

**Lateglacial-Interglacial transition: glaciotectonic, seismoactivity,
catastrophic hydrographic and landscape changes**

**INQUA Peribaltic Working Group Meeting and Excursion 2018
19 – 25 August 2018**

**International Scientific Conference
and School for Young Scientists**

Excursion guide and Abstracts



Edited by Subetto D.A., Shelekhova T.S., Slukovskii Z.I., Druzhinina O.A.



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Preface

The Peribaltic Working Group is an INQUA (International Union for Quaternary Research) research group. It brings together Quaternary and ice age researchers from countries around the Baltic Sea once a year for over twenty years now. The Peribaltic WG is one of the most active working groups and its activities are subordinated to the INQUA Commission on Terrestrial Processes, Deposits and History (TERPRO). The aim of the working group is to enhance the research co-operation between the countries around the Baltic Sea and to create contacts between researchers in different countries.

The meeting includes a one meeting day (August 20th) and 4-day-excursion (August 21st-24th) in Karelia and Lake Ladoga, including the Valaam Islands with the theme of 'Lateglacial-Interglacial transition: glaciotectonic, seismoactivity, catastrophic hydrographic and landscape changes'. The participants will visit different kind of geological localities in the central Karelia and the Northern part of Lake Ladoga, where the glacial dynamics and the examples of the glaciotectonic, seismoactivity during the Late Pleistocene and Holocene are well visible. There is one day symposium with paper and poster presentations in the Karelian Research Centre of Russian Academy of Sciences, Petrozavodsk. Researchers from seven different countries are gathered together to give lectures, discuss and share the latest research results.

The symposium and excursion are organised by the Karelian Research Centre of Russian Academy of Sciences, by the Saint Petersburg State University, Moscow State University, Institute of Geography of Russian Academy of Sciences, Herzen State Pedagogical University of Russia (Saint Petersburg), Geological Institute of Russian Academy of Sciences. Special thanks go to Alexander Rybalko, Sergey Shvarev, Alexsey Rusakov, Alexander Makeev, Natalya Zaretskaya, Lilit Pogosyan. Financial support was given by the Russian Foundation for Basic Research (Grant No. 18-35-10020). The concept of the meeting aimed at studying the seismic phenomena of the past was formed on the basis of the project supported by Russian Foundation for Basic Research (Grant No. 16-05-00727) "Sudden drastic transformation of the hydrographic network and landscapes during the Holocene in the South-East of the Baltic Shield (paleohydrological and geodynamic aspects)". The editors express our gratitude to all supporting people and organizations.

Dmitry Subetto, Zakhar Slukovskii, Tatyana Shelekhova, Sergey Svetov and Olga Druzhinina

Petrozavodsk 14.08.2018

INTRODUCTION

The Karelian Republic is situated in the north-western part of the East-European Plain. It lies mainly between 60° 41' N.L. and 29° 39' N.L., and 29° 40' E L. - 37° 55' EL.

The greatest extension from north to south is 672 km; from west to east it measures 324 km; its area is 173 300 sq. km.

It is bounded on the west by Finland. Karelia has a temperate-continental climate with some features of marine climate: a long and relatively mild winter and short cool summer. The monthly temperature is +14 to +16 in July and -9 to -13° C in February.

Karelia territory lies in the northern and middle taiga subzones. The borderline between the subzones is found at the latitude of the village of Laksozero - the town of Medvezhgorsk - Lake Vyg. The prevailing kinds of trees in the woods of the Republic are pine in the north and spruce in the south. Other kinds of trees are birch, aspen alder and others. The area covered by woods accounts for 87 percent of the Republic's territory. Typical components of Karelia landscape are lakes and marshes. There are more than 60 thousand lakes in Karelia with a total area of about 16 000 sq. km. 30% of the territory are marshes and swamped land.

The Republic of Karelia lies in the south-eastern Fennoscandian Shield and is composed dominantly of old Archean and Proterozoic (3.5 to 1.5 Ga) rocks overlain by a discontinuous Quaternary rock cover. It is only in southernmost of Karelia, where the Fennoscandian Shield joints the Russian Platform, that Paleozoic rock sequences occur.

THE PRECAMBRIAN

The heterogeneous Precambrian is divided into Archean and the Proterozoic acrothems. The main stratigraphic characteristics of Precambrian rock sequences in Russian Karelia, described by K.O.Kratz (1958), are still used as a basis for a stratigraphic scheme of the Karelian-Kola region endorsed at the Interdepartmental Regional Stratigraphic Meeting held in Petrozavodsk in 1999. The main units of the scheme are incorporated into the General Chronostratigraphic Scale accepted for the Lower Precambrian of Russia at the All-Russian meeting on general problems in the subdivision of the Precambrian (Apatity, 2000) and approved by the MSC Bureau on 2 February, 2001.

According to the scale, the Archean acrothem is subdivided into the Lower Archean (Saamian) and Upper Archean (Lopian) eonothems with an age boundary of 3.2 Ga between. The type sequence for the Saamian is the Volotsky Group in Eastern Karelia. The group comprises a tonalite-trondhjemite-gneiss complex. The Lopian is subdivided into three erathems: Lower (3.2 – 3.0 Ga), Middle (3.0 – 2.8 Ga) and Upper (2.8 – 2.5 Ga). The Lower Lopian erathem is represented by the upper part of the Vodlozero tonalite-trondhjemite-gneiss complex. The type sequence for the Middle Lopian erathem is the Hautovaara Group (mainly volcanic rocks varying in composition from felsic to ultramafic. The type sequence for the Upper Lopian erathem is the Gymoly Group (mainly BIF).

Proterozoic rocks make up a large part of the Fenno-Karelian greenstone province. They constitute up to twenty relatively big (10-200 km) synclinal and synclinorial structures and dozens of smaller ones. In accordance with the above scales, the Lower Proterozoic (Karelian) eonothem, distinguished in the general scale, is subdivided into the Lower Karelian (2.5-2.1 Ga) and Upper Karelian (2.1-1.65 Ga) erathems. The lower one comprises the Sumian, Sariolian and Jatulian as type units with boundaries of 2.4 and 2.3 Ga; the upper one consists of the Ludicovian, Kalevian and Vepsian units with boundaries of 1.92 and 1.8 Ga. The Archean-Proterozoic boundary has conventionally been considered to lie at the base of the Sumian, although its precise position in local scales is still uncertain.

The Lopian (3.2-2.5 Ga)

The Karelian granite-greenstone terrain (GGT) consists largely of two major rock complexes – granite-greenstone and migmatite gneisses. The Karelian GGT includes 7 NNW- trending greenstone belts of Late Archaean age. They are restricted to big deep intra- to interblock faults

and associated with conformal fault systems. Some greenstone belts, such as the Vedlozero–Segozero, Sumozero–Kenezero and Parandovo–Tikshozero belts, are over 300 km long and over 50 km wide. Regional cratonic data are shown in Table 1.

The greenstone belts are separated by TTG fields that occur as infrastructural blocks. They consist mainly of mafic-ultramafic rocks with subordinate intermediate to felsic volcanic and volcanoclastic lithologies and sedimentary rocks. The maximum thickness of Karelian greenstones is 6 km in the Hautavaara area.

The rocks that constitute komatiite assemblages have no definite position in the stratigraphic sequences of greenstone structures, but they are typically restricted to the lower and less commonly middle portion of the sequences.

Table 1. Regional data

Region	Karelian Craton
Area	300000 km ²
Age range of greenstones	3.1–2.9, 2.9–2.85, 2.85–2.75 и 2.75–2.65 Ga
Present crustal thickness	39–56 km
Present lithosphere thickness	130–160 km
Number of greenstone belts	7
Number of greenstone domains	25
Maximum thickness of greenstone belts	6580 m
Average ages of TTG	3210±12, 3166±14, 3151±18, 3138±63 Ma (SHRIMP-data, Lobach-Zhuchenko <i>et al.</i> 1993)
Average isotopic signatures of granitoids	$\epsilon_{Nd}(3.2Ga)=+1.0$ to +4.0
Deep crustal characteristics	tonalitic to mafic granulites
Granite-greenstone ratio (surface estimation)	7:3

The reconstructed thickness of the komatiite–tholeiite assemblages varies from hundreds of metres to 2.8–3.0 km. High–Mg volcanics are closely–spaced and cover an area of 2–4 sq. km, less commonly about 30 sq. km (Palaselga, Semch). Facially, komatiites occur as massive, pillowed, variolitic, differentiated lava, spinifex–structured lava, and pyroclastites (tuffs of pelite to agglomerate size). Pyroclastic facies make up not more than 3–5% of total rock volume in the sequences studied. The rocks of Archean komatiite–tholeiite assemblages were metamorphosed regionally under greenschist– to amphibolite–facies conditions.

The Central Karelian terrain consists of volcanic andesitic– dacitic (BADR and ADR) rocks of two age ranges (2.95–3.05 and 2.85– 2.90 Ga) that differ in geochemical characteristics.

Geodynamic reconstructions have revealed magmatic systems in GGT associated with an ancient island arc, a back-arc basin, and a young volcanic arc, which are consistent with the formation of a greenstone belt as a convergent protoocean–protocontinent zone between microplates.

The Sumian (2.5 – 2.4 Ga)

The Sumian is composed of conglomerates, sandstone and siltstone interbedded with tuffites and quartz porphyry lava. The conglomerates and breccia rest unconformably on the highly eroded surface of folded Lopian greenstone and sedimentary units, gneisses and granitoids. Conglomerate clasts are made up of bedrock such as granite (except for plagioclase granite with blue quartz), gneiss, greenschist and mafic volcanics, various cherty, quartzite-like and arkose-like rocks. There is no evidence for the weathering of the bedrock and clasts. It shows again that monomictic quartz sediments are not common at the base of the Proterozoic sequence in Karelia.

Sumian conglomerates and the finer clastic rocks that interbed with them contain fine to coarse pyroclastics and scarce lava outliers. Clastic rocks build up a ca. 100 m thick bed which often wedges out, and quartz porphyry then rests on older rocks and their eluvial breccia.

Lying higher upwards is a quartz porphyry unit. Based on a succession of brecciated, massive, banded and spheruloid varieties (type structure of a flow), over 10 lava flows, up to 150 m in thickness, separated occasionally by ca. 100 m thick clastic rock beds are distinguished in the unit. Felsic veins that occasionally cut underlying granitoids sometimes occur in the central part of the flows. Subvolcanic quartz porphyry bodies, dykes and stocks are encountered. Some quartz porphyry dykes have been reported from the Nuorunen massif. They also cut the Kivakka and Tsipringa layered intrusions. However, there is evidence showing that gabbro cuts the Sumian conglomerate.

In the Shuezero and Paanajarvi synclinoria, quartz porphyry has an age of ca. 2.45-2.4, which is close to that of Nuorunen granite.

Quartz porphyry makes up lava and subvolcanic bodies that are common in an almost rectilinear belt. It is 30-50 km wide and extends for about 600 km from the southern shore of Lake Vygozero to Lake Paanajarvi and then farther to Central Finnish Lapland, where the Rookiapa Formation, built up by coarse quartz porphyry breccia, has been described near the Koitelainen intrusion

The Sariolian (2.4 – 2.3 Ga)

In Karelia, the Sariolian is formed of andesite-basaltic volcanics and clastic rocks, polymictic conglomerates, sandstone and varved aleurosiltstone associated with rocks that contain variable quantities of inequidimensional pyroclastics.

Resting at the base of the Sariolian on the eroded surface of folded Archean or Sumian units are eluvial breccia or polymictic clastic rocks. In some sequences, one to two packets are built up by andesite-basaltic lava sheets higher upwards in succession. Their total thickness is up to 1.5 km. However, the packets pinch out of the column over several kilometers northeast and north and can be traced NW over considerable distances.

Two marker horizons are traced in volcanics throughout almost all of Karelia. Their rock constituents owe their appearance to albite amygdaloids and phenocrysts.

Relics of volcanic apparatuses with feeder channels, contours and constituents of volcanic edifices are mapped at some sites.

In this region, the wedging-out of lava packets usually exhibits a regular distribution pattern. The lines, on which wedging-out occurs, are traced over large distances. The same lines control the arrangement of the volcanic apparatuses and hypabyssal gabbroids in feeder channels. The above lines often lie near the axial lines of Sariolian folds proper which become structurally asymmetrical: one fold flank is formed by lava and the other by conglomerates. It is safe to assume that the lava-covered portions of the surface were topographic lows in Sariolian time and the lines on which lava wedged out were active boundaries between lava-filled grabens.

Varved clay layers, diamictites and scarce dropstones are typical of the upper part of Sariolian sequences, suggesting that glacial processes were involved in the formation of the deposits. The total thickness of clastic rocks is 500-600 m.

The Jatulian (2.3 – 2.1 Ga)

Owing to the characteristic pattern of its quartzite, red argillite and carbonate constituents, widespread over the entire shield, the Jatulian is used as an important marker in Proterozoic sequences. The marker role played by carbonate rocks enriched in a heavy carbon isotope is of global significance because rocks of similar age are now known in almost all Precambrian regions.

Jatulian rocks rest unconformably on all eroded Sumian, Sariolian and other older rocks. Chemical weathering crusts are ubiquitous at the lower contact of the unit. The substrate of the crusts retains the textural pattern of original rocks, whereas mineral constituents, except for some weathering-resistant minerals, primarily quartz, are replaced by sericite aggregate which is occasionally mixed with carbonate and chlorite.

The weathering crust is overlain by coarse, clastic basal deposits clearly dominated by quartz conglomerates, gravelstone and sandstone. Carbonate lenses are encountered locally at the base of the sequences. The thickness of these units is highly variable, increasing generally NW from several metres in Prionezhye to almost 1000 m in the Shuezero and Voloma structures. They pass upwards into a 100-250 m thick silica-rich (up to 99%) quartzite bed. The upper portion of Lower Jatulian terrigenous rocks (Yangozero and Medvezhyegorsk formations.) consists of quartz conglomerate, quartzite and arkosic sandstone, and siltstone. There are two levels of basaltic lava (up to 100 m thick and up to 350 m thick, respectively) in the unit. Total thickness of the Lower Jatulian is up to 1500 m.

The Upper Jatulian (Tulomozero Formation. Stops 5, 6) unit is composed of a ca. 800 m thick siltstone-dolostone unit. It is remarkable for relics of various biogenic textures (stromatolites etc.), the abnormally heavy isotopic composition of carbon in carbonates and numerous indications of an evaporitic depositional environment. This assumption is supported by carbonate pseudomorphs (talc and quartz pseudomorphs after gypsum are less common), nodular and cloud-shaped (chicken wire) aggregates characteristic of gypsum emanations, carbonate layers and beds after gypsum locally deformed by volumetric gypsum-anhydrite and anhydrite-gypsum transitions as well as scarce pseudomorphs after cubic and skeletal halite crystals. Drilling data suggest that some breccia was formed by salt karst collapse. Available evidence has led the authors to conclude that Upper Jatulian rocks were generated from sediments which deposited in sulphate-type evaporite basins. Based on the above indications, sulphates made up 30-40% of the sequence.

The Ludicovian (2.10 – 1.92 Ga)

The Ludicovian is distinguished in some sequences in the Tulomozero, Suojärvi and Panakuojärvi local structures (northern Lake Ladoga region). It is best studied in the Onegian synclinalorium (Trans-Onega and Suisari formations).

The Trans-Onega formation falls into two units: 1) a lower, carbonate-siltstone and 2) an upper, volcano-sedimentary unit in which the bulk of C_{org} -rich (shungite-bearing) rocks is concentrated.

The lower Trans-Onega Subformation rests subconformably on the eroded surface of Upper Jatulian carbonate rocks. The erosion surface slightly truncates underlying rocks and is locally overlain by thin conglomerates and congl-breccia. The boundary between the Jatulian and Ludicovian varies from area to area because the upper part of the Jatulian and the lower portion of the Ludicovian have dropped out of the column. At some places, red-coloured Jatulian dolostones pass gradually into overlying Ludicovian siltstones. At others, the boundary exhibits scour, a crust of weathering and a distinct lithologic discordance indicated by sharp changes in the elemental composition of rocks. When the boundary is poorly defined, it is indicated by the first fine dark-grey quartz siltstone seams and the disappearance of the last stromatolites *Djulmekella*.

The base of the lower subformation is composed of feldspathic-quartzite sandstone and siltstone supported by carbonate and mica-carbonate matrix. In the lower portion, dolomitic conglomerate lenses are occasionally encountered.

The upper portion of the column is formed by grey and dark-grey horizontally-bedded fine-grained quartz-feldspathic sandstone, siltstone and quartz-sericite-chlorite schist. The subformation is 170 to 200 m thick.

All the rocks that build the upper subformation are enriched in organic matter. In nine beds the percentage of C_{org} is in excess of 20%. The rock constituents of the subformation vary in proportions from one part to another. Three types of sequences: volcanogenic, sedimentary-volcanic and volcano-sedimentary have been studied.

In this complex, subvolcanic sequences are represented by numerous sheeted and cross-cutting gabbro-dolerite sills.

Resting on the rocks of the Trans-Onega Formation are those of the Suisari formation dominated by high-MgO tholeiite-series volcanics. Sedimentary rocks are scarce, but pyroclastic rocks are abundant. The boundary between the formations extends along the base of coarse clastic gravelstone and fine-pebble conglomerates that occur above the basaltic lava-andesite-basalt

member of the Trans-Onega formation. In the absence of a basal bed, the base of the lowermost high-MgO volcanic flow or a basaltic tuff-tuff conglomerate bed are accepted as a boundary.

The Kalevian (1.92 – 1.80 Ga)

In the northern Lake Ladoga region (Priladozhye), recognized as a type sequence, the Kalevian is represented by the Ladoga Group. The conglomerates and quartzite that occur at the base of the group rest unconformably on folded Jatulian rocks that form part of the Sortavala and Soanlahti formations. The pebbles and boulders of the conglomerates contain amphibolite, dolerite, carbonate rocks, quartzite, various shales, as well as cherty and cherty-iron rocks. The upper part of the bed and thin conglomerate patches are dominated by quartzite-like and cherty rock pebbles. The conglomerates are 10-140 m thick. They pass upwards into graded biotite-quartz shale (Ladoga group) with calcareous concretions.

In the stratigraphic schemes, the aforementioned rocks that represent the Kantiosaari formation are overlain by the Pälkjärvi, Naatselkä and Leppälampi formations. The former two formations are dominated by quartz-biotite schist and argillite with staurolite, andalusite and garnet. The latter incorporates biotite schist and amphibolite. Ilola, the uppermost formation in the Ladoga Group, was formed in Vepsian time. The total thickness of the rocks that build up the Ladoga Group is ca. 3 km. The marker feature of the Ladoga Group is due to the uniform composition of its rocks (biotite-quartz and quartz-biotite schist and phyllite) and an abundance of calcareous concretions.

Kalevian rocks are now known also in the Onega synclinorium where Kalevian is formed by the Besovets group which is similar in uniform composition and widespread graded bedding to the Ladoga group.

The Vepsian (1.80 – 1.65 Ga)

In Karelia, the Vepsian is chiefly represented by the Petrozavodsk and Shoksha formations and is correlated with the Ilola Formation in the Ladoga Group. The Petrozavodsk Formation is composed of coarse-, medium- and fine-grained sandstone with siltstone interbeds. There are clasts of chert, carbon-bearing shale and mafic rocks in the sandstone near Petrozavodsk. The formation is up to 600 m thick. On the western shore of Lake Onega, Shoksha rocks occur on weathered basalt that makes up the top of the Petrozavodsk Formation. Their base is formed of thin fine-pebble conglomerates with tuff siltstone, basalt and cherty rock pebbles. These are overlain by red and crimson-coloured quartzitic sandstone and quartzite with large-scale cross-bedded series and ripple marks. Occurring in the middle and upper parts of the formation are pink, red, crimson and lilac-coloured quartzite and quartzitic sandstone, red-coloured siltstone and conglomerates. The formation seems to be over 1000 m thick. Shoksha red beds can obviously be used as a marker in Paleoproterozoic successions.

The Vepsian rocks are cut by gabbro-dolerite sills (Ropruchei complex). Syenite aggregates of the gabbro-dolerite have an U-Pb zircon age of 1770 ± 12 Ma (Bibikova et al., 1990).

The Vepsian sedimentary formations, together with intruding dolerite sills, form a gentle asymmetric syncline displaced locally by NW- and NE- trending faults. Vertical movements of up to 100 m have taken place along the faults that are quite distinct in the relief.

QUATERNARY DEPOSITS OF KARELIA

The Quaternary Period is characterized by the cyclic alternation of continental glaciations and warm interglacial epochs provoked by global climatic changes and accompanied by large-scale sea transgressions. During the last Upper Valday (Weichselian) Glaciation a large part of Karelia was in an intense exaration zone of the Scandinavian glacial cover. As a result, the bulk of pre-Upper Valday Quaternary deposits were assimilated and redeposited by the glacier. Therefore, Karelia now has no natural Quaternary exposures of pre-Upper Valday age. Quaternary strata over most of Karelia consist of glacial and aqueoglacial deposits build up by the Last Scandinavian Late Valday (Weichselian) Glaciation. They commonly rest on Precambrian

crystalline rocks. Quaternary deposits vary in thickness from less than 1.0 m to 150 m (average thickness 8–12 m). Pleistocene strata in southern and south-eastern Karelia are 100–150 m thick. Drilling has revealed four (Oka, Dneprobian, Moscovian-Saalian and Late Valdai) levels formed by old glaciations and composed of glacial and aqueoglacial sediments and marine, lacustrine and lacustrine-alluvial strata formed during the Interglacials (Likhvinian, Shklovian, Mikulinian-Eemian). Older Early Pleistocene tills were revealed in core samples from adjacent Leningrad and Arkhangelsk areas.

All genetic types of glacial and aqueoglacial deposits, together with accumulation landforms produced by the last glaciations, are well-defined over the study territory. Therefore, Karelia is recognized as a model region, where ice sheets evolved in various geological and paleoglaciological settings such as zones formed of Precambrian crystalline or Palaeozoic sand-and-clay rocks and the peripheral or central parts of glaciation.

The main characteristic of Karelia's glacial morphosculpture is its radial-concentric structure inherited from the last ice sheet. Six belts formed by marginal strata are differentiated to trace the degradation of the last Scandinavian ice sheet from initial (Vepsuvian?) to final (Salpausselka I and II) stages.

There are more than 60 000 lakes in Karelia, including Europe's largest lakes, Ladoga and Onega. Their bottom sediments and ancient shorelines provide valuable evidence for the time of retreat of the ice margin, the evolution of large glacial and periglacial basins, the intensity of the glacioisostatic rebound of the earth crust, and cyclic variations of climate in the Late- and Post-Glacial periods responsible for some characteristics of plant evolution and the formation of the present environment.

Pleistocene

Data obtained by analysis of core samples from southern and eastern Karelia provided a basis for palaeogeographic reconstructions and a stratigraphic scale for the Pleistocene in Karelia (Ekman, 1987; Devyatova, 1972, 1982; Agranova et al., 1977).

Neogene (?)–Lower Quaternary deposits have been identified on the western shore of Lake Onega, including the Petrozavodsk area and the lower reaches of the Neluksa, Orzega and Derevyanka rivers. These sediments make up 26 to 57 m thick fluvial-lacustrine silt-sandy strata. They were revealed by drilling in a bedrock depression at an altitude of 42 to 62 m.a.s.l. An older till unit (Prionezhian?) is known in the adjacent area of the Leningrad Region (Fig.4).

Lower Pleistocene sequences are composed of 1.5–1.8 m thick reddish-brown boulder clay and loamy soil (till) formed during the Oka Glaciation and intersected by drill holes in the Onega–Ladoga Isthmus near Matrosy and Orzega towns at a depth of 74 to 122 m. They rest on either bedrocks or Neogene–Lower Quaternary (?) lacustrine–alluvial (?) sand–and–clay deposits (Orzega). Till is overlain by marine sediments formed during the Likhvinian Interglacial.

Two global climatic cycles in Karelia are reliably identified **in the Middle Pleistocene**. The rock sequences deposited in the **Likhvinian Interglacial** are most reliably identified near Matrosy, where pollen zones L1, L2, and L3 (after Grichuk, 1961), corresponding to the early half of the Likhvinian Interglacial, are recognized. The pollen of relict and exotic plants, such as *Picea sec. Omorica*, *Pinus sec. Strobus*, *Abies cf. firma*, *A. alba*, *Osmunda claytoniana*, *O. cinnamomea*, and *Asolla* sp., is commonly present in Likhvinian layers together with poor foraminifera fauna (*Elphidium* ex gr. *clavatum* Cushman). These strata are up to 29 m thick.

In **Dneprobian time**, Karelia was subjected to the Scandinavian Glaciation. Dneprobian till, composed of boulder loam, clay, and late glacial sand and clay is up to 14 m thick in the Onega–Ladoga Isthmus and 40 m thick in south-eastern Karelia. In the latter region, Late Dneprobian strata comprise Desna layers and marine loam generated at the final stage of the Dneprobian Glaciation (Agranova et al., 1977).

Marine and lacustrine deposits, produced in the **Shklovian Interglacial**, were reported by Agranova (1977) from the Kolodozero area, eastern Karelia, where they occur at a depth of 72 to 113 m. In a pile of Shklovian rocks that have a total thickness of 32 m. V.P. Grichuk identified

marine layers that correspond to the Glazovian and Rosslavlian warming periods separated by Krasnoborian cooling. Lacustrine sediments accumulated there at the final stages of the Shklovian Interglacial.

In Moscovian (Saalian) time, Karelia was completely ice-bound. The strata deposited at that time consist of ca. 30 m thick brown (less commonly grey) boulder loam and clay (till) and ca. 6 m thick Interstadial lacustrine glacial and marine-glacial deposits that contain glacial vegetation (Devyatova, 1972).

Mikulinian (Eemian) marine sediments, deposited in the warmest Interglacial of the Pleistocene, are widespread on the shore of lakes Onega and Ladoga, in the Vodla River basin and along the White Sea–Baltic Sea Canal. Lacustrine sediments were encountered in the Vodla River basin and on the shore of Lake Onega, where they typically rest on marine deposits. The total thickness of Mikulinian sediments is 18 m. Mikulinian layers occur at a depth of 3 to 80 m and are overlain by Valdai and Holocene sediments. In intense lacustrine abrasion zones (on the first Lake Onega terrace) they are overlain solely by Holocene deposits.

To throw light on the pattern of variations in climate, vegetation, and palaeohydrology of water bodies that occurred in Karelia in the Mikulinian Interglacial, Mikulinian deposits revealed by drilling in the vicinity of Lake Onega (Petrozavodsk, Derevyannoye, and Povenets), in East Priladozhye (Vasilyevsky Bor, Vidlitsa), and along the White Sea–Baltic Sea Canal (River Onda) were studied in detail palynologically and paleontologically (Lavrova, 1962; Devyatova, 1972, 1982). Pollen of broad-leaved species, such as oak, elm, filbert, linden and hornbeam, was found to culminate consecutively in pollen-and-spore diagrams obtained for major sections. The above succession is characteristic of the Interglacial. Recognized in the most complete Petrozavodsk column are 13 palynological zones M1–M8 (after Grichuk, 1961). The climatic optimum coincides with zone M5. The pollen spectra of Mikulinian deposits, obtained in the eastern Lake Ladoga area, contain more pollen of broad-leaved species than those available for the Petrozavodsk area and the White Sea–Baltic Sea Canal (River Onda). They are more similar in this respect to the pollen spectra of Mikulinian deposits in Central European Russia (Devyatova, 1972, 1982). Differences in mollusc and foraminifera fauna and diatom flora reflect sea transgression and subsequent regression.

Early Valdai (Weichselian). According to earlier evidence, Early Valdai deposits are formed of ca. 24 m thick glacial and aqueoglacial sediments and a bed under Middle Valdai interglacial sequences. (Devyatova, 1972; Ekman, 1987). However, arguments in favour of its occurrence between the marine Mikulino unit and the freshwater Middle Valdai unit is based solely on correlation of drill holes that intersected Middle Valdai deposits or Mikulinian sediments on the first and second terraces of Lake Onega. There are no boreholes either in Petrozavodsk and other areas that penetrated interglacial Middle Valdai and Mikulinian layers separated by Lower Valdai glacial strata. Therefore, we have no reliable geological evidence for Early Valdai Glaciation both in Karelia and in the Leningrad Region. Early Valdai Glaciation did not spread as far as northwestern Russia.

In **Middle Valdai time**, when there was no ice in Karelia, lacustrine, alluvial-lacustrine, and bog deposits were formed. Core samples, taken from some most representative parts of these deposits near Petrozavodsk, were analysed in detail. Middle Valdai sediments, built up on the first terrace of old Lake Onega, fall into seven palynological zones consistent with two cold periods separated by a warm period (Devyatova, 1972). Lacustrine–bog sediments, deposited on higher hypsometric levels (100–180 m) in Petrozavodsk, are composed of loam, peat, and sapropel. The age of the oldest organic layers is estimated at $46\,700 \pm 1\,100$ (TA 927), based on radiocarbon data (These data seem to be beyond the radiocarbon limit), the youngest layers being dated at $32\,520 \pm 600$ (TA 1015). Peat and sapropel that accumulated at the warmest time of the Interglacial are dated at $43\,900 \pm 900$ (TA 487), $41\,800 \pm 950$ (TIn 629), and $38\,700 \pm 850$ (TIn 630) (Ekman, 1987). The upper part of Middle Valdai sediments was destroyed by the glacier in Late Valdai

time. Golikovka and Drevlyanka warming, separated by the Kukkovka cold period, are recognized in the preserved part of the sequence, based on available palynological evidence.

In **Late Valdai time**, Karelia was entirely covered by the last Scandinavian ice sheet. Its stadial degradation pattern was controlled by cyclic climatic variations in Late Glacial time and Karelia's geological structure, e.g. the composition and relief of underlying rocks, the occurrence of big ice lakes, and distance from the centre of glaciation. Deglaciation was accompanied by the formation of different lithomorphogenetic complexes of Quaternary deposits, the evolution of big ice lakes and more active neotectonic movements.

An areal type of deglaciation, accompanied by the stagnation of large ice-bound areas in the peripheral zone of the glacier and following the formation of kame fields and zvonsties, dominated at the initial (**Vepsovian–Krestets, Luga and Neva (?)**) stages of deglaciation. Vast dead ice fields were formed in eastern Karelia (Andoma, Kolodozero, Sumozero and Volozero areas) and in the Onega-Ladoga Isthmus (Vokhtozroro-Veshkelsk uplift, Urakka ridge. They kept melting slowly for thousands of years up till the Early Holocene. **Bolling (?)** deposits, consisting of varved clay, were intersected at the base of varved clay units on the River Shuya in the Onega-Ladoga Isthmus and in south-eastern Karelia. A frontal type of deglaciation prevailed in the **Allerod Interstadial**, which followed the cold Middle Dryas period, and a cross-cutting type of deglaciation dominated in the large Onega, Ladoga, and White Sea basins. As a result of vigorous ice melting, the festooned-lobate structure of the glacier was transformed to smoother ice margins. A linear pattern of fluvio-glacial accumulation predominated in a warm interstadial environment, an active ice sheet, and the highly rugged relief of hard Precambrian rocks, as indicated by the vigorous formation of esker ridges, fluvio-glacial debris cones, and deltas. In Allerod time, about 450 esker ridges (ca. 75% of all Karelia's eskers), totalling 4800 km in length, were formed in Karelia (after V.A. Ilyin). In late Allerod time, the area covered by periglacial Lake Onega was maximum, exceeding the present area by 20-25%. In the **Late Dryas**, several cold periods triggered ice movement at cold Salpausselka I and II stages.

Holocene

In Karelia, Holocene deposits are dominated by lacustrine (sand, silt, sapropel, diatomite), bog, and marine sediments. Based on pollen-and-spore and diatom spectra obtained for these sediments, numerous radiocarbon datings, and geologic-morphological observations, a stratigraphic scale was constructed for the Holocene in Karelia, and light was cast on some evolutionary characteristics of its climate, vegetation, and hydrographic network in the Post-Glacial period (Devyatova, 1972, 1982, 1986; Yelina, 1981, 1984, 2002 and others). Figure 3 shows a climatic variation pattern for Karelia in Late Glacial and Holocene time.

By about 9 500 y.a., the glacier had retreated from West Karelia. Glacial erosion and accumulation were followed by weathering, paludification and a gradual drop in the level of large water bodies such as the White Sea and lakes Onega and Ladoga, accompanied by small-scale transgressions. About this time, as a result of glacioisostatic crustal uplifting, the Onega-White Sea watershed was drained and water continued once more to discharge from Lake Onega down the River Svir (Saarnisto et al, 1995).

Rapid glacial waning and dramatic changes in the outlines and depth of late glacial and postglacial water bodies contributed to a considerable glacioisostatic rebound of the earth crust accompanied by some powerful earthquakes. Traces of these events in the form of large-scale land-slips and other paleoseismic dislocations may be seen in the Trans-Onega Peninsula, in northern Ladoga and in West Karelia (Lukashov, 1995).

It was not until the Boreal Period (8.8-7.5 ka) that substantial climatic warming commenced, reaching a maximum during Atlantic period (7.5-4.5 ka), which constitutes the climatic optimum of the Holocene epoch. Vigorous paludification began during Boreal Period and reached its maximum in the Atlantic Period. As mean annual temperatures then exceeded present-day temperatures by 2-5 degrees, half of Karelia was covered by south-taiga spruce and pine forests mixed with broad-leaved species (Yelina et al, 2002).

Geomorphology and neotectonics

The distinctive geologic-geophysical and tectonic structure of Karelia's crystalline basement has markedly affected the recent structural plan and tectonic movements which manifested themselves during the Neogene-Quaternary time and was responsible for its major topographic features. The recent structural plan of Karelia is controlled by the block system of the crystalline basement. The blocks, controlled by the same movement rhythm, are grouped into complex structures which differ in the direction of their tectonic development and exhibit considerable inheritance from the ancient structures of the basement. The recent structural zones, subjected to intensive and moderate uplifts, are commonly conjugated with ancient anticlinorium structures, whereas recent structures with a relative and absolute subsidence are confined to ancient grabens and synclinorium structures.

The style of Karelia's neotectonics is controlled by the movement of rigid basement blocks along long-lived and rejuvenated ancient fractures that display a different movement pattern. The vertical movement of the blocks along fractures prevailed. They occasionally have a horizontal component. Recent movements in Karelia display a complex spectrum and are differentiated in space and time. The neotectonic regime is a continuation of a platform stage in shield evolution. It is characterised by oscillating motions and a general uplifting trend. One essential feature of Karelia's recent neotectonic regime is the compensation of glacioisostatic movements in late glacial time and in the Early Holocene. These movements occurred together with tectonic movements proper, made their rhythm more complex and affected the rate of movement in postglacial epochs. Modern movements generally exhibit an inherited pattern and generally agree with Karelia's structural plan.

It should be noted that a few tens of epicentres of modern M 3-4 weak earthquakes have been revealed. Many various palaeoseismodislocations in the bedrock and in Quaternary deposits, together with the historical record, suggest more powerful M 5-6 to 7-8 earthquakes in postglacial time. As the knowledge of Karelia's palaeoseismicity is poor, no final conclusions about its manifestation pattern can be drawn. However, we can conclude from C¹⁴ data on sedimentation in seismicity-generated lakes that seismic activity took part 9500-9300 years ago in West Karelia and 7300-7100 and 3500-2300 years ago in Central Karelia. It seems that a Neolithic settlement was destroyed by an earthquake near former Pegrema village on the Trans-Onega Peninsula in Lake Onega 4400-4100 years ago.

PALAEOSEISMOLOGICAL STUDIES IN THE KARELIAN REGION

Special palaeoseismological studies were launched in Russian Karelia in 1986, being undertaken, in conjunction with other investigations, by the Laboratory of Quaternary Geology and Paleocology at the Institute of Geology.

Eight zones of local seismic dislocations have been distinguished in Karelia on the basis of air photo interpretations, aero visual investigations, and analysis of field data. The eight zones are 1) Ladoga zone, 2) Onega zone, 3) Segozero zone, 4) Nuhcha zone, 5) Lehta zone, 6) Kalevala zone, 7) Paanajarvi zone and 8) Kandalaksha zone (Fig.1).

The boundaries of these eight zones are fairly arbitrary because areas with abundant seismic dislocations in crystalline rocks are most readily recognized in a terrain with abundant seismic dislocations, in crystalline rocks are most readily recognized in a terrain with a relatively prominent dividing structural – trends and an erosional relief. Therefore, some seismic zones may extend further into the adjoining sediment-covered lowlands. It is, however, very difficult to identify seismogravitational dislocations in loose rocks, because young glaciotectonic formations are widespread, while the dislocations themselves are relatively old. Therefore, specialized methods and additional studies in such areas are needed. Although there are zones indicative of seismogravitational dislocations in loose sediments, they are as yet isolated.

Structures within each of the zones recognized have been studied in different degrees of detail. The Onega, Ladoga, and Segozero structures have been studied in greater detail (utilizing aerial-

and satellite photography, aero visual observations, and field studies of all local seismic dislocations, including an instrumental survey of certain sites). The Kalevala and Paanajarvi zones have been studied in less detail (air photo interpretation, aero visual observations, field checking of some seismic dislocations). The Nyukhcha and Lehta zones are poorly understood (air- photo interpretations, some aero visual observations and consulting with geologists who have worked in these regions).

In spite of disparities in the amount of available information for the areas studied, some structural characteristics of all the zones have been revealed. The presence of common features in the structural zones requires the manifestation of seismic dislocations of the same type, and similar compositions and physical and mechanical properties of crystalline bedrock, as well as special association with particular Precambrian and recent structures.

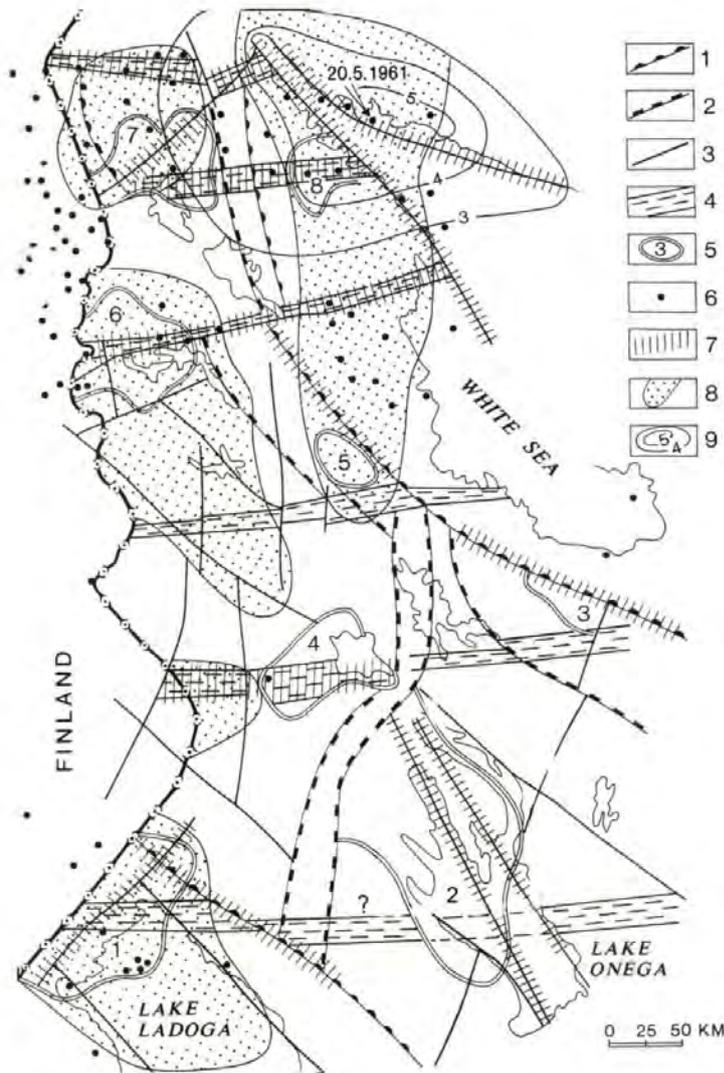


Fig. 1. Outline map of seismic zones in Karelia

Legends

1) intrageoblock deep fault zones, 2) intrablock deep fault zones, 3) innerblock deep-fault zones, 4) fault zones active before the Proterozoic, 5) borders of local palaeoseismic domains, 6) epicentres of modern earthquakes (Panasenko, 1980), 7) probable earthquake zones (zones of 7 and over 7 points intensity), 8) probable centres of low earthquake activity deduced from analysis of geological and geophysical data according to a Prospecting Programme (Ivanovskaya & Firsova et al., 1988), 9) isoseismal lines of earthquakes in Kandalaksha Bay, White Sea 20.05.1967, intensity of 5 and more points (Panasenko, 1974; Ananjin, 1980).

Numbers on the map refer to the names of palaeoseismotectonic domains: 1) Ladoga domain, 2) Onega domain, 3) Nyukhcha domain, 4) Sergozero domain, 5) Lehta domain, 6) Kalevala domain, 7) Paanajarvi domain and 8) Kandalaksha domain.

Lake Onega

Lake Onega is one of Europe's largest water lakes. It is 248 km long and 80 km wide and covers an area of 9682 sq.km. The Lake Onega basin has a complex structure and a long evolutionary history. The Onega Lake basin falls distinctly into two parts: northern and southern, based on coast morphology and floor topography.

The northern part has a rugged coastline. It is rather deep (60-120m) and its floor relief is rather dissected. The predominant topographic features in the northern part are denudation-tectonic and structural-denudation forms. The southern part of the basin is known for its smooth coastlines and gentle coasts and a smooth, slightly dissected floor relief. The southern part of the basin displays lacustrine abrasion and accumulation forms. Glacial exaration forms, such as "roche moutonee" rocks, are common in the Onega Lake basin.

The structure of the various parts of the basin is controlled by the structural plan of the area. The Onega Lake basin was generally confined to a large graben in the peripheral part of the Fennoscandian Shield in the Upper Late Proterozoic when the shield separated from the Russian Platform as an independent geostructure. The graben originated at the contact of two older structures: the Lower-Proterozoic trough (northern part) and an Archean granite-gneiss field overlain by the mantle of Palaeozoic sedimentary rocks (southern part). The difference in the geologic structure of the various parts of the graben is reflected, as shown above, in the basin relief. The basin is assumed to have been formed in the Late Precambrian. In the Palaeozoic and Mesozoic, the Onega Lake area was occupied by a basin which was a freshwater body or a part of a sea basin. Evidence for the existence of the depression at that time is provided by a great increase in the thickness of Palaeozoic deposits on the Onega Lake floor (up to 500m), whereas the deposits beyond the basin are thinner (150-200m). In the Cenozoic, the most recent movements along the ancient fractures resulted in the reconstruction of the ancient graben and the lake basin acquired a shape which is close to the present one. During the Pleistocene, the Onega Lake basin repeatedly became the receptacle of a glacial lobe as a large glaciodepression. In Holocene time, Lake Onega acquired the present appearance.

1st excursion day. August 21

During the field trip to the south-western shore of Lake Onega participants will visit:

1. A structural-denudation ridge (Shoksha Ridge) separated from the Onega Lake basin by neotectonic scarps with traces of postglacial tectonic activity;
2. Traces of the seismogenic crushing of the rock shores of Lake Onega;
3. Traces of seismogenic wave impacts and fluidization in the unconsolidated sediments of the 2.5-3 m thick Onega Lake terrace that occurred 4.5-1.3 thousand years ago.
4. Cultural and historical sites such as the 17th-18th century Gimoretzky rural community and the Sheltozero Vepsian Museum of Ethnography in Sheltozero Town.

