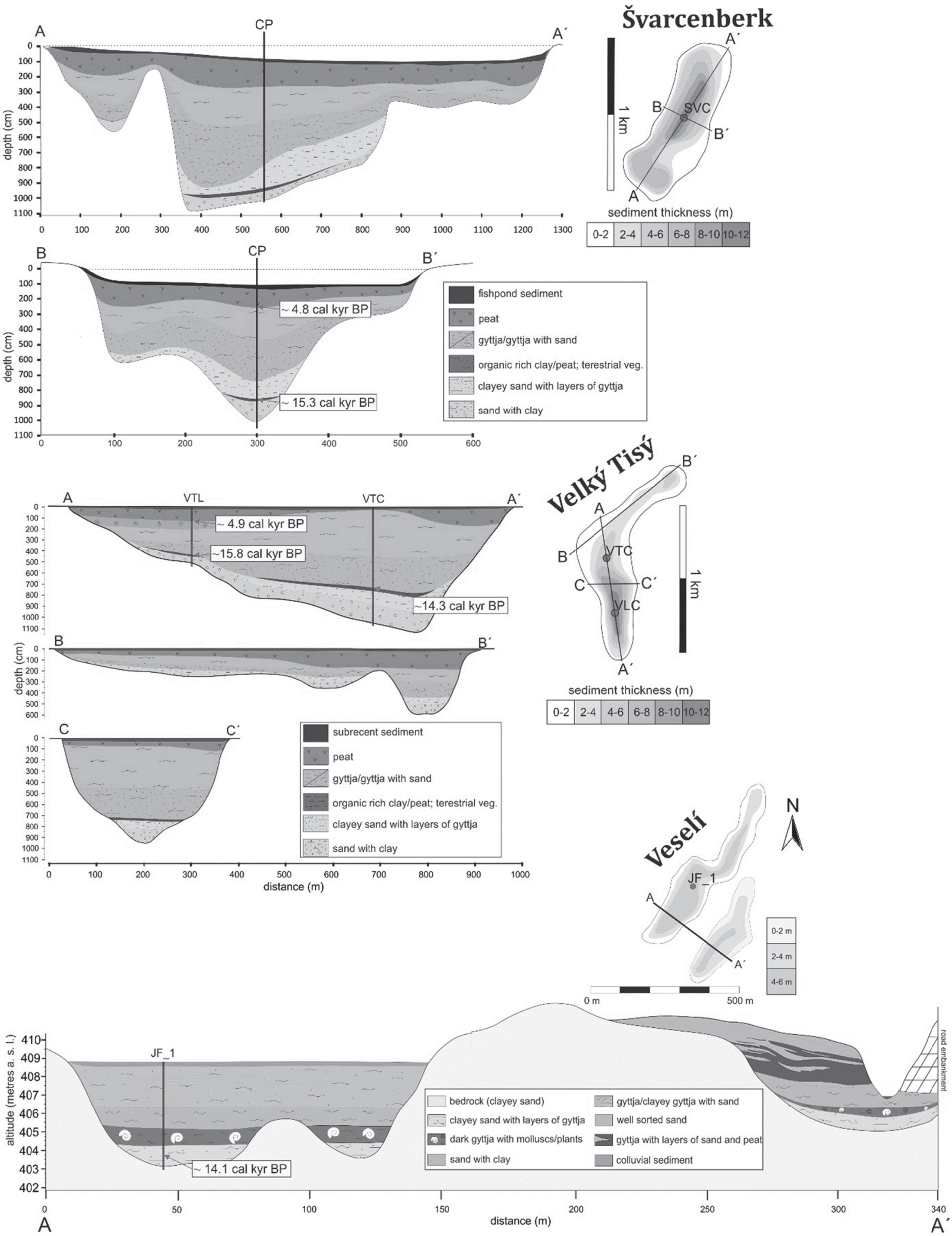

Fig. 2. Cross-sections through three biggest lake basins –, Švarcenberk, Velký Tisý, and Veselí n. L. together with results of radiocarbon dating of the basal sediment (calibrated radiocarbon ages)

SHAPE VARIATIONS OF GRASS PHYTOLITHS IN EURASIA: TOWARDS IMPROVED INTERPRETATION OF FOSSIL PHYTOLITH RECORD USING NEW METHODS OF GEOMETRIC MORPHOMETRY

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Analysis of microfossil silica phytoliths is becoming an increasingly important research tool in paleoecology. A considerable amount of investigations focused, for instance, on the evolution of grassland ecosystems. Such an advance was achievable mainly by the fact that generally used classification of grass phytolith short cells (*GSSC*) allows determination of grasses to the subfamily level. The standard method used in phytolith analysis is based on qualitative identification of idealized morphotypes (Madella et al. 2005), which relies mostly on visual cues of the shape and requires highly trained experts. An alternative quantitative approach could minimize the observer's bias and ensure the consistency of data between labs. Moreover, quantitative approach provides data on a continuous scale, which reflects better the continuous variation of phytolith shape.

Here, we demonstrate a modern methods of size and shape analysis, called geometric morphometry, which have a considerable potential for classification of phytoliths. This method focuses on analysis of so called *landmarks* - structurally homologous anatomical loci (Zelditch et al., 2004). The *landmarks* contain in their coordinates information about their relative positions, which can provide entire image of shape variations of the investigated object. We present an example of such an analysis performed on phytolith data obtained from reference collection of various grass species of Eurasian flora.

Our findings suggest that application of geometric morphometry for analysis of phytolith *landmark* coordinates has a considerable potential to discriminate between species. Besides, the analysis of *landmarks* allows to explore (and quantify) intra-specific variation in phytolith shapes, which is assumed to be controlled by changing environmental conditions. Understanding of environmentally induced variations in phytolith shape, which was not possible with qualitative methods, is, nevertheless, crucial for correct interpretation of fossil record. Thus, a dataset of *landmarks* acquired from modern reference material can be utilized for objective interpretation of the fossil phytolith record

We conclude that methods based on geometric morphometry represent highly effective tool with a considerable potential not only to enhance objectivity of phytolith research, but also to improve the ability of phytolith analysis to differentiate between grass taxons considering also intra-specific variations in phytolith shape. We suggest that such an approach, which can be readily performed thanks to freely distributed software (Rolf 2006), could be reasonable alternative to standard methods used in phytolith analysis.

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RECONSTRUCTION OF THE PAST CONDITIONS OF IVANOVO REGION USING SUBFOSSIL CLADOCERA ANALYSIS OF LAKE RUBSKOYE

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It is widely known that Cladocera is an important group of organisms of modern aquatic ecosystems that inhabit all types of recent continental water bodies. Standard hydrobiological analysis can assess the current state of the lake, while the study of subfossils can explain changes in taxocenoses at all stages of the lake sedimentogenesis. Chitin structures of the Cladocera exoskeleton preserve well in the bottom sediments (carapax, postabdomen, postabdomenal claws, mandibles, head shields, etc.) that allows to identify the remains up to species or generic ranks.

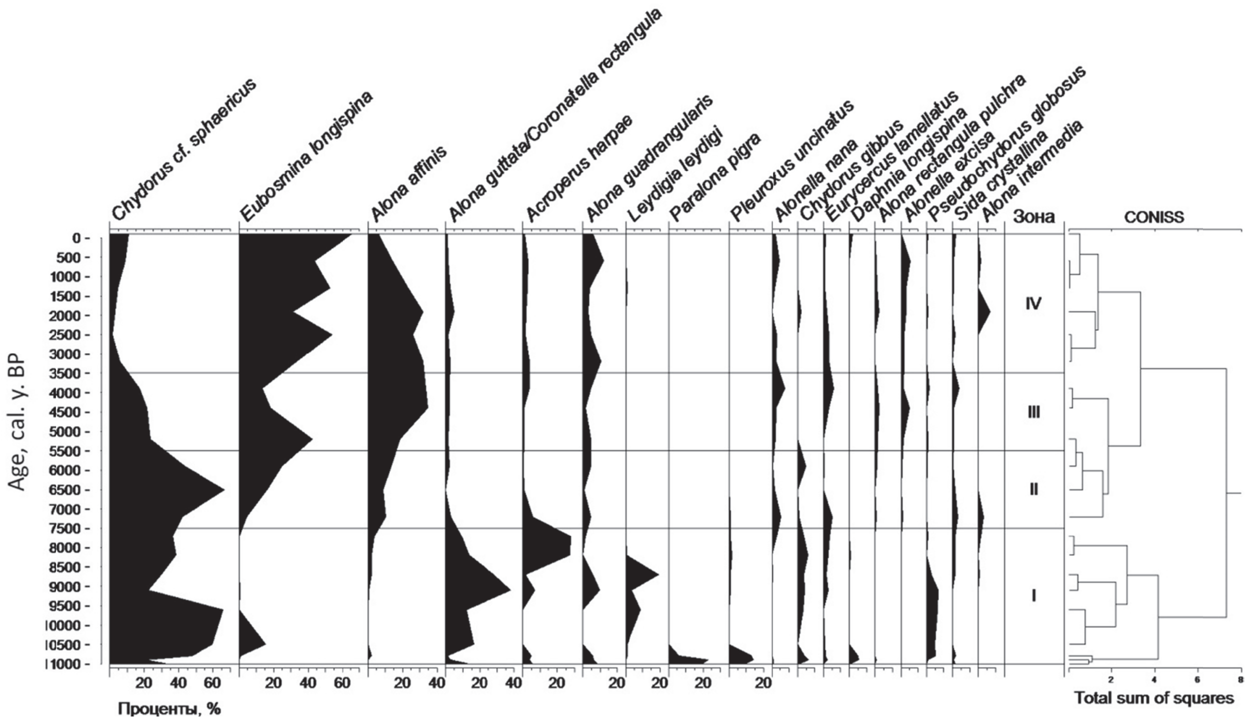

Fig. 1. Statigraphyc diagram of the Rubskoye lake cladoceran community

Rubskoe Lake (N 56°43′33″, E 40°36′51″) being a relict lake of glacial origin, is located in Ivanovo Area and belongs to the territories of special natural importance of the pan-European level. A core of bottom sediments of 4.98 m depth was taken from Lake Rubskoe. Age of lower layer is 11000 cal. y. according to results of radiocarbon dating conducted at the Institute of particle physics of the Federal University of technology of Switzerland (ETN). 23 subsamples of sediments (with the step of 10 cm) were selected for a cluster analysis. Key-books for subfossil and recent Cladocera were used to identify remains from the sediments.

As a result of the samples study, we identified remains of 38 taxa of the Cladocera. According to the Lyubarsky scale, there are no dominant taxa among the cladocerans, *Chydorus* cf. *sphaericus* and *Bosmina* (*Eubosmina) longispina* are subdominants. Typical arctic species inhabiting the lake at earlier stages of its formation are replaced by taxa preferring temperate conditions in course of the water body development. Four faunistic zones were separated according to the statigraphyc diagram of the cladoceran community (Fig. 1). Increasing of *Bosmina (Eubosmina*) *longispina* in the layers of 8500 cal. y. probably associated with increasing of the pelagic zone surface in the water body at that time. In many cases there is an obvious correlation between changes of certain taxa rates in the taphocoenosis of Lake Rubskoe and climatic changes at that time.

The Shannon-Weaver index values are ranged from 1.66 to 3.37, average is 2.56+0,08. Index Pielou values are ranged from 0.29 to 0.6, with an average of 0.46+0,01. Such values characterises the community structure as not sufficiently aligned.

The attempts to explain the faunal succession and detailed analysis of incremental changes will be presented in our communication.

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GEOCHEMICAL SIGNS OF EXTERNAL CONDITIONS OF SEDIMENTATION IN SALT LAKES BY THE DATA OF HIGH-RESOLUTION RECORDS

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Modern lakes are sensors - recorders of external conditions of sedimentation. Essentially they are an integral part of the geochemical system gas + liquid + solid, limited by the catchment area in space and developing in time from the origin of the water basin to the present. The study of such a system is aimed at climatic conditions restore by geochemical variations, measured in the solid phase (bottom sediments). If we follow to the climate definition as the average annual weather oscillations, then the problem is the search for the geochemical response of bottom sediments to the current weather fluctuations first of all, and then - quantification of this response that can be extrapolated for the age layers. Thus, the final reconstruction of paleo-conditions to the complete depth of sampling is based on synchronous hydro meteorological observations and is representative of the chosen system.

Lakes accumulate runoff products representing more or less disintegrated and chemically weathered eroded rocks. Bottom sediments of salt lakes in comparison with freshwater ones contain additional chemically precipitated mineral masses (mainly carbonates and sulphates). In eutrophic lakes and marshes, large quantities of organic matter accumulate. Thus, the constituents of bottom sediments are three basic substances: aluminosilicates, carbonates and organic masses. The geochemical indicators served as signals of external conditions of sedimentation is a direct problem to be solved by regime observations on modern objects. Periodic layered structure (including annual layering) allows revealing geochemical indicators in bottom sediments due to high resolution from tens of microns with the help of modern technology such as XRF scanning. Accordingly, the available ranges of climatic events have a time resolution of year-season. In this case, the annual range of changes (winter-summer) of the main external parameters in the sludge formation system, as a rule, overlaps the amplitude of long-term oscillations of the same parameters. Thus, the correlations between indicators and weather meteorological observations allow us to reveal the geochemical indicators necessary for further calculations of a transfer function, which converts analytical data into the time series of the target parameter. Point numerical estimates are useful in assessing the physicochemical conditions of mineral formation by the equilibrium system diagrams.

The figure shows the main geochemical indicators for the bottom sediments of Lake Shira, representing the composition of the layers and the environmental conditions (Fig. 1).

Geochemical characteristics of bottom sediments constitute a multiple response to changes in the external environment, including short-term events and age-old fluctuations. Some of them can have a significant statistical connection with the desired target parameter. Within the quantitative approach to solving the inverse problem (paleo reconstructions), it is necessary to have an initial time series for the natural target parameter to provide statistically correct training in calculating the multiple regression equation for past reconstructions. For example, the optimal duration of a year's series is 60-100 years. The most relevant reconstructions for the temperature of surface air, the amount of atmospheric precipitation, the hydrological regime, including the level of water bodies correspond to the weather scale (monthly, seasonal, annual, 10-year).

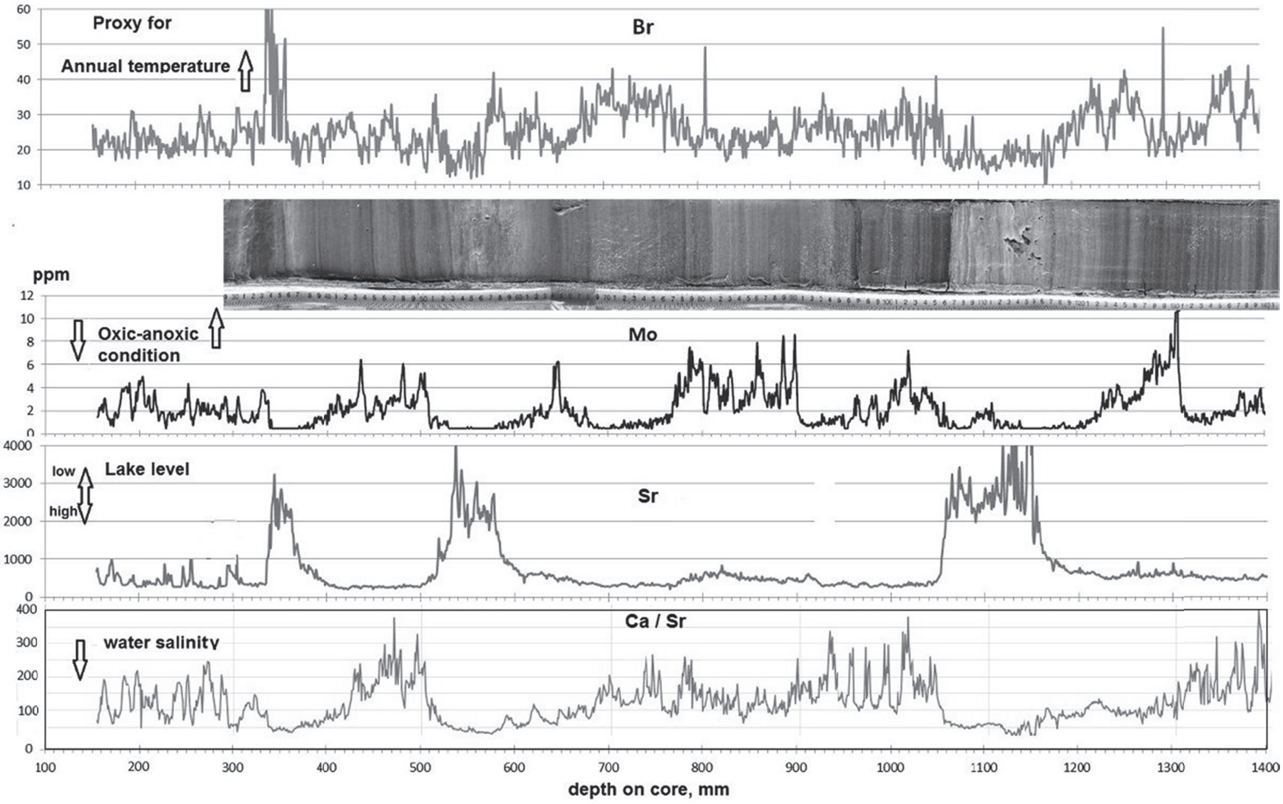

Fig. 1. The composition of the layers in the bottom sediment column of the lake Shira

Dark intervals on the core foto, correspond to the meromictic state of the lake, they are more clayey and saturated with organic matter. The light intervals, which also appear in Sr profile, mark the holomictic state of the lake and a lower level with increased salinity; they are mainly composed of carbonates in composition, a few of organic matter.

A new set of techniques for analytical microstratigraphy based on X-ray fluorescence analysis on synchrotron radiation (XRF SR) allows the creation of detailed weather and climate reconstructions on annual scale. The submillimeter scanning of the samples provides high performance, variability and low detection limits that are not available with conventional discrete sampling methods. Accordingly, it becomes possible to identify sources of matter in bottom sediments from local to global, and events of different duration - from "instantaneous" catastrophic to long-period orbital types. Thus, docking of qualitative stratigraphic models of sedimentation with absolute chronologies (time series) is appeared. In part, these developments are implemented in our publications, which contain the following results (see the list of references). * Detection of catastrophic events and evaluation of their actual duration: volcanic eruptions, earthquakes, relief change, meteoric bombardment, dust storms, forest fires, ice cover and melt, floods, typhoons, level and salinity of lakes, anthropogenic pollution. * The rate of sharp climatic changes such as Younger Dryas and modern warming. * Estimates of the lag of the regional climate response of biomes "steppe" and "taiga" in palynological reconstructions. * Interpolation of sparse sampling data through training - calibration of the geochemical transfer function, for example, in palynological series for the same samples, creating new time series such as "proxy to proxy" on a year-decade scale. * Extension (extrapolation) of dendrochronological time series by learning the transfer function of geochemical indicators for synchronous changes in shorter tree-ring series. * Comparison (correlation) of independent lithologic-geochemical, isotopic and biological time series, combination them in one function and building on this basis combined reconstructions of the external environment. * Analysis of trends and climate cyclicity of different orders allows to predict climatic parameters for 50 years and beyond.

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MECHANISM OF VARVES FORMATION IN THE OBDEKH RIVER PALEOVALLEY (PSKOV REGION, RUSSIA)

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Varves are a unique paleogeographic archive allowing to reconstruct the paleohydrology regime of lakes, the nature of sedimentation and changes of the environments and climate in the catchment area with an annual resolution. Classic varves accumulated in the extensive proglacial lakes on the North-West of the Russia in the Late Valday (Late Weichselian) are found in the lower parts of lowlands and ancient buried paleo-incigions. The varves in depressions on the lowlands are studied by a number of researchers. They have been known better than those into the paleo-incisions.

The series of varved clays are found in the Obdekh R. paleovalley during our investigations. The valley is located at the base of the eastern slopes of the Haanja Upland. Specific features of varve formation are predetermined by the morphology of the paleovalley and its deglaciation character. The cross profile of the valley has the shape of a trapezium. The width of the valley is 400-1000 m and the width of the bottom - 100-200 m. The depth of the modern river valley is 40-50 m, while that of the buried paleovalley is about 100 m. The thickness of the Late Pleistocene glacial deposits filling the paleovalley reaches 50 m. There are two structural terraces on the right slope. The left slope is steep and with landslide processes widely spread on it. Both slopes are cut by gullies (small erosion landforms). The bottom is complicated by hummocky moraine, some kame terrases, depressions and meltwater channels to the north of the Lake Malskoye only. The difference in relative heights does not exceed 10 m. South from the marked border the most part of the bottom is flat and occupied lakes (Malskoye, Gorodishchenskoye) and swamps (Sukhoe and the Nizhniy Krupsk bogs). The studied area is situated in 4 km to the north-east of the Luga stage boundary of the Late Valdai (Late Weichselian) glaciation.

During the field investigations it was established that varves occur on the bottom of the paleovalley and the depth of their top varies from 6,40 to 8,20 (probably more). There is a decrease in the depth of the top of varved clays towards the lakes. The southern boundary of the varves is presumably at the beginning of valley, the northern one is to the north-west from the Lake Malskoye. It can be assumed that the hummock moraine and other landforms originated under condition of melting dead ice which dammed the runoff from the proglacial lake. The varved clays were deposited in this lake.

The discovered varved clays are clastic. The chemical composition of varved clays is characterized by high proportion of the mineral constituent, high content of Si and other elements typical of the mineral class of silicates – Al, Na, K, Mg, Ti, and Fe. There are two series of clays characterised by a rhythmical seasonal lamination. These series are separated with the layer of sandy-silt material. The individual varves in the lower part of clays are from 10 to 77 mm thick, those in the upper part are from 3 to 52 mm thick. The main part of the varve thickness falls on the summer layer. The granulometric composition of both layers of varved clay is also different. The varves of the lower layer are predominantly clayey and silty. The proportion of clay decreases, but silt and sand increases significantly in the upper of varves. The amount of sand in the summer layers of the upper horizon of varves increases from the bottom to top of the series. The seasonal rhythmicity of microlayers is emphasized by the granulometric composition in the varved clays of the upper series, while it is poorly expressed for the lower varves. Seasonal layers within individual varves contain finer microlayers and disturbances visible in the photographs of thin sections at large magnification. The lower series microlayers are more abundant and better pronounced disturbances of the layered microstructure are also observed in the microlayers, which could be the impact of bottom currents transporting material from the melting dead ice nearby. The upper series of varved clay has mainly undisturbed seasonal laminations.

The results obtained suggest that the key borehole penetrated both and proximal and distal varved clays. The formation of proximal varves (those in the lower varved clay series) took place under conditions of close location of melting dead ice, abundant supply of fine-grained clastic material, turbid flows taking an active part in the deposition. Accumulation of distal varves (those in the upper varved clay series) took place in the remote part of the basin in calm water with predominance of gravitational sedimentation processes. The results obtained, that are in good agreement with early works (Kolka, 1996; Bakhmutov et al., 2006, and others), established that for the purposes of the varvochronology only distal varved clays are suitable. In our main core, 217 distal varves are counted within the upper varved clay series. Similar distal-type varved clays were found in other boreholes drilled farther south of the main one. By now, the results of varvometric measurements are difficult to correlate with chronological scale accurately because of the lack of 14C dates available.

The correct radiocarbon age of sediments was obtained only for the upper – organogenic - part of the key borehole. The difference in 14 C dates noticed from varved clays is connected with the insufficient carbon content in the samples of varves, and the uncertainty in the origin of dated organic matter. The content of organic matter in the samples was about 3%, the dating was carried out in terms of total carbon. The plant detritus was found in the upper series of the varves (the results of dating are not ready yet). In addition, the results of pollen analysis of lake sediments near the studied area indicate the first peak of carbonate accumulation to correspond to Preboreal (materials of geological survey). Accordingly, varved clays occurring 0,5 to 1,5 m lower in the section could be formed in the Allerød.

Initially the varved clays were deposited in the water-filled cracks in the dead ice. In the upper part of the paleovalley the dead ice melting proceeded unevenly, the ice blocks in place of the modern lakes (Malskoye, Gorodizhchenskoye) persisted the longest. The difference in the time of the ice melting is confirmed by increasing depth of the varve position from the periphery towards the Lake

Gorodizhchenskoye. As the ice melted, a single proglacial lake developed in the upper part of the paleovalley, northwest of the Lake Malskoye, its level not exceeding 75 m abs. (the elevation of the terrace II surface). Then the proglacial lake was rapidly drained, the spillway traces are recognizable by preserved meltwater channel (now occupied by the Obdekh R.) and structures of sediments studied in cores.

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FIRST RADIOCARBON RESULTS OF ONEGA LAKE BOTTOM SEDIMENTS BASED ON CONVENTIONAL AND AMS METHODS

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The Lake Onega is a huge important polygon for palaeoreconstruction due to its location, history development and specific features. The most particular studies are belonged to Pleistocene-Holocene transition when Fennoscandia deglaciation was occurred [Saarnisto, Saarinen, 2001] Huge amount of data was obtained in 20th century during Finnish-Russian collaboration when geological, biostratigraphical, neotectonical, glaciological and geomorphological studies were conducted [Saarnisto, 1995; Saarnisto, 2016]. Most part of palaeoevent reconstructions for Onega Lake are based on stratigraphic approach using varve clay consequence, pink horizon [Demidov, 2006] and other markers, while absolute ages are almost absent [Filimonova, Lavrova, 2017]. Such situation can be explained by specifics of Onega Lake sediments. Big and especially postglacial lakes tend to form the sediments with extremely low organic carbon content that makes such objects a quite complicated for radiocarbon dating. According to published data there are no absolute ages for bottom sediments of Onega Lake. Samples for radiocarbon measurements were taken mostly from surrounding lakes and bogs.

Current work represents the first radiocarbon results of Onega Lake bottom sediments obtained by measurements with applying of liquid scintillation spectrometer (conventional method) and Accelerator mass spectrometer (AMS). Pollen analysis was also carried out to establish stratigraphy of bottom sediments and verify absolute age by non-absolute dating approach.

Classic radiometric measurements were conducted in “Geomorphology and Palaeogeography of Polar Regions and the World Ocean” Laboratory (Köppen-Lab) in Saint Petersburg State University, Russia. AMS measurements were carried out by CologneAMS laboratory in University of Cologne, Germany.

During the expedition that was headed by Prof. Aleksandr Rybalko in 2016 the seismoacoistic profiling was conducted and 7 sediment cores were collected. The different core location is supposed to represent the complete record of Onega Lake bottom sediments deposition in case of complicated morphology of lake basin and different rate of sedimentation. Two sediment cores ONG-2 and ONG-5 were chosen for complex studies, that also includes radiocarbon and pollen analysis, due to its maximum thickness of deposits. Sampling intervals for radiocarbon dating were chosen according to results of loss-on-ignition method that represents distribution of organic carbon (OC) content throughout cores.

In ONG-5 core OC distribution is irregular that points out complicated character of sediment deposition. Also it could mention some important palaeoevents connected with changes of lake water level, neotectonics or climate changing. Samples for radiocarbon dating were taken from the intervals with the highest amount of OC to conduct precise measurements. Sampling intervals for ONG-2 core: 45-50 cm, 165-170 cm and 230-235 cm for both conventional method and AMS; ONG-5 core: 49-51 cm, 80-85 cm for liquid scintillation counting and 50-53 cm, 84-88 for AMS. Unfortunately, the date for interval 80-85 of ONG-5 core could not be obtained by liquid scintillation counting due to extremely low organic carbon content.

Table 1

Radiocarbon results for ONG-2 and ONG-5 cores

Core	Depth, cm	Lithology	Radiocarbon age, yr BP (scintillator spectrometer)	Yr Cal BP, (scintillator spectrometer)	Radiocarbon age, yr BP (AMS) 95,4% probability	Yr Cal BP, (AMS)
ONG-2	45-50	Clayey silt	1420±100	1340±100	2346±48	2685-2182
ONG-2	165-170	Clayey silt	2420±100	2510±130	2447±56	2711-2357
ONG-2	230-235	Clayey silt	4910±150	5660±180	4881±61	5747-5472
ONG-5	49-51	Sandy silt	4150±180	4680±260		
ONG-5	50-53	Sandy silt			5795±76	6775-6413
ONG-5	80-85	Clayey silt	could not be measured due to low organic carbon content			
ONG-5	84-88	Clayey silt			12168±117	14600-13746

The table above (Table 1) represents radiocarbon ages obtained by liquid scintillation counting and AMS measurements. It is supposed to accept two dates for ONG-2 core from 165-170 cm and 230-235 cm intervals due to high results repeatability. Samples from interval 45-50 cm dated by 1420±100 BP (AMS: 2346±48 BP) seems to be contaminated by older radiocarbon isotopes due to complexity of sampling technique. These results are still under discussion.

For ONG-5 core only 3 dates were obtained. Received ages for intervals 49-51 cm and 50-53 cm are in chronostratigraphical sequence. Moreover, these results are confirmed by palynological data. The ages 4150±180 BP and 5795±76 BP for interval 165-170 cm are accepted. This interval is belonged to Atlantic-Subboreal transition according to our biostratigraphical results and published data. Probably, the age (12168±117 BP) for 84-88 cm interval obtained by AMS is not convenient. In this core interruption in sediment deposition was observed. According to our pollen results, the Boreal period and beginning of Atlantic period are absent. This gap could be referred to the abrupt fall of lake water level, that was being occurred exactly in the Boreal period [Filimonova, Lavrova, 2017], that is confirmed by lithology of core ONG-5.

The first radiocarbon dates obtained for Onega Lake bottom sediments by both conventional radiocarbon and AMS dating are mostly in a good agreement. These results confirm possibility of convenient 14C method application to lake sediments with extremely low organic carbon content. Further investigations are required to prolong and clarify the absolute scale for this important region.

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PALEOHYDROLOGY OF LAKE SELIGER (VALDAI UPLAND, RUSSIA)

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Lake Seliger is located on the Valdai Upland, the main watershed of the East European Plain, which divides the river runoff between the basins of the Caspian and Baltic Seas. The Valdai Upland is in the margin zone of the last glaciation. This area has a typical post-glacial landscape with marginal moraines, kamas, eskers and kettle holes. The Valdai Upland gave the name to the last glacial epoch in the Russian geological systematic - the Valdai glaciation. Traditionally, the Lake Seliger is considered relict lake (Kvasov, 1976), which remained after degradation of a huge proglacial lake.

Lake Seliger is a system of 24 semi-isolated bays (so-called Ples), which stretch for 60 km from north to south. The lake has an area of 212 sq km (The State Water Register.., 2008), an average depth of 5 m, and a maximum of 24 m. The length of its very winding coastline is 528 km. In the lake there are more than 160 islands, the largest of which is the island Khachin. In Lake Seliger, there are 110 inflows. The largest inflows are the rivers Krapivenka, Soroga and Seremuha. The catchment area is 2310 sq km. The river Selizharovka flows out from Lake Seliger. It is the left inflow of the Volga River.

Sediments of the lake Seliger were studied in the 1930s in the exploration of deposits of sapropel (Soloviev, 1934), which was used as an organic fertilizer. In 1960s a lot of boreholes were drilled in the bottom sediments of the lake in search of sand and gravel, which was supposed to be used for construction needs (Savary, 1963). As a paleoarchive, the bottom sediments of Lake Seliger have not been studied before.

In winter of 2018, the bottom sediments of Lake Seliger were drilled from ice. Drilling was carried out on 5 profiles in the southern part of the lake. A modified piston corer of Livingston (Wright, 1967) was used. In total, 14 borehols were drilled. Received and delivered to the laboratory 43 m of cores. For samples from reference cores, the loss on ignition and the particle size distribution were determined. 15 samples of organic matter were submitted to the radiocarbon laboratory of the Institute of Geography of the Russian Academy of Sciences.

In all boreholes at the bottom of the lake, 2-3-meter, and in some cases 6-meter lake mud, have been discovered. The upper part of the mud has a dark gray color due to enrichment with organic matter (30-60%). This is the Holocene sapropel (gyttja). The lower layers of mud in many boreholes have a light gray or blue-gray color, because they contain little organic matter (3-10%). This is a sign of formation in a cold climate - at the end of the last glacial epoch. Everywhere under the mud coarse sands occur. It is deposits of a fairly fast water flow.

There is reason to believe that the sands lying in the lower part of the sections are deposits of river flows, but not glacial melt-water deposits. Firstly, on a narrow and sinuous Selizharovo Ples, a transverse profile along top of sands has triangular shape. It is typical for a meandering river: at the concave bank of the river - deep, near the convex - shallow, there is a beach. Secondly, here and on other sites in the surface of the sand there are two steps. It is similar to the bottom of the riverbed and the flood plain. Third, at the bottom of the mud on the former floodplain, features similar to buried soils are encountered. And peat layers are encountered in two places. This indicates a long period of subaerial development (i.e., in the open air, not under water), which would not be possible if the large proglacial lake is simply drying up.

Thus, after the melting of the glacier in the place of Seliger the river flowed, apparently inheriting the ancient (before glaciation) river valley. Then, for unknown reasons, the flow stopped and the valley was flooded. On the sites studied, the water level rose by 5-8 meters. The reasons for this phenomenon remain to be determined.

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PRELIMINARY RESULTS OF POLLEN STUDY FROM LAKE IMANDRA SEDIMENTS

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The Arctic landscapes are highly sensitive to climate variations. Therefore, it is an important region for understanding present and past climate changes. Lake sediments are a good source of information for studying permanent environmental changes. Territory of Lake Imandra was covered by Arctic Ice Sheet during the Late Pleistocene. Studying lake sediments on this polygon can help in the reconstruction of lateglacial and postglacial conditions. Pollen analysis provides information about local and regional vegetation climate changes.

The two cores of bottom sediments were collected during joint field campaign of the Saint-Petersburg State University, Kola science centre and University of Cologne in September of 2017. The total trickiness of core is about 8.5 m. At the present time the samples from corecatchers have studied by pollen analysis. The 26 samples with variable interval (from 2-5 cm to 50 cm) were analyzed. The 58 pollen, spores and non pollen palynomorph taxa were indentified.

Three pollen zones were distinguished according to changes in pollen spectra. The first zone (PZ-1) from 8.5 m to 7.0 m shows low concentrations of microfossils. The single grains of *Betula nana*, Cyperaceae, Chenopodiaceae, Ericaceae, Polypodiaceae, *Sphagnum* and *Lycopodium* taxa were indentified. Such low concentration may indicate cold and dry conditions. The second zone (PZ-2) from 7.0 m to 4.7 m shows domination of trees and shrub pollen taxa (65%). *Betula nana* is prevailed in this group. The herbs pollen taxa are presented by *Artemisia*, Chenopodiaceae, Ericaceae, Cyperaceae and Poaceae. The single grain of *Ephedra* pollen was identified in this zone.

Polypodiaceae is dominated among spores. That pollen spectra may reflects dry conditions, when shrub tundra landscapes with periglacial vegetation communities were dominated. The third zone (PZ-3) from 4.7 m to 0.8 m is characterized by the highest concentration of pollen and spores and amount of pollen and spores taxa diversity. Increasing of trees and shrub pollen taxa up to 90% is fixed there. *Pinus s/g Diploxylon* is dominated among that taxa. Poaceae and Cyperaceae are dominated among herbs taxa. Polypodiaceae still dominates in spore group. The pollen spectra of PZ-3 probably reflect the most favorable conditions of Holocene. Summarize pollen results it is possible to conclude that excavated sediments formed during lateglacial and Holocene time. The work was supported by joint grant SPBU-DFG 18.65.39.2017

NORTH-SOUTH DISPERSION VECTOR IN POSTGLACIAL RECOLONIZATION OF EUROPE AND WESTERN SIBERIA IN MICROSCOPIC FRESHWATER CRUSTACEANS: SEARCH FOR EXPLANATIONS

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Cladocera is a very important group of the microscopic animals in continental water bodies (Forró et al., 2008) with a long and complicated evolutionary history (Van Damme, Kotov, 2016). They are well-known models of recent evolutionary biology. Their remains are widely used in the palaeoecological reconstructions (Van Damme, Kotov, 2016). Several genera of the Cladocera became to be models of studies of the invertebrate phylogeographic patterns in continental waters.

Pioneer phylogeographic works concerning the Cladocera have started at the end of the 20th century (Taylor et al., 1998). Recently a new level of such studies is achieved, now the authors try to analyse global phylogeographic patterns in contrast to previous works mainly focused on Europe or North America. Several trans-Eurasian studies were made by our team, with different collaborators. Such studies revealed in several cases (among other patterns) a peculiar pattern in the postglacial dispersion of the cladocerans in European Russia and Western Siberia: from particular northern regions to more southern regions (Xu et al., 2009; Kotov et al., 2016; Bekker et al., 2018). Such pattern is unusual keeping in the mind a great prevalence of the south-north direction in the postglacial recolonization of the Holarctic from southern refugia (Hewitt, 2000). The north-south dispersion was previously discussed only in few other animal groups. It is proposed that they have survived during Pleistocene glaciation cycles in some "cryptic northern refugia" (Stewart, Lister, 2001). In our poster we will try to find explanations of such pattern of recolonization in the Cladocera (Crustacea: Branchiopoda). Among possible explanations, there are hypotheses referring to an unusual hydrologic situation in Pleistocene. Namely, the Weichselian ice sheet was associated with huge proglacial lakes (ice-dammed lakes) whose drainage changed from south-north to a north-south direction (Mangerud et al., 2001; Astakhov, 2006). Such water movement may have enabled dispersal of cladocerans in a southern direction. Our data demonstrate that this region of proglacial lakes may have acted a source for recolonization. But other explanations are also possible.

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PLEISTOCENE CLADOCERA: A REVIEW

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Cladocera is a very important group of the microscopic animals in continental water bodies (Forró et al., 2008). They are well-known models of recent evolutionary biology. It is known that after death, the chitineous remains of some cladocerans (head shield, valves, appendages) are defragmented and preserved in the sediments (Frey, 1964; Smirnov, 2010). There are records of fossil cladocerans from Mesozoic (Smirnov, 1992; Kotov, 2007) and even from Palaeozoic (Smirnov, 1970; Womack *et al.*, 2012) age, although the latter are dubious (Van Damme, Kotov, 2016). But Quaternary subfossils of the Cladocera are better preserved than in previous periods, and much more numerous.

Remains of several groups of the Cladocera are usual in the bottom sediments of large lakes. Because of their high preservation potential in the Holocene deposits, cladocerans are informative in the reconstruction of past aquatic food webs, in which they occupy a key role (Smirnov, 2010). Tens, even hundreds of papers concerning the cladoceran remains from different Holocene cores are published annually.

But the community composition of cladocerans sometimes are unchanged in last 130,000 years (Frey, 1964). In Pleistocene sediments, the cladoceran remains are common, mainly chydorids and bosminids (head shields, valves, postabdomens). If the value of the chydorid remains for such studies is well-known, only recently the daphniid ephippia become to be objects of such detailed works. An unusual, new direction in the studies of Quaternary cladoceran fossils deals with remains associated with excrements (Kirillova et al., 2016a) and hair (Kirillova et al., 2016b) of the “Mammoth fauna”.

The aim of this presentation is to make a review of such records and provide some comments on their using in palaeoecological reconstructions.

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CHARACTERIZATION OF SAPROPELIC DEPOSITS OF NOVOSIBIRSK REGION, SOUTH-WESTERN SIBERIA

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Sapropel is an important biogenic resource usable in agriculture and industry, and it is an alternative to hydrocarbon resources. There are few examples of sapropel explorations in the south of Western Siberia: Lake Puchay on Omsk region (liquidated in 2016) and Lake Beloye in Novosibirsk Region. Experts explain low effectiveness of these enterprises by relatively high net costs and limited product market. Our project run in 2017 is aimed to investigate perspective of sapropelic business in Novosibirsk Region in terms of Earth science research: structure of sapropel deposits, regularities of their accumulation, composition, valuable properties, and also to propose new technologies of their processing. There were several lakes investigated by our team in Novosibirsk region; among them, the largest deposits are Lake Minzelinskoe, Lake Bolshie Toroki, Lake Itkul, Lake Malye Chany, and a minor deposit is Lake Beloye (Fig. 1).

Our field investigations allowed us to recalculate reserves of sapropel in Lake Minzelinskoe, which the geological survey (1998) claims as the largest, 8 million tons, sapropel deposit of the region. According to our data, total stock of sapropel in this lake is no larger than 3 million tons. Consequently, Lake Bolshie Toroki seemingly hosts the largest sapropel deposit of Novosibirsk Region.

Our investigated lakes show the following regularities of their sediment structure and development. Biogenic sedimentation started in the lakes since the beginning of middle Holocene, 8-7 cal. ka BP according to the radiocarbon dating. The sediments include several layers of different origin indicating variations of the sedimentation environments. Usually brown color peaty sapropels lay in the bottom parts and greenish color macrophytogenic sapropels occur in the upper parts of the sediment sequences. This suggests boggy or marshy (wetland) stage in the beginning of the lakes history followed by lacustrine stage. Change of the sedimentation environments is individual for each lake and its time vary from ca. 6 to 4 cal. ka BP. Dating gives estimates of sedimentation rates of these two parts of the sapropel deposits as 1.4-2.6 и 0.2-0.4 mm/yr., respectively, i.e., sedimentation (bioproductivity) in marshy environment was much higher than in lacustrine one.