TRACES OF POSTGLACIAL SEISMIC ACTIVITY IN THE BEDROCK AND UNCONSOLIDATED SEDIMENTS ON THE SOUTH-WESTERN SHORE OF LAKE ONEGA

Shvarev S.V.

Institute of Geography RAS, Staromonetny lane 29, Moscow, RUSSIA

Schmidt Institute of Physics of the Earth, Bol. Gruzinsky street 10, Moscow, RUSSIA

E-mail: shvarev@igras.ru, shvarev@ifz.ru

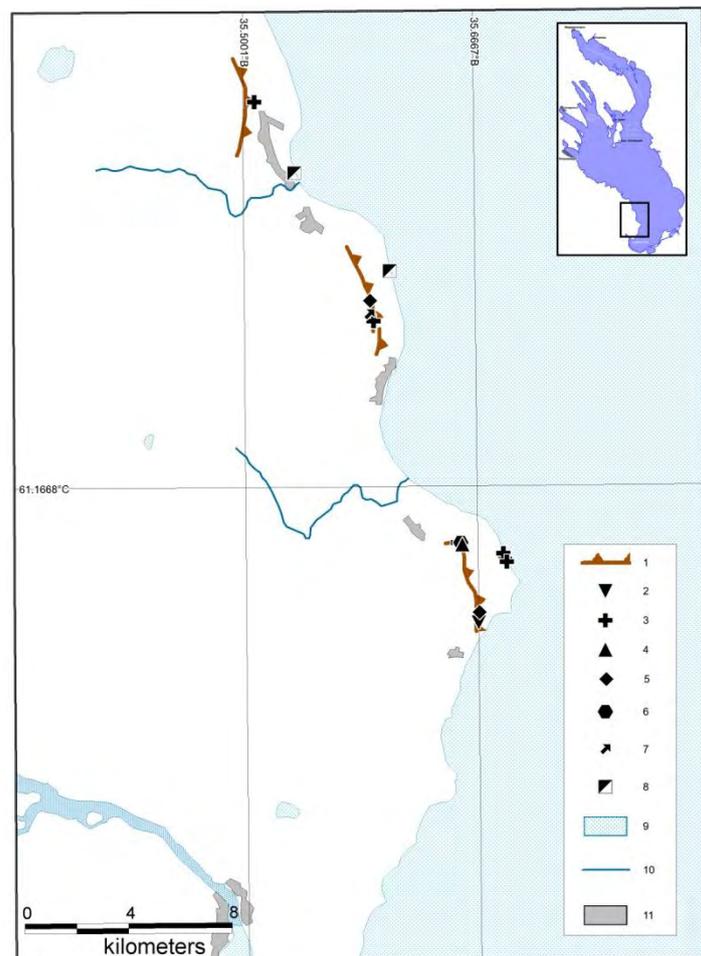


Fig.1 Neotectonic and young seismogenic deformations on the SW margin of the Onega Lake basin: 1 – neotectonic scarps; 2 – seismogenic trenches; 3 – fracturing (cracking); 4 – detachment of blocks from the massif («cutting-off»); 5 – lateral displacement of blocks; 6 – collapse of scarce large blocks; 7 – directed collapse trails; 8 – fluidization in unconsolidated sediments; 9 – lakes and large rivers; 10 – rivers and creeks; 11 – residential areas.

The discontinuous Shoksha Ridge with absolute altitudes of 150-205 m, extending from south-east to north-west from Point Cheinavolok to Derevyanka Town over about 80 km, is characteristic of the south-western margin of the Onega Lake basin. The formation of the structural-denudation ridge was triggered by the evolution of a thick gabbro-diabase dyke which cuts Proterozoic quartzitic sandstone. Conspicuous near-vertical scarps, tens of metres in height, facing the Onega Lake basin, occur in the rock massifs that make up the south-eastern end of the ridge (Fig.1, Fig.2, fragment 1). The continuous fragments of the scarps within the massifs stretch for 3.5-4.5 km. Over 50 years ago they were interpreted as having been produced by neotectonics [Biske, 1961]. This interpretation seems to be correct. The smooth surface of the scarps and glacial striation on them are indicative of their dominantly preglacial evolution. Distinctive landforms, such as seismogenic trenches in the bedrock, are occasionally encountered under the scarps. One trench, extending along the base of a scarp, is near Shcheleiki Town (Fig. 2). The glacial processing of its flanks supports the preglacial evolution of major deformations.

Characteristic signs of post-glacial seismic renewal in both rocky material and loose sediments indicate young, post-glacial movements of impulsive nature. The seismogenic deformations encountered in the investigated region (in accordance with the terminology and classification of A.A. Nikonov) in rock formations include: 1) cracking or "cleavage" in which the rocky material is broken by tension cracks, the orientation and parameters of the expansion of which correspond to both the fracture of the massif, and with the direction of passage of seismic waves; 2) displacement of the blocks separated from the array by laterals; 3) knocking out rock fragments from the array along laterals (with blocking of blocks in the array after passing a seismic pulse); 4) collapses of single large blocks with their removal from the massif; 5) directed at an angle to the normal avalanche loops. In most cases, the deformations are paragenetically related series.

The most characteristic deformations are shown on an arbitrary profile (Fig.2), which illustrates the type relations of the deformations (fragments) of the neotectonic scarp, inclined and straightened rock surfaces and accumulative lacustrine sediments.

Vertical neotectonic scarps (Fig.2, fragment 1) look like steep (up to 70-80°) 20 to 50 m high walls elongated in a near-north-south direction. Some of the scarps form steps produced by subsiding blocks, 5-10 m in length and up to 2-3 m in height. A characteristic seismogenic trench (Fig.2, fragment 3) cuts a gently dipping (3-5°) slope, which was formed near the base of the scarp and is oriented along it. The trench is 3-5 m deep, 5-8 m wide and 30-50 m long.

An interesting deformation structure is exemplified here by a column detached by a crack from the massif. It consists of several blocks resting on each other so that one block is shifted relative to another (Fig.2, fragment 2). Sharply angular fragments are jammed in vertical fractures. The "column" is 5 m high. Its base is displaced by 0.5 m from the massif along the subhorizontal rocky base. It should be noted that the slabs, resting on the "column", are displaced at 20°, i.e. largely along the wall. This structure could have been formed by shaking during an earthquake. Blocks with their bases shifted from the wall at 20°NNE and 50°NE and their tops resting on the wall occur near the "column". A north-eastern trend (30-60°) is characteristic of detached big blocks (up to 3-4 m across) and directed collapse trails (50°). However, both individual blocks (up to 4 m across), cut out from the scarp base and let move around freely over the subhorizontal surface, and benches of slabs about 2.5 m in height, cut out from the massif by 20-30 cm and jammed (Fig.2, fragment 4), also display clear signs of northerly displacements.

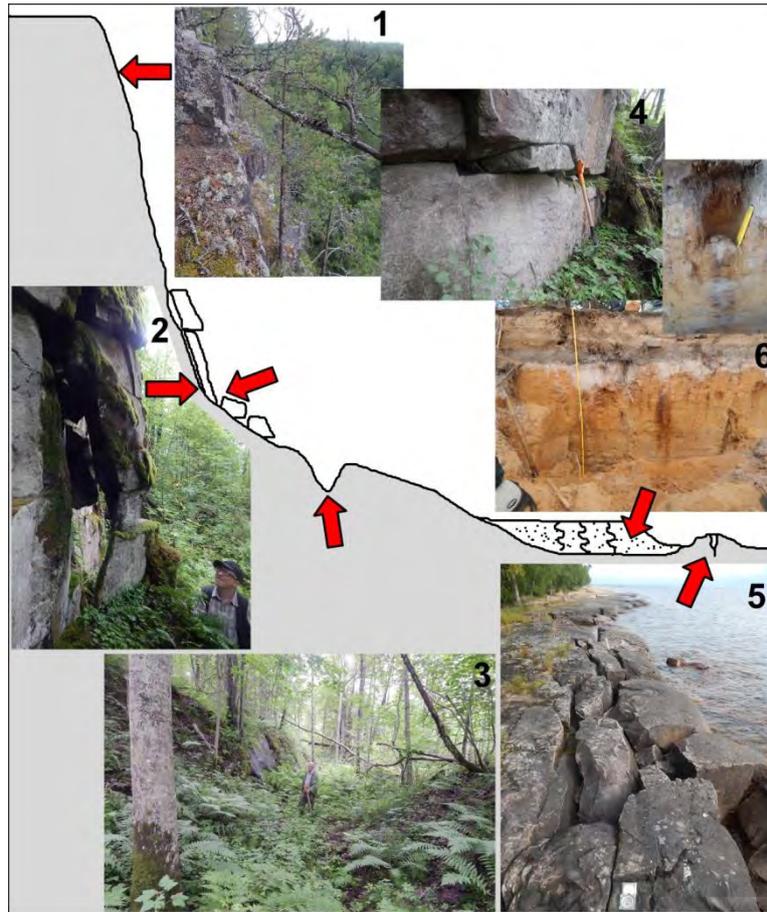


Fig.2 Conditional standard profile of the neotectonic ledge with the location of the main deformations.

In addition to «fresh» (postglacial) crushing on and near the scarps, extensive open fractures in the coastal zone of Lake Onega were encountered (Fig.2, fragment 5). One NNW-trending ($350\text{-}355^\circ$) fracture, extending for over about 100 m and consisting of several subparallel 10-20 cm wide branches, cuts off blocks, 0.5-1 m in width and up to 2 m in length. The blocks are shifted systematically at $50\text{-}60^\circ$ by 25-30 cm.

The fact that the blocks are displaced in north-eastern and northern directions clearly contradicts with the possible glacial or gravity transfer mechanism and suggests either two consecutive impulses or the shearing kinematics of displacements, because they are directed along rejuvenated N-S-trending scarps. Available data are too scanty to precisely date the deformations studied. However, the area seems to have been seismically active not only in Late Glacial time (an active relaxation period after ice melting) but also in the Holocene. This assumption is supported by D.S. Zykov [Zykov, 1997], who found hydrolaccolith, which cuts a sand sequence, in 2.5 thick terrace deposits. Such a hydrolaccolith is typical of liquefaction structures produced by earthquakes.

We have found traces of the intense redeposition and scour of bottom sediments in a 2-3 m thick terrace accompanied by undulating deformations along the shore presumably associated with a tsunami-type seismic effect on the perturbation of the aquatic environment. The redeposited sand and fine gravel were formed 4.5 ± 0.4 thousand years ago, as shown by IC-OSL dating (RLQG 2506-058, Molodkov, 2018).

Traces of active fluidization observed upwards in the same terrace strata over a large distance, are indicative of subsequent tectonic activity. These are overlain with scour by sediments dated at $ca. 720\pm 70$ years (^{14}C) (IGAN 5118) or 1270 ± 50 cal. y.a. and interpreted as the upper boundary of the textures revealed in unconsolidated sediments.

Shoksha quartzite. Since the end of the 18th century in the southern Lake Onega area, there have been a few fields of quartzites, the most interesting one of which is located near a Vepsian village called Shoksha (3 km to the east). Old quarries and quartzite outcrops are nature monuments of federal importance. Since then, the famous Shoksha porphyry deposit has been gradually worked out. However, in the Brusnenskiy Monastery area, the quarrying of so-called "blue stone" (sandstone used to make millstone, whetstone and paving-stone) was launched. For a long time, the Brusnenskoye deposit has been known as "a golden hill". A shop, sell items made of Shoksha maroon quartzite, was opened in St.Petersburg.

Shoksha quartzite is fine-grained, solid, durable ornamental and facing stone. Dark-crimson quartzite, known as Shoksha porphyry, was particularly valuable. Quartzite blocks, presented to France by Russia in 1847, were used to erect Napoleon Bonaparte's tomb in Paris, the pedestal of the monument to Nikolai I and the columns in the hall of the Old Hermitage in Saint-Petersburg. Rare natural rocks were used in to decorate many famous buildings in Petersburg. One example is black graphite slate from the north shore of Lake Onega. Another example is red Shoksha quartzite quarried near Shoksha village. The monumentality of the southern facade of Mikhailovsky (Engineers) Castle is emphasized by a wide frieze made of deep-crimson Shoksha porphyry (Shoksha quartzite). The stones were used to incrustate and decorate Lenin Mausoleum in Moscow. Blocks, slabs, and macadam are also made of Shoksha quartzite.

Shoksha quartzite is typical of the formation of the same name. Old pits and modern quarries are located on the Shoksha Peninsula on the Lake Onega shore. The old pits expose the top of the Petrozavodsk Formation, which consists of grey-coloured enequigranular quartzo-felsphatic sandstones with conglomerate lenses containing quartz, quartzite and iron-cherty rock pebbles. Fine-grained sandstone contains magnetite-, zircon-, tourmaline-bearing interlayers. Quartzo-felsphatic sandstones are overlain by lilac quartz sandstone of the Shoksha Formation with quartz conglomerate at the base. The quartz sandstone unit is succeeded upwards by a red-coloured siltstone and quartz sandstone unit, a crimson quartz sandstone unit and a pink-coloured quartz sandstone unit at the top. The red colour of the rocks is due to the iron dioxide coating of the quartz grains. There are numerous symmetric ripple marks and mud cracks on the bedding planes, as well as various types and sizes of cross-cut and horizontal bedding. The palaeoenvironmental interpretations proposed are a low energy tidal-supratidal sandflat for sandstones with wave ripples and siltstones with mud cracks, and a meandering fluvial system on a coastal plain for cross-stratified sandstones with asymmetric ripples.

References:

Biske G.S. Contribution of tectonics to Karelia's geomorphology // Problems in the geology of Karelia and the Kola Peninsula. Murmansk: Murmansk Publishers. 1961. P.32-42

Zykov D.S. On active structures and probable paleoseisimodeformations in Karelia // Geomorfologia. 1997. no.3. P.58-62.

Translated by G. Sokolov

TRIP TO LADVA-PAJ

Pogosyan, L.A.^a, Gerasimova, M.I.^b

^a *Instituto de Geología, Universidad Autónoma de México, Cd. Universitaria, 04510, Cd. de México, México, Posgrado en Ciencias de la Tierra*

^b *Moscow Lomonosov University, Faculty of Geography*

E-mail: lilit-tos@yandex.ru

The region is located in the southern climatic zone of Karelia, which is characterized by earlier spring and later autumn than the rest of Karelian territory. The air and soil temperatures are higher than in other regions, and it leads to some peculiarities of soil formation in the area. The period with the temperature over 5°C is 140-160 days long, and there are more than 100 days a year with the temperature higher than 10°C. The number of days with the temperature above 15°C is relatively stable in this area. The first frosts start in the second half of September or even in October. The last frosts were recorded in the mid-May. Frost-free period lasts 110-140 days. The mean temperature of February is -10°C, and that of July is +16.6 to +17°C. Stable snow cover is established in the second half of November and sustains to the end of May. The snow cover depth is 40–70 cm. In summer, northern and northeastern winds prevail, while in winter – western and southwestern ones. Summer precipitation is 250 mm, and annual precipitation is 600 mm.

The denudation-tectonic hilly and hilly-ridged moderately swamped landscapes with spruce forests prevail in the region. The route passes through the Onega-Ladoga watershed plain. The surface of the plain is relatively smooth, swamped, with occasional hills and ridges. The plain comprises the *Shuya depression* in the north and is inclined to the Onego Lake in the northeast. To the east of our route, the *Shoksha ridge*, about 70 km wide, composed of quartzite and red sandstone is seen. The maximum absolute altitudes reach 210 m, and relative altitudes range within 60-100 m. The ridge consists of dome-like hills and is descending the Onego Lake by a series of terraces.

Geologically, the territory is characterized as *Western-Onega uplifted massif* originated due to tectonic activity in the zone of a Lower-Proterozoic syncline that existed at the contact of the Fenno-Scandian shield and the Russian platform. The massif was uplifted in the Mesozoic, and reworked by the glacier. To the west from the Onego Lake there is *Ladva lacustrine depression* which occupies a relatively small area, and is filled by loams and varved clays. Rock outcrops can be found only on the shore of the Onego Lake.

The crystalline basement is directly covered by the Luga moraine of the Valdai glaciation; it is mostly sands or sandy loam abounding in boulders, clay loams, locally sands.

Boulder sands (and loamy sands) occur in the northern part of the region, and are characterized by a high amount of coarse fragments, up to 70% of the moraine material; rock outcrops (mainly gabbro) are infrequent, they disintegrate producing a lot of non-weathered blocks of various size. The content of particles < 0.01mm hardly reaches 5%. The primary minerals in the fine earth are presented by quartz, potassium feldspars, plagioclases, and micas; the clay fraction is dominated by illite. The chemical composition of boulder sands inherits that of granites; with iron and magnesium contents being slightly higher in the fine earth.

The data on the mineralogical and chemical composition of boulder sands indicate that they originated by mechanical destruction of rocks, and were subjected to a very slight chemical weathering. The soils formed on these sands are rich in weatherable minerals.

Boulder sandy loams have less skeletal particles and more silt and clay particles. The content of the fraction less than 0.01 mm varies from 8 to 16%. The chemical composition of boulder sandy loam is similar to that of boulder sand; it evidences the similar origin of these sediments. The most important minerals are quartz and potassium feldspars. The fine fractions contain illite and other clay minerals. A high percentage of mica indicates that the initial materials for these sediments were metamorphic rocks, such as gneiss and granite-gneiss.

Clay loams contain a lot of silt and clay particles; skeletal fragments are rare or absent. The mineralogy is characterized by a high proportion of biotite, muscovite, and amphiboles. Clay

fraction has a mixed illite and kaolinite composition. The chemical composition of clay loamy moraine differs from that of coarser sediments by the lower content of silica (70%), and higher content of aluminum and iron; though, its composition is also close enough to that of acid igneous and metamorphic rocks (granite, granite-gneiss). The presence of illite and kaolinite indicates the importance of chemical weathering in the formation of these sediments.

All the glacial sediments have much in common in their chemical composition, because of the similar origin of their initial material. The coarser sediments are abundant in the northern part of the region, the southern part is characterized by the presence of finer and more sorted material.

Of special interest in this area are the limnoglacial sediments that are characterized by fine stratification and sorting; they are common in the Ladva limnoglacial plain. The content of particles < 0.01 mm is about 85% there. The main minerals in the varved clays are illite, quartz, and amphiboles. Less important minerals are muscovite, biotite, goethite, plagioclases, tourmaline. The chemical composition is characterized by higher iron and lesser silica content than that of glacial sediments.

The vegetation of the region is relatively diverse. There are 15 types of forests there – 12 primary, and 3 secondary types – which makes up for 41% of the whole diversity of forest types in Karelia. Forest sites with ‘dry’ soils occupy about 7% of the territory, with ‘fresh’ soils – 54%, with ‘humid’ and ‘moist’ soils – 23%. The area of the primary *Piceeta* sites is over 66%. In the composition of the vegetation cover, the *Piceeta* forests are the major ones, covering 70%, followed by *Pineta* forests (23% of the total forested area). Among the spruce forests, *Piceeta myrtillosa* fresh (43%) and humid (17%) forests are prevailing. Among the pine forests, the following types are common: *Pineta myrtillosa* rocky (22%) and humid (17%), *Pineta vaccinosa* rocky (20%) and *ledosa-sphagnosa* forests. The deciduous forests are dominated by *Betuleta graminoso-vaccinosum* forests. The pattern of enumerated forest types is very mosaic owing to the hilly topography, which is responsible for a great diversity of sites in the landscape.

The soils of the landscape are formed on sediments with underlying rocks relatively close to the surface; still, they are not close enough to change the classification position of the soils. In the southern part of Karelia, in the region of Onega-Ladoga Lakes divide, loamy soils with *argic* horizon are widespread. In upland sites, there are Albic Luvisols (or Albeluvisols) formed on boulder loamy sands and loams. In some places bedrocks (quartzite and gabbro) crop out to form Leptosols. Soil formation is greatly affected by the heavy texture of the parent material; thus, significant areas are occupied by Gleyic Luvisols. The Histosols and Histic Gleysols are confined to depressions with clay loams, and, more rarely, with sands as parent materials.

The soil is formed on loamy moraine under spruce forest. The soil has an *argic* horizon, which is identified both by data of particle-size and micromorphological analyses (Fig. 1, Table 1).

The micromorphological evidence permitting to qualify the soil as Luvisol. As for Gleyic qualifier, the pedofeatures related to iron mobilization are common and diverse (segregations, flakes, coatings).

The profile is peculiar by mineralogical richness, abundance of weathering phenomena, transformation of coatings.

The morphological examination of the profile shows distinct bleached tongues that occupy more than 10% of total area of subhorizon. Because of the presence of the *fragic* horizon, the profile should be classified as Fragic Albic Retisol Cutanic Differentic.



Fig. 2. Ladva-Paj soil perfil photo by John M. Galbraith, 2nd Conference for Soil Classification – Aug. 2-8, 2004, Petrozavodsk, Karelia (Russia) Additional Field Tour Notes Concerning Soil Taxonomy Classification

Micromorphological characterization.

E 8-20 cm.

Very light in colour, apedal, c/f related distribution. The colour may be qualified as ‘bleached’, only a few plasma-enriched microzones are weakly pale. The size of skeleton grains varies strongly – from 1-2 mm to 0.05, their distribution is irregular, although some bleached silt-sized grains tend to arrange in (cryogenic?) circles. The mineralogical composition is rich and diverse¹; there are many weathering features, more related to iron release than to clay pseudomorphs. Many iron nodules with clear forms and boundaries and microrootsteins with skeleton grains and irregular boundaries, weathering films and clusters of flakes.

Clay coatings are common, they are homogeneous in texture and differ in colour (bleaching) from a light pale brown to bright brown; coatings fill in the pores, mostly packing voids among mineral grains, sometimes there are coarse grain coatings. Their birefringence is weak to medium.

EB 20-35 cm.

There are two types of microfabric, with few iron pedofeatures in both.

One microfabric type resembles the above horizon – it has a porphyric c/f related distribution with a more elevated proportion of plasma; it is obviously heterogeneous in colour – light brown and whitish pale mottles are alternating. Very weak pedality – small rounded aggregates may be sometimes identified. Many brown clay coatings within the groundmass with degradation features – they are separated into fragments (layers), while their fluidal appearance is rare.

The second microfabric type is peculiar by lesser share of skeleton grains, and their more homogeneous size (plasmic-silty fabric), the groundmass is also more light in colour. Coatings are common, they are also fragmented into strata when being located in voids or adjacent to grains; some coatings are assimilated, although the share of such is lower as compared to the above horizon. Coatings seem to have a greyish hue.

¹ Feldspars, epidote, mica, hornblende, even micrite inclusions were encountered.

Presumably, in both fabric types part of clay coatings may derive from weathering phenomena, and this is more clearly seen in the lower horizon. It is not improbable that the first type of fabric corresponds to the degradation zone (or EL/BT interface), it may be indicated as 'mottled ELBT', the second – to whitish tongues filled with bleached material of finer texture than the enclosing horizon. Therefore, coatings are more fragmented there.

EBx 35-40 cm.

In the fragic horizon the nodules are few, they are smaller and have an irregular shape and diffuse boundaries. This horizon is compact and has no platy structure. There are no both eluvial and illuvial features, because also clay coatings are absence, they appear more deep in the profile.

Btx 40-50 cm.

This horizon is also very compact. It has a lot of clay coatings, that are laminated with strong interference colours and have less or more the same look and pack all the space in pores. Also there are some Fe-Mn nodules, but they have an irregular shape and diffuse boundaries.

Unlike the above horizons, the microstructure is weak to moderate: peds are angular blocky, and are pronounced in less skeletal microzones. Rock fragments are common, their size may reach 2 mm, weathering phenomena are diverse and abundant, including thin clay pseudomorphs. As for the porphyric c/f related distribution, the groundmass is composed of coarse fragments, sand grains and plasma, silt-sized grains are few.

Clay coatings are bright brown with clear stratification, medium to high birefringence, they mostly occur in voids, even in biogenic channels, some are adjacent to coarse rock fragments ('penetrating into the skeletal microzones'). Along with small and medium, there are coarse coatings – 1 mm in width; the majority of coatings are pure, in few cases inclusions of skeleton grains are found. Some coatings are accompanied by papules of the same appearance. Among the latter, papules of a weathered shale are found ("lithocoating").

Iron neoformations are few: fine 'pure' coatings and clusters of flakes on weathered rock fragments.

Bt 50-80 cm.

Similar to the above horizon. More brown, the size and number of coatings decreased, papules derived of weathered micas or slates are common. Single large coating along the decayed root. The distribution of papules and iron oxides flakes produced in the course of weathering is dictated by the rock fabric.

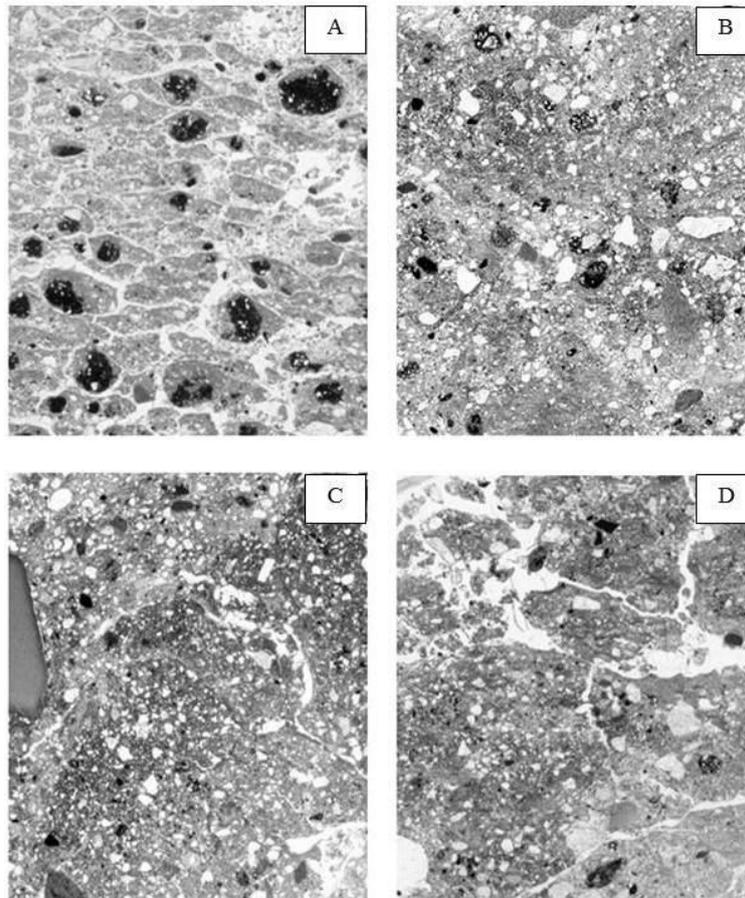


Fig. 2. Microphotographs of the horizons of “Ladva” profile: A – E horizon; B – EBx horizon, C – Btx horizon, D – Bt horizon.

Table 1. Chemical properties of soils of “Ladva” site

Horizon	Depth, cm	pH _{H2O}	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	EA	BS	CEC/kg of clay	C	N	C/N
			cmol•kg ⁻¹							g•kg ⁻¹		
AE	5-8	4.8	1.5	0.4	0.8	0.2	2.7	52	41.3	6.0	0.2	30.0
E	8-20	5.1	2.1	0.7	0.4	0.8	2.7	60	71.9	2.2	0.5	4.4
EB	20-35	5.2	2.5	1.7	0.4	0.3	3.6	58	73.9	2.4	0.6	4.0
Btx	40-50	5.8	4.1	2.8	0.4	0.6	2.7	75	60.7	1.6	0.6	2.7
Bt	50-80	6.2	5.6	3.6	0.4	0.2	2.7	78	62.2	1.2	0.4	3.0
BC	90-105	6.3	5.9	3.5	0.4	0.2	2.7	79	148.3	1.4	0.1	14.0

Table 2. The texture of the soils of “Ladva” site (Russian particle size classification: Vadyunina, Korchagina, 1973)

Horizon	Depth, cm	1-0.5	0.5-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	FAO textural classes
AE	5-8	14	14	21	25	8	12	5	Loam
E	8-20	6	15	27	23	8	14	7	Silt loam
EB	20-35	6	14	19	17	9	15	19	Clay loam
Btx	40-50	10	11	19	22	8	11	18	Loam
Bt	50-80	12	12	16	21	8	13	17	Clay loam
BC	90-105	10	16	20	21	8	11	13	Loam

Reference:

Field Workshop Guidebook of the International Conference (August, 3-8, 2004, Petrozavosk, Karelia, Russia). Petrozavodsk, 2004. - 34p.

2nd excursion day. August 22
TRIP TO GIRVAS

Shelekhova, T.S., Svetov, S.A., Medvedev, P.V.
FIC KarRC RAS Institute of Geology, Karelian Research Centre, RAS, Petrozavodsk,
Pushkinskaya str., 11, RUSSIA
E-mail: shelekh@krc.karelia.ru

Stop 1. Sulazhgora (Sulazh Hill) glaciofluvial delta

The delta is located in the northern environs of Petrozavodsk. Standing on the top of the hill, a visitor will enjoy a spectacular view of the Shuya Lowland (40-75 m.a.s.l.) and the Solomennoye denudation ridge (122m.a.s.l.).

The delta consists dominantly of ca.40 m thick sandy, occasionally gravel sediments. In the southern part of the delta, deltaic sediments are covered by ablation till. The laminae dip at 15 to 40 degrees. The material was transported from west to east. This big delta evolved in Middle Dryas (Neva cold stage) - early Allerod time, when the ice front rimmed the northern and eastern slopes of the so-called Olonets denudation uplift at an altitude of 120-313 m.a.s.l. The Shuya Lowland was already ice-free at this time and was covered by meltwater from Shuya Ice Lake. The lake had an outlet to the east into Onega Ice Lake located in the southern part of modern Lake Onega and adjacent lowlands. Delta was formed between the ice front on the north and bedrock uplift on the south. It looks like a glaciofluvial terrace, 3 km in length and up to 2 km in width. The maximum altitude of the delta is 117 m.a.s.l. It shows the maximal level of Onega Ice Lake at this time. The northern slope of the delta is very sharp because it was formed at the contact with the ice front. Paleomagnetic measurements of a varved clay sequence north of the Sulazhgora delta (Bakhmutov et al, 1986), and new data on the age of a western declination peak in Onega Ice Lake sediments (Saarnisto&Saarinen, 2002) have led us to conclude that the ice front retreated from the delta and varved clay deposition began about 11800 C14 years ago.

At about 11200, the ice front retreated from the Lake Onega - White Sea water divide and Onega Ice Lake acquired a lower threshold to the north into the White Sea basin. The Ice Lake level dropped to ~ 20-30 m over a short time and stabilized at ~ 95 -85m a.s.l. Offshore formations on these levels are well known both in the Petrozavodsk area (~85m) and on the northern shore of Lake Onega between Povenets and Medvezhyegorsk (~95m).

The rapid decline of the lake level and changes in drainage direction (previously, Onega Ice Lake had discharged to the south-west along the ancient Svir River) provoked an intensive mixture of oxygen-enriched surface water and oxygen-poor bottom water in Onega Ice Lake. Rapid changes of hydrochemical conditions, followed by oxidation of sediment ($Fe^{2+} \rightarrow Fe^{3+}$) at the water-sediment contact triggered the formation of a so-called pinkish-brown varved clay horizon slightly enriched in iron. The layer is 15-20 cm thick, displays a sharp, erosion-free lower contact and a gradual upper contact. The layer is in the upper part of a varved clay unit in Lake Onega. It is a reliable stratigraphic marker reported from 15 boreholes in Onega Ice Lake deposits. Radiocarbon measurements (AMS method) have shown that it formed about 11 200 C14 years ago (Saarnisto & Saarinen, 2002; Wohlfarth et al, 1999).

The trip continues at the western flank of the Onega Structure (OS).

The Onega Structure is dominated by Paleoproterozoic (2.5-1.7 Ga) sedimentary, volcanic and intrusive rock sequences.

The Onega Structure is dominated by Paleoproterozoic (2.5-1.7 Ga) sedimentary, volcanic and intrusive rock sequences.

Stratiform rock associations make up six suprahorizons (Sumian, Sariolian, Jatulian, Ludicovian, Kalevian and Vepsian) preserved to a varying extent (from old to young). The age boundaries of the suprahorizons (see Table 1) and their geochronological equivalents are shown on a regional chronostratigraphic scale [General stratigraphic..., 2002].

Table 1. Subdivision of the Lower Proterozoic in Karelia on the General Precambrian Stratigraphic Scale of Russia.

Age of lower boundary, Ma	Type stratigraphic units (suprahorizons) of the regional stratigraphic scale of the Lower Proterozoic:	Local units:
1800	Vepsian	Shoksha suite
		Petrozavodsk suite
1920	Kalevian	Ladoga series
2100	Ludicovian	Suisari suite
		Trans-Onega suite
2300	Jatulian	Tulomozero suite
		Medvezhyegorsk suite
		Yangozero suite
2400	Sariolian	Seletsk suite
		Vermas suite
2500	Sumian	Ozhijarvi suite
		Tunguda suite
		Okunevo suite

During this field trip participants will see the Paleoproterozoic rock associations of the Ludicovian and Jatulian complexes in the Onega structure. The bus will drive down Highway R-21 Kola (M-18) and R-15.

It should be noted that these are Russia's and Karelia's classical geological localities, where Academician Grigory Helmersen, the first Director of the Geological Committee of Russia, took his first trip to the Olonets Province in June-July 1856. The aim of his trip was to examine the most important old mines, to assess their possible use and to compile a geognostic map of the Olonets Mining District with Petrozavodsk in its centre.

Stop 2. Shuiskaya Station

The hill at Shuiskaya Station and Mount Bolshaya Vaara, seen from the hill and located on the opposite shore of Petrozavodsk Bay of Lake Onega, consist of ca. 1.95 Ga agglomerate tuffs of plagioclase and pyroxene-plagioclase basalt of the Suisari volcanic complex. These rocks are also known as Solomennnoye breccia, which has been used since the early 18th century in architecture to decorate many buildings, e.g. the interior of the Isaac Cathedral in St.Petersburg.

Standing on the hilltop, participants will enjoy a beautiful view of the plain (Fig.1), which hitherto was the old floor of Lake Onega (together with the periglacial Shuya Lake basin) between 11000 and 6000 years ago, when the shoreline was 35-44 m higher than the present one. Seen far away are the outlines of Petrozavodsk Bay of Lake Onega and part of Lake Logmozero. When the glacier retreated from Petrozavodsk ca. 11 700 y.a., two large periglacial lakes, namely Lake Shuiskoye located in the Shuya River valley, and Lake Onega located at that time in the southern part of what is now Lake Onega, the Vodla River valley and the southern Lake Onega area, joined. The water level of this periglacial basin in the Petrozavodsk area was at an absolute altitude of 85 m (the present Lake Onega level is at an altitude of 33 m). Thus, most of the area discussed was covered by its cold water. It is important to point out that the road leading to Stop 1 extends along an abraded morainic ridge, about 450 m in width and 2 km in length. Facing old Lake Onega are boulders washed out from moraine and scattered on the eastern slope of the ridge. Most boulders are 40-50 cm in diameter, but some are up to 1-1.5 m across. 10- to 15-cm thick washed-out sand lenses occur under a soil-plant layer. These are underlain by ca.60 cm thick greyish-yellow sandy, unconsolidated moraine, which, in turn, is underlain by highly consolidated grey sandy loam. The strand (wavecut platform) passes eastwards into a paludified lacustrine-

glacial plain composed of varved clay. The edge of the strand is at an absolute altitude of 44 m and the rear suture (water edge) is at an altitude of 35 m. The absolute altitudes indicate that the strand was forming from about the mid-Atlantic to the early Sub-Atlantic Period of the Holocene (6.5 – 2.7 thousand years ago). The Onega Lake level varied considerably but generally declined: the Atlantic regression of the lake was followed by short-term transgression in the Subboreal Period. The formation of glacial deposits was largely responsible for the modern topography of the area and the discrete exposure of Precambrian rock complexes.

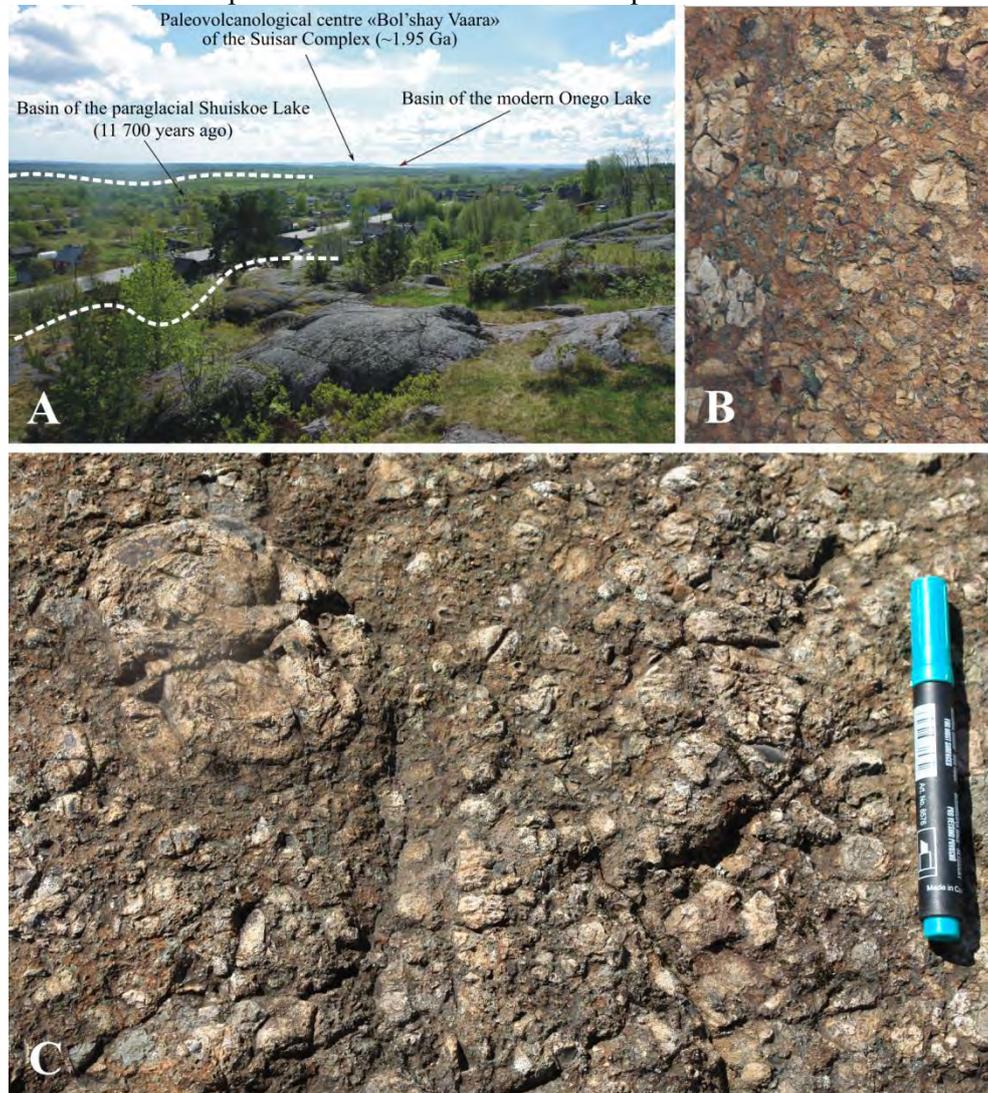


Fig. 1. View from the hilltop at Shuiskaya Station (A) and rock lithotypes of Suisari volcanogenic rocks (B- agglomerate tuffs, C-scarce bombs in agglomerate tuffs).

Agglomerate tuffs that make up the hill at Shuiskaya Station (Stop 2) consist of plagioclase and pyroxene-plagioclase basalt, which contains numerous sharply angular fragments and less common rounded clasts supported by the finely divided matrix. The tuff sequence at this locality is about 30 m thick.

Suisari rocks will also be seen in road cuts at the intersection of Highway R-21 Kola and R-15 (turn-off to Girvas Town). The pyroclastic sequence at this locality (Stop 2) is formed as alternation of fine-grained tuffs with agglomerates and coarse bomb tuff horizons (Fig.2).

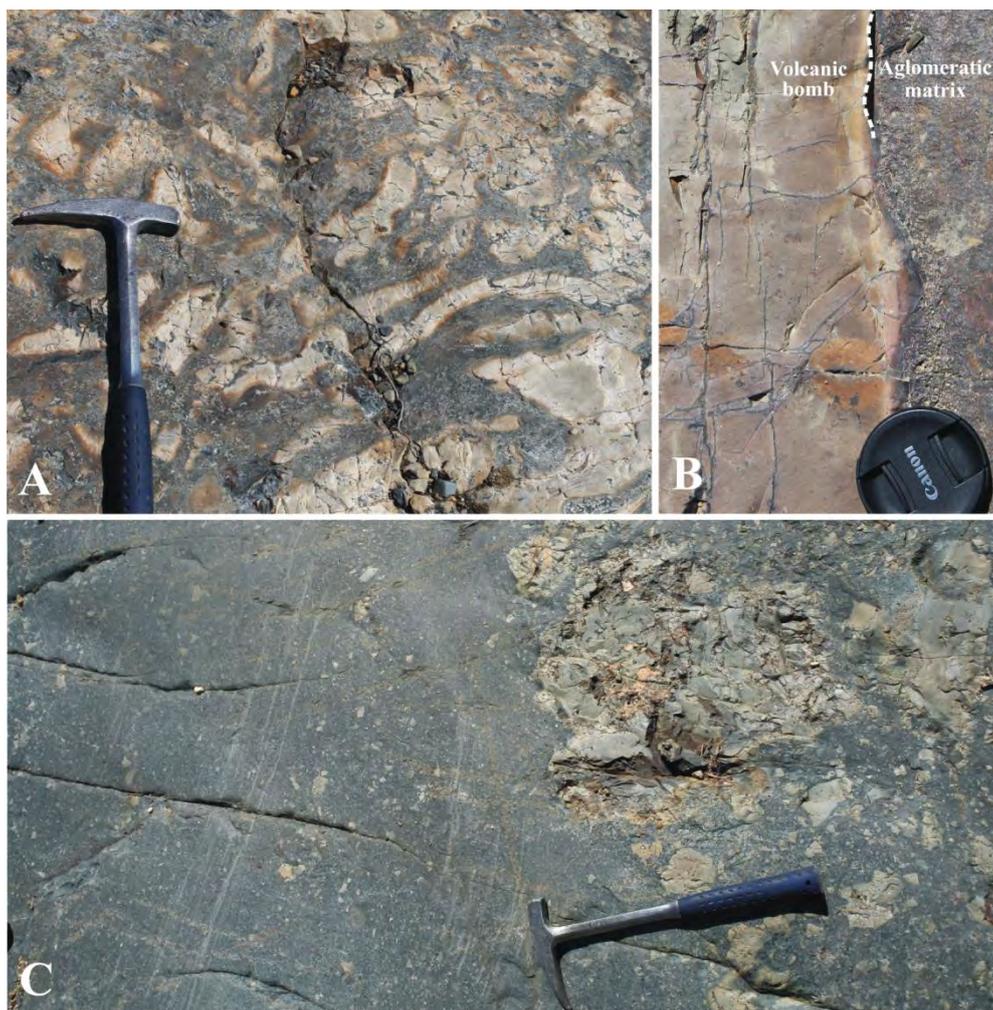


Fig. 2. Rock lithotypes of the agglomerate sequence of the Suisari complex (road cut, turn-off to Girvas). A – flat lenticular bombs in agglomerate matrix; B- chill zone of a large volcanic bomb; C- local stratification pattern of a pyroclastic sequence (succession of fine agglomerate and bomb tuff layers)

The agglomerate sequence, which contains tuff interlayers of various sizes, is exposed in road cuts. Pancake-like bomb tuffs, often “flattened”, are common here. The bombs vary in size from 10-15 to 150 cm along the long axis. The bombs have thin to thick (up to 3 cm thick) chill zones, which reflect changes in eruption conditions and a difference between the temperatures of the matrix and volcanic explosive bomb material. Some of the bombs display internal cavities that contain recrystallized quartz-carbonate material.