Fig. 1. Three largest sapropelic deposits of Novosibirsk region.
Frames in the map are spy-glass views of the lakes

Our sedimentological and geochemical investigations show the following average sapropel composition (measured from dry weight of the samples): 30-36 % of organic matter, 13-31 % of Ca-carbonate matter and 6-27 % of silicate matter. Volumetrically, the organic matter is the main component of the sediments which proportion is 60-72 %. Variations of proportions of the carbonate and silicate matters describe differences between layers which can be interpreted as alternations in precipitation of authigenic components and transportation of terrigenous ones. Additionally, in some layers enriched by mollusk and ostracod shells, carbonates have biogenic origin. In fact, all labile carbonates appear in the lakes in water solution forms sourced (leached) from carbonate-rich loess-like sediments of the lake catchments. High carbonate content is a typical feature of the lake sapropels in the south of West Siberia which is considerably different from the low-carbonate sapropels of the Baikal area (Leonova et al., 2015).

Detailed biogeochemical study gave us valuable information about distribution of organic components and chemical elements along the sediment sequences (Leonova et al., 2018). Pyrolisis of the sediment samples indicates stages of the early diagenesis of the organic matter, removal of the protein components and appearance of the kerogen components with depth (Melenevsky et al., 2011, 2015). Additionally microbiological treatment of the organic matter is investigated. Finally, the obtained data highlights a complex of biological, chemical and hydrological processes in the lakes which combination predetermine the sapropel qualities important for its utilization and elaboration of its treatment technologies.

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INVESTIGATION BOTTOM SEDIMENTS STRUCTURE IN LAKES WITH THE USE OF THE ACOUSTIC METHOD

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Lacustrine sediments contain a long, high-resolution record of sedimentation processes associated with changes in the environment. Paleomagnetic, paleobiological, geochemical studies of the properties of these sediments provide a detailed trace the changes in the paleoenvironment. However, there are factors such as landslides, earthquakes, and the presence of gas in the sediments affecting the disturbing sediment stratification. Seismic profiling allows investigating in detail the bottom relief and getting information about the thickness and structure of the deposits, which makes this method ideally suited for determining the configuration of the lake basin and the overlying lake sediment stratigraphy. Most seismic studies have concentrated on large and deep lakes containing a thick sedimentary sequence, but small and shallow lakes containing a thinner sedimentary column located in key geographic locations and geological settings can also provide a valuable record of Holocene history. Seismic data is crucial when choosing the optimal location of core sampling. Thus, continuous seismic profiling should be used regularly before coring lake sediments for the reconstruction of paleoclimate.

We have carried out seismic profiling on 20 lakes which are situated in the Volga region and the South Ural region. For example, Lake Turgoyak (Chelyabinsk region) is a unique object of research and the second cleanest lake in Russia after Lake Baikal (Figure 1).

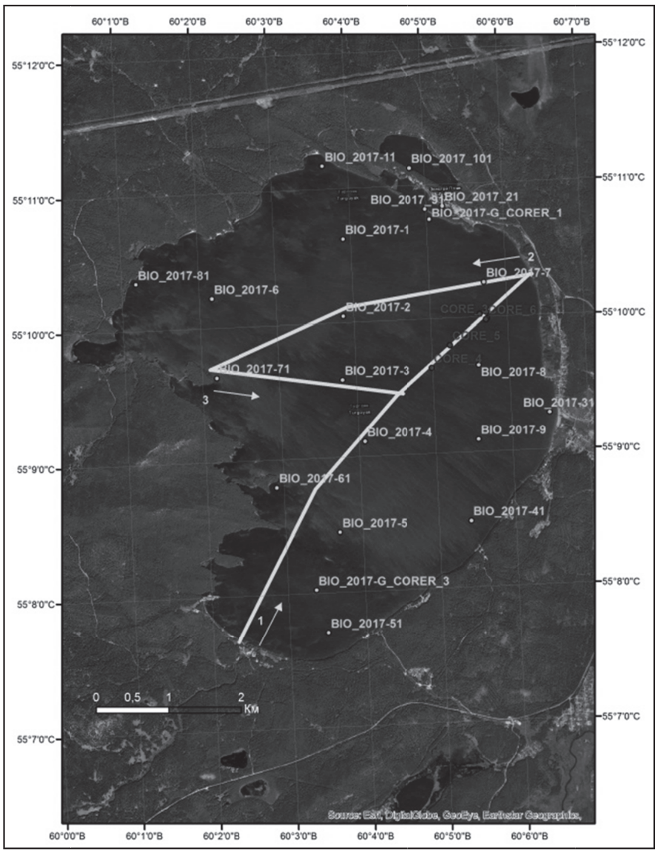

Fig. 1. Location of acoustic profiles, core sampling points and biological samples

Acoustic data showed uneven distribution of sediment, outcrops of bedrock into the water column and break in sedimentation (Fig. 1). The depth reaches 31 m. The largest thickness of sediments (up to 7 m) was found in the northeastern part of the lake basin. The upper 4 meters are represented by weakly consolidated organogenic sediments, below 3 meters of denser sand sediments.

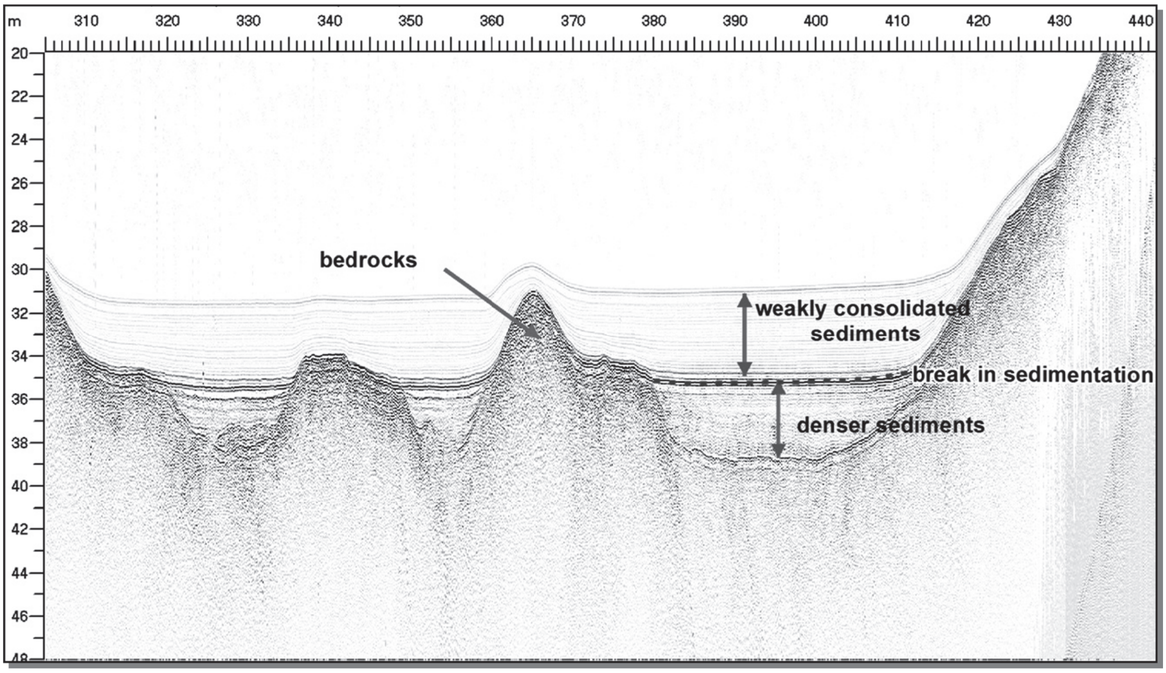

Fig. 2. Fragment of acoustic profile_1 with the most complete stratigraphic sequence

The study of the most complete column of bottom sediments will allow us to reconstruct the region climate over the past several thousand years. A comparison of the data set for several lakes in the region makes it possible to create a detailed model of climate change.

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COSMIC DUST AND MICROMETEORITES IN LAKE SEDIMENTS

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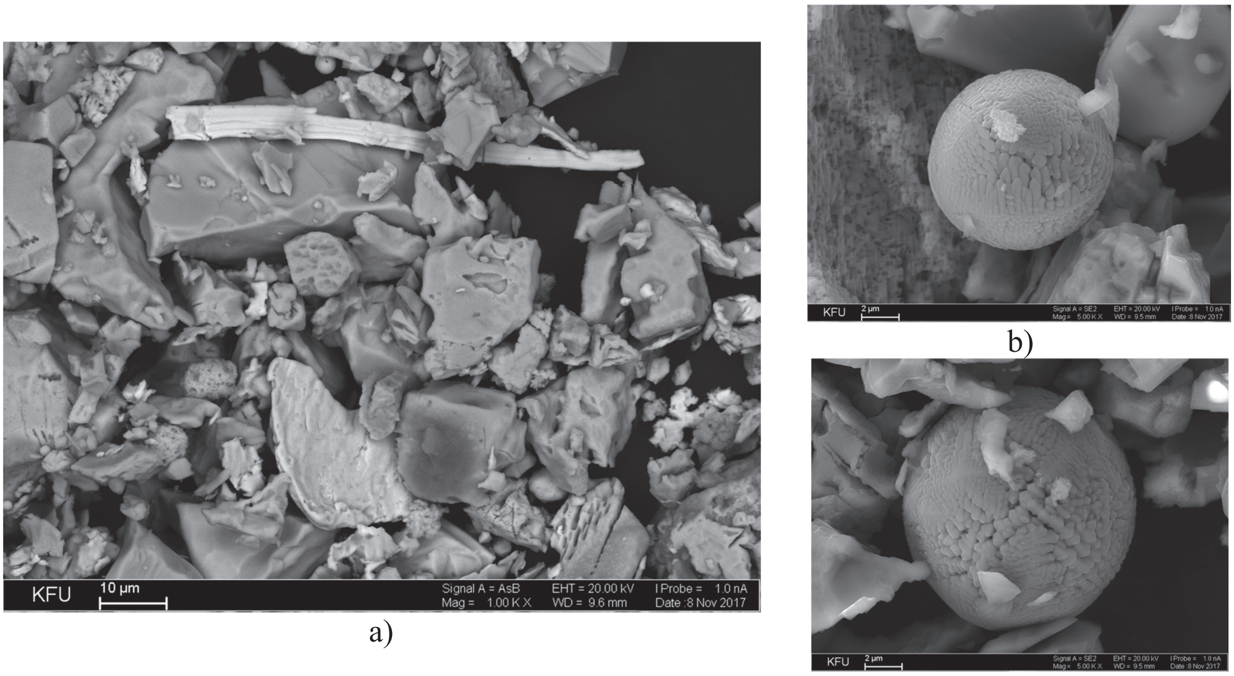
Well known, that a lot of extraterrestrial matter rich the Earth surface every day. Such material can be find in different geological objects [1, 2]. Investigations of different types of sediments proofs the idea about quantity variations of cosmic dust in time. It can be caused by different reasons such us different concentrations of dust in universe, by impact events and etc. Seasonal sedimentation and possibility of precise age determination of sediments make lakes one of the best archives for studying Holocene. Sediments are composed of grains of different genesis: authigenic grains formed in the lake or brought into it by water flows and wind, grains of cosmic and volcanic origin, dust from the other continents, grains of biological and anthropogenic origin and so on. This study concentrates on investigations of cosmic dust. Many of these particles have the same composition as terrestrial matter; however, we can separate the cosmic components from the terrestrial components using their unique magnetic properties such as Curie temperature (Tc) and using scanning electron microscope (SEM) for determination elemental (mineralogical) composition and surface morphology. Several lakes were sampled during summer field works. Cores length usually 5-6 meters which cover last 11 Ka.

Differential thermomagnetic analysis was carried out for tracing magnetic minerals according their Curie temperature. Measurements were carried out on Curie express balance. the temperature dependence of induced magnetization in air at a heating rate of 100 °C/min up to a maximum temperature of 800°C. were measured in a constant magnetic field - 400 mT. We have got thermomagnetic curves of the first and second heating. Hysteresis properties were determined by a J-coercivity spectrometer for each sample a modified hysteresis loop, backfield curve, acquisition curve of isothermal remanent magnetization, and a viscous IRM decay spectrum. Each measurement set is obtained in a single run from zero field up to 1.5 T and back to -1.5 T [3]. Magnetic separation of samples was made by using permanent magnet. Firstly 3-6 grams of the sample were added to distilled water. Then the magnet in the rubber case fell into the vessel and mixing was going on. The material that adhered to the magnet was dispersed in an ultrasonic bath to separate the stacked particles and again the procedure with the magnet was repeated. The morphology and elemental composition of magnetic separates studied using scanning electron microscopy "Merlin" Carl Zeiss equipped with an energy-dispersive spectrometer "Aztec X-Max" Oxford Instruments. Surface morphology was investigated at an accelerating voltage of 5 keV on SE mode (secondary electrons). Elemental analysis was carried out at an accelerating voltage of 20 keV with AsB mode.

According to results of thermomagnetic analysis data samples with decrease of magnetization around 720 °C were choosen for magnetic separation. This temperature indicates presence of iron with impurities, because Curie temperature of pure iron is 770 °C.

SEM results show a wide range of various types of particles from terrestrial magnetite to Fe-Ni alloys. SEM results show presence of magnetite spherules in each sample, iron sulphide spherules, detrital material (magnetite, titanomagnetite, hematite), iron with impurities (Figure 1).



a) b) c)

Fig. 1. Electronic images of sample 1141,
a) – magnetic fraction overview; b), c) – micrometeorites of Fe, O composition

Microscopic investigations showed wide spread of micrometeorites in all studied samples. Shape of particles from round to egg-shape. Size of particles varies from 5 to 30 microns. Almost all microparticles have specific wavy surface. Finding differences in extraterrestrial matter in time would be helpful for understanding changes in material falling to the Earth's surface.

It is shown that lake sediments can be good archives of extraterrestrial matter. Based on the results of the thermomagnetic analysis, samples were sampled for the investigation using an electron microscope. TMA can serve as the first stage of the rejection of samples, which greatly simplifies the work, since it is impossible to view all the samples on the SEM.

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THE STUDY OF PRESENT POLYGONAL PONDS OF ARCTIC ECOSYSTEMS (YAKUTIA) IN PALAEOLIMNOLOGY

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Abstract. Polygonal ponds common in the North-East of Yakutia are poorly understood and represent interest in limnology and nature management. The comprehensive study of polygonal water was held in July 2017 at the monitoring plot area of Kytalyk Allaykhovskiy district of Yakutia (Indigirka river valley).

Study area, objects and methods.

The study area was located on the right bank of the Berelekh River (70°83’12.1”N., 147°48’29.9”E, altitude above sea level of 11 m) 28 km northwest of the settlement Chokurdakh (Fig.1). The study ponds were divided by location into two prevailing types of landscape – edoma and alas. In the fieldwork were measured morphometric and hydrochemical parameters of water and samples of a surface layer (0-1 cm.) The field material was collected using conventional methods with a standard set of accessories and equipment [1, 2]. Selected samples were preserved and stored at ~+4°C.

In General the studied reservoirs are shallow with a maximum depth of 0.6 m. and transparency to the bottom. The average water temperature during the study period did not exceed 10.4°C; pH varies from 3.6 to 7.8 with an average of 6.4 (neutral). Water is characterized by low mineralization and a high concentration of oxygen in the surface layer of water (to 11,18 mg/l). Data at the level of intraspecific taxa were used to determine the ecological characteristics of diatoms because the varieties of one species have different environmental indicators. Identified the relationship of diatoms to the conditions of the habitat, salinities, active reaction of the environment and geographical distribution [3, 4]. Ratio of algae to water salinity determined using the scale of globnet R. W. Kolbe [5]. The detected diatoms were separated into freshwaters and oligohalines (indifferents, halophobes, halophiles) and mesogalobic or saltwater groups. To determine the ratio of diatoms to the active reaction of water (pH) was used the scale Of F. Hustedt [4]. In the composition of the diatom flora was a dedicated group: Alkaliphile occurring at pH = 7, with optimum distribution at pH> 7, alkalibionts preferred water only with pH> 7; neutrophils develop at acidic and alkaline water; acidophiles with a predominant development at pH <7; aticidobiots - pH < 7, preferably 5.5 and below.

Results.

Diatoms in the preparations were determined before the species, variety and form. According to the results of the study of diatomic flora of the surface layer were identified 91 species of Bacillariophyceae’s class relating to 21 genera, 19 families and 11 orders. The highest quantity of species recorded in generas: *Eunotia* (26) и *Pinnularia* (13). Similar taxonomic structure of composition with the predominance of these genera typical for standing waters with occasionally changing hydrological regime. High species diversity (up to 33 species) noted in ponds of alas at a high level. The list of mass forms consists of 26 species. Of these dominates *Tabellaria flocculosa*

(Roth.) Kutz. on all ponds (up to 70%) belongs to the arctoalpine biogeographic group. The species is characterized by different habitats, by salinity and pH halophobe and acidophil. Then two species from the Eunotia genus (*E.bilunaris u E. subarcuatoides*).

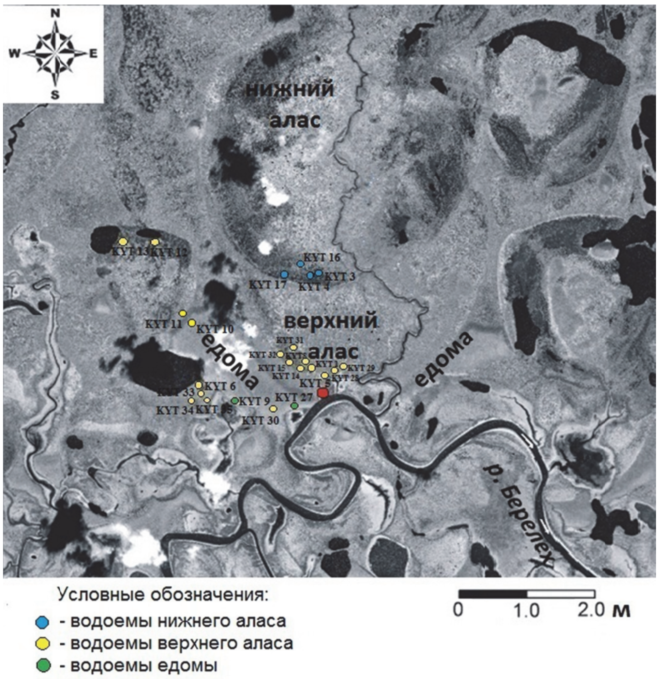

Fig. 1. The study region in the lower reaches of the Berelekh River

In General, in most of the studied reservoirs dominated epiphytic forms (from 37% to 100%), other part represented by bottom views (from 2% to 62%). Relative to water salinity indifferents dominated from 20% to 77%, to the pH acidophiles dominated (from 6% to 82%). Geographical analysis of the quantity of diatoms showed the dominance of the arctoalpine forms (from 4% to 75%) characteristic of northern arctic habitats.

This research was performed within the Russian Foundation for Basic Research (RFBR grant no. 13-05-00327), the Project of the North-Eastern Federal University (Regulation SMK-P-1/2-242-17 ver. 2.0, order no. 494-OD) and was conducted in the framework of research activities defined by the Russian Ministry of Education and Science (grant no 5.2711.2017/4.6).

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INTEGRATED METHODOLOGICAL APPROACH TO THE DETERMINATION OF SOURCES AND GENESIS OF THE BURIED (FOSSILIZED) ORGANIC MATER OF LAKE SAPROPELS

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Determination of sources and genesis of buried (fossilized) organic matter (OM) in stratigraphic sequences of sapropelic lake sediments is a complex task requiring a multidisciplinary research. The study includes a set of special methods and criteria to reveal the OM nature and find a relationship with their sources, which can be autochthonic (water biota) or allochthonic (on land plants). Sources of modern OM in lakes have been investigated in the first stage of our research. The dominant producers of autochthonic OM are autotrophic phytoplankton, periphyton, and macrophytic water plants [Leonova et al., 2014]. Changes of the OM sources were determined by calculation of proportions of remains of different plants and other organisms in the sapropel layers according to [Korde, 1960]. These data is the basis for biostratification of the Holocene sediment sequences and it allowed us to deepen our understanding of the sedimentation environment and the OM origin.

The approach is exampled here by the data of a 3 m long core of the organic sapropel from Lake Ochki (southern Transbaikalia) and 4.4 m long core of the organic-mineral sapropel from Lake Minzelinskoe (south-west Siberia). Biostratification of the sapropel in Lake Ochki (Fig. 1A) indicates mixt OM sources and changeable dynamics of sedimentation of phyto- and zooplankton (autochthonic) and pieces of soil and remains of green (*Drepanocladus*) and sphagnum mosses (allochthonic). The proportion of the autochthonic part recurrently varies from 90 to 40 % in the upper 190 cm of the core and tends to decrease with depth. In the allochthonic part, soil particles are dominant, and their proportion increases with depth. The particles are rather coarse due to the remains of the macerated tissues of the peat-forming angiosperms (mostly grasses and reeds). These data allowed us to conclude that plankton was the main source of the Lake Ochki sapropel during 10.8 kyr of the Holocene. Changes of the proportions of OM sourced from the lake and the land indicate some alternations in the sedimentation environments.

Biostratification of the sapropel in Lake Minzelinskoe (Fig. 1B) also indicates mixt of the OM, nevertheless of different origin. There are remains of semi-submerged and submerged water macrophytes as the autochthonic part and remains of *Hypnum* green mosses as the allochthonic part. The upper 300 cm of the section is macrophytogenic sapropel which gradually changes to peaty sapropel below. The sediment record and its biostratigraphic interpretation suggests a swampy Minzelinskoe basin since ca. 5.9 ^{14}C kyr BP. A humus-rich highly mineralized sediment with a number of mollusk shells formed there in the beginning (core depth of 440-420 cm) represents a shallow lake overgrown by water macrophytes. Then, a true lowland-type swamp dominated by *Drepanocladus aduncus* existed till ca. 4.0 ^{14}C kyr BP. The lake appeared to rise in the interval of 4.-3.2 ^{14}C kyr BP, and the lake sediments formed from the macrophytogenic source since then.

Together with the direct biological estimations of the OM sources, indirect methods are also available. We used several criteria resulted from the organic geochemistry study of the sediments by the pyrolysis chromatography-mass spectrometry: molecular composition of the aliphatic hydrocarbons (*n*-alkanes) and labile components of the protein-carbohydrate compounds [Melenevsky et al., 2012] usually named biomarkers. In the Lake Ochki sediments, products of the polysaccharide decomposition mark the autochthonic phytoplanktonic OM, components of the protein-carbohydrate compounds mark the autochthonic zooplanktonic OM and uneven *n*-alkanes mark allochthonic OM sourced from mosses [Melenevsky et al., 2015, Leonova et al., 2018].

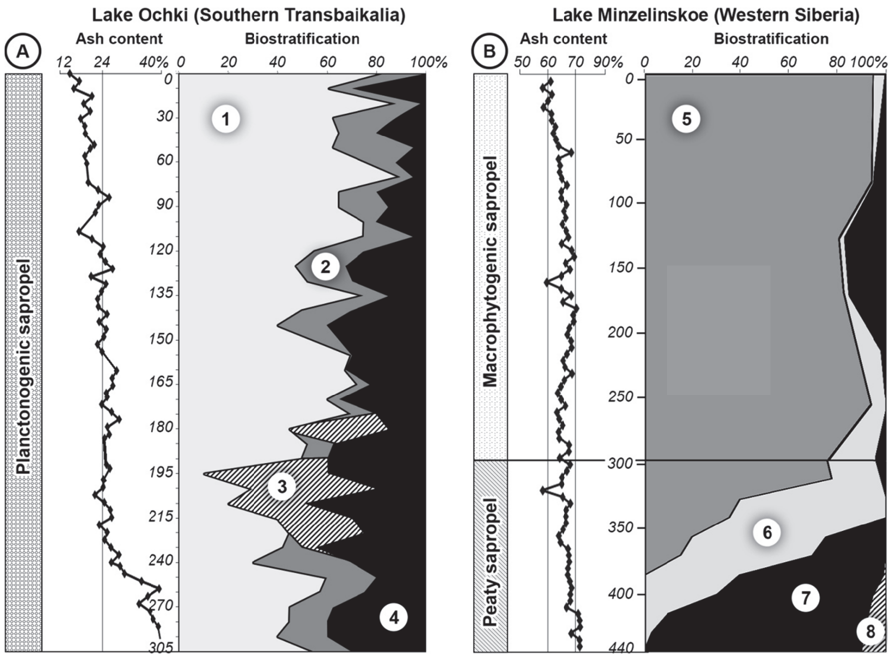

Fig. 1. Biostratification of the Holocene sapropel sediment sequences from Lake Ochki (A) and Lake Minzelinskoe (B). The analyses were done by T.A. Kopoteva (IVEP FEB RAS). 1 – plankton; 2 – green mosses; 3 – sphagnum mosses; 4 –particles of humus; 5 – submerged macrophytes; 6 – hypnum mosses; 7 – semi-submerged macrophytes; 8 – mollusk shells

Figure 2 presents pyrograms of the OM producers and sapropels of our three investigated lakes. The pyrograms have specific peaks: high-temperature peaks (500 C) witnesses presence of the macromolecular aliphatic structures (kerogen considerably reduced due to the anaerobic conditions in the sediments) and several low-temperature ones (300–400 C) witness labile components of the protein-carbohydrate compounds. Comparison of the pyrograms shows that in the sapropel the labile components of the protein-carbohydrate compounds disappear from the depth of 5 cm and kerogen appears. This suggests that decomposition of the OM and generation of kerogen is a very young process which starts in the uppermost parts of the sapropel and can be qualified as the early diagenesis stage. Due to this, only a persistent OM is left in the deeper parts of the sapropel and its further decomposition occurs much slower.

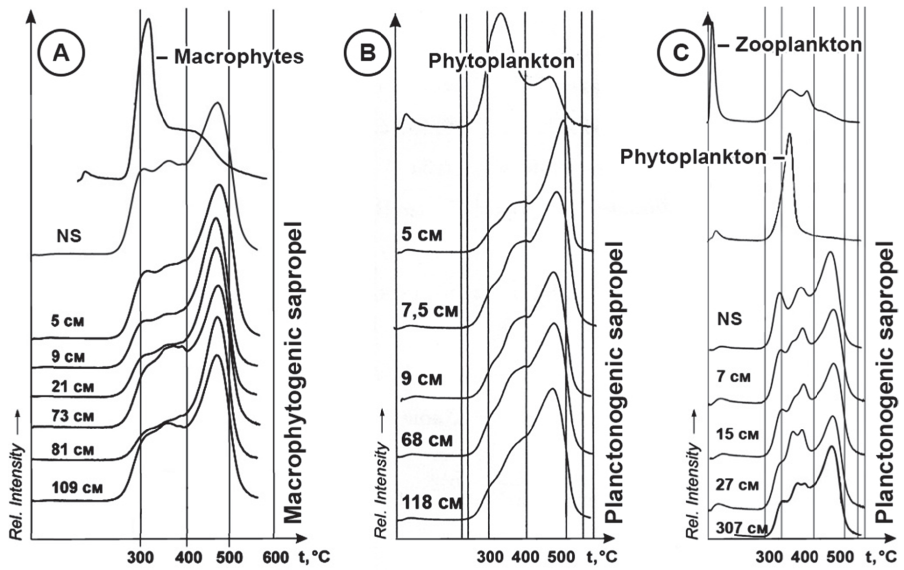

Fig. 2. Pyrograms of the OM poriducers and sapropels of the Bolshoe Toroki Lake (A) (south-western Siberia), Dukhovoe Lake (B) and Ochki Lake (C) (eastern Transbaikalia). NS – nonconsolidated sediment (0–2 cm). Rel. Intensity – rate of the pyrolithic fractionation at a certain temperature.

Besides, the authors used the organic carbon to the organic nitrogen ratio (C_{org}/N_{org}) as additional organic-geochemical indicator. The sapropels of the small lakes of Transbaikalia were found to have the lowest C_{org}/N_{org} ratios (5,7–7,0), which marks the autochthonic phytoplanktonic component of the OM. The West-Siberian lake have higher C_{org}/N_{org} ratios in the sediments and represent both autochthonic (water macrophytes) and allochthonic (mosses) OM sources [Melenevsky et al., 2015; Leonova et al., 2018].

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PALEOLIMNOLOGY INVESTIGATIONS OF THE ANZERSKY ISLAND, THE SOLOVETSKY ARCHIPELAGO, THE WHITE SEA

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A complex study of bottom sediments of lakes on different hypsometric marks allows reconstructing the shoreline moving and environmental changes in the Late Pleistocene and Holocene for the White Sea region. (Subetto, 2009; Kolka *et al.*, 2013). The method of isolated basins is used in the research. The lakes of the Solovetsky Archipelago and Onega Peninsula were investigated in numerous expeditions before (Subetto *et al.*, 2012, Leontev *et al.*, 2015, 2016).

In 2015 paleolimnological field research on the Anzersky Island (the Solovetsky Archipelago, the White sea) were held in the course of complex expedition on board of Northern Water Problems Institute scientific ship «Ecolog». The participants of expedition present Herzen State Pedagogical University (St-Petersburg); Northern Water Problems Institute Karelian Research Centre RAS (Petrozavodsk); Institute of Limnology RAS (St-Petersburg); Geological Institute Kola Science Centre RAS (Apatity), Moscow State University.

The field research included reconnaissance, study of the position of reservoirs, selection and visual inspection of the lakes, specification marks the water's edge and threshold runoff, bathymetric survey, sampling of modern sediments, sampling of selected lakes bottom sediments from the platform with using russian peat corer (for subsequent pollen, diatom, chironomid, grain size analysis, determining the weight of loss on ignition and radiocarbon dating), lithological description of the sediment cores.

With the aim of paleogeographic reconstruction the lakes were chosen at different hypsometric levels: Nadbannoye (21 m ASL), Bannoye (14 m ASL), Golgofskoye (11 m ASL) and Kaporskoye (6 m ASL) (Fig. 1).

The lithological analysis of the Anzersky Island lakes sediments allow to preliminarily attribute limno-glacial, marine, transition and contemporary lake sediments. The first results of the laboratory analysis and radiocarbon dating will be presented at the conference.

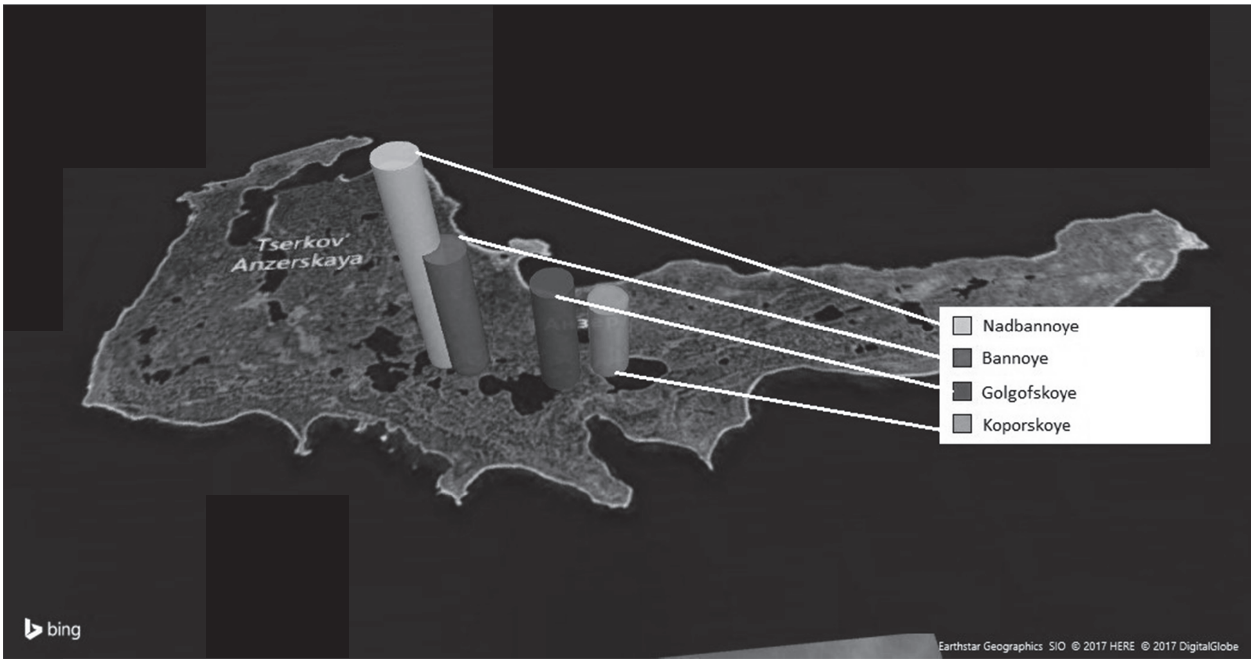

Fig. 1. Investigated lakes hypsometric position

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THE FIRST DATED PREGLACIAL DIATOM RECORD IN LAKE LADOGA, NW RUSSIA

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Lake Ladoga is the largest lake in Europe (18740 km^2, maximum depth 235 m) with a very large catchment area of >282000 km^2. It is located in northwestern Russia, close to the city of St. Petersburg and the Baltic Sea within the limits of Scandinavian ice-sheets. The lake bottom sediment record is therefore a valuable archive of regional environmental and climatic changes. During the Eemian (Mikulino) Interglacial and after the Last Glacial Maximum, for instance, the Ladoga basin became a part of huge waterbodies, which have occupied the deglaciated Baltic basin, the Eemian Sea and the freshwater Baltic Ice Lake (BIL), respectively. The BIL sediments are widespread at the bottom and in the vicinity Lake Ladoga, while the sediments older than the Late Glacial are very poorly investigated in the Lake Ladoga depression.

This study presents the first dated preglacial (MIS5, Late Eemian – Early Weichselian) diatom record obtained in Lake Ladoga, and thus contributes to Russian-German research project '**P**aleo**l**imnol**o**gical **T**ransect' (PLOT) initiated to investigate the Late Quaternary climate and environment history across Northern Eurasia. Within the scope of the PLOT project, a 22.75 m long sediment core (Co1309) was retrieved from the northwestern deep-water part of Lake Ladoga (111 m water depth) in order to provide new information on the regional climatic and environmental history during Late Quaternary.

The diatom record in the preglacial part of the Co1309 sediment core OSL-dated between ~118 and 80 ka has a number of marine and brackish-marine species and marine flagellates common with other marine Eemian records in the region, but some differences also exist.

Generally, unstable sedimentation environments, unfavourable for the diatom preservation and accumulation prevailed in the coring site during the Late Eemian and the Early Weichselian. Such environments are characterised by unstable/variable sedimentation rates, high current velocities, and wave action in the shallow-water part of the basin. The salinity in the Ladoga basin could have been slightly higher from ~118 to 113 ka, but starting from ~113 ka the influence of fresh water masses increased. No major salinity changes related to the regression of the Eemian Sea can be inferred from our diatom data. Thus, reworking of marine Eemian sediments is thought to be a source of allochthonous diatoms into the basin during the Late Eemian and Early Weichselian from ~113 ka to ~80 ka, obscuring possible salinity shifts, if there were any.

The period from ~113 to 90 ka is characterized by lower sedimentation rates, increased freshwater supply, and apparently increased input of allochthonous siliceous microfossils. These changes might have been related to the climatic and environmental changes with the onset of the Weichselian glacial epoch. From ~90 to 80 ka, the environments in the Ladoga basin became progressively unfavourable for the diatom growth and preservation. Increased sedimentation rates are also suggested.

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THE USAGE OF MODERN TECHNOLOGIES (GIS) IN THE CREATION OF THE LAKE GEOLOGICAL PROSPECTING MODEL AND THEIR USAGE IN PALEOLIMNOLOGY

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Lakes Peschanoe and Kambala are located in the central part of Baraba lowland in the South of Western Siberia in the forest-steppe zone. The nature of the territory surface is typical for the Central Baraba: the southwestern part of the surface is complicated strictly parallel, elongated from Southwest to Northeast, alternating manes and hollow. The landscape integral part is abundant of small and large lakes, swamps and dry valleys [Ilyin, Syso, 2001; Strakhovenko et al., 2016]. Lacustrine bottom sediments belong to the modern and Quaternary sediments deposited on the modern lacustrine-swamp deposits (Lake Peschanoe) and middle Quaternary sediments Fedoseevskaya Suite (Lake Kambala) [Explanatory..., 1967].

Currently, there are no methodological materials on sapropel lake deposits exploration, which would take into account modern GOST, modern analytical methods and devices. Recent work with methodical manual was conducted almost 50 years ago [Instructions…, 1975; Guidelines..., 1976]. In connection with the necessity of using the old methods, the high cost of works multiplied. Therefore, at issue of the license demand to carry out works by outdated methods and on the technique, which demands correction in connection with the scientific knowledge gained for these years.

We have proposed the idea of using modern computer technologies (GIS) to build geological prospecting models of lakes, as it is done for oil fields or mineral deposits.

During the research and exploration works on lakes Peschanoe and Kambala we used software packages ArcGis (10.2.2) and Qgis (2.18.16) to build models of deposits (Fig. 1.), as well as layer-by-area models of element contents distribution in sapropel deposits (Fig. 2.).

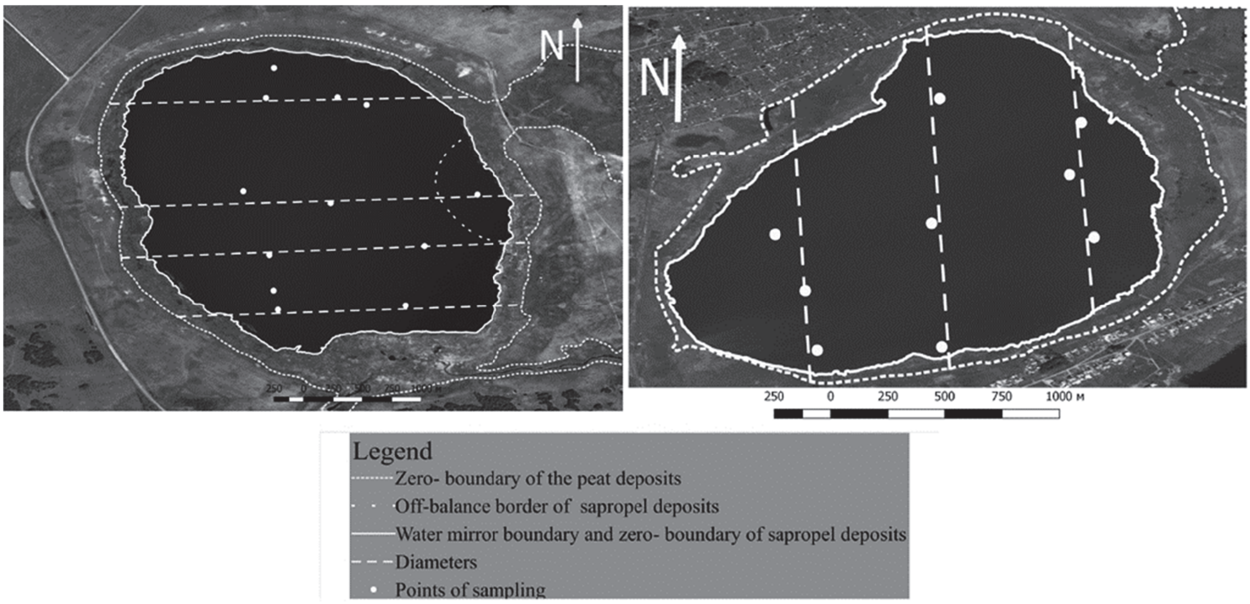

Fig. 1. Scheme of Peschanoe and Kambala lake deposits

Layer-by-area models have shown that most of the elements are distributed uniformly with the range of ± one standard deviation, but some of the elements of the range can vary from -2 to +3 standard deviations (Al, Si, Ca, Mn, K, etc.).

The models of ash content distribution were given the opportunity to identify eolian sources of terrigenous material. Positive anomalies of ash content (Fig. 3) are located in the Northern and Eastern parts of the lakes and coincide with the direction of the wind rose of the area. At the same time, there are no anomalies in the modern places of the confluence of streams, which indicates the decisive role of the eolian material over the alluvial in modern times.

K, Si, Al and ash content distribution models qualitatively showed the role of biota in the formation of silica sediments. The ash distribution of K and Al are the same, which corresponds to X-ray diffraction analysis and shows that K and Al are only in the terrigenous part, namely in feldspar and mica. At the same time, the Si distribution is not connected with K and Al distribution, and shows that Si has different source (not an eolian). The answer was found in a detailed mineralogical study on the scanning electron microscope TESCAN MIRA 3, the main source of Si is diatoms. Therefore, the main source of Si in lacustrine bottom sediments is represented by chalcedony of biogenic genesis (diatoms).

Si and Ca distribution models in the lacustrine bottom sediments of Lake Kambala change symmetrically with depth, indicating a possible species change in the lake biota, as well as a change in abiotic habitat. Thus, we can use the layer-by-area models to perform an environmental study (assessment of individual elements contamination). Qualitatively estimation of sapropel mineral material sources (their changing, migration, etc.) can be used in paleolimnological researches. In addition, modern computer technology is much easier topographic work in exploration.

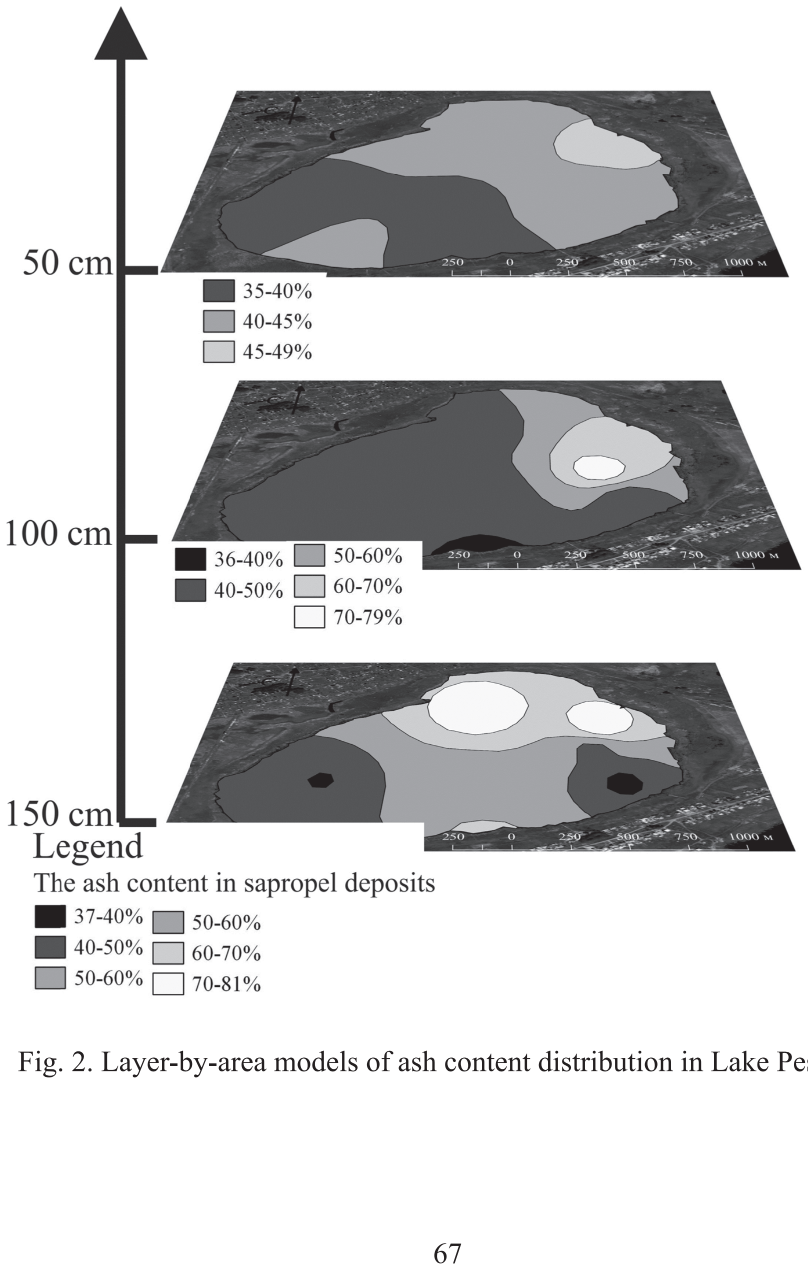

Fig. 2. Layer-by-area models of ash content distribution in Lake Peschanoe

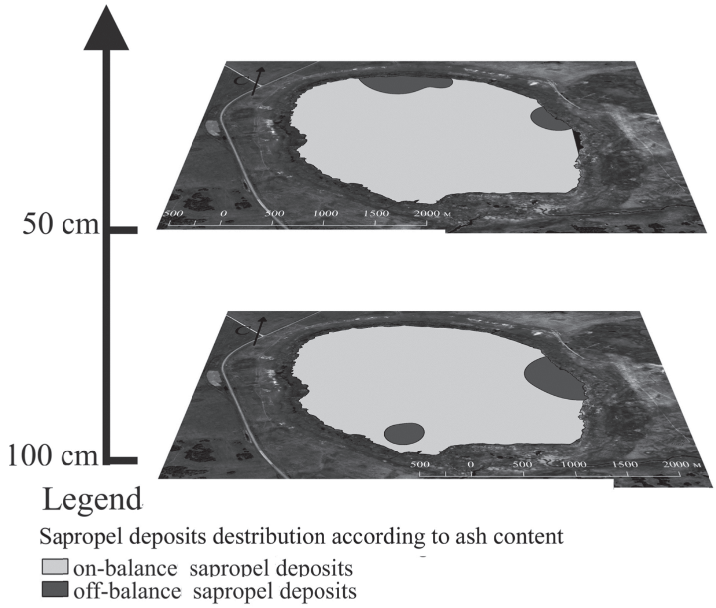

Fig. 3. Sapropel deposits distribution according to ash content in Lake Kambala

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GEOCHEMICAL MULTIPLE REGRESSION MODEL FOR LAKE CONDUCTIVITY RECONSTRUCTION

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The understandings of current environmental changes and the predictions of future climatic processes need accurate and precise reconstructions of the Holocene paleoenvironment. The electrical conductivity (EC) is a zonal characteristic of a water regime of the Urals lakes (Andreeva, 1973). EC increases from north-west to south-east of the territory with a decrease of effective moisture. These changes are reflected in the chemical composition of the lake sediments. In the southern regions, climate fluctuations can directly cause changes in salinity and electrical conductivity of water by increasing evaporation in enclosed lakes (Andreeva, 1973). Other mechanism of climate driven EC changes is increase in chemical weathering intensity due to a temperature increase (Moiseenko and Gashkina 2010).

Previous research showed correlations between salinity and losses on ignition (LOI) for lakes with EC less than 1012 μS/cm (Maslennikova et al, 2018 (in press)). New data on chemical composition of

56 Urals lakes (EC=55-3780 μS/cm) allow to calculate the multiple regression equation for the EC reconstruction. Parametric (Pearson correlation coefficient – r) and nonparametric (Spearman rank correlation coeficient – R_{sp}) correlation analysis showed positive relationships between log-transformed EC-data and $LOI_{950ºC}$ (R_{sp}=0.66, r=0.38), CaO (R_{sp}=0.75, r=0.53), Sr (R_{sp}=0.74, r=0.49), and MgO (R_{sp}=0.7, r=0.76). Negative relationship was determined for EC and $LOI_{550ºC}$ (R_{sp}=—0.49, r=—0.49).

All variables were included to the primary multiple regression model. Sr and $LOI_{950ºC}$ were excluded from the model after checking it for multicollinearity due to the high correlation with CaO content (r>0.9). The organic-matter variable ($LOI_{550ºC}$) was removed after p-values checking. Summary model consists of two variables (tab. 1) and characterizes by the following equation:

$$lgEC=1.93+0.22MgO+0.0165CaO$$

Table 1

Regression summary of dependent variable (lgEC)

	Beta	SD (Beta)	b	SD(b)	t(53)	p-value
Intercept			1.934	0.061	31.4	$0.0059\ 10^{-26}$
MgO	0.65	0.09	0.222	0.03	7.17	$0.0023\ 10^{-6}$
CaO	0.267	0.09	0.0165	0.0056	2.95	0.004652

The root-mean-square error (RMSE) of the model is 0.23 lg μS/cm. Analysis of residuals show their normal distribution and the absence of dependence on the predicted values. The values of the Fisher test (F (2.53) = 46.73) and t-statistics for the regression coefficients (tab. 1) exceed their tabulated values for available degrees of freedom. The coefficients of correlation (r = 0.8) and determination (r^2 = 0.64) between measured and predicted EC values were relatively high which confirms the reliability of the model (fig. 1).

Comparison of the electrical conductivity values, calculated on the basis of the diatom transfer function (Maslennikova, in press) and obtained with the geochemical model confirms their good agreement (r = 0.77; r^2 = 0.6) (Fig. 2). The relationship was disturbed for lakes with presense of serpentinites in the source area (i.e. Lakes Aushkul and Arakul).

Although the diatom-inferred model is characterized by lower mean-square error (RMSE= 0.06-0.13 lg μS cm-1), the proposed geochemical model has the advantage of simplicity allowing to quickly assess the lake water EC, even in an absence of diatoms in the lake sediments.

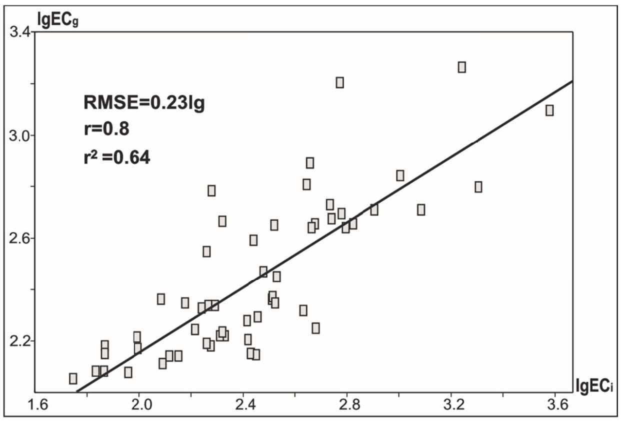

Fig. 1. Relationship between measured (lgECi) and modelled (lgECg) values of lakes electroconductivity

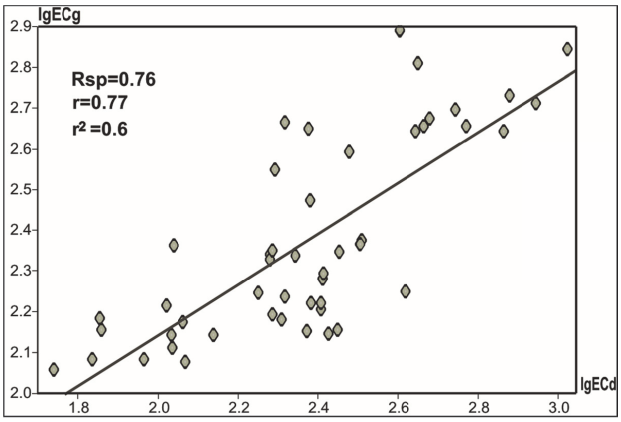

Fig. 2. The relationship between diatom-inferred (lgECd) and geochemical-inferred (lgECg) conductivity of the lakes waters

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THE PROJECT PLOT (PALEOLIMNOLOGICAL TRANSECT) - OVERVIEW AND PRELIMINARY RESULTS ON THE PREGLACIAL TO POSTGLACIAL HISTORY OF THE RUSSIAN ARCTIC

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The effects of global warming are documented and predicted to be most pronounced in the Arctic, which plays a crucial, albeit not yet well-understood role within the global climate System. This so-called "Arctic Amplification" is traced back to interplays of temperature, water vapour, cloud cover, Arctic Ocean sea ice, and associated feedbacks, and is hypothesised to trigger mid-latitude climate variations. The reliability of climate projections for high northern latitudes is, however, hampered by the complexity of the underlying natural variability and associated feedback mechanisms. A prerequisite for the improvement and validation of climate projections is a more thorough understanding of the natural variability of past Arctic climate change on a range of geological timescales, when external forcings and boundary conditions have been different. A key record of the climate history in the Arctic has recently become available from Lake El´gygytgyn, NE Russia (e.g. Melles et al. 2012, Science 337, p. 315-320). This record covers the entire Quaternary and penetrates down to 3.6 Ma BP into the Pliocene. Its investigation has provided a number of key findings concerning the long-term climate variability of the Arctic, however, it partly remains an open question, how representative the information is for the circum-arctic history.

As a consequence, we established the project ´PLOT – Paleolimnological Transect´, which aims to recover lake sediment sequences along a >6000 km long longitudinal transect across the Russian Arctic in order to investigate the Late Quaternary climatic and environmental history. The PLOT project is conducted under the umbrella of a bilateral Russian-German agreement in the field of polar and marine research and is funded by the German and Russian Research Ministries. Since 2013 extensive fieldwork, including seismic surveys, coring, and hydrological investigations, was carried out at lakes Ladoga (NW Russia), Bolshoye Shuchye (polar Urals), Emanda (Verkhoyansk Range), Levinson-Lessing and Taymyr (both Taymyr Peninsula), with the special aim to recover preglacial sediments. Fieldwork in the Ural Mountains and on the Taymyr Peninsula was conducted in collaboration with the Russian-Norwegian CHASE (Climate History along the Arctic Seaboard of Eurasia) project. A multiproxy analysis strategy was applied to all cores, including (bio-)geochemical, sedimentological, physical, and biological analyses. First data implies the presence of preglacial sediments in the cores from all lakes except Lake Emanda. Age-depth models, based on radiocarbon dating, OSL dating, paleomagnetic measurements, identification of cryptotephra, and varve counting (where applicable), are in progress. Here, we present and discuss the most important results available thus far from the geophysical site surveys and core analyses, and provide an outlook on the future strategy and foci of the project.

STUDY OF LAKES MORPHOMETRY IN THE BORDERS OF PLEISTOCENE GLACIATIONS OF THE NORTHWEST RUSSIA

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Abstract: There are lakes on the territory of the North-West of Russia within the Pleistocene glaciations different in genesis and morphometric parameters. The study of the lakes is necessary for the future pattern of development of lakes and territories on which they are located.

Key words: paleolimology, GIS, morphometry.

The aim of the work is to create a database of morphometry of lakes in the glacial and periglacial zones of the North-West of Russia.

The structure of the database is created in MS Excele and includes the name of the lake, the coordinates, the height of the lake above sea level, the relation to the glaciation boundaries, the catchment basin, the area, the length of the shoreline, the average width, the length of the lake, the average depth, coefficients of ruggedness of the coastline and elongation, the state of the lake.

The database serves the purpose of systematization of freshwater land basins and contributes to the further study of the complexes of the lakes of the Northwest of Russia.

Numerous glaciations in the Pleistocene occurred on the territory of the Northwest of Russia, which reached 50^0 latitude. After various glaciations, the lakes developed in accordance with their landscape features.

In each separately developing landscape, the lakes have a unique morphology and history of development.

ECOLOGICAL CHARACTERISTICS OF GREAT SERTEYA PALEOLAKE BASED ON PALEOECOLOGICAL RESEARCH AT THE SERTEYA II SITE IN WESTERN RUSSIA

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The landscape of the Serteya region was formed in the late Pleistocene during the last Valdai (Weichselian) glaciation and in the Holocene. In the late Valdai, the first generation of lakes was created between dead-ice blocks. In the Holocene, the blocks of ice melted and, as a result, the second generation of lakes developed. In the lower Serteya River Valley, four paleolake basins created in the subglacial channel were recognised. Those lakes were subsequently drained by the Serteyka River channel from the lower section (Kalicki et al., 2015). The Great Serteya Palaeolake Basin functioned probably until the Modern Period.

The Serteya region landscape provided great food resources for Neolithic communities. The numerous archaeological sites from the Mesolithic to the Middles Ages have been documented there since the 1960s. Approximately 30 of the sites date back to the Neolithic Period and to the period between 8300 cal. BP and 3800 cal. BP. In last years, the North-Western Expedition of Hermitage State Museum in Sankt Petersburg has been intensively exploring interesting Neolithic settlement remains at the Serteya II site. The Neolithic cultural layer lies ca. 1.2-2.0 m below the water table of melioration canal. During an archaeological underwater excavation, remains of six pile-dwellings were discovered. The location of these constructions in the Great Serteya Palaeolake Basin in lacustrine sediments is very important. Archaeological structures, artefacts and ecofacts are very well preserved within gyttja layers. The pile-dwelling settlement functioned mainly between 4200-3800 cal. yr. BP. The Neolithic settlement existed during the 4.2 ka BP cooling event, which might be strictly related to the climate conditions and hydrological regime (Mazurkevich et al., in press).

The purpose of our multi-proxy research is a detailed reconstruction of the paleoenvironmental conditions which accompanied the prehistoric community of the Serteya region. Geomorphological analysis and geological mapping allowed to reconstruct the landscape of the study site and its development from the Mesolithic to the Middles Ages. The two cores of organic deposits collected from the Serteya II site were analysed with the use of paleoecological methods, among others: pollen, plant macrofossils, diatoms, Cladocera, Chironomidae, molluscs, geochemical and sedimentological analyses. Based on those proxies, the following palaeoenvironmental and paleoclimate features were reconstructed: seasonal water level fluctuations, trophic status of the waters, continentality, and palaeotemperature (average July temperature). Data obtained from multi-proxy research provided information about local and global factors as well as the human-environment relationship. The results allowed us to recreate the background of the prehistoric settlement. The water-level changes of the palaeolake were strong limiting factors for the human settlement.

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PRELIMINARY RESULTS OF PALYNOLOGICAL INVESTIGATION OF BOTTOM SEDIMENTS FROM LAKE TURGOYAK (CHELUABINSK REGION, RUSSIA)

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Lake Turgoyak is a unique natural object. It is one of the largest water bodies of Chelyabinsk region. Turgoyak is a repository of pure natural water, the quality of water is close to such like in the Baikal Lake [1]. Water surface area of the lake is 26.4 km. The average depth of the lake is 19.1 m, the maximum depth is 36.5 m. Water transparency is 10-17.5 m. The climate of the lake basin is continental with a steady snow cover in cold winter and short summer with high rainfall in July [2]. As a natural monument Turgoyak has a particularly important environmental and recreational value. Due to bottom sediments that contain and store the information on ecological situations of the past the lake has important paleoclimatic value [3]. Biological paleoindicators such as diatoms, remains of vascular plants and invertebrates (cladocera, chironomidae, ostracoda), spores and pollen used for more accurate qualitative and quantitative reconstruction of past conditions [4]. The border location of the Urals, as the climate divide, makes paleoclimatic and paleoecological investigations of Lake Turgoyak especially important [5].

The article presents preliminary results of pollen analysis of the core of bottom sediments from Lake Turgoyak. In 2017, a 560 cm long sediment core was recovered from 5 m depth of the lake (55°09' N, 60°04' E). The core was retrieved with a modified Mackereth corer. A total 30 samples were taken at a 20-cm average intervals and were treated for pollen analysis using standard procedure [6]. Pollen residues were analyzed under a light microscope Axio Imager A2 (Carl Zeiss) with 400x magnification. Identification of pollen and spores was performed using pollen atlases [7-8]. The microscopic analysis revealed a high pollen concentration and generally good preservation, which allowed the identification of at least 300 terrestrial pollen grains per sample in upper part of the core (the first 21 samples). The lower part of the core did not contain a number of pollen grains sufficient for statistical processing. Percentages of taxa were calculated based on a pollen sum of all pollen taxa taken as 100%. The results are displayed in a diagram (Fig. 1) produced with Tilia/TiliaGraph and CONISS software [9]. The first 400 cm of precipitation was included in the diagram. The pollen diagram is subdivided in three pollen zones (PZs) based on changing pollen taxa composition and abundance. The pollen record is dominated by *Pinus sylvestris* and *Betula* throughout the core. *Picea*, *Artemisia* and *Chenopodiaceae* pollen grains are presents in all PZs.

The lower part of the PZI (370-290 cm) is characterized by the highest abundance of herbaceous pollen taxa (*Artemisia* up to 65 %, *Chenopodiaceae* up to 10 %) and low content of arboreal pollen taxa (10-30 %). Presumably this part of the PZI corresponds to the end of the Late Pleistocene. A sharp decline of the concentrations of non-arboreal pollen taxa and increase of *Betula* (up to 60 %) and *Pinus sylvestris* (20-40 %) pollen content is observed closer to the upper boundary of PZI. This event corresponds to warming preboreal period of the Holocene. According to radiocarbon data of the samples from a 350 cm depth coincides to 11770 ^{14}C Yr BP and development of arboreal taxa (*Betula, Pinus, Picea*).

PZII (290-70 cm) is characterized by the phase of development of dark coniferous forests with broad-leaved species. The content of *Betula* and *Pinus sylvestris* pollen is relatively high (35-55 %). The *Picea* pollen concentration changes slightly and remains low (up to 5 %). The broad-leaved species pollen occurs in this zone (*Alnaster*, *Tilia*, *Ulmus*) – up to 5 %. The content of *Artemisia* pollen reaches up to 10 %, Chenopodiaceae - up to 3 %. According to radiocarbon dates the samples from 250 cm depth coincides to 6625 ^{14}C Yr BP. It correlates with warming of the Atlantic period of the Holocene by the Blitt-Sernander scheme [10].

PZIII (70-0 cm) is characterized by an increase of *Picea* pollen (up to 10 %), *Artemisia* pollen (up to 15 %) and by a decrease of broad-leaved species pollen. Presumably the upper part of the core corresponds to the cooling of the Subboreal period of the Holocene.

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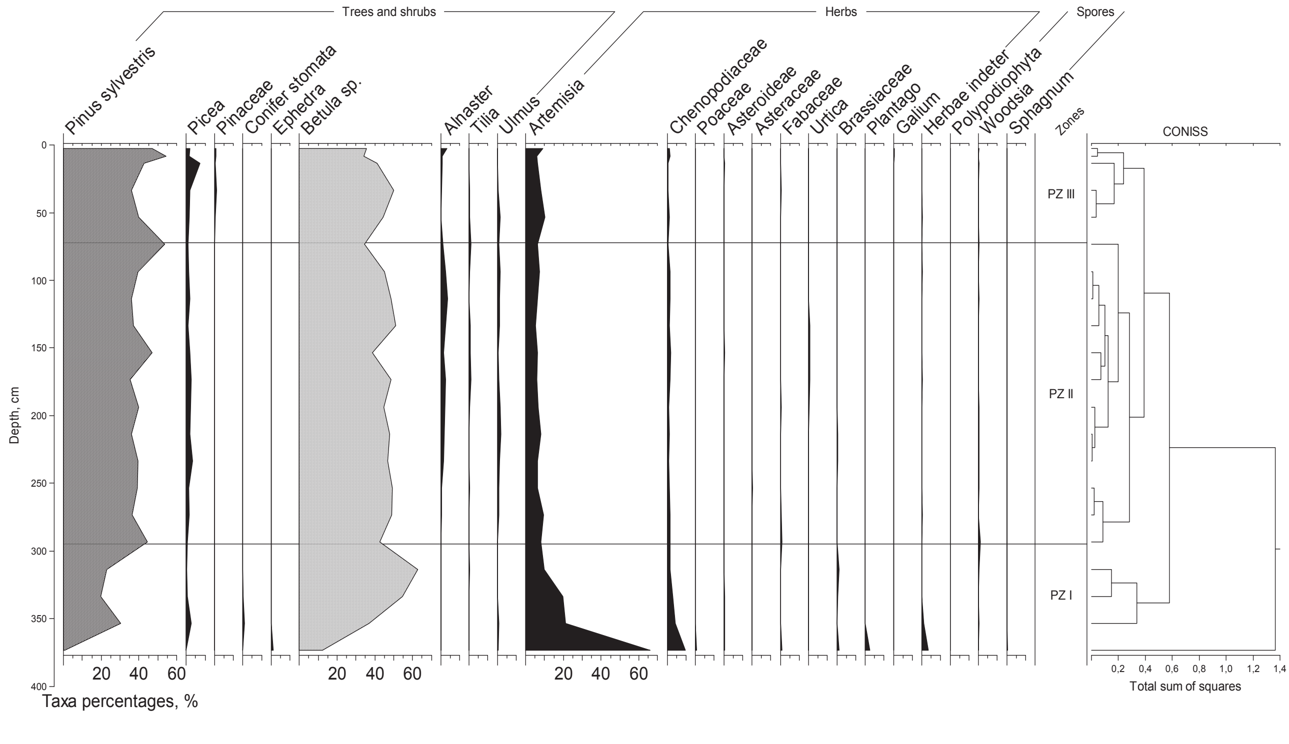

Fig. 1. Percentage pollen and spore diagram of the core of Lake Turgoyak

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PALEOLYMNOLOGICAL CHANGES IN THE LAKE-LEVELS ON THE TERRITORY OF BELARUS, LATVIA AND ESTONIA IN THE LATE GLACIAL AND THE HOLOCENE

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Analysis of the sedimentary cores of Belarus, Latvia and Estonia located within the meridional transect with a pronounced gradient of the natural conditions of the Late Glacial and Holocene allows us to trace and explain the synchronism/asynchrony of the changes in lake levels as an indicator of the transformation of climate, vegetation, landscapes, in a fairly large region of Europe – The Baltic Lakes District. As the reference objects of the study, Juusa in Estonia, the lake. Kuji in Latvia and the lake. Dolgoe in Belarus. The choice of these objects is due to a single glacial genesis and similar features of the lagging of lakes within various marginal stages of the Wurm ice retreat, as well as to a complex of paleogeographical studies of the history of the development of the water bodies themselves and the adjacent watersheds on the basis of lithologic-stratigraphic, paleofloristic, radiocarbon and isotope-geochemical diagnostic methods.

Based on the analysis of the conducted paleogeographical studies, the reconstruction of the level changes in the lakes of Estonia in Latvia and Belarus in the postglacial period was carried out, during which a number of general patterns (Fig. 1).

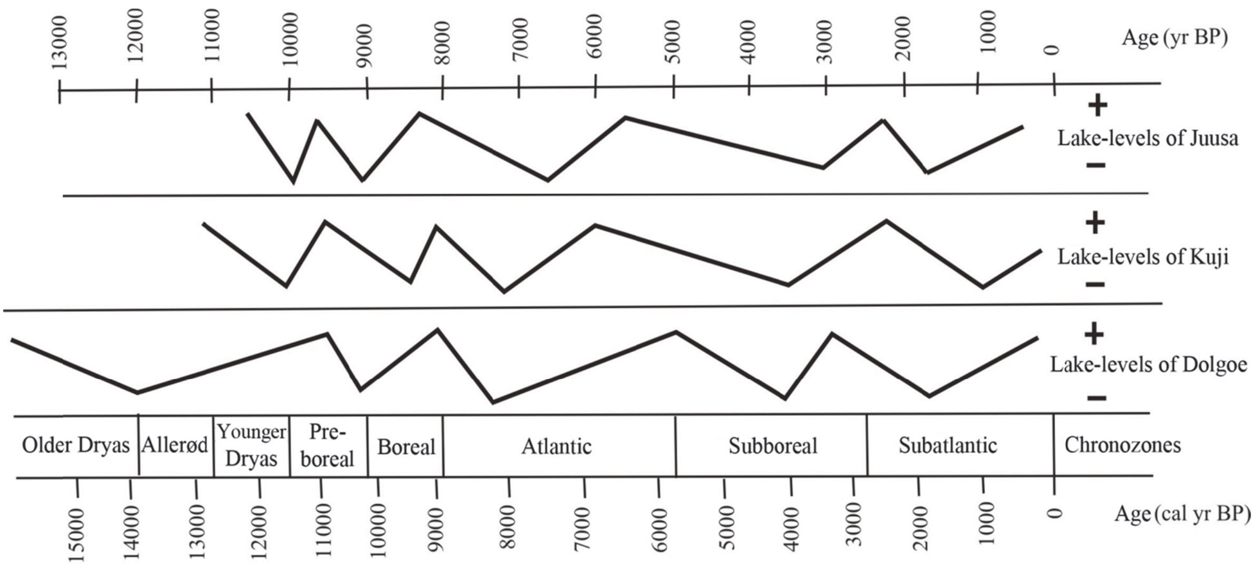

Fig. 1. The dynamics of changes in lake levels in the Baltic Lakes District in the postglacial period

First of all, a clearly expressed minimum of levels, characteristic of the early stages of the late glacial period, is recorded in the lake Dolgoe. Low level marks, were due to a sharp cooling and the incompleteness of the process of the conservation of glaciocarst. A slight increase in watercut in the territory, which occurred in the Allerød - the beginning of the Younger Dryas, is observed in the lakes of Kuji and Dolgoe, which is associated with the warming of the climate of that time and the activation of glaciokarst processes. The deepest depressions of the lake basins of southern Estonia at that time remained canned ice. The increased cooling in the Younger Dryas was probably accompanied by an increase in the humidity of the climate and the rise in lake levels. Intensive soil nutrition in the waters of the Juusa and Kuji caused the flow of carbonate and terrigenous material and the beginning of the formation of lake sediments. However, already in the first half of the Preboreal, there was a tendency to lower levels for all three lakes, which was due to a decrease in the humidity of the climate and a decline in fluvial activity. This period includes finds of low-power layers of ancient peat in all the studied lakes.

The formation of peat was facilitated by the onset of warming of the climate and activation of the processes of unloading thawed waters of permafrost due to the intensification of infiltration processes. From the second half of the Preboreal, the region-wide dynamics of lake level rise is observed in the investigated lake sections, due to the global trend of warming and humid climate in the northeast of the Holocene. The mineral and organomineral deposits of late glaciation prevailing before that date start to overlap with rocks of the carbonate composition due to the leaching of carbonate moraine as a result of increased fluvial activity. In the epoch of sedimentation of carbonate sediments, the lakes possessed the character of oligo-mezotrophic water bodies with a low organic content in the bottom sediments. Important in this case were the morphological features of the lake basins and the lithology of the water reservoir rocks. The process of raising the levels continued until the beginning - the middle of the Boreal. The next fall in temperature, which occurred at that time, led to a decrease in hydration and lowering of levels.

At the end of the Boreal - the beginning of the Atlantic, the process of stabilizing levels with a general tendency to overflow is traced, but already about seven thousand years ago the stage of the next decline of levels has come, which reflects the interruption of the lake sedimentation in the section on the littoral zone of the lake Dolgoe. This period corresponds to a change in the nature of sedimentation in all the lakes studied. The predominant carbonate component of lake sediments towards the middle of the Atlantic is either reduced by a fraction of the $CaCO_3$ content, or completely smoothed by an organomineral one. The reasons for the replacement of carbonate deposits by organic ones were complex: leaching of catchment areas, which resulted in a reduction in the inflow of hard waters; cooling in the beginning of Subboreal, determining the termination or slowing down of the formation of lake carbonates; increase of trophic status due to the development of plant and animal life in them. The cold and humid conditions of the Subboreal contributed to the onset of another trend towards higher levels, which was accompanied by an increase in mineral components in the sediments of all lakes. In addition, in the former littoral parts of lake Dolgoe, the process of lake sedimentation resumed. In the second half of Subboreal, the fluctuations differed in their diverse nature, which was due to local factors, but by the beginning of the Subatlantic, the process of warming and humidifying the climate caused another common phase of recovery in all the lakes in the region studied. At present, the analysis of lake sedimentation confirms the regression stages in the dynamics of changes in the levels of the studied lakes, which began about a thousand years ago.

Most of the revealed regularities in lake sedimentation have general tendencies for the Baltic Lakes District, which is associated with global paleoclimatic transformations in the Late Glacial and Holocene. However, in climatic cycles associated with periods of cooling and increase in moisture content from northwest to southeast, some delay in the stages of changes in the nature of sedimentation and, as a consequence, fluctuations in lake levels, are found. Conversely, for paleocycles with a warming and a decrease in moisture content, a reverse scenario is observed that, in addition to the influence of local factors in the catchment areas, can be explained by an increase in the gradient of the continentality of the climate along the meridional transect: the lakes Juusa - Kuji - Dolgoe. This is confirmed by palynological data, according to which it was established that the most significant climatic events of the Holocene (late Boreal, middle Atlantic and early Subboreal cooling) in Belarus looked brighter than in the territory of the Baltic States.

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THE FEATURES OF MINERAL FORMATION PROCESSES IN LAKE PETUKHOVO (KULUNDA PLAIN)

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Lake Petukhovo (Altai Krai) is located in the ribbon-like (relict) pine forest of the Kulunda plain steppe zone. Lake Petukhovo is a small drainless lake with sapropel deposits (the lake mirror area is 4.7 sq. km). Large stromatolite formations were found in the coastal zone of the southeastern shore of the lake.

The aim of the work is to establish the features of modern mineral formation in the Lake Petukhovo and compare the mineralogical and geochemical characteristics of the lake ecosystem components. The objects of study – the Lake Petukhovo ecosystem components.

The fieldwork was carried out as part of a complex expedition in 2015 and 2017. Bottom sediments were collected from the catamaran by a cylindrical sampler with a vacuum shutter (diameter 82 mm, length 50 cm). The core samples of bottom sediments were sampled with an interval of 3-5cm. Coastal area sediments were sampled in layers. Physical and chemical variables were recorded in situ (pH, Eh, TDS).

Further studies of the samples chemical composition were held at the Center for collective usage of scientific equipment for multi-element and isotopic studies of SB RAS, Laboratory of Geochemistry of noble and rare elements and ecogeochemistry of IGM SB RAS. The bottom sediments macro- and microelement composition was determined by atomic absorption method. The macroelement composition was determined by X–ray fluorescence analysis. X-ray diffractometry (XRD) was used to determine the mineral composition. Study of morphology, phase and chemical composition of the samples was performed using scanning electron microscope equipped with an energy spectrometer. Determination of REE content was carried out with the ICP-MS.

The classification variety and sapropel characteristics are associated with the complexity of their origin. Depending on ash content, sapropel is divided into types and depending on the predominance of Si or Ca is divided into classes [Strahovenko et al., 2016]. Lake Petukhovo bottom sediments are mineralized type, calcium sapropel class. According to X-ray diffractometry: quartz, dolomite, plagioclase, disordered smectite dominate in the upper horizons of the lake Petukhovo bottom sediments. Halite, throne, Kfsp are noted in the impurities form. In the lower horizons dolomite prevails sharply, all other above-mentioned minerals are present in the impurities form. According to studies on SEM, dolomite is represented by small (<5 μm) rhombohedral crystals sometimes having a saddle shape and crystal clusters,

Lake Petukhovo is a mesotrophic lake. According to the overgrowth degree by macrophytes and the volume of the primary products formed by them, the lake can be attributed to the overgrowth border type, where rigid air-water vegetation prevails, producing from 259 to 1127 g/m^2 per year of organic matter with an area of the water area overgrowing of not more than 30%.

The Lake Petukhovo water is a chloride-hydrocarbonate sodium brine with the (TDS= 52.3 g/l, pH 9.8). According to the results of ICP-MS, the content of Ce and Y in lake water was determined, the rest of REE are BDL. The amount of REE in water is 0.0011 mg/l.

Along the lake eastern shore, under algo-bacterial mat in the coastal area sediments we sampled large (up to tens of sq. cm) formations – stromatolites. In the paper [Samylina et al., 2016] authors consider small dense crusts selected from the same lake on the southern shore.

The authors of this work studying at the SEM found that the stromatolites consists of terrigenous and biochemical parts. The terrigenous part consists of rounded quartz grains and feldspars, which are the seed for the carbonates crystallization of biochemical genesis. Biochemical part consists of collomorphic zonal aggregates of calcite (with a Sr impurity), low-Mg calcite and small crystals of scalenohedral habit. At the interface of the stromatolite-water border edges width of not more than 20 μm sometimes present, composed of fine aggregate dolomite composition (Fig.1).

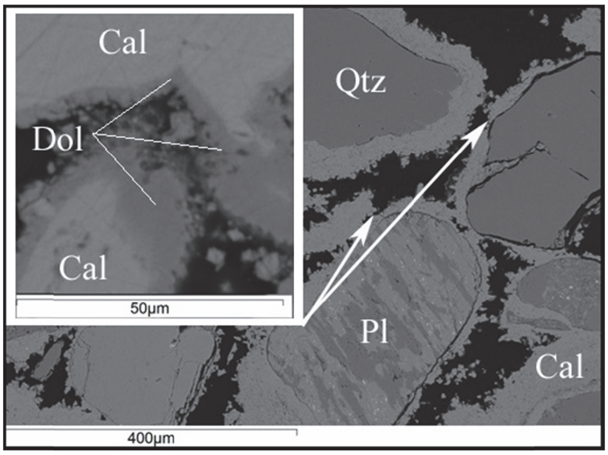

Fig. 1. Stromatolite. Overgrowing of the Qtz (quartz), Pl (plagioclase) grains by Cal (calcite). The dolomite edges formation on the stromatolite periphery. Pictures using SEM Tescan Mira 3

The averaged concentrations of all studied elements in the Lake Petukhovo bottom sediments, catchment area soils, algo-bacterial mat, stromatolite and coastal area sediments in which stromatolites are formed (Fig.2). The highest concentrations of Ca, Sr, V and depletion of K, Be, Na, Al, Cr, Fe, Co, Ni, Zn are set for stromatolite. Lake Petukhovo bottom sediments and algo-bacterial mat are enriched with Mg, which is confirmed by dolomite in the main phase of Lake Petukhovo bottom sediments. The chart indicates inheritance of the algo-bacterial mat chemical composition in the Lake Petukhovo bottom sediments and stromatolite composition.

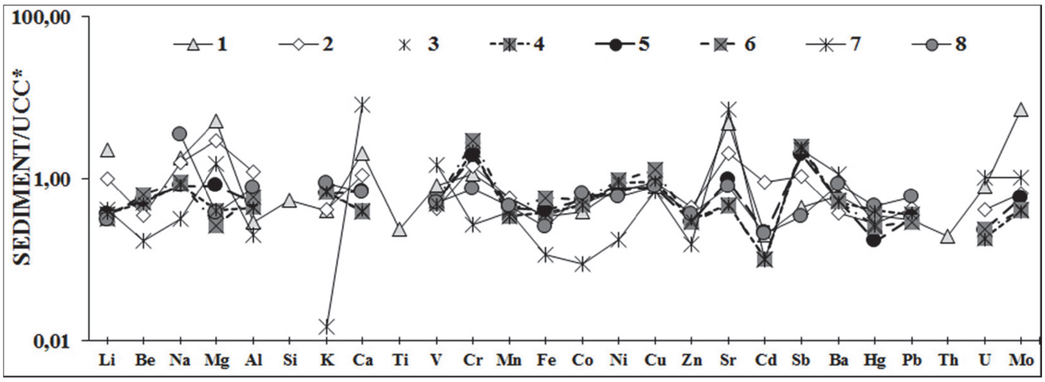

Fig. 2. Multielement spectrum of the studied elements averaged values, normalized to the values of the UCC concentrations by [Wedepohl, 1995]. 1– lacustrine bottom sediment; 2 – algo-bacterial mat; 3 – green coastal area sediment; 4 – bright green coastal area sediment with black interlayers; 5 – bright green coastal area sediment with white/red interlayers, 6 – black sand; 7 – stromatolite; 8 – soil

On the REE distribution chart (Fig.3) there is an enrichment in MREE of coastal area sediments compared to LREE and HREE, which may be due to the influence of groundwater, because in the Lake Petukhovo southwest shore there is a well of self-discharge fresh waters (TDS=150 mg/l) with a hydrocarbonate-sodium composition. The Eu-anomaly values are positive and range from 1.05 in algo-bacterial mat to 1.46 in the coastal area sediments. Positive Eu-anomaly is a distinctive feature of stromatolites [Kuptsova et al., 2011]. Ce-anomaly is positive for the coastal area sediments and catchment soils (oxidizing conditions) and negative for algo-bacterial mat and stromatolites (reducing conditions). The lowest REE contents are set in stromatolite. Because of biogenic carbonates do not accumulate REE in significant quantities [Dubinin, 2006] and there is a similar distribution of macro, micro – and REE in the algo-bacterial mat and stromatolite, that proves the stromatolite biogenic origin.

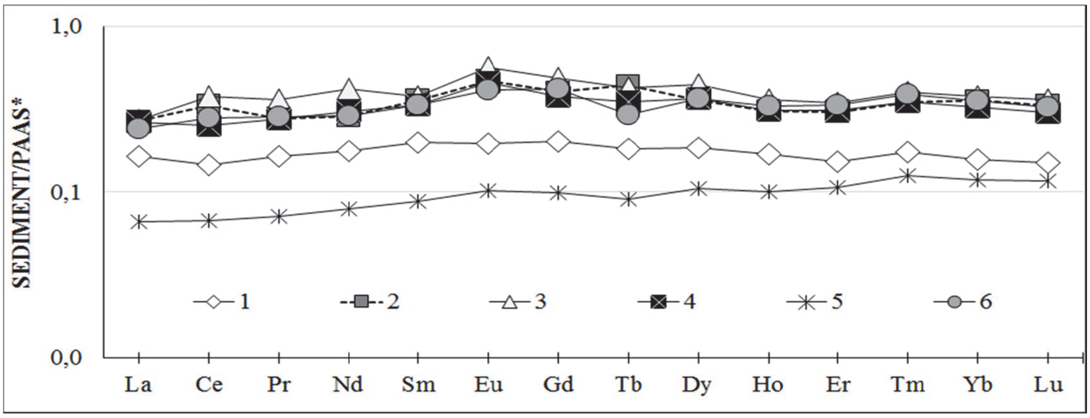

Fig. 3. The chart of REE values distribution normalized to PAAS [Taylor, McLennan, 1988] 1 – algo-bacterial mat; 2 – bright green coastal area sediment with black interlayers; 3 – bright green coastal area sediment with black interlayers; 4 – black sand; 5 – stromatolite; 6 – soil

Conclusion. Stromatolites are formed under algo-bacterial mat in the coastal area sediment in the Lake Petukhovo southeastern shore. Stromatolites mainly composed of calcite. Stromatolite has a biochemical origin, which is confirmed by the distribution data on the macro-, micro - and REE in stromatolite and algo-bacterial mat. Dolomite sediments of Lake Petukhovo is of chemogenic origin. Detailed consideration of their interaction requires further research.

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THE LATE MIDDLE PLEISTOCENE PROGLACIAL LAKE IN THE KELTMENSKY HOLLOW, SEVERNYE UVALY UPLAND

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The Keltmensky Hollow is a buried canyon that crosses the Severnye Uvaly Upland and connects the basins of Vychegda and Kama. According to a number of authors, this is a relic of the erosion network of the Early Pleistocene, when the present upper reaches of the Kama belonged to the Pechora Basin and flowed into the Arctic Ocean. Periodic blocking by glaciers in the Middle Pleistocene led to the reverting of the upper Kama into the Volga basin and the filling of the canyon with a thick (up to 70-80 m) body of sediments of different origin. Now, along the hollow, rivers flow down: North Keltma - to Vychegda, Southern Keltma - to Kama. However, in the Late Pleistocene, according to a number of authors, the waters of glacier-dammed lakes that filled the basins of Vychegda and Pechora flowed through the Keltmensky Hollow and into the Volga basin. It was assumed that the last such event occurred at the maximum of the last glaciation.

To clarify the history of the Keltmensky Hollow, in 2017 we drilled a 45-m core 17843 at 61.16812 ° N, 54.98654º E. The upper 23.5 m of the section, represented by eolian, alluvial and fluvioglacial sands, document the Late Pleistocene history of the valley, which will be the subject of a special publication. In this paper we consider the lower half of the section, the lithologic-stratigraphic structure of which is the following (Fig. 1).