Stop 3. Shuiskaya Chupa

The rocks that underlie the Suisari suite are exposed at Shuiskaya Chupa (Konchozero Lake shore). They make up the upper unit of the Trans-Onega suite, where several andesite-basalt, trachyandesite-basalt, and lesser basalt lava flows, up to 10 m thick, are interbedded with tuffaceous-sedimentary rocks that contain carbonaceous rock lenses.

Three more lava sheets of the Trans-Onega suite, interbedded with tuffaceous-sedimentary rocks, were revealed at Shuiskaya Chupa, above the sheet described above.

The key sequence of the overlying 389 m thick Suisari suite in the Konchezero-Ukshezero area (Konchezero volcanic zone) was revealed, based on cores from borehole 5 drilled by the Karelian Geological Survey 420 m south-east of Lake Angozero. V.S.Kulikov and B.S.Lavrov (1999) identified five volcanogenic rock members in this sequence varying in chemical composition. Participants in the field trip will see the rocks that constitute the first (Shuiskaya Chupa) and second (Tsarevichi) members.

Occurring near the south-western roadside of the Highway Petrozavodsk-Girvas in the first member is a so-called transitional unit composed of tuffaceous-sedimentary rocks, in which a 0.5-1.5 m thick horizon with coarse-clastic rock beds (2-3) (conglomerates and gravel stones) was encountered. The clasts consist dominantly of Trans-Onega volcanics and sediments (plagiobasalt, andesite-basalt, shungite, etc.). V.S.Kulikov described this horizon as the basal bed of the Suisari suite. Compositionally similar psephites were revealed at the base of the Suisari suite and in other parts of the first member of the suite (Solommenoye Town, Peski Airport, Lake Karelskoye, Lake Surgubskoye, Ternavolok Village, Suisar Island, etc.).

The sequence of the first member of the Suisari suite displays areal facies variability. At Shuiskaya Chupa, this member consists of mafic tuffites (0.5-15 m thick) and tuffs (breccia) of aphyric basalt (over 20 m thick) occurring above Suisari basal conglomerates on the ridge, which extends north-west along the Highway Petrozavodsk-Girvas. The rocks dip SW at 45-80°.

Stop 4-5. Tsarevichi Village

The second member of the Suisari suite is most complete at Tsarevichi, where it is over 100 m thick and actually constitutes the entire isthmus between Lakes Konchezero and Ukshezero. The village was called Tsarevichi in honour of the Emperor Peter the Great, who used to stop over here on his way from St.Petersburg to Martian Waters health resort. To commemorate his visits, a chapel was built on the northern side of the highway (Fig.3).

The lower portions of the member consist of three augite melabasalt flows (9-13% MgO) interbedded with similar tuffs exposed on the Konchezero side of the isthmus.

Stop 4. (Tsarevichi village, Konchezero Lake shore). Before entering Tsarevichi village, the bus will stop to let participants look at agglomerate tuffs exposed at the contact with pillow basalt lava with thin (up to 1m) tuff-tuffite horizons (lenses) (Fig.3).

Stop 5. (Tsarevichi village, Ukshezero Lake shore). The Ukshezero side of the isthmus is made up of several tuff and picrobasalt beds and thin (up to 3-5 m) massive picrobasalt flows. The rocks dip SW at 40-60°.

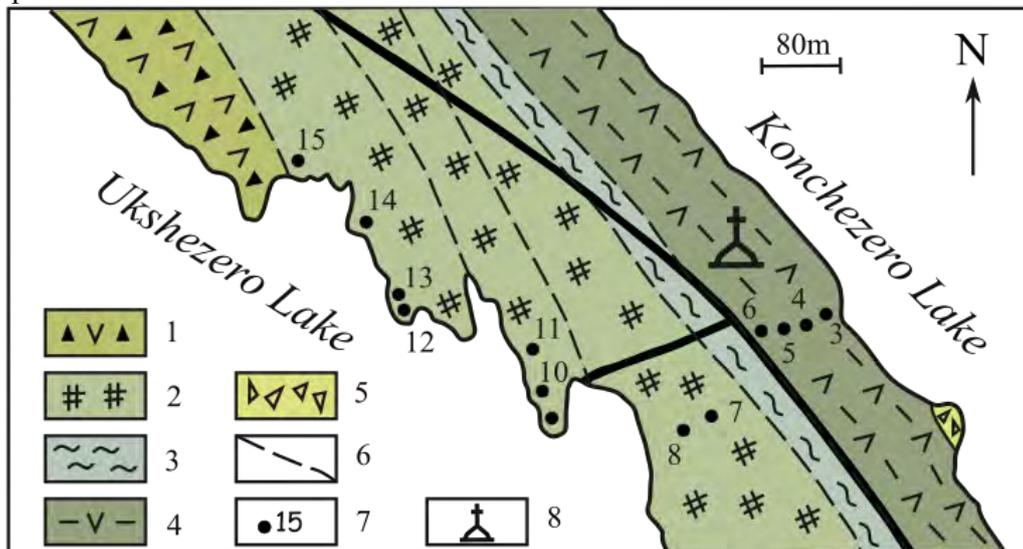


Fig. 3. Scheme showing the geological structure of Tsarevichi locality (2nd member of the Suisari suite).

Legend: 1 – plagiopyroxene basalt and its breccia; 2 – picrobasalt and its breccia; 3 – tuffites; 4 – melabasalt and its breccia; 5 – basalt tuffs; 6 – geological boundaries; 7 – sample numbers (Table1); 8 – chapel.

The trip continues along the western limb of the Onega trough made up of sedimentary, sedimentary-volcanic, volcanogenic and intrusive (diabase, gabbro-d diabase and ultrabasic) rocks of Lower Proterozoic age. The rocks are thrown into various folds and are broken into a series of axial faults. Both folds and faults generally strike north-east. The area along the route offers a complete idea of the denudation-tectonic and structural-denudation relief so common to Karelia. The relief is composed of alternating ridges normally confined to volcanogenic and intrusive rock

exposures. The relief generally displays a linear orientation and the strike of the ridges and depressions are fully consistent with the strike of the structures. The accumulative relief, confined to erosion-denudation topographic lows, consists dominantly of lacustrine, glacio-lacustrine accumulation and abrasion-accumulation planes, isolated moraine and esker ridges and fluvio-glacial deltas.

Stop 6. Mount Sampo. (Svetov at all., Field Guide, 2015). The mountain was called Sampo because a feature film, based on the Karelian-Finnish epos “Kalevala”, was being shot here in the 1960s. Sampo is a magic mill, a source of happiness, well-being, and profusion.

Occurring along the Petrozavodsk-Girvas Highway, near Kosalma (north of the village outskirts) and on Mount Sampo, are mafic rocks (Suisari suite) formed as a series of alternating lava flows and agglomerate tuffs with thin sedimentary intercalations.

The top of the ridge on the isthmus between lakes Ukshozero and Konchozero provides a good view which gives a good idea of how the ancient structural elements of the crystalline basement are reflected in the relief. Direct and indirect correlations between the relief and the structure can be seen here.

The Ukshezero basin is situated in the central Ukshezero syncline. The core of the structure is made up of arkose and quartz sandstone, siltstone and shale, and the flanks are composed of picrite-porphiryte, tuffite and tuff breccia. In this case, a direct reflection of structure and landforms can be observed (Fig.4). The Lake Konchozero basin displays a linear shape (22 km in length and 3 km in width) and is rather deep (10 to 19m). The basin is confined to the axial part of a linear anticline, whose crown is broken into a system of axial faults. This fault system contains diabase and gabbro-diabase bodies traceable along the axial part of the basin as a chain of islands and underwater bottom swells. In this case, the reflection of structure and relief is indirect.

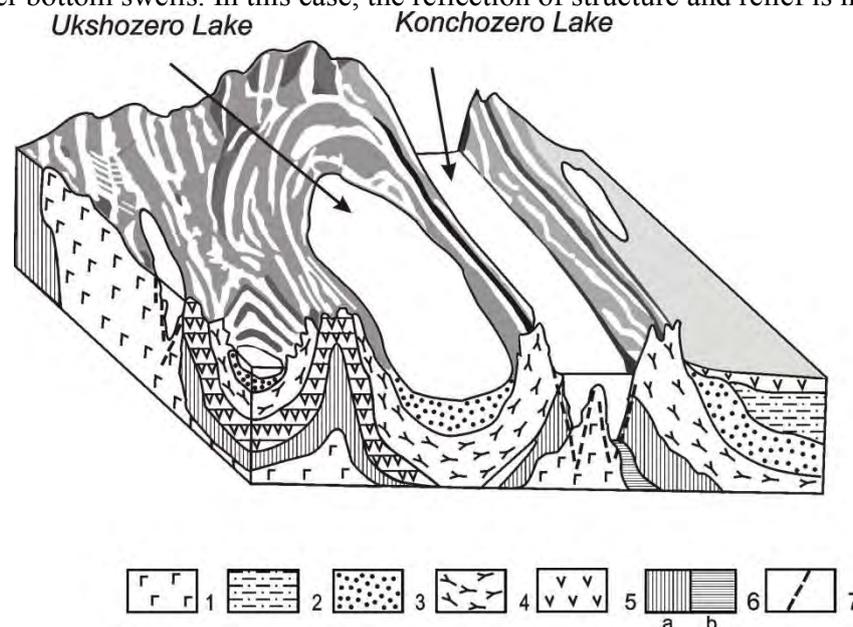


Fig.4. Geological structure of the area Ukchozero-Konchozero

1 – intrusive sheets and dykes of diabase and gabbro-diabase; 2 – schist-sandy rocks; 3 – siltstone, schist, sandstone, conglomerates; 4 - tuffaceous lava rocks; 5 – amygdaloidal diabase and diabase porphyrite; 6 a – shungite shale, limestone, tuffaceous rocks; 6 б - shale; 7 - faults.

Stop 7. Martian Waters Town

Martian Waters, Russia’s first health resort, which became famous for its mineral springs, was founded on 20 March, 1719. The springs were discovered in 1714 by Ivan Ryaboev, a peasant, who worked at a copper smelter. He informed Mr.Genin, Director of Olonets metal-producing plants, about his discovery. Genin sent a letter to the Emperor Peter the Great. In 1717, the czar asked the court physician L.L.Blumentritt to analyze the spring water. A church and a wooden

palace were built near the springs for Peter I, who came here with his family in 1719, 1720, 1722 and 1724.

In 1724, while at the resort, the czar signed a decree on the establishment of St.Petersburg Academy of Sciences and Art (now the Russian Academy of Sciences).

After a preliminary study, mineralized water from the springs, rich in active bivalent iron, was called Martian in honour of Mars, God of War and Iron.

According to A.V.Ieshina, sulphate-type Martian water is formed in the lower hydrogeochemical subzone. Its mineralization varies from 0.27 to 0.67 g/l, and its composition ranges from hydrocarbonate-sulphate-magnesium-calcium-iron to sulphate-hydrocarbonate-magnesium-iron-calcium (Table 2). Its iron concentration is 16-87 mg/l. The presence of the water in the lower hydrogeochemical subzone is confirmed by elevated water mineralization and the composition of dissolved oxygen-free gases. The total gas concentration of 60-80 mg/l is higher than the background value. CO₂ (72-76 vol.%) and nitrogen (22-26 vol.%) are the dominant gases. Martian water is famous as one of Russia's major iron-rich water types with a high active iron concentration and spring flow. It is used in medicine for healing blood, stomach, liver, kidney and metabolic diseases. In addition to Martian water, muds from Lake Gabozero are used here for medical purposes. The muds display anti-inflammatory, spasmolytic, anesthetic and resolving effects and are used to heal diseases of the peripheral nervous system, motion organs and chronic inflammatory diseases.

Table 2. Chemical composition of mineral water from Martian Waters health resort

Constituent s and indices	Unit of measurement	Well 1	Well 2	Well 3	Well 4
HCO ₃	mg/l	96.3	122.6	108.6	134.2
SO ₄	Same	80.7	224.8	261.1	343.7
Cl	"	1.0	1.0	1.1	1.1
NO ₃	"	-	-	-	-
F	"	0.2	0.2	0.2	0.2
Na	"	3.0	4.5	4.5	5.5
K	"	2.3	4.6	5.0	5.7
Ca	"	24.0	39.0	34.0	49.0
Mg	"	14.6	44.4	37.7	45.6
Fe ²⁺	"	16.0	31.0	56.0	76.9
Fe ³⁺	"	Traces			
Mn	"	0.4	0.8	1.0	1.0
H ₄ SiO ₄	"	4.0	10.4	16.6	18.6
Mineraliza	"	242.5	482	525.8	681.5
on	"	-	-	-	-
H ₂ PO ₄	µg/l	-	-	35	35
Al	Same	13	30	25	20
Cu	"	9	23	34	47
Zn	"	13	100	72	150
Co	"	2,5	3,7	4,8	10
Sr	"	43	46	72	100
Ni	"	6	46	72	15
Li	"	10	40	20	20

Note. Resources and geochemistry of Karelia's underground waters. Petrozavodsk, 1987, 151 p.

Stop 8, 9. Raiguba – Pyalozero. During the field trip the participants will be shown Paleoproterozoic sedimentary rock sequences containing organic remains.

The geological localities to be visited first represent the lower part of the Upper Jatulian unit (Onega Formation). The rocks exposed here from the base upwards are as follows

1) Beds with *Lukanoa* (on₁^a). Sandstone with argillaceous dolomite calcareous matrix, pink fine-grained dolomitic limestone, and brown clastic dolomite occurs at its base. These are followed upwards by sedimentary largely dolomitic breccia which contains problematic rounded bodies *Lukanoa* Medv. The total thickness of the beds is 140 m.

2) Beds with *Nuclephyton* (on₁^b) made up of various granular grey, pink and red dolostones with carbonate matrix in sandstone interbeds. At the base of this member the participants will see a nuclephytonic dolostone stratum. Pinkish colour rocks with a medium- grained structure contain lenses and biostromes made up of the stromatolite *Nuclephyton confertum* Mak. On the plane parallel to the bedding surface, the stromatolites show a characteristic pattern of rounded figures or smoother-angular polygons, 5-7 cm in diameter. In the section perpendicular to the bedding, polygonal cells can be seen to correspond to the outcrops of subparallel prisms and cylinders (columns) made up of fine-to medium grained, almost massive dolomite (thin relics of gently convex stromatolite laminations are hardly distinguished). Columnar buildups are either oriented perpendicular to the general bedding or are slightly oblique. The columns are separated from each other by relatively thin (fractions of centimetre) intracolumnar portions (interspace filling); normally recrystallized and silicified, hence they are well-defined on the weathering surface. The nuclephytonic dolostone stratum is 2.0-2.5 m thick. The total thickness of the Beds with *Nuclephyton* is 42 m.

3) Beds with *Sundusia* (on₁^c) are composed of pink-grey dolostones, dark-brown carbonate-bearing matrix and siltstone intercalations. The dolostone contains large elongated biostromes, indistinctly isolated dome-shaped bioherms or small lens-shaped bodies consisting of the rock-forming stromatolites *Carelozoon metzgerii* Mak., *Sundusia mira* (But.) and *Parallelophyton raigubicum* Mak. At point 1, a dolomitic exposure with the rock-forming stromatolite *Carelozoon metzgerii* Mak. can be seen. Abundant *Carelozoon* structures, showing a cell relief, occur on the weathered bedding surface. Cells are formed where stromatolitic columns are exposed, as the intracolumnar portions (interspace filling); containing silica material and dividing the columns, appear to be more resistant to weathering. The stromatolites *C. metzgerii* make up lenses and gently undulating biostromes. Their fragments are occasionally presented as low-relief domal bioherms, up to 3 m in diameter.

In the upper part of the carelozonic dolostones, small lens-shaped portions with *Sundusia mira* (But.) stromatolites are encountered. These are subcylindrical branching columns, 1.5-2.0 cm in diameter. In one of the small outcrops horizontal sections of these structures, looking like concentric laminated circles, can be seen.

The appearance of biostrome-forming stromatolites *Parallelophyton raigubicum* Mak. is confined to the top of the dolostone bed described. These structures display either a planeprismatic or parallelepipedal shape. The long axes of the structures are parallel and are commonly oriented E-W, suggesting that the E-W direction of tidal currents predominated. The total thickness of the Beds with *Sundusia* is 60 m.

After examining the lower part of the Onega Formation, the trip continues in the Pyalozero area.

Beds with *Omachtenia kintsiensis* occur in the middle portion of the Jatulian carbonate sequence (on₁^d). The beds consist of various granular pink and red dolostones with silica intercalations and arenaceous dolostones (with abundant sandy and siltstone quartz impurity). The rocks contain the index species *Omachtenia kintsiensis* Mak., elongated biostromes with the complex columnar stromatolites *Carelozoon jatulicum* Metz., isolated buildups comprised of *Colleniella palica* Mak., *Colonnella carelica* Mak., *Parallelophyton strictum* Mak. and oncolites *Palia septentrionalis* But., *P. bicolor* G.Kon. and *Glebosites palosericus* G.Kon. The maximum thickness of the Beds with *Omachtenia kintsiensis* is 130 m.

Girvas Hamlet. Extramarginal glaciafluvial delta

To the east of Girvas Town, in the Palyeozero-Sundozero lake isthmus, there lies a large accumulation plain, which is the surface of an extramarginal delta formed at the mouth of big glacial meltwater discharge systems on the shore of Onega Ice Lake (Fig.5). The surface of the delta has dunes, rill channels, and is inclined to the east towards the lake. Therefore, its absolute altitudes decrease from 100 m in the west to 75 m in the east. The delta then passes into a glacio-lacustrine plain formed of varved clay and loam. Its surface has an altitude of 70-75 m., but varved clays are known at an altitude of up to 80 m.a.s.l. The delta covers an area of about 36 sq. km, and the total thickness of its sediments is 40 m. The catchment area of the ancient delta, which incorporates several powerful glacial meltwater discharge systems, about 90 km in length, was over 400 sq. km. Till or crystalline rocks occur at the base of the sequence. These are overlain by layered silt and loam lenses. Resting on them is a 35 m thick pile of fine-, medium-, and less common coarse-grained sand and silt (Biske, 1959). In the sand, which constitutes the delta, well-defined units of obliquely laminated series alternate with parallel-laminated series. The laminae are inclined at 20-40° in obliquely laminated series. It has been shown by measuring the direction of oblique laminae that the material was transported northeast, east, and southeast. Submarine landslide folds, characteristic of deltas, can be seen in the lower part of the sand unit. The pollen of birch, pine, alder, spruce, willow and plants of the grass, sedge, sheaf-leaf, cruciferae, and aster families, etc. was revealed in the pollen spectra of sand along with club-moss, fern, and moss spores. The pollen spectrum remains unchanged over the entire sequence (from a depth of 7.7 m to 13 m). The pollen of woody species is less abundant than that of grasses, and indicates sedimentation in poorly forested forest-tundra or forest-steppe terrains (Biske, 1959).

The Girvas delta began forming at the end of Allerod time, when Onega Ice Lake got a new outlet into the White Sea basin and its level has dropped from 120 m.a.s.l to 100 m.a.s.l. A fluvio-glacial delta, located south of the Girvas delta, was formed originally in the Lake Kudzyulampi area, near the ice margin. The delta consists dominantly of coarse-grained sand and semi-gravel. The Girvas delta began to form after the retreat of the ice margin northwest beyond the deep basin of lakes Sukhoye, Vikshozero, and Lavalampi. Gravel and coarse sand, carried by glacial meltwater, were deposited in the deep basins of these lakes. Fine- to medium-grained sand and silt were basically accumulated near the isthmus, between lakes Palyeozero and Sundozero. It took several hundred years for the delta to be formed. Meanwhile, the ice margin had retreated by about 90 km. At that time new discharge thresholds were opened in the Onega-White Sea Isthmus (~11 300 y.a. according to M. Saarnisto), and the Onega Lake level dropped by about 20 m. A terrace was formed on the delta slope at an absolute altitude of 75-80 m. The inflow of meltwater had markedly decreased because the delta was fed solely by the glacial meltwater discharge system down the River Suna controlled by lakes Gimoly and Lindozero, large periglacial water bodies. The Semch and Yangozero fluvio-glacial systems supplied the material into Lake Segozero. In Late Dryas-Early Holocene time, the Onega Lake shore retreated from the area discussed, so that river erosion, accumulation and dune formation dominated in the delta area.

After the Second World War the River Suna was diverted and began flowing along a new channel, Pionerny Canal, as the construction of the Girvas power station began. It took a few days for an alluvial+ delta, covering an area of about 3 sq. Km, to be formed at its mouth on the shore of Lake Palyeozero.

Therefore, the Girvas delta is a periglacial, rather than fluvio-glacial, delta which was forming far from the ice margin from mid-Allerod to late Young Dryas time. This conclusion is supported by the absence of coarse-grained sand and gravel in the delta, the geological and geomorphological structure of the area, its geological evolution, and pollen spectra characteristic of periglacial conditions.

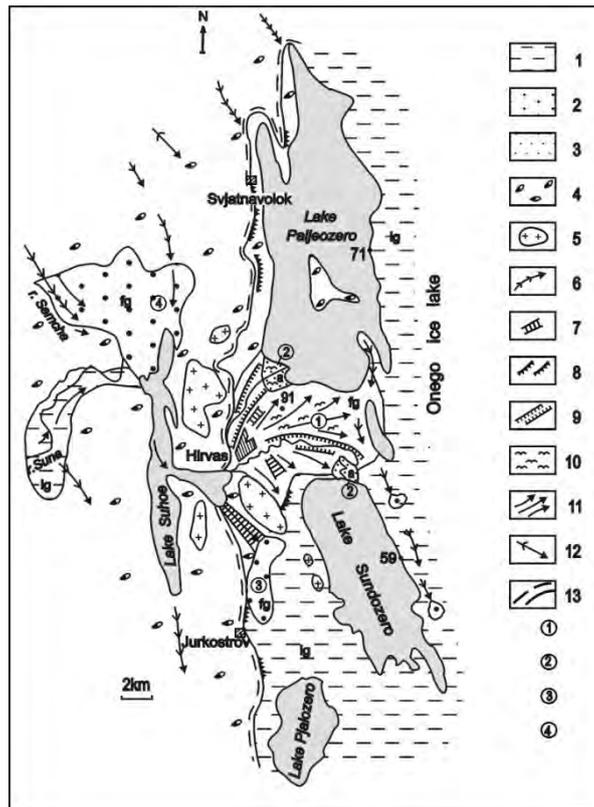


Fig. 5. Structural scheme of the Quaternary cover in the Yurkostrov-Hirvas-Svyatnavolok area

Key: 1 – limnoglacial silt and clay; 2- fluvio-glacial gravel-sand deposits, 3- sand, 4 – till, 5 – bedrock exposures, 6 – eskers, 7 – rills of glacial melt water discharge, 8 – shore scarps, 9- erosion scarps, 10- dunes, 11- direction of transport of glacial meltwater material, 12- direction of ice movement, 13- shoreline of periglacial Lake Onega 1 – Girvas periglacial delta, 2- present alluvial deltas, 3 – Kudzyulampi fluvioglacial delta, 4 – outwash plan.

Suna River canyon

Stop 10. River Suna. Lower Jatulian tholeiitic basalts in the Suna River channel are overlain by ca. 10 m thick conglomerates and quartzitic sandstones that alternate from the base upwards.

1. Pinkish-grey, greenish-grey quartz conglomerates and gravelstones. Rock colour depends on the colour of the quartz pebble-supporting micaceous or quartzite sandstone matrix. The micaceous sandstones are rich in green chlorite responsible for the dark-green colour of the rock; sandstones with limonitized hematite, imparting a pinkish-grey colour, occasionally contain feldspar grains. The unit varies in thickness from 10 to 50 cm.

2. Fine- to medium-grained quartzitic sandstone with scarce quartz pebbles and coarse feldspathic sandstone. The rock is commonly dark-grey, while pinkish and cherry-grey colours are more scarce. Ten to forty centimetre thick cross-bedded series, wedging out along the strike, are characteristic of the quartzitic sandstones. Cross-bedded series, which are sometimes trough-shaped, truncate each other. The base is formed of coarser stuff. Laminated schist pebbles are occasionally encountered. The laminae are unidirectional, and sometimes pinch out towards the base.

The top of the bed is formed of horizontally-bedded quartzitic sandstone with ripple marks on the bedding planes. The ripples are asymmetric, and the waves are 3-6 cm long and up to 1 cm high. Bedding planes with crescent-shaped cellular-elongate ripple marks are observed upwards. The bed is 2 m thick.

3. Ca. 1.0 m thick pinkish-grey coarse-grained quartzitic sandstones with dirty-grey thick-and cross-bedded series. Straight and curved seams are flattened towards the base. 4. Quartz conglomerates and gravelstones with angular-rounded pebbles, up to 3-5 cm in size along the long axis, that rest on the rough scoured surface of quartzitic sandstones. The conglomerates are

supported by arkose matrix with poorly rounded feldspar clasts, up to 1 cm across. The quartz conglomerates vary in thickness along the strike, fill pockets and grade upwards into coarse-grained quartzitic sandstone. These, in turn, pass into medium-grained sandstone mixed with feldspar grains. The rock is pinkish-grey. The bedding is commonly coarse and horizontal. Poorly-defined oblique lamination is locally observed. The top is always formed of dark-grey, irregularly fine-grained quartzitic sandstone which occurs beneath an overlying mafic bed.

The mafic bed incorporates a series of lava sheets. The base of the lower bed is composed of pillow lava supported by a matrix, which has arenaceous stuff of underlying sediments. An undulating surface, formed by a lava flow, is visible at the top of the second lava sheet.

Lava sheets 2 and 3 are separated by a bed consisting of tuffaceous-carbonate rocks, tuffaceous sandstone, and tuff schist in which hydrothermal siliceous rocks are deposited.

Lava sheet 3 displays a columnar jointing which is uncommon to Precambrian units.

Stop 11. Paleovolcano Girvas

Relics of a volcanic conduit system, produced by Jatulian mafic volcanism, occur here. The visible portion of the conduit system consists of the following morphological elements: the south-eastern slope of the lava cone, part of the diatreme and a larger part of a subordinate (parasitic) vent occurring as a volcanic pipe.

The volcanic cone is composed of several 10-15 m thick basalt flows, which overlie one another. The flows consist of abundant lava breccia. The vent of the subordinate volcano is clearly seen. It has an oval shape and is 10x20 m in size. The diatreme is filled with small blocks of basaltic breccia. Intense tourmalinization has been revealed in the rocks near the western endocontact.

When conducting palaeovolcanological studies of volcanic rocks at the northern end of Girvas, geologists found bizarre volcanic rocks in the water discharge channel of the Palyeozero hydropower plant. The rocks make up a structurally complex volcanic conduit system associated with Jatulian mafic volcanism and known as Girvas Volcano (Svetov & Golubev, 1967).

In the present erosion section, one can see only a small portion of the volcano, which consists of the following morphological elements: part of the eruptive vent, the southeastern slope of the lava cone and presumably most of the subordinate (parasitic) crater (volcanic pipe). The rest of the volcano is buried under a thick pile of unconsolidated lacustrine-alluvial Quaternary rocks.

The eruptive vent of Girvas Volcano is located on the left slope of the water discharge channel. In the present erosion section it has a rounded shape and is slightly elongate in a northeastern direction. Its exposed portion is 20 x 50 m in size.

The eruptive vent acted as an excurrent channel through which lava was transported in Middle Jatulian time to form a lava plateau in the western Lake Onega region (Prionezhye). In the contact zone, the vent is filled with massive, locally highly fractured, basalt and basaltic porphyrite that occasionally pass into thinly-laminated, fine-clastic collapse breccia. Off the endocontact, the rocks attain some features increasingly characteristic of blocky vent breccia in medium-grained basalts. Sharp south-eastern and eastern contacts with rocks of the volcanic lava cone are emphasized by vertically dipping thinly-laminated breccia zones and by zones in which tourmalinization is intense and albite and albite-quartz veins are abundant. Gradual transition from eruptive vent rocks to a gabbro-dolerite type of rocks occurs chiefly as the degree of recrystallization of rocks rises and porphyreous brecciated varieties of basalts are succeeded at first by fine-grained, massive varieties and then by medium- to coarse-grained (pegmatoid) gabbro-dolerites.

Stop 12. Kivach Falls. It is located in the centre of Federal Kivach Reserve. It was founded in 1931 to protect and restore a model site in the mid-taiga subzone of European Russia. Integrated studies and monitoring, conducted here for decades, are now in progress. The reserve covers an area of 10 870 hectares. Its mature coniferous forests are most valuable. Pine forests make up 42%, spruce forests 32% and secondary stands over 20%. Broad-leaved trees, such as mountain

elm, lime and black alder, are less abundant. The average age of the forests is 120 years, but some of the pine-trees are 300-350 years old. The reserve's flora consists of over 580 vascular plant and 193 cormophyte moss species. 268 terrestrial vertebrate, 24 fish and 977 insect species have been reported. Some of these plant and bird species are listed in the Red Data Books of Russia and Karelia. The knowledge of Kivach Reserve's geological structure is scanty.

A scheme, showing the geological structure of the adjacent area, is in **Fig.6.** (V.S.Kulikov & V.V.Kulikova, 1998)

Kivach Reserve is located at the northwestern flank of the large Konchezero anticline composed of sediments and volcanics (Trans-Onega and Suisari suites), which are cross-cut by Paleoproterozoic gabbro-dolerite and dolerite. Their isotope age has not been estimated.

The rocks dip gently ENE at 10-15° and become steeper only in fault zones. Trans-Onega rocks are dominated by shungite shale, siliceous schist and pelite; basalt and andesite lava is less common. The Suisari suite is made up of basalt tuffs; clastic stuff is dominated by blocks and sharply angular fragments of Trans-Onega shungite shale and siliceous schist. A Suisari tuff unit has been traced along the Suna River for over 2.5 km.

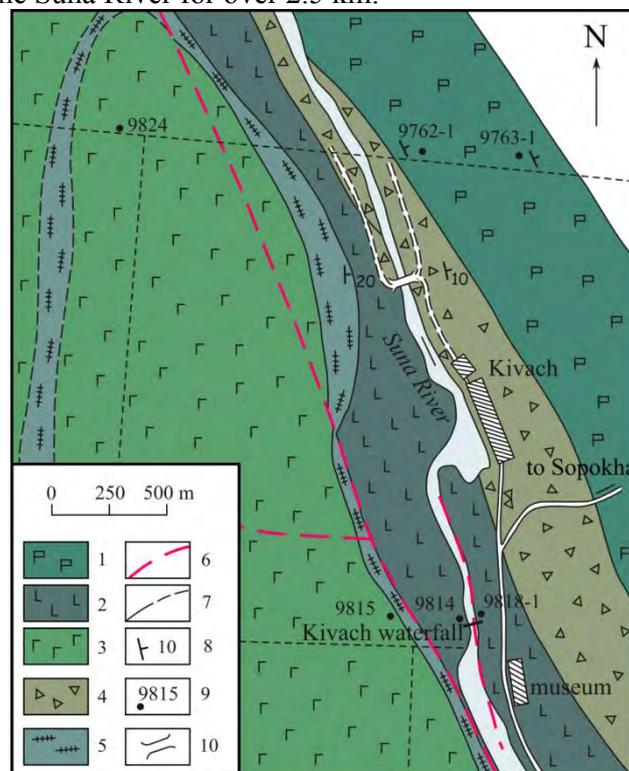


Fig.6. Scheme showing the geological structure of the Kivach area [V.S.Kulikov & V.V.Kulikova, 1998]

1 – gabbroic rocks in Levoberezhny Sill; 2 – gabbro, ferrogabbro, and dolerite in Vodopadny Sill; 3 – gabbroic rocks in Pravoberezhny Sill; 4 – Suisari tuffs and tuffaceous conglomerates; 5 – Trans-Onega shungite shale and schist; 6 – faults; 7 – boundaries of rock bodies and units; 8 – inclined mode of occurrence of rocks; 9 – sample numbers in Table 4; 10 – hanging bridge.

Gabbro-dolerite predominates. Three large bodies, named Levoberezhny, Pravoberezhny and Vodopadny, depending on their position relative to the Suna River, are distinguished (Fig. 6). Each of the sills is up to 100 m thick in the swells.

The sills differ in chemical composition, mainly in iron, calcium and titanium concentrations, and presumably in age.

Vodopadny Sill, on which Kivach Falls is located, is a major tourist attraction. The name Kivach seems to originate from the Finnish word “kivi” (stone). Prior to the construction of Girvas Hydropower Plant in pre-war time and the diversion of Suna River water into another water system (Lake Sandal), Kivach Falls was a magnificent sight. It is Europe's second plain fall with respect to water fall elevation (11 m).

You can see a shatter zone in a near-N-S-trending gabbro-dolerite body, which coincides with the Suna River channel and a small mylonitization zone within it. Occurring on the left-hand bank, 10-20 m from the river channel, is a spheroidal jointing in dolerite. Its genesis is the subject of debate: some scholars argue that it is a spheroidal jointing typical of basalt, which flowed into a water body; others assume that it is a distinctive jointing produced by massive rock weathering. If further studies prove that the former version is correct, then this body is a large lava sheet, rather than a sill. This igneous mafic body is differentiated, displays a more melanocratic composition at the base (right-hand bank) and a mesocratic composition on top (left-hand bank). Shatter zone rocks are brown and contain elevated iron oxide concentrations. While touring the Olonets Province, Academician G.P.Helmseren was impressed with “giant boilers” - rounded cavities of various sizes on the exposed rock surfaces in the river channels and in the near-bank portions of water bodies. Such cavities with an oval bottom and smooth walls are similar to iron boilers in bath-houses. They are up to several metres in diameter, suggesting that tremendous efforts were made to produce them. Hence, the name “giant boilers” [Sokolov & Erte, 1984]. Such boilers are common in Fennoscandia. Local tales say that the “boilers” were created by the Jatulians, mythic giants, who allegedly lived in this province.

G.P.Helmseren saw such “boilers” near Helsinki, on Lake Ladoga and in the Olonets Province. He said, "I visited many places with favourable conditions for their formation, such as Kivach Falls, Porporog and Girvas, but I didn't see any boilers".

At that time the water level on the Suna River was very high. Therefore, the “giant boilers”, which one can see now on Kivach Falls, were then under the water surface. The biggest known “boiler” is located on a second cascade in the river channel, near the left-hand bank.

The structural-denudational, glacial and aqueo-glacial types of relief predominate in Kivach Reserve. The last Late Weichselian ice cover had retreated from the area described about 11 500 years ago, but the biggest part of the reserve was covered by water of ancient Lake Onega till mid-Boreal time 9000–8500 Ma ago.

After examining the geological sites, you can walk around to enjoy the beautiful nature or visit the Kivach Reserve Museum, which has many interesting and informative exhibits.

References:

- Ananjin, I.V. 1980. Russkaya ravnina i Ural. In: Seismicheskoye rajonirovaniye territorii SSSR. Moskow, Nauka, p. 109-114.
- A guide to the geological field trips held as part of the 12th All-Russian Petrographic Meeting "Petrography of igneous and metamorphic rocks". Petrozavodsk: Karelian Research Centre, RAS, 2015, 96 p. (references are therein).
- Golubev A.I., Svetov A.P. Geochemistry of Kaelia's basalt produced by platform volcanism. Petrozavodsk: Karelia, 1983. 192 p.
- Demidov I.N. Varved clay formation and deglaciation in the northern Lake Onega area. // Contribution to the origin of Quaternary deposits and their resources in Finland and northwestern part of the Russian Federation. GSF. Espoo. 1997. P.57-65.
- Demidov I.N. Quaternary deposits // Biotic diversity of Karelia: conditions of formation, communities and species. Karelian research Centre. Petrozavodsk. 2003. P 17-23.
- Ekman I, Iljin V. Deglaciation, the Young Dryas end moraines and their correlation in Russian Karelia and adjacent areas. // Glacial deposits in North-East Europe. Balkena. Rotterdam. 1995. P.195-209
- Ekman I., Bakhmutov V., Zagniy G. Upper Valdai-Veiksel (Valdai-Weichselian) chrono- and magnetostratigraphy in southeast Fennoscandia. Examples from Russian Karelia // Contribution to the origin of Quaternary deposits and their resources in Finland and northwestern part of the Russian Federation. GSF. Espoo. 1997. P.75-85.
- Ivanovskaya, L.V., Firsova, D.B., Homenjuk, U.V., Schukin, U.K., 1998. Dolgovremennoye prognozirovaniye seismicheskoy opasnosti po kompleksu geologo-geofizicheskikh dannih. Moskow, Nauka, p.108.
- Kulikov V.S., Kulikova V.V., Lavrov B.S. et al. Paleoproterozoic Suisari picrite basalt complex, Karelia: key sequence and petrology. Petrozavodsk: KarRC, RAS, 1999. 96 p.
- Lukashov A., Ekman I., Iljin V. Guidebook for excursion, A-4 C-4. XI CONGRESS INQUA. Moscow, 1982. 57 pp.
- Lukashov A.D. Paleoseismotectonics in the northern part of Lake Onega // Geological Survey of Finland. Report YST-90. Espoo, 1995. 36 pp.

Lukashov A.D. Geomorphological characteristics // Biotic diversity of Karelia: conditions of formation, communities and species. Karelian research Centre. Petrozavodsk. 2003. P 12-17.

Medvedev P.V., Makarikhin V.V. Stromatolites in the Palaeo-Proterozoic ^{13}C -Enriched Carbonate Successions of the Fennoscandian Shield. //EUG XI, Sinip. EVO4, Strasburg, 2001, p. 191-192.

Melezhik V.A., Fallick A.E., Medvedev P.V., Makarikhin V.V. Extreme $^{13}\text{C}_{\text{carb}}$ enrichment in ca. 2.0 Ga magnesite-stromatolite-dolomite-"red beds"association in a global context: a case for the world-wide signal enhanced by a local environment. //Earth-Science Reviews, 48, 1113. 1999, p. 71-120.

Melezhik V.A., Fallick A.E., Medvedev P.V., Makarikhin V.V. Palaeoproterozoic magnesites: lithological and isotopic evidence for playa/sabkha environments. //Sedimentology, v. 48, №2, April 2001, p. 379-397.

Melezhik Victor A., Fallick Antony E., Makarikhin Vladimir V., Lyubtsov Valery V. Links between Palaeogeography and rise and decline of stromatolites: Fennoscandian Shield. //Prec. Research, 82, 1997, p. 311-348.

Ojakangas R.W., Marmo J.S., Heiskanen K.I. Basin evolution of the Paleoproterozoic Karelian Supergroup of the Fennoscandian (Baltic) Shield). // Sedimentary geology, 2001, v. 141-142, p. 255-285.

Panasenko, G.D., 1980. Seismichnost vostochnoi chasti Baltijskogo schita. In: Seismichnost I sovremennije dvizhenija zemnoi kori vostochnoi chasti Baltijskogo schita. Apatity, p.7-24.

Pisarevsky S.A. and Sokolov S.J. The magnetostratigraphy and a 1780 Ma palaeomagnetic pole from the red sandstones of the Vazhinka River section, Karelia, Russia. Geophys. J. Int. (2001) 146, p. 531-538.

Resources and geochemistry of Karelia's underground waters. Petrozavodsk, 1987, 151 p.

Saarnisto M., Gronlund T., Ekman I. Lateglacial of Lake Onega - contribution to the history of the eastern Baltic basin // Quaternary International. Vol. 27. 1995. P. 111-120.

Saarnisto M, Saarinen T. Deglaciation chronology of the scandinavian Ice Sheet from the lake Onega basin to the Salpausselkya End Moraine //Global and Planetary Changes.31. Elsevier Science. 2002. p. 383-405.

Svetov S. A., Smolkin V.F. Model P–T Conditions of High-Magnesia Magma Generation in the Precambrian of the Fennoscandian Shield // Geochemistry International, Vol. 41, No. 8, 2003, pp. 799-812.

Svetov S.A., Svetova A.I. Accretion-collision model for the formation of Archean greenstone belts in the central Karelian craton // in Weihed P, Golubev A. (eds) Abstract volume & Field trip guidebook, 3rd annual GEODE- Fennoscandian field workshop on Paleoproterozoic and Archean greenstone belts and VMS districts in Fennoscandian Shield, Russia, SC "Mineral" & Karelian Research Centre, 2001, pp.82-83.

Svetov S.A. New data on geochemistry of the oldest 2.95-3.05 Ga andesite association in Eastern Fennoscandia //Doklady Earth Sciences, Vol. 389, No. 2, 2003, pp. 195–198.

Svetov S.A., Huhma H., Svetova A.I., Nazarova T.N. The Oldest Adakites of the Fennoscandian Shield // Doklady Earth Sciences, Vol. 397, No. 6, 2004.

Yelina G., Lukashov A., Yurkovskaya T. Lateglacial and Holocene in the East Fennoscandia (palaeovegetation and palaeogeography), Karelian research centre. Petrozavodsk 2002. 241pp. (in Russian.)

Wohlfarth B., Bennike O., Brunberg L., Demidov I., Possnert G., Vyahirev S. AMS ^{14}C measurements and macrofossil analyses of a varved sequence near Pudozh, eastern Karelia, NW Russia // BOREAS v.29 . Oslo, 1999. P.575-586.

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KIVACH NATURAL RESERVE

Pogosyan, L.A.^a, Gerasimova, M.I.^b

^a Instituto de Geología, Universidad Autónoma de México, Cd. Universitaria, 04510, Cd. de México, México, Posgrado en Ciencias de la Tierra

^b Moscow Lomonosov University, Faculty of Geography

E-mail: lilit-tos@yandex.ru

The Kivach natural reserve (Fig. 1) is situated in the middle taiga subzone between 61—62° n.l.; the main objects are soils formed on glaciofluvial deposits under pine forests and soils on varved clays under spruce forests. In terms of soil-geographic regionalization this area is included in the Karelian province of shallow Podzols.

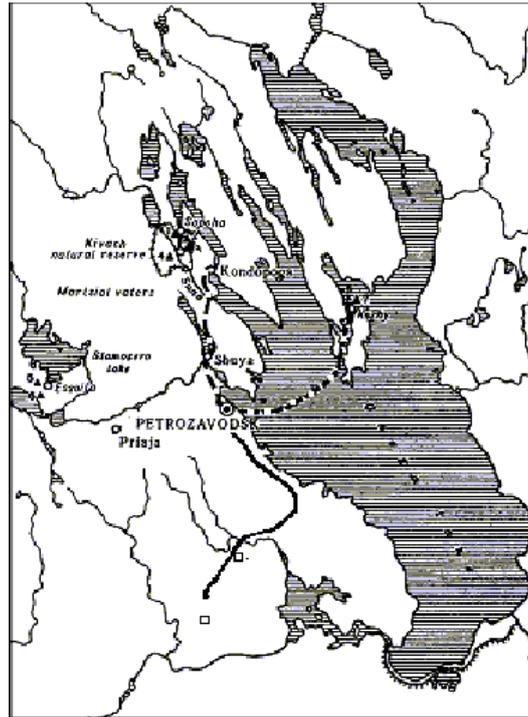


Fig. 1. Scheme of routes and disposition of profiles

The relief of the area of the Onega – Ladoga Lakes divide is an undulating plain represented by two genetic types: denudation-sculptural and accumulative moraine plain, the former type prevailing. Elevations range about 100 m a.s.l. Geologically, this territory corresponds to Petrozavodsk tectonic depression, 150 m deep, filled with Quaternary deposits. The upper sequence of sediments is composed of moraines of several glaciation stages (Kalinin, Ostashkov, Karelian) alternating with interstadial deposits: glaciofluvial sands and boulder loamy sands; the uppermost part is composed of the lacustrine sands and organogenic formations.