Layer 6, 23.5-26.0 m: dark gray brownish aleuritic clay with inclusions of clasts (small gravel), very tight. According to the grain size analysis, the average particle diameter is in the range 0.004-0.019 mm, the sorting coefficient varies within the range of 0.23-0.53. As a working hypothesis, the layer was interpreted as the moraine of the Vychegda glaciation (MIS 6).

Layer 7, 26.0-27.6 m: gray fine-grained sand - probably fluvioglacial.

Layer 8, 27.6-42.9 m: a silty stratum with thin horizontal stratification. Up to a depth of 35.6 m, a fairly uniform stratum of sandy-clayey silt with rare interlayers of silty clay is observed. At depths of 36.5 and 37.2, interlayers of fine-grained clayey-siltsty sand were encountered. Below (interval 37.7-40.4 m) there is clayey-sandy silt, downward shifting to sandy-clayey silt. The stratum is interpreted as lacustrine sediments.

Layer 9, 41.3-43.2 m: Brownish-gray fine sand with rare gravel up to 1 cm in diameter, with interlayers of brown sandy loam. The grading coefficient is average and varies within the range of 0.31-0.43. The average particle diameter is in the range of 0.073-0.153 mm. Below 43.2 m, the material could not be trapped by the cylindrical sampler, which indirectly indicates the continuation of the sand composition of the deposits (liquefied sand).

Spore-pollen analysis allowed to recognize the following pollen zones and to reconstruct the following types of vegetation (from the bottom up):

1. Interval 42.70-37.63 m. Light coniferous forests with pine dominance, considerable participation of spruce, admixture of birch (mainly shrub), alder and willow. The climate was relatively warm.

2. Interval 37.5-31.5 m. Forest groups retained their predominance, but the role of bog-grass communities rises. Climate cooling is evident.

3. Interval 31.5 - 24.0 m. Development of birch bush tundras. In addition to the bog-tundra formations, xerophytic communities of wormwood *Artemisia* sp., *Chenopodiaceae mastum*, *Ephedra* sp. All this indicates cold and dry climate.

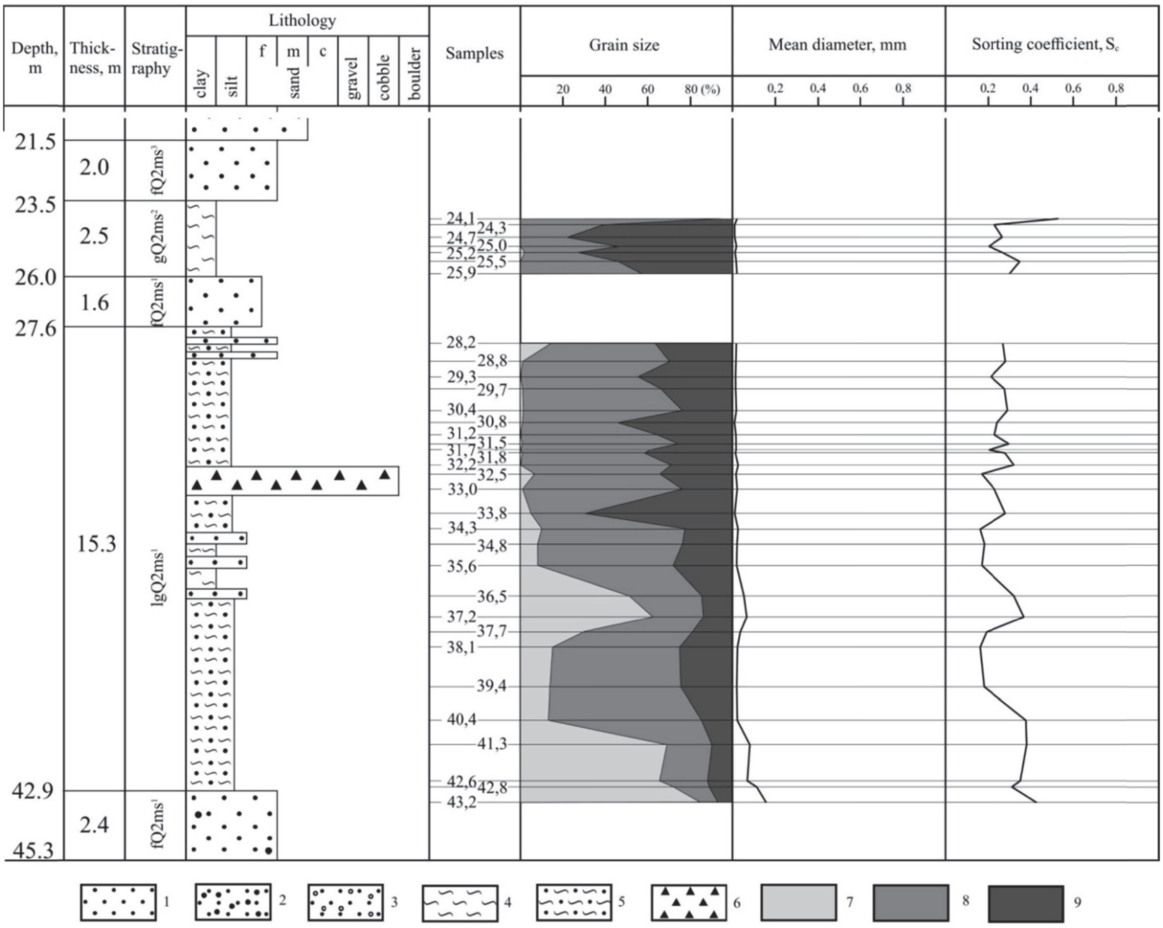

Fig. 1. Lithology of sedimentary filling of the Keltmensky Hollow, core 17843, lower part.
Legend: 1 – sand, 2 – sand with gravel, 3 – sand with cobble, 4 – clay, 5 – loam, 6 – small gravel; grain size fractions 7 –1-0,1, 8 – 0,1-0,01, 9 – <0,01 mm.

On the spore-pollen diagram, a “wave” of warming with the most forested conditions (taiga) in the interval 33-40 m is clearly visible. It was followed by cooling. The upper part (to a depth of 26 m) is already treeless. It is, at best, a forest-tundra. At the same time, drying of the climate occured, which is evident from the growth of wormwood pollen. If the assumption of the glacial origin of layer 6 and its Vychegodskian (MIS 6) age is correct, then the composition and dynamics of the vegetation cover allow us to relate the studied part of the section to the pre-Vychegodskian (pre-Moscovian, MIS 6) interstadial or the ending of the interglacial epoch of MIS 7.

Thus, the available data indicate that in the Keltmensky Hollow the advance of the Vychegda (MIS 6) glacier was preceded by the formation of a proglacial lake. Judging by the great thickness of the sediments, the lake existed for a long time - several thousand years. The high content of sand fractions in the lower half of the section indicates that at first the lake was semi-opened, but later the flow decreased or disappeared at all. Immediately before the arrival of the glacier, a sand layer accumulates - apparently, sediments of glacio-fluvial streams in the vicinity of the ice sheet front that could invade the lake as a delta.

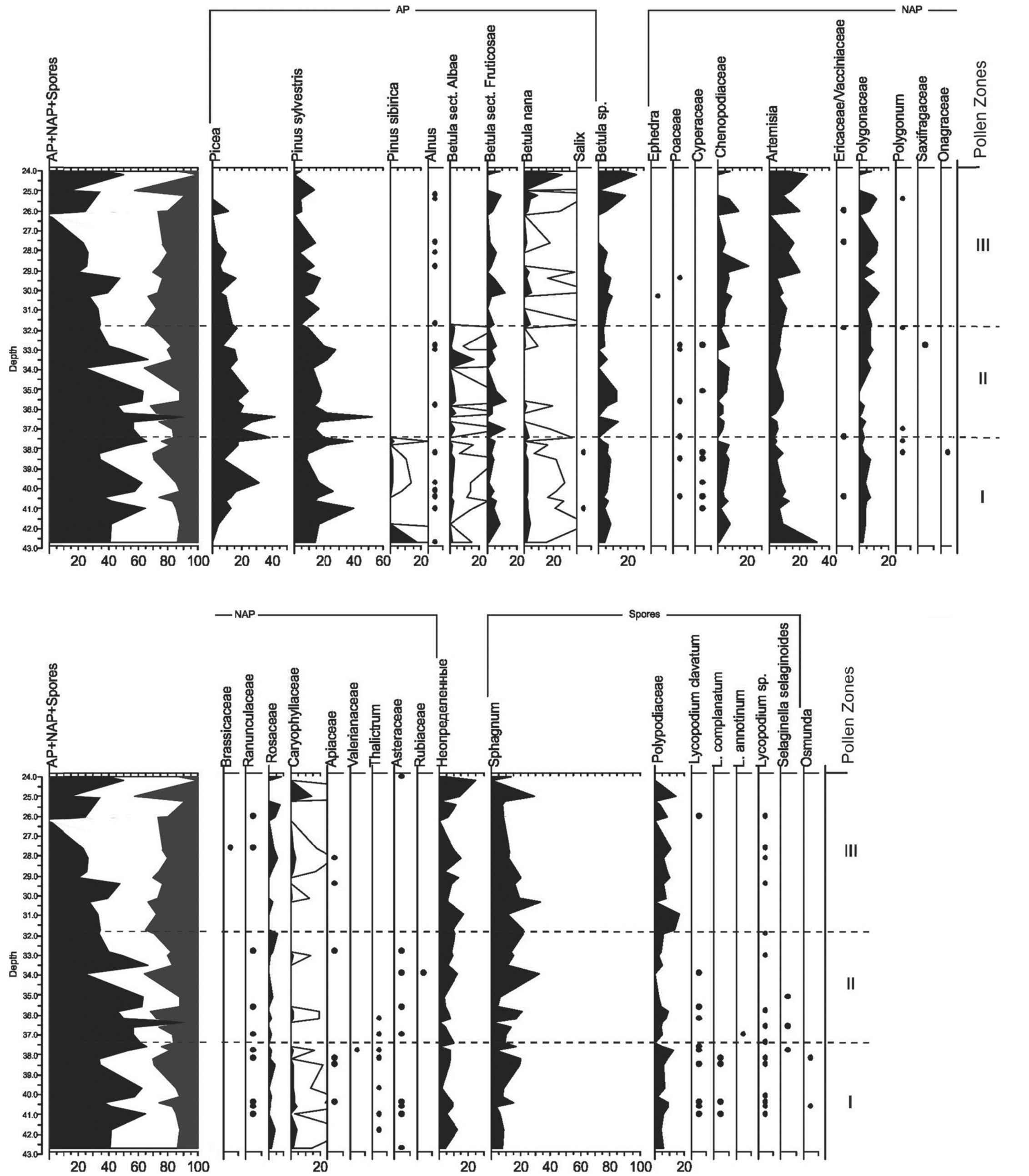

Fig. 2. Pollen diagram of core 17843 (lower part) in Lithology the Keltmensky Hollow

The reason for the formation of the proglacial lake was most likely the subsidence of the earth's crust under the glacier. In the case of the Late Valdai (Scandinavian) ice sheet in the northwest of the Russian Plain, glacioisostatic depression extended 100-200 km beyond the ice sheet and formed a kind of flexure type at the edge of a glacier with an amplitude of just under 100 m. The Vychegodsky (Moscow) glacier was more powerful, and its proglacial flexure could be deeper and wider. The sides of the Keltminsky hollow prevented the outflow of water from the sides, which created favorable conditions for the formation of the lake. Judging by the purely sandy composition of the upper half of the section, immediately after the degradation of the glacier, the lake was not restored, although the crustal rise must have taken place with considerable delay. This indicates that the presence of a glacial dam in the north could be an important factor for the formation of the lake. With its disappearance, the conditions for the formation of the lake basin also disappeared.

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APPLICATION OF FRESHWATER DIATOMS IN THE PALEOLIMOLOGY OF YAKUTIA

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As north Siberia is an area with high present-day warming rates (IPCC, 2013), reliable tools for environmental reconstructions to track lake-system adjustments to climate change on millennial to decadal time scales is of high importance. In addition, the use of environmental indicators that can assess past environments by analysing samples collected from remote sites where continuous monitoring is not feasible would help to decipher recent change. For that purpose, this study aims to set up a regional indicator-diatom set for selected environmental variables for Yakutia. In arctic and subarctic lake waters where low temperatures and ice cover limit other algae, diatoms often substantially contribute to or even dominate the lake primary production (Smol & Douglas, 2007).

Diatoms are sensitive to various environmental variables such as nutrient content and salinity (Anderson, 2000). Diatoms thus have a high potential for indicating change in most environments given that regional diatom–environment relationships are known. Such knowledge is mostly based on diatom assemblages obtained from lake surface-sediments as diatom remains, in contrast to most other algae, are preserved due to their resistant silica valves. While such sub-fossil data-sets already exist for other parts of the Arctic or Eurasia, the distribution of diatom assemblages and their relationship to environmental characteristics in lakes from Siberia in general and Yakutia in particular has not been extensively explored.

Typically, the environmental indication of complete diatom spectra are investigated using multivariate statistical methods, while the indicator value of individual taxa is less often examined (Lotter et al. 1998; Ter Braak & Van Dam, 1989; Wunsam et al., 1995). Gaining such information for Yakutia would be particularly useful to allow a more reliable qualitative and semi-quantitative interpretation of the remarkable number of available fossil diatom spectra (e.g. Pestryakova, 2000; Laing et al., 1999) previously published without the need for taxonomic harmonisation as would be necessary when applying multivariate transfer functions to fossil data.

In particular, this study aims (1) to examine the indicator value of individual species for specific environmental variables and (2) vegetation types (arctic tundra, forest tundra, northern taiga, mountain taiga, typical taiga), and (3) to evaluate the use of such information for both past environmental reconstruction and modern environmental assessments in Yakutia.

The study area comprises the Republic Sakha (Yakutia) situated in eastern Siberia, Russia. The investigated sites are scattered across a large area (56.35-72.83°N; 110.2-161.0°E) covering more than 3,000 km^2. Around 70% of the Yakutian territory is covered by mountains and upland areas. Lowland plains are widespread in the northern and central areas. Modern relief was formed during the Cenozoic. Yakutia is dissected by thousands of rivers (among them the Anabar, Olenek, Vilyuy, Lena, Aldan, Indigirka, and Kolyma) which mostly originate in the various mountainous regions and flow towards the Polar Sea. Yakutia experiences an extreme climate and belongs to three climatic zones: arctic (along the Arctic Ocean shore), subarctic (north of the Vilyuy and northeast of Aldan River), and temperate (the Lena-Vilyuy and Aldan region in Central Yakutia). The upland areas of the Central Siberian Plateau, the Aldan Mountains and the Verkhoyansk-Kolyma highland act as barriers to the warm airflows of western, south-western, and eastern origin (Matveev, 1989).

Arctic vegetation dominates about 26% of Yakutia, the other regions are covered by boreal vegetation (Isaev et al., 2010). The forest-tundra border lies along 72°N in the West of Yakutia and gradually descends to 69°N in the East.The arctic tundra is mainly composed of mosses, Carex, Dryas, Cassiope and dwarf Salix and in its southern part of shrubby Betula, Alnus and further Ericaceae. Trees in forest-tundra and the northern taiga are formed by Larix gmelinii in the eastern part (to the Lena River) and by Larix cajanderi in the west. The typical taiga of central Yakutia is mainly composed of Larix cajanderi (on sandy sites also of Pinus silvestris), and various shrub taxa (Vaccinium vitis-idaea, Arctostaphylos uva-ursi), Forest-steppe occur at few dry places in central Yakutia.

Yakutia has a large number of lakes, (there are ~700,000 lakes with a size >1 ha; most of them of permafrost (thermokarst) origin. Central Yakutian lakes are usually ice-covered from late October until mid May, whereas lakes in the northern part do not become ice-free until late June. Lake levels rise in spring due to snow melt, reach their maximum in July, and are at their lowest from November to April. Many central Yakutian lakes with closed lake basins are characterised by high ion concentrations due to strong evapotranspiration and evaporative ion concentration (Herzschuh et al., 2013).

We collected surface sediments from 206 lakes scattered throughout Yakutia in summers between 2001 and 2009. The lakes were chosen in order to cover large gradients in geography, climate, vegetation, and lake chemistry. The investigated lakes are generally shallow (median: 2.9 m) and small (median: 0.74 km^2), with small catchments. Our selected sample set includes lakes from five vegetation zones: 40 lakes are located in the arctic tundra zone, 21 lakes in the forest-tundra zone, 25 lakes in the northern taiga zone, 16 lakes in mountain taiga, and 104 lakes are located in the typical taiga zone among them 15 in Pinus-Larix forests and 13 in Betula-Larix forests and 76 in Larix forests. Surface sediments were obtained from the deepest part of each lake using a sediment grab or a UWITEC® gravity corer (upper ~2 cm of sediment).

Limnological parameters (pH, electrical conductivity, lake area, maximum lake depth, and Secchi depth) were measured in the field. Water samples were collected from 0.5 m below the surface of each lake, immediately prior to retrieval of the sediment samples. Cation content of the water was analysed by inductively coupled plasma optical emission spectrometry (ICP-OES, Perkin-Elmer Optima 3000 XL), while the anion content was determined by ion chromatography (IC, Dionex DX-320). Alkalinity was measured using a Metrohm Basic Titrino 794. The ion balance was calculated for each sample in order to ensure the reliability of the analytical methods, resulting in deviations of less than ±5% for most samples. In this study only the information on Si concentration was finally included. Information on mean July air-temperature was taken from New et al. (2002) and interpolated for the geographical position of each lake.

Diatom analyses were conducted on about 1 g of sediment. The calcareous and organic components were removed by heating with HCl (10%) and H2O2 (30%). Cleaned diatom samples were mounted on microscope slides with Naphrax®. About 500 diatom valves per slide were counted along random transects. The samples were analysed using a Zeiss microscope equipped with a differential interference contrast at a magnification of 1000x.

Out of the 26 environmental variables we selected Electrical conductivity (EC), pH, silica concentration, water depth and mean July air temperature (TJuly) because of their known relevance for structuring diatom communities and their relatively weak inter-correlation as inferred from a PCA of environmental parameters.

EC of the lake waters ranges from 8 to 7743 μS/cm which equals an ion concentration of roughly 5 to 5000 mg/l (Table 1). Further reliable indicators, but only occurring rarely, are *Epithemia turgida* (424 μS/cm) and *Navicula oblonga* (414 μS/cm). Electrical conductivity optima of >500 μS/cm are inferred for 13 species among them all taxa that belong to the genera *Anomoeoneis*, *Cocconeis*, *Stephanodiscus*, and *Epithemia*, which may indicate the preference of these genera for high electrical conductivities. Reliable indicators of high conductivities are *Epithemia adnata* (586 μS/cm), *Cyclotel-*

la meneghiniana (866 µS/cm), *Anomoeoneis sphaerophora var. jakutica* (1489 µS/cm), and *Anomoeoneis sphaerophora var. polygramma* (1641 µS/cm).

Table 1

Ranges (minimum and maximum values) and median values (in brackets) of environmental variables for the studied lakes by vegetation type

	Arctic tundra (n = 40)	Forest tundra (n = 21)	Northern taiga (n = 25)	Typical taiga (n = 104)	Mountain taiga (n = 16)	All lakes (n = 206)
EC (µS/cm)	8-277 (47.3)	14-306 (45.1)	47-633 (176)	31-7744 (609)	19-550 (133)	8-7744 (218)
T_{July} (°C)	7.6-11.7 (10.8)	9.8-13.8 (11.8)	11.5-15.2 (13.4)	16.2-18.8 (17.9)	8.2-15.1 (12.6)	7.6-18.8 (15.0)
Si (mg/l)	0.1-4.7 (0.4)	0.1-3.2 (0.7)	0.4-10.4 (2.6)	0.0-26.0 (1.4)	0.0-37.2 (3.1)	0.0-37.2 (2.4)
pH	4.8-7.5 (6.9)	5.2-7.9 (7.0)	6.0-9.6 (7.6)	6.4-10.2 (8.4)	5.0-7.5 (6.6)	4.9-10.2 (7.7)
Depth (m)	0.3-12.4 (2.8)	1.5-6.3 (3.5)	1.5-10 (2.8)	0.9-72 (2.5)	1.7-80 (5.5)	0.3-80 (2.9)

The range of mean July air temperatures (TJuly) covered by this data-set spans from 7.6 to 18.8°C. For 35 taxa TJuly is selected as the major or second major split variable in the BRT analysis, but for only 8 taxa did it cause >50% of the splits. In total, 54 taxa have a low TJuly optimum (<13°C) with taxa from the genera *Achnanthes*, *Aulacoseira*, and *Cymbella* being most common. The 50 taxa with intermediate TJuly optima (13–15°C) belong to a large variety of genera. According to our definition no taxa have been selected as reliable indicators for intermediate temperatures, because of their large tolerances (median: 3.25°C). In total, 53 taxa have a high TJuly optimum (>15°C): among them all species of the genera Amphora and Anomoeoneis and most taxa of the genera Fragilaria (12 taxa). Furthermore, the more common and abundant taxa such as Fragilaria construens, Staurosira venter, Cocconeis placentula, Epithemia adnata, Fragilaria ulna, Navicula radiosa, and Stephanodiscus hantzschii belong to this group but either they have a large tolerance or temperature was not selected as the major split variable in BRT. Rhopalodia gibba (16.1°C), Amphora veneta (18.1°C), and Cyclostephanos dubius (18.2°C) are identified as reliable indicator species for high TJuly.

Silicate concentration in the Yakutian lakes ranges from 0 to 37.2 mg/l (median: 2.4 mg/l). Highest concentrations were observed in oxbow lakes on river floodplains, while lakes with zero silicate content are located in the Viluyi region of central Yakutia. Silicate concentration is the major split variable for only 17 taxa. Pseudostaurosira parasitica var. subconstricta (optimum: 0.5 mg/l), Sellaphora bacillum (0.5 mg/l), Cymbopleura cuspidata (0.8 mg/l), Eunotia sudetica (1.1 mg/l), Aulacoseira lirata (5.4 mg/l), and Stephanodiscus minutulus (12.5 mg/l) represent reliable silicate indicators.

pH ranges from 4.9 to 10.2. Only 10.7% of the lakes are acidic (pH <6.6) most of them are located in the tundra, forest tundra, and the mountains, while lakes in northern and typical taiga cover a wider pH range. Highest pH values were found in alas lakes of the Lena-Amga interfluve. In comparison to electrical conductivity, pH is less frequently selected as the major splitting variable in BRT (SOM 1). No taxon had an optimum below pH 6.5. Only Achnanthidium affine (pH optimum 7.0), Diploneis ovalis (7.1), Eunotia triodon (6.5), and Fragilaria construens (8.0) are identified as reliable pH indicators.

The water depth varies from 0.3 to 80 m (median: 2.9 m). Most of the central Yakutian lakes are shallow thermokarst lakes, while the deep lakes sampled are only found in the mountains. Within the data-set only three species are reliable indicators of water depth: Cyclotella radiosa (optimum 2.9 m), the epiphytic Cocconeis pediculus (2.0 m), and Navicula peregrina (2.4 m). Furthermore, Cavinula cocconeiformis can be accepted as a reliable indicator (88% of splits in BRT) even though it has a high tolerance relative to other taxa (0.35 (log+1) m), because of its large optimum of 6.2 m and the low number of lakes sampled within this depth range.

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DATABASES OF THE NORTHERN LAKES AS A BASIS FOR ECOLOGICAL AIMS

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Data about abiotic and biotic factors are necessary condition to conduct modern investigations in ecology and in paleogeography (and other areas). All our knowledge about modern features of ecosystems' functioning is basis for understanding of past ecosystems conditions. Furthermore the value of the system information about environmental components increases for the farthest poorly known regions such as Arctic or the North of Siberia.

One of the most interesting and sensitive component of the environment is lakes. They accumulate the most useful and informative material about natural conditions of their surroundings in bottom sediments (as remains of diatoms, cladocerans, chironomids etc.). During our every year work we have been gathering the information about the investigated lakes and systemize it into our databases. According with this activity during a few past years we invented useful databases. Among them are "Database of the Central Yakutian lakes", "Diatoms, morphometric and hydrochemical characteristics of the lakes located in basins of major rivers of Northern part of Yakutia", "Morphometric and hydrochemical parameters of thermokarst ponds located in the river basins of Northern Yakutia", and "Diatom spectra of the Anabar River basin". All the information which contains in the databases reflects the modern conditions of the water ecosystems because we use the results of the upper sediment observations (for biota), water chemistry analyzes and lake morphological measurements. On the basement of the database information we conduct researches in different areas of water ecology such as estimation of diatom assemblages' diversity (Gorodnichev et al., 2015b) and similarity (Gorodnichev et al., 2015c), evaluation of lakes' saprobity, relationships between biotic and abiotic components (Gorodnichev et al., 2015a) of the ecosystems etc. All our lake investigations are based on the regional morphological classification of lakes' genesis which was founded by Innokentiy Zhirkov in 1977 (Zhirkov, 1977). According with the classification the most part of lakes in Yakutia has thermokarst, fluvial-thermokarst, and fluvial-erosion genesis. Today above then 200 lakes and water ponds are involved in our databases. It is not enough for such big region as Yakutia because recent counting reveals that the territory of the region is covered by more than 800000 lakes (Arzhakova et al., 2007).

For some districts of Yakutia lakes are the only source of fresh drinking water for the people so this is why the researches of modern and future water conditions of lakes are very important. Thus our databases could be used not only for the aims of environmental monitoring and past environmental analogies, but also for the purposes of nature protection. Especially the information about the water objects will be useful after industry development in the Northern part of Yakutia.

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TOWARDS BETTER UNDERSTANDING EUROPEAN ICE AGE POLLEN RECORDS: A LESSON FROM MODERN POLLEN ASSEMBLAGES OBTAINED FROM YAKUTIAN LAKES

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Pollen analysis of lake sediments and peat accumulations has been, over more than a century, the most widely used method to reconstruct past vegetation cover and character of the landscape. Sophisticated models considering pollen–vegetation relationship are often calibrated in current conditions (modern landscapes, climates) and seem to be robust enough to enhance reliability of reconstructions of the Holocene vegetation cover and its changes (e.g. Abraham et al. 2016). However, the same approach can be hardly applied to European records of the coldest (cryocratic) stages of the Pleistocene. In these records, high proportions of non-arboreal pollen (NAP), especially Poaceae and

Artemisia, are often canonically interpreted as the evidence of treeless vegetation. Small proportions of arboreal pollen (AP) are then often considered to be a result of long distance transport. Based on this traditional reconstruction, the glacial vegetation is usually interpreted as a steppe, tundra, or "steppe-tundra", with its closest recent analogy in southern Siberia (Kuneš et al. 2008, Magyari et al. 2014). We asked the following question: Is this traditional reconstruction of European cryocratic vegetation, as being mostly treeless, always valid? To solve this question, we compared fossil pollen data from the Ice Age in central Europe with the modern ones, obtained from treeless regions in southern Siberia, as well as from central Yakutia covered by taiga. We analyzed pollen in 12 surface sediment samples from small *alas* lakes located in a flat landscape in central Yakutia. All the sampled lakes were surrounded by dense northern taiga, dominated by *Larix* with admixture of *Pinus*, *Betula* and (near streams) *Picea*. Nevertheless, the lakes, although similar in size, differed in vegetation characteristics of their proximal surroundings – usually, there was a belt of steppe and/or meadow vegetation near the lakeshore.

We have found that AP:NAP ratio in the modern lake pollen assemblages in central Yakutia was highly variable and ranged from 6:1 to 1:3, while the median was about 1:1. This is a surprising result, considering the dense taiga forest surrounding all the sampled lakes. What is the reason of such a high proportion of non-arboreal pollen in observed pollen spectra? We propose several working hypotheses, which will be discussed below: (1) Larch (*Larix*), despite its dominance in taiga forest, is almost invisible in pollen spectra, due to its low pollen productivity as well as low dispersal ability; (2) Trees, in general, do not produce much pollen under extreme climatic conditions; (3) Local taphonomic processes in central Yakutia (and/or during the Ice Age in Europe) differed from those in current Europe, i.e., the majority of pollen in lacustrine sediments probably originated from their closest surrounding, as a result of both the light wind and low precipitation during the short summer. Naturally, these working hypotheses do not necessarily contradict each other.

To compare fossil pollen assemblages from central Europe and the modern ones from Siberia, we performed a multivariate (DCA) analysis. For this purpose we used several hundred individual pollen assemblages stored in the Czech Quaternary Palynological Database (PALYCZ). We selected samples dated to the Last Glacial Maximum and the Late Glacial, according to radiocarbon chronologies. For the comparison of fossil pollen assemblages with the modern ones, we followed similar method as previously used by Kuneš et al. (2008) and Magyari et al. (2014). While these two studies offered available recent pollen assemblages from vegetation plots (moss pollsters) collected in south Siberia, we included to the data also the 12 pollen samples from the small lakes in Yakutia.

Our results show that most Central European Last Glacial, especially the Late Glacial, pollen spectra show high similarity to pollen spectra from recent Yakutian lakes. This result provides evidence that at least the Late Glacial pollen samples from the Czech Republic shouldn't be interpreted as a reflection of steppe-tundra vegetation, which was considered previously e.g. by Kuneš et al. (2008). On the contrary, our results can support an alternative interpretation (considering a comparable degree of confidence), i.e. the forested landscape (larch-dominated taiga with only small treeless patches) similar to that existing today in Yakutia. The long lasting discussion (as being popularized by Willis & Van Andel, 2004) about the possible nature of LGM climate and the Late Glacial vegetation, as well as about possible existence of northern forest refugia ("microrefugia") in central Europe, must be therefore brought into reconsideration again.

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LATE QUATERNARY EROSION AND SEDIMENTATION DYNAMICS WITHIN THE SANDSTONE AREAS: A CASE STUDY FROM BOHEMIAN PARADISE (CZECH REPUBLIC)

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Rapid and pronounced environmental changes along the Last Glacial Termination (LGT; ~ 15-10 ka BP) caused deep ecosystem conversions and evoked distinct interactions within and between the different components of terrestrial environments. Although most research has demonstrated the effects of the climatic instability on the biological components of the environment, significant insight into the LGT climatic and, consequently, landscape dynamics can also be gained by the study of the associated erosion and sedimentation processes.

Due to their lithological composition, weathering susceptibility and high relief dynamic, sandstone areas are sensitive to climatically involved landslides and rockfalls; consequently they represent suitable regions where the relationships between climate and erosion-sedimentation processes can be studied. "Rock cities" of Bohemian Paradise in Northern Bohemia (Czech Republic) is one of the most detailed studied sandstone area at the world, offering diverse sedimentary archives and conserving various types of records of the Late Glacial and Holocene environment (Svoboda et al., 2017). From those archives, peat bogs and lake basins both provide the most valuable source of the paleoenvironmental information on the regional and supra-regional scale. Origin of these basins and depression located at the bottom of deep valleys was found as landslide-dammed. According to the radiocarbon dating and palynostratigraphy of the basal lacustrine sediments and peats, massive landslides and rockfalls occurred in this area at the begging of the Late Glacial (~ 16-15 ky BP), most probably due to increasing precipitation at this period.

In this contribution we present some results of multidisciplinary research from the case site *Pelešanské* paleolake – with surface area of ~ 3 km^2 the largest lacustrine basin in the Bohemian Paradise. Because of its large watershed, the former lake provides valuable archive of the erosion-sedimentary processes at the regional level. Based on detailed sedimentological and geochemical analyses of the allochtonous component of the lacustrine sediment, accompanied by geophysical, geomorphological as well as paleobotanical investigations, we were able to reconstruct the dynamics of the erosion-sedimentary process during the Late Glacial and Holocene and discuss our observation in the context of climate change and human activities in the region.

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PALAEOENVIRONMENTS ON THE KOLA PENINSULA DURING ISOLATION OF THE OSINOVOYE LAKE FROM PRA-IMANDRA BASIN (N-W RUSSIA)

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In this paper we consider climate changes on the Kola Peninsula in early Holocene. To achieve this goal we studied bottom deposits from Osinovoe Lake (67°34′18″ N., 32°38′11″ E), which was isolated from pra-Imandra basin at that time and now locates in the Imandra Lake depression (Fig. 1). Osinovoe Lake is an oval-shaped open basin. The shoreline altitude and its size are 129.0 m a.s.l. and c. 10 km2, respectively. The adjacent drainage area is occupied by a locally waterlogged mossy and sphagnum spruce-birch forests.

A field study was carried out in 2011. Bottom lake sediments were drilled from ice in winter. Cores of 1.0 m length and 52 mm diameter were sampled with overlapping of several centimeters using a handled corer that allowed an undisturbed depositional succession to be obtained.

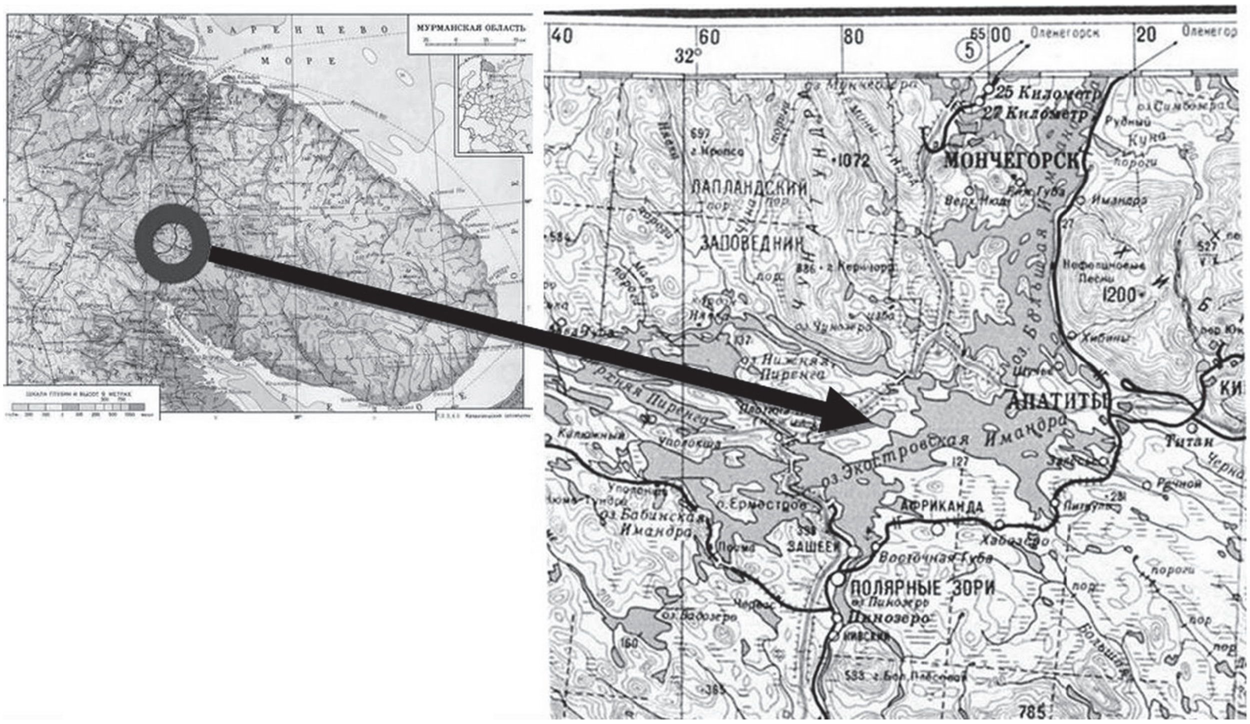

Fig. 1. Location of the Lake Osinovoe, Kola Peninsula

In total, 1.25 m of sediments was recovered. We investigate sediment sequences by litological, diatom and spore and pollen methods; radiocarbon dating has also been conducted. Obtained data allow us to assume that Osinovoe Lake basin isolated from paleo-lake Imandra 11.317-11.156 cal.yr. ago and exists as an autonomous basin [Tolstobrova et. al., 2016]. According to diatoms, a shallow-water basin overgrown with macrophytes was in the studied lake depression prior to its isolation; spore and pollen data show evidence that *Typha latifolia* and Nymphaeaceae dominated the hydrophytes. In the period of isolation, the taxonomic composition of diatoms has changed; diatom concentration taxonomic diversity increased, halophils decreased, while indifferents and acidophils and number of boreal diatoms species increased [Tolstobrova et. al.,2016]. Pollen of *Betula* represent a highest persentage in the spore-pollen spectra, along with a significant number of *Belula nana* and *Pinus* pollen grains. The herb pollen is mostly represented by Poaceae and Chenopodiaceae.

According to diatom data [Tolstobrova et. al., 2016], the biological efficiency of the basin significantly increased during isolation time. The number of *Pinus* pollen increased and single grains of *Picea* emerged, while *Betula nana* totally disappeared.

At the latest stage of isolation and during post-isolation time, the diatoms continued to change towards the increase of indifferents and halophobs. After isolation, Osinovoe Lake became a relatively deep oligotrophic reservoir. *Betula* and *Pinus* dominate in the pollen spectra and proportion of *Picea* increases. Up to sediment succession, *Betula nana* disappears and Poaceae and spores (mostly Polypodiaceae and Lycopodiaceae) decrease. Diatoms and the spore-pollen record suggest an environmental warming, which took place during that time.

At the early stage of autonomous Osinovoe Lake development, *Betula* pollen dominated the pollen spectra, proportion of Pinus pollen increased and *Betula* pollen gradually declined. Single Picea pollen grains appeared in the samples correlated to the middle stage of isolation; its proportion rose during the lake development.

Obtained results are in good correlation with those earlier published by Elina with coauthors [Elina et al., 2010] and Solovieva &Jones [Solovieva &Jones, 2002]. This fact confirms a suggestion that pine-birch forest with dominated *Betula* and *Pinus* additive, similar to contemporary Boreal forests (northern taiga), grew in the central Kola Peninsula in the early Holocene. We obtained preliminary data and recognized paleoenvironment affected by the climate change in the paleo-Lake Imandra catchment area.

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LONG-TERM TRANSFORMATIONS ASSESSMENT FOR THE LAKE ECOSYSTEMS OF THE NORTHERN EUROPE AND WESTERN SIBERIA BY THE METHOD OF DIATOM COMPLEXES TAXONOMIC PROPORTIONS GRAPHIC ANALYSIS

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Initially, the method of graphical analysis (MGA) was developed in the spatial studies of diatom data complexes from modern lake sediments of the Kola Peninsula. Later lakes from different regions of European Russia were studied (Razumovsky, Moiseenko, 2009; Razumovsky, 2012). More than 150 lakes were explored in total. The diatomic complexes structural transformations in time was studied by bottom sediment columns from 21 lakes, which are located in different landscape and climatic regions of the European Russia from the Kola Peninsula to Caucasus (Razumovsky, 2012; Razumovsky, 2014).

MGA core is the following: we putting on the X-axis is the number of identified species taxa of and lower ranks (hereinafter referred to as taxa), and Y-axis is their relative abundance. The taxa are ranked by relative abundance in the direction of its decline. According to the relative numbers the taxons divided into a groups: dominant (usually at least 8-10%), related (more than 1-2%) and rare (usually less than 1%). As a result, the initial graph or histogram is built in the linear coordinate system. Using the developed method of analysis, the lakes were divided into two spatial categories: with a water surface area of less than 1 km^2 (small) and with a water surface area of 1 to 4 km^2 (medium).

The analysis of the obtained data is carried out in a linear and logarithmic coordinate system.

In the linear coordinate system, two types of natural undisturbed taxonomic proportions graphs of diatom complexes were distinguished.

One of them is close to the exponential dependence and is typical for small lakes (the "simple" systems). For the medium-sized lakes (the "complex" systems) form of the obtained graphs has a certain similarity with logistic dependence (Shitikov et al., 2005).

In the logarithmic coordinate system, not the graphs themselves, but their trends represented by the resulting straight lines are analyzed. These lines forms the generation of certain outlines.

In the logarithmic coordinate system analysis, three main scenarios of spatial-temporal transformation of taxonomic proportions were identified.

The most pronounced (indicative) differentiation by dimension categories is typical for tundra and forest-tundra zones of the European part of Russia. This is due to the landscape and climatic features of the Kola Peninsula. The differentiation in the size of lakes is expressed in different types of taxonomic proportions distribution and in different types of spatial-temporal transformation.

From 2001 to 2010, MGA was used in the study of lakes (mostly small) in other areas of the European part of Russia. 53 lakes was studied in total, 15 of which are located in zones of tundra and forest-tundra, 11 from the zone of Northern taiga, 11 from the zone of middle taiga, 13 from the zone of southern taiga and pottage and 3 of the steppe zone.

In addition, 26 small lakes in the highlands (Caucasus) were studied. The following patterns are observed in the direction from North to South:

1. Weakening, "erosion" of identification features by categories of dimension between small and medium lakes in the plains.

2. Differentiation in the category of small lakes in two spatial transformation scenarios. This differentiation is particularly pronounced in the high mountains (Caucasus).

On the territory of Western Siberia, the pronounced differentiation of taxonomic proportions in the linear coordinate system (between small and medium lakes) extends to the South, up to the Northern taiga zone inclusive. Accordingly, the weakening of this differentiation is confined to the middle taiga and sub-taiga zone. The secondary differentiation within the lakes of small dimension by two types of spatial transformation is confined to the sub-taiga and forest-steppe zones.

The analysis of the lakes of Western Siberia by the bottom sediment columns revealed the previously unrecognized type of transformation: with the change of climatic conditions towards warming, transformations in the lakes of small dimension are observed in a more complex scenario typical for the lakes of medium dimension. However, due to shallow depth of the lakes, the reverse transformation happens and the lakes returns to the script, typical for the lake ecosystem of small size.