The moraine plain is replaced by the *Shuya-Logmozersk* boggy lowland, with relative altitudes ranging from 5 m to 30 m, formed by the most ancient deposits of the Holocene — lacustrine-glacial varved clays. It is further replaced by the denudation-tectonic relief at the route section from the *Shuya* station to the town of *Kondopoga*. The crystalline foundation is composed by the Middle-Proterozoic rocks, but in this area it is covered by the mantle of glaciofluvial deposits of varying depth. Elevations seldom exceed 100 m, while relative altitudes range within 10 to 50 m. To the north of the town of *Kondopoga*, the denudation-tectonic relief is replaced by an undulating lacustrine-glacial sandy plain, locally interrupted by boulder-pebble-sandy eskers.

Thus, the first part of the route from Petrozavodsk to the Kivach natural reserve crosses the territory covered mainly by the Quaternary deposits. Outcrops of bedrocks sporadically occur along the road, and are locally superimposed by shallow Quaternary deposits. The bedrocks are represented mainly by the Suisar suite of the Middle-Proterozoic, sedimentary-volcanic by origin (porphyrites, tuffs, tuff slates, occasionally by schungites) along with the intrusive rocks –

gabbro-dabase and diabase. The ridges are of a northwestern orientation, which coincides with the predominant stretch of the main tectonic structures. Large ridges are separated by the lacustrine depressions, smaller ones — by low moors. Absolute altitudes seldom exceed 100 m, relative ones range from 10 m to 50 m. This region is famous for its mineral waters and medicinal mud. The underground water is enriched in iron due to its removal from schungite slates and gabbro-dabase.

The drainage network of this area is associated with the Onega Lake. The largest rivers to cross are the *Shuya* and *Suna*; their length is about 300 km. Just as other rivers of Karelia, they are characterized by unworked, step-like profiles. The rivers abound in rapids with accordant falls alternating with reaches. The participants will visit the *Kivach waterfall* 8-m-high on the *Suna* river. In this place, the river is squeezed by diabase rocks. The lakes: *Onega*, *Konch*, *Uksh* and *Gabo* have their kettle depressions situated in rifts with walls strongly eroded by the glacier. Almost all the lakes are sewage and flowing.

The diversity of landforms and soil-forming rocks determines the soil cover diversity and that of plant communities, their floristic composition and productivity. Various types of spruce and pine forests grow here. There is an admixture of deciduous small-leaved species: *Betula pubescens*, *Betula verrucosa*, *Populus tremula L.*, *Alnus incana L.* in both pine and spruce forests. The forest frequently acquires the character of a mixed spruce-pine one with an admixture of birch. The area occupied by deciduous forests has increased within the past years as a result of wood felling.

The entire area around the Kivach waterfall was announced to be a state reserve in 1931. The area of the reserve is now 10 000 ha.

The relief of the Kivach national reserve is defined as a denudation-tectonic one. Longitudinal fractures of northwestern orientation in Proterozoic rocks form kettle depressions sometimes occupied by lakes. Crystalline rocks often outcrop as long narrow ridges – ‘selgas’.

The activity of the glacier has considerably changed the ancient relief, leveling it to a different extent in various parts of the reserve. Three types of landscapes are distinguished in the reserve territory:

Type I — ridgeous. It embraces an upland formed by gabbro-dabases, which are the divide of the Lake *Muno* and a series of small forest lakes. Elevations of the divides are about 170 m.

Type II — sandy undulating fluvioglacial plain occupying a significant part of the *Suna* and *Sandalka* river divide. Varved clays underlie sands in numerous flat depressions. Here and there oozes and moraine hilly ridges with rare outcrops of crystalline rocks interrupt the plain. Absolute altitudes of oozes are 70 m to 80 m. Interridge rounded depressions are occupied by sphagnum peatbogs and shallow “lambas” (small ponds).

Type III — undulating moraine plain typical of the watershed of the Lake *Perte* — Lake *Koguilamba* on the *Suna* River right bank. The lower part of slopes, depression bottoms, lacustrine and river terraces are covered by varved clays, which have leveled the ruggedness of the ancient relief.

The major part (84 per cent) of the reserve territory is covered by forests; water bodies occupy 9.6 per cent, bogs — 4.8 per cent and croplands — 1.6 per cent of the total area. Pine forests account for 41 %, spruce forests — 30 %, birch groves — 24 %, and aspen groves — 5 % of the area covered by forests. More than 600 species of higher plants are identified in the vegetation cover of the reserve. Although the reserve is situated in the middle taiga, there are many boreal grass species in its forests, especially in the spruce ones, owing to a relatively high fertility of soils on the outcrops of the mafic rocks and schungites.

The soils of the reserve compose a complicated mosaic. The main soil units present are Podzols, Albeluvisols, Gleysols and Histosols. There are three main soil districts in the area.

1. The western part of the reserve is an uplifted zone, composed of gabbro, with a shallow layer of Quaternary sediments and frequent rock outcrops. The dominant soils are Leptosols under lichen pine forests on the summits of selgas, and Leptic Entic Podzols occupying lower positions, where fine earth is accumulated. On the tops and moderate slopes of the hills with a

shallow cover of loamy sandy moraine one can find underdeveloped Podzols under pine green-moss forests. Microdepressions are occupied by Histosols and Histic Gleysols under *Pineta hylocomiosa* forests. Some hard rock outcrops have Histic and Mollic Leptosols under *Piceeta uliginio-herbosa* forests with *Alnus incana* admixture.

2. The medium part of the reserve is a hilly moraine plain, where the uplifted areas are covered with silty and sandy silty tills. The soils are represented by Rustic Podzols under *Piceeta myrtillosa* forests, and Albeluvisols under *Piceeta myrtillosa* and *oxalidosa* forests; the latter ones occupy the lowest positions in the relief. The moraine hills with shallow till cover are occupied by Entic Podzols under *Piceeta hylocomiosa* forests, by Leptosols on the outcrops of hard rock under lichen pine forests, and Leptic Histosols under *Piceeta polytrichosa* forests. Imperfectly drained flat plain on the lower altitudinal level, composed of varved clays, is occupied by Stagnic Albeluvisols under *Piceeta myrtillosa* and *oxalidosa* forests. In the lowest topographic positions, there are Histic Gleysols and Histic-Gleyic Albeluvisols. The deepest depressions are occupied by Dystric and Eutric Histosols.

3. In the south-eastern part of the reserve, which is a hilly limnoglacial plain, composed of sandy and gravelly-sandy sediments, there are Podzols; the largest area is occupied by Rustic Podzols under *Pineta vaccinosa* forests. If varved clays underlie the sand close to the surface, gleyization occurs, and the pine forests are of *Pineta myrtillosa* type. On the tops of high hills with a deep layer of sandy sediments there are Entic Podzols. In deep depressions there are Ombric Histosols, and in their periphery – Histic Carbic Podzols under *Pineta ledosa-sphagnosa* forests. Also few rock (diabase) outcrops occur, where Leptosols form under *Pineta vaccinosa* forests.



Fig. 2. Kivach soil perfil photo by John M. Galbraith, 2nd Conference for Soil Classification – Aug. 2-8, 2004, Petrozavodsk, Karelia (Russia) Additional Field Tour Notes Concerning Soil Taxonomy Classification

One soil profile is presented.

The profile (“Kivach”) is formed on glaciofluvial sand under *Pineta myrtillosa* forest. Chemical and physical characteristics of the soil are presented in the Tables 1–3. According to the Russian classification, the soil is defined as Podzol or Podzolic Podbur (soil with distinct evidences of Al, Fe, and humus migration – *spodic* horizon, and with a shallow discontinuous

albic horizon, or more commonly with bleached sand/silt grains in the upper part of the spodic horizon). The classification problem is that these soils have *spodic* horizons too close to the surface. These horizons do not fit the upper limit depth for *spodic* horizons both in WRB and the US Soil Taxonomy. It is not clear, if we should measure the upper *spodic* horizon limit from the mineral soil surface, or from the surface of the forest floor. In the latter case, some problematic soils do fit the depth criteria. However, forest floor thickness is variable, and the depth of the upper limit of *spodic* horizon also varies in a wide range.

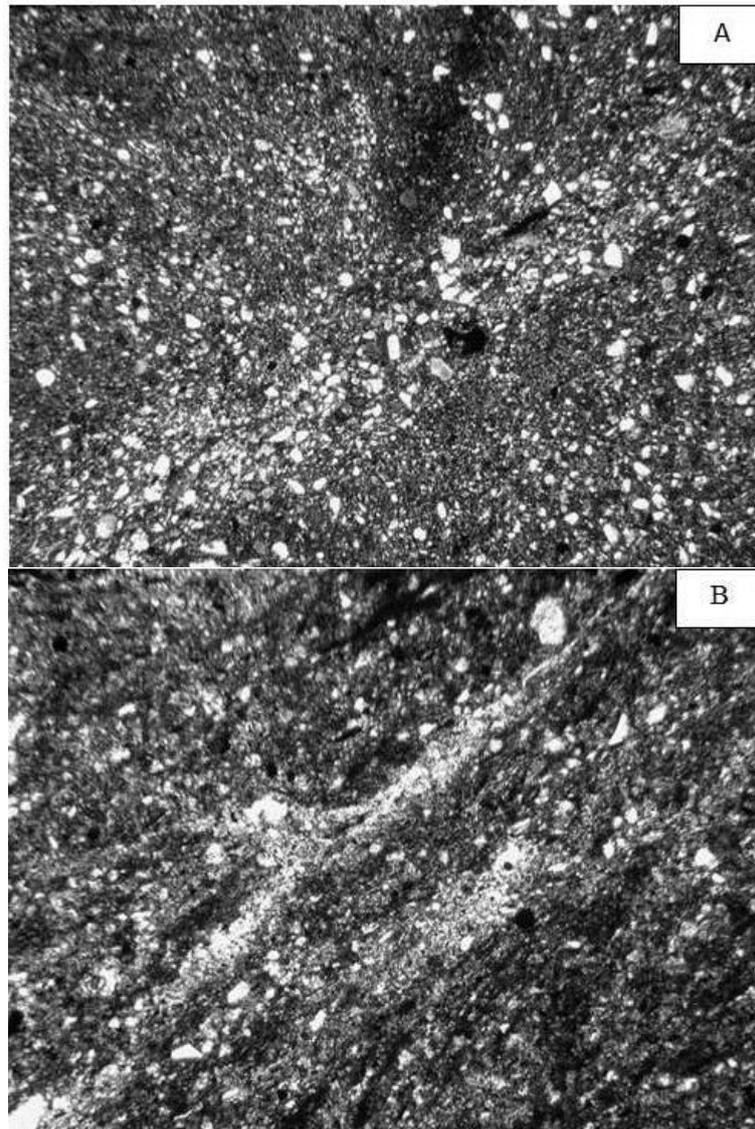


Fig. 3. A – Microstructure of Btg horizon of “Kivach” profile, B – the same, crossed nickols

Reference:

Field Workshop Guidebook of the International Conference (August, 3-8, 2004, Petrozavosk, Karelia, Russia).
Petrozavodsk, 2004. - 34p.

Table 1. Chemical properties of soils of “Kivach” site

Horizon	Depth, cm	pHH ₂ O	Ca ⁺⁺	Mg ⁺⁺	K ⁺	Na ⁺	EA	BS	C	N	C/N
			cmol•kg ⁻¹					g•kg ⁻¹			
EB	3-8 (11)	4.81	0,79	0,26	0,51	0,66	2.47	47.3	6.5	0.5	13.0
Bs1	8 (11)-24	5.43	0,39	0,16	0,31	0,57	0.35	80.3	5.9	0.6	9.8
Bs2	24-44	5.21	0,49	0,21	0,20	0,54	0.25	85.2	4.1	0.3	13.7
BC	44-100	5.31	0,60	0,23	0,41	0,62	0.21	88.1	2.4	0.2	12.0
C	100-120	5.89	1,05	0,36	0,72	0,94	0.21	93.6	2.1	0.2	10.5

Table 2. Granulometric composition of the soils of “Kivach” site (Russian particle size classification: Vadyunina, Korchagina, 1973)

Horizon	Depth, cm	1-0.5	0.5-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	FAO Textural Classes
EB	3-8 (11)	45.9	30.8	14.2	3.9	1.9	0.7	1.8	Fine sand
Bs1	8 (11)-24	32.2	45.4	15.3	1.9	1.9	0.3	2.3	Fine sand
Bs2	24-44	55.3	31.4	8.6	1.9	0.2	0.5	1.3	Fine sand
BC	44-100	59.7	27.4	9.0	1.5	0.6	0.5	0.7	Fine sand
C	100-120	18.8	63.2	16.2	0.5	0.6	0.4	0.3	Fine sand

3rd excursion day. August 23-24
TRIP TO LADOGA

HISTORY OF LAKE LADOGA AND ITS CONNECTION WITH THE BALTIC SEA

Subetto D.A.

Department of Geography, Herzen State Pedagogical University of Russia, emb. Moika 48,
Saint-Petersburg, 191186 Russia

E-mail: subetto@mail.ru

The problem of the history of Lake Ladoga and the formation of the Neva River still remains controversial in many respects. The fundamental generalizations available at the moment by the authors (History of Ladoga, Onega ..., 1990; Evolution of Natural ..., 1993; Kvasov, 1975; Davydova et al., 1994; Subetto et al., 1998; The First International ..., 1996) leave a number of important issues that require further scientific study and solution. The main of these are the time of the origin of the river and the direction of flow from Ladoga to the formation of the Neva River.

The depression of the Lake Ladoga began to fill with water as the glacier of the Last Valdai glaciation collapsed and melted. According to studies (Saarnisto, Saarinen, 2001), devoted to the problem of deglaciation of the Ladoga and Onega Lake's basins using varvochronological, radiocarbon and paleomagnetic analyzes of varved clay, it was proved that Lake Ladoga was free of ice in the interval 14000-12500 calendar years (11800-10300 ¹⁴C years ago) (Fig. 1).

Within the basin of Lake Ladoga, there was a deep-water, cold, oligotrophic periglacial water reservoir (Figure 2), which was the easternmost part of the Baltic Ice Lake (Davydova et al., 1998; Kvasov, 1975; Subetto et al., 1998), where during 2000 years formed a thick stratum of limnio-glacial varved clays (Subetto, 2002).

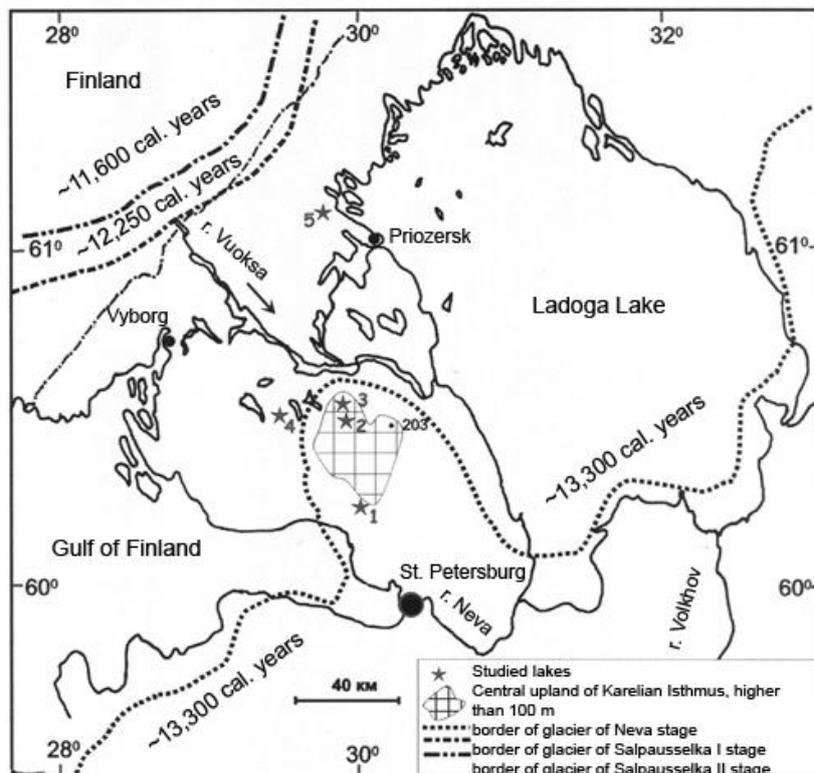


Fig. 1. Stages of deglaciation of Lake Ladoga.

A characteristic feature of laminated clays is their distinct graded bedding layering. In the sections of varved clays, as already indicated, alternating layers of two genera are observed:

clayey, comparatively thin and colored in darker tones, and coarser, aleuritic or sandy high power and light colored.

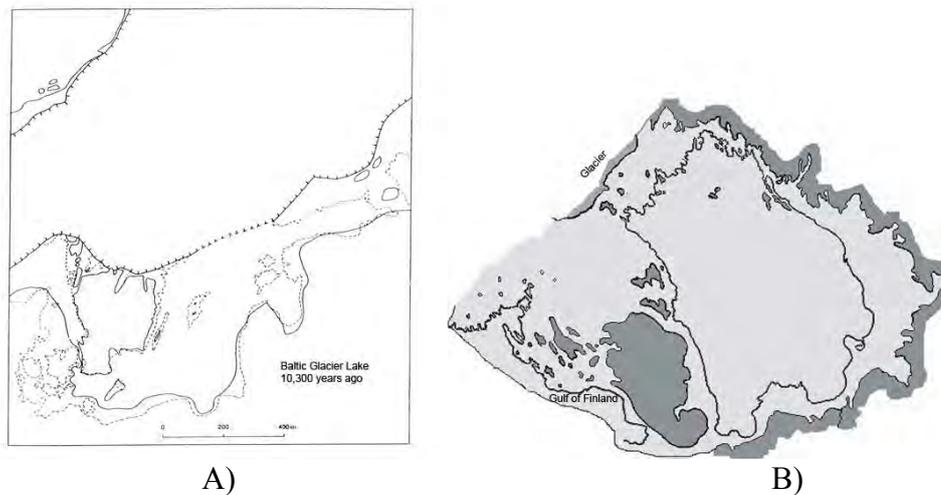


Fig. 2. A) The position of the edge of the glacier and the adjacent Baltic Ice Lake (BIL) 10300 ¹⁴C years ago or 11500 calendar years ago before its descent after the retreat of the edge of the glacier from the mt. Billingen in the Central Sweden. The dashed line shows the current position of the coastline of the Baltic Sea (Björck, 1994). B) Ladoga Lake was part of a large preglacial lake (BIL). The water level marks reached 50-60 m. The northern part of the Karelian Isthmus was flooded.

The first ones are called winter layers, the latter ones are called summer layers. Banded clays were formed from a glacial turbidity - a product of erosion of moraine, brought by streams of melt water into the periglacial water reservoir (Fig. 3).

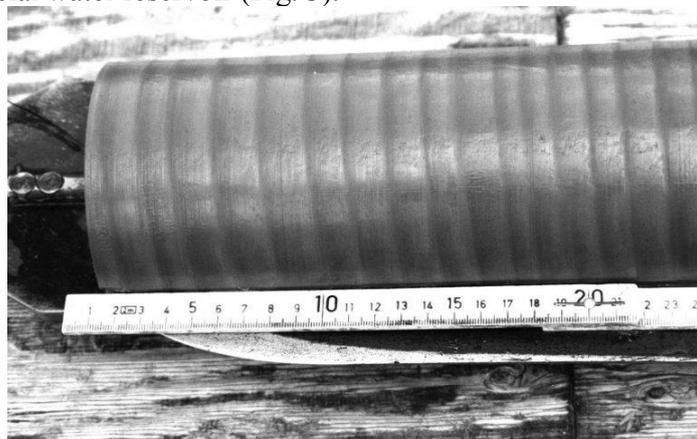


Fig. 3. Photo of varved clays formed in the conditions of a glacial lake. One layer corresponds to 1 year.

The sedimentation of a larger clastic material in the spring-summer period to the bottom of the lake, and the thinner material, suspended in the autumn-winter season, led to the formation of laminated (varved) clays. In the conditions of the cold, sharply continental climate of the late glaciers, the productivity of the lake and terrestrial ecosystems was low, which was reflected in the very low content of organic matter in banded clays. The powerful thickness of the lacustrine-glacial deposits of the BIL covers almost the entire bottom of the Ladoga Lake and their thickness reaches 20-30 m (Subetto et al, 1990). Deposits of the Baltic Ice Lake are also found in the sections of the bottom sediments of many lakes located in the northern lowland part of the Karelian Isthmus (Sevastyanov et al., 1997; Subetto et al, 1999, 2002).

Above the cut of the varved clays, the layers gradually subside until they disappear completely: the banded-layered clays are replaced by microlayered and homogeneous clays (Fig. 4).

This facial transition from one type of clay to another was associated with the gradual degradation of the glacier, the retreat of its edge from the lake catchment and, accordingly, with

the decrease in the arrival of clastic material and the precipitation of a predominantly suspended matter.

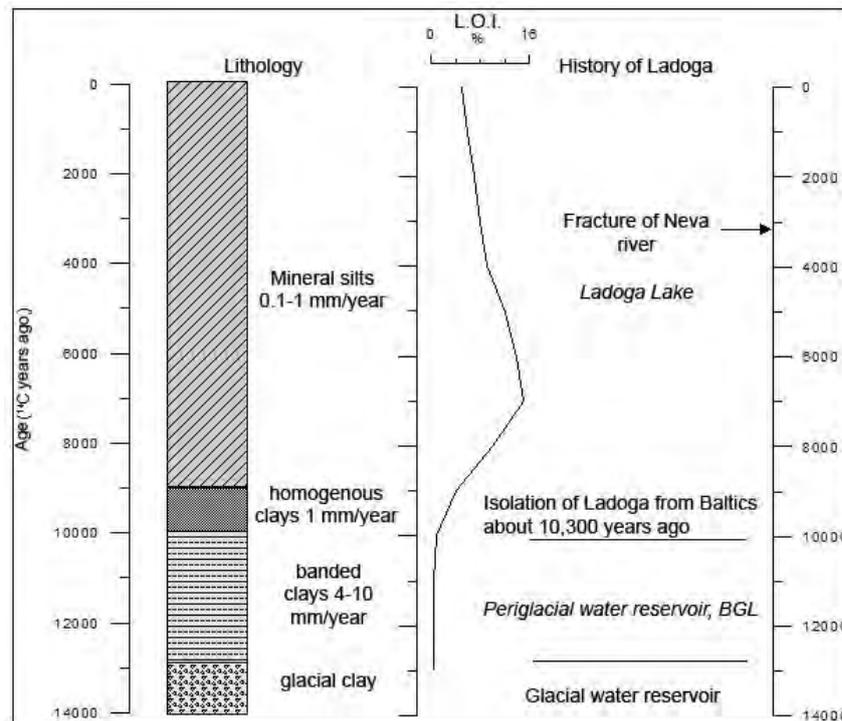


Fig. 4. General section of bottom sediments of the Ladoga Lake and paleogeographic reconstruction (Subetto, 2002)

The change in the structure of the sediments of the Ladoga Lake in time from glacial deposits (glacial clay) to limno-glacial (varved clays) and to lake sediments (homogeneous clays and silts) is shown. L.O.I. - loss on ignition of samples of bottom sediments, an index of change in the content of organic matter, which in turn is an indicator of the bioproductivity of the reservoir and changes in the temperature regime. The maximum content of organic matter in bottom sediments correlates with the optimum of the Holocene.

According to existing ideas, *the last reduction of the Baltic Ice Sheet took place unevenly*, as well as the subsequent isostatic uplift of the territory. It is believed that about 10,300 ¹⁴C years ago in the area of present-day of mt. Billingen in Central Sweden (Figure 2), *the collapse of the glacial lobe led to the open of the straits, a sharp lowering of the sink threshold and a drop in the level of the BIL*, which caused the opening of a huge area from the Baltic Sea to the White Sea, adjacent to the edge of the ice sheet. *The lowering of the BIL was catastrophic and short-lived*. In the basin of the Baltic Sea waters of the world ocean penetrate, forming the salt-water conditions of the stage of the Yoldia Sea (Fig. 5). *From that moment the Ladoga Lake was isolated from the Baltic*.

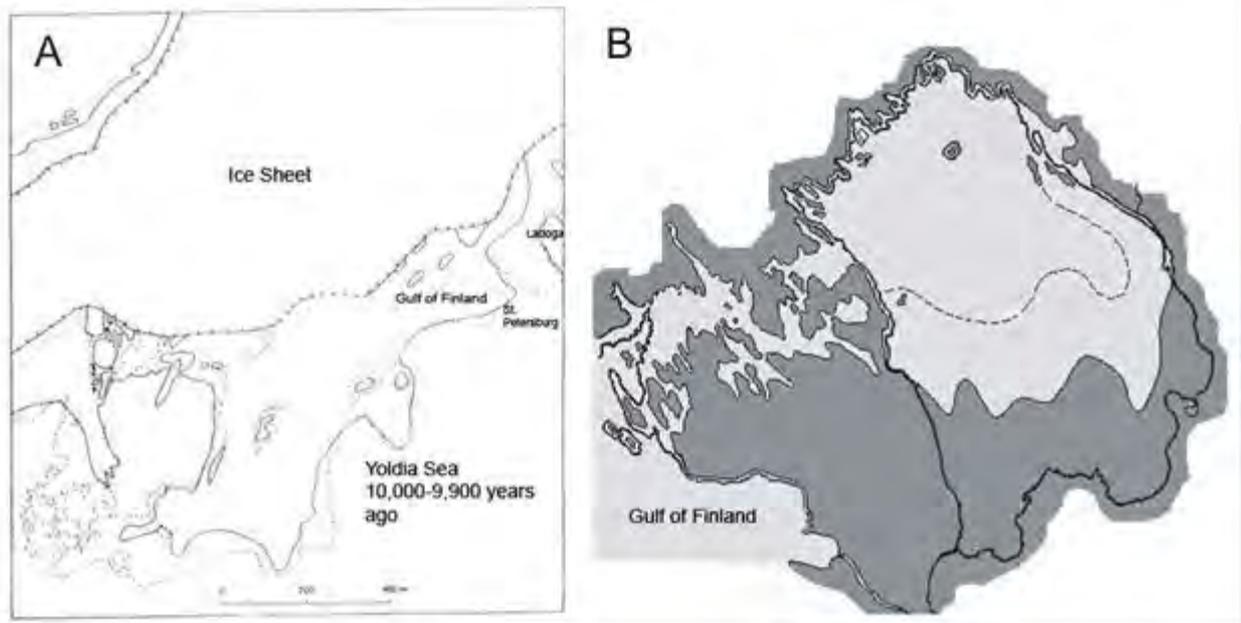


Fig. 5. A) The position of the edge of the glacier and the outlines of the Yoldia Sea, connected with the Ocean through the straits in Central Sweden (Björck, 1994). B) Ladoga Lake was connected with the Yoldia Sea in the northern part of the Karelian Isthmus. The dashed line shows the southern boundary of Ladoga Lake in the Yoldia stage.

The decrease in the level of the BIL was accompanied by strong processes of denudation and erosion of exposed parts of the bottom, as a result of which in the sections of the bottom sediments of most lakes in the northern part of the Karelian Isthmus there is a sandy layer at the contact of clays and overlying silt or a sharp boundary between them, indicating a break in sedimentation. In the structure of the sediments of lakes located within the Karelian Isthmus - the Hejnioki Strait, connecting the Ladoga Lake and the Baltic Sea, sand interlayers up to 0.5 m thick are found (Sevastyanov et al., 2001, Subetto et al. 2002), overlapping banded clays. Above, sand interlayers overlap with organomineral lake sediments (sapropels) and peat.

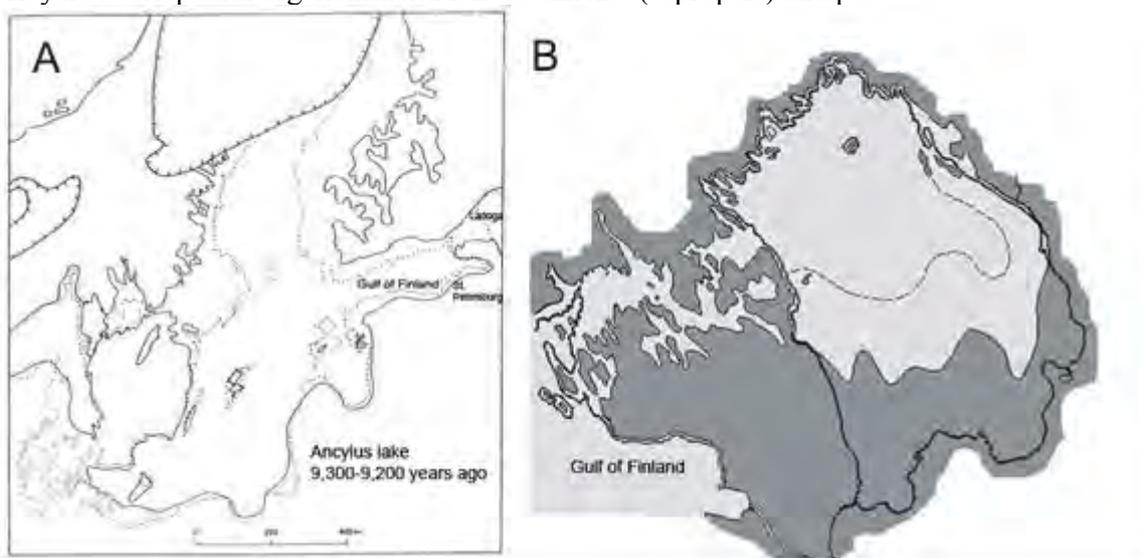


Fig. 6. A) Ancylus stage of the Baltic Sea during the maximum of the transgression associated with the closure of the straits in Central Sweden due to the isostatic uplift of areas liberated from ice (Björck, 1994). B) Ladoga Lake was connected with the Baltic through the strait in the northern part of the Karelian Isthmus where the water level reached 25 m.

In the early Holocene (10,300-9,500 years ago), due to the significant warming of the climate in the Northern Hemisphere, the rapid destruction of the Baltic Ice Sheet, the descent of the Baltic Ice Lake, and as a result the isolation of the Ladoga Lake, a lake-glacial type of sedimentation by lake type (Fig. 4) took place. Characteristic low-power gray homogeneous clays (0.2-0.8 m) are formed.

In the second half of the Preboreal time, the level of the Ladoga Lake rose to a height of 18 to 20 m. This was a consequence of the Ancylus Lake transgression of the Baltic (Fig. 6) of about 9200 years ago, which led to a sprinkling of the runoff from the Ladoga Lake and, as a consequence, a rise in the water level in the lake (Fig. 7). During the maximum of the Ancylus transgression, the southern shallow water of the Ladoga Lake was flooded to modern isobaths of the order of 20 m (Figure 6).

About 9,500 / 9,000 years ago, approximately at the boundary of the Preboreal and Boreal, in the basin of Ladoga Lake, lacustrine sediments (silt, silty clay) begin to accumulate (Fig. 4). Due to the fact that the water area of the lake in the Holocene has been repeatedly reduced, the full and most powerful sections of the silt are observed in the northern deep-water region. In the process of sedimentation, the role of organic matter of autochthonous origin increases. In silts there is an increase in the content of organic matter in comparison with clays.

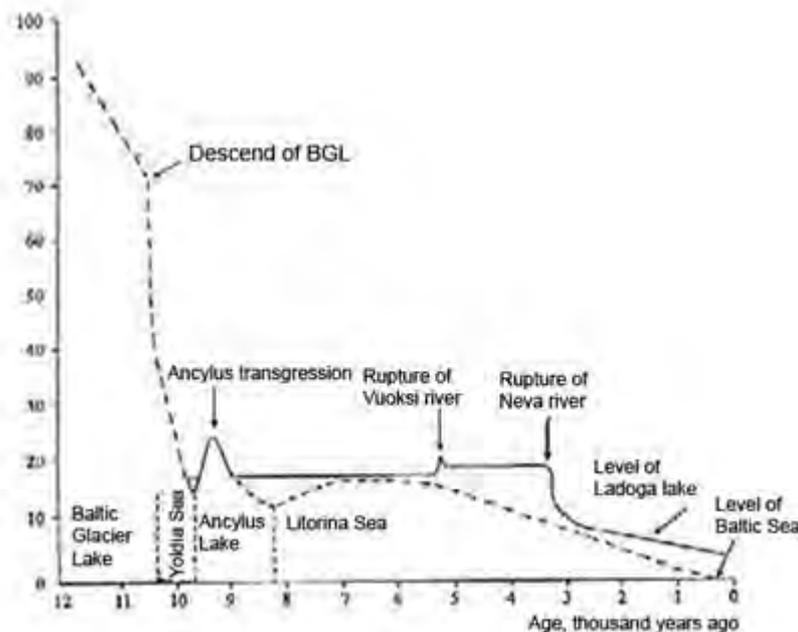


Fig. 7. Reconstruction of changes in the levels of Ladoga Lake and the Baltic Sea in the late and postglacial periods (after Saarnisto, Grönland, 1996).

At the turn of the Preboreal and Boreal about 9000 years ago the level of Ladoga again decreases due to the regression of the Baltic to the markings below the current situation, which is recorded from the study of bottom sediments in the shallow southern part of the lake (History of Ladoga, Onega ..., 1990, Subetto et al., 1998, Subetto et al., 1999).

There is a dismemberment of the Ladoga and the Baltic, the Hejnioki Strait dries up, and many lakes of the Karelian Isthmus are separated, in which organogenic silt is formed, and peat bogs are formed in the mouths of rivers. According to different authors, the radiocarbon age of peat bogs is 7870 ± 110 years ago in the area of Pitkyaranta, 7970 ± 260 and 7960 ± 230 years ago at the mouth of the Ojat River; 7110 ± 170 BP on the river Vjun, 6900 ± 70 years ago on the Olonka River (Koshechkin, Ekman, 1993; Subetto et al., 1999; Abramova et al., 1967).

The stream from Ladoga at that time was directed through the system of the Vuoksa river-lake system to the Vyborg Bay, and the drainage threshold from Ladoga was in the area of the modern Veschevo settlement (Finnish name of Hejnioki) at an altitude of 15.4 m above sea level.

The most interesting and debatable period in the history of Ladoga is the period of the last 5000 years. This stage, which received the name "Ladoga transgression" in the literature, corresponds with the interval 5000 - 3000 years ago (Fig. 8). The reasons for this transgression are treated ambiguously. M. Saarnisto (Saarnisto, 1970) saw the main reason in the leading isostatic uplift of the earth's crust on the northern coast of the Finnish and Baltic Gulf, as a result of which the flow of water from the Saimaa system of lakes to the Gulf of Finland stopped. As a result of skew, a new threshold of flow arose through the marginal ridge of the Salpausselkia-I moraine from the city of Imatra to the river system. Vuoksi, which at that time flowed from Lake Ladoga to the Baltic. The waters of the largest Saimaa lake system of Finland, which is sprung by the moraine ridges of Salpausselkä, according to his idea, broke into Ladoga, sharply increasing the input part of the lake's water balance.

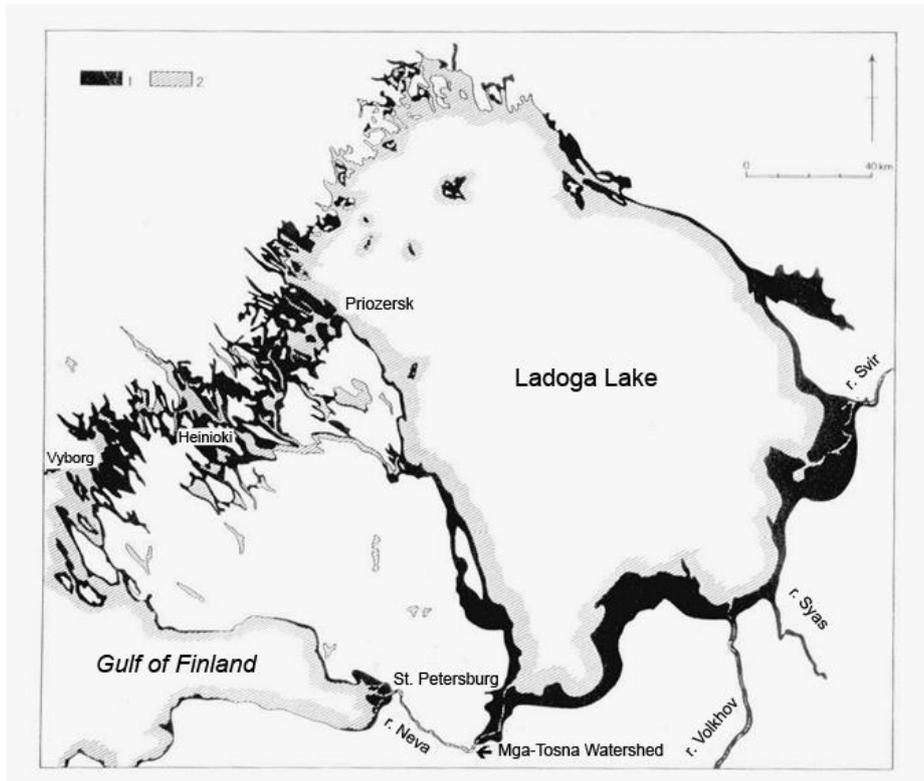


Fig. 8. The map showing the modern outlines of the Ladoga Lake (oblique shading (2)) and during the maximum of the Ladoga transgression (black color (1)) before the rupture of the Neva river (after Saarnisto, Grönland, 1996).

The result of the development of the Ladoga transgression, as commonly believed, was the overflow of Ladoga through the Mga-Tosna watershed and the formation of the Neva River. Most researchers, beginning with G. de Geer, Yu. Ailio, E. Huppä, who later were referred to by D.D. Kvasov (Kvasov, 1975) believed that the Neva channel between Ladoga and the Baltic was formed mainly as a result of the glacioisostatic uplift of the northern Ladoga and the skewing of the Ladoga basin, as a result of which the lake's waters flooded its southern part and infiltrated the valley of the river Old Mga, which flowed into Ladoga. They reached the height of the Mga-Tosna watershed represented by a ridge (about 18 m), composed of morainic loam), washed it and carried out the descent of the Ladoga waters along the valley of the river Old Tosna, which had previously flowed into the Gulf of Finland. At the same time, the lower parts of the valleys were widened and deepened by a drainage from Ladoga (Fig. 8).

The time of the maximum of the Ladoga transgression and the beginning of the formation of the Neva River have different datings for different authors. Yu. Ailio (Ailio, 1915) and S.A. Yakovlev (1926) believed that the Neva arose in the period 4,500-4,000 years ago. Later K.K. Markov et al. (1934) pointed to the short-lived nature of the Ladoga transgression, which fit into

part of the subboreal period. O.M. Znamenskaya et al. (1970) dated its age 2000 years ago, and D.D. Kvasov (1975) considered it in the interval of 2300 - 1200 years ago. According to M. Saarnisto and T. Grönlund (Saarnisto, Grönlund, 1996) the Neva arose around 3100 years ago.

In the study of D.B. Malakhovsky et al. (1993) there are new conclusions about the time of the Ladoga transgression and the formation of the Neva River, which are specified by dating of the differently aged terraces and roofs of peat bogs underlying the sediments of the transgression in the section "Nevsky Forest Park" (3000-2800 years ago) and overlapping them in the section "Nevsky Bridge-head" (2400 years ago). Thus, on the basis of these data, in a short period of time about 400 years, the level of Ladoga has decreased from 18 m to 5-6 m, which is quite realistic, given that the southern watershed of the lake was composed of loose sedimentary rocks, while the northern one - Heinik - was composed of crystalline.

With the isostatic uplift of the northern part of the Karelian Isthmus, drying and swamping of the Heinik Strait occurred, as a system of lake-river ducts on the line Priozersk-Veschevo-Vyborg.

In the course of the regression of the Ancylus Lake and the continuing uplift and distortion of the northern part of the Ladoga Basin, the level of Ladoga and the Baltic has become equal. It was at this time that a new drain from the north broke out of the Saimaa system of lakes and its bifurcation arose. Partly this flow went along the old valley of the Hejnik Strait to the Gulf of Finland, and part of the runoff continued to the Baltic Sea. A large volume of sediment transported along the western shore of Lake Ladoga and contributed to the blockage of the flow from Lake Ladoga along the valley of the Sukhodolskoye Lake (former Lake Suvanto). The powerful sandy shorelines of the subboreal time, 17 meters high, adjacent to the glacial sediments (the ancient esker stretching from the north to the south almost from Priozersk to Pyatirechye), are recorded along the western shore of Ladoga. They were breached by a water flow in 1818 in the area of the present mouth of the River Burnaya (Gulf of Taipole).

It should be emphasized that the expected overlap of the runoff from Ladoga could be achieved only as a result of time-combined block movements on the Karelian Isthmus caused by the activation of isostatic uplifts of the northern Ladoga area, an increase in moisture content and a change in the flow direction from the Saimaa system. The relative lowering of the southern part of the basin could lead to the breakthrough of water from Ladoga and the formation of the Neva river (or a significant increase in runoff along the channel of the Old Neva, if it existed before these events, that is, there was a bifurcation of the flow from Ladoga).

The River Burnaya was formed as a result of a sudden breakthrough in the waters of the lake Suvanto (Sukhodolskoye) through the man-made channel and its descent to Ladoga only in May 1818. The level of Lake Suvanto dropped by 11 m, and its bottom was exposed on an area of more than 5000 hectares. The protuberance flowing from it to the west in the Vuoksi River was completely dry, in its place a rocky isthmus was formed. It was from this time on Vuoksi flowed back and began to flow into Lake Ladoga, and the numerous lakes of the Karelian Isthmus sharply lowered their level and became shallow. This was due to a 10-11 m drop in level of Lake Suvanto and other local erosion basins in the Vuoksi basin. Significant changes were also caused by a further artificial increase in flow at the site of the river Vuoksa - Lake Suvanto in 1857 and the formation of the Losevskya channel. This event also affected the entire hydrographic network of the Karelian Isthmus and entailed an appropriate restructuring in the structure of its landscapes (Isachenko, 1995, 1998). Numerous lakes of the Karelian Isthmus dramatically reduced their level, became shallower and substantially reduced the size of the water areas as a result of the reduction of local erosion bases in the basin of the Vuoksa River.

References:

1. Abramova S.A., Davydova N.N., Kvasov D.D. The history of Ladoga Lake in the Holocene according to the data of spore-pollen and diatom analyzes. In the book: The history of the lakes of the North-West. Otv. Ed. S.V. Kalesnik. L., 1967. P. 113-132.
2. Davydova N.N., Rybalko A.E., Subetto D.A., Khomutova V.I. Late Pleistocene history of Lake Ladoga. - History of the Pleistocene Lakes of the East European Plain. Khomutova V.I., Davydova N.N., Raukas A.V., Rummyantsev V.A. (ed.). St. Petersburg. Science, 1998, p. 134-140.