We think this is due to the objective impossibility of self-organization of the ecosystem at a higher level because of the insufficient amount of ecological space (depth), which hinders further potential development at a higher level. Such a scenario of transformation in the European part of Russia was not observed yet.

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CIRCULATION REGIME AND REDOX-CONDITIONS IN SALINE LAKE SHIRA (KHAKASIA, SIBERIA): FROM MODERN OBSERVATIONS TO PALEO-RECONSTRUCTION

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Meromictic lakes are lakes in which the deep recirculation does not include the entire water body. In meromictic state the nutrients accumulated in the monimolimnion with the sedimentation flow of organics are not available for the primary producers. Thus, in case of meromixis destruction, nutrients are released from the monimolimnion, resulting in outbreaks of phytoplankton bloom, i.e. in deterioration of water quality and changes in the species composition of plankton organisms. The weather conditions are among the main reasons for destruction of meromixis. Another reason for destruction of meromixis is change in water level. Since the change in mixing regime gives rise to changes in the composition of the sediments, the alterations between mixing regimes can be reconstructed for the long period of a lake history (Schmidt et al., 2002). In particular, hydraulically closed water bodies located in arid climates sensitively react by changes in water level to the changes in the balance of precipitation and evaporation in the area. In turn, the change in water level may result in change in mixing regime. Therefore reconstruction of mixing regimes of closed lakes provides valuable information on their level dynamics, consequently – about effective moisture of local climate.

Lake Shira (N 54.30, E 90.11) is located in Southern Siberia, in the steppe zone of the northern part of the Minusinsk valley (Republic of Khakassia, Russia). The average salinity in the mixolimnion during the summer stratification is about 15 g l^{-1}, and in the monimolimnion — about 19 g l^{-1} We analyzed the long-term field data on the vertical structure of Lake Shira and demonstrated for the first time the documented change in the lake stratification regime from meromictic to holomictic (Rogozin et al., 2017). The disappearance of purple sulfur bacteria from monimolimnion was a consequence of meromixis breakdown.

It was shown that in the period from 2002 to 2007 an increased inflow of fresh water caused the lake level rise, increasing the stability of the water column and consequently decreasing the depth of the autumn mixing. In the period from 2007 to 2015 the water level did not increase, reducing the stability of the water column and making the lake mixolimnion more sensitive to the wind stress. We assume that the most influential factor contributing to the winter mixing in 2015 was strong wind action due to early ice melt in the spring of 2014. The established causal relationship between meromixis stability and the level increase can be used for the reconstruction of paleo-climate humidity based on the indicators of anoxia in bottom sediments.

From bottom sediments of saline closed Lake Shira we estimated the switches between meromictic and holomictic conditions caused by climate-induced fluctuations of water level. The fossil carotenoid of phototrophic sulfur bacteria (okenone) was considered as a proxy of anoxia in water column (Zykov et al., 2012). Our latest observations on purple sulfur bacteria in Lake Shira confirmed that their biomass tends to increase in years of 2002-2007 when stable meromixis took place in the lake due to level increase. And vice versa: in the years of 2008-2016 the decrease in purple sulfur bacteria was correlated with constant level and weak meromixis (Rogozin et al., 2017). So we presume that stable meromixis developed at the periods when the lake level increased due to increase in annual atmospheric precipitation. Consequently, we presume that the older sediment layers with high okenone content indicate the periods of sharp increases in Lake Shira level.

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ENVIRONMENTS OF SOUTHWESTERN SIBERIA AND NORTHWESTERN MONGOLIA IN THE LATE HOLOCENE (BASED ON THE LAKE SEDIMENTS STUDY)

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The Southern part of West Siberia and neighboring Northwestern Mongolia are regarded a key connection for human migrations between the Central Asian steppes and the North Asian forest-steppe. Holocene environmental changes are hypothesized to have had a significant influence on the development of the human societies in this region. Many well-studied world-famous archaeological objects from the Bronze, Iron and Middle Ages are situated in Southwest Siberia (e.g. Chicha, Tartas, Vengerovo, Pazyryk).

This study has an overarching goal to establish the link between past climate change, human migration and society development at the boundary of Asian steppe and North Asian forest-steppe. The first specific task of the research is providing a general scheme of environmental dynamics in Southwestern Siberia and Northwestern Mongolia as a natural transitional area between North and Central Asia during the Holocene by combination of bioproxy records from the key sites and previously published data.

To address past linkages between humans and climate in NW Asia, we have collected a suite of lake sediment archives over the region based on the following criteria: (a) location at the steppe/forest boundary sensitive to past climate variations, and (b) location within the corridor for human migrations in Bronze, Iron and Middle Ages. The time span of our study is Late-Holocene (last 4 kyr BP) which is presented in all our studied lake sediment cores.

Our studied lakes (Fig. 1):

1. Bolshie Chany and Bolshie Toroki (Zhilich et al., 2017) in the Baraba forest-steppe (Novosibirsk region, Russia).
2. Kuchuk in ghe Kulunda steppe (Altai region, Russia).

3. Teletskoye in the Altai Mountains (Altai Republic, Russia; Rudaya et al., 2016).

4. Bayan Nur (Uvs aimak, northern Mongolia).

Methods:

Coring and sampling; radiocarbon dating using AMS; geochemical and sedimentological methods; pollen methods: pollen analysis, biomization, best modern analogue (BMA) method for climate and woody coverage reconstruction, quantitative transfer functions for climate reconstruction; diatom analysis; chironomid analysis; analysis of stable carbon isotopes.

Preliminary results:

Clear tendency of the increase of the July temperatures (Tjuly) after 1.5 kyr BP and decrease of annual precipitation (PANN) after 0.9 kyr BP show both palaeorecords from lakes Bolshie Chany and Kuchuk. Pronounced peak of decrease of Tjuly and increase of PANN is revealed at 2-2.1 kyr BP. Based on the biomization of Bolshie Toroki and Bolshie Chany pollen records forest spread in the Baraba region at that time.

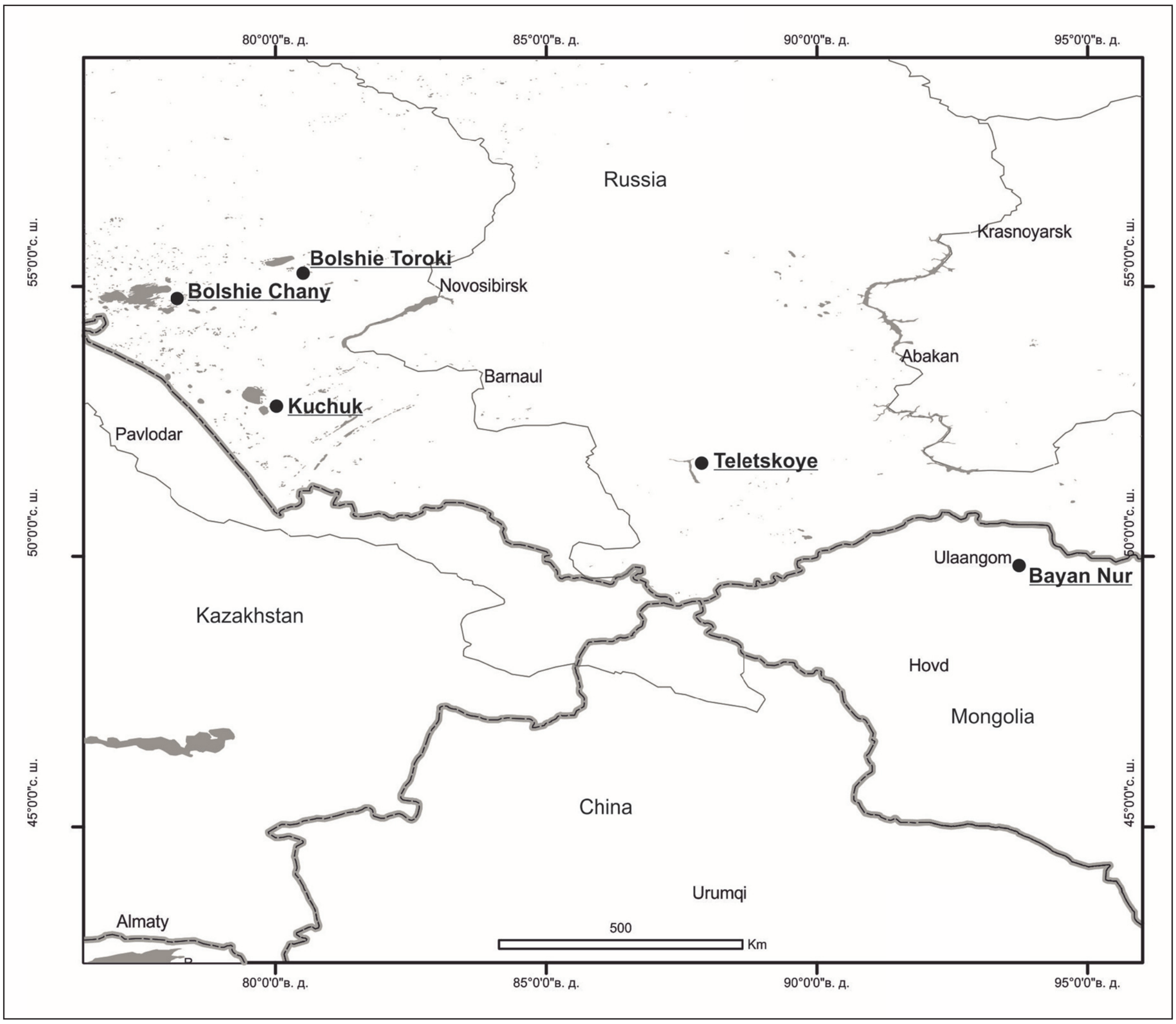

Fig. 1. Map of the studied area and studied lakes

Results of pollen study of Lake Teletskoye are to a certain degree intermediate between those from the lake Bayan Nur situated southwestward and from our investigated Siberian lakes situated northwestward. Decrease PANN during last 1 kyr remind data from Bolshie Chany and Kuchuk, however, with simultaneous decrease of Tjuly makes it closer to Bayan Nur.

Palaeorecord from Bayan Nur reveals significant increase of PANN after 1.2 kyr and decrease of Tjuly after 1.5 kyr BP. Maximal afforestation around Bayan Nur is recorded between 1.2 and 0.4 kyr BP.

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METHODS OF CONDUCTING COMPLEX STUDIES TO RESTORE THE PALEOLIMOLOGICAL CONDITIONS AND UNDERWATER LANDSCAPES OF LARGE LAKES BY THE EXAMPLE OF PETROZAVODSK BAY OF LAKE ONEGA

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Paleolimnological studies of lakes are one of the most effective ways of restoration paleogeographic conditions in the late Neoplestocene-Holocene At the present time, at the international level, a methodology has been developed for the study of small lakes, consisting in the drilling of the entire thickness of loose sediments and carrying out high-resolution biostratigraphic and lithological studies and conducting absolute dating. One of the favorable factors in this case is the presence of thick layers of organogenic silt. Researchers of large lakes meet great difficulties from to their size, depth, and the presence of permanent water cover. The deterrent is the position of these lakes in densely populated areas, as well as the fact that they serve as strategic reserves of drinking water for large areas. This imposes restrictions on the carrying out on them of production, including geological exploration work.

Despite its great importance of European lakes - Ladoga and Onega, is still not well understood, especially in the field of modern geophysical methods. Until now, the main weapon of researchers are easy sampling of sediments. In total (using samplers and heavy seismic profiling) are also in 90 years time, serious studies have been conducted on Lake Ladoga. On the Lake of Onega at the same time, Finnish researchers conducted a comprehensive study of bottom sediments using modern research methods. Palaeolimnological new stage of work is largely associated with the Institute of Water Problems of the North Karelian Research Center, which began systematic studies paleolimnological on both lakes. These works were conducted jointly with the MSU Science Park, as well as with the involvement of the staff of the Institute of Earth Sciences of SPbSU. Within this framework, the complex geological and geophysical studies in the Lake Onega for various tasks have been organized, including palaeolimnological. Petrozavodsk Bay was chosen as an experimental polygon.

Complex of geophysical methods included: Very High Resolution Seismic (VHRS), Ultra High Resolution seismic (UHRS) sonar and echosounding. The task of this block of research was to obtain information on the section of unconsolidated deposits, as well as on the presence of gases, manifestations of tectonic, etc. One of the important tasks of this stage was to obtain information for selecting sampling points. The total length of the profiles was about 80 km.

Geological sampling was carried out to verify seismoacoustic data, as well as obtaining material for further lithologic-stratigraphic studies. A gravity corer with a plastic liner with a diameter of 127 mm was used. Geological sampling was performed at 8 stations, the location of which was determined from seismoacoustic profiling data. At each of the points samples were taken for lithological, biostratigraphic studies. In the cores of all stations, X-ray texture analysis was carried out, and samples were taken for studying the physical and mechanical properties. In addition, gas geochemical studies were carried out at all stations.

As a result of the interpretation of seismoacoustic data, several reflecting boundaries and seismostratigraphic horizons between them were identified. The deepest reflecting boundary is associated with the roof of crystalline rocks. The next clear reflecting boundary was compared with the roof of glacial deposits. Between these horizons lies the thickness of the moraine formations of the Ostashkov glaciation. On seismograms, these deposits are usually characterized by a chaotic irregular record reflecting the scaly structure of the bottom till. The third reflecting boundary is developed locally and passes along the surface of the ridge in the central part of the test site. The thickness of the sediments composing the ridge is referred to us as fluvioglacial, and the ridge itself is interpreted as a esker. Another reflecting boundary is located on the contact between the distinctly layered and translucent strata with poorly developed undulating lamination. By analogy with the Ladoga Lake, we identify this boundary as a section between the Holocene marine and glacial-lake of Upper Pleistocene sediments. Upward along the cut, the lamination becomes more subtle and gradually passes into an unstructured thickness. In lake deposits one can sometimes observe a boundary separating the Lower Holocene and Middle-Upper-Holocene silts.

The second task, performed with the help of geophysical methods, is the detection of gas accumulations. In Petrozavodsk Bay large area gas accumulations are absent, but their distribution in the sediments is quite wide. They are determined on seismograms by the appearance of bubble accumulations or by the general weakening of the record with profiler. Often, you can see numerous points ("bright spots"), indicating the accumulation of gases, as well as the characteristic structure of the output of gas fluids from the sediments - pok-mark.

Geological methods have allowed clarify geophysical information. It concerned the choice of places for sampling, which made it possible to test the geological section , with the exception of glacial and water-glacial formations. A total lithostratigraphic section was constructed, based on cyclically repeated packet of warves. At the base limnoglacial series occur distinct warves, sometimes painted in pink or brownish colors. They pass up a section into thinlaminated soft clays. These clays are overlaped by the thickness of lakustrine silt.

Additional material on the formation of bottom sediments was obtained as a result of tomographic studies of the cores. At the base of series of the glacial-lacustrine deposits, texture features of landslides were revealed. In the strata of Holocene nepheloid sediments have been found authigenic sulfides of psammite dimension were detected. With the help of tomography was described in detail the contacts between the sedimentation packets, was revealed traces of a erosion. It was found that sometimes all thickness of Holocene silt was permeated with numerous pores oriented mainly in the subvertical direction. This is due to the infiltration of gas to the lake bottom. Inclusions of hydrotroilite were also established, as well as single white formations, which probably correspond to the half-decomposed carbonate detritus.

In addition to lithological characteristic and seismoacoustic data of bottom sediments palynological studies and radiocarbon dating were carried out. It was revealed sediments of ONG 2 core formed during the second part of Holocene and from interstadial Allerod of ONG 5 core. Radiocarbon dating is performed using conventional and AMS methods.

The study of physico-mechanical properties of bottom sediments made it possible for the first time to begin to systematize their the physical and mechanical properties in Petrozavodsk Bay.

The presented methodological complex for studying Quaternary deposits of large lakes in key areas in our opinion can serve as a kind of standard for paleoliminological research. It allows us to cover with great clarity the main features of the structure of the cover of unconsolidated deposits, dismember it to stratigraphic and genetic subdivisions, give their lithologic and biostratigraphic characteristic. Further development of the presented methodology is associated with the introduction of new research methods. In particular, the use of ocean bottom nodes in conjunction with the continuous seismo-acoustic profiling will allow to construct the depth-velocity model of the medium (Vp, Vs) from the data of reflected, refracted, surface and converted waves. Hence this will allow us to perform seismic migration, improve the reliability of data interpretation and to try predict the physical properties of rocks.

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The survey has been conducted on the topic: “Hardware and software systems development for the search, exploration, geophysical and geochemical monitoring of the exploitation of hydrocarbon reservoirs, including remote regions and challenging climate conditions,” with funding from the Ministry of Education and Science of the Russian Federation, using equipment purchased under the Development Program of Lomonosov Moscow State University (MSU), Grant Agreement No. 14.607.21.0187 of September 26 2017 (Unique Identifier of the Agreement: RFMEFI60717X0187).

USAGE OF NEW SEISMOACOUSTIC METHODS FOR PALEOLYMNOLOGICAL STUDY OF THE LADOGA AND ONEGA LAKES

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Regional paleolimnological reconstruction of lakes and restoration of paleogeographic evolution of regions on the basis of the received results are getting more and more widespread recently. Tracing the spatial position of stratigraphic - genetic complexes, assessment the thickness of deposits, revealing characteristic of bottom relief reflecting the gradual development of paleobasins are important factors in these studies. In the conditions of lake basins, this function is currently performed by geophysical, mainly seismoacoustic, methods. Similar studies in both the largest lakes of the North-West of Russia after 2000 were carried out only sporadically. They was stopped after 2005. A new stage of seismoacoustic research was launched in 2014 as part of a joint program of three organizations: the Institute of Earth Sciences of St.Petersburg State University, the Institute of Water Problems of the North of the Karelian Center of the RAS and of the Center for Marine Studies of the Moscow State University. A distinctive feature of these works was the use of a new generation of high-frequency seismoacoustic equipment, which allows for multi-channel profiling. This made it possible to carry out a more detailed subdivision of the upper part of the section and obtain new data on the structure of the supraglacial deposits, and also on the nature of the manifestation of modern geodynamic movements. In 2014, works were carried out on Lake Ladoga, in 2015 - on Ladoga and Onega lakes, and in 2016 -

only on Lake Onega. NIS "Ecolog" and NIS "Professor Zenkevich" were the main research vessel of the expedition.

In 2014, very high resolution seismic (VHRS) with "boomer" source was used for detailed subdivision of the quaternary section (up to 0.3-0.5 m). Hardware parameters: energy source CSP-P Applied Acoustic with working voltage 2500V, working power 50-350J, electrodynamic energy source "Boomer" type with central frequency of signal 1700 Hz, seismic 16-channel streamer with 2 meter hydrophone step, navigation equipment - Trimble DSM132.

In 2015, a VHRS was used with "sparker" surce placed in a container with salt water. The following parameters were selected: the signal source energy is 400 J; working voltage - 3 kV; number of electrodes - 60; the central frequency of the radiation is 700 Hz. In 2016 the works were carried out mainly with the use of the Sparker source. The geophysical complex also included a side-scan locator. The work was carried out through a network of regional profiles with condensation of network of observations in interesting areas.

In Ladoga Lake, the main attention was paid to the study of the ratio of the of Riphean sandstones and Vendian argellites in the southern part of the lake, the assessment of the distribution and types of glacial deposits, and the detection of modern geodynamic movements. So, in 2015, it was succeeded to track in detail the relation of cross-bedded sandstones of Riphean age with the angular age overlapped by the Vendian argillites, which are already part of the platform cover of the Russian plate. These data allow us to more accurately assess the position of the platform cover at the bottom of the lake basin, suggest that the Vendian power is not large and does not exceed the first tens of meters. The facts of dislocations of these sedimentary rocks were revealed. Primary stratification was broken, and individual laminas were broken. Probably, these are traces of the exaration activity of glaciers moving along the soft surface of the Vendian mudstone. In some cases, seismic dislocations also capture the surface of Riphean sandstones.

Particular attention was paid to tracking glacial deposits. The spread of moraine was discontinuous in Ladoga and Onega lakes. Along with complete absence of till on the lake bottom, ridge-like forms of reliea were noted. Most often they are associated with uplifts in the preglacial relief. Typical drumlino-shaped forms have been established in a northern part of the lake and in the Solovetsky archipelago region. The main accumulation of moraine material were observed from the southern side of the ridges, opposite from the direction moving of the glacials. In the core of these uplifts, crystalline rocks are exposed, most likely represented by diabases forming the sill of the Valaam archipelago.

Other form of accumulation of glacial deposits is a chain of small uplifts crossing the Ladoga Lake from the mouth of the River Burnaya to the eastern shore of the lake. As expected, these ridges are composed mainly of glacial material. However, often in the core of these ridges are protrusions of bedrock. Perhaps, a chain of such residual positive forms of relief indicate on the northern contours of the Vendian Sea. These ridges have an asymmetrical shape with a gentle north-west and steep southeast slopes. Their relative height can reach 20-50m. Sometimes the protuberances of the bedrock are represented by the rocks of the dike complex. Such dykes of diabase are common in the Solovetsky archipelago.

Glacial deposits are practically absent in the zone of development of the structural relief, in the northern part of the lake. However, a similar pattern is typical for crystal ridges that form the basis of the structural relief of the Ladoga skerries. Thus, seismoacoustic works has made it possible to clarify the position of glacial complexes in the Ladoga Lake.

The carried out geophysical studies, accompanied by an interpretive sampling in the open part of the Onega Lake, made it possible to significantly refine the contours of the geological map of Quaternary sediments. The map of Quaternary sediments in present time composed mainly of date of small sampling (think cores up to 1 m and a significant limitation of the possibility of selection of glacial-lacustrine clays), has been substantially corrected by seismic profiling data and interpretation sampling. It has turned out that the Onega Transgression, as a result of which the Onega Basin actually formed, occurred under conditions of a relative deficit of detrital material. This did not allow the glacial muds of Holocene age to cover all irregularities of the pre-Holocene relief. As a result, the surface of the glacial-lake clay of the Late Neoplestocene was more widely represented at the bottom of the lake. Accordingly, the underwater landscapes developed on the leveled abrasion surface at depths of 30-40 m are represented by clayey sands and sandy silt with inclusion of crushed stone and semi-crocked pebbles of crystalline rocks.

In Lake Ladoga it was succeeded to specify significantly the structure of transect of glacial-lacustrine clays. The till is covered directly by a series of sediments with an obscure subhorizontal stratification, which is completely lost in places due to the appearance of a diffuse record. They occur in negative valley-like forms of relief. Perhaps these are deposits of fluvioglacial streams alternating with deposits of intraglacial lakes with layered texture. The thickness of supraglacial sediments is 17-20 meters. Above lies a pattern criptostratified sediments of thickness up to 12-15 meters. The sediments itself, judging from the texture, is homogeneous and very fine-grained by results to the granulometric composition. It is these deposits that carry out the upper part of the paleovalleys. Overlays these paleovalleys and lies on the moraine surface of a pattern of glacial-lacustrine clays with a clearly subhorizontal layering. Its thickness is 8-10 meters. Thus, one can imagine the following order of formation of the paleolakes. At the first stage, streams of melt water emerged from the front of the retreating glacier, and when changing their direction in the depressions, small lakes appeared where normal sedimentationof sandy sediments was already occurring. Further melting and retreat of the glacier has already led to the formation of large glacial lakes where conventional warves have already accumulated.

Seismoacoustic studies have made a special contribution to the evaluation of the nature of geodynamic postglacial processes. Many researchers pointed to seismotectonic activity in this region in the Holocene (B. Assinovskaya, A. Lukashov, A. Nikonov and others). The performed studies were able to confirm these assumptions. This is particularly evident in the northern part of the lake, where the shore is dissected by deep bays, and numerous islands form a skerry-like landscape. The northern basin of the Ladoga Lake has a very complicated relief with numerous underwater ridges separating isolated deep-water basins. Some of these structural ridges have a direct continuation on land, sharing separate fiards. The height of these ridges can reach 80-100 and more meters. Sometimes, the discontinuity of the uniform horizons stand out in the lakustrine deposits of Holocene age which allows one to assume that tectonic movements occur in Holocene time. On the steep slopes of these trench, gravitational processes are actively developed, at the foot, there are observed accumulations of landslide masses.

Traces of modern geodynamic movements are noted also in other places of Lake Ladoga. To the west of the island of Valaam, a tectonic disturbance dissects both the moraine ridge itself and the horisonts of the Holocene lacustrine sediments. Amplitudes of such displacements are up to 5 m, and the gliding plane is fairly hollow (up to 15 degrees).

These data confirm our opinion about the subsidence of blocks of crystalline rocks in the western part of the lake, which was accompanied by the "subsidence" of the strata of clays, their disturbation, up to the complete disappearance of structural elements of bedding. On the slopes of the trench, located from the island of Konevets to Priozersk along the coast numerous landslides were previously identified. These data were confirmed in our works. At the same time, outflows of gas fluids in the form of pok-marks were detected on the eastern side of these trench. Thus, along with the degradation of glaciation, transgressive-regressive fluctuations in lake level, the geodynamic factor significantly influenced the formation of modern and paleolandscapes.

This work was supported by grants from the St. Petersburg State University No. 18.42.1258.2014, 18.42.1488.2015, 0.42.956.2016 (for field research) and No. 18.40.68.2017 (for purchase of scientific equipment), grant from the Russian Foundation for Basic Research (RFBR) No. 18-05-00303, and the FEEL foundation, "Life Under the Ice project" (http://wiki.epfl.ch/ladoga) and projects of the Russian Science Foundation (RSF) No. 16-17-10076 and 14-17-00766.

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NEW DATA ON THE RESULTS OF THE MOLOGA-SHEKSNA LOWLAND LAKES RESEARCH (VOLOGDA REGION, RUSSIA)

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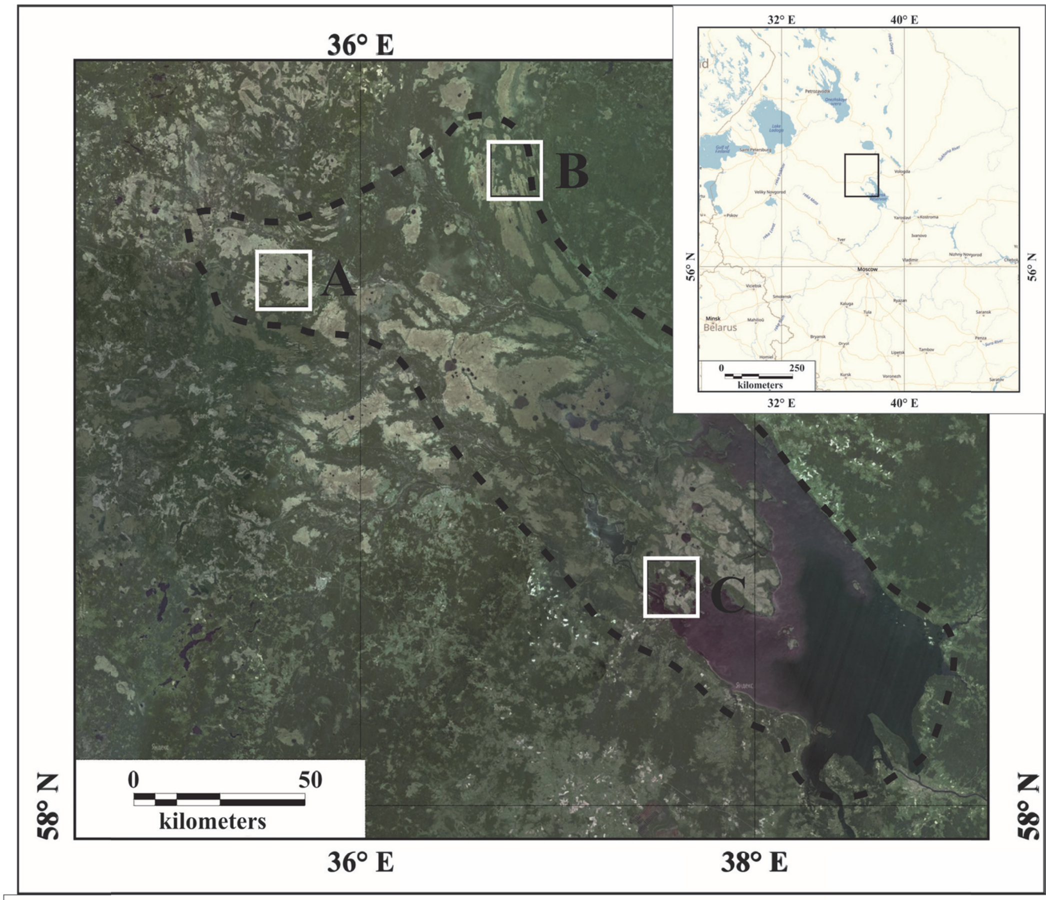
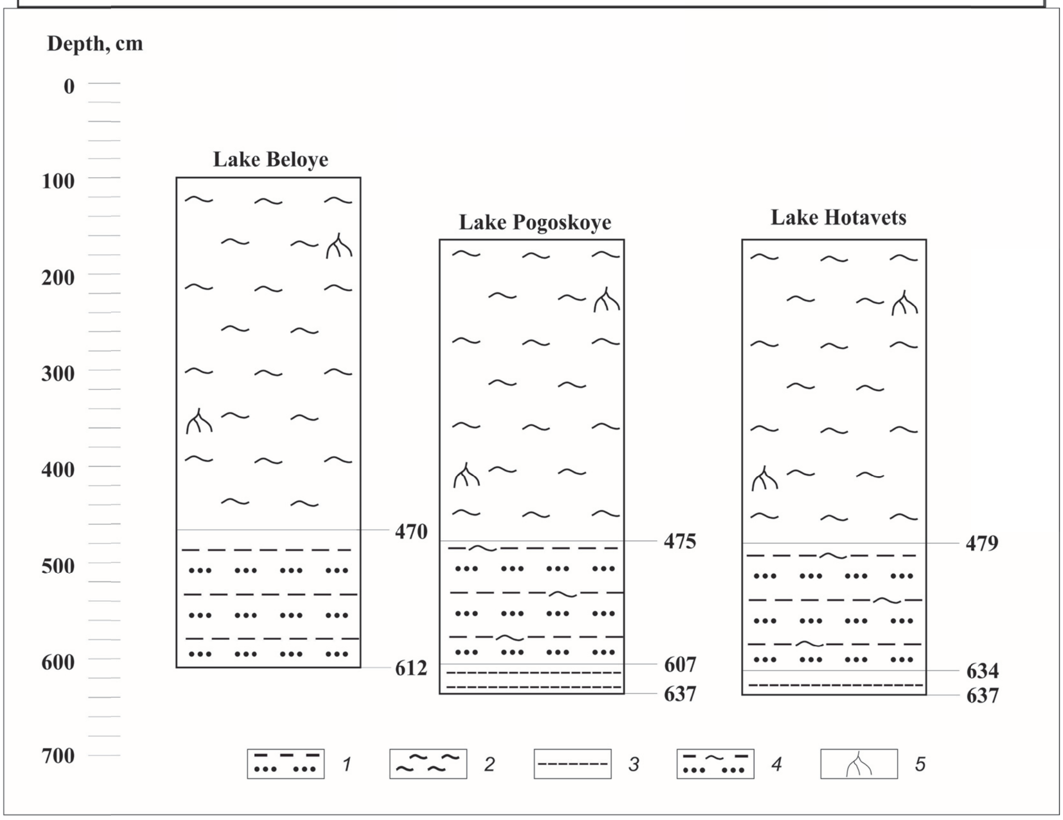
Scandinavian ice sheet deglaciation is closely connected with forming and dynamics of the Glacial Lakes in Upper Valday period. Mologa-Sheksna Lake was one of the Largest Glacial Lakes on the north-west of East-European Plane with an approximate area 23 282,84 km2 (calculated by the altitude of the lacustrine terrace 140-152 m) (Anisimov et al., 2016). The Mologa-Sheksna Lowland was covered by an ice sheet during Late-Pleistocene period, which reached it maximal boundaries approximately 19-18 thousand years ago, according to a range of radiocarbon and OSL dates (Hughes et al., 2016).

Most of the ice-margin relief patterns are poorly developed or even absent in the region which makes it difficult to specify the ice sheet true boundaries during the Last Glacial Maximum (LGM). Glacial sediments and moraines are overlaid by lake and lake-glacial sediments, and the material could have been distributed by floating ice masses (Kvasov, 1975). According to most prominent reconstructions. A variety of glacial landforms are found on the north of the Mologa-Sheksna Lowland (including the Mologa-Suda Lowland), and here on this basis several zones can be distinguished: an interior (proximal) zoneand also an exterior (distal) zone (Mokrienko et al., 1976), where the lakes Beloye and Pogoskoye are situated (Fig.1).

Lowland, according to the literature and geomorphological data and also on the open remote sensing materials. The main objective of the survey was to work out a characteristic of spatial and temporal margins of the Mologa-Sheksna Lake, especially about the time of its termination as a Glacial Lake. Another objective was to record the beginning of the Mologa-Sheksna Lake gradual regression. The locations of the sampling were chosen on the necessity to identify the Mologa-Sheksna lake's spatial boundaries, particularly in conditions of the glacial relief of the Lowland's north. Kvasov (1975) draws the Glacial Lake boundaries in its maximum by the isohypse 145 m; Anisimov et al. (2016) in this way take the isohypse 152 m, Lake Pogoskoye (Vologda region, Belozersk destrict, N 59,697° E 36,853°, alt. 146,3 m) and Lake Beloye (Vologda region, Babaevo district, N 59,379° E 35,626°, alt. 150,5 m) were studied in order to investigate the northern periphery of the lake (which probably was covered with floating ice here at certain time period). Also the Lake Hotavets (Vologda region, Cherepovets district, N 58,568° E 37,603°, alt. 102,4 m) was studied for interpolation the data from the central part of the Lowland and making a correct palaeogeographical reconstruction. All the three lakes are drainless mire relict lakes, and notable for their small depth (100-175 cm of water over the upper gyttja layer).

First stage of the research was profile georadar (GPR) survey of the lacustrine sediments which took place on early March, 2018. The survey was conducted using the "OKO-2" instrument with 150 MHz (shielded) and 50 MHz (unshielded) antennas. The profiles were laid evenly on the ice-snow cover of the lakes in order to detect most applicable positions for core sampling. The software Geoscan32 was used for processing and analyzing radargrams.





Field work based on the primary information about the assumed boundaries of the

Fig. 1. Location map of the research area (A – Lake Beloye, B – lake Pogoskoye, C – Lake Hotavets). Dashed line shows hypothetical boundaries of the Mologa-Sheksna Glacial Lake after LGM

Fig. 2. The lithology of the investigated lakes. Legend: 1 – clay, 2 – organic gyttja, 3 – sandy clay, 4 – clayey gyttja, 5 – macrofossils

Within the framework of the cooperation between the Institute of Limnology RAS and the Darwin State Nature Biosphere Reserve the lakes were cored from ice in March 2018 with a Russian corer (chamber length 1 m, inside diameter 5 cm), according with the initial results of GPR survey interpretation. The sequences were photographed and described visually after acquisition, and then packed into 50-mm PVC-pipes and rolled by sticky tape, and have been held in the refrigerator at the Institute of Limnology RAS (Saint-Petersburg). Approbation and brief lithological description of the lake sediments sequence were executed, which had been obtained as a result of deposits coring on the lakes at different locations of the Mologa-Sheksna Lowland (Fig.2).

Lake Beloye (area 1,26 km^2) located in a boggy depression between flat moraine ridges overlaid by the lake-glacial sediments. Flat and undulated moraine relief formed by the EarlyValday icesheet is spread to the north from the moraine ridges, and Lake Beloye is located directly by the mapped boundary of the flat moraine relief extension (Mokrienko et al., 1976). The depth is 100 cm at the site of the coring.

Lake Pogoskoye (area 0,14 km^2) is located within the Andoga drumlin field (north-east of the Mologa-Sheksna Lowland), where glacial accumulative relief is typical. The drumlins consist of till with depth 0,5-6 m, and linear depressions typically have lacustrine and peat sediments in upper layers (Mokrienko et al., 1976). Lake Pogoskoye is located within one of the depressions, with water depth near 175 cm.

Lake Hotavets (area 1,24 km^2) is situated on the territory of Darwin Nature Reserve, on the surface of lake-delta flatland with distinctive landforms of abrasive-accumulative relief. The lake is surrounded by a plenty of semi-buried elongated spindle-shaped landforms on the flat boggy Glacial Lake terrace, and the 'spindles' indicate fluvioglacial streams directions. Surfaces of the 'spindles' are often complicated with dunes (Spiridonov, 1947).

Depth of Lake Hotavets at the place of coring is nearly 175 cm. Lake Hotavets is notable for its complicated bed morphology in profile revealed in GPR profile data, under muddy deposits, unlike lakes Pogoskoye and Beloye. The sequences were sampled from one of the prominent depressions visible on the radargram. Lithostratigrafical analys showed similar transitional horizons which probably correspond to the Mologa-Sheksna Lake considerable water level oscillations as a result of fluvioglacial meltwater inflow from the descending ice-sheet, and due to gradual regression of the lake level which finally led to the complete drainage of the Glacial Lake.

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PALEOLIMNOLOGICAL RESEARCH:
NEW POSSIBILITIES AND POSSIBLE MISTAKES

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In recent years, new methods of paleolimnological research have been developing. In addition, new approaches and the improvement of old classical methods are proposed. With the advent of new methods, the conclusions about the lakes development sometimes changes and sometimes the conclusions are confirmed or not confirmed.

All steps that paleolimnologists follow in analyses, including core collection, core sampling, dating, a summary of the main indicators and climate proxies, are very important. In the last years, there have been significant advances made in the development and application of new approaches in paleolimnology. Multy-proxi method of lakes study includes few new techniques and new combination of methods. We studied several Holocene sequences of small lakes in Russia using pollen analysis, the results of which we compared with the analysis of macrofossils, phytolites, algae, fungal spores. As a result, additional information was obtained on the reconstruction of vegetation. The climatic reconstructions performed on pollen analysis are compared with climatic reconstructions performed according to chironomid analysis. The use of rizopods analysis, a new method in studying the history of lakes, made possible to determine the change in the trophic status of the lake and the dynamics of the lake bogging processes. The available radiocarbon dates allowed the construction of age models for the studied lakes. The specifics of sedimentation were clarified by studying the dynamics of phosphorus and metals, which allowed us to confirm the conclusions drawn on lithology. All the new additional methods allowed obtaining a more correct lakes history reconstruction.

As research shows, lake sediments most adequately reflect changes in the natural environment, and island lakes because of their isolation are the best archives for testing methods of environmental reconstruction (Sapelko, Anisimov, 2011). Since 2015, complex paleolimnological studies have been conducted on the Solovetsky Islands in the White Sea (Subetto et al., 2012). In the framework of these studies, pollen data were obtained from island lakes, over which the paleoclimate reconstruction was carried out over the last 8 thousand years for three lakes located on one island (Sapelko et al., 2017). Data from surface samples of lake sediments located in different parts of the island were also obtained (Fig.1). For the reconstruction of climatic parameters based on copyright materials (Sapelko, Subetto, 2014), the Russian pollen base ((http://pollendata.org) and the European pollen database (http://www.europeanpollendatabase.net/wiki/doku.php?id=epd_surface_samples_contents), the data relating to the territory of the northern part of the Russian Plain to the latitude of Minsk and also of Fennoscandia to the Scandinavian mountains were selected.

As a result of the reconstruction, some problems were identified

1. Surface samples do not always correctly reflect the current state of natural vegetation and climate due to the high contribution of anthropogenic factors to the development of vegetation at the present time.

2. The number of surface samples used for reconstructions should be large enough for all reconstructed natural areas.

3. The sections with interruptions of sedimentation are unpromising for the paleoclimate reconstructions.

The study was partially financed by Russian state budget as a branch of research project №0154-2018-0003 (state registration №01201363379) and partially financed by Russian Foundation for Basic Research № 18-55-05008 Арм_а.

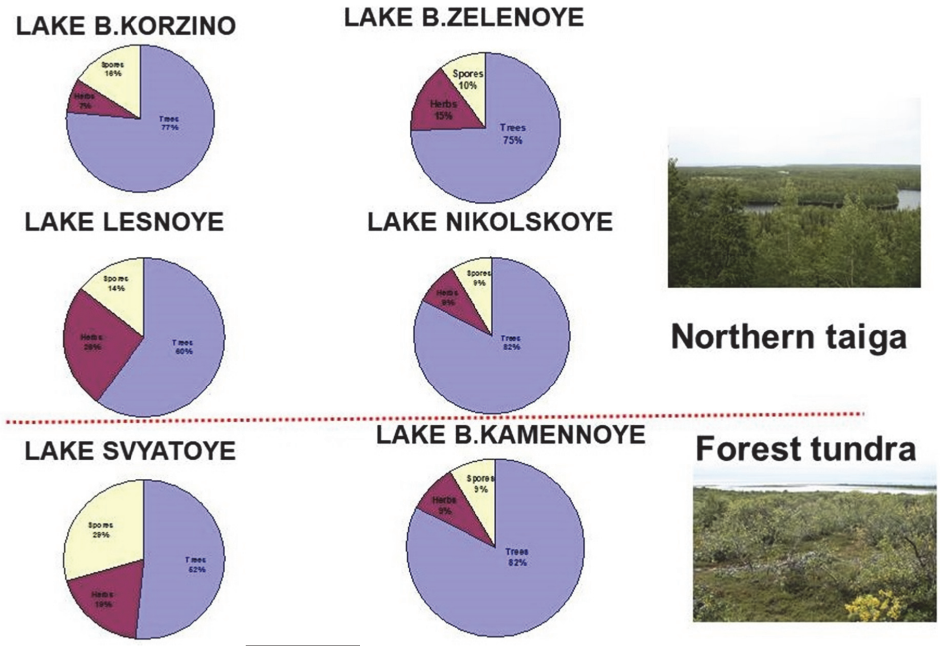

Fig. 1. Subrecent pollen spectra. Total percentage

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RESPONSE OF VEGETATION TO CLIMATE CHANGES DURING LATE GLACIAL AND HOLOCENE INFERRED FROM POLLEN RECORD OF LAKE ONEGA

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The seven cores of bottom sediments were collected for comprehensive studies during the joint expedition of the Saint-Petersburg State University, Center for Analysis of Seismic Data (Lomonosov Moscow State University) and Northern Water Problems Institute (Karelian Research Centre of RAS) in Lake Onega (Petrozavodsk bay) in 2016.

Basing on the seismic results, the two cores 3.2 m (ONG2) and 3.04 m (ONG5) thickness were selected. The water depth at the coring sites was 22 m and 23.3 m correspondingly. The ONG2 core is represented by Holocene sediments whereas the ONG5 core is represented mainly by late Glacial sediments. The excavated sediments in both cores are consisted on silt and clay with an admixture of sand, and underlying 1.12 m of the ONG-5 includes clay layers.

A total 50 samples from the ONG2 and 70 samples from the ONG5 with interval from 3 to 5 cm were analyzed for pollen and 42 pollen, spores, and non-pollen-palynomorph taxa were identified in the studied samples.

According to detailed palynological investigation bottom sediments of ONG5 core started to form during Allerød interstadial warming period. Tundra landscapes with *Betula nana,* possibly shrub *Alnus* as well as herbs were dominated on surrounding area in that time. The area occupied by periglacial vegetation communities with dominating *Artemisia*, Cyperaceae and Chenopodiaceae and participation of *Ephedra* increased during Younger Dryas period. Amelioration of climatic conditions in the beginning of the Holocene contributed to the reduction of territories occupied by vegetation of open habitats. However, the shrub and dwarf forms of *Betula* still dominated in the vegetation cover. This interval is attributed with the Preboreal period of the Holocene. The sharp changes in composition of pollen spectra were fixed above upper boundary of Preboreal. Probably, it is connected with hiatus in sedimentation. The rate of sedimentation sharp decreased at the same time. The uppermost 60 cm of sediments contain pollen and spores of the end of the Atlantic, Subboreal and Subatlantic period. End of the Atlantic period is characterized by the development of spruce and pine forests with the participation of *Alnus*, an admixture of *Ulmus* and *Quercus*. Participation of broadleaved species decreased, spruce and pine forests with *Betula* and *Alnus* were widespread during Subboreal time. Pine forests with *Betula*, *Picea* and *Alnus* participation are main feature of Subatlantic period as well as appearance of *Secale* and anthrophorous herbs at the end of the period.

The ONG-2 core is represented by sediments formed during the end of the Atlantic, Subboreal and Subatlantic periods according to pollen stratigraphy. Spore-pollen spectra received to allow more detailed reconstructed vegetation cover changes during the second part of the Holocene.

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BEENCHIME SALAATINSKY CRATER IN NORTHERN YAKUTIA - ORIGIN AND ENVIRONMENTAL DYNAMICS IN THE 8-KM CIRCULAR STRUCTURE

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Short-term scientific goals of our study are to reveal the origin of the crater (impact crater or volcanic crater) and the late Quaternary environmental history in the area. Beenchime Salaatinsky Crater (BSC) is a potentially multi-million-year-old ring structure that has a diameter of 8 km and is located west of the Olenyok River in northern Yakutia (Figure 1A). The altitude difference in the crater is around 60 m (140 m to 208 m above sea level) with forest tundra (i.e. larches) and shrubs and grass covering much of the area. The basin structure consists of three geomorphic levels: a lower level at 140-150 m asl. with polygonal frozen ground, partly boggy and filled with water in the meadows and with a drainage pattern that is seasonally active; a medium level at 150-165 m asl. has slopes and erosive remains of ancient fluvial terraces; the upper level at 165-208 m asl. consists of bedrock forming the crater rim. It includes a polygonal pattern from periglacial frost cracking in the weathered bedrock (Figure 1B).

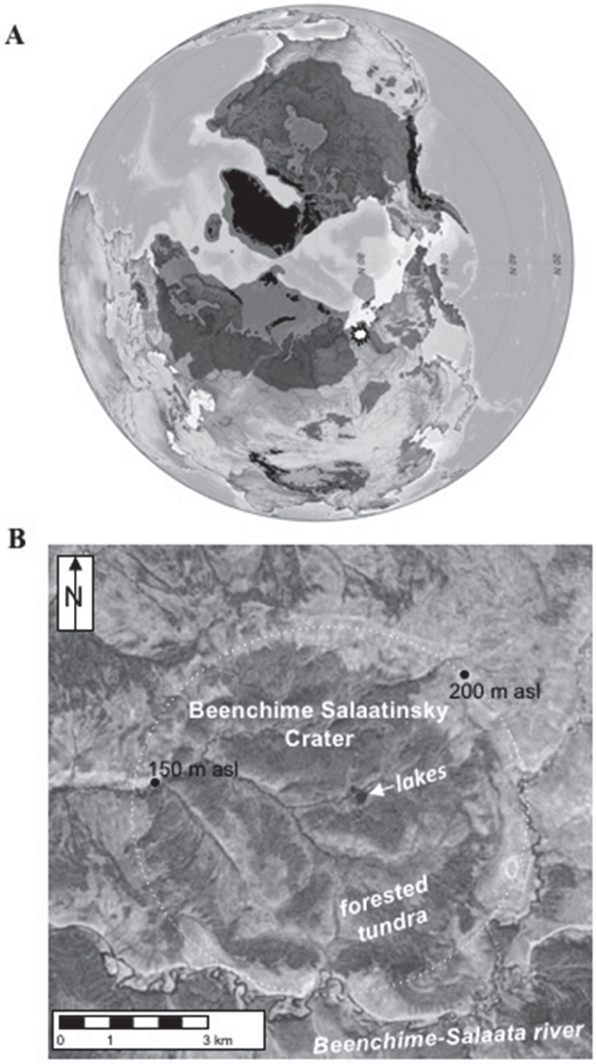
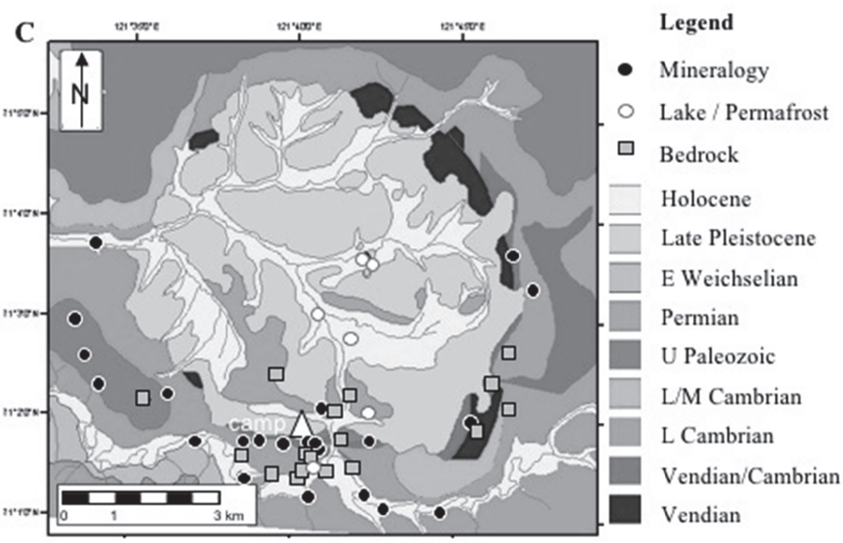


Figure 1: A) Beenchime Salaastinsky Crater is exposed in northern Yakutia, in the uplands west of the Lena river (see star). The crater escaped major Pleistocene glaciations (shaded areas, H. Grobe, 2008, redrawn from Ehlers and Gibbard, 2007, Niessen et al., 2013).
B) The crater is named for its neighboring river. Drainage in the low relief terrain exits to the west. Periglacial weathering takes place in the crater rim dolostones. The basin center holds a group of small lakes [WorldView-2 imagery 2013].
C) Paleozoic sediment rocks form the crater rim, the crater inside and outside (based on Mikhailov, 1978, Masaitis, 1999, modified).



Following earlier geomorphological surveys, it is assumed that the basin is the result of a Mesozoic volcanic explosion similar to Kimberlite Pipes elsewhere in Yakutia (Pinchuk et al., 1971, Khain, 1985). Alternatively, a meteorite impact is blamed, because suevitic breccias have been identified (Mikhailov et al., 1979, Masaitis, 1999). According to geomorphological age estimates, the crater is between 65 and 40±20 Ma old (Moon et al., 2001; Grieve, 1987, Earth Impact Database, 2018).

In a pilot study during summer 2016 we sampled several landforms of the basin interior (a peat plateau, ancient river terraces, a modern lake depression) and geologic formations (Paleozoic bedrock and modern river sediments) (Figure 1C). In the central part of BSC the biggest of three lakes, 300 m in diameter, has been studied using 50 MHz ground penetrating radar profiles and short cores. At four sites of the lower and medium levels soil pits were dug into the ground and short cores of about 1 m extended the sediment records into the underlying permafrost. Placer examinations are in progress to identify the precious metal and heavy mineral fractions from fluvial samples. Several fractions obtained by sieving are under inspection (i.e. 2-1, 1-0.5, 0.5-0.25, and 0.25-0.16 mm).

Thin section studies on various bedrock samples from outcrops are analyzed using polarized light microscopy that allows identifying possible shock metamorphic effects. In fact, shocked quartz with PDFs (planar deformation features) was found in a sample taken from a Permian sandstone outcropping in the crater interior. The crystallographic orientations were measured using a U-stage microscope. Some other samples of the crater rim are only slightly shocked.

We sum up our results in a preliminary scenario, which suggests a Paleozoic meteoritic impact event, a Mesozoic overburdening of the area and a subsequent erosion in the course of the Olenyok Uplift. Finally, we propose late Quaternary landscape dynamics based on sediment dating using AMS ^{14}C and sediment properties in the crater; fluvial sediment transport is documented for the MIS 3 and MIS 1 periods whereas mid to late Holocene lake sediments indicate increasing aridity in the area with lake level lowering during the past ca. 2000 years.

Our long-term scientific goals are to identify, if the site is a suitable target for deep drilling efforts. It would allow studying the depth and depositional history of the basin filling and would aid reconstructing the crater origin. Optionally, boreholes and cores can serve to study the permafrost temperature field and an extreme habitat of microbial life.

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VOLCANIC ACTIVITY WITHIN THE JOM-BOLOK RIVER VALLEY (EAST SAYAN MTS., BAIKAL REGION) DURING THE LATE GLACIAL-HOLOCENE: THE FIRST CONTINUOUS TEPHROCHRONOLOGICAL RECORD FROM LAKE SEDIMENTS

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Lava flows and volcanoes of the Jom-Bolok River valley represents the largest manifestation of Holocene eruptions in Central Asia. The overall volume of the erupted products has been estimated (Yarmolyuk et al., 2003) to be 16 km^3. Detailed data of the structures, compositions, sources and effusion principles of the valley lava flows are available (Yarmolyuk et al., 2003; Ivanov et al., 2011). However, their chronological order has not yet been reliably reconstructed. It is only known that the volcanic events were multiphase (Yarmolyuk et al., 2003) and began during the Pleistocene-Holocene transition and lasted until the last millennium (Arzhannikov et al., 2017).

In 2015, during field studies performed in the Jom-Bolok River valley, we carried out a detailed survey of the bottom relief of the water basin and compiled its bathymetric map. The drilling point was placed in the profundal zone of the basin. The coring point reached a water depth of 6,5 m. Bottom sampling was carried out by using inflatable boats with a UWITEC (Austria) gravity core sampler with an inner liner with a diameter of 63 mm. The cross-section of the bottom sediments was completely penetrated, up to the underlying glacial sediments.

The distribution of absolute age values along the core depth (Fig. 1) demonstrates the absence of inversions and an almost linear trend of increasing age along the core depth. The core lithology and age model suggest that the uninterrupted accumulation of sediments occurred over the last 14290 years, as well as the absence of cryoturbation in the bottom sediments, which occurs when the water basin freezes completely.

Samples from the tephra horizons contain microparticles of volcanic material, which are present as both pure glass without inclusions and as glass with fine-grained mineral inclusions of two types: 1 – xenomorphic glass with dust-like inclusions of fine-grained minerals, and 2 – vitreous masses with low degrees of crystallization, including micrograins of quartz, plagioclase, olivine, pyroxene and dust-like inclusions of ore material. X-ray spectral microanalysis results showed that crystalline mineral grains are represented by brown olivine, green pyroxene, and colourless plagioclase and quartz grains.

The maximum content of pyroclastic material was discovered in the lower part of the studied section, ranging from 150 to 138 cm (Fig. 1). Higher along the section, from 138 to 52 cm, the content of pyroclastic material drops to singular occurrences. In the interval ranging from 10-5 cm, the amounts of microtephra glass shards again increase considerably; in the upper 5 cm of the sediments, only rare microtephra shards can be found.

As a reference event, we chose the eruption that occurred ca. 6280 BP, which is related to the formation of the Khara-Nur lava-dammed lake in its modern shape (Bezrukova et al., 2016). At that time, considerable amounts of pyroclastic material entered the Kaskadnoe-1 lake sediments. Its peak content in the studied samples, which formed ca. 6280 BP, was chosen as a minimal benchmark signal, marking the occurrence of the volcanic eruption in the Jom-Bolok river valley. Lower microtephra contents were considered to be baseline values and were thus excluded from the statistical analysis. Undoubtedly, part of this pyroclastic material was brought into the lake after the ash falls due to the rainwash in the catchment basin, thus causing the overall volcanic material "contamination" of the lake sediments. Although this circumstance does not considerably affect the distinction of volcanic events, it can have a negative impact on the chronometric reconstruction of separate eruptions, as it appears to increase the duration of the "volcanic" signal in the sedimentary chronicles of the lake.

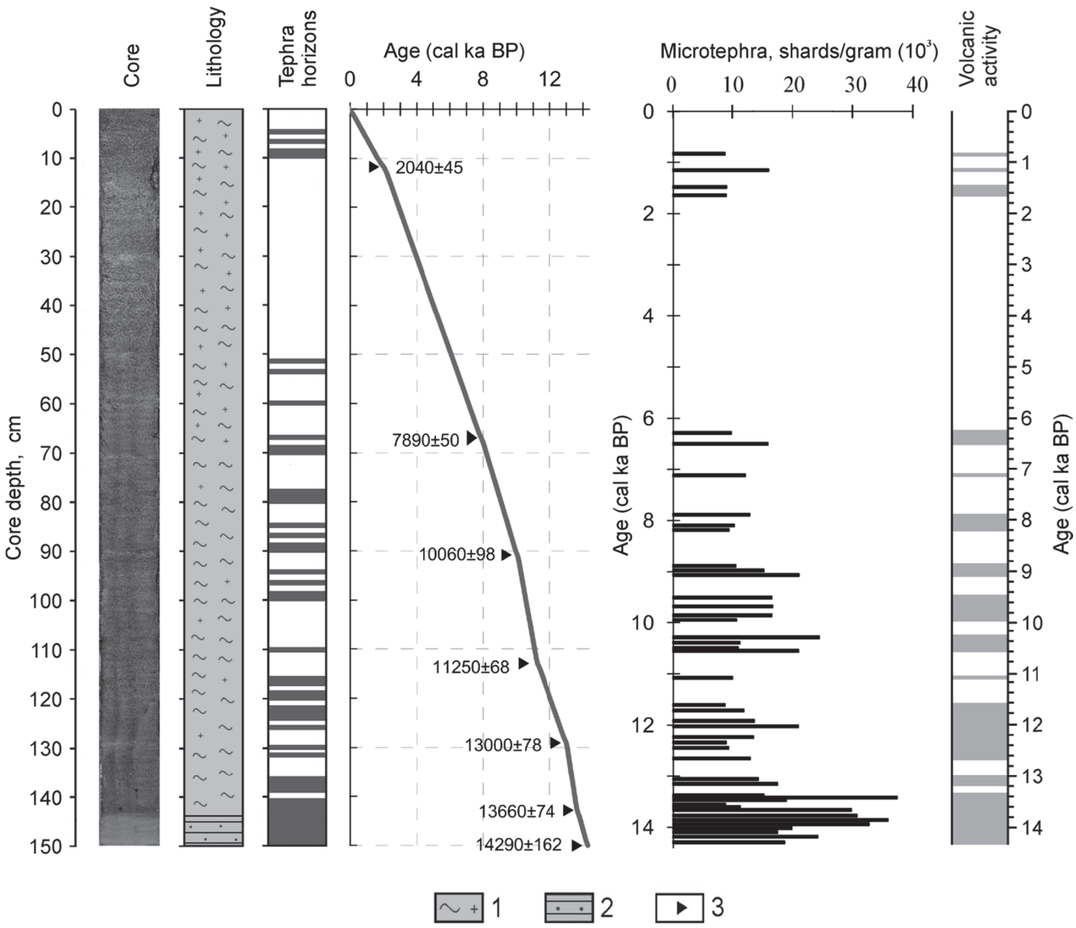

Fig. 1. Tephrostratigraphy of the Kaskadnoe-1 lake sediments and the timing of volcanic activity in the Jom-Bolok River valley. 1 – Biogenous-terrigenous silt with diatomic algae, 2 – silty blue clay of the periglacial lake sediments, 3 – sampling points for AMS C^{14} dating

The first phases of eruptions occurred in the presence of glaciers within the upper valley. Tephra was depositing on them and a part of volcanic matter could gradually arrive to the Cascade Lakes system with ice melt during the final stage of deglaciation. We are to ask ourselves: if that could result in considerable contamination of sediment record by microtephra from earlier eruptions? Maximum peaks of the tephra content in the base of studied section of the lake sediments, seemingly lead to such assumption. However, Lake Cascadnoye-1 has no direct fluvial feed. Watercourses that drain the valley upper parts do not fall into it, and this was one condition of importance to choice this object for tephrostratigraphic studies. If the volcanic matter from the ice tephra horizons fell finally into the Lake Cascadnoye-1 their volume could not be substantial. The rainwash is of greater importance here, but the volcanic glass particles are quickly destructed herewith.

The highest concentrations of microtephra particles are located in the layer of silty clays formed between 14300-13770 BP; high amounts of microtephra are typical for the lower layers of these biogenous-terrigenous silts (13770-13300 BP). Obviously, the most widescale volcanic events occurred ca. 14300-13300 BP, when eruptions occurred almost continuously and the explosive activity reached its maximum development.

The age of 13300 BP represents the start of the weakening intensity of explosive activity, which is marked by the lesser inflow of microtephra shards into the lake sediments. However, these eruptions still continue, with few interruptions, until 6280 BP. In total, from 14300 to 6280 BP, 10 groups of microtephra enrichment peaks can be distinguished in the sediments of Lake Kaskadnoe-1. The detailed age model allows us to calculate the average interval between the eruptions during this time; these calculations yield an average interval length of 500-600 years.

The Lake Kaskadnoe-1 sediments, which accumulated between 6280 and 1600 BP, contain only rare microtephra shards, which can probably be related to a period of relative quiescence in the volcanic activity of the Jom-Bolok region. New microtephra enrichment peaks are fixated in the upper part of the exposed section of the Lake Kaskadnoe-1 sediments, suggesting that volcanic activity was reinitiated in the Late Holocene. These peaks reach maximal values in the sediments formed ca. 1150 BP. According to these acquired dates, therefore, the last volcanic events occurred approximately 800 years ago. At that point, it seems, a modern stage of volcanic quiescence began in the Jom-Bolok River valley.

The correlation of eruption dates, sediment density and wetness variations in Lake Kaskadnoe-1 between 14300 and 6280 BP show that there is no considerable dependency between the changes in the physical properties of the sediments and the eruptions that occurred in the Jom-Bolok region. After 6500 BP, the MS values increased several times with increasing sediment density, but this occurred during the long period of stillness in the regional volcanic activity.

The last volcanic activity peak, which is recorded in the Lake Kaskandoe-1 sediments ca. 1600-800 BP, could probably have been the reason for the short-term decrease in the bioproductivity of the lake system.

Thus we acquired the first and, to date, most complete record of volcanic activity in the Jom-Bolok River valley. This record represents the longest of the currently known, reliably dated sequences of Holocene eruptions in North Asia and unites the results of previous studies of microtephra shards, the physical and chemical properties of bottom sediments, and their AMS ^{14}C ages. The lithological structure of the exposed section of the bottom sediments of Lake Kaskadnoe-1 and their reliable age model allow us to state that, at least during the late ice age period, which began 14300 years ago, the upper reaches of the Jom-Bolok River valley (at an altitude of 2080 m above sea level) were clear of glaciers and that the formation of glacial lakes occurred there.

The analyses conducted here allow us to identify distinct phases of the intensification of explosive activity in the Jom-Bolok River valley. However, due to the peculiarities of the local, Hawaiian-type eruptions, these effusive phases could have been longer or more numerous.

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STUDY OF PALEOGEOGRAPHIC FEATURES OF THE NORTHERN PART OF THE KARELIAN ISTHMUS DURING THE HOLOCENE

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In the conditions of modern climate change, special attention is paid to paleogeographic reconstructions, because the prediction of climate scenarios in the future is modeled on the basis of data from past eras (Kuznetsov *et al.* 2007). One of the most reliable method for reconstruction of natural conditions of the Late Pleistocene and Holocene is a complex study of bottom sediments of lakes. Climate changes causes the nature and intensity of sedimentation processes, which is reflected in the formed sedimentary sequence of bottom sediments of lakes.

The territory of the Karelian isthmus is of great interest to paleogeographers, as it is located between two large water objects and the history of their influence on the formation of the isthmus is not fully studied (Subetto, 2009). The reconstruction of natural conditions in the southern part of the Karelian Isthmus (Miettinen *et al.* 2007) has been carried out. However, the question remains about the boundaries of the flooding of the northern part of the Karelian Isthmus by Ancylus and the Littorina stages of the Baltic Sea, as well as the formation of the so-called Henijoki Strait connecting the Baltic Sea with Ladoga Lake before the Neva breakthrough.

With the aim of reconstructing the dynamics of the transgression-regressive cycles of the Baltic Sea and changing the natural conditions in the northern part of the Karelian Isthmus, the lakes were chosen at different hypsometric levels: Goluboye (11 m ASL), Mozhevelnoye (14 m ASL) and Trigorskoye (16 m ASL).

Sampling of bottom sediments was conducted in October 2017 from the platform with using russian peat corer. The bathymetry was measured in the field; the territory around lakes was detailed studied; the primary lithological description of bottom sediment columns, their packaging and transportation to the laboratory was performed.

Laboratory studies will include: analysis of the loss on ignition, diatom, geochemical, palynological, chironomidae and radiocarbon analysis. The obtained data will show the relation between organic and inorganic material, physico-chemical features and bioproductivity of lakes, the duration of sediment formation, vegetation change, average temperatures in July.

The first results of the lithological description and geochemistry will be presented at the conference.

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EVOLUTION OF THE NONMARINE BIVALVE MOLLUSK ASSEMBLAGES IN THE PERMIAN LAKES OF NORTHERN EURASIA

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At present, among all known Permian faunas of nonmarine bivalves, the East European *Palaeomutela* Fauna is most thoroughly investigated and unequivocally understood by different researchers. The zonal scale of the Permian deposits developed on the basis of the *Palaeomutela* sensu lato phylogenetic lineages (Silantiev, 2014) and contemporaneous beds with the fauna of accompanying genera of nonmarine bivalves (Silantiev, 2016) form a detailed biostratigraphic basis suitable for correlation of localities of Permian nonmarine bivalves from other regions with the sections of the East European Platform.

The genus *Palaeomutela* sensu lato appeared at the end of the Kungurian Age of the Cisuralian time (Late Kungurian, Cisuralian). The first records of this genus are known from the lower part of the Solikamsk Formation (Ufimian Regional Stage, *stegocephalum* Zone) of the Solikamsk Depression of the Cis-Ural Foredeep. *Palaeomutela* sensu lato rather rapidly (Sheshminskian Regional Stage, *ovatiformis* Zone) occupied nonmarine basins of the Cis-Urals and eastern marginal area of the East European Platform. Simultaneously, some species of *Palaeomutela* sensu lato could have migrated into coal-bearing basins of the Angarian Realm (Kuznetsk Basin, northern China). Subsequently, in the Wordian Age (Urzhumian Regional Stage), members of *Palaeomutela* sensu lato penetrated into the basins of Gondwana (India and South Africa). In the second half of the Capitanian Age (Severodvinian Regional Stage), *Palaeomutela* sensu lato community changed considerably and began to include (in approximately equal proportions) two morphologically different species groups, i.e., the *P.* (*Palaeomutela*) *keyserlingi* (chevron-shaped hinge) and *P.* (*Palaeanodonta*) *fischeri* (toothless hinge) groups. During the Lopingian time (Vyatkian Regional Stage), members of these groups became widespread throughout the globe (Silantiev, Carter, 2015).

During the cold climatic phases of the Permian, cold-resistant Angarian genera of nonmarine bivalves migrated beyond the initial range, first, into the basins of the Cis-Ural Foredeep and, then, into the basins of the East European Platform. Thus, the territory of Eastern Europe was occupied by members of *Sinomya*, "*Concinella*," *Intaella*, *Redikorella*, *Prilukiella*, *Anadontella*, and *Concinella* sensu stricto (Silantiev, 2015). In the Wordian Age (Urzhumian Regional Stage), members of the Angarian Fauna reached Gondwana, penetrating into the basins of India (Silantiev et al., 2015). The events of migration and faunal exchange of nonmarine bivalves can be used for correlation.

The analysis of distribution of nonmarine bivalves in the Permian beds of various regions of the Earth has revealed three faunal groups most significant for correlation.

Family Palaeomutelidae, including members of *P. (Palaeomutela)*, *P. (Palaeanodonta),* and *Oligodontella*, is of the greatest significance for correlation. It allows comparisons of the Permian nonmarine beds of the Euramerican, Angarian, Cathaysian, and Gondwanan realms. *The lower correlation level,* i.e., the Kungurian–Roadian (Kazanian) interval, is traced in the Euramerican and Angarian realms by a set of similar morphotypes characteristic of the *ovatiformis–umbonata* zones (*P. umbonata* group) and *castor–olgae* zones (*P. castor* group). *The middle correlation level* is the Late Capitanian (Late Severodvinian) interval, which is traced in the Euramerican, Angarian, and Gondwanan realms. It is characterized by the presence of *Oligodontella* and forms of *Palaeomutela* with the well-ordered "chevron-shaped" hinge characteristic of species from the *keyserlingi* Zone. *The upper correlation level* is the Lopingian (Vyatkian) interval, which is traced in the Euramerican, Angarian, Cathaysian, and Gondwanan realms. It is characterized by co-occurrence of *P. (Palaeanodonta)* and species of *P. (Palaeomutela)* with a reduced hinge.

The Anadontella–Prilukiella group, including members of these genera, can be used for comparison of the Permian nonmarine beds of the Euramerican, Angarian, and Gondwanan (coal-bearing basins of India) realms within the interval of the Wordian (Urzhumian) Stage.

The Concinella group, including members of the genus *Concinella* and primarily the type species *Concinella concinna* (Jones), can be used as an additional marker for correlation of the Late Capitanian (Late Severodvinian) interval of the Euramerican and Angarian realms (Pechora, Kuznetsk, and Tunguska basins and Taimyr).

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PALEOGEOGRAPHIC RESEARCHES OF LATE GLACIAL AND EARLY HOLOCENE IN THE NORTHWEST OF THE EAST EUROPEAN PLAIN

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Nowadays the problem of changing natural conditions at the boundary of the Late Pleistocene and the Holocene is given special attention, because during this period of time the ice sheet was destroyed and the subsequent transformation of the environmental conditions from cold, arctic to warm and wet.

Within the Russian part of the north-west of the East European Plain, work is underway to reconstruct the natural conditions of the Late Pleistocene and Holocene transition: in the Kaliningrad Region [Druzhinina et al. 2015; Kublitskiy et al. 2014; Kublitskiy 2016], and Karelian isthmus [Andronikov et al. 2014; Kuznetsov, 2014; Subetto et al. 2016; Syrykh et al. 2017].

The purpose of the study is to reveal the synchronicity / asynchrony of the processes of lakes sedimentation and changes in natural conditions at the boundary of the Pleistocene and Holocene in the northwestern part of the East European Plain on the basis of generalizing and supplementing the paleogeographic data. It is planned to create a paleogeographic and paleoecological database for the objects of the northwest of the East European Plain (the Kaliningrad, Smolensk, Pskov, and Leningrad regions of the Russian Federation, as well as the territories of Lithuania, Latvia, Estonia and the Republic of Belarus), which has a qualitative geochronological link to the Late Pleistocene and Holocene to monitor the conditions of the lake systems and the dynamics of their changes in the past. This approach is actively developing in Russia [Grekov et al. 2014; Grekov, Subetto, 2015; Grekov et al. 2018]. After summarizing and analyzing the available information, it is planned to identify key areas, information on which is not sufficient to perform paleogeographic reconstruction.

As a result of the project implementation, a general paleogeographic reconstruction for the claimed time interval will be built on the basis of lithological, geochemical, palynological, chironomid, geochronological analyzes and LOI of the selected objects bottom sediments in the northwest of the East European Plain.

On the basis of the reconstruction, a synchronous / asynchronous scheme of the processes of lake sedimentation and development of the environment in the northwestern part of the East European Plain at the boundary of the Pleistocene and Holocene will be compiled using the geoinformation method.

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MINERALOGY AND CRYSTAL CHEMISTRY OF AUTHIGENIC CARBONATES FROM CALCITE-DOLOMITE SERIES OF SHALLOW LAKES SEDIMENTS (BAIKAL REGION)

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The high degree of influence of regional natural and climatic factors on sedimentation in intracontinental reservoirs requires a comprehensive study of their bottom sediments. The important information is contained in the mineralogical and crystallochemical characteristics of authigenic mineral phases, since the composition and structure of the precipitating minerals are directly dependent on the chemistry of lacustrine water, salinity, temperature and biological productivity of the paleobasin, which in turn are controlled by the regional climate. This dependence is most clearly manifested for low-temperature authigenic carbonates possessing a wide spectrum of isomorphism in their crystal lattice and significant variations in the degree of order / disorder in the structure [Reeder, 1983].

We present the results of mineralogical and crystallochemical studies of the authigenic carbonates from bottom sediments of shallow saline lakes at Baikal region. The objects of studying are Holocene evaporite sections of three closed lakes with carbonate type of sedimentation –Verchnee Beloe, Bol'shoe Alginskoe and Kiran. They are located in western Transbaikalia - the region with prevailing of arid and semi-arid climate conditions. The main methods of investigations are: X-ray diffraction analysis (ARL X'TRA, Cu K_{α} radiation) and IR-spectroscopy; additional methods are scanning electron microscopy, SR XFA, analysis of stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) and others.

The assemblage of authigenic carbonate minerals of the lacustrine sediments consists of Mg-calcites with different Mg contents and excess-Ca dolomites. 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 $CaCO_3$ and stoichiometric dolomite ($CaMg[CO_3]_2$). Natural low-temperature Mg-calcites are poorly crystallized; the crystallites are smaller than 10 μm. Their detailed study encounters difficulties because of the lack of single crystals of required quality and size.

Carbonate mineralogy was considered on the basis of the position of the most intense reflection (*hk* =104) in the trigonal varieties in the range of angles of 28.5–32.5º (2Θº Cu*K*α) (Fig. 1). The interplanar spacing d_{104} varies from 3.036Å (calcite) to 2.887Å (stoichiometric dolomite) and serves as a measure of the Mg content of these carbonates. For a detailed description of the Mg-calcites, we divided them into three groups: (1) low-Mg calcites (LMC) with $MgCO_3$ < 4–5 mol.% (3.036 Å > d_{104} > 3.02 Å); (2) intermediate-Mg calcites (IMC) with 5–18 mol.% $MgCO_3$ (3.02 Å > d_{104} >2.98 Å); and (3) high-Mg calcites (HMC) with 18–43 mol.% $MgCO_3$ (2.98 Å > d_{104} > 2.90 Å). The excess-Ca dolomites, in which excess of $CaCO_3$ can amount to 7 mol.% as compared with the stoichiometric dolomite, are characterized by d_{104} of 2.90 to 2.887Å. On the high-resolution X-ray patterns of the studied samples, the peaks corresponding to d_{104} of carbonate minerals look like two maxima of varying intensity: (1) LMC and IMC and (2) HMC and excess-Ca dolomites (Fig. 1).

The conventional boundary between them is located at 30º 2Θ Cu*K*α (d_{104}=2.98 Å). These broadened diffraction peaks are of intricate shape, and each of them is a superposition of several peaks of carbonate phases with different contents of Mg in the structure. Decomposition of complex XRD-profiles of carbonates into individual peaks by the Pearson function VII provided the whole set of existing carbonate minerals in each sample [Solotchina et al., 2012]. The model approach allowed us to determine the position of the maximum, integral intensity of the analytical peak of each phase and to obtain their quantitative ratios with a high accuracy. The concentration of $MgCO_3$ in Mg-calcite structure was determined by the calibration plots of dependence between the d_{104} and $MgCO_3$ content (mol.%) [Goldsmith, Graf, 1958].

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At present, Mg-calcites are regarded as mixed crystals varying from true solid solutions (low-Mg calcites) to mixed-layered structures (high-Mg calcites) in the series calcite-dolomite and characterized by different stabilities [Deelman, C., 2011]. These structures are sequences of calcite and magnesite layers alternating with different degrees of ordering and forming nanosized domains. Mixed-layer structure of excess-Ca dolomite [Drits et al., 2005] is more similar to the structure of high-Mg calcite than to that of dolomite *sensu stricto*, this mixed crystal is the end-member of the series of anhydrous Ca–Mg carbonates including low-Mg calcite, intermediate-Mg calcite, high-Mg calcite, and excess-Ca dolomite. Moreover, stoichiometric and nonstoichiometric dolomites are, most likely, of different genesis. Stoichiometric dolomite is extremely rare in Holocene and modern sediments of continental water basins, even when the waters are oversaturated with $CaMg(CO_3)_2$ [Last, 1990]. Our investigations have shown that the excess-Ca dolomites are a permanent component of saline lakes sediments just as Mg-calcites. We have established that the lacustrine Mg-calcites do not form a continuous series from low-Mg to high-Mg varieties: there is a break between Mg-calcites containing <18 mol.% $MgCO_3$ and >30 mol.% $MgCO_3$ (a blank space on the XRD spectra near 2Θ Cu*K*α = 30º). We suppose that the break in the series of Mg-calcites is probably due to the transition from true solid solutions ($MgCO_3$ < 18 mol.%) to layered "domain" crystals, which are regular in their utmost form.

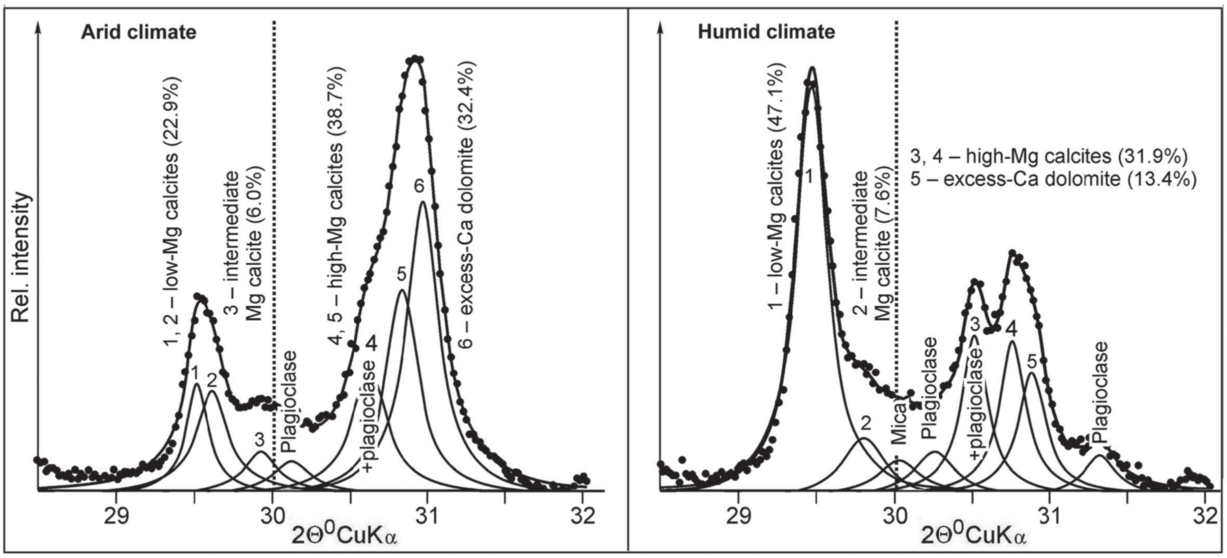

Fig. 1. Results of modeling of experimental XRD profiles of carbonates in the range of d_{104} peaks. The total modeled profiles (solid line) are in agreement with the experimental ones (dotted line). The diffraction peaks of individual phases are described by Pearson VII function. The total content of carbonates in the sample is taken equal to 100%

It is known, that sedimentation of carbonates of the calcite–dolomite series is determined by a number of factors: Mg/Ca ratio, total carbonate alkalinity, salinity, pH value, temperature, and organic productivity of the water [Nechiporenko, Bondarenko, 1988]. These factors are controlled by the lake water balance depending mainly on the regional climate. Based on the studies performed, we obtained a carbonate record carrying the information about the stratigraphic distribution of Mg-calcites and Ca-dolomites in sedimentary sections. Juxtaposing the carbonate record with the data of lithological analysis, determined stable isotopes ($\delta^{18}O$ and $\delta^{13}C$), and distribution of some geochemical indicators of climatic changes, we reconstructed the intricate evolution of lakes, which was controlled by the regional climate [Solotchina et al., 2012].

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PALEOCLIMATE RECORDS OF THE HOLOCENE INFERRED FROM PROGLACIAL LAKE BOTTOM SEDIMENTS OF EAST SIBERIA

Stepanova O.G.[1], Trunova V.A.[2], Vorobyeva S.S.[1], Osipov E.Yu.[1], Melgunov M.S.[3], Petrovskii S.K.[1], Krapivina S.M.[1], Zheleznyakova T.O.[1], Enushchenko I.V.[1], Vershinin K.E.[1], Parhomchuk E.V.[4], Rastigeev S.A.[5], Petrozhitsky A.V.[4], Fedotov A.P.[1]

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Currently, glacier area in the south part of East Siberia is not extensive. In most causes, these glaciers are less than 1 km^2 [Margold and Jansson, 2011; Stokes et al., 2013; Osipov and Osipova, 2014; Kitov et al., 2015]. However, alpine relief and other geomorphological evidences such as terminal moraines, fossil shorelines and deltas of glacial lakes indicate extensive glaciation of the area in the past [Back and Strecker, 1998; Osipov et al., 2003].

The goal of this study is to reconstruct a glacier response to climate changes during the Holocene based on high-resolution geochemical proxies inferred from the East Siberian proglacial lakes of the East Sayan Ridge, the Baikalsky Ridge and the Kodar Ridge.

Dating of the sediments cores and fluvio-glacial deposits was based on ^{210}Pb and ^{137}Cs chronology for the upper sediment layers, and radiocarbon (14C) calibration performed by AMS built by Budker Institute of Nuclear Physics, Novosibirsk, Russia.

According obtained 14C data, forming of Tompuda moraine (Northern Baikal) was two studies. The first study begun from Belling-Allered and ended to 11.8-12.4 ka BP. The second study of deglaciation was 9-11 ka BP. In general, Pleistocene glaciers of the East Sayan Ridge, the Baikalsky Ridge and the Kodar Ridge were melted to the early Holocene. The modern glaciers most likely formed during the Little Ice Age.

The intensity of the supply of surface water into proglacial lakes has primarily depended upon a rate melting of glaciers and summer air temperature. The distribution of Rb, Zr, Nb, Y and Th will be closely associated with the clastic material and can be related with a rate melting of glaciers. The elemental composition of bottom sediments were investigated by two methods: X-ray fluorescence spectrometry and inductively coupled plasma mass spectrometry. X-ray fluorescence spectrometry was undertaken to provide quantitative information on 20 trace elements (from K to U) and a time resolution in “year-season”[Stepanova et al., 2015; Trunova et al., 2015].

We defined three periods of significant increased glacier flow/melting during the last 210 years. The first period (ca. 1800-1890), the supply of suspended material by meltwater into proglacial lakes of the East Sayan Ridge was not intense until 1850 and into proglacial lakes of the Kodar Ridge did until 1875. However, a rate of the supply of meltwater into proglacial lakes of the Baikalsky Ridge was high during the Little Ice Age and decreased at a transition from the Little Ice Age to the Recent Warming. During the second period (ca.1890- 1940) the regional glacier water balance were most likely positive. The third period (ca. 1940 - the present), the malting rates of glaciers located on the Baikalsky Ridge and the Kodar Ridge were moderate, in contrast to the East Sayan Ridge demonstrated the highest ratio of melting and changes in outlines during this period.