3. Znamenskaya O.M., Sokolova V.B., Khomutova V.I. A comparative analysis of the paleogeographical conditions for the development of the southern and western shores of Lake Ladoga. - The history of lakes. Vilnius, 1970. pp. 319-331
4. The history of Ladoga, Onega, Pskov-Chudskoye lakes, Baikal and Khanka. (Series: "History of the Lakes of the USSR"). Kvasov D.D., Martinson G.G., Raukas A.V. (ed.). L., Science, 1990. 280 pp.
5. Kvasov D.D. Late Quaternary history of large lakes and inland seas of Eastern Europe. L., 1975. 278 p.
6. Koshechkin B.I., Ekman I.M. Holocene transgressions of Ladoga Lake. - Evolution of natural settings and the current state of the geosystem of Lake Ladoga. Ed. N.N. Davydova, B.I. Koshechkin. St. Petersburg, ed. RGO, 1993, p. 49-60.
7. Malakhovsky D.B., Arslanov Kh.A., Gay N.A. New data on the Holocene history of Lake Ladoga. - Evolution of natural environments and the current state of the geosystem of the Ladoga Lake, Ed. N.N. Davydova, B.I. Koshechkin. St. Petersburg, ed. RGO, 1993, p. 61-73.
8. Markov K.K., Poretsky V.S., Shlyamina V.E. On fluctuations in the levels of the Ladoga and Onega lakes during the postglacial period, Tr. Komit. on studied. fourth. period. 1934. Vol. 4. Ed. 1.
9. Sevastyanov D.V., Subetto D.A., Arslanov Kh.A. and others. The processes of sedimentation in the lake-marshy geosystems of the Northwest Ladoga area // SPb. Izv. RGO. T. 128, no. 5, 1996, p. 36-47.
10. Sevastyanov D.V., Subetto D.A., Sikatskaya E.D., Stepanchikina O.E. Peculiarities of the evolution of the lake-river network in the Ladoga Lake basin in the Holocene // Herald of St. Petersburg State University. Ser. 7, 2001, vol. 1 (No. 7), p. 88-100.
11. Subetto D.A. Structure, features and history of formation of bottom sediments. In the book: "Ladoga Lake: Past, Present, Future". Drabkova VG, Rumyantsev V.A. (ed.). SPb, Nauka, 2002. P. 122-136.
12. Subetto D.A., Davydova N.N., Wolfard B., Arslanov H.A. Litho-, bio- and chronostratigraphy of lacustrine deposits of the Karelian Isthmus at the boundary of the late Pleistocene-Holocene. News of the RGO. T. 131, vol. 5, 1999, p. 56-69.
13. Subetto D.A., Rybalko A.E., Spiridonov M.A. General characteristics of bottom sediments. Ladoga lake. - The history of Ladoga, Onega, Pskov-Chudskoye lakes, Baikal and Khanka. D.D. Kvasov, G.G. Martinson, A.V. Raukas (ed.). Leningrad, Science, 1990, p. 35-42.
14. Shnitnikov A.V. Variability of the general moistening of the continents of the Northern Hemisphere. M. ; L., 1957. 337 p.
15. Shnitnikov A.V. Intra-century variability of components of total moisture. L., 1969.
16. Evolution of natural settings and the current state of the geosystem of the Ladoga Lake, Ed. N.N. Davydova, B.I. Koshechkin. Sat. sci. tr. St. Petersburg, ed. RGO, 1993. 118 pp.
17. Yakovlev S.A. Sediment and relief of Leningrad and its environs. L., 1925. Part 1, 186 p. ; 1926. Part 2, 264 p.
18. Ailio J. Die geographikche Entwicklung des Ladogasees // Fennia., 1915. Bd.8, N3. 157 s.
19. Davydova N., Khomutova V., Pushenko M., ..., Subetto D. New data on Late Pleistocene and Holocene history of Lake Ladoga // Report on Lake Ladoga Research in 1991-1993. Joensuu, N: o 111. 1994a. P. 137-143.
20. Björck S. A review of the history of the Baltic Sea, 13.0-8.0 ka BP // Quaternary International, Vol. 27, pp. 19-40, 1994.
21. Saarnisto M. The Late Weichelian and Flandrian history of the Saimaa lake complex, Helsinki, 1970, 108 p.
22. Saarnisto M., Grönlund T. Shoreline displacement of Lake Ladoga - new data from Kilpolansaari // Hydrobiologia 322. 1996. P. 205-215.
23. Subetto D., Davydova N., Rybalko A. Contribution to the lithostratigraphy and history of Lake Ladoga // Palaeogeography, Palaeoclimatology Palaeoecology. 1998. No. 140. P.113-119.
24. The First International Lake Ladoga Symposium // Hydrobiology, 1996. Vol. 322. 328 p.

Added excursion day. August 25

TRIP TO KIZHY

(The description is based on the Guide to WRB field trip on soil classification, 2004)

This day the participants will get acquainted with one of the most picturesque places in the Transonega land — the Kizhy island.

The Kizhy island is situated at a distance of 60 km to the Northeast of Petrozavodsk, the starting point of the tour. A steamer crosses the open area of the lake (Large Onego) and passes by numerous islands of the archipelago.

The Onego Lake is of tectonic provenance: it is a large trough, its area is 9720 km², the maximum depth is 120 m (Bolshaya Guba), while in the southern part of the lake the depth is considerably less (Pudozh, Vozneseniya) – from 20 to 50 m. Water in the lake is fresh, the sum of ions being about 25 mg/l, transparency – 8-10 m, water is coloured by organic matter.

The coastline of the Onega Lake has a specific sinuous shape with numerous peninsula and capes, and frequent rock outcropping the banks. Rocks of the northern and northeastern parts of the Onega bank are represented by quartzites, quartzite-sandstones, shales, dolomites, limestones, and schungite-clay shales. These rocks alternate with intrusions of diabase and gabbro-diabase. The Transonega Peninsula located in the northern part of the lake is composed almost completely of diabase and gabbro-diabase. Grayish pink and pink massive crystalline rocks are most frequent in the eastern part of the depression among gneissic granites. The southeastern part of the coast is chiefly formed by gray sandstones and sandy-argillaceous shales, to be replaced by “shoksha” shales, pink and crimson quartzite-sandstones. The southmost areas are composed of Low Cambrian and Devonian deposits such as “blue clays”, aleurolites, sandstones.

An almost continuous mantle of eluvial-deluvial and glacial Quaternary deposits from 1.5 m to 50 m deep covers the crystalline rocks of the coastal part of the Onega Lake. More seldom are glaciofluvial sediments with horizontal and inclined stratification; they are composed of fine- to coarse-granular boulder-free sands alternating with pebble and gravel lenses. Such stratified sands with bands of loams and pebbles compose the terraces of the Onega Lake.

Spruce forests of high quality abounding in bilberry in the grass-shrub canopy are restricted to loamy and partly to sandy-loamy podzolic (Albi-Arenic Luvisols) soils. These forests often acquire the character of a mixed spruce-pine stand with admixture of birch. Pine forests are widely spread on more light-textured sediments – sandy and loamy sandy ones. Lichen pine forests with *Cladina* predominating and a sparse grass cover composed of cowberry and heather occur on sands.

Albic Luvisols / Albeluvisols with varying depth of the *albic* horizon are developed on moraine and lacustrine-glacial sediments. The soil cover is characterized by great irregularity due to frequent changes in the parent rock composition and in topography.

Weakly and moderately developed Albic Luvisols / Albeluvisols and associated Histosols are widely spread to the south of the Onega Lake. For the Transonega hilly region soils with a dark almost uniform profile on shungites (graphite-like carbon shales) are typical. Near the lake there are depressions with soils with excessive moisture (Umbric and Histic Gleysols).

Recently, a natural reserve with the architecture and genre museum was organized on the island to preserve the relics of wooden architecture brought there from nearby villages. The centre of the Kizhy natural reserve is well-known for the ensemble of two wooden churches built in 1714-1764 with a marquee bell tower (1874).

The geological structure of Kizhi island, namely, the participation of dark-coloured shungite material (both fragments and fine earth) in parent rock composition determines the unique character of soils. Most common are dark-coloured Cambisols, varying in texture, stoniness, chemical properties, and degree of anthropogenic transformation (cultivation). In the western part of the island, there is a moraine ridge, formed by boulder loamy sands. The dominant soils on the ridge are Cambisols under agricultural management of various intensity (gardens, arable lands, and grazing).

The eastern part of the island is a big sandy esker, covered with shunghite-containing sands, loamy sands, and boulder loams. The soils are “shunghite” Cambisols. This “qualifier” (or a similar one indicating specific rock-inherited features, which is important for Cambisols) is not provided in the WRB system. In the second version of the Russian system there is a special property for ‘dark-colored’ subtypes in some soil orders.

All the soils were previously cultivated, but now the arable area greatly reduces; the soils are very compact due to high recreation pressure.

Along the moraine and eskers ridges there are abrasion and accumulative lake terraces, where Gleyic Cambisols, varying in their texture and chemical properties, occur. The soils of the abrasion terrace contain more shunghite material, and thus have almost no morphological evidences of gleying. On the accumulative terrace, where the shunghite material content is lesser, the soils are defined as Mollic Gleyzems.

Deep depressions in the northern and western parts of the island are occupied by Histosols. In the northern massif the center is formed by Fibric Histosols, while the periphery is composed of Rheic Histosols and Histic Gleysols. The formation of these soils is connected with specific peat formation in the shallow-water bay between the ridges. In the western part of the island, Eutric Gleysols and Eutri-Histic Gleysols are formed in small depressions.

The soils of Kizhi island were used for agriculture for a long time; even in the 60-s of the XX century there were arable lands under barley, rye, potatoes and other crops. Nowadays, the northern part of the island is partially used for grazing and, to a less extent, for growing vegetables. However, the antropogenic pressure on the soils of the island is great due to tourism, and it results in soil compaction.

Two profiles are shown at shunghite-rich parent material (glaciofluvial sediments and moraine till) at Kizhi island. The first profile has a relatively uniform clay distribution, but with a discontinuity at the depth of 70 cm (Fig. 1); the second profile has evidences of clay illuviation. Both soils are rich in organic matter; however, the organic carbon is mostly presented by lithogenic carbon, which is impossible to separate from pedogenic one by wet combustion technique. Thus, these soils rich in organic carbon, and base-saturated should be classified as Phaeozems. We are still not sure that this is the best solution name for these specific soils.

It is interesting to compare the data obtained by the analysis of the fine earth using the treatment used in Russia (1-mm sieve), and in Europe (2-mm sieve). Sometimes there is a minor difference in the obtained values, but in the other cases the difference is great. There are no regularities in the data: some values of the analyses of <1 mm fine earth are higher, than that of <2 mm fine earth, and some of them are lower. More studies are needed to make the data obtained in Europe and in Russia comparable.



Fig. 1. Soil in fluvio-glacial sands enriched in shungite shales

Table 1. Chemical properties of soils of “Kizhi” site.

Horizon	Depth, cm	pH _{H2O}	Ca ⁺⁺	Mg ⁺⁺	K ⁺	Na ⁺	EA	BS	CEC/kg of clay	TOC	N	C/N
			cmol•kg ⁻¹									
Kizhi-1												
Ap1	0-10.	5.7	14.2	2.2	1.1	0.4	0.5	97	89	14.5	1.4	10.4
Ap2	10-30	6.0	10.6	3.2	0.5	0.3	0.4	97	73	11.9	1.0	11.9
AB	30-50	6.5	9.5	3.4	0.3	0.1	0.2	98	79	7.5	0.6	12.7
Bw1	50-60	6.1	7.7	3.1	0.2	0.6	0.1	99	69	9.8	0.8	12.3
Bw2	70-90	6.5	5.3	2.1	0.5	0.6	0.1	99	32	10.2	0.9	11.3
BC	90-100	6.3	3.0	1.3	0.3	0.4	0.1	98		8.7	0.9	9.7
C	100-120	6.2	2.6	1.1	0.1	0.4	0.1	98		10.3	0.9	11.4
Kizhi-2												
Ap1	0-10.	6.0	7.6	1.7	1.4	0.3	0.4	97	58	23.7	2.6	9.1
Ap2	10-30	5.8	10.2	2.0	2.0	0.3	0.2	99	63	36.8	3.4	10.8
Bt	30-40	5.5	11.3	3.6	0.8	0.4	0.3	98	59	29.3	2.3	12.7
Bw1	40-70	6.1	10.8	2.8	1.2	0.5	0.3	98	72	22.3	1.7	13.1
Bw2	70-90	5.9	11.0	3.3	0.7	0.2	0.3	98	116	15.0	1.6	9.4
BC	90-100	6.4	11.0	4.0	0.4	0.4	0.3	98		12.6	1.3	9.7
C	100-120	6.4	72.3	14.5	0.6	0.5	1.2	99		12.2	0.8	15.3

Table 2. The particle-size distribution of the soils of “Kizhi” sites (Russian particle size classification: Vadyunina, Korchagina, 1973)

Horizon	Depth, cm	1-0.5	0.5-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
Kizhi-1								
Ap1	0-10.	3	16	25	21	8	17	8
Ap2	10-30	3	13	23	25	10	16	9
AB	30-50	1	8	30	31	6	12	9
Bw1	50-60	4	15	24	28	5	11	10
Bw2	70-90	3	21	26	22	5	11	10
BC	90-100	3	14	46	19	4	7	7
C	100-120	8	10	37	21	6	10	7
Kizhi-2								
Ap2	10-30	10	16	21	16	12	16	7
Bt	30-40	21	16	16	14	8	15	7
Bw1	40-70	27	11	14	16	10	14	7
BC	90-100	9	12	18	25	8	17	9
C	100-120	13	20	22	19	6	11	5

References

1. Morozova R.M. 1991. Forest soils of Karelia. Nauka Publ., Leningrad. 184 p. [In Russian]
2. Russian Soil Classification System, Moscow, 2001 [in English], 1997 [in Russian].
3. Vadyunina A.F., Korchagina Z.A. 1973. The methods of the study of physical properties of soils and grounds. Vysshaya shkola, Moscow. 244 p. [In Russian]
4. van Reeuwijk, L. P. (ed.) 2002. Procedures for soil analysis. 6th edition. ISRIC-FAO. ISRIC Technical Paper No. 9.
5. Yakovlev F.S., Voronova V.S. 1959. Karelia forest types and their natural division into districts. Petrozavodsk. 190 p. (In Russian)
6. World Reference Base for Soil Resources Technical Paper No. 9.

Glossary of local names

- **Guba** – bay of the lake
- **Lamba** – a small lake, a pond
- **Selga** – a moraine ridge, mainly with rock outcrops on the top
- **Shungite (schunghite)** – local sedimentary and metamorphic rocks of Proterozoic age enriched with organic carbon. Carbon is present in these rocks in various amounts (0.5–95%) and forms: disordered graphite structures, fullerenes, aromatic compounds, and “carbon glass”.

ABSTRACTS

GEOMORPHOLOGY AND MORPHOMETRIC PROPERTIES OF GLACIAL CURVILINEATIONS (GCLS) IN THE EUROPEAN LOWLAND

Adamczyk, A.¹, Wysota, W.¹, Piotrowski, J.A.²

¹ *Faculty of Earth Sciences, Nicolaus Copernicus University, Toruń, Poland*

² *Department of Earth Sciences, Aarhus University, Aarhus, Denmark*

E-mail: adams@doktorant.umk.pl

The area of the Dobrzyń Plateau (north-central Poland) is characterized by enigmatic subglacial landscape firstly ascribed by Lesemann et al. (2010). It comprises glacial curvilineations (GCLs) which are consisted of sets of parallel and sinuous ridges and troughs occurring in tunnel valleys, and forming a complex and extensive fields (Lesemann et al., 2010, 2014; Adamczyk et al. 2016). It is supposed (Lesemann et al., 2010, 2014; Adamczyk et al., 2016) that the glacial curvilineations are erosional features created by the longitudinal vortices within subglacial meltwater flows. Lately Clark and Livingstone (2018) discovered GCLs sets along the southern sector of the Laurentide Ice sheet. The authors hypothesized that these glacial curvilineations were produced by subglacial bank and slope failures occurring at the widening of tunnel valleys or near subglacial lake shores.

In the area of the south-western fringe of the Scandinavian Ice Sheet around 60 GCLs fields were found. Based on their morphological properties (field area, number of swarms, number of topographic levels and number of ridges in the field) the three main types of GCLs fields have been distinguished: tunnel channel, tunnel valley and complex GCLs fields. Tunnel channel GCLs fields are the smallest ones; they have up to 5km² area and consist only one swarm with a maximum 10 ridges and troughs sets. Tunnel valley GCLs fields are much bigger than tunnel channel GCLs fields and could have even several dozen of square kilometers. They comprise up to 50 sets of ridges and troughs in few swarms located in different topographic levels. Complex GCLs fields consist of two or more tunnel channel or tunnel valleys GCLs swarms. They could have more than several hundred square kilometers and hundreds of individual GCLs landforms (ridges and troughs).

Morphological properties of GCLs landforms were examined in detail within the Zbójno GCLs field (north-central Poland). The Zbójno field represents the complex GCLs field and consists of 21 separated GCLs swarms both tunnel valleys and tunnel channels types. The first of all more than 300 individual GCLs landforms (ridges and troughs) were mapped based on DEM. Then morphometric parameters of GCLs troughs including length, width, depth, average slope and vertical and horizontal sinuosity were measured and afterward statistically analyzed. Obtained results shows that morphometric features of GCLs troughs, especially average slope and horizontal sinuosity, are close enough to morphometric characteristics of tunnel valleys and eskers.

Morphologic features of GCLs fields and morphometric properties of GCLs yield significant circumstances for subglacial meltwater origin of GCLs.

References:

Adamczyk A., Wysota W., Karasiewicz M.T., Piotrowski J.A., Lesemann J.-E. 2016. Site Zbójno - geomorphology and postglacial evolution of glacial curvilineations (GCL) landscape in the Dobrzyń Plateau, north-central Poland. In *Quaternary geology of North-Central Poland: from the Baltic coast to the LGM limit*. Sokołowski R.J., Moskaiewicz D. (eds.) Wydział Oceanografii i Geografii Uniwersytetu Gdańskiego: Gdynia: 99-121

Clark, C. D., Livingstone, S. J. Glacial curvilineations found along the southern sector of the Laurentide Ice sheet and a hypothesis of formation involving subglacial slope failure in tunnel valleys and subglacial lakes. *Earth Surface Processes and Landforms*.

Lesemann J.-E., Piotrowski J.A., Wysota W., 2010. 'Glacial curvilineations' produced by longitudinal vortices in subglacial meltwater flows. *Geomorphology* 120: 153-161.

Lesemann J.-E., Piotrowski J.A., Wysota W. 2014. Genesis of the 'glacial curvilineation' landscape by meltwater processes under the former Scandinavian Ice Sheet, Poland. *Sedimentary Geology* 312: 1-18.

TYPOMORPHIC FEATURES OF GARNETS FOR SUBDIVISION AND CORRELATION OF THE MIDDLE NEOPLEISTOCENE TILLS

Andreicheva, L.N., Buravskaya, M.N.

Institute of geology, Komi Science Centre, Ural Division of RAS, 54, Pervomaiskaya, 167982, Syktyvkar, Komi Republic

E-mail: andreicheva@geo.komisc.ru, buravskaya@geo.komisc.ru

The actual task in Quaternary geology is the substantiated and reliable subdivision and correlation of sediments and paleogeographic events needed for the creation of a new generation of Quaternary geological maps. For this purpose, it is extremely important to improve the old methods and to use new methods and approaches to the Quaternary geology. For the first time we began to study typomorphic features of the garnets from the Middle Neopleistocene tills (Pechora and Vychegda horizons) in the valleys of the Laya and Vychegda Rivers – in the north and south of the European North-East of Russia (Andreicheva and Buravskaya, 2017).

The garnets are separated from the heavy fraction of Middle Neopleistocene tills, since they play an important role in the composition of the mineral association with the dimension of 0.25-0.1 mm. Their average content is 17-18 % in the Pechora till, and 19-22.5 % in the Vychegda till. All grains of the garnets are represented by two color groups. The first group includes the garnets of orange and light orange color. The second group consists of pink and light pink grains.

We discovered certain areal and age specific properties of the garnets, similar in color and size, which were associated with different glacial provinces during formation of the tills (centers of glaciation): with Pay-Khoy-Ural-Novaya Zemlya in the Pechora time, the Fennoscandian during the Vychegda glaciation.

In the valley of the Laya River the heavy fraction of the tills is dominated by garnets of the second color group – pink and light pink grains. In the Pechora horizon their content is higher than in the Vychegda one. At the Vychegda River the tills are enriched with garnets of the first group – of orange and light orange color. The maximum concentration of such garnets is typical for the Vychegda till.

The Pechora till is dominated by pyrope-almandine among the pink garnets (up to 90 % at the Laya River, 60 % at the Vychegda River). In the group of orange garnets grossular-pyrope-almandine contains 50 % at the Laya River and 40 % at the Vychegda River (fig.).

In the orange color group of garnets pyrope-grossular-almandine prevails in the Vychegda till. At the Laya River its content is 44 %, at the Vychegda River – 50 %. Among pink garnets, pyrope-almandine predominates. At the Laya River its content is 56 %, on the Vychegda River – 45 %.

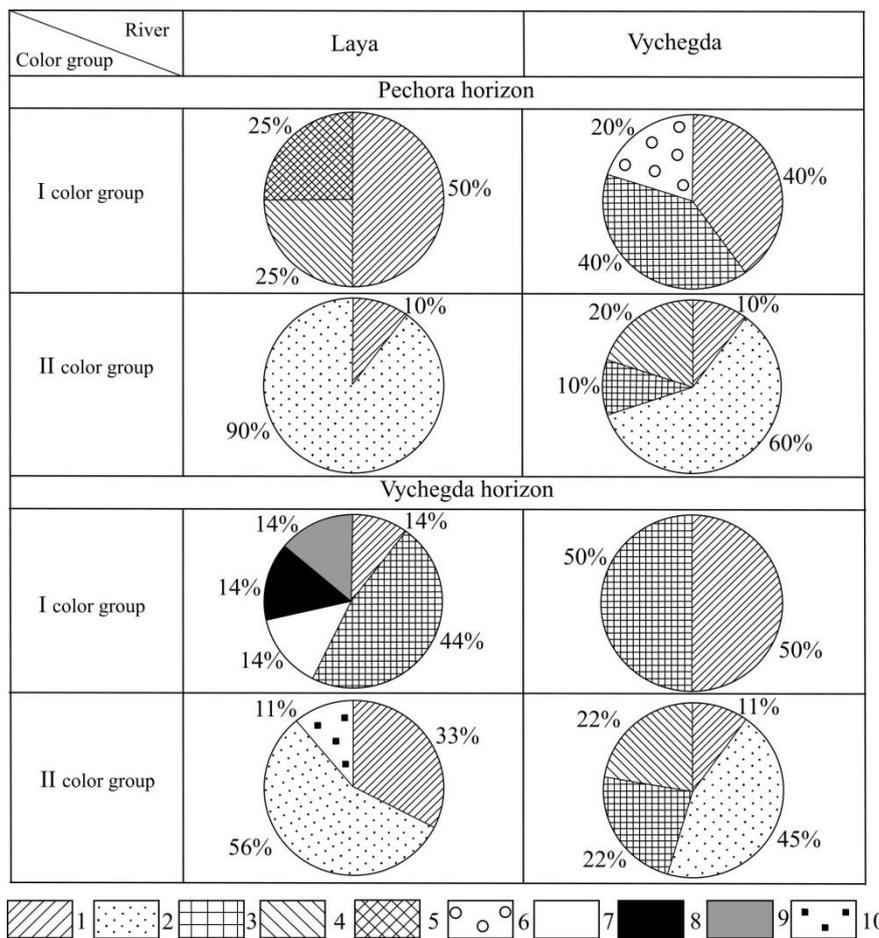


Fig. Minerals of garnet group of the Middle Neopleistocene tills

1 – grossularite-pyrope-almandine; 2 – pyrope-almandines; 3 - pyrope-grossularite- almandines; 4 - grossularite-almandine-pyropes; 5 - grossularite-spessartine-almandine; 6 – spessartine-grossularite-almandine; 7 - almandine-spessartine; 8 - grossularite-almandine-spessartine; 9 - grossularite-andradite; 10 – grossularite.

The ratio of the color groups of garnets in the tills of different ages is also different. In the Pechora till at the Laya River the ratio of the minerals of the first and second color groups is 1:10, in the Vycheгда River it is 1:4. At the Vycheгда River in the Pechora till, there are two times less orange garnets than pink ones, and in the Vycheгда till, on the contrary, it is twice as large.

It is planned to continue the study the garnets, as well as zircon, epidote and amphiboles to identify typomorphic features of minerals-indicators of the tills. The minerals will be studied in valleys of other rivers and in the bedrocks of glacial distributive provinces.

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References:

Andreicheva L.N., Buravskaya M.N. Typomorphic features of garnets from the Middle Neopleistocene tills on North and south of the Timan-Pechora-Vycheгда region. Vestnik of Institute of geology Komi Science Center of Ural Branch RAS, 2017, № 1. pp. 16-21.

THE LACUSTRINE SEDIMENTATION DURING THE MIDDLE NEOPLEISTOCENE IN THE EUROPEAN NORTH-EAST OF RUSSIA

Andreicheva, L.N., Marchenko-Vagapova, T.I.

Institute of geology, Komi Science Centre, Ural Division of RAS,

54, Pervomaiskaya, 167982, Syktyvkar, RUSSIA

E-mails: andreicheva@geo.komisc.ru, timarchenko@geo.komisc.ru

The accumulation of clastic, organic and chemical sediments deposits takes place in lacustrine depositional environment. The type of deposits and their composition depend on climatic conditions. On the territory of the European North-East of Russia lacustrine sediments are composed of clastogene material. Sand-clay deposits with thin horizontal bedding predominate. They are enriched with plant remains, contain interlayers of peat and lake mud – sapropel. In the composition of the Middle Neopleistocene rocks, the Chirva (Likhvin) and Rodionovo (Shklov) interglacial lacustrine deposits are distinguished in the wells and coastal outcrops (Andreicheva, Marchenko-Vagapova, 2015). Their granulometric composition was studied, average particle diameters (d_{av}) and coefficients of sediment sorting (S_c) were calculated. Composition of heavy minerals was determined in a fine sandy fraction (0.25-0.1 mm). The palynological spectra of lacustrine sediments were studied.

According to the granulometric composition, the average degree of sediment sorting (S_c) of the Chirva deposits ($Q_{II}^{1\check{c}}$) is 0.31-0.41. Deposits vary from very thin clays with an average particle diameters (d_{av}) equal to 0.006 mm to silts with $d_{av} = 0.049$ mm. Lacustrine deposits of the Rodionovo age (Q_{II}^{3r}) have a very diverse composition and are represented by clays, silts, loams, sands of fine- and medium-grained, sometimes inequigranular, with a small admixture of gravel material. The lacustrine sediments in the valleys of the Laya and Northern Dvina Rivers is characterized by the coarsest granulometric composition, where d_{av} are 0.072 and 0.098 mm, respectively, and sediments are better sorted: in the Laya River $S_c = 0.51$, in the Northern Dvina River $S_c = 0.59$. Variations in the granulometric composition probably are related to the position of the samples in a section: clay deposits could form in the bottom of the lake, and silts and sands precipitated in a shallower water.

The average content of heavy minerals of the Chirva deposits varies from 0.32% in the valley of the Vycheгда River up to 1.02% at the latitude of the Pechora River. Epidote is the main mineral, it forms up to a third of the heavy fraction. The total content of the titanium and metamorphogenic minerals is increased, corresponding to 5-9 and 5-10%, respectively. The total amount of pyrite and siderite is 20-23% in the north of the region, whereas in the south (the Vycheгда valley), these minerals are absent. In the Rodionovo deposits in the north of the Pechora lowland the content of heavy minerals is highly variable: from miserable 0.03-0.08% (at the lower Pechora and in the Seyda valley) up to 1.01% (in the valley of the Usa River). The composition of mineral spectra changes on the area, but the basis is epidote (30-42%). The maximum concentrations of epidote are confined to the center of the Bolshezemelskaya tundra (basin of the Laya River). The content of garnets varies within a wide range: from 10% in the Laya valley up to 35% in the Usa valley. The pyrite and siderite are completely absent and ilmenite contents are increased (up to 8%) in lacustrine sediments in the south of the studied territory. Despite some changes in the mineral composition of the lacustrine deposits on the area, it is rather monotonous in the section. This, apparently, is due to the location of the source areas and the constancy of the sedimentation conditions throughout the formation of the lacustrine sediments.

Division of vegetation phases for the Chirva and Rodionovo interglacials is based on the generalization of our materials and the published data of other researchers.

Five plant phases have been established in the Chirva interglacial.

Č_I – the phase of birch, pine-birch sparse forests and various shrubby groups from *Betula* sect. *Fruticosae*, *Betula nana*, *Alnaster* sp. Vegetation reflects the cold climatic conditions of the tundra zone.

Č_{II}¹ – the phase of spruce, pine forests with the constant presence of *Betula* sect. *Albae*, *Betula* sect. *Fruticosae*, *Betula nana*, *Alnus* sp., *Alnaster* sp., *Salix* sp., with xerophytic communities (*Artemisia* sp. – 19%, *Chenopodiaceae*) and herbaceous associations. Vegetation is characterized by cool conditions.

Č_{II}² – the phase of birch, pine-birch forest communities with the participation of spruce and various shrub groupings. Vegetation reflects fairly cool climatic conditions.

Č_{II}³ – the phase of coniferous forests dominated by *Pinus sylvestris* and *Picea* sp. Birches, *Alnus* sp., *Alnaster* sp., *Caprifoliaceae* were constantly present; single broad-leaved species were encountered. The pollen of herbage and aquatic plants prevailed. The climate is more favorable.

Č_{III} – the phase of pine, pine-spruce-birch, birch forests. The phase characterizes the short cooling.

Č_{IV}¹ – the phase of forests where the representatives of coniferous species dominated and the participation of birch was great. Single grains of *Picea* sect. *Omorica* were noted.

Č_{IV}² – the phase of dark coniferous forests with a predominance of spruce and pine, with the participation of birches, with single broad-leaved species (*Carpinus* sp.). The environmental conditions were quite favorable.

Č_V – the phase of pine, pine-birch, birch forests, in which the birch is represented mainly by shrubby forms.

The phases reflect the forest flora in interglacial conditions. Two climatic optima are singled out. The lower optimum of Č_{II}³ is characterized by the great participation of the pollen of *Pinus sylvestris* and single broad-leaved species. Pollen of *Picea* sp., *Pinus sylvestris* predominate in the upper climatic optimum (Č_{IV}¹-Č_{IV}²). *Picea* sect. *Omorica* and broad-leaved species are presented by single grains.

Five plant phases are established by the palynological method in the Rodionovo interglacial in the region.

R_I – the phase of the vegetation such as modern tundra and forest tundra. Pollen *Betula humilis* predominates; *Betula nana*, *B.* sect. *Albae*, *Alnaster* sp., *Pinus* sp. is found. The climate was cold and dry.

R_{II} – the phase of birch-pine and birch-spruce forests with an admixture of *Pinus sibirica* and broad-leaved species (oak, elm, hornbeam). The climate was moderately warm.

R_{III} – the phase of birch sparse forests with the participation of pine and spruce. The role of *Betula nana* increased to 10%, *Alnaster fruticosus* – to 16%. Shrub and bog associations have become very broadly expanded. The climate was cool.

R_{IV} – the phase of birch-spruce forests with an admixture of pine. The spruce sect. *Omorica* and nemoral *Quercus* sp., *Ulmus* sp., *Carpinus* sp., *Corylus* sp. are presented by single grains. The composition of the herbaceous plants varied: at the same time with xerophytes (*Chenopodiaceae*, *Artemisia* sp.), mesophilic and aquatic plants (the family *Nymphaea*) were noted. The vegetation characterizes quite warm and humid climatic conditions.

R_V – the phase of birch-spruce forests, shrubby associations and bogs. There was a cooling of the climate.

The phases characterize the interglacial vegetation with two climatic optima (R_{II} and R_{IV}). The conditions of the first climatic optimum were less damp than in the Chirvin period. The second optimum is cooler and more xerophilic. At that time the territory was covered with dark coniferous forests of the southern taiga with broad-leaved and exotic species.

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References:

Andreicheva L.N., Marchenko-Vagapova T.I. The lacustrine sedimentation during the Middle Neopleistocene in the Timan-Pechora-Vychegda region. *Vestnik of Institute of geology Komi Science Center of Ural Branch RAS*, 2015, №15, pp.14-22.

TRACES OF THE PENULTIMATE INTERGLACIATION IN NORTHERN RUSSIA

Astakhov, V.

A. P. Karpinsky Russian Geological Research Institute, St. Petersburg State University

This problematic issue depends heavily on dating of the topmost glacial complex. The situation became more comprehensible after the international stratigraphic works of the last two decades within the European programs QUEEN and APEX. A position of the lower boundary of the Upper Pleistocene in the regional succession is crucial. This chronohorizon is now pinpointed by one glacial/interglacial cycle higher than was customary for conventional stratigraphic frameworks. The shift stems from the position of the Eemian strata which are till-covered only beyond the Arctic Circle but south of it occur on the surface (Svendsen et al., 2004). Therefore, sub-till marine formations with Atlantic fauna, including the strata locally called the Kazantsevo or Boreal, south of the Arctic Circle must be pre-Eemian. The second boreal transgression was first suggested in the 1950-s by Yakovlev for European Russia and later by Zubakov for West Siberia. This conclusion is independently supported by shells of *Cyrtodaria angusta* = *C. jensenseae* in marine strata uncovered by boreholes beneath the second from the surface diamictic formation. These shells do not occur in uppermost Arctic marine formations with interglacial fauna called Boreal Strata in European Russia and Karginy Strata in Siberia.

Another indication of a Middle Pleistocene interglacial is provided by peat layers in the Pechora Basin which occur between two thick diamict formations conventionally mapped as youngest Middle Pleistocene tills. The Seyda peat in present tundra at 67.5°N has yielded pollen spectra of southern taiga and the age ca 200 by 10 OSL measurements and by uranium-series dating (Andreicheva, 2002; Astakhov, 2004; Murray et al., 2008). Slightly older ages are obtained by OSL and ESR dating from marine clay with *Cyrtodaria* shells and arboreal pollen overlain by sand with Eemian dates on Yangarei river, 68°44'N (Semenova et al., this volume). The Rodionovo peat 3.5 m thick yielded U/Th dates ca 250 ka at its stratotype on 65.5°N (Arslanov et al., 2006). All these results confirm a MIS 7 age for the penultimate interglaciation identified as 'the Rodionovo thermochron' in northeastern European Russia.

Thus, the data obtained so far in northern Russia looks like evidence of a MIS 7 interglacial as warm as the Eemian. It might be a climatic echo from the opposite edge of the European continent, where the interglacial marine strata with 'Senegal' molluscs in southern Spain yielded two U-series dates ca 190 ka (Hillaire-Marcel et al., 1986). If corroborated these warm formations would provide an important stratigraphic landmark for the Eurasian Quaternary.

References:

Andreicheva L.N. 2002. Pleistotsen yevropeiskogo Severo-Vostoka. Yekaterinburg: RAS Uralian branch Press, 222 p. (in Russian).

Arslanov Kh. A. et al. 2006. International Workshop 'Correlation of Pleistocene Events in the Russian North', St. Petersburg: VSEGEI, Russia, 12.

Astakhov V. 2004. *Quaternary Science Reviews* 23(11-13), 1285–1311.

Murray A. et al. 2008. *Radiation Measurements* 43, 776–780.

Svendsen J. I. et al. 2004. *Quaternary Science Reviews* 23(11-13), 1229–1271.

Hillaire-Marcel. et al. 1986. *Geology* 14, 613–616.

THE RESOURCE POTENTIAL OF SUSTAINABLE REE EXTRACTION FROM OFFSHORE HEAVY MINERAL BEARING SANDS OF THE GERMAN BALTIC SEA FLOOR

Börner, A.¹, Rother, H.², Schütze, K.¹

¹ *State Agency of Environment, Nature Conservation and Geology, State Geological Survey, Goldberger Str. 12, DE-18273 Güstrow, GERMANY*

² *State Agency of Geology and Mining Saxony-Anhalt, State Geological Survey, 38678 Köthener Str. 38, DE-06118 Halle (Saale), GERMANY*

E-mail: andreas.boerner@lung.mv-regierung.de

SEEsand project aims at assessing the technical feasibility and viability of the extraction of Rare-Earth Elements (REE) from zircon minerals actually being mined as a byproduct from offshore aggregates. The project SEEsand is formed by an interdisciplinary team from geological state agencies, industry, academia, and a geosciences network provider. The project addresses the outlined supply issues and environmental challenges by contributing to the supply security in terms of by-product valorisation of aggregate mining; an ongoing mining of a high mass balance. The most important primary minerals in which REE occur are found in alkaline magmatic and metamorphic complexes and carbonatite rocks. Eroded rocks of that types were transported by the advancing Scandinavian Ice Sheet during the Late Quaternary period and are associated with several glacial deposits.

The project focuses on the extraction of REE from zircon in heavy-mineral enriched marine sands of the south-western Baltic Sea, following earlier studies from the study region, which have demonstrated that zircon minerals from Baltic heavy mineral bearing marine sand contain approximately 0.7 % of extractable REE (Becker *et al.*, 1986). These sands are being heavily mined for coastal protection and construction purposes and offer a steady resource stream of heavy mineral concentrate. A spatial examination of 21,251 heavy mineral measurements, selected from 7,123 drilling and surficial picker localities and 31,692 granulometric across 15 offshore exploration areas show an aerielly averaged (mineralogically undifferentiated) heavy mineral content (HMC) between 0.063 and ≥ 1.0 % mass (derived from averaging the HMC from the <1.0 mm fraction of all available sediment cores). During the first phase of SEEsand project the distribution and concentration of detrital heavy minerals in offshore areas of the southwestern Baltic Sea have been determined, using archival information from the exploration of near-surface clastic soft-sediments on the Baltic Sea shelf conducted from 1975 to 1989 by the Central Geological Institute of GDR (ZGI and PIG, 1976, Weinert and Stephan, 1983, 1985). The prospective mining areas in southwestern Baltic Sea were calculated by Weinert and Stephan (1985) as follows:

1. Calculation medium rate of HMC from all layers of single drilling (medium HMC)
2. The economic capacity were calculated by general factors:
 - HMC < 0.6% = low capacity
 - HMC 0.6-0.75% = medium capacity
 - HMC > 0.75% = high capacity
3. aggregation and mapping of drilling areas with similar HMC-potential of low, medium and high economic potential.

Granulometric and mineralogical analyses of these sediments show that zircon minerals are enriched in the 0.063 - 0.1 mm sand fraction. The zircon maximum in this fraction is likely to reflect the general small zircon crystal size within the Scandinavian source rocks, rather than being caused by a transport related grain size reduction. Detailed mineralogical investigations in areas with elevated heavy mineral contents show a zircon concentration in the 0.063 - 0.1 mm size fraction of up to 13.8 % mass (Weinert and Stephan, 1983).

The technical processing concept of the heavy mineral fraction in connection with the extraction of the aggregates aims at developing an integrated processing step on board. Further mineral processing on land will extract zircon and other heavy minerals from the pre-concentrate using a standard combination of magnetic, electrostatic and density separation methods (Fig. 1). The biggest challenge is to separate the REE bearing zircon-fraction and to extract REE by means of hydrochemical and biochemical leaching. The extraction of heavy-REE (HREE: Y, Gd, Tb, Dy, Ho, Er, Tm, Lu, Yb with focus on Yttrium, Dysprosium, Terbium, and Ytterbium) from zircon will use beyond conventional and mechano-chemical leaching methods an innovative approach of microbial leaching by acidophilic bacteria (Glombitza *et al.*, 1988). The light-REE (LREE: Sc, La, Ce, Pr, Nd, Pm, Eu, Sm) e.g. Neodymium, Praseodymium) which represent the majority of the SEEsand resource target, are regarded as key elements in the automotive, wind-energy, electronics, and metallurgy sectors.

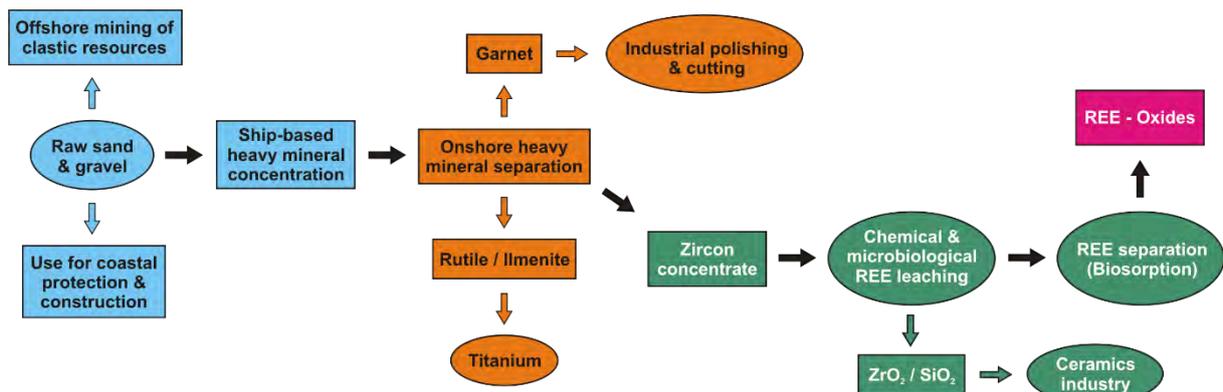


Fig. 1. SEEsand pilot scheme of heavy mineral separation and zircon extraction from Baltic Sea sand deposits

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References:

- Becker, S., Bullmann, M., Dietze, H.-J. & Iske, U., 1986. Massenspektrometrische Analyse ausgewählter chemischer Elemente bei der mikrobiellen von Zirkon. *Fresenius' Zeitschrift für analytische Chemie* 324: 37-42. [in German, English abstract]
- Glombitza, F. Iske, U., Bullmann, M. & Dietrich, B., 1988. Bacterial leaching of zircon minerals for obtaining trace and rare earth elements. In: *Biohydrometallurgy*, P.R. Norris, D.P. Kelly, (eds.), Science and Technology Letters Kew Surrey U.K., 407-418.
- Weinert, G. and Stephan, W., 1983. Höffigkeitsabschätzung Kiesssande Ostseeschelf III. Teilbericht: Bewertung des Schwermineralpotentials im Ostteil des Festlandssockels der DDR, Zentrales Geologisches Institut der DDR, Berlin. 74 p. [unpubl., in German]
- Weinert, G. and Stephan, W., 1985. Höffigkeitsabschätzung Kiesssande Ostseeschelf III. Teilbericht: Bewertung des Schwermineralpotentials im Zentral- und Westteil des DDR-Festlandssockels, Zentrales Geologisches Institut der DDR, Berlin. 106 p. [unpubl., in German]
- ZGI and PIG (1976): Abschlussbericht zur INTERMORGEAO-Aufgabe 9.3.3 - Ausarbeitung einer Methodik und Durchführung von Such- und Erkundungsarbeiten auf feste mineralische Rohstoffe in der Ostsee und Verallgemeinerung zur Geologie auf dem Festlandssockel im Grenzgebiet der DDR und der VR Polen. Zentrales Geologisches Institut der DDR (ZGI), Berlin; Polski Instytut Geologiczny (PIG), Warszawa. [unpubl., in German]

ISOTOPE COMPOSITION OF GROUNDWATER IN KARELIA

Borodulina, G.^a, Tokarev, I.^b, Krainiukova, I.^b, Levichev, M.^a

^a Northern Water Problem Institute Karelian Research Centre, Russian Academy of Sciences, 50 Al. Nevsky St., 185030 Petrozavodsk, Karelia, RUSSIA

^b St. Petersburg State University, Research Park, Resource Center for X-ray Diffraction Studies at the Research park of St. Petersburg State University, Decabristov lane 16, Vasilyevsky Island, St. Petersburg, 199155, RUSSIA

E-mail: bor6805@yandex.ru

The isotopic composition of hydrogen and oxygen ($\delta^2\text{H}$ and $\delta^{18}\text{O}$) in groundwater is the basis for assessing the conditions for their formation and the rate of water exchange (Ferronsky, Polyakov, 2009). Isotopic data also help to solve a number of hydrogeology problems, for example, identification of secondary processes (evaporation and freezing), mixing of fresh water with saline water of different genesis, identification of "regenerated" waters formed due to degradation of permafrost and etc.