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FEATURES OF FORMATION OF AUTHIGENIC MINERALS IN HOLOCENE BOTTOM SEDIMENTS OF SMALL LAKES OF WESTERN SIBERIA

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Research of features of modern mineral formation and laws of generating of components of autigenic minerals in natural reservoirs of the Western Siberia is actual in connection with need of an assessment of influence of organic matter on processes of sedimentation and stability of biogeochemical cycles of macro elements (C, O, H, Ca, Si, Fe, etc.) in them. The biogeochemical aspect of sedimentology attracts wide attention of researchers, but due to the complexity of the object of study, many questions remain unclear [Lee, 1992 et.al.]. There is practically no information on the influence of biochemical transformation of organic substances on the mineral composition of bottom sediments of lakes in the process of their accumulation, in the early stages of diagenesis and their geochemical features.

This article discusses the features of modern mineral formation in small shallow lakes (171) located in taiga, forest-steppe and steppe landscapes in the south of Western Siberia. Primary field measurements of variables of different components of the lake system were carried out in all lakes. The selected samples were analyzed by a complex of modern analytical methods in the center for collective use of scientific equipment for multi-element and isotopic studies of IGM SB RAS, a detailed description of the methods is given in previously published articles [Strahovenko et al., 2014; Ermolaeva et al., 2016 et al.].

Strakhovenko, V. D. established that the bulk of the bottom sediments of the studied lakes were formed in the early stages of diagenesis is converted in a reducing conditions without H_2S or with H_2S by the representative material [Strahovenko et al., 2010]. Comparative analysis of petrochemical modules in various mineral types of bottom sediments of Siberian lakes showed that sediments are been represented by siltstone-pelite material with an admixture of carbonates. The level of average concentrations of elements in the terrigenous fraction in the bottom sediments of small lakes corresponds to the level of the upper continental crust.

During the expedition we visually observed the sedimentation of newly formed minerals on submerged algae, grains of terrigenous fraction on the interphase boundary "bottom sediments-water" on the surface of unattached algal and bacterial formations in the lakes. There are the presence of autigenic minerals in almost all lakes from different landscape zones by the study of samples of bottom sediments of lakes investigeted the modern complex of mineralogical methods. Methods of X-Ray diffractometry, electron microscopy and other were been used for analysis of mineral phases formed on non-fixed algae-bacterial formations (atmosphere-water interface), submerged algae and macrophytes (water-bottom sediment) and in bottom sediment. These materials do not discuss the hydrochemical deposition of alkaline metal salts and gypsum in the salty waters of this lakes of forest-steppe and steppe landscapes of Siberia.

The opal or chalcedony is added to the grains of terrigenous quartz in total mineral mass of lakes in all landscape zones of Western Siberia, The grains of the chalcedony are formed due to amorphous SiO_2 of diatoms (fig.1 a,b), by substituted mortmass of the macrophytes (photomorphs) (fig.1 (c) and globules (fig.1 d, e) which are have different genesis. The pyrite is the second minerals of the occurrence, but not in quantitative abundance (fig.2). Studies of samples of bottom sediments on the scanning electron microscope MIRA 3 TESCAN are show that pyrite is present in the form of individual crystals, crystal groups octahedral, cubic, pentagon dodecahedron (fig.2 (a), 1 to 2 μm in size) and not more than 0.01 mm in size in lakes of all landscape areas. Framboid pyrite formations are spherical aggregates ranging in size from 2 to 80 microns of densely packed microcrystals having a rounded shape at the initial stage of formation (fig.2 (b), octahedral or

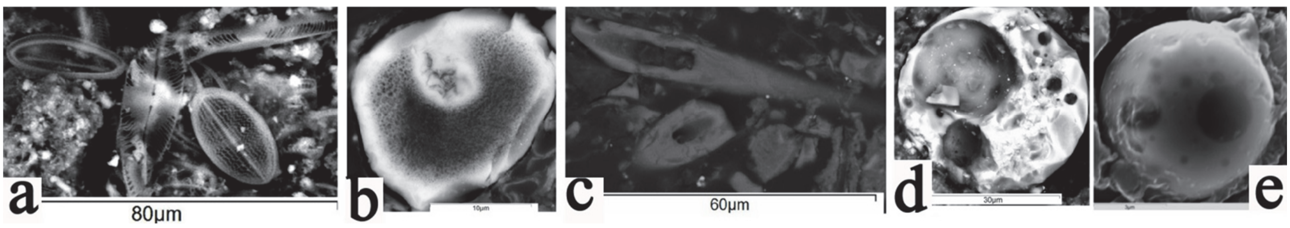

Fig.1. Electron microscope images: a, b – valves of diatoms, composed of SiO_2; c – SiO_2 have substituted mortmass of the macrophyte; d, e – globules of SiO_2 are formed by different genesis

Pyrite`s composition usually corresponds to the formula, sometimes Mn is present as isomorphic impurity (<1%), and the water impurity(up to 3%) is inherent in the initial stage of the formation of framboids. The availability of pyrite and its amount in bottom sediments does not depend on the total mineralization of water and its ion composition. It is known that as aresult of microbiological processes of decomposition of organic matter occurs recovery Fe3+. Under conditions typical for the interface of media (water-algae (OM)), water-BS) anaerobic microorganisms are able to oxidize H_2S, while receiving sulfur (Potekhina, 2005). It is important that the sulfur obtained during oxidation of H_2S is color-coded; the processes of colloid coagulation lead to the formation of the characteristic framboidal shape of pyrite, regardless of further pyrite formation occurs due to the microbiological process or hemogenic (Belogub, 2009). Sometimes the aggregates of the pyrite takes the place of the macrophyte detritus – pseudomorphs (fig.2 (e).

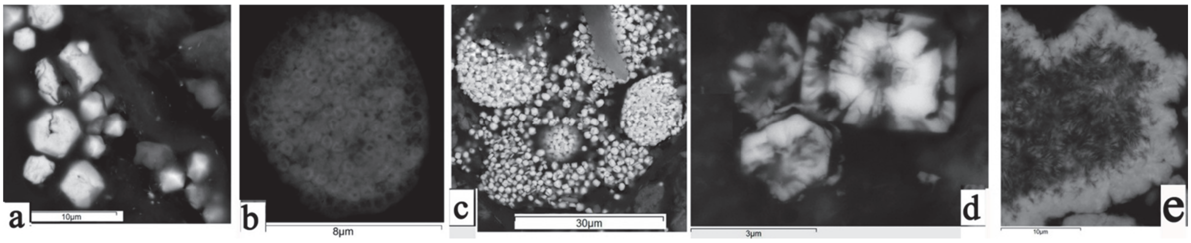

Fig. 2. Electron microscope images of the pyrite: (a) – pyrite individual crystals, crystal groups in the form of octahedral, cubic, pentagon dodecahedron habitus in the bottom sediments of the Lake Barchin; (b) – framboid pyrite formations are spherical aggregates of densely packed microcrystals having a rounded shape at the initial stage of formation in the bottom sediments of the Lake Peschanoe; (c) – framboid pyrite formations are spherical aggregates ranging in size from 2 to 80 microns of densely packed microcrystals in the bottom sediments of the Lake Bergul; (d) - recrystallization of the framboid pyrite formations in covering crystals in the bottom sediments of the Lake Kukley; cubic (fig. 2 c), up to 20 microns in size in the recrystallization of the framboid pyrite formations in covering crystals (fig.2 d)

The calcite – dolomite carbonates, aragonite are widely distributed among modern autigenic minerals of small lakes in Siberia, occasionally siderite, rhodochrosite, magnezite. It is established that the minerals form thin films on the primary frame of algae, consisting of fine-grained releases of aragonite and /or low-Mg calcite that decompose during the life of algae at the boundary of the media “water-algae” in lakes of any landscape zone and mineralization of waters from ultra frech to brine (fig. 3). It was found that the original except aragonite, the composition of thin films on the primary frame of algae (fig. 3 (a) submitted by either magnesium sulfate (fig. 3 (b) or magnesium carbonate (fig. 3 (c). The formation of the first magnesium minerals may be due to the presence of magnesium in the chlorophyll molecule. It is known that photosynthetic organisms, extracting carbon dioxide dissolved in water, changing the pH of the medium in the alkaline side, cause precipitation of dissolved carbonates. As a result of the activity of bacteria and fungi that live on the bottom in the first cm of bottom sediments in large quantities, anaerobic degradation of the original organic matter of silt produces gases – CO_2, H_2S, NH_3 etc. The roundish micrograins of the Ca-excess dolomite (fig. 4 a) and high-Mg calcite (fig. 4 b) are precipitated from water in the bottom sediments after contributes to the dissolution and disappearance of magnesium sulfates and carbonates, partially aragonite in lakes with a hydrocarbonate sodium content in water more than 4 g/l. The aggregates of the aragonite, low-Mg calcite (fig. 4 (c)) and calcite (fig. 4 (d). are accumulated in all lakes with a different type of water. The formation of aggregates of the calcite or aragonite composition are one of the most common cases of fossilization (fig. 4 (e).

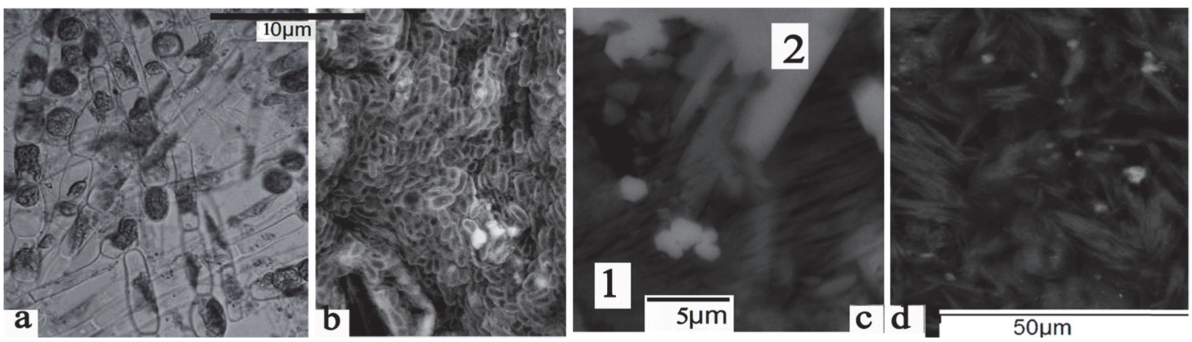

Fig. 3. (a) Foto *Ctenocladus circinnatus Borz* from the Kulunda Steppe soda lake Tanatar VI (b). Scale bar 10 µm [Samylina et. al., 2014]; (b) Electron microscope images of mineral (Mg-sulfate) films on the algae-bacterial consortia from bottom sediment of Lake Petuchovskoe; (c) – Electron microscope images of mineral (Mg-carbonate – 1), films on the algae-bacterial community from bottom sediment of Lake Danilovo, and replaced its calcite $CaCO_3$ – 2; (d) – Electron microscope images of mineral (Mg-carbonate) replaced algae-bacterial community from bottom sediment of Lake Tanatar-6

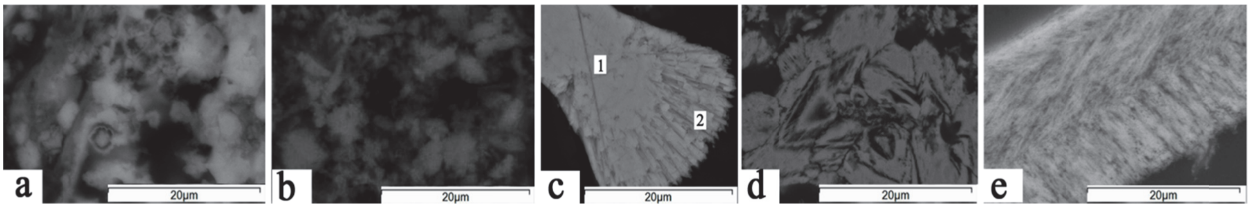

Fig. 4. Electron microscope images of minerals (a) – roundish micrograins of the Ca-excess dolomite; (b) – micrograins of the high-Mg calcite; (c) – the crystals of the aragonite - 1, low-Mg calcite – 2; (d) – the crystals of the calcite; (e) the aggregates of the calcite takes the place of the macrophyte detritus

Thus, it is established that in lakes there is a modern autigenic mineral formation with active participation of organic matter on two borders of the phase division: "water-atmosphere", "water-bottom sediment". Minerals that decompose during the life of algae can be composed of chalcedony (diatoms), or form thin films on the primary frame of algae, consisting of fine-grained, aragonite, sulfate and magnesium carbonates. Low-Mg calcite, aragonite, pyrite, and pyrite accumulate in the bottom sediment as a result of bio-hemogenic deposition. The Ca-excess dolomite, high-Mg calcite accumulate in the bottom sediment of lakes with hydro-carbonate sodium composition of waters, and lakes with chloride and chloride-sulphate sodium – magnesium composition falls out the crystals of the calcite.

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PALEOLIMNOLOGY OF THE LARGEST EUROPEAN LAKES – LADOGA AND ONEGA

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The largest European lakes, Ladoga and Onega, have a long history of development. Lakes, in their modern form, began to form after the glacier's degradation of the last Valdai glaciation about 15000-14500 years ago. Morphometric, bathymetric, limnological characteristics of both lakes changed significantly over the course of 15000 years, due to changes in the physico-geographical characteristics of the drainage basins, climate, hydrological regime, hydrographic network. The main stages of lakes development are revealed and their interrelation with sedimentation conditions and corresponding genetic types of bottom sediments is shown.

The RF Security Council on 20 November, 2013, called for special attention to the study and recovery of Russia's three largest lakes: Baikal, Ladoga and Onega. Both Ladoga and Onega are Europe's largest freshwater lakes. Lake Ladoga is located close to St. Petersburg, NW Russia. The lake is 219 km long and 125 km wide, covering an area of 18,740 km^2 with the maximum water depth of 235 m, the average depth is 47 m, and the water volume of about 848 km^3. Lake Ladoga is a dimictic lake with vertical stratification in summer, when the water temperature rises up to 15-18°C in the epilimnion (the uppermost 15-20 m) while in the hypolimnion it does not exceed 4°C (Lake Ladoga Atlas, 2002). The ice-free period lasts ca. 120-130 days per year. Lake Ladoga is a soft-water low-mineralization lake with an ionic concentration ca. 60-65 mg·l^{-1}. By 2010 the total phosphorus content in Ladoga water was ca. 11-13 μ·l^{-1} assessing its present trophic state as oligo-mesotrophic (Ladoga, 2013). The catchment area of Lake Ladoga is about 283,000 km^2 and includes the basin of Ladoga itself (48,339 km^2), the watersheds of the Lake Onega-Svir' system (82,255 km^2), the Ilmen'-Volkhov - (82,232 km^2), and the Saimaa-Vuoksa - (69,838 km^2). The lake is fed by direct precipitation (11.6 km^3 yr^{-1}) and inflow from numerous rivers and streams (71,1 km^3 yr^{-1}), of which the largest are Svir' (34%), Vuoksa (27%), and Volkhov (23%) Rivers. The coefficient of water exchange is 0.088. Ladoga discharges via the Neva River into the Gulf of Finland (Rumyantsev and Drabkova, 2002).. Lake Onega is Europe's second largest lake (area: 9720 km^2; maximum depth: 120 m; mean depth: 30 m; volume: 295 km^3; catchment area: 53100 km^2; $\sum_{ions}$: 37 mg/l). It is a cold-water lake. Its water has low mineralization, most of the lake remaining oligotrophic. They are part of the River Neva watershed basin, the only source of water supply of St.Petersburg, the largest city in Northwest Russia, and the factor largely responsible for the water quality of the Gulf of Finland and the entire the Baltic Sea. The study of bottom sediments, conducted to reconstruct the evolution of water bodies and their ecosystems, is an essential aspect in the study of the current state of lakes.

The northern part of the Ladoga catchment, including Lake Onega' catchment, consists of Precambrian crystalline bedrocks of the Baltic Shield, while its southern part belongs to the Russian Plate consisting of Paleozoic sedimentary rocks.

First geological studies of the Lake Ladoga sediments started in 1906-1907, when a project for a water pipeline construction had stimulated some drilling activities in the area of Cape Osinovets (Erassi, 1910) and later in 1934–1935 the survey has been repeated. Based on the study results Krasnov and Reineke (1936) concluded that lake sediments consisted of interglacial Mikulino (Eemian) clays, moraines and varved glaciolacustrine clays, which are interbedded with postglacial sands.

Later, the numerous investigations of Lake Ladoga deposits (mostly gravity-type sediment cores up to 4 m) give the knowledge about the Late Glacial and the Holocene evolution of Lake Ladoga (e.g. Subetto, 2009 and references therein). Aquatic sedimentation in Lake Ladoga started as its basin has been deglaciated between 14.200 and 13.300 cal yr BP according to Saarnisto and Saarinen (2001), or even earlier, ca. 15.400 cal yr BP according to Bakhmutov et al. (1993). Following the deglaciation, Lake Ladoga became the eastern bay of the extensive periglacial basin, the Baltic Ice Lake (BIL) extended along the southeastern margin of the Scandinavian Ice Sheet. At that time glaciolacustrine sedimentation (varved clays) took place in the lake basin (Subetto et al., 1998). The clay deposition lasted for over 2000 years (Subetto, 2002). These glaciolacustrine sediments cover Lake Ladoga bottom nearly throughout, and their thickness estimated by seismoacoustic studies reaches 10-20 m (Subetto et al., 1990, 1998). The clays can be subdivided into three main sedimentary units: gray silty-clay with indistinct subhorizontal ribbon lamination with couplet thickness of 10-15 mm (the lowermost unit 1), overlain by typical grayish and brownish varved clays with 5-8 mm couplet thickness (unit 2), and gray microlaminated clays with 1 to 0.5 mm couplet thickness, characterized with a higher density (unit 3). The second unit is often missing, therefore unit 3 usually overlays unit 1 with erosive contact. The subsequent catastrophic short-term drainage of the BIL ca. 12.000 cal (10.300 ^{14}C) yr BP (Björck, 1994), resulted in the isolation of Lake Ladoga from the Baltic Sea basin. It was accompanied by intensive denudation and erosion of previously accumulated sediments in the southern Lake Ladoga basin recorded as a sandy intercalation at the interface of varved clay and overlying sediments or as an abrupt transition suggesting a hiatus in sedimentation. After the isolation, Lake Ladoga started to drained to the Baltic Sea basin via the network of channels in the Vuoksa lake-river system in the northern part of the Karelian Isthmus having its threshold at the area of Veshchevo (Heinjoki), presently located at 15.4 m a.s.l. (Subetto, 2009).

The history and evolution of Lake Onego since deglaciation and in the present time were revealed as a result of paleogeographic investigations, based on the study of sediment cores. Paleogeographic maps for individual time periods were drawn; the main hydrological characteristics of the lake at different stages of its development were calculated using ArcGis and Surfer. The basic morphometric characteristics of Lake Onego in its present state and its mirror for a number of historical periods have been identified (http://onegolake.ru).

Time-space variations in the sedimentogenesis and diagenesis of Lake Onega at all stages of its evolution from its basin deglaciation ca.15000 years ago to the present is reconstructed for the first time using a digital relief model. Long drill cores of bottom sediments from Lake Onega were collected, based on seismoacoustic profiling data to obtain more detailed objective information on the distribution of Holocene and Late Peistocene sediments. Palaeogeographical reconstructions of the Onego ice-dammed lake development ca 14500-125000 yrs BP were based on the GIS approach. The palaeo-water-level surfaces were interpolated using a point–kriging approach. 14500-14000 yrs BP: An ice-dammed lake occupied the southern part of the Lake Onega depression. The level of this lake was at 130-120 m a.s.l. and was controlled by a threshold of the water divide between the River Oshta and River Oyat', with discharge southwestward into the Oyat' basin. The surface area of the ice-dammed lake was 3500 km^2. 14000-13300 Yrs BP: When the ice melted away from the mouth of the River Svir, the lake level dropped to 85-80 m a.s.l. and runoff was directed into the Lake Ladoga - easternmost part of The Baltic Ice Lake at that time. 13300-12500 Yrs BP: As the glacier retreated from the Lake Onega depression, the ice-dammed lake was occupied it and reached the maximum sizes (the surface area was 33000 km^2). The new threshold in the northern part was opened and runoff was directed into the White Sea basin.

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THE DATABASE PALAEOLAKE IN MODERN PALAEOGEOGRAPHICAL STUDIES

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The lake bottom sediments are often used for the palaeolimnological studies as an indicator of dynamics of lakes' physical, chemical and biological parameters and the extent of anthropogenic influence.

The database PalaeoLake (DB) was developed to systematize the data on the sediment sequences and on the genesis of lakes situated on the East European (Russian) Plain (Subetto and Syrykh, 2014; Subetto et al., 2017; Syrykh et al., 2014). DB created on base of existing data, information and maps contains the information on over 200 lakes studied using palaeolimnological methods. The metabase includes geographical (geographical coordinates, altitude, the region), morphometric (mean and maximum depths, area) and palaeolimnological (type and thickness of sediments, type of sediment sampling, dating methods, the sedimentation time interval, types palaeolimnological methods) data (Syrykh et al., 2014, Grekov et al., 2018).

The data were collected in MS Excel files that allows introducing it to different GIS-program easily. Additionally, structuring and mapping of information makes possible to perform spatial analysis of the territory on different periods of time and at the set requests. The sources of the PalaeoLake database consists of publications, references, fundamental monographs, international and national journals, proceedings of conferences, authors' own field data.

The analysis of the DB can show features of palaeoecological events on the studied territory. This research continues of the previous studies on lake zoning and on the reconstruction of the timing of the development of lakes during the Last Glacial and changes in the level regime of lakes in northern Eurasia (Harrison et al., 1996).

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NEW DATA ON BALTIC SEA RELATIVE LEVEL CHANGES DURING HOLOCENE WITHIN HOGLAND (SUURSAARI) ISLAND, GULF OF FINLAND

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Introduction

Hogland Island (or Suursaari) is located in the center of Gulf of Finland (60.056°N 26.983°E) about 40 km away from the coast of Finland, 55 km away from Estonia and 180 km away of Saint Petersburg (Fig. 1). The island is elongated from NNW to SSE for about 11 km, its maximum width is 3 km.

The relief of the island is abnormally high among the islands of Gulf of Finland and the surrounding mainland. There are four well distinguished peaks elevated from 108 to 175 meters above present Baltic Sea level (Fig. 2). Verzilin & Oknova (2006) report some evidences of intense vertical and horizontal movements that suggested to be produced by earthquakes. But previous geomorphic investigations and geodetic levelling (Sauramo (1958)) revealed the presence of an identical set of ancient Baltic Sea shores, composed mainly of coarse well-rounded material, on the same heights throughout Hogland. Therefore, it could be supposed that Holocene coastal forms are affected only by glacio-isostatic movements.

Precambrian bedrock outcrops are exposed all over the island, therefore quaternary deposits consist generally of described ancient coastal forms and of lake and mire bottom sediments (Puura et al. (1992)), which makes them a valuable object for paleoenvironmental studying.

The first attempt to correlate ancient shorelines with Baltic Sea post-glacial stages was made by Berghell (1986), but it did not include any microfossil evidences. Thus, some more studies on diatom (Heinsalu (1997)), pollen (Veski et al., (1995)) and multi-proxy analysis (Heinsalu et al. (2000)) of bottom sediments concerning the isolation of inland water bodies from the sea were reported.

These studies included the investigation of the top-most mire and lakes. The results show that sedimentation in the mire started in the late Allerød, while the lakes were isolated during Ioldia Sea stage from around 10 to 9.5 ka BP.

Fig. 1. Location of study site (Hogland, or Suursaari, Island)

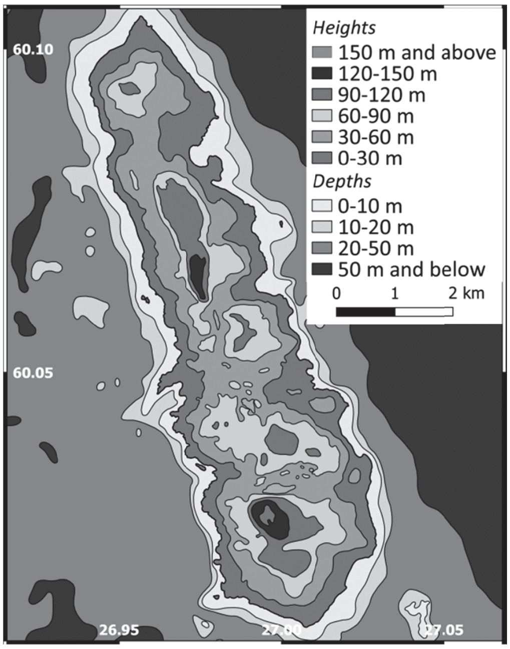

Fig. 2. Hypsometric map of Hogland (Suursaari) Island

Materials and methods

New lake sediment sequences from two unprobed earlier inferior lakes of the island (Fig. 3) were collected by using a Russian peat corer by a paleolimnology group from Institute of Limnology (Russian Academy of Sciences).

The first probed lake called Lounatjärvi is the largest lake of the island and lays c. 45 meters above present Baltic sea level (60.0317°N 26.9950°E). Four cores were collected, maximum thickness of deposits taken is 2.1 m. Lower parts of the cores consist of coarse sand followed by a thin layer of fine sand. Sands are superposed by clay gyttja and, in the upper part, by organic gyttja.

The second lake called Pahalampi (60.0350°N 27.0088°E) is, in contrast, the smallest and very shallow lake, surrounded by quagmire. It is at c. 55 meters a. s. l., overall thickness of deposits taken – 4.95 m. Lower part of the cores consist also of coarse sand followed by a thin sandy clay layer, superposed by clay gyttja, then by organic gyttja which gradually changes upwards to peat.

Conclusion

Cores taken from two lakes are intended for multi-proxy paleogeographical analysis. At this time, litho-stratigraphic analysis is made and radiocarbon (AMS) dating, pollen and diatom studies were started.

It is expected that this research will provide data on vegetation and landscape transformation in early to middle Holocene which will make possible to reconstruct climatic parameters during this period. Dates of moments of lakes isolation from Baltic Sea will make its contribution in correlating of different relative sea level curves (and glacioisostatic adjustment patterns as well) from Northern Estonia, Southern Finland and North-Western Russia.

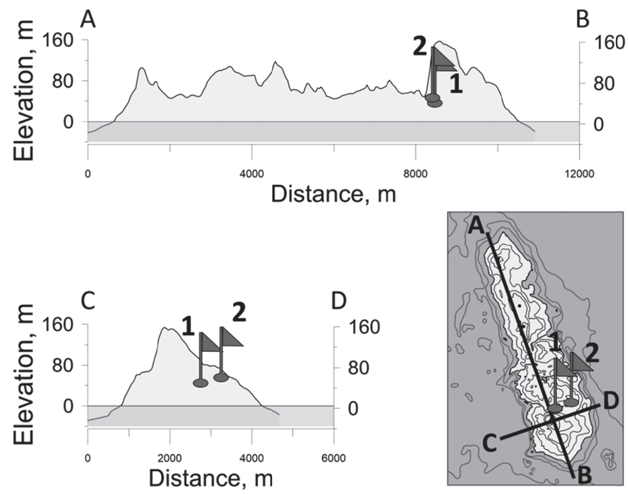

Fig. 3. Location of new coring sites: 1 – Lounatjärvi Lake, c. 45 m a. s. l., 2 – Pahalampi Lake, c. 55 m a. s. l.

Acknowledgements

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STUDIES ON THE ANNUAL RADIAL INCREMENT OF PINE TREES FOR RECONSTRUCTION OF CHANGES IN THE WATER LEVEL OF RAIFA LAKE

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The role of key factors determining the functioning of tree stands can be identified by studying the annual radial increments of trees, which enables reconstruction of environmental conditions with a high temporal resolution (Shiyatov et al., 2000). Climate and hydrological conditions can be reconstructed using tree-ring chronologies built form a relatively large number of trees belonging to a single or several species and growing within the same habitat or in several habitat types (Shiyatov et al., 2000). This methodology could be used to reconstruct the water level history of lakes, as in these published studies: Lake Baikal in Russia (Galazii, 1972), Lake Bienville in Canada (Begin, 2001), Great Salt Lake in the USA (Gillies et al., 2015), etc.

The purpose of current research was to study the annual radial increment of pine trees growing around Raifa Lake in order to reconstruct its hydrological regime.

Raifa Lake is the main water body of the Volga-Kama State Nature Biosphere Reserve (Republic of Tatarstan, Russia). The lake contains more than 82% of all waters of the surface water bodies in Raifa. The main source of the lake water supply is snow melt water, whereas rain, ground, and swamp sources bring smaller amount of water (Taisin, 2006). According to (Taisin, 2006), the size of Raifa Lake decreased very rapidly up to the 1990s. In the 1840s-1890s, rate of changes of lake length increased from 3m per year to 7 m per year, after the 1890 the rate of changes intensified and reached a value of more than 21 m per year by 1920. In the 1970s, the rate of changes of lake length reduced to 12-15 m per year. The lakes's water surface area and the water volumes diminished accordingly to these rates of change in length. However, the maximum depths varied little. By 1990 the lake length reduced to 1316 m, water surface area reduced to 32.3 ha, maximum depth was 19.6 m (Taisin, 2006).

The trees were cored in the summer of 2016. Two sampling sites were established on the northeastern shore of the lake: "Shore" and "Control". In the Shore group, trees grow at a distance of 0.5-6 m form the water edge within the first floodplain terrace. For these trees, the water level of the lake is an important factor influencing the dynamics of soil humidity. The Control group included trees growing at a distance of 50-100 m from the shore line and at the height of 6-7 m above the water surface within the third above-floodplain terrace. This location of the control trees suggests that the hydrological regime of the lake has a minimal impact on their annual radial increment (Fig. 1).

Sampling was performed with the help of an increment borer. Core samples were obtained from the trees of Scots pine (*Pinus sylvestris* L.) at the height of 1 m from the root collar. The age of tree and annual tree-ring widths can be identified more accurately if two core samples are taken from it, so a total of 26 core samples were taken from 13 trees: 20 core samples (10 trees) of the Shore group and 6 core samples (3 trees) of the Control group, respectively. The tree-ring study was performed by the standard dendrochronological methods (Shiyatov, 2000). The widths of annual tree-rings were measured on a LINTAB semiautomatic system using the TSAPWin software (Rinn, 2011).

Tee-ring chronologies and tree-ring indices with age-related trend removed were calculated using the Arstan software (Holmes, 1995). The data were processed by the statistical methods standard for dendroecology. Calculations were performed by the PAST (version 3.8) software (Hammer, 2001). The study of impact of climatic factors on the dynamics of tree-ring indices was based on the average monthly temperatures and monthly total precipitation amount provided by the "Kazan-University" weather station, which holds an exceptionally complete data set for the period of 1901-2014.

Dendrochronological analysis helped to identify the pine, which is the oldest in both the Volga-Kama State Nature Biosphere Reserve and the Republic of Tatarstan. This tree is 288 years old and it has been growing on the shore of Raifa Lake since 1728. Two 250-year tree-ring chronologies were obtained on the basis of standardized tree-ring indices.

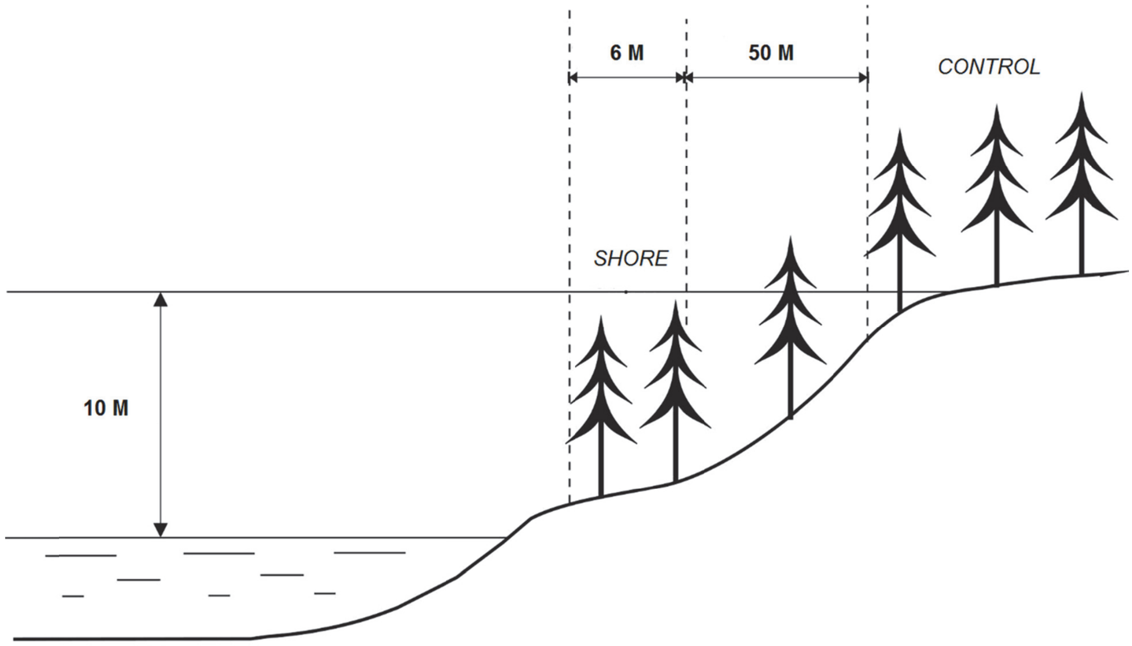

Fig. 1. The scheme of location of trees in the "Shore" and "Control" zones
on the northeastern shore of Raifa Lake

The analysis of the Shore zone tree-ring chronology allowed to determine the years with minimum (1771, 1812, 1906, 1942, 1964, 1982, 2010) and maximum 1781, 1795, 1821, 1913, 1990, 2000) widths of annual rings. For the chronology of the Control zone, the years with maximum (1777, 1836, 1910, 1947, 1963, 2000) and minimum (1793, 1829, 1891, 1921, 1944, 1965, 1992, 2006) widths of annual tree-rings were also registered.

The water level of Raifa Lake depends mainly on the volume of water masses brought by the Ser-Bulak and Sumka Rivers. From the nature records of the Volga-Kama State Nature Biosphere Reserve, it was discovered that the hydrological regime of the lake has underwent no dramatic and long-term changes during the recent 50 years. The water level in the lake was high in 1978, 1993, and 2008. Floodings were short-term and seasonal. In the above years, no sharp fluctuations in the annual radial growth were observed for trees in the Shore zone. Short-term rises in the water level of the lake likely have no significant impact on the dynamics of annual radial growth of trees growing on the lake shore. The effect of the hydrological regime seems to be indirect and manifested itself through changes in the sensitivity to other factors. This is an open question that requires further and detailed study.

The chronologies are weak correlated (R=0.2, p=0.01, n=254) (Fig. 2). The similarity between the two chronologies increases in the 1840s, 1920s, and after 1990s. Asynchrony was observed during the period of 1790-1810 and in the 1890s. We attribute the observed differences in the annual radial growth of trees in two zones under study to the changes in the hydrological regime of Raifa Lake. There could have been a short-term rise in the water level of the lake at the above times.

To estimate the impact of meteorological factors on the annual radial growth of trees, we performed a correlation analysis of the annual tree-ring indices with the air temperature and precipitation for the period of 1970-2014. The annual radial growth of trees in the Control zone is correlated to the precipitation in June ($R=0.51$, $p<0.001$). And this is quite logical, because trees in the Control zone grow in the dry forest sites, thereby being well-adapted to the lack of atmospheric precipitation. The tree-ring indices of radial growth of pine trees in the Shore zone have a low correlation with the weather factors: they correlate positively with the precipitation in February and negatively with the temperatures in May and August. This weak climatic signal can be explained by the high humidity of the substrate due to the continuous influence of the lake backwaters.

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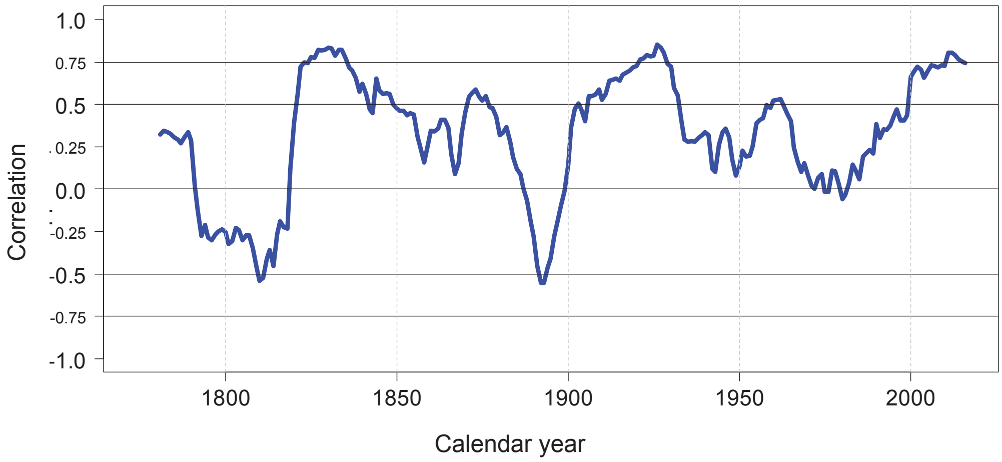

Fig. 2. The moving correlation between "Shore" and "Control" chronologies (the size of the moving window is 20 years).

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EXTINCTION AND RECOVERY OF NON-MARINE BIVALVES FROM THE MIDDLE AND UPPER PERMIAN LAKE DEPOSITS OF THE SEVERNAYA DVINA RIVER BASIN

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More than 20 non-marine bivalves' localities are known from the Middle and Upper Permian continental (lake) deposits of the Severnaya Dvina River Basin (north-west part of the East-European Platform) (Plotnikov, 1945, 1949; Gusev, 1955, 1963, 1977, 1990; Kanev, 1986; Betekhtina and Tokareva, 1988). Revision of the systematics of the Permian non-marine bivalves from this area has been performed by the author in 2014-2018 and has allowed specifying their diversity (35 species, 9 genera, 5 families, 4 superfamilies, 1 subfamily and 3 orders).

Remains of non-marine bivalves are represented by shells, internal and composite molds, and imprints. Usually, separate bivalve valves located parallel or subparallel to the bedding planes.

Four phases of extinction and recovery are established in the evolution of Permian non-marine bivalve fauna from continental deposits of the Severnaya Dvina River Basin. The definition of the phases is based on:

– analysis of taxonomic diversity of non-marine bivalves (number of genera and species, maximum diversity);

– analysis of the paleobiogeographical structure of the non-marine bivalves assemblages, including interrelations of autochthonous, cosmopolitan and endemic genera, and allochthonous migrant genera.

The Late Urzhumian-Early Severodvinian phase is characterized by a predominance of Angarian genus *Prilukiella*. Cosmopolitan subgenus *Palaeomutela* (*Palaeomutela*) has a subordinate significance.

Late Severodvinian phase differs by the predominance of cosmopolitan genus *Palaeomutel*a sensu lato. Representatives of endemic genus *Opokiella* appears in the beginning of this phase.

Terminal Severodvinian-Early Vyatkian phase is characterized by increasing of endemic genera and appearance of rare representatives of Angarian genus *Concinella*.

Cosmopolitan genus *Palaeomutela* sensu lato has predominant significance during the Late Vyatkian phase. The number of endemic genera decreases in this phase.

It is assumed that disappearance of Angarian non-marine bivalves is correlated to relative warming as evidenced by the general direction of the positive excursions of carbon and oxygen isotopes on the isotope curves (Arefiev et., 2015).

The work was supported by the Russian Foundation for Basic (grant № 16-04-01062 «Late Permian Palaeonodonta-like non-marine bivalve fauna of European Russia: systematics, evolution, paleoecology, paleobiogeography, biostratigraphy»).

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DIATOMS FROM THE BOTTOM SEDIMENTS OF THE EAST SIBERIAN LAKES

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The study of natural climatic changes in the past (Holocene) is important for obtaining knowledge on the time of these changes and their causes. The bottom sediments preserve diatoms in a good state, which are widely used as indicators of ecological conditions, as well as for reconstructions of the natural environment in the past. Many factors determine the development of diatoms: the temperature regime, the presence of biogenic elements (especially silicon for the construction of valves), pH of the environment, transparency, etc. In other words, they reflect the natural features of a water body. Climate fluctuations are associated with the changes in habitat conditions leading to restructuring the ecosystem of lakes.

We have studied the bottom sediments of lakes of different types and trophicities in both, mountainous and lowland landscapes. The lakes of the East Sayan (12 lakes) are located at altitudes of 1240 – 2496 m above sea level. The species diversity of the planktonic diatoms in the sediments of the lakes varied from 9 to 27 taxa. The abundance of diatoms reached 0.15-157 million valves/g. The share of planktonic diatoms was 0.7-99.3% of the total number. The maximum number was observed in the Vysokogornoe Lake due to the species of the genera Cyclotella, Discostella, Aulacoseira, and Pliocaenicus.

On the Baikal ridge, we have studied 9 lakes located at altitudes of 1220-1645 m above sea level and 4 lakes – at 456-520 m. Species composition was 8-16 taxa. The diatom abundance in the sediments of the lakes varied significantly, 0.1-292 million valves/g, as well as the share of planktonic diatoms was up to 96%. The species of the genera Aulacoseira, Cyclotella and Pliocaenicus dominated.

The Khamar-Daban lakes (6 lakes) were located at altitudes of 453-848 m above sea level. In the sediments of the lakes, we found 8-18 taxa of diatoms, which abundance ranged within 2.8-224 million valves/g, and the share of planktonic diatoms reached 20-98.5%. Maximum number was observed in Lake Kotokel. The species of the genera Aulacoseira and Cyclotella dominated.

The lakes of the Barguzin Range (7 lakes) were located at altitudes of 1360-1754 m, and Lake Florikha – at 524 m. The abundance of planktonic diatoms was 14-27 taxa. Their content in the sediments reached 1.3-98.1 million valves/g, and the share in the total number was 14-83%. The species of the genera Aulacoseira, Pliocaenicus and Tabellaria dominated. Some single species of the Baikal diatom complex, *Aulacoseira baicalensis, A. islandica, Cyclotella minuta* and *C. baicalensis*, were also found. They were present in a small amount in the sediments of a number of lakes of the East Sayan, Baikal and Khamar-Daban ranges, as well as Lake Oron.

The dominant complex of the sediments of mountain lakes mainly consists of the cosmopolitan species, acidophils indifferent to the pH of the environment, predominantly psychrophilic ones from the genera Aulacoseira, Cyclotella, Discostella, Pliocaenicus, and Tabellaria. These species prefer oligotrophic and oligo-mezotrophic waters. The dominants in the lakes located at low altitudes prefer mesotrophic and meso-eutrophic waters. These cosmopolitan species are eurythermal or moderate, which are alkaliphils indifferent to the pH of the environment. They are mostly representatives of the genera Asterionella, Fragilaria, Synedra, Aulacoseira, and Stephanodiscus. In some lakes, the species composition in the sediments did not change, and their abundance fluctuated sharply. In other lakes, some species were replaced by other species better adapted to new conditions. The index of species diversity (Shannon) showed that the change in diatom complexes occurred rarely in some lakes, and frequently – in other, which indicated the change in habitat conditions.

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LATE PLEISTOCENE PROGLACIAL LAKES IN THE SEVERNAYA DVINA RIVER BASIN

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Glaciation lobes entering the river valleys can block the outflow and cause the formation of ice-dammed (or proglacial) lakes. Such lakes occupied the river valleys during the glaciations and their outline usually repeated the river drainage pattern. The proglacial lake evidences are usually represented by "varved clays" i.e. laminated silts or clays alternating with sands deposited in the deep water sedimentary environment, and shoreline which mostly is not well preserved.

The river Severnaya Dvina (SD) catchment basin occupying the vast area in the European North-East affected the influence of Scandinavian Ice Sheet during the Quaternary and thus the proglacial lakes could develop within the valleys of SD river and its large tributaries Vychegda, Sukhona and Vaga. The main goal of this study was to analyze a variety of the Late Pleistocene ice-dammed lake reconstructions in the SD river basin and the results of our field observations of their sediments and pattern.

The idea of proglacial lake formation during the Quaternary glaciations within the Severnaya Dvina catchment area was first proposed by I.I. Krasnov (1948) who reconstructed its outflow rerouting southward into the Kama -Volga - Kaspian Sea basin via the Keltma trough (spillway) after exceeding the water level of 135 m a.s.l. Further studies in this region exploited this idea intensively basing upon the high preservation rate of strandlines in the Keltma spillway, digital elevation models of the Last Glacial Maximum (LGM) limits and various terrace levels in the Vychegda river valley (Kvasov, 1975; Lavrov, Potapenko, 2005; Lysa et al., 2011; 2014; Fredin et al., 2012; Larsen et al., 2013).

Two separate ice-dammed lake systems had been reconstructed inside the SD river basin during the LGM (Kvasov, 1975). Vazhskoe Lake occupied the lowland, enclosing the Vaga and Kokshen'ga river valleys. The drainage threshold was assumed at the elevation of 150 m a.s.l. The lake was also thought to have the reversal drainage to the Sukhona river. Varved clays of this lake were found within the Vaga valley. Kotlasskoe Lake was suggested to occupy the valley of Severnaya Dvina, part of the Malaya Dvina, Vym' and almost the entire Vychegda valley (Kvasov, 1975). Reverse flow was assumed to the south into the Kama-Volga basin through the Keltma spillway, which can be overflowed at 135 m a.s.l. Nevertheless, the deposits of Kotlasskoe Lake had not been documented and all reasoning grounded on landscape topography only.

During our studies of Vychegda – Severnaya Dvina and Vaga fluvial systems we performed the search, identification and observation of deposits related to the Late Pleistocene ice-dammed lakes within the SD river basin.

Working through the Vychegda valley we examined the sections of 1-st and 2-nd river terraces. The 1-st terrace is dated back by ^{14}C and OSL and was forming in two stages: right before the LGM (~23 kyr BP) and right after the LGM (after ~ 17 cal. kyr BP). The composition of the terrace is completely alluvium, without any evidence of proglacial lake deposits such as varved clays. Accumulation of this terrace had probably been promoted by the backwater effect from the proglacial lake forming downstream. The traces of LGM glaciation which could block the river valley and cause the lake formation also had not been identified. The so called Oz'jag terrace (18-20 m above the river bed, 80 m a.s.l.) identified in (Lavrov, Potapenko, 2005) as of LGM-lake origin is composed of coarse alluvium and covered by aeolian cape and is more likely of early Wichselian or post-Saalian age and of fluvial origin. The only section with well-expressed LGM-related varved-like fine interlayering of sands and silts is Tolokonka in middle reaches of Severnaya Dvina river. This evidence is in good agreement with LGM limits reconstructions (Atlasov et al., 1978; Demidov et al., 2007) upstream the Vaga confluence.

Another situation is observed in the Vaga fluvial system. We identified the well-expressed grayish varved clays within the valleys of Vaga and its tributaries Kuloi and Kokshen'ga. The maximum (10 m) thickness of varved clays was observed in the outcrop near the Kuloi-Vaga confluence; thickness of sand and silt layers varies significantly, from several mm to several tens of cm, that means the unstable hydrodynamic regime, with alteration of lacustrine and fluvial sedimentary environment. At the top of the lacustrine unit there are water-escape structures characteristic for the proglacial lake deposits. Upstream the thickness of varved clay layer decreases and then recedes completely. The limit of varved clay deposits goes form SW to NE from Vaga to Kokshen'ga rivers.

Therefore, we can identify one episode of proglacial lake formation in the Late Pleistocene within the Severnaya Dvina catchment area. Two separate lake systems formed during the LGM (~ca 20 kyr BP): the Severnaya Dvina rather small, short-lived and shallow lake occupying only the middle reaches of SD river valley, and large, deep, long-living and braided Vaga lake occupying the valleys of Vaga and its tributaries Kuloi and Kokshen'ga. Such a difference in lake configuration and history could be explained by morphological features of river valleys, runoff volume and position of glacioisostatic forebulge crossing these river systems. The absolute height of water level could reach 80 m a.s.l.

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EXTINCTION AND RECOVERY OF THE CONCHOSTRACAN FAUNA ON THE PERMIAN-TRIASSIC BOUNDARY IN THE LAKES OF NORTHERN EURASIA

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Conchostracans are small crustaceans with a bivalve calcium phosphate chitinous shell. They were widespread in the Paleozoic and Mesozoic lakes in the various regions of the Earth (Lutkevich, 1941; Novozhilov, 1950; Novozhilov, 1959; Novozhilov, 1970; Molin, Novozhilov, 1965; Webb, 1978; Tasch, 1987; Lipatova, Lopato, 2000). At the same time, conchostracans were characterized by a high rate of evolution and some of their species existed for a short time. A great mass extinction took place at the end of the Permian period. However, many conchostracan species have managed to adapt to the negative environmental events. The most interesting are the changes of conchostracan assemblages at the Permian-Triassic boundary.

Late Permian conchostracan assemblage was represented by numerous genera: *Limnadia, Cyclestheria, Curvacornutus, Cornia, Glyptoasmussia, Megasitium, Pseudestheria, Polygrapta, Concilla, Loxomicroglypta, Brachysteria, Palaeolimnadiopsis, Lioestheria, Tigjanium, Gabonestheria, Lioleaiina, Kaltanleaia, Ulugkemia, Estheria, Concherisma, Palaeolimnadiopsis, Estheriella, Cyzicus, Leaia, Pseudoasmussia, Euestheria, Palaeolimnadia.* Some species were widely distributed in the Late Permian lakes: *Limnadia timanica* Mol., *Megasitium lundongaense* Novoj., *Pseudestheria novacastrensis* Mitchell*, Cyclestheria mitchelliana* Novoj., *Polygrapta chatangensis* Novoj., *Kaltanleaia rhodendorfi* Novoj. (Webb, 1978; Tasch, 1987). All these species are characteristic only for the Upper Permian deposits, and never occur in the Triassic.

Early Triassic conchostracan assemblage includes *Limnadia*, *Palaeolimnadiopsis, Cornia*, *Lioestheria*, *Pseudestheri*a, *Cycloestheria*, *Glyptoasmussia*, *Loxomicroglypta*, *Euestheria*, *Polygrapta*, *Concherisma*, *Gabonestheria* as well as Late Permian conchostracan assemblage (Webb, 1978; Tasch, 1987; Lipatova, Lopato, 2000). Such genera as *Rossoestheria*, *Caenestheria*, *Sphaerestheria*, *Cyclotunguzites*, *Estheriina*, *Nestoria*, *Palaeoleptestheria*, *Leptestheria*, *Sphaerograpta*, *Eulimnadia*, *Rhynchositum*, *Vertexia*, *Cornoleaia*, *Pseudestheriella* are characterized only for Triassic conchostracan assemblage (Lipatova, Lopato, 2000). Many new species first appeared in the Early Triassic. Following species are widely distributed in the Triassic deposits: *Lioestheria blomi* Novoj., *L. propinqua* Novoj., *Pseudestheria kashirtzevi* Novoj., *P. vjatkensis* Novoj., *P. rybinskensis* Novoj., *P. tumaryana* Novoj., *P. wetlugensis* Novoj., *P. sibirica* Novoj., *P. putjatensis* Novoj., *Cyclestheria obliqua* (Mitchell), *C. rossica* Novoj., *Sphaerestheria ovata* Novoj., *Cyclotunguzites elongatus* Mol., *C. gutta* (Lutk.), *Glyptoasmussia blomi* Novoj., *G. wetlugensis* Novoj., *Concherisma tomiensis* Novoj., *Estheriina aequalis* (Lutk.), *E. itilica* Novoj., *Limnadia blomi* Nov., *Vertexia tauricornis* (Lutk.), *Brachysteria kotscbetkovi* Novoj.; *Palaeolimnadiopsis albertii* Volz (Lipatova, Lopato, 2000).

The wide variety of new species appeared in the Triassic makes it possible to conclude that the conchostracans were highly adaptable to the changing of environmental conditions. The disappearance of Permian species and the first appearance of Triassic ones help to more clearly define the Permian-Triassic boundary in continental formations.

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CLADOCERA IN SURFACE SEDIMENTS OF THE LAKES OF THE KHATANGA RIVER BASIN

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The study of lake sediments allows us to reconstruct abiotic and biotic conditions of lake and its surrounding area. Of particular interest are studies of Arctic and subarctic ecosystems, due to lakes of current zones are exposed to minimal anthropogenic influence. Cladocerans (Cladocera: Branchiopoda: Crustacea) are a key component of aquatic ecosystems, which have been used often in paleoecological reconstructions of climatic and environmental change. Their chitinous exoskeletal components (head shield, shell, postabdomen, postabdominal claws, antennal segments, and mandibles) are usually well preserved after death in lake sediments [1]. Our research was conducted to study the composition of cladoceran community of lakes in the Khatanga River basin using paleoecological methods.

The study sites included 20 lakes distributed along a north–south transect across the Khatanga-river basin (70°40'02.1" to 72°24'09.8" N and 97°43'38.2" to 101°01'31.5" E) (Fig.1)

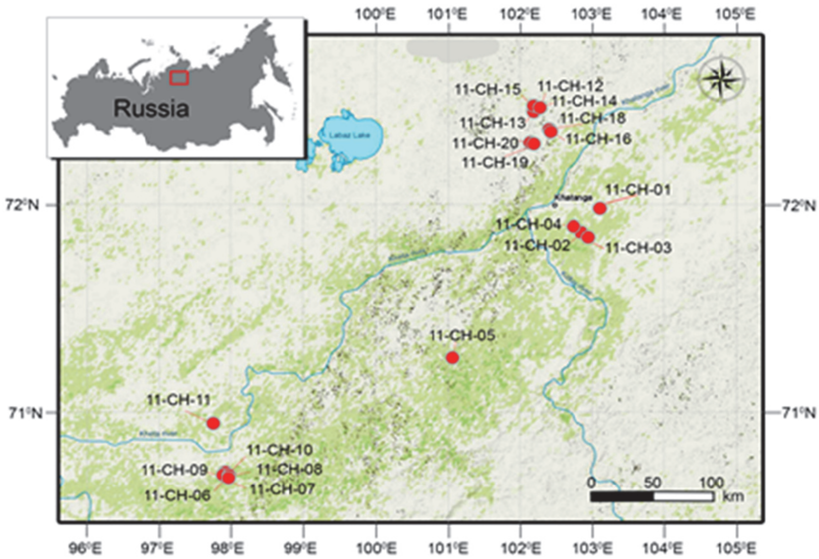

Fig. 1. Map of the studied region of the lakes of Khatanga river basin

Fieldwork was carried out as part of a joint Russian-German Expedition to the Khatanga region in 2011. The hydrochemical samples for each site were taken from the surface water layer (0.5-1 m) at the centre of each lake

The cladoceran remains were prepared according to Korhola and Rautio [2]. Each sample (2-5 g of fresh sediments) was boiled for half an hour in a 10% solution of KOH to remove humic matter and treated with HCl to eliminate carbonates. The Cladocera remains were screened using an Zeiss Axio Scope A1 light microscope. The cladoceran percentage diagram was created using the Tilia program, version 2.0.41 [3].

Twenty cladoceran taxa were identified in the 20 investigated lakes, belonging to six families (Fig 2). 12 taxa belonged to family Chydoridae, 3 taxa to Bosminidae, 3 to Daphniidae, 1 taxa to Sididae and 1 taxa to Macrothricidae.

Most abundant taxa were *Eubosmina longispina, Chydorus cf. sphaericus, Daphnia longispina.* Several taxa have been found for the first time for the Northcentral Siberia: *Eurycercus macracanthus, Camptocercus fennicus* and *Camptocercus lilljeborgi*. Most of the cladocerans in our investigation belonged to littoral species, which occur among macrophytes and in muddy substrate within the macrophyte zone at the lake margins. The littoral component was represented by *Chydorus sphaericus,* *Alona rectangula* and other taxa from the family Chydoridae. An increase of *Chydorus cf. sphaericus* is typical sign of increased level of nutrients and of eurtophication processes. In all lakes cladoceran assemblages are quite rich and diverse with relatively stable structure.

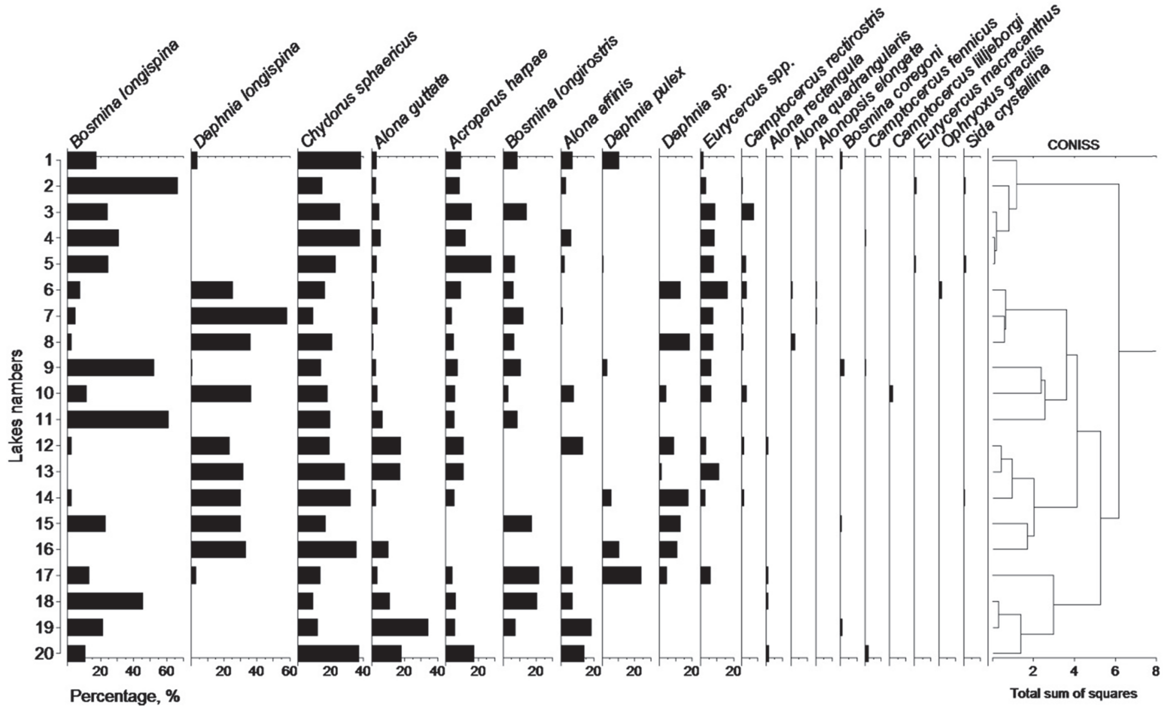

Fig. 2. Relative abundance of the cladoceran taxa in the lakes of Khatanga river basin

The average value of the Shannon index was 2.41, that allows to classify lakes as moderately polluted. The average value of the Pielu index was 0.80, that indicates the proximity to stable and aligned community structure. The index of the species diversity of Simpson was calculated, values varied from 0.53 to 0.85 (average value - 0.75), indicating a uniform distribution of species in the lakes.

Field work was supported by the Russian Science Foundation (project 16-17-10118). Analysis of subfossil Cladocera, interregional comparison and interpretation of the data was supported by RFBR (research projects № 18-05-00406 A).

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DIATOM COMPLEXES IN THE BOTTOM SEDIMENTS OF TURGOYAK LAKE (CHELYABINSK REGION, RUSSIA)

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The research species composition and ecological parameters of diatoms from lake sediments provide an informative historical record of changes in lake ecosystems. Reconstruction of past environment is usually based on chemical information from sediments or microfossils Diatoms, pollen, and remains of plants are used as indicator groups in paleoecological studies [1]. Due to the large number of taxa, diatoms are good indicators of a variety of lake water conditions including salinity, pH, light availability, temperature and nutrient levels [2]. But diatoms as palaeoindicators are relatively poorly studied in the Chelyabinsk region. Our results will provide additional data for regional databases and will help increase the accuracy of paleoecological reconstructions. The purpose of this work is to study the taxonomic composition and ecological features of diatoms in the palaeoarchives of Turgoyak Lake.

The Turgoyak Lake (N 55°09'; E 60°05') is located in the Chelyabinsk Region (Southern Ural, Russia). It is the second cleanest lake in Russia after Lake Baikal. The area of the lake is 26.4 km^2, the total catchment area is 76.0 km^2. The average depth is 19.1 m. The maximum depth is 36.5 m. The water of the lake has a high transparency which is from 10 to 17 m. Altitude above sea-level is 320 m.

Core no. 5 (N 55° 09' 48,1'; E 60° 05' 14,2') was taken from Lake Turgoyak during the KFU expedition in July 2017. The 560 cm-long lake sediment core covers the time from 27000 cal years BP to the present-day. All samples were processed by the standard methods using 37% hydrogen peroxide as an oxidant of the organic matter present in the samples, including 10% HCl treatment in order to remove calcium carbonate, followed by rinsing with distilled water [3]. The slides were prepared with the help of high refracting Naphrax® resin (RI=1.7). Diatoms were identified under a Zeiss Axio Scope A1 microscope using oil immersion at an objective magnification of 100× (1.4 n.a.) with Nomarski differential interference contrast. Diatom identification and taxonomy was based mainly on the Russian and foreign publications [4-7]. The diatom valves were counted up to a maximum of 300.

According to preliminary results the fossil diatom flora from Lake Turgoyak consists of 48 species that belong to 31 genera. The spectra are dominated by planktonic, oligotrophic and alkalinophilous to neutrophilous forms. The species-rich genera include of *Amphora* Ehrenberg, *Tabellaria* Ehrenberg, *Diploneis* (Ehrenberg) P.T. Cleve, *Navicula* Bory, *Staurosirella* D.M. Williams & Round, *Gomphonema* Ehrenberg, *Cymbopleura* (Krammer) Krammer, *Encyonema*, *Cymbella* Agardh and *Cavinula* D.G. Mann & Stickle [Fig 2]. At the same time, the presence of centric diatoms *Ellerbeckia arenaria* (Moore ex Ralfs) Crawford indicates the well-developed littoral vegetation, probably with an inclusion of separate species of mosses (Fig. 1). The presence of representatives of the genus *Campylodiscus spp*. reveals the high degree of water transparency in the lake.

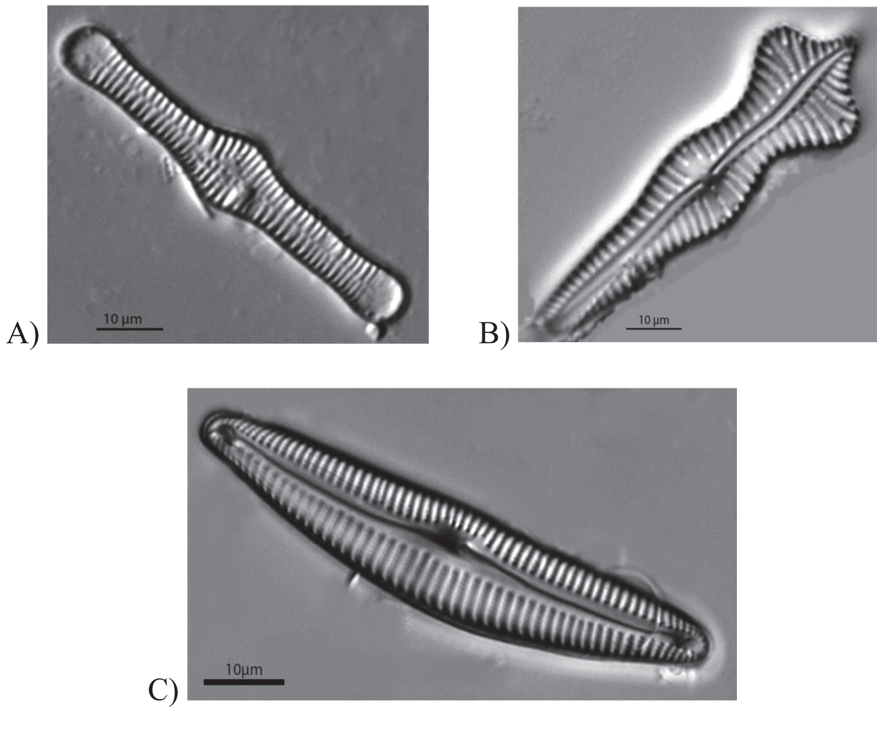

Fig. 1. A) *Tabellaria sp*., B) *Gomphonema sp*., C) *Cymbella sp*.

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AREA AND VOLUME CHANGES OF THE LAKE ONEGO IN THE LATE GLACIAL TIME

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Formation and development of lakes during and after ice sheets retreating were evident to be one of the crucial factors in shaping the landscape, regional climate changes, making an impact on the global ocean-climate system [Clark et al., 2001]. While development of large proglacial lakes (Agassiz, Baltic Ice Lake and etc.) are well studied, the history of relatively small ice-lakes, especially associated with southeastern and eastern flanks of the Scandinavian Ice Sheet (SIS), as well as their meltwater volumes and drainage routings remain unclear [Larsen et al., 2014].

Lake Onego (61°42´N, 35°25´E) is the second largest lake in Europe with surface area approximately 10 000 km^2. The lake is located in the tectonic depression in suture zone of Fennoscandian Shield and East European Platform. Mainly tectonic forces formed the Onego lake depression; however, Pleistocene Scandinavian glaciations significantly affected its structure. The lake depression was numerously enveloped by the ice streams during glaciations and fresh and sea waters in interglacial periods [Stroeven et al., 2016]. In the Late Weichselian time, the lake depression was covered with the Onego ice stream of the White Sea ice stream complex located in the southeastern part of the SIS. The retreat of the Onego ice stream in the Late Glacial time led to the formation of the proglacial lake and its evolution during and after the ice sheet retreatment.

Several original models of the Onego lake depression deglaciation in the Late Glacial are presented. The models differently assessed sizes of the lake, glacioisostatic uplift of the territory, and location and altitude of drainage thresholds. Demidov's [2006] model was created on the basis of acomprehensive study of ancient costal and forms and bottom sediments, used new and previously obtained data on the geological and geomorphological structure of the lake depression, paleomagnetic and radioisotope dating of sediments. The model aggregated all the available isobase values until that time together with a new paleo dates and presently is the most detailed of them.

The studied area lies in North-West part of Russia between the coordinates 60° N, 30° W and 65° N, 39° W and covers 570 km from North to South and 502 km from West to East. The GIS method by Leverington et al. [2002] was applied to reconstruct such a wide region. The primary source of the modern elevations was the DEM developed by J. Ferranti [2018] with spatial resolution three arc seconds, which was complemented with Onego lake depression and depressions of other 125 lakes, situated within the largest stage of the Onego lake development.

Quantities of sediment deposition and erosion in the lake basin were not accounted during the calculations and interpretation of results, because taking them into account resulted in only 1 % larger lake volume, how it was shown earlier for neighbor locations [Jakobsson et al., 2007]. Geo-referenced calculations and map algebra operations with DEMs were implemented with the ArcGIS 10.2.2 with Spatial Analysis package. The spatial resolution of the combined DEM, involving modern topography and bathymetry, was 90 m.

Ice margins were used only for proglacial stages of the lake development in Late Glacial time (14.5-13.2 Cal. yrs BP). The general ice margins configurations were derived from those of Demidov [2006] with minor modifications. The first two stages of the proglacial lake formation were evolved by Demidov [2006] using Luga (14.5 Cal. yrs BP) and Neva (14.0 Cal. yrs BP) ice margins positions [Saarnisto, Saarinen, 2001]. The next two stages (13.3 and 13.2 Cal. yrs BP) were evolved by Demidov [2006] based on interpretations of moraine and stratigraphic evidence. Ice margins were digitized from the preliminary georeferenced sketches. Later they were adjusted in accordance with glacial and fluvio-glacial landforms locations using topographic maps and geomorphological charts.

Isobase values for Late Pleistocene period were adopted from works of Demidov [2006] involving all previously available isobase data. The tilt of the depression 13.3 Cal. yrs BP was accounted for entire the Late Pleistocene while it was supported with maximum of data points (12) regularly distributed over the studied area. To take into account the lake level change in other stages in the Late Pleistocene the water level was corrected by its difference between 13.3 Cal. yrs BP and the target stage. Glacioisostatic uplift was not accounted for period 14.5 Cal. yrs BP, because only one point of water level was available.

Area and volume calculations were implemented using ArcGis 10.2.2 software with spatial analysis package. The method of GIS reconstruction and uncertainty calculations are described in a detail in [Zobkov et al., 2017]. Palereconstructed maps of different periods in the Late Pleistocene are available online [Subetto et al., 2018]. Volumes, areas, mean and maximum depths for six stages of Lake Onego in the period from 14.5 to 12.3 Cal. yrs BP are given in Table 1.

Table 1

Volumes, areas, mean and maximum depths of the Onego paleolake in different periods. Confidential interval with α=0.05

Period, Cal. yrs BP	Volume, km^3	Area, km^2	Mean depth, m	Max depth, m
14.5	180 ± 5	2710±64	66.5±0.5	114±2
14.0	795.5 ± 72.5	14 790±684	53.5±2.5	168±5
13.3	1639.5±166.5	32 330±1480	50.5±2.5	184±5
13.2	1201±117	24 880±1080	48.5±2.5	174±5
12.4	1080±112	22 590±1170	47.5±2.5	169±5
12.3	967±105	21 480±1150	44.5±2.5	164±5

The results allow us to track back the quantitive changes that took place in the Onego lake basin beginning from the last glaciation. In the Late Pleistocene maximum fluctuations of water volume and area were observed. They were generally resulted from ice sheet melting and opening of new water thresholds during glacier retreatment to the North. Our reconstructions of Late Pleistocene period confirmed the discharges directions and formation of Lake Onego through six main stages proposed by [Demidov, 2006].

Now only the one model of the Onego lake development by Gorlach et al. [2017] with area and volumes estimates is available. The model suggests two stages of Onego proglacial lake development, that were interfere with ours at 14.4 and 13.8 Cal. yrs BP. The first one is proglacial lake formation stage in south part of the lake depression and the second one represents partial depression deglaciation. Taking into account linear trend of area and volume raising in this period it is allowed us to estimate the volume and area at the same periods as Gorlach et al. [2017]. However, data comparison shows high discrepancy in the results: our model suggests that 14.4 Cal. yrs. BP the area and volume of the proglacial lake in average were 5080 km^2 and 304 km^3, while Gorlach et al. [2017] reports 820 km^2 and 21.95 km^3 respectively. At 13.8 Cal. yrs BP ours results shows the area 19 900 km^2 and volume 1030 km^3, while Gorlach et al. [2017] reports 6852 km^2 and 131.91 km^3 only. Despite the numerous simplifications, employed by Gorlach et al. [2017], namely using the robust GTOPO30 DEM data in the studied region and modest glacioisostatic uplift interpolation between 19 and 12 Cal. yrs BP followed by Ågren, Svensson [2007], the observed strong discrepancies seemed only partially linked with them.

The largest discrepancies seemed to be coupled with ice margins positions, as it was shown in [Leverington et al, 2002]. Gorlach et al. [2017], as well as our model, applied end-moraine positions from Saarnisto, Saarinen [2001] and Demidov [2006]. However, over the lake surface ice margins were interpreted differently: for both stages, ice margins by Gorlach et al. [2017] were southward from ones evolved by Demidov [2006]. As a result, relatively small differences in ice margins positions led to manifold variation in area and volume estimations. Taking into account linear trend of area and volume rise in our study it is possible to adjust the time scale in work Gorlach et al. [2017].

In the work Gorlach et al. [2017] 14.4 Cal. yrs BP the initial phase of the first deglaciation stage was reconstructed: that time the ice margin remained southward from the current lake shoreline which coincides with 14.6 Cal. yrs BP of our model. 14.5 Cal. yrs BP we reconstructed the last phase of this stage, then ice margin was northward from the current shoreline, but Svir' outlet was still dammed by the ice. The same is valid for the second stage (13.8 Cal. yrs BP), which initial phase of lake surface deglaciation Gorlach et al. [2017] reconstructed (14.3 Cal. yrs BP in our model), while the last phase (14.0 Cal. yrs BP) was shown on our reconstructions where the ice sheet released most part of the lake surface, but its tongue remained on Zaonesh'skii Peninsula.

It is obvious from the comparison that ice margins positions and time scales discrepancies are the major factors of the area and volume uncertainties, however, in the luck of the information about their variations we were unable to account them statistically.

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PALEOECOLOGICAL EVIDENCES FOR THE LATE PLEISTOCENE LAKE VEGETATION IN THE SOUTH OF THE VALDAI HILLS (BASED ON PLANT MACROFOSSILS DATA)

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The complex study of sections of the Upper Pleistocene lacustrine sediments located in the marginal parts of the last ice sheet provides paleocological records that contribute to an increased understanding of long-term environmental changes during the Late Pleistocene. These investigations contribute also to the reconstruction of the boundaries and dynamics of the Valdai (Weichselian) glaciation. Buried lake-swamp sediments rich in organic matter make it possible to use both paleobotanical and radiometric methods to determine their choronostratigraphic position.

The present paper is focused on paleobotanical, especially paleocarpological, study of the Upper Pleistocene buried lacustrine-palustrine sediments located in the Central Forest State Natural Biosphere Reserve. The study area is situated 360 km west of Moscow (the Tver' region) in the south of the Valdai Hills. The boundary of the Valdai ice cover was situated 15–20 km to the north of the Natural Reserve (Chebotareva, Makarycheva, 1974; Velichko et al., 2004). Geological and geomorphological studies have shown that buried lacustine and palustrine deposits were common in the Natural Reserve. They accumulated in isolated depressions on the moraine of the Moscow stage of the Dnieper glaciation epoch (Puzachenko, Kozlov, 2007).

The most complete Upper Pleistocene section was investigated earlier by N. N. Sokolov. Palynological analysis showed that the section contains Mikulino (Eemian) and Early Valdai (Early Weichselian) deposits (Sokolov, 1948). However, Minaeva et al. (2005) supposed that the buried organogenic sediments of the Natural Reserve are of Middle Valdai age on the basis radiocarbon dating and analysis of macroscopic plant remains from the upper part of the buried peat. Recently, scientists of the Institute of Geography RAS and Severtsov Institute of Ecology and Evolution RAS accomplished an additional complex study of four sections of buried lacustrine and palustrine deposits in the Natural Reserve (Fig. 1).

Section Natural Reserve-1 ("Sokolov borehole") is situated at a steplike part of a slope of a Moscow moraine range in the southern part of the Natural Reserve. Drilling revealed (from bottom to top): carbonate clays with gruss (moraine), fluvioglacial, lacustrine and palustrine deposits about 680 cm thick. They are overlain by loesslike loam, heavy loam and Holocene peat (Fig. 1). Section Natural Reserve-2 resembles section Natural Reserve-1 by it's geomorphological position. It is also situated on a steplike part of a moraine slope. The thickness of buried organogenic deposits (peat and organic-rich clays) slightly exceeds 2 m. It should be noted, that section Natural Reserve-3 does not contain buried lake deposits so it is not considered in this paper. Section Natural Reserve-4 is situated in a small depression, on a watershed. Buried lacustrine deposits are thin there, represented (from bottom to the top) by lacustrine clays, sand, and organic-rich clay (Fig. 1).

In spite of differences between the compositions of the local fossil assemblages from the studied sites two generalized carpological assemblages can be distinguished for the region under consideration. They include local assemblages of the studied sections with the similar composition or occurrence of particular plant taxa.

Carpological assemblage 1 includes local assemblages from the peaty deposits in the sections Natural Reserve-1 and Natural Reserve-2. Their common feature is the presence of species characteristic of s. c. "*Brasenia* assemblage". It includes the remains of thermophilic species of aquatic and wetland plants. The numerous seeds of the extinct species *Brasenia holsatica* were identified in studied sections. Fossil fruits of *Dulichium arundinaceum*, which currently grows only in North America, were found in local carpological assemblages from the section Natural Reserve-2. Numerous remains of various aquatic plants such as *Aldrovanda vesiculosa*, *Salvinia natans*, *Trapa natans*, *Najas marina*, *Potamogeton acutifolius* were identified. Most of these species occur in the modern flora of Europe, but to the west and south from the region under consideration. Some of them, such as *Aldrovanda vesiculosa* and *Najas marina*, also occur in some isolated northern localities.

The wetland herbaceous plants were represented by numerous remains of *Typha* sp., *Carex* sp. div., *Eleocharis palustris*, *E. ovata* and *Scirpus sylvaticus*. The role of palustrine plants, such as *Chamaedaphne calyculata, Andromeda polifolia, Menyanthes trifoliata, Rhynchospora alba,* increased in the upper part of peaty deposits in studied sections. While the remains of aquatic and wetland plants predominated in carpological assemblage under consideration, some fruits and seeds of arboreous plants (*Carpinus betulus*, *Acer* sp., *Alnus glutinosa*, *Picea* sp.) were identified.

In general, assemblage 1 reflects local vegetation of shallow organic-rich water bodies, so-called lake-swamps, which existed under conditions of warm and mild climate. The abundance of palustrine plant macroremains in upper parts of studied peaty deposits was due to the paludification of water bodies.

Assemblage 1 is comparable by its composition to Mikulino carpological assemblages of adjacent areas of the Tver Region and the basin of Zapadnaya Dvina River (Velichkevich, 1982). The comparison with palynological data from the same sites in Natural Reserve (Novenko et al., 2008) showed that assemblage 1 corresponds to pollen zones M2–M6 of the Mikulino Interglacial and, in particular, to its climatic optimum.

Carpological assemblage 2 includes similar in composition local assemblages of sections Natural Reserve-1, Natural Reserve-2 and Natural Reserve-4 and is restricted to organic-rich clays. The assemblage is characterized by a sharp domination of fruits of *Batrachium* sp., prominent amount of megaspores of *Selaginella selaginoides*, and the presence of the extinct species *Potamogeton dorofeevii*. Species that are tolerant to climatic conditions are present, and thermophilic elements are absent. The prominent role of the microthermic species *Selaginella selaginoides*, which probably grew in wet meadows along coasts of water bodies, reflects the progressive climatic cooling.

The prevalence of *Batrachium* on shoals indicates an increased water level under conditions of relatively cold and humid climate. Communities of charophytes formed underwater meadows in deeper areas of water bodies, that testifies to the increased concentration of carbonates in water. The comparison with palynological data from the same sites (Novenko et al., 2008) showed that assemblage 2 corresponds to the end of Mikulino Interglacial, transitional period and the beginning of the first post-Mikulino cooling.

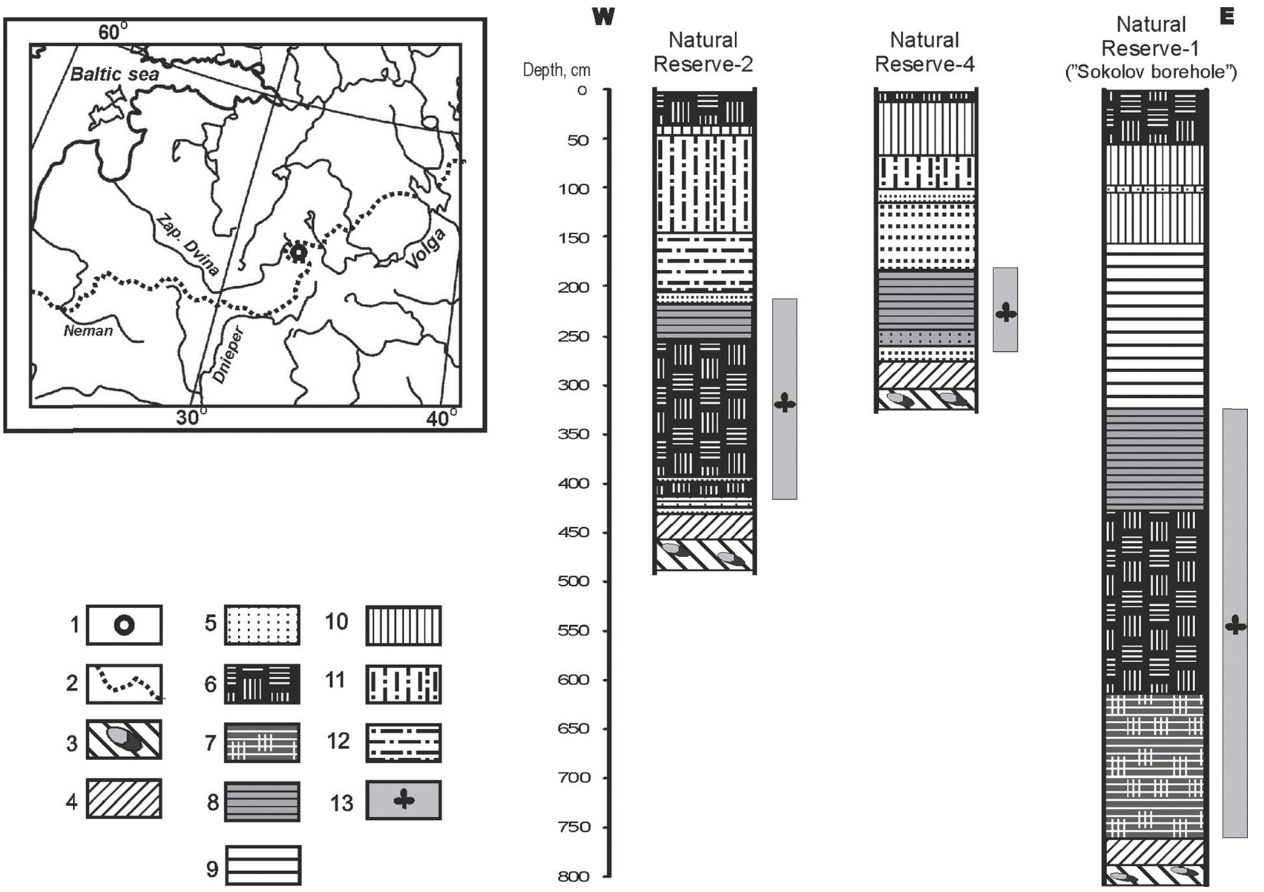

Fig. 1. The location and lithology of the sections studied in the Central Forest State Natural Biosphere Reserve. Legend: (1) the Central Forest State Nature Biosphere Reserve; (2) boundary of the ice cover (Velichko et al., 2004); (3) moraine (carbonaceous loam with gruss); (4) bluish-gray carbonaceous clay; (5) sand; (6) peat; (7) highly terrigenous peat; (8) clay with high content of organic matter; (9) clay; (10) loam; (11) loesslike loam; (12) sandy loam; (13) intervals studied using paleocarpological methods

Few East-European localities are known to contain data that are comparable with those obtained about carpological assemblage 2 of the Natural Reserve. Similar assemblages are known from Pryalitsa section in Tver' Region (Velichkevich, 1982) and Medininkai section in eastern Lithuania (Satkunas et al., 2003). These assemblages were obtained from sediments corresponding to the transitional stage between the Mikulino interglacial and Valdai glaciation.

The obtained data allowed us to reconstruct the dynamics of local lake-swamp vegetation and changes in conditions in small paleolakes in the south of the Valdai Hills. These paleolakes were characterized by shallow-water eutrophic conditions during the Mikulino interglacial. Thermophilic species, which now are alien to the flora of the region under consideration, were represented in water plant communities. The processes of paludification intensified in the second half of the climatic optimum of the Milulino Interglacial. Paleocarpological data for the end of Interglacial indicate an increase in the water level under conditions of the progressive climatic cooling.

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