Fresh groundwater of Karelia in the zone of active water exchange has predominantly bicarbonate calcium-magnesium composition. In the zone of slow water exchange, there is groundwater of various chemical types up to salt chloride sodium ones. The hypotheses both the autochthonous and allochthonous of salinity origin of groundwater in crystalline shields are considered (Nurmi et al., 1988; Lampen, 1992; Krainov, Ryzhenko, 1999], as well as conception of the cryogenic concentration of marine and/or sedimentary waters in glacial times (Herut et al., 1990; Bein and Arad, 1992; Stotler et al., 2009).

In the southern part of region the saline groundwater (TDS > 10 g/l) is located in the platform layered sediments of the Upper Proterozoic and Paleozoic age. There is brackish groundwater (TDS up to 10 g/l) in the Karelian part of the Baltic shield. Note, that boreholes give data only about the upper part (200–300 m) of the shield. Usually the open hole crosses the several fissured or fault zones with groundwater of the specific chemical composition, so blend of waters from different zones is discovered on surface, when water pump out. It could be assumed that the salinity of the deep groundwater is much higher, than the total sample.

Generally, groundwater of Karelia (n = 250, measurements were done in Center of X-ray diffraction studies at the Research park of SPSU) are depleted by heavy isotopes and isotopically "lighter" than weighted average value of atmospheric precipitations ($\delta^2\text{H} = -84\text{‰}$ and $\delta^{18}\text{O} = -11.7\text{‰}$). The brackish water of the crystalline shield has the lightest isotopic composition ($\delta^2\text{H} < -100\text{‰}$ and $\delta^{18}\text{O} < -14\text{‰}$), which approaches to the average value of the snow (Fig. 1). It is known the paleoclimate temperature gradient is $-5\text{‰} / 1\text{°C}$ for $\delta^2\text{H}$ and $-0,6\text{‰} / 1\text{°C}$ for $\delta^{18}\text{O}$ (Ferronsky, Polyakov, 2012). The calculated annual air temperature was lower 5–6 °C, than the modern one during formation of the isotopically "light" saline groundwater.

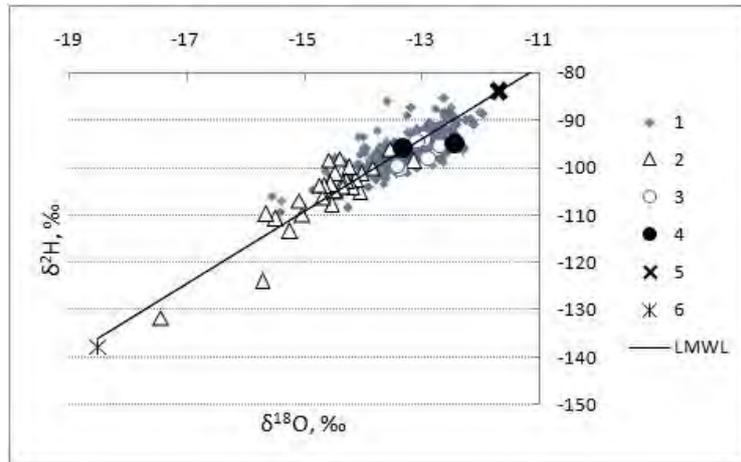


Fig. 1. The isotopic composition of groundwater relative to the meteoric water line (LMWL)
 1 - fresh groundwater, 2 - brackish groundwater of the crystalline shield, 3-brackish platform groundwater, 4
 – spring “Salt Pit”, 5 - precipitation (weighted average), 6 - snow (weighted average).

We associate this type of groundwater in the crystalline rocks with the Valdai glaciation, when the cryogenic concentration of marine water of the Mikulino transgression (the Eemian seawater) took place. Note, that these seawater could slightly diluted by very isotopically light fresh water from continent like it is happened in modern Finnish Gulf or North Dvina estuary. The weak hydraulic permeability of crystalline rocks and small gradients of the regional piezometric surface should be result a very low rate of water exchange in the deep part of the shield. This consideration is supported by high concentrations of helium in salty groundwater.

The brackish groundwater of the Vendian-Phanerozoic deposits are isotopically heavier than the waters of crystalline rocks, and are not distinguished by isotopic composition among the fresh groundwater. Brackish groundwater in platform sediments are much more quickly depleted by sodium and enriched by calcium with increasing salinity in comparison to the brackish groundwater of crystalline rocks, and have more obvious signs of metamorphization of the buried seawater (Fig. 2).

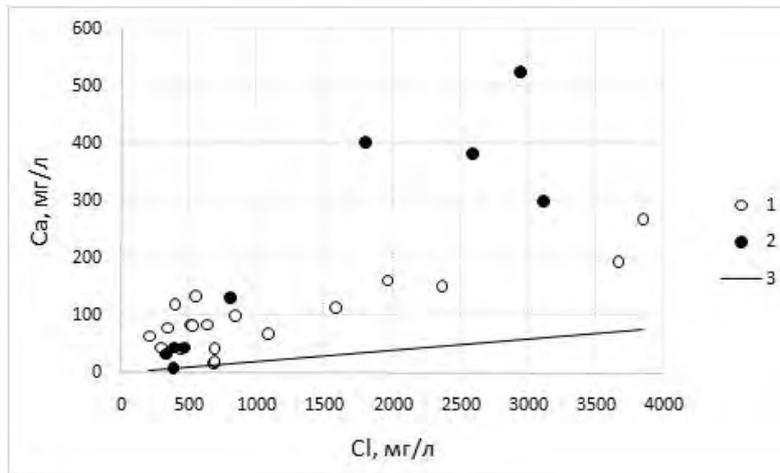


Fig. 2. The Ca^{2+} concentrations plotted against Cl^- concentration in chloride groundwater. 1 – brackish groundwater of crystalline shield, 2 – brackish platform groundwater, 3 – dilution line of sea water

The spring with name "Salt Pit" located on the Zaonezhsky peninsula of Lake Onega is the only known in Karelia natural source of chloride sodium water ($\text{TDS} \approx 4 \text{ g/l}$). Among the brackish waters of the crystalline shield, the isotope composition of this spring is the heaviest (in winter $\delta^2\text{H} = -95,8 \text{ ‰}$ and $\delta^{18}\text{O} = -13,3 \text{ ‰}$; in summer $\delta^2\text{H} = -94,8 \text{ ‰}$ and $\delta^{18}\text{O} = -12,4 \text{ ‰}$) (Fig. 1). It could be assumed their connection with the halite deposits found in the crystalline shield (Palaeoproterozoic..., 2011).

However, in general, the origin of brackish water in Karelia still requires study.

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References:

- Avramenko, I., Borodulina, G., Tokarev, I. 2014. Isotope composition of Karelian groundwater and its use in climate paleoreconstructions. Proceedings of the International Conference "Paleolimnology of Northern Eurasia". Petrozavodsk. P.64-66.
- Bein A., Arad A. 1992. Journal of Hydrology 140. 75–87.
- Bottomley, D., Katz, A., Chan, L.H., Starinsky, A., 1999. Chemical Geology 155. 295–320.
- Herut, B., Starinsky, A., Katz, A., Bein, A. 1990. Geochimica et Cosmochimica Acta 54. 13–21.
- Krainov S, Ryzhenko B 1999. Reports of the Academy of Sciences. P. 365. № 2. 245-249.
- Lampen P. 1992. Saline groundwater in crystalline bedrock – a literature survey. 91 p.
- Nurmi, P., Kukkonen, I., Lahermo, P. 1988. Applied Geochemistry 3. 185–203.
- Palaeproterozoic Onega Structure (geology, tectonics, deep structure and mineralogeny). 2011. 431 p.
- Tokarev, I., Borodulina, G., Kayukova, E., Polyakov, V., et al. 2008. Bulletin of St. Petersburg State University, series 7 "Geology and Geography" 2. 25-36.
- Stotler, R., Frappe, S., Ruskeeniem, T., Ahonen, L., Onstott T., Hobbs, M. 2009. Journal of Hydrology 373, 80–95.
- Ferronsky V., Polyakov V. 2012. Isotopy of the Earth's hydrosphere. Springer 632 p. ISBN 978-94-007-2856-1.

BURIED SOILS UNDER STONE MOUNDS IN THE EASTERN PART OF THE Leningrad REGION (ON THE EXAMPLE OF THE MONUMENT ZABEL'E 1)

Fedorova, M., Ruakov, A.

Saint-Petersburg State University, Institute of Earth Sciences, Saint-Petersburg, Russian Federation E-mail: mas2792@yandex.ru

In 2016 during the archaeological excavations in the forest near the village of Zabel'e (Boksitogorsk district, Leningrad region) some areas with unusual stone mounds were discovered. These objects are restricted to the flat top of the moraine hills (a.s.l. ~ 160 m) of the last Late Pleistocene glaciation (MIS2). This study area belongs to the landscapes of the Valdai Upland.

We have to stress that the complex of archaeological methods did not give an unambiguous answer to the questions about the genesis and time of creation and functionality of these stone mounds (embankments). During the excavation at the sites, neither objects of material culture nor traces of burial were found. This fact allowed specialists to assume that the stone mounds were not cultural, but had an economic purpose. So, stone mounds could have arisen during the cleaning of agricultural lands from stones or as a result of the collection of stones as raw material for construction needs.

Soil studies were carried out on two excavation sites during fieldwork in the summer 2017. The profiles of buried and surface soils (during excavation works the original vegetation was cut) located in close proximity to one another (2-3 m) were described and classified. An additional soil profile was in the forest. Our studies have shown that soils under a bulk material, whose thickness does not exceed three dozen cm, have a good profile safety with an undisturbed sequence of genetic horizons. The buried and surface soils are formed on bipartite sediments: water-glacial sandy deposits, underlain by carbonate moraine loams. The depth of change of parent material in the studied sections varies from 33 to 75 cm. The all soils of both chronosequences are preliminarily classified as Entic Podzol (Arenic) (IUSS Working Group WRB, 2015), which supports the fact that a relatively short time has passed since the construction of the embankments.

The main purpose of the research is to study the soils of the chronosequence "buried soil - surface soil" in order to reconstruct the soil and landscape conditions that existed before the construction of the stone embankments. To study the detected soil profiles, a complex of various

natural-scientific methods will be used, including paleopedologic ones. In particular, radiocarbon dating of humic acids of buried soils will allow estimating the time of creation of these stone mounds.

Based on the formulated aim, the following objectives were set: 1) morphological and genetic analysis of the soil structure and identification of the properties of surface and buried soils to establish the degree of preservation of the latter one; 2) study of phytolith and spore-pollen spectra of soil chronosequence to define the degree of anthropogenic change in the landscape; 3) establishment of an evolutionary trend for the formation of soils on dated surfaces.

It is expected that, as a result of the work, it will be possible to reveal the character and degree of anthropogenic transformation of the territory (such as changes in the complex of soil properties, type of land use) which will help to determine the possible causes for the formation of the stone structures.

This study was supported by the Russian Science Foundation (Project No. 16-17-10280).

References:

IUSS Working Group WRB, 2015. World Reference Base for Soil Resources 2014, updated 2015. Int. soil Classif. Syst. naming soils creating legends soil maps.

CHARACTERISTICS OF ESKERS IN CENTRAL POLAND ILLUSTRATED WITH SELECTED EXAMPLES

Frydrych, M.

*Department of Physical Geography, Faculty of Geographical Sciences, University of Łódź,
Poland*

E-mail: malgorzata.frydrych@geo.uni.lodz.pl

Eskers are fluvio-glacial forms, which originate in subglacial or englacial tunnels, in ice-walled supraglacial channels, subglacial cavities and subaerially or subaqueously at tunnel or channel mouths (De Geer, 1897; Brennand, 1994; Warren & Ashley, 1994). Detailed studies of eskers provide a great deal of information on the drainage system, dynamics and conditions of ice sheet deglaciation. The presented research was conducted in the area of Central Poland, which was selected as the test area representing the conditions of permeable and soft substratum, on which the ice sheet moved. The aim of the research was to recognise the conditions of glacial water circulation and to reconstruct the sedimentation environments of eskers.

Identification of eskers in Central Poland took place during the preparation of the Detailed Geological Map of Poland 1:50 000 and regional research (e.g. Baraniecka & Sarnacka, 1971; Michalska, 1971; Jaksa & Rdzany, 2002; Frydrych, 2016). On the basis of existing literature, about 70 eskers built of over 300 smaller forms can be distinguished in Central Poland. Eskers of Central Poland, which were formed during the late Saalian (MIS 6, Warta glaciation) are characterised by considerable disintegration. Single forms were divided into sections: from several to less than 1 km in length. The conducted morphological analysis revealed that the predominant length of the forms in Central Poland ranges from 1 to 5 km (43 %). The longest, uninterrupted fragment of an esker is located in the sequence of the Grójec esker and is ca. 7 km long. The width of the forms ranges between 1.5 km and ca. 100 m. The length to width ratio is 7.2, and the maximum value is 16.5. In Central Poland, only a few visibly sinuous forms have been identified. The distribution of esker orientation is bimodal, and the largest number of eskers are oriented NW-SE and NNE-SSW, which is related to the direction of ice sheet movement in different ice streams.

In sedimentary terms, eskers of Central Poland show a significant diversity. There are eskers with typical lithofacies such as massive gravels accumulated in closed glacial tunnels under hydrostatic pressure (Brennand, 1994; Fard & Gruszka, 2007) or gravels with flat and trough

cross-bedding. Accumulation of sediments in recurrent subglacial floods has been observed only in some of the forms. Evidence for strong subglacial erosion includes tunnel channels, in which most eskers of Central Poland originated and, possibly, also most eskers of areas with soft and permeable substratum. Strong erosion is also indicated by a very high content of rocks of local Mesozoic bedrock in gravelly sediments of some eskers or by the presence of rip-up clasts in forms where the Mesozoic bedrock was lying too deep. Episodes of subglacial floods are recorded in the presence of the massive boulders and gravels (BGm) or planar cross-stratified boulders and gravels (BGp) (Frydrych, 2016). They resulted from increased ablation of the ice or a release of a subglacial, englacial or supraglacial reservoir. Esker sediments differ significantly as regards their sorting. Both unsorted flow sediments and nearly ideally washed gravels with openwork structure were found. Some eskers are missing a clear esker core and are dominated by gravelly-sandy lithofacies. In most forms, the complex of glacial tunnel sediments is overlaid with a thick complex of open crevasse sediments. This poses problems while determining the genetic kind of these forms and marking them on geological and geomorphologic maps. A considerable portion of eskers are complex forms and sediments of esker accumulation overlap with crevasse and kame sediments.

In terms of morphology, eskers of Central Poland are slightly different than eskers described in the areas of Canada or Scandinavia. It is related to the different substrata, on which they were formed, and the subsequent relief transformation. In Central Poland, eskers were mostly formed in tunnel channels, cut in a soft bed, where the proper part of the esker was created. It was then overlaid with sediments from an open channel or crevasse and their original morphological features were transformed. The sedimentologic record of sediments in eskers provides a valuable source of information on the condition of their transport and accumulation in the environment of glacial tunnels. In Central Poland, the conditions were very diverse, from lower flow regime to high energy flows of glacial floods. The transportation mode was also varied. The observed modes include accumulation of sediments in the conditions of flows under hydrostatic pressure, from migration of bedforms of different sizes, sheet floods, hyperconcentrated flows or debris flow.

References:

- Baraniecka, M.D & Sarnacka, Z., 1971. Stratygrafia czwartorzędu i paleogeografia dorzecza Widawki. Inst. Geol. Biul. 254.
- Brennand, T.A., 1994. Macroforms, large bedforms and rhythmic sedimentary sequences in subglacial eskers, south – central Ontario: implications for esker genesis and meltwater regime. *Sedimentary Geology* 91, 9–55.
- De Geer, G., 1897. Om rullstensåsarnas bildningssätt. *Geol. Fören. Stockholm Förhand* 19: 366-388.
- Fard, A.M. & Gruszka, B., 2007. Subglacial conditions in a branching Saalian esker in northcentral Poland. *Sedimentary Geology* 193, 33–46.
- Frydrych, M., 2016. Structural and textural response to dynamics of fluvio-glacial processes of the Rzymisko esker sediments, Central Poland. *Geology, Geophysics & Environment* 42, 411-428.
- Jaksa, A. & Rdzany, Z., 2002. Sedymentologiczny zapis dynamiki deglacji Wysoczyzny Rawskiej na przykładzie Wału Rylska. *Acta Universitatis Nicolai Copernici. Nauki Matematyczno-Przyrodnicze. Geografia* 32, 169–181.
- Michalska, Z., 1971. Zagadnienia genezy ozów na tle wybranych przykładów z obszaru Polski środkowej. *Studia Geol. Pol.* 7, 1-83.
- Warren W.P. & Ashley, G.M., 1994. Origins of the ice – contact stratified ridges (esker) of Ireland. *Journal of Sedimentary Research A: Sedimentary Petrology and Processes* 64, 433-449.

LATE HOLOCENE VEGETATION IN THE MIDDLE KUYA VALLEY, EUROPEAN ARCTIC RUSSIA

Golubeva, Y.

Institute of Geology, Komi Scientific Centre, Ural Branch of RAS

E-mail: yvgolubeva@geo.komisc.ru

Lake, swamp and floodplain deposits in the Middle Kuya valley in the European part of the Russian Arctic were pollen analysed, reconstructing vegetation history during the Late Holocene (the Subatlantic). The investigated section K12 (67°37'N, 53°24'E) is a bank cutting 4 m high. According to Khotinsky (1987) the Subatlantic period is subdivided into three phases. This contrasts Nikiforova (1980), subdividing the period into four phases. This abstract presents reconstruction of four phases of regional vegetation development within the study area:

1. Sandy and clayey sediments in the base of the section contain spectra (pollen zone K12-I, 4-2,65 m; Fig.) 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.

2. Overlying peaty loam deposits (pollen zone K12-II, 2,65-2,05 m) probably accumulated during the middle Subatlantic. 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. The presence of an aquatic environment supported by *Menyanthes*, *Potamogeton* and *Nymphaea* pollen. The occurrence of *Nymphaea* confirms that temperatures were higher than present.

3. 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, Caryophyllaceae, *Filipendula*, Fabaceae, *Valeriana*, Asteraceae, *Thalictrum*, *Chamaepericlymenum* grew in the area.

4. Pollen zone K12-II, 2,65-2,05 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-II is notable for an increase *Picea* and Poaceae pollen contents. Increases in *Sphagnum* and Polyodiaceae percentages are also characteristic, while Bryales is decreased.

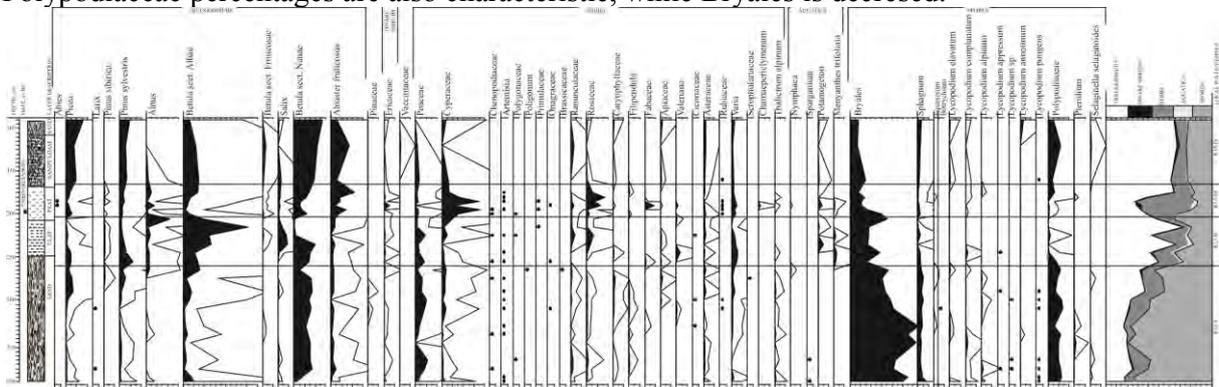


Fig. Pollen percentage diagram of the Kalya 12 section

References

Nikiforova L. D., 1980. Environment dynamics during the Holocene in the Northeast of the European part of the USSR. Thesis for a degree of D. Sc. (Geol. & Min.) Moscow, 25 p (in Russian).

Khotinsky N. A., 1987. Radiocarbon chronology and correlation of natural and anthropogenic boundaries of Holocene // New data on Quaternary geochronology. Moscow, 1987. P. 39–45 (in Russian).

PARAMETERS OF SEISMIC INFLUENCES DURING THE FORMATION OF POSTGLACIAL DISLOCATIONS IN THE ROCKY MASSIFS OF THE KARELIAN COAST OF THE WHITE SEA

Gorbatov, E.S., Sorokin, A.A.

Schmidt Institute of Physics of the Earth IPE RAS, 123242, Moscow, B. Gruzinskaya, 10, b.1, RUSSIA.

E-mail: e.s.gor@mail.ru; aas@ifz.ru

With the accumulation of paleoseismological data on the Fennoscandian crystalline shield, the long-term seismic hazard of the region began to be actively discussed. However, the estimates in the publications of the maximum magnitude of earthquakes (M_{\max}) are still debatable. In particular, a number of authors allow for the presence of traces of paleoearthquakes in the region of late Pleistocene and Holocene age with $M = 6.5-8$, typical not for platforms, but for highly seismic folded belts (Mörner, 2003, Nikonov, 2003). One of the assumed seismogenerating structures of the region is the Karelian coast of the White Sea, associated with the Kandalaksha neotectonic graben, characterized by a high contrast of block movements and an increased level of modern seismicity in comparison with the adjacent areas.

With the purpose of revealing, genetic interpretation and dating of the violations of the relief of the Karelian coast of the White Sea, a standard set of geomorphological methods was used, including the interpretation of aerial and satellite imagery, topographic and structural geomorphological surveys, trenching through colluvial accumulation and their documentation, sampling of palaeosoil and their dating by radiocarbon method. These methods have established that individual ledges and stepwise surfaces, widespread in the relief of rock massifs, appear to be the result of glacial denudation and subsequent erosion of structural heterogeneities. At the same time, the mass displacements of the punctured blocks against the slope and their systematic rotation in the rock ledges of different strike allow intensive seismic effects even after the formation of the stepped surfaces and the completion of their abrasion processing during the postglacial elevation of the territory. On the basis of the analysis of block displacements (systematic translational displacements and rotations of fragments of rocky ledges), the possibility of their use as kinematic indicators of paleoearthquakes is shown, which allows to restore both the directions of the maximum seismic action in individual detailed areas and the parameters of strong motions.

The proposed methods in the relief of the rocky massifs of the Kindo Peninsula area (Fig. 1) established the area of secondary seismic dislocations (10x6 km) by radiocarbon age not exceeding 5.5 thousand years, which is the zone (4x2 km) of the development of tension cracks and numerous displacements of rock blocks surrounded by belt of seismogravitational disturbances (Gorbatov et al., 2018). It has also been established that the effects of high-frequency seismic oscillations with high values of peak accelerations (0.4-0.8 g) and velocities (100-300 cm/s) are necessary to form block displacements. To determine the location of the epicenter of paleoearthquakes at several points, the directions of the maximum seismic effect were restored using kinematic indicators. The zones of 7- and 8-point shocks are examined in order to estimate the depth of the focus ($H = 1.9 \pm 0.2$ km) and the magnitude ($M = 4.4 \pm 0.2$) of the seismic event according to the macroseismic field equation (Drumya, Shebalin, 1985) with averaged attenuation coefficients:

$$I_i = 1.5M - 3.5 \lg \sqrt{R_i^2 + H^2} + 3$$

, где I_i и R_i – seismic intensity and epicentral distance (km) at the observation point; M – magnitude; H – depth of focus (km).

Typical WNW elongation of the first isoseist along the northern coast of the Kindo Peninsula is indicative of a seismogenic fault at the southern end of a micrograben of the Velikaya Salma Strait, which feathers the southeastern wall of the Kandalaksha Graben. The Holocene activity of this fault is confirmed by normal fault displacements of young sediments, which have been revealed in a series of transverse seismoacoustic profiles (Maev et al., 2010).

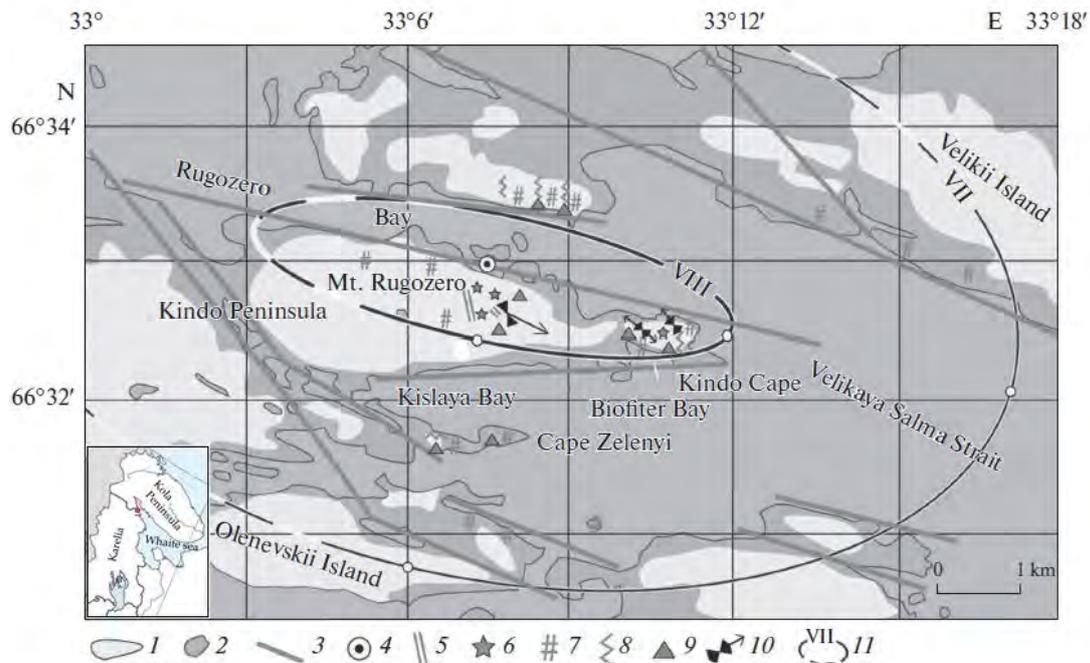


Fig. 1. Distribution of possible paleoseismic dislocations in area o Kindo Peninsula, structural position of focus, and isoseists of paleoearthquake. 1 – rock massifs; 2 – quaternary sediments; 3 – lineaments based on morphostructural analysis; 4 – epicenter of paleoearthquake; 5 – extension cracks; 6 – stone displacements and rotations; 7 – areas of areal fracturing; 8 – linear faults (cuttings, fissures) with features of seismic renovation; 9 – landslides; 10 – directions of maximum seismic impact along displacements of stones (arrows) and quadrants of seismic impact from interpretation of systematic rotation of stones; 11 – isoseists and intensity of earthquakes.

The results obtained for the first time at a quantitative level showed that small-focus earthquakes with high seismic intensity and moderate magnitude, not exceeding the magnitude of the Kandalaksha earthquake of 1967 ($M_S=4.8$), the strongest of the instrumentally fixed in the region, appeared in the Kandalaksha Graben in the Holocene. The possibility of the recurrence of such earthquakes should be taken into account when operating particularly critical technical structures in the region, including the cascade of the Nivsky hydroelectric power station, the infrastructure facilities of the Kandalaksha seaport and the October Railway.

The research also proposed a new methodical approach for the detection and analysis of secondary seismic dislocations, which, in conditions of inaccessibility to study seismotectonic disturbances, solve seismogeological problems on the crystalline shield for the purpose of seismic zoning and seismic hazard assessment in areas of highly responsible and technically complex infrastructure facilities.

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References:

1. Gorbatov, E.S., Sorokin, A.A., Marakhanov, A.V., Lar'kov, A.S. Results of Detailed Paleoseismic Studies of the Kindo Peninsula (Karelian Coast of the White Sea) // Seismic Instruments, 2018, Vol. 54, No. 3, pp. 299–313.

2. Mörner, N.-A. Paleoseismicity of Sweden. A Novel Paradigm. Stockholm, 2003. 320 p.
3. Drumya, A.V., Shebalin, N.V. Earthquake: Where, When, and Why?, Sadovskii, M.A., Ed., Kishinev: Shtiintsa, 1985. (in Russian).
4. Maev, E.G., Saf'yanov, G.A., Frol', V.V., Zverev, A.S., Thickness of sediments and bedrock relief in the Great Salma Strait, White Sea, Geomorfologiya, 2010, no. 1, pp. 59–67. (in Russian).
5. Nikonov, A.A. Fennoscandia, an underestimated seismogenerating province // Geophysics of the 21st Century, 2002: Proceedings of the IV Readings on Geophysics in Memory of V.V. Fedynskii, Moscow: Nauchnyi mir, 2003, pp. 207–214. (in Russian).

LASER SCANNING TECHNOLOGY IN MAPPING AND CLASSIFYING OF MELTWATER EROSIONAL FORMS IN FELL AREAS OF FINNISH LAPLAND

Johansson, P.

Geological Survey of Finland, B.O. Box 77, FI-96101 Rovaniemi, FINLAND

Juurakkotie 24, FI-96190 Rovaniemi, FINLAND

E-mail: peter.johansson241@gmail.com

A combination of aircraft-based laser scanning data (LiDAR) and GIS has evolved into an important tool for surveying different kind of geological landforms. In this study it was discovered that the laser scanning data provide a good basis for classifying of the erosional landforms, palaeohydrography and development of ice lake stages not only on treeless fellslopes and in valleys between them but in forested areas beneath the vegetation canopy, too. Erosional landforms formed by glacial meltwaters have been carved into the Quaternary deposits and frequently further deep into the crystalline bedrock. They are grouped according to time and place of origin: subglacial gorges, proglacial gorges, marginal and extramarginal channels and canyons.

Subglacial gorges were formed as a glacial river flowing in a subglacial tunnel eroded the rock floor. They are always connected with esker sequences. The meltwater stream under high pressure carried away overburden and rock material that it forcefully eroded from the walls and the bottom of the gorge. The results were steep-sided V-shaped gorges, e.g. 50 metre-deep Peurakuru at Pyhäntunturi and the 20 metre-deep gorge Kulmakuru, which angular form is due to the crossing fracture zones in the bedrock. Proglacial overflow channels cross the otherwise gently-rounded fells in the form of sharp cuts. They formed as meltwaters flowing along the margin of the glacier gathered as a marginal ice lake between the fell tops, where they discharged across the fell ridge at the lowest point, thereby eroding a gorge. Because the flow of meltwater and erosion it caused only lasted a short time, the proglacial channels remained smaller gorges cutting through the crest of the fell range. The five to ten metres-deep gorges at Kiilopää, the Kellostapuli gorge at Ylläs and Sarvikuru at Pyhäntunturi are typical overflow channels.

The meltwater action at the boundary of the melting ice sheet and an exposed fell terrain next to it produced series of parallel lateral drainage channels. They formed in spring as meltwaters accumulated at the ice lobe margin and flowed along the contact between ice and fell slope, eroding a channel into the slope. The lateral drainage channels are up to hundreds of metres long but only one to two metres deep. These channels can be used as indicators in determining the surface gradient of an ice sheet and the rate of melting at the end of the latest deglaciation phase. Examples of lateral drainage channels are seen on the slopes of the fells Ylläs, Lainiotunturi and Teräväkivenpää, in Saariselkä area. They reflect the gradient of the ice surface and indirectly describe the annual retreat of the ice margin, which was 130-170 metres per year.

At the foot of the fells and in the valleys gently curved marginal and extramarginal channels are found, along which meltwater from the ice sheet flowed into ice-free areas. The channels are several metres deep and frequently one to five kilometres long. The steep sides and even bottoms resemble the channels of dried rivers. Considerable water volumes must have flowed in them, which is difficult to imagine, since the channels are at present either dry or have a minor brook

flowing on the bottom. Examples are found everywhere in Lapland, especially in northwestern Lapland and Saariselkä fell areas.

The precipitous, hundreds of metres deep canyons are the largest erosional landforms. E.g., Kevo canyon, Vaijoki canyon at Lemmenjoki and the canyons crossing Pyhä-Luosto fell range are not only results of the meltwater erosion of the last deglaciation. Their polygenetical formation was influenced by weakness zones in the bedrock, where deep fracturing had occurred due to movements in the Earth's crust millions of years before the Ice Age. During the Quaternary period ice lobes caused effective erosion and plucked blocks off the fractured bedrock. Finally meltwater streams have cleaned the canyon floors, carrying away loose rock material and spreading it at the canyon mouths. At Pyhä-Luosto rugged canyons and gorges divide the fell range like huge cuts into several peaks. Among them the most remarkable canyon, Isokuru, with a depth of 220 metres is Finland's deepest.

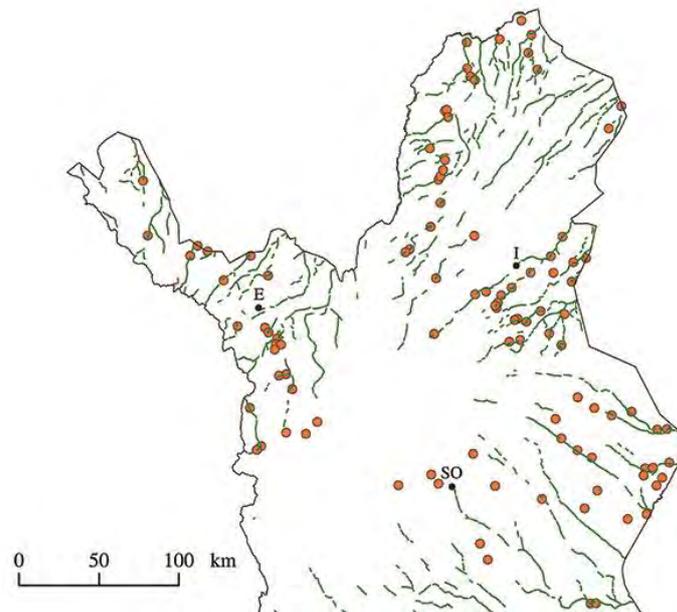


Fig. Locations of subglacial gorges (red point) and Late-Weichselian esker chains in northern Finland.
E=Enontekiö, SO=Sodankylä and I=Ivalo

References:

- Johansson, P. 1995. The deglaciation in the eastern part of the Weichselian ice divide in Finnish Lapland. Geological Survey of Finland, Bulletin 383. Espoo: Geological Survey of Finland. 72 p. + 1 app. map.
- Johansson, P. & Palmu, 2013. LiDAR data and elevation model used to produce information of geological landforms and development of ice lake stages. In: (Eds.) A. Damusyte & A. Grigiene. Palaeolandscapes from Saalian to Weichselian, South Eastern Lithuania. Abstracts. INQUA Peribaltic Working Group, International Field Symposium, 38-39.
- Kujansuu, R. 1967. On the deglaciation of western Finnish Lapland. Bulletin de la Commission géologique de Finlande 232. 92 p.
- Sarala, P., Räisänen, J., Johansson, P. & Eskola, K.O. 2015. Aerial LiDAR analysis in geomorphological mapping and geochronological determination of surficial deposits in the Sodankylä region, northern Finland. GFF 137, 293-303.

UŽVENTIS GLACIOFLUVIAL KAME TERRACE

Karmazienė, D.

Lithuanian Geological Survey, S. Konarskio 35, LT-03123 Vilnius, Lithuania
E-mail: danguole.karmaziene@lgt.lt

The Upper Nemunas (Vistulian, Weichselian) glaciofluvial kame terraces in the territory of Lithuania occur at the slopes of elevations formed at different stages of deglaciation and terraces within lake basins in elevated areas. The Užventis terrace at the slope bottom of Middle Žemaičiai Uplands is ascribed to this type of glaciofluvial kame terrace.

An elongated kame terrace extends in an almost meridian direction from Užventis across Želviai, Naikmiškė and Junkilai till Gedvilai. The terrace is 8 km long; its average width is 1.2 km. The surface of the Užventis kame terrace loops in a northerly direction ranging in altitude from 121 m up to 140 m. The terrace is separated from the adjacent uplands by a 10–15 m high straight slope. Junction canals and hollows extend along the terrace slope. Most of them are boggy. The slope is dissected by numerous ravines and gullies opening on the slope bottom.

The kame terrace is separated from the lower glaciolacustrine plain by an ice-marginal slope. The contour line of the slope is uneven and serrated. The slope of the terrace was abraded by glaciolacustrine basin waters.

The terrace relief is complex in character due to the negative and positive forms of relief that includes numerous eskers and kames. A chain of eight kames occurs at the terrace step between Želviai and Junkilai. Chains of eskers extend from the middle of the terrace (Gedruičiai) to its southern edge. The kames are typically 6–8 m in height although they do reach up to 12 m. They vary in width from 200 m to 350 m and are typically around 500 m in length. Their slopes are steep.

The esker crests display meandering plan forms. The crest line is uneven and undulating. The eskers are typically 3–5 m in height although some reach up to 10 m in height. The average length of the eskers is 500 m; the shorter eskers are 300 m long whereas the longer ones extend for up to 1.5 km. The width at the slope bottom varies from 30–50 m to 100 m. The esker deposits dip towards the deposits of the kame terraces. Eskers of this type are called “eskers with roots”.

Glaciokarst depressions and pits occur on the terrace surface. The hollows are large – up to 800 m in length and 100–200 m in width – and extend along the terrace surface. The pits are funnel shaped, concentric and display steep sides. They are 50 m in diameter and up to 7 m deep.

According to morphographic and morphometric analyses, three types of relief were distinguished in the kame terraces: flat, slightly undulating and undulating plains. The undulating plain relief is dominant. Three terrace levels were distinguished: low, medium and high. Their surfaces are characterised by different types of relief.

The Užventis kame terrace borders the eastern slope of Middle Žemaičiai hill terrain. It is classified as a glaciofluvial kame terrace formed by glacial meltwater streams. The meltwater streams fell into an 8 km long and 1.2 km wide depression south of Užventis and infilled it with glaciofluvial deposits. The average thickness of glaciofluvial deposits of the Užventis kame terrace is 20–22 m. The maximal thickness is 38.2 m, the minimal thickness is 7.5 m. The thickest deposits accumulated along the slope bottom (Fig. 1).

Fine-grained sand occurs on the terrace surface between its middle part and the edge (from Užventis till Želviai). Gravely sand is dominant between Želviai and the southern periphery of the terrace. As glaciofluvial sediments were transported into the depression from all sides, the lithological composition of the deposits is varied, comprising gravel-sand deposits, various sand, and fine-grained sand. These lithological varieties often are silty and sometimes clay-rich. The vertical distribution of deposits shows no regular pattern. In some places fine-grained silty sand occurs in the upper part of the layer whereas gravelly-sand or various sand occurs in the lower. In other places, fine-grained silty sand occurs in the lower or middle parts of the layer. The portion

of gravel in gravely-sand deposits accounts for 41 % of the total. In the sections of the southern part of the terrace, the sequence contains intercalated layers of ablation till up to 5 m thick.

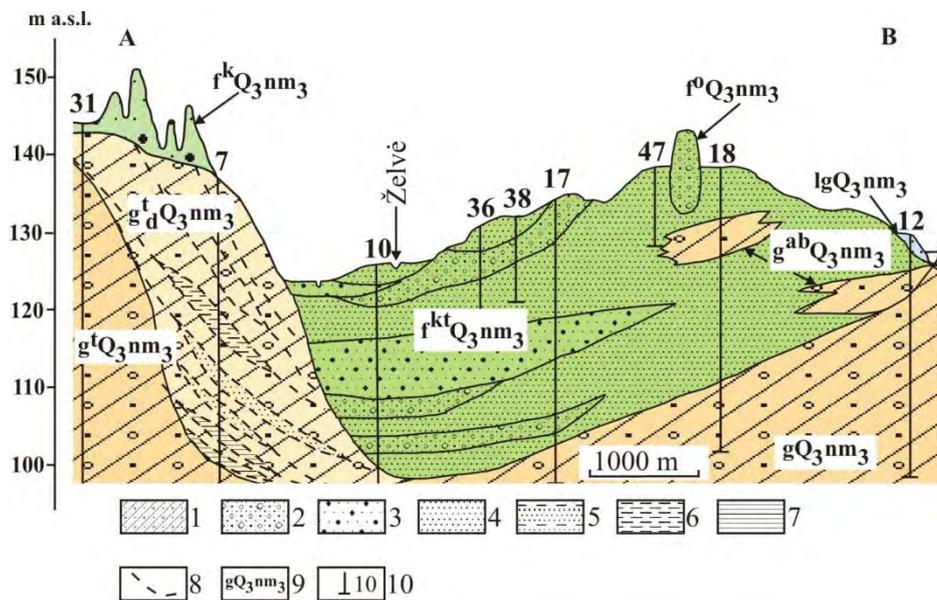


Fig. 1. Profile and deposits along the Užventis kame terrace.

1 – till; 2 – gravel and sand; 3 – various sand; 4 – fine-grained sand; 5 – silty sand; 6 – silt; 7 – clay; 8 – shear planes; 9 – genetic and stratigraphic index of deposits: Upper Pleistocene Upper Nemunas (Vistulian, Weichselian) formation: glacial deposits: gQ_3nm_3 – lodgement till; $g^dQ_3nm_3$ – deformation till; $g^tQ_3nm_3$ – deposits of ice marginal formations; $g^{ab}Q_3nm_3$ – ablation till; glaciofluvial deposits: $f^oQ_3nm_3$ – esker; $f^kQ_3nm_3$ – kame; $f^{kt}Q_3nm_3$ – kame terraces; lgQ_3nm_3 – glaciolacustrine sediments; 10 – borehole site and its number.

The terrace deposits overlie grey compact till with gravel – 7–10%. The 10 m high kame is composed of gravel and gravely-sand deposits with gravel fraction (5–70 mm) accounting for 35% (dominant fraction 10–20 cm).

Eskers meandering on the kame surface have “roots”. The sections of esker deposits usually are distinguished for alternation of various sand and gravely-sand and slanting stratification.

NEW DATA ABOUT THE LGM POSITION ON THE VALDAY UPLAND NEAR SELIZHCHAROVO (RUSSIA)

Karpukhina, N.V.¹, Kostantinov, E.A.¹, Panin, A.V.^{1,2}, Baranov, D.V.^{1,2}, Zakharov, A.L.¹, Utkina, A.O.^{1,2}

¹ *Institute of Geography, Russian Academy of Sciences, Staromonetnii pereulok, 29, 119017, Moscow, Russia*

² *Lomonosov Moscow State University, Geographical Faculty, 119991 Leninskie Gory 1 GZ MSU, Moscow, Russia*

E-mail: natalia_karpukhina@mail.ru

Problems of the position and age of the glacial boundary in the Last Glacial Maximum (LGM) on the East-European Plain have remained relevant. One of our investigation regions is the central part of the Valdai Upland where the Upper Volga tongue of the SIS Ladoga stream was active in the Late Weichselian (Chebotareva, 1977). An overview of published literature has shown that at least four versions of the LGM glacial limits exist. To validate the ice sheet borders, different researchers applied methods of glaciomorphological analysis, correlation of end moraines and stratigraphic investigation of sections with the Mikulinian (MIS 5e) Interglacial and Early -

Middle Weichselian deposits (Chebotareva, 1977) or analysis of remote sensing data and digital terrain models (Kalm, 2012). Recently, first results of TCN (^{10}Be) dating of boulders has been reported (Rinterknecht et al., 2016), though they have not allowed to elaborate a non-ambiguous figure of the LGM glacial limits yet.

During our research were provided geomorphometrical study, stratigraphic investigation some key sections and boreholes extracted from unpublished geological survey reports stored in the Federal Geological Archive. Also the authors tried to revise different versions of the LGM position in field, as well as conducted an analysis of the remote sensing data and digital terrain models to identify end moraines. From Ostashkov town to the Yeltsy village, about some festoon belts crossing the central part of the Valdai Upland with a hilly-ridge relief reflecting different stages of the glaciations development were found. The samples of deposits from outcrops were collected for radiocarbon and OSL dating.

The compiled data allows us to suggest some corrections for the SIS maximum limits in the Upper Volga region south from Ostashkov (the so called the Upper Volga tongue of Ladoga ice stream).

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References

- Chebotareva, N.S. (ed.). 1977. *Struktura i dinamika poslednego lednikovogo pokrova Evropy* (The Structure and Dynamics of the Last Ice Sheet of Europe). Publ. Haus. Nauka. Moscow. 143 p. (in Russian)
- Kalm, V. 2012. Ice-flow pattern and extent of the last Scandinavian Ice Sheet southeast of the Baltic Sea. *Quaternary Science Reviews*, 44, pp. 51–59.
- Rinterknecht, V., Hang, T., Gorchach, A., Kohv, M., Kalm, V., Subetto, D., Bourlès, D., Léanni, L., Aumaître, G., Keddadouche, K. 2016. The Scandinavian Ice Sheet Last Glacial Maximum extent in the Valdai Heights, western Russia: the ^{10}Be evidence. Proceedings volume contains the extended abstracts presented at the Third Nordic Workshop on Cosmogenic Nuclide Techniques: Celebrating 30 years of counting cosmogenic atoms (Stockholm University, June 8–10, 2016), pp. 23–24.

PLAEOENVIRONMENTAL SITUATION OF THE MESOLITHIC AND NEOLITHIC SETTLEMENT IN SERTEYA (WESTERN RUSSIA)

Kittel, P.^a, Dolbunova, E.^b, Gauthier, E.^c, Mazurkevich, A.^b, Mroczkowska, A.^a, Okupny, D.^d, Plóciennik, M.^e, Pawłowski, D.^f, Rzodkiewicz, M.^g, Słowiński, M.^h, Wieckowska-Lüth, M.ⁱ

^a *Department of Geomorphology and Palaeogeography, Faculty of Geographical Sciences, University of Lodz, Lodz, POLAND*

^b *The State Hermitage Museum, St. Petersburg, RUSSIA*

^c *UMR CNRS 6249, Laboratoire de Chrono-Environnement, Université Bourgogne Franche-Comté, Besançon, FRANCE*

^d *Pedagogical University of Cracow, Institute of Geography, Krakow, POLAND*

^e *Department of Invertebrate Zoology and Hydrobiology, University of Lodz, Lodz, POLAND*

^f *Institute of Geology, Adam Mickiewicz University, Poznań, POLAND*

^g *Department of Quaternary Geology and Paleogeography, Institute of Geoecology and Geoinformation, Adam Mickiewicz University, Poznań, POLAND*

^h *Department of Environmental Resources and Geohazards, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Toruń, POLAND*

ⁱ *Archaeobotanical and Palynological Laboratory, Institute of Prehistoric and Protohistoric Archaeology, University of Kiel, GERMANY*

E-mail: piotr.kittel@geo.uni.lodz.pl

The Serteya region is located in Western Russia, within Vitebsk (or Western Dvina) Lakeland. The land relief of the area was formed after the recession of the Weichselian (Valdai) Ice Sheet. The main axis of the region is the Serteyka River Valley, the left-bank tributary of the Western Dvina River. The present day Serteyka River Valley uses a subglacial channel that was earlier occupied by few lake basins of two generations. The water basins of first generation existed there after ice sheet recession between dead ice blocks, and lakes of the second generation developed after dead ice melting in the Late Valdai. The Serteyka River drained successively several lake basins during the whole Holocene as a result of headward river erosion (Kalicki et al. 2015). In the present day Serteyka River Valley, numerous widening (basins) with biogenic plains and narrow gap sections in between exist. Four main post-lake basins occur within the researched lower section of the valley. These basins are 100-600 meters wide and 100-2000 meters long and are filled with organic deposits (mostly gyttjas) up to 6.5 meters thick (Kittel et al. 2016).

The former palaeolakes' basins and later the Serteyka River Valley were the main axis of Stone Age settlement. The human occupation of Serteya region passed development since Palaeolithic in the Late Weichselian and then Mesolithic groups existed there in the Early Holocene. The Serteya region is also one of the key areas of Neolithic occupation of Eastern Europe. Local settlement and economy depended strongly on landscape geo- and biodiversity and climate and hydrologic fluctuations (mainly 8.2 and 4.2 ky BP events) (Mazurkevich et al. 2009, 2012; Kul'kova et al. 2015).

The Serteya II site is one of the most interesting archaeological sites in the area, situated in the Great Serteya Palaeolake Basin. Until now, remains of six pile-dwelling were documented there, dating to ca. 4200-3800 cal. BP. The settlement existed almost 140 years and developed in the period of a domination of hunter-gatherer economy and beginning of agriculture (Mazurkevich et al. 2012). It was a part of wider settlement structure covered probably ca. 1 hectare of the surface. Archaeological artefact and features found in the recent years at the site area are dated from 8th to 3rd mill. BC and they existed both on the inorganic surface of sandy crevasses fillings and within organic deposits of the biogenic plain. The Mesolithic and Neolithic cultural layers were also found within the lacustrine deposits – mostly coarse-detritus gyttja, what encompasses for a good preservation state of remains, mainly the Neolithic pile-dwelling settlement remnants. The Mesolithic and Neolithic settlement at Serteya II functioned in a period when palaeolakes existed and were affected by transgression and regression of the water table. The archaeological context suggests the presence of short-term episodes of lake regressions (ex. ca. 4200 BP), allowing the pile-dwelling settlement's development on a post-lake plain (Mazurkevich et al. 2017).

The intense geological and geomorphological field survey was based on detailed mapping of the area with the use of geological augering and outcrops supplemented by analyses of topographical maps and aerial photographs. The results show that the site Serteya II is situated on the sandy ground of crevasses fillings in the shore zone of the palaeolake, while the pile-dwelling constructions' remains are located in the deep-water zone of the palaeolake basin. Nevertheless the wooden constructions were built originally not in the water, but in the area of post-lake bottom, only episodically (or periodically) covered with the water. In the shore zone the traces of the butchering of animals were documented within the coarse detritus gyttja layer. The gyttja is underlain by silty-sandy deposits with redeposited Early Neolithic (7–6th mill. BC) potsherds. It demonstrates intense transgression in the Middle Holocene, ca. 6 ka BP as confirmed by 14C data from the bottom of gyttja. In the upper part of the gyttja, bones of three human skeletons were found dated to the end of 3rd mill. BC. Human remains were deposited at the surface formed by lacustrine sediments, and covered with trees' branches.

For better understanding of ancient life conditions and economic base, it is necessary to carry out palaeoenvironmental reconstruction based on various palaeoecological proxies. Material for palaeoecological research, i.e. the core of organic deposits with cultural layers was taken into metal boxes from the wall of the archaeological excavation (ST II M25) up to the depth of 160 cm below the ground level. The profile was divided to three units: 23.0-65.5 cm b.g.l. – organic mud, 65.5-75.0 cm b.g.l. – loam, 75.0-148.5 cm b.g.l. – coarse detritus gyttja, and 148.5-160.0 cm b.g.l.

– sand with organic mud and plant detritus. The research on palaeoenvironmental changes is based on palaeoecological analyses (pollen, plant macrofossils, charcoal, diatoms, Cladocera, Chironomidae, geochemistry, sedimentology). A few AMS radiocarbon dating was made for elaboration of absolute chronology of the profile and for correlation with archaeological chronology of the site.

The plant macrofossil analysis revealed some changes within the macrophyte assemblages found in the core, demonstrating water table fluctuations. The results show a distinct increase of the water table in the initial phase of the basin development. Nevertheless the site was situated in shallow freshwater conditions in the close vicinity to the shoreline as demonstrated by still occurrence of terrestrial botanical remains. A few horizons with potential gathered plant remains and other ecofacts (shells, fish bones, charcoal) were also found and recognised as cultural layers. The phases of water table lowering were connected with a main settlement activity period at the site and mainly with the period of human remains deposition, when a terrestrialization took place. The later rising of water horizon caused a partial distribution of bones.

Reconstruction based on subfossil Chironomidae and Cladoceran assemblages was made with 2 cm resolution. In the top of the profile, only singular remains were noticed, and their numbers rapidly increase below 90 cm and were high up to 150 cm of the core depth. Chironomidae are represented mainly by Chironomini tribe, mostly lake and littoral species. Based on qualitative and quantitative analysis of species composition, palaeoenvironmental reconstruction was elaborated - among others: mean July paleotemperature, lake dynamics, and microhabitats composition. The results of subfossil Cladocera analysis show the changes of water level and content of organic matter in the water of the palaeolake basin.

The multi-proxy study allows for better understanding of the ancient communities interactions to local environmental and global climate fluctuations.

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References:

Kalicki T., Alexandrovskiy A.L., Kittel P., Krupa J., Mazurkevich A., Pawłowski D., Płóciennik M., Stachowicz-Rybka R. 2015. From Lake Basins to River Valley – Late Vistulian and Holocene Evolution of Last Glaciation Area: Serteya Basin (Western Russia), [in:] G. Baryshnikov, A. Panin (eds.), Gradualism vs catastrophism in landscape evolution. International Association of Geomorphologists (IAG) Regional conference, July 2-4, 2015, Barnaul, Russia, Extended Abstracts, Barnaul: Publishing House of Altai State University, p. 159-161.

Kittel P., Mazurkevich A., Dolbunova E., Kalicki T., Kulkova M., Pawłowski D., Płóciennik M., Stachowicz-Rybka R., Zaitseva G. 2016. Evolution of lake basins in the Serteya region (Western Russia) in the context of Neolithic settlement's development, [in:] S. Levina, R. Gorodnichev, I. Yadrikhinski, P. Davydova (eds.), Paleolimnology of Northern Eurasia. Experience, Methodology, Current Status: Proceedings of the International Conference. Yakutsk, 22-27 August, 2016. North-Eastern Federal University, Yakutsk, p. 13-15.

Kul'kova M.A., Mazurkevich A.N., Dolbunova E.V., Lozovsky V.M. 2015b. The 8200 calBP climate event and the spread of the Neolithic in Eastern Europe. *Documenta Praehistorica*, Vol. XLII, s. 77-92.

Mazurkevich A., Korotkevich B.N., Dolukhanov P.M., Shukurov A.M., Arslanov Kh.A., Savel'eva L.A., Dzinoridze E.N., Kul'kova M.A., Zaitseva G.I. 2009. Climate, subsistence and human movements in the Western Dvina – Lovat River Basins, *Quaternary International* Vol. 203, s. 52-66.

Mazurkevich A.N., Dolbunova E.V., Kul'kova M.A. 2012. Dynamics of landscape developing in early-middle Neolithics in Dnepr-Dvina region, [w:] *Geomorphic Processes and Geoarchaeology: from Landscape Archaeology to Archaeotourism*. International conference held in Moscow-Smolensk, Russia, August 20-24, 2012. Moscow-Smolensk: "Universum", p. 192–194.

Mazurkevich A., Dolbunova E., Kittel P., Fassbender J., Maigrot Y., Mroczkowska A., Płóciennik M., Sikora J., Słowiński M., Sablin M., Shirobokov I. 2017 (in press) Multi-disciplinary research on the Neolithic pile-dwelling Serteya II site (Western Russia) and the landscape reconstruction, [in:] *Nie tylko krzemień-not only flints*. Księga pamiątkowa Prof. Lucyny Domańskiej, Łódź.

HISTORY OF LAKE SELIGER (VALDAI UPLAND, RUSSIA): NEW DATA

Konstantinov, E.^a, Panin, A.^{ab}, Karpukhina, N.^a, Zakharov, A.^a

^a *Institute of Geography, Staromonetnyy pereulok 29, Moscow, RUSSIA*

^b *Faculty of geography Lomonosov Moscow State University, GSP-1, Leninskie gory, Moscow, RUSSIA*

E-mail: eakonst@igras.ru

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 boreholes 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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References:

- Kvasov, D., 1975. Late Quaternary history of large lakes and inland seas of Eastern Europe. 278 p. (In Russian)
- Savary, I. (ed.), 1963. Report on geological exploration for sand and gravel material within Lake Seliger. Moscow geological and hydrological expedition.
- Soloviev, M., 1934. Historical essay sapropel case in the Lake Seliger. Proceedings of the Sapropel Institute. Vol. I, p. 19-26 (In Russian)
- The State Water Register of the Russian Federation. 2008 - <http://www.textual.ru/gvr/>
- Wright, H., 1967. A square-rod piston sampler for lake sediments. Journal of Sedimentary Petrology. 37, p. 975-976

NEOPLEISTOCENE STRATIGRAPHY IN THE KOLA-KARELIAN REGION (N-W RUSSIA): KEY-SITES.

Korsakova, O.^a and Lavrova, N.^b

^a*Geological Institute of KSC RAS; 14, Fersman Str., 184209 Apatity, RUSSIA*

^b*Institute of Geology of KRC RAS; 11, Pushkinskaya Str., 185910 Petrozavodsk, RUSSIA*

E-mail: korsak@geoksc.apatity.ru; lavrova@krs.karelia.ru

In the context of the DATESTRA Project (<http://datestra-seqs.strikingly.com/>), the review of available data includes the key-sections with Neopleistocene (middle and upper Pleistocene in the Europe) stratigraphic units that were identified according lithological, paleontological (pollen, diatoms, foraminifera, and others) features in the Kola-Karelia region. Deposits of stratigraphic subdivisions from Kola are geochronometrically (C^{14} , U-Tr, ESR, or OSL) aged; single sediment successions are C^{14} aged in Karelia. Descriptions of stratigraphic date for the applicable key-points, their location, main features, and references included, will be presented in the poster report.

Consisted of Prionezhsky, Pai, Uriya, Svir, and Oka horizons (Zastrozhnov, 2014), **lower Neopleistocene** (pre-Holsteinian middle Pleistocene in NW Europe) glacial and interglacial deposits have been found by drilling in southern Karelia. Their relative age has been approximately derived from their positions in the sediment succession. Lacustrine and fluvial clayey sediments of the interglacial Pay horizon (c. MIS 15-17) and glacial boulder-loam of the Prionezhsky and Svir horizons (c. MIS 18 and 14, correspondently) are probably present in the boreholes at the Pay Village in central part of the Onega-Ladoga Isthmus (ca. 61.2023 N, 34.4495 E) (Akromovskiy et al., 2000, Bogdanov et al., 2013). Glacial diamicton of the Oka Horizons (MIS 12) occur in southern Karelia between the Svir (c. MIS 13) and Likhvin (MIS 11) interglacial units in the sediment succession known from borehole near Orzega Village, western Coast of Onega Lake (c. 61.6459 N, 34.4858 E); glacial gravel-bolder diamicton with 18 m thickness are identified here under Likhvin interglacial deposits in the borehole situated near Matrosy Village (c. 61.7628 N; 33.7973 E) (Agranova, Gaigerova, 1973; Akromovskiy et al., 2000).

Middle Neopleistocene includes the interglacial Likhvin (MIS 11), Chekalin (MIS 9), and Gorky (MIS 7) horizons and the glacial Kaluga (MIS 10), Vologda (MIS 8), and Mockow (MIS 6) horizons, which correlate to the middle Pleistocene Holstein and Saale in NW Europe (Zastrozhnov, 2014). Key-sites Matrosy (c. 61.76280 N; 33.79726 E) and Orzega (c. 61.6459 N; 34.4858 E) on the Onega-Ladoga Isthmus in southern Karelia proved the sediment succession included interglacial marine and lacustrine clay and degraded paleosoil with pollen spectra of Likhvin (Holstein in NW Europe) type. Indicated Pinus-Picea-Betula forest with broad-leaved trees admixture, coniferous and birch pollen dominate in spore-pollen spectra, scarce pollen of *Carpinus*, *Quercus*, *Ulmus*, *Tillia* and tertiary pollen of *Juglans* sp., *Liquidambar*, *Tsuga* are also present (Agranova, Gaigerova, 1973; Apukhtin, Ekman, 1967; Ekman, 1987). Any sediments of

glacial Kalyga horizon (MIS 10) are not known in Kola-Karelian region. Marine deposits correlated to the Chekalin horizon (MIS 9) were identified according paleontological (spore-pollen, diatoms, foraminifers, mollusc) data and geochronometrically aged in southern Kola Peninsula on the right bank of the Lower Varzuga River (Korsakova et al., in press). The basal part of the Varzuga key-section (66.3961 N; 36.6497 E) is represented by superposition of consolidated clay, loam, sandy loam with subfossil mollusc shells ESR dated between 319 and 316 ka B.P. Recurring vegetative assemblages are characterized by increasing quantity of *Betula* sect. *Albae* with occurrence of mesophilous and thermophilous components (*Alnus*, *Quercus*, *Tilia*, *Ulmus*, *Carpinus*, *Corylus*, *Osmunda*, *Nuphar*, *Nymphaea*) indicate here several middle Neopleistocene warm climatic events. The middle Neopleistocene Vologda (MIS 8) and Gorky (MIS 7) horizons are probably presented in the Varzuga key-section too (Korsakova et al., in press); the key-site Kolodozero (61.78430 N; 37.73372 E) provide the spore-pollen evidence of these both units in the S-E Karelia (Agranova et al., 1977). Till and melt-water deposits of the Moscow (MIS 6) horizon are known in numerous outcrops from Kola and southern Karelia. The key-sections are situated in the head of the Svyatoi Nos Bay of the Barents Sea (N 68.0328; E 39.8736), in the valleys of the Lower Chapoma (66.1131 N; 38.8442 E), Ponoï (67.0781 N; 41.1313 E), and Malaya Kachkovka (ca. 67.4 N; 40.9 E) Rivers, in Petrozavodsk area on the Onega Lake terraces (61.8122 N; 34.3292 E and 61.8103 N; 34.3342 E) (Gudina, Yevzerov, 1973; Kopsakova, 2009; Korsakova et al., 2011, 2016; Devyatova, 1972; Ikonen, Ekman, 2001).

Upper Neopleistocene incorporates Mikulino (MIS 5), Podpopozhie (MIS 4), Leningrad (MIS 3) and Ostashkovo (MIS 2) horizons (Zastrozhnov, 2014). Generally represented by marine and brackish-water sediments, Mikulino (MIS 5) horizon includes the both Ponoï and Strelna Beds identified in the Kola upper Neopleistocene Stratigraphy. The ESR/OSL-age of the Ponoï Beds and Strelna one ranges from approximately 120-130 to 100-105 ka (MIS 5e-d) and 100-105 to 70-80 ka (MIS 5c-a), correspondingly (Korsakova et al., 2004; Korsakova, 2009). The key-sections are situated in the valleys of the Strelna (66.0983 N; 38.5269 E), Chapoma 66.1131(N; 38.8442 E), Malaya Kachkovka (c. 67.4 N; 40.9 E), and Ponoï 67.0781(N; 41.1313 E) Rivers (Gudina, Yevzerov, 1973; Korsakova, 2009; Korsakova et al., 2016). Palynological proxies and diatoms from Ponoï Beds indicate more favorable environments as compared with the modern one; indicated from the Strelna Beds, environments are close to the modern one or colder. Three key-sections in the Petrozavodsk area (c. 61.8122 N; 34.3292 E; c. 61.8103 N; 34.3342 E; c. 61.7497 N; 34.4254 E) in southern Karelia proved the sediment succession included interglacial marine and lacustrine sand, silty clay, silt, and clay with Mikulino spore-pollen spectra (Ikonen, Ekman, 2001; Devyatova, 1972). Glacial deposits of the Podporozhie (MIS 4) horizon are known from the central and western Kola region and from southern Karelia. Two natural exposures with the Podporozhie horizon till, melt-water and glaciomarine sediments have been found on the Terskii Coast of the White Sea in the outcrops from Chavanga (66.1508 N; 37.7819 E) and Kamenka (66.0844 N; 38.2861 E) River valleys, and are known from borehole in the Lovozero Tundra Mountains (c. 67.8125 N; 34.9424 E) (Korsakova, 2009; Grave et al., 1964). Glacial diamicton and melt-water sand were identified in the key-sections Petrozavodsk (61.7983 N; E 34.3694) and Kukovka (61.7692 N; 34.3800 E) in southern Karelia. These deposits are overlaid here by interstadial Leningrad (MIS 3) lacustrine sand or peat. Interstadial Leningrad horizon sediment from both mentioned sections and from the key-section Drevlyanka (c. 61.75 N; 34.33 E) have been yielded ages 43900 ± 900 , 41800 ± 950 , 38700 ± 850 , 31750 ± 500 ^{14}C yr. BP (Ekman, 1982; Ekman, Liyva, 1980). In the Kola region, the Kamenka key-section (66.0844 N; 38.2861 E) provides a record of Valdaian (middle and late Weichselian) glacial and marine deposition. ESR-dated to about 59 ka and 52 ka, marine loam and sand correlate here to the Leningrad horizon. In addition, interstadial peats and lacustrine sands are known from the Kovdor open pit (c. 67.554 N; 30.455 E) in the western Kola, and from boreholes in the Lovozero Mnts (c. 67.8125 N; 34.9424 E) (Korsakova, 2009; Yevzerov, Koshechkin, 1980; Grave et al., 1964). Tills and melt-water sediments of glacial Ostashkov (MIS 2) horizon have a landforming value in the Kola-Karelian region. Substantiated by paleontological data and ^{14}C aged, key-sections with Ostashkovan

sediment succession are Sortavala (Kheljulia) (c. 61.7500 N; 30.7167 E) on the northern Ladoga coast (Bakhmutov, Zagniy, 1986), Pudozh (c. 61.8056 N; 36.4667 E) and Tambichozero (61.9350 N; 37.9022 E) in southeastern Karelia (Wohlfarth et al., 1999, 2002).

SOIL AND LANDSCAPE DEVELOPMENT IN AN ARCHEOLOGICAL SETTLEMENT AREA OF FRANCONIA (GERMANY)

**Krause, J.^a, Rothemel, K.^a, Krech, M.^a, Terhorst, B.^a, Falkenstein, F.^b, and Honeck,
M.^b,**

Ottner, F.^c

*^aInstitute of Geography and Geology, University of Würzburg, Am Hubland, 97074
Würzburg, GERMANY*

*^bChair of Prehistoric and Protohistoric Archaeology, University of Würzburg, Residenzplatz
2, Tor A, 97070 Würzburg, GERMANY*

*^cUniversity of Natural Resources and Life Sciences, Vienna, Peter-Jordan-Straße 82, 1190
Vienna, AUSTRIA*

E-mail: julian.krause@uni-wuerzburg.de

Along the Upper Triassic (Keuper)-cuesta escarpment of the Steigerwald several hill-top settlements can be found. One of those settlements is situated on the Bullenheimer Berg plateau, an escarpment outlier located 13 km south-east of the so-called Main-Triangle. For several years archeological excavations have been executed here, which are accompanied by soil geographical investigations.

The overall objective is to reconstruct, to what extent former settlers have affected or rather modified soils and landscape. Therefore, a small-scale survey of soils and sediments was conducted. Based on detailed soil mapping, characteristic soil horizons were selected and locally analysed by laboratory methods. Moreover, samples were taken from archeological excavation sites and further analysed in order to obtain pedological, sedimentological, and mineralogical data.

Our poster presents the soil and landscape development of the Bullenheimer Berg plateau, based on the results of the mentioned investigations. Prior to the field survey it was unclear, which soils could be found and whether an undisturbed Holocene soil was preserved on the plateau. Since then, the archeological excavations and soil mapping enabled insights into anthropogenic influenced soils and related sediments. Furthermore, mineralogical analysis should clarify, whether the clayey-silty parent material is part of the stratum Hassberge-Formation or part of the underlying stratum Steigerwald-Formation, respectively whether the clayey material is weathered material. Overall, ten profiles were analysed, four of them related to our new soil map and six accompanying the archeological excavations. Apart from the bulk analyses (e.g. grain size, pH-value, carbonate content), clay and bulk minerals of three profiles were analysed using the X-ray diffractometer.

As a result, soil mapping could not prove undisturbed Holocene soils on the plateau. The whole plateau is covered by Colluvisols consisting of several horizons (according to the German German Soil classification). Charcoal as well as ceramics were found in all horizons. The sedimentological analyses showed a very similar grain size distribution of the various colluvial horizons. These facts strongly indicate an intense reworking of soils and sediment during various phases of intense settlement and use of the plateau area. With the presence of buried A-horizons it is clear that during the past 3000 years at least phases of initial soil formation took place, which were later stopped by accumulation of colluvial sediments. Based on the clay- and bulk mineral analyses, the clayey parent material could not clearly be assigned to a geological strata, since the claystones of both possible strata are nearly identical in their composition. However, it is clear that there is no

evidence for strong soil formation on the plateau and the whole area shows only weak signs of pedogenesis, as, for instance, secondary chlorites. Moreover, the analyses reflect mixed and homogenised material, locally affected by young pedogenetic processes. Based on these results, the soil and landscape development could be subdivided into five main phases. The natural Holocene soil was a Cambisol developed in Pleistocene periglacial cover beds. Major reworking of soils started already during the Urnfield period (11 th century B.C.) with the removal of forest and the construction of a fortified permanent settlement. The related archeological findings are situated on top of the clayey parent material and soils have been removed so far. Corresponding soil sediments may have been stored on dumps or used for other activities on the plateau, a fact which could lead to the homogenisation of soil sediments. After abandonment of the settlement around 800 B.C., secondary forest grew and a new phase of soil formation could start. It was not until the high Middle Ages that this phase was interrupted by land use and farming. Ridges and furrows from the Middle Ages are significantly recorded in a high-resolution DEM. Since the 15 th century, the plateau is permanently used as forest and a further soil formation phase took place, resulting in a weak browning of the colluvial horizons.

THE RECONSTRUCTION OF THE ENVIRONMENTAL DEVELOPMENT ON SOUTHERN PERIPHERY OF THE VALDAI (POOZERIE) GLACIATION IN THE LATE GLACIAL AND HOLOCENE

**Kublitskiy, Y.^a, Subetto, D.^{a,b}, Vlasov, B.^c, Novik, A.^c, Leontev, P.^a, Grekov, I.^a, Syrykh,
L.^a, Sokolova, N.^a, Brylkin, V.^a**

^a *Herzen State Pedagogical University of Russia. 191186, Emb. Moyki, 48, St. Petersburg, RUSSIA*

^b *Northern Water Problems Institute, Karelian Research Centre of the RAS. 185030, A. Nevskogo Avenue, 50, Petrozavodsk, Republic of Karelia, RUSSIA*

^d *Belarusian State University. 220030, Nezavisimosti avenue, 4, Minsk, REPUBLIC OF BELARUS.*

E-mail: uriy_87@mail.ru

The environmental changes and the evolution of post-glacial landscapes in the late Neopleistocene and Holocene are actual direction of contemporary paleogeography both in Russia and in the World. Interdisciplinary studies based on close interaction of specialists in the field of natural sciences (botany, zoology, soil science, geochemistry, geomorphology, landscape science, radiocarbon dating, etc.) can be considered as the most promising. Currently, the direction of integration and correlation of separate paleogeographic materials has been actively developed, with the aim of establishing spatio-temporal relationships of natural and climatic changes.

To reconstruct the environmental development on southern periphery of the Valdai (Poozersky) glaciation in the Late Glacial and Holocene, research group plan to create a paleogeographic database, including archival data, information on the location of all studied objects and the results of different analyzes for each horizon of each object.

At the present, the development stages of the Vyshtynets Upland lakes (east of the Kaliningrad Region) have been determined. The dynamics of natural conditions in the Late Neo-Pleistocene and Holocene in the region has been reconstructed by correlating the obtained data with the results of studies by Polish and Lithuanian scientists (Kublitskiy 2016, Kublitskiy et al. 2016). For the first time, the main regularities of the forest and marsh ecosystems development in the Kaliningrad region at each stage of the Holocene, including taking into account the anthropogenic influence (Naprenko-Dorokhova, 2015)

The work was carried out in the west of the Smolensk region, as a result 4 complete columns of the peat bog bottom sediments (13 meters each) were selected and described. This bottom sediment thickness indicates high sedimentation rates, which makes this material representative for paleogeographic reconstructions, since it becomes possible to perform analytical studies with a high resolution (Kublitsky Yu.A., Leontiev P.A, Grekov I.M - unpublished data).

The evolution of lakes ecosystems in the Belorussian Lakeland in the past 10,000 years has been established (Vlasov, 2004; Novik, 2017).

As a result of the project, it will be possible to trace the submeridional asynchrony of the nature development processes on southern periphery of the Valdai glaciation stage of the Late Glacial and Holocene. At the conference will present the first results of the research.

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References:

Kublitsky, J. 2016: The dynamic of nature condition of SE part of Baltic region during Late Neopleistocene and Holocene. Ph. D. Thesis, Saint-Petersburg, 150 pp. [In Russian].

Kublitsky, J., Kharin, G.S., Subetto, D., Arslanov, Kh. 2016: Reconstruction of origin and sedimentary processes of lakes and swamps of Vishtynetskaya highland (Kaliningrad region). Society. Environment. Development, 1, 100-106. [In Russian].

Napreenko-Dorokhova, T.V. 2015: Paleoecological reconstruction of the vegetation cover of the southeastern part of the Baltic region in the Holocene. Ph. D. Thesis, Kaliningrad, 174 pp. [In Russian]

Novik, A. A. 2017: Space-time correlation development of the lake levels change during the late glacial and holocene of the Baltic Lake Districts. J. Belarus. State Univ. Geogr. Geol. 1. 26–35. [In Russian].

Vlasov, B. 2004. Estimation of pollution of lakes of Belarus under the contents of heavy metals in water plants and bottom sediments. Limnological review. – 2006. – Vol. 6. – 289-294.

BIPARTITE SEDIMENTS WITHIN THE MOSCOW GLACIAL LIMITS OF THE RUSSIAN PLAIN: FEATURES AND ORIGIN OF THE COVER LAYER

Kust, P.*^{a, b, c}, Makeev^{a, c}, Lebedeva, M.^{b, c} and Rusakov, A.^d

^a Faculty of Soil Science, Lomonosov Moscow State University, GSP-1, 1-12 Leninskie Gory, 119991 Moscow, Russian Federation

^b Dokuchaev Soil Science Institute, Russian Academy of Science, Pyzhevsky lane 7/2, 109017, Moscow, Russian Federation

^c Institute of Geography, Russian Academy of Sciences, Staromonetnyi Pereulok 29, 119017, Moscow, Russian Federation

^d Institute of Earth Sciences, Saint-Petersburg State University, Universitetskaya nab. 7-9, 199034, Saint-Petersburg, Russian Federation

*E-mail: pavelkust@yandex.ru

Basal tills of Moscow (Late Saalian, Warthe, MIS6) glaciation form important component of landscapes in northern Europe, including the center of the Russian Plain. They are often covered only with a thin veneer (cover layer), of sands, sandy and silty loams so that surface soils are formed on bipartite sediments. For this territory, several phases of gully erosion are recorded from late Moscow to Late Valdai time: activation of insequent streams with transition to Mikulino interglacial (MIS 5e, 125-115 Ka), stabilization during Mikulino interglacial when peat sediments were formed in the gully bottoms, activation during transition to Early Valdai, and during Late Valdai. Gully erosion is better presented on the surfaces covered by mantle loams. The uplands with bipartite sediments mostly keep Late Moscow surface undisturbed by erosion due to high resistivity of lodgement tills and keeps record of all depositional episodes.

Field geological survey of the pedosedimentary pattern was conducted both in the central and peripheral parts of glacial moraine uplands with different elevations. The soilscape pattern was

documented by a regular network of soil pits, trenches and boreholes with documentation of pedostratigraphic units. It was shown, that cover layer is characterised by a set of the following features:

1) spatial extent of the depth: pedosedimentary mapping shows that bipartite sediments mantle the slopes of studied moraine hills with the cover layer depth ranging from 30 to 85 cm and a mean depth of 45 cm. The depth of the cover layer can slightly increase within the supraglacial meltwater channels (insequent gullies) to the depth of more than 2 m and varies in different soil pits. According to our numerous observations the depth of the cover layer is only slightly dependent or not dependent from the topography. Such mantle deposition was possible only during deglaciation when the topography did not play an important role for flood washing.

2) contact zone with adjacent sediments: the cover layer gradually merges with kame and glaciofluvial sands (Fig. 1) – within approximately 300 m the depth of the cover layer increases, sandy material becomes coarser, the amount of gravel increases, while the basal till submerges deep below a thick layer of sand. Lateral contacts of the bipartite and adjacent sediments confirm that the sandy cover layer and the sands of the kame and of the glacial outwash of Moscow time are paragenetic sediments.

3) texture: the textural classes of constituting materials of the cover layer vary from loamy sand to silty loam. Also, the cover layer may be represented by sandy and silty patches in the same soil pit. The silty patches predominate in the upper part. The microstructure of the cover layer has a complex character depending on the sandy patches or silty patches. The sand grains could be well sorted and unsorted, in some cases stellate grains predominate. All reference profiles meet the criteria of the abrupt textural difference and show the imbalanced clay content between the basal till part and cover layer. The abrupt textural change takes place on both sand-till and silt-till boundaries. Both sandy and silty patches contain gravel, sometimes showing an increase in the sandy part. Some of the sand material could also appear due to the local aeolian input. The sand with gravel advocates glaciofluvial genesis of the cover layer. Its deposition could probably have happened when the area was freed from continuous ice cover and was subjected to flood washing of the basal till by streams from adjacent bodies of dead ice, which resulted in the deposition of the sandy material rich with gravels. In some cases, the cover layer could be an ablation material deposited as a result of passive imposition of the particles suspended in a dead ice body during its degradation. Though we cannot exclude periglacial activity that could partly explain why aeolian silty material became mixed with the slightly gravelly coarse sand. Nevertheless, the presence of separate sand and silt layers and patches evidences against prominent mixing of material of the cover layers by periglacial processes. The mechanisms described above are the only way to explain mantle bedding of the cover layer on the top and slopes of ground moraine hills.

4) the character of the boundary between the basal till and the cover layer: The boundary between the cover layer and the basal till is mostly abrupt and irregular, being complicated by albeluvic glossae. It is especially striking on a microscale when the abrupt transition of the matrix of the basal till to that of the cover layer occurs on a distance of a few microns. The fissures are filled either with the sandy or the silty material depending on the overlying cover layer. The boundary between the basal till and the cover layer may also be marked by very firm thin intermittent layer of coarse sand. Such abrupt boundary between the cover layer and the basal till can be interpreted as a lithic discontinuity. The bipartite character of sediments is well seen in the contact zones: the size of grains vary between ~200 and 250 mm in the sandy, or ~100 and 150 mm in the silty cover layers and between ~30 and 50 mm in the basal till. The contact zone can be violated by shearing. Pieces of till incorporated into the cover layer fully retain their identity. A boundary between frost fissures and the basal till remains abrupt. Frost sorting of sand and silt grains (circular pattern) could be noticed in the cover layer. Shearing and mixing may result in a gradual transition in parts of the contact zone. Due to this, small patches enriched in clay are interlayered with the material of the cover layer. This shows that the basal till was not fully stabilized during the deposition of the cover layer.

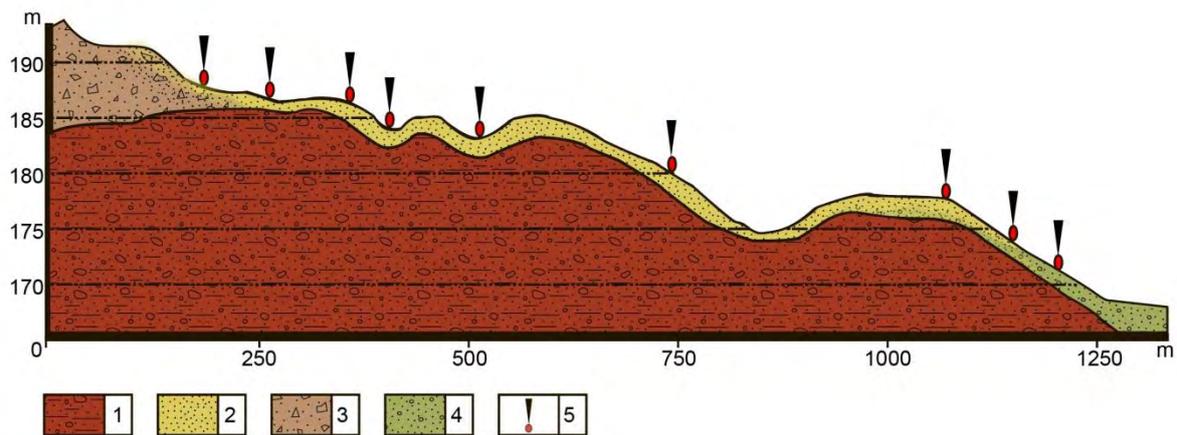


Fig. 1. Lateral contacts of the cover layer with kame and fluvio-glacial sediments, 165-195 m a.s.l. (on the base of SRTM30 Digital Elevation Model supplemented by geodetic levelling). Generalized profile.

1 - basal till; 2 - complex sediment of sandy/silty cover layer; 3 - kame sediments; 4 - glaciofluvial sediments; 5 - position of soil pits.

Similar lithological features of the cover layer and the basal till, similar coarse fragments, uniform distribution of geochemical indexes may indicate that the deposition of the cover layer took place close in time to the deposition of the basal till. Our numerous laboratory studies allow to confirm that the formation of the cover layer happened simultaneously to or immediately after the deposition of the basal till and resulted from washing of the till surface by temporary streams with local aeolian input. Thus such bipartite sediments are among the oldest parent materials for surface soils subjected to pedogenesis starting from Late Moscow time till now. This was confirmed by spatial field studies and numerous OSL datings of cover layer (but the shallow depth of the cover layer makes it subjected to further reworking by bioturbation, especially uprooting).

STUDIES OF CONTEMPORARY GLACIERS IN ARCTIC AND ANTARCTICA AT THE UNIVERSITY OF LATVIA

Lamsters, K., Karušs, J., Krievāns, M.

Faculty of Geography and Earth Sciences, University of Latvia, Jelgavas street 1, Riga, LATVIA

E-mail: Kristaps.lamsters@gmail.com

Since 2014 scientists from the University of Latvia have realised five scientific expeditions in Arctic and Antarctic focusing on geophysical studies of modern glaciers. Scientific expeditions to Iceland have been realized in 2014, 2015 and 2017, and the expedition to Greenland has accomplished in 2016. The first Latvian scientific expedition to Antarctica was realised in 2018. Although the main goal in these polar expeditions was investigation of glacier thickness, structure and subglacial topography using ground penetrating radar (GPR), interdisciplinary studies were performed in the fields of geology, geomorphology, glaciology, soil science, remote sensing and microbiology. Thereby, a new research area in Latvia – polar studies, has been developed at the University of Latvia, and it is planned to organize scientific expeditions to Arctic or Antarctica each year.

The first expeditions to Iceland have resulted in the revealing of drumlins beneath Múlajökull outlet glacier (Lamsters et al., 2016), and the methodology of studying subglacial topography by using GPR, GPS systems and aerial unmanned vehicles (UAV) was developed. In 2016, similar

survey was done on the Russel glacier, Southwest Greenland. As the surface topography of the Russell glacier is quite articulated, gathering of GPR data and creation of precise surface elevation map was complicated but the aerial photographs was successfully captured with drone DJI Phantom 3 advanced and models of ice surface and subglacial topography were created by SAGA GIS software and Thin Plate Spline (Global) interpolation method. We discovered (Karušs et al., 2018) linear bedrock depression close to the ice margin suggesting favourable path to subglacial meltwater that flows periodically from the ice-dammed lake due to jökulhlaups, and showed that such methodology can be used, even if the ice surface is complex

In addition to these studies, several other investigations were performed. Fine-grained mineral material was collected from the cryoconite holes at the ablation zone of the Russell Glacier, as well as from different sedimentary environments in the ice-free territory. The shape, character of surface and microtextures of mineral quartz particles were analysed in scanning electron microscope (SEM) to provide information about particles character and their origin (Kalińska-Nartiša et al., 2017a, 2017b). It was concluded that investigated quartz grains carry transportation features originating from numerous, but local sources, except few grains that argue for a dry and warm climate conditions existing in distant deserts.

In 2018, the first expedition to Antarctica was conducted, and it is considered as a significant step forward for Latvian scientists in developing long-term studies in this region. For the realization of the polar investigations it was substantial to cooperate with country, which operates research station in Antarctica. Therefore the cooperation agreement was signed between the University of Latvia and the National Antarctic Scientific Center of Ukraine in 2017, and the 2018 expedition was realized to Akademik Vernadsky Research Base. This station is situated on the Galindez Island in the Argentine Islands, and this is very suitable point for the studies of ice caps of the surrounding islands. We collected more than 70 km of GPR data, as well as more than 11000 aerial photographs using UAV from Argentine Islands. Small ice caps were found and investigated for the first time on the Galindez, Winter, Skua, Uruguay, Irizar and Corner islands, and on the two of the Barchans. Besides of these investigations, cryoconite, sediment, and water samples were collected from ice, as well as from different environments as small ponds, streams, and inlets to characterize sand formation processes, soil development, and microbial diversity in this part of Antarctica.

For the future work in Antarctica we realize that it is essential for Latvia to sign Antarctic Treaty, which regulates the international relations in this region, and it would be necessary to develop National Antarctic research programme. We are also looking to expand our cooperation with countries operating research bases in Antarctica. For the future work in Antarctica it is essential to develop collaborative projects between countries from the Peribaltic Region, which are interested and capable to carry out polar investigations.

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References:

Karušs, J., Lamsters, K., Krievāns, M. & Rečs, A. 2018. Geophysical and remote sensing survey of the Russel glacier, Southwest Greenland. Geophysical Research Abstracts Vol. 20, EGU2018-17752, EGU General Assembly 2018.

Kalińska-Nartiša, E., Lamsters, K., Karušs, J., Krievāns, M., Rečs, A. & Meija, R. 2017a. Fine-grained quartz from cryoconite holes of the Russell Glacier, southwest Greenland – a scanning electron microscopy study. Baltica 30 (2), 63-73.

Kalińska-Nartiša, E., Lamsters, K., Karušs, J., Krievāns, M., Rečs, A. & Meija, R. 2017b. Quartz grain features in modern glacial and proglacial environments: A microscopic study from the Russell Glacier, southwest Greenland. Polish Polar Research 38 (3), 265-289.

Lamsters K., Karušs, J, Rečs, A., Bērziņš, D. 2016. Detailed subglacial topography and drumlins at the marginal zone of Múlajökull outlet glacier, central Iceland: evidence from low frequency GPR data. *Polar Science*, 10, 470-475.

HUMAN IMPACT ON SOIL FORMATION IN CENTRAL FRANCONIA (GERMANY) DURING THE HOLOCENE

**Meyer-Heintze, S.^{a*}, Terhorst, B.^a, Sprafke, T.^b, Krech, M.^a, Beigel, R.^c, Nadler, M.^d,
Wagner, F.^d, Solleiro-Rebolledo, E.^e, Diaz Ortega, J.^e, Damm, B.^f and Falkenstein F.^c**

^a *Institute for Geography und Geology, Physical Geography, Julius-Maximilian-University of Würzburg, Am Hubland, D-97074 Würzburg, GERMANY*

^b *Institute of Geography (GIUB), Paleo-Geoecology, University of Bern, Hallerstrasse 12, CH-3012 Bern, SWITZERLAND*

^c *Institute for Antiquity Studies, Chair for Pre- and Protohistoric Archeology, Julius-Maximilian-University of Würzburg, Residenzplatz 2, Tor A, D-97070 Würzburg, GERMANY*

^d *Bavarian State Office for Heritage Management, Department Nuremberg, Burg 4, D-90403 Nuremberg, GERMANY*

^e *Institute of Geology, National Autonomous University of Mexico (UNAM), Circuito de los Institutos s/n, C.P. MX-2376 Mexico City, MEXICO*

^f *Applied Physical Geography (Department II), University of Vechta, Driverstr. 22, D-49364 Vechta, GERMANY*

E-Mail: simon.meyer-heintze@uni-wuerzburg.de

In general, the factors parent material, climate, geomorphology (relief), organisms, and time control soil formation (Dokuchaev, 1883; Jenny, 1994). Since humans' sedentary presence during the Holocene, they increasingly transform their environment and become a considerable element in the genesis of modern soils (Leopold and Völkel, 2007; Richter et al., 2015).

The Central Franconian geology is widely characterized by Upper Triassic (Keuper) sediments (Geyer, 2002; Haunschild, 1971). These units contribute to the geomorphological appearance of the landscape: while resistant rocks like sandstones generally appear as topographic molds and escarpments, clays and marls are soft and erodible and form open landscapes and smooth morphological shapes (Müller, 1996). In the plains, the natural soils are Vertisols or soils with vertic properties, but Cambisols developed in solifluction layers of the Pleistocene (periglacial cover beds) cover the slopes. Today these soils are eroded or disturbed indicating the massive impact of human land use.

Rich deposits of gypsum located in the area are in parts subject to intensive karst formation. The incipient subrosive processes lead to the development of sinkholes and dolines. The onset of the subterranean solution is supposed to date to the end of the Pleistocene / Early-Holocene. Since then the successively growing depressions were filled by colluvial pedosediments in a rather continuous manner – sinking and infilling were more or less at equilibrium (Fig. 1A). Due to the increasing settlement and agricultural activity in the region, the colluvial processes were intensified and beside soil material with different properties the sediments stored in the sinkholes contain archeological material from the Neolithic to the pre-Roman Iron Age (Fig. 1C). The geoarcheological archives become accessible during the ongoing exploration of the gypsum.

Our comprehensive dataset consists of physicochemical and micromorphological analyses. The aim is to characterize the pedosediments and infer pedogenetic and site-formation processes. By underpinning the data with radiocarbon ages and relative dating derived from pottery and ceramics we complement our study and link our findings to the paleoenvironmental development during the Holocene.

The studied sediments and soils inherited large amounts of clay from the local geology. Striated b-fabrics micromorphologically point to the presence of vertic processes, while speckled b-fabrics are an evidence of iron release or clay-mineral synthesis (Fig. 1E). The appearance of Fe/Mn nodules in various shapes identify phases of water logging. The Fe chemistry and ratios unravel chemical weathering, hence pedogenesis and phases of stability within the sinkhole records.

The lowermost horizons of the sinkhole infillings often consist of mudstone and sandstone of the nearby escarpment mixed by solifluction processes. Therefore, these units reflect basal layers according to the concept of periglacial cover beds. Above, usually Gley horizons developed which indicate water stagnation in the initial phase of the sinkhole development. Colluvial layers which contain material of cultural soils of the surrounding burry this Early Holocene soil formation since the mid-Bronze age (Fig. 1B). The well-resolved stratigraphy highlights the importance of these unique records of Holocene landscape and cultural development.

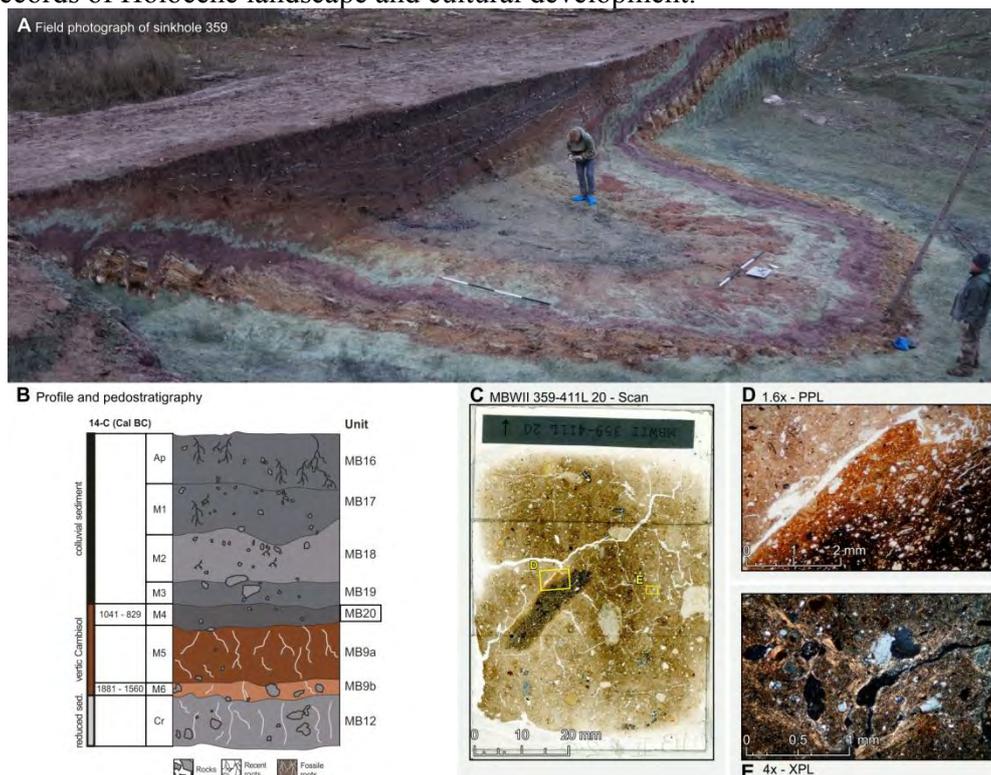


Fig. 1A. Field photograph of sinkhole 359. The colorful units represent the local mudstone geology. Colluvial layers with different properties accumulated above. B. Profile and pedostratigraphy. The label M is borrowed from the German Soil Classification (Ad-hoc-AG-Boden, 2005). It indicates colluvial layers which result from human agricultural and settlement activity. C. Microscan of unit MB20. D shows a burnt ceramic which incorporates local mudstone. The black color points to incomplete burning due to the lack of oxygen. E. Porostriated and speckled b-fabric. PPL: plain-polarized light, XPL: cross-polarized light.

References:

- Ad-hoc-AG Boden, 2005. *Bodenkundliche Kartieranleitung*, 5 ed. Schweizerbart, Stuttgart.
- Dokuchaev, V.V. 1883. Russian Chernozem. In *Selected Works of V.V. Dokuchaev*, Vol. 1, p. 14–419. Moscow, 1948. Israel Program for Scientific Translations Ltd. (for USDA-NSF), S. Monson, Jerusalem, 1967. (Translated from Russian into English by N. Kaner).
- Geyer, G., 2002. *Geologie von Unterfranken und angrenzende Regionen*. Klett Perthes, Gotha, pp. 588.
- Haunschild, H., 1971. *Geologische Karte von Bayern 1:25000 - Erläuterungen zum Blatt Nr. 6527*. Bayerisches Geologisches Landesamt, München.
- Jenny, H., 1994. *Factors of soil formation: a system of quantitative pedology*. Dover Earth Science.
- Leopold, M., Völkel, J., 2007. Colluvium: Definition, differentiation, and possible suitability for reconstructing Holocene climate data. *Quaternary International*, 162, 133-140.
- Müller, J., 1996. *Grundzüge der Naturgeographie von Unterfranken*. Gotha, Justus Perthes Verlag, pp. 324.
- Richter, D.d., Bacon, A.R., Brecheisen, Z., Mobley, M.L., 2015. Soil in the Anthropocene. *IOP Conference Series: Earth and Environmental Science*, 25, 012010.

MIGRATION OF ELEMENTS AND DEEP DECALCIFICATION IN GLACIAL TILL FROM THE SAALE GLACIATION IN NE POLAND

Muzińska, A.^a, Woronko, B.^b

^a *College of Inter-Faculty Individual Studies in Mathematics and Natural Sciences, University of Warsaw, Banacha 2C, 02-097 Warsaw, POLAND*

^b *Faculty of Geology, University of Warsaw, Żwirki i Wigury 93, 02-089 Warsaw*

E-mail: a.muzinska@uw.edu.pl

The area of NE Poland covered by the Saale glaciation (MIS 6), out of reach of the Weichselian glaciation (from MIS 2) is an interesting example of geomorphological and pedogenic transformation of sediments. It took place under double periglacial conditions and transformed in the warm climate of the Eemian Interglacial (MIS 5e) and Holocene (MIS 1). Glacial-interglacial cycles led to the creation of a unique soil complex, which features were inherited from previous climatic conditions. This kind reworked sediments are described incidentally (Felix-Hennigsen 1981, Kowalkowski, 1990, Schaetzl, Thomson, 2015), which made subject an interesting to provide next research.

Cycle consists of one cold-glacial and one warm-interglacial period (Iverson, 1964, Dziągiewski, Tobolski, 1982, Birks, Birks, 2004). It can be also divided into 5 shorter stages: cryocratic - during glaciation or in periglacial conditions, protocratic and mesocratic, characterized by increasing biomass and fertility of soils related to increase in temperature, which reaches the climate optimum with maximum vegetation. Afterwards, decrease in temperature leads to oligocratic and telocratic phases, with decreasing biomass and fertility (Iverson, 1964; Dziągiewski, Tobolski, 1982; Birks, Birks, 2004).

In the area of NE Poland during climate change sediments were completely transformed. From the deposition of glacial till, through development of soil profiles, to the periglacial conditions thus creating characteristic structures - ice wedges. It has changed also the structure of glacial till and initiated active eolian processes to the last warm period with the next development of soil. In each site there are thick glacial till series. Their thickness varies from 1,5 to over 5 m with the top containing pseudomorphosis after ice wedges initially filled with sand (sand wedges), is overlain by an aeolian pavement, covered by approximately 0,3-0,4 m thick aeolian and slope sediments. The active layer had a thickness of approximately 0,5-0,6 m.

Research were made for around 170 samples from 3 sites from NE Poland (Koczery, Żabiniec, Wierzchuca). In each site samples were collected from 2-3 profiles - between sand wedges in normal horizontal profiles, from glacial till along the sand wedges and from sand filling the pseudomorphosis. Decalcification was measured using the Scheibler method (Bednarek et al., 2004). Furthermore, geochemical characteristics have been measured for one of the sites (Koczery). It covered sediments such as: SiO₂, Al₂O₃, TiO₂, Fe₂O₃, MnO, CaO, MgO, K₂O, Na₂O, P₂O₅. The analysis was performed in specialized laboratories BVM (Canada). The Chemical *Index* of Alteration (CIA) was calculated for chosen samples.

In periglacial conditions mobilization of colloidal clay caused the formation of leaching zone, which is also visible in different color in outcrop. The till is decalcified in average to 0,7 m in places undisturbed by presence of sand wedges to more 2-2,5 m along the sand wedges structures. The thickness of decalcification zone is generally deeper in areas directly related to the sand wedges and more shallow between them. Migration of elements is also related to the occurrence of sand wedges.

References:

Bednarek, R., Dziadowiec, H., Pokojska, U., Prusinkiewicz, Z., 2004, *Badania ekologicznogleboznawcze*, Wydawnictwo naukowe PWN, Warszawa.

Birks H.J., Birks H., 2004. Paleoeecology - The rise and fall of forests. *Science* 305: 484-489.

Dzięgielewski, W., Tobolski, K., 1982. Quaternary climatic-ecological cycles and the evolution of soils. *Soil Science Annual* 33, 201-211

Felix-Henningsen, P., 1981. Soils from Warthe till at the Emmerlev Kiev in southern Denmark Stratigraphy and paleopedology. *Tidsskrift* 81: 33-88. French, H.M., 2007. *The Periglacial Environment*. Longman, London

Iverson, J. 1973. The development of Denmark's nature since the last glacial. *DanmarksGeologiske Undersogelse V. rakke* 7C

Kowalkowski, A., 1990. Evolution of Holocene soils in Poland, *Quaestiones Geographicae* 11/12: 93– 120

Schaetzl R.J., Thomson M.L., 2015. *Soils. Genesis and Geomorphology*. 2nd Edition. Cambridge University Press.

Shao J., Yang S., Li. C., Chemical indices (CIA and WIP) as proxies for integrated chemical weathering in China: Inferences from analysis of fluvial sediments. *Sedimentary Geology* 265-266, 2012, pp. 110-120.

LOWLAND AND MOUNTAIN REGIONS IN NORTHERN AND CENTRAL GERMANY UNDER (PERI-)GLACIAL CONDITIONS DURING THE PLEISTOCENE – A LITERATURE AND FIELD EVIDENCE DISCUSSION

Opp, C.

Philipps-Universität Marburg, Faculty of Geography, Deutschhausstr. 10, 35032 Marburg, GERMANY

E-mail: opp@staff.uni-marburg.de

The presentation reflects a substantial part of the 19th century research history of the recognition of the Pleistocene Scandinavian glaciation in the central parts of present day Germany by studying the available literature sources. In the second part the presentation discusses the evidence of mountainous glaciation versus periglacial forming in the German Uplands.

During a speech in Berlin in 1875, the Swedish geographer *Otto Martin Torell* presented polished surfaces and scratches, he had found in Rüdersdorf, near Berlin. Since then many scientists have confirmed the influence of the Scandinavian glaciation on large parts of the Central European lowlands during the Pleistocene. And Swiss and German geographers had found clear evidence of the Pleistocene glaciation of the Alps even before that. But the extent of the glacial and periglacial processes in the lower mountain ranges between the lowlands and the Alps remained unclear for a long time.

The Hohburg Mountains (northeast of Leipzig), became a research object central to this question and for several decades ignited controversial discussions about glacial versus periglacial forming of this intersection area between the uplands in central and southern Germany on one side and the lowlands in northern Germany on the other side. *Bernhard von Cotta (1844)*, *Carl Friedrich Naumann (1844)*, and *Adolph von Morlot* had described both glacial and periglacial traces in the Hohburg Mountains, independently of each other in 1844, 31 years before *Torell*. But *Charles Lyell* and *Albert Heim*, who had previously studied glacial traces in the Swiss Alps, in 1874 rejected the glacial origin of the traces found in the Hohburg Mountains and defined them as periglacial in nature. Later on and up to today the glaciation of the Hohburg Mountains during the Saalian Glaciation became widely recognized (*Eissmann & Müller 1994*).

Other areas of the upland mountain ranges between the lowlands in the north and the Alps in the south with confirmed glaciation during the Pleistocene are: the Harz Mountains (*Duphorn 1968; Hövermann 1973/1974*), the Bavarian Forest (*Ergenzinger 1967; Raab & Völkel 2003*), the Black Forest (*Fromherz 1842; Deecke 1918*), and the Vosges (*Frey 1965*). The potential glaciation of the Ore Mountains, on the other hand, is still debated, but there are recognizable features that suggest the influence of glacial processes.

A mighty fossil rock glacier in the Rhön (Rhoen Mountains) is a clear evidence of the strong periglacial influence of this mountain range during the Pleistocene, although this area was not covered by glaciers. The micro-scale survey of the block forms shows, that the central part of the Schafstein block accumulation has edged blocks at the upper part and shaped blocks at the

bottom. A special feature at the bottom is a characteristic wall and depression structure, with more than 30° inclination between the walls, caused by different tensions of different ice cement saturated parts of the block accumulation. By refraction seismic measurements it has been proven that the central part of the block accumulation has a thickness of about 30 and 40 meters. During summer time, when air temperature was about 30°C, temperatures between 0°C and -1°C have been measured between the blocks. Nearly all studied features prove that the central part of the Schafstein block accumulation represents a fossil rock glacier, while the western part represents a block field, and the eastern part is a block slope (Opp 2005).

References:

- Coota, B. v. 1844. Jb. Mineral. 558-561.
 Deecke, W. 1918. Geologie von Baden. Berlin 629 p.
 Duphorn, K. 1968. Eiszeitalter & Gegenwart 19, Öhringen.
 Frey, C. 1965. Basler Beiträge zur Geographie und Ethnologie, Geogr. Reihe 6, 150 p.
 Fromherz, C. 1842. Freiburg, 443 p.
 Eissmann, I. & Müller, A. 1994. Altenburger Nat.-wiss. Forsch. 7, 378-430.
 Ergenzinger, P. 1967. Eiszeitalter & Gegenwart 18, 152-168.
 Morlot, A. v. 1844. Bern.
 Naumann, C. F. 1844. N. Jb. Mineral.: 557-558, 561-562.
 Opp, C. 2005. Beiträge Region und Nachhaltigkeit 2, 71-83.
 Raab, T. & Völkel, J. 2003. Quaternary Science Reviews 22, 581-593.



Fig. Locations of glacial and/or periglacial influences (marked in yellow) discussed here

DEVELOPMENT OF WARTA AND ODRA VALLEY IN SANTOK
GEOARCHAEOLOGICAL SITE (NW POLAND) IN THE LIGHT OF SEA-LEVEL
CHANGES

Piotrowski, A.^a, Sydor, P.^b, Żuk, T.^b, Zamelska-Monczak, K.^c, Krzymińska, J.^d,
Rzodkiewicz, M.^e, Noryśkiewicz, A.^f

^aPolish Geological Society, Szczecin Branch, 20 Wieniawskiego St., 71-130 Szczecin, POLAND

^bPolish Geological Institute – National Research Institute, Pomeranian Branch in Szczecin, 20 Wieniawskiego St., 71-130 Szczecin, POLAND

^cPolish Academy of Sciences, Institute of Archaeology and Ethnology, 46A Rubież St., 61-612 Poznań, POLAND

^dPolish Geological Institute – National Research Institute, Marine Geology Branch in Gdańsk, 5 Kościerska St., 80-328 Gdańsk, POLAND

^eAdam Mickiewicz University in Poznań, Department of Geology and Quaternary Paleogeography, 27 Dziegielowa St., 61-680 Poznań, POLAND

^fNicolaus Copernicus University in Toruń, Faculty of History, 44/48 Szosa Bydgoska St., 87-100 Toruń, POLAND

E-mail: andrzej.k.piotrowski@gmail.com

Introduction. Santok was „the watchtower and key” to the Polish kingdom. Similarly to its past significance, nowadays it is the key geoarchaeological site to understand the environmental conditions of people living in this part of Europe in the Middle Ages. The aim of the study was to reconstruct the natural conditions in Santok geoarchaeological site between branches of the Warta and Noteć rivers, which belongs to the Odra drainage basin, in the northwestern Poland taking into account Baltic sea-level changes.

Methods. The fieldwork involved drilling boreholes, geophysical survey and excavating archaeological trenches. Sixty eight boreholes to depths ranging from 2.0 to 9.6 m supplied samples for analysis and laboratory testing which included grading, palynology, geochemical composition, diatoms, ostracods, molluscs and radiocarbon dating. Ground penetration radar with 250 MHz antenna was used to collect approximately 1km of GPR profiles and three 3D datasets in order to image sedimentary strata underlying the cultural layers and determine the geology of the location chosen for the first settlement and later for the stronghold.

Results. The expansive Toruń-Eberswalde meltwater valley underwent significant evolution from the beginning of its existence almost 15 ky BP. This evolution was controlled mainly by fluvial processes involving the interplay of erosion and accumulation which changed with the Holocene climate. Initially, the bottom of valley was shaped by high water discharges enforcing braided river pattern. These deposits were later incised when the river pattern changed to meandering. When sea-level was stabilized ca 8 ky BP Warta and Odra river changed to anastomosing type.

Both the geophysical data and detail topography revealed by LIDAR images showed that the early settlers chose an elevated area, probably a remnant of sandy river terrace, which could also have been modified by aeolian processes.

Radiocarbon dating and archaeological excavations at the study site confirmed that the settlement at the confluence of rivers flowing in the former meltwater valley started in the 8th Century. Initially it was unfortified, and acted as a trade location also providing necessary supplies to those travelling by water. In the 10th Century, a well-fortified stronghold with multiple sections was built raising its importance to an administrative, trade as well as church centre at the border of the first Polish state. This valley passage formed a natural border between Greater Poland and Pomerania. It was wide, inaccessible, boggy, with branching channels, steep edges and surrounded by dense forests. Thus natural conditions formed a barrier which was difficult to

cross by migrating people. The stronghold was also threatened by the risk of flooding which required a lot of work on building flood defences.

Summary. Approximately 8 ky BP, a significant decrease in the rate of Baltic sea-level rise resulted in increased organic and clastic accumulation, also apparent near Santok located 240 km up river from the coast. The rate of accumulation gradually decreased inland which was observed on many sites in the Odra and Warta valley near the towns of Świnoujście, Szczecin, Widuchowa, Cedynia and Kostrzyn.

The research was funded by the National Science Centre, Poland (project Sonata Bis No.2015/18/E/HS3/00425)

THE FRAGIPAN IN KARELIA LUVISOL PROFILE IN THE CONTEXT OF THE HOLOCENE LANDSCAPE EVOLUTION

Pogosyan, L., Sedov S.

Instituto de Geología UNAM, Ciudad Universitaria, 04510, Cd. de México, México.

E-mail: lilit-tos@yandex.ru

Fragipan is compacted but non-cemented subsurface horizon, considered as a pedogenic horizon, but its exact genesis is not well understood. The main “Bryant hydro-consolidation” hypothesis of its formation involves a collapse of soil structure when it is “loaded and wet” (Assalay et al., 1998). Many authors that this structural collapse takes place as a result of frost heave in presence of permafrost under periglacial conditions (Fitzpatrick, E.A., 1956; Gallardo et al., 1988). The fragipans have been mapped primarily in the USA and New Zealand, also in Europe but have never been registered in soil maps of Russia.

The northern part of European Plain has been chosen for the search of fragipan as the result of comparative study of climatic conditions. In the South Karelia (34.50921 East Longitude and 61.33186 North Latitude, asle 110m) were found soil profile of Albic Fragic Luvisol Cutanic was found, developed on the glacial till of Last Glaciation (13-14.2 ka (Svendsen et al., 2004)) on the subhorizontal watershed surface in an aspen-spruce forest.

The propose of this study was to understand how the fragic horizon incorporates into the Luvisol profile and what kind of processes are responsible for its formation. During the field description we marked the fragipan in EBx and Btx horizons, located between EB and Bt horizon respectively. In the fragic part of the profile there are some well-defined differences in structure and composition of soil material, and also in distribution of Fe-Mn nodules. No signs of a lithological discontinuity have been detected in the particle size distribution.

The micromorphological analysis was needed to see how the fragic horizon fits in a distribution of pedogenetic characteristics in the studied soil profile. The E horizon is characterised by well-developed platy structure of fairly loose arrangement because of crumbly pack of coarse sand and silt grains, dominant in the soil material. Also Fe-Mn nodules are frequent with rounded forms and sharp boundaries. All those properties are presented in a EB horizon, but sharply decrease in a EBx horizon: the nodules are few, they are smaller and have irregular shape and diffuse boundaries. This horizon is compact and has no platy structure. There are no both eluvial and illuvial features, because also clay coatings are absent, they appear deeper in the profile. The Btx horizon is also compact horizon. It has a lot of clay coatings that are laminated with strong interference colours and fill a large part of available pore space. Also there are some Fe-Mn nodules, but they have irregular shape and diffuse boundaries. In the underlying Bt horizon a specific type of gray heterogeneous coatings with low interference colours and silty impurities occurs. They are not so frequent as limpid laminated coatings, but their size is bigger. They could be formed by short distance translocation of heterogeneous suspension. The main part of pure clay coatings are deformed, fragmented and incorporated in ground mass that is a result of turbation

processes. The BC horizon has rock fragments containing clay coatings derived from parent material.

We consider that in the fragipan, the high density soil horizon, the features of eluvial, gleyic and turbation processes are less intensive than in overlying and underlying soil horizons because it was developed in the transitional zone of eluvial-illuvial profile. We also suppose that a compaction process has occurred in a Sub-Boreal period after a previous illuviation took place during the Atlantic optimum (Fig.1).

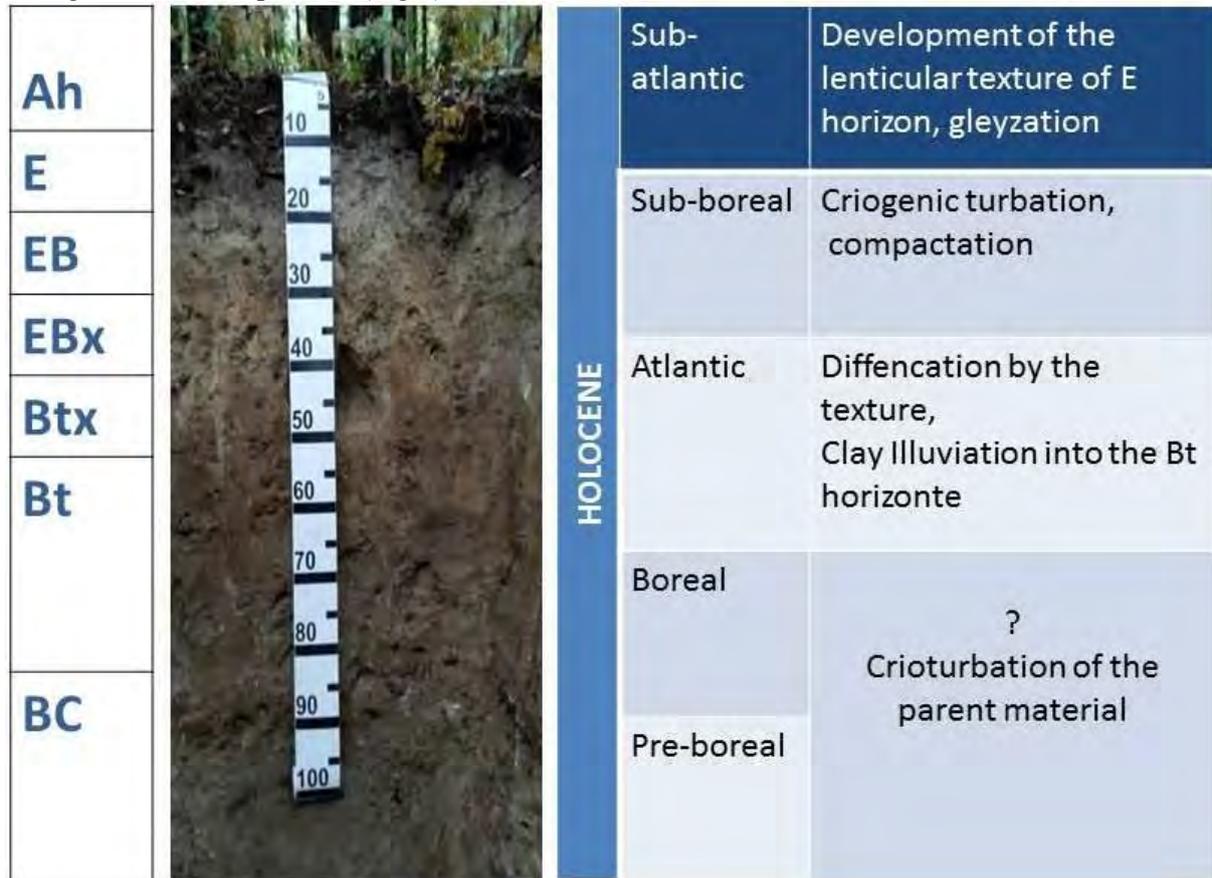


Fig. 1. Karelia Luvisol profile and stages of its development in a Holocene

References:

- Assalay, A.M., Rogers, C.D.F., Smalley, I.J., Jefferson, I.F., 1998. Fragipan formation in loess soils: development of the Bryant hydroconsolidation hypothesis. *Geoderma*, 83: 1-16
- Svendsen, JI, Alexanderson, H, Astakhov, VI, Demidov, I, Dowdeswell, JA, Funder, S, Gataullin, V, Henriksen, M, Hjort, C, Houmark-Nielsen, M, Hubberten, HW, Ingolfsson, O, Jakobsson, M, Kjaer, K, Larsen, E, Lokrantz, H, Lunkka, JP, Lysa, A, Mangerud, J, Matiouchkov, A, Murray, A, Möller, P, Niessen, F, Nikolskaya, O, Polyak, L, Saarnisto, M, Siegert, C, Siegert, MJ, Spielhagen, RF & Stein, R 2004, 'Late quaternary ice sheet history of northern Eurasia' *Quaternary Science Reviews*, vol 23, no. 11-13, pp. 1229-1271.
- Fitzpatrick, E.A., 1956: An indurated soil horizon formed by permafrost. *J. Soil Sci.* 7, 248-257.
- Gallardo, J., Alvarez, A., Cala, V., 1988. Horizontes de fragipan de tipo "ison" formados por permafrost en la Sierra de Guadarrama/. *Estudios geol.*, 44: 83-91

SEARCHING FOR SEISMIC DISLOCATIONS IN LAKES SEDIMENTS WITH GROUND PENETRATING RADAR

Rodionov A.I.*, Nikolaeva S.B.*, Ryazantsev P.A.***

* Institute of Geology of the Karelian Research Centre of the Russian Academy of Sciences

**Geological Institute of Kola Science Center of R Academy of Sciences

E-mail: Fabian4695@gmail.com

Introduction. The study of Quaternary sediments is an important and quite difficult task for geological disciplines. Analysis of the structure of glacial landforms, as well as water bodies formed during interglacial periods, can play an important role in the restoring process of the climatic conditions of the environment formation, as well as in the allocation of catastrophic events that occurred in the Quaternary period (Nikolaeva et., all 2016).

The study of glacial deposits is usually carried out by direct sampling methods, by digging exploration pits on ground investigations and drilling wells in the process of studying water bodies. However, it is worth noting that as a complement to existing techniques often include methods of near-surface Geophysics, particularly ground penetrating radar. Literature provides multiple examples of GPR usage for shallow water areas research. Thus, for example, one publication Gomez & Miller (2017) demonstrates GPR utilization in surveying lake slopes deposits and lake sediments. The GPR enabled the authors to detect the ways in which layers with different genesis are reflected in the GPR wave field. There is an example of obtaining bathymetric maps based on GPR (Bava and Sambuelli, 2012). Researchers emphasize the high efficiency of the GPR method in such activities and point out the importance of recording the value of electric conductivity of water while detecting the marginal depth of relevant signal distribution.

Investigated object and used GPR. Our paper describes the experience of the GPR research on a shallow lake located on the Kola Peninsula, in the watershed area of the largest lake in the region – lake Imandra. At this object in the period from 2013 to 2015, researchers from the Kola research Center were drilled several wells and detailed drilling column with a step dimension of 5-10 cm. During the survey, in the thickness of the bottom sediments was allocated horizon containing an increased amount of wood residue, as well as sand and silt. According to researchers, this horizon marks a catastrophic event that occurred in the region about 6500 years ago (Nikolaeva et., all 2017).

The GPR recording was conducted by the GPR OKO-2, a 150M antenna unit with the signal penetration depth up to 12 m and the resolution ability of 30 cm. Data processing was carried out by the program GeoScan 32. The surveys were conducted from ice surface in the winter period.

Example of radar profile. As an example of the wave pictures obtained at the object, figure 1 show one of the radar profiles obtained during the study. On radar profiles, the value ϵ was not taken into account and as a consequence, a deep incision was not obtained. The thickness of the ice on the lake was up to 0.7 m. Increased amount of noise in the upper part of the section due to the water layer in the ice and is localized at times up to 100 ns and does not interfere with the interpretation of the underlying layers. Further interpretation of ice has the value ϵ is formed of 3 and 81 for water. Horizon 2 corresponds to the roof of the deposits of lake sediments (sapropel) and is clearly correlated with drilling data. The magnitude ϵ for horizon 2 was established in the analysis of hyperbolic diffracted waves and amounted to 64. Layer 3 was interpreted as a horizon marking the change of sedimentation regime. Layer 3 has dissimilar petrophysical property's than containing it sapropel layer which causes the formation of clearly visible correlation lines on the borders. This fact allows us to confidently allocate layer 3 in the areas of its localization. The boundary 4 localizes the boundary between sapropel layer and the mineral (sand) base of the lake The boundary 5 is interpreted as a noise – fold reflection from the boundary between organic and mineral sediments.

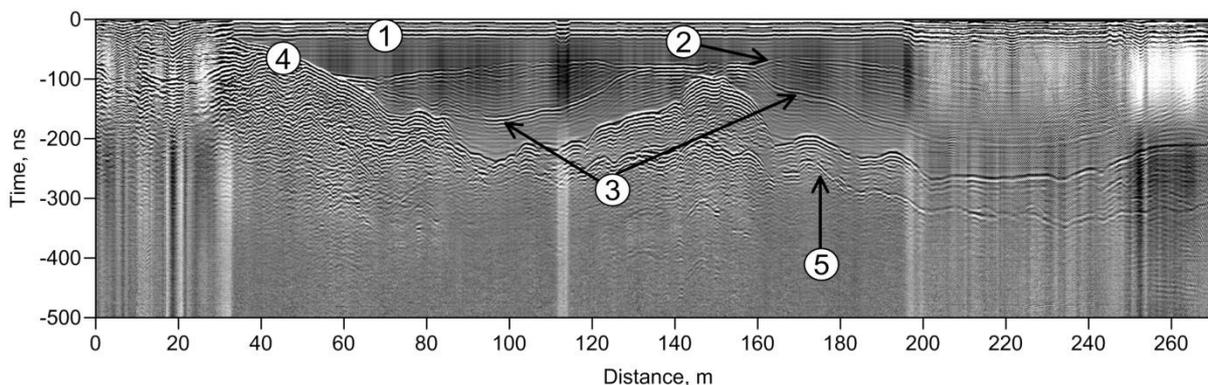


Fig. 1. Radar profile and some interpreted layers.

In addition, on the radar profile has been allocated a region interpreted as fault formed after a catastrophic event, as indicated by the violation of the horizon 3 border form. The area is localized in the range of 100-180 m at times of 100-300 ns.

Summary. GPR made it possible to quickly and thoroughly explore the shallow lake. Drilling data greatly facilitated the process of interpretation of radar profiles, as well as allowed to correlate geological layers and areas of the wave field. In addition to the marking horizon selected during drilling, the use of GPR allowed to localize areas which possibly exposed to tectonic effects. This experience makes it possible to recommend GPR method in other shallow lakes in Kola and Karelian region.

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References:

C Gomez, J Miller. Ground Penetrating Radar Analysis of Slope and Lake Sediments Interplay: A Survey of Lake Pearson // [Research Report] Kobe University. 2017.

A. Neal. Ground-penetrating radar and its use in sedimentology: principles, problems and progress // *Earth-Science Reviews*, 2004. 66 (3-4), p. 261-330.

S. Bava, L. Sambuelli. Case study: A GPR survey on a morainic lake in northern Italy for bathymetry, water volume and sediment characterization // *Journal of Applied Geophysics*, 2012, vol. 81, p. 48-56.

S.B. Nikolaeva, A.A. Nikonov, S.V. Shvarev, M.V. Rodkin. Comprehensive paleoseismic geological studies in a key site in southwestern Kola Peninsula (Northeast of the Fennoscandian Shield) // *Doklady Earth Sciences*. 2016. T. 469. № 1. P. 656-660.

S.B. Nikolaeva, N.B. Lavrova, D.B. Denisov. A catastrophic Holocene event in the lake bottom sediments of the Kola region (northeastern Fennoscandian shield) // *Doklady Earth Sciences* 2017. T. 473. № 1. P. 308-312.

THE HISTORY OF SOIL MAPPING IN LENINGRAD REGION

Rusakova, E., Sukhacheva, E.

Federal State Budgetary Scientific Institution Central Soil Museum by V.V. Dokuchaev
E-mails: el.rus@mail.ru, lenasoil@mail.ru

The modern soilscape of the area is very diverse due to landscape variability and anthropogenic impact. In 1905 R.V. Rispolozhenskiy conducted the first soil survey and presented schematic soil map at a scale 1:840.000 with 50 soil taxa (Rispolozhenskiy, 1908).

In 1932 - 1936 a team of soil scientists under the leadership of Academician L.I. Prasolov made detailed soil survey of the region. Soil map at a scale 1:500.000 based on 25.000 soil pits was published in the three-volume monograph, describing landscapes and soils, their classification and land use features (Soils of the Leningrad region, 1937).

In 1967 Leningrad state University published an Atlas of Leningrad region with 125 maps, including the soil map 1: 500000, compiled by the Central Soil Museum by V.V. Dokuchaev. The new soil map at a scale 1:300.000 was published by the Central Soil Museum by V.V. Dokuchaev in 1971.

In the next years, the region was severely influenced by anthropogenic impact. Industrial enterprises, road constructions and pipelines considerably reduce the area of virgin soils. Currently agricultural lands include extensive areas of drained soils. Anthrosols and Technosols are widely spread. In 2018 the Central Soil Museum by V.V. Dokuchaev together with the Cartography Department of Saint-Petersburg University presented a new digital soil map at a scale of 1:200.000 with a special focus on Anthrosols and Technosols. New approaches to their classification and mapping techniques were tested in this map. E.g., the following soil patterns were outlined on the map: drained forest, cultivated forest, forest logging, fire-prevention, recreational forest, agricultural, drained agricultural, park, residential soil patterns, together with soils of urban areas and highways.

APPLICATION OF GROUND PENETRATING RADAR TO STUDY OF BOTTOM- SEDIMENT STRUCTURE IN LAKES

Ryazantsev, P., Rodionov, A.

IG KarRC RAS, 11 Pushkinskaya str., Petrozavodsk, RUSSIA

E-mail: chthonian@yandex.ru

As far as shallow water objects research is concerned, bottom-sediments are of no less interest than the water column. Data on the composition and texture of lake sediments are a source of information about the life cycle of the waterbody, possible climate change during its life time, and the current ecological situation in the region (Subetto et al., 2017). The prospecting for bottom-sediment in lakes is done by direct bottom sampling, i.e. drilling. Reserve calculation based on drilling data is not always accurate, considering the spotty nature of such surveys. It is therefore necessary to introduce new, highly informative research methods, including geophysical ones.

Seismoacoustic profiling is a traditional geophysical method for sub-bottom surveying (Shalaeva, Starovoytov, 2010). However, it is often inexpedient to apply this method to shallow waterbodies. An alternative to seismoacoustic profiling is the ground penetrating radar (GPR) method, which is less deep-reaching, but with a higher resolution capacity, which is essential when working with thin bottom sediments (Starovoytov et al., 2016). For example, GPR is used for estimating bottom-sediment variability and bathymetric mapping (Sambuelli, Bava, 2012). A GPR survey the bedding of lake slope deposits and lake sediments is described in (Gomez et al., 2017). It enabled the authors to detect how layers of different geneses appear in the GPR wave field. The principles of the GPR method are set out in several books, such as (Jol, 2009).

Within this study, the GPR method was applied to several small- and medium-size lakes in the Republic of Karelia. The surveyed lakes are of fluvio-glacial genesis, and emerged during the Valdai Glaciation. Shoreline paludification is underway at all the lakes – the lake basins are gradually getting overgrown with vegetation. The surveys were done by an OKO-2 GPR, a 150M antenna unit with 12 m effective depth range and 30 m resolution. The data were processed using GeoScan 32 software. The surveys were conducted from a boat in the summer and from ice surface in the winter. In waterborne studies GPR parameters permittivity of the medium (ϵ) and the conductivity of the medium (σ) have been defined.

As an example informative of method Fig. 1 shows the layer-by-layer interpretation of the GPR profile from Lake Gankovskoye. The assigned ϵ values were 81 for the water column, 63 for to the sapropel layer, and 20 for the underlying mineral bed. The sheath of sapropel deposits was localized at a depth between 25 and 73 cm. The sapropel layer contains extensive wave patterns

correlated with boundaries at which local conductivity changes or the layer gets compacted. The bottom of the sapropel layer follows the configuration of the top surface of the mineral bed. The boundary between them is discrete, and clearly recorded in profile.

Except for the main GPR boundaries, additional ones are found in bottom-sediment. This allows us to identify three separate layers of internal structure of deposit. The first layer one is characterized by frequent intense axes GPR signal. This indicates variability of density and decomposition sapropel. The second layer has not clear GPR signal reflections in internal structure. Probably this sapropel is well-condensed and includes aleurite. In the third layer the structure of the GPR wave field changes and reflectors appear again. This indicates the presence of aleuritic deposits. In addition, an area of anomalous GPR signal attenuation is identified at the interval pickets 50-100. This may be due to several causes, such as the arrival of mineralized water from the lower layer or clay substance.

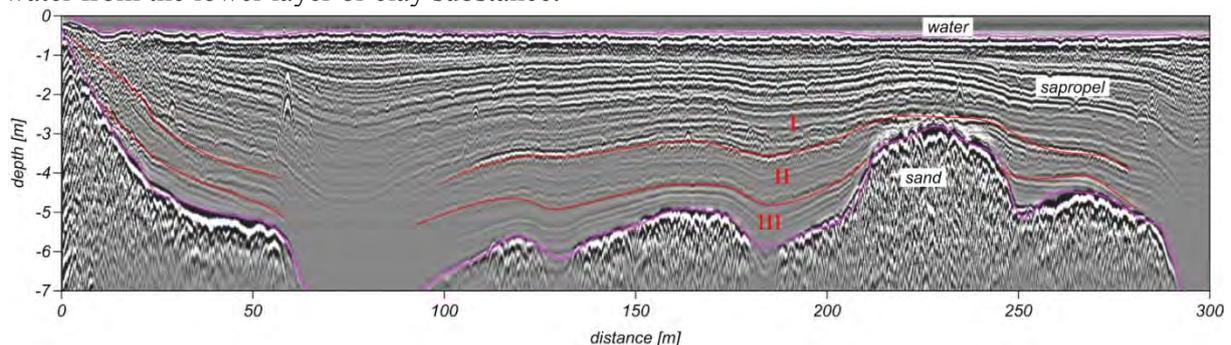


Fig. 1 GPR profile from Lake Gankovskoye

Data collected from GPR surveys of waterbodies are highly informative. Apart from water column thickness, GPR provides a detailed picture of the characteristics of bottom sediments and lake bed. With these results, the error in estimating sapropel reserves can be reduced compared to calculations based on drilling. By analyzing the characteristics of the reflected signal one can draw conclusions about the conductivity of bottom sediments and mineral characteristics.

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References

- Subetto, D.A., Strykh, L.S., Grekov, I.M. et al., 2017. Contemporary Problems of Ecology 10, 327-335.
- Shalaeva, N.V. and Starovoytov, A.V., 2010. Moscow: Moscow State University, 254 p.
- Sambuelli, L. and Bava, S., 2012. Journal of Applied Geophysics 81, 48-56.
- Gomez, C. and Miller, J., 2017. Research Report Kobe University, 21 p.
- Jol, H. (eds.), 2009. London: Elsevier Science, 544 p.

MAY DUST BE ABLE TO PROTECT AGAINST GLOBAL WARMING?

Rybakov, D.S.

FRC Karelian Research Center, Russian Academy of Science

E-mail: rybakovd@krc.karelia.ru

It is known that the space, volcanic, desert and technogenic dust globally spreading in the Earth's atmosphere, like clouds, increases the albedo. This automatically leads to cooling of the earth's surface. The content of continental dust in the ice cores from Antarctic Vostok station was determined in the time interval of 420–4.5 thousand years ago (<ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/vostok/dustnat.txt>). These data, together with the data on the anomalies of the Antarctic temperatures (<ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/vostok/deutnat.txt>), were used to

construct a diagram of changes in the corresponding parameters (Fig. 1). The tests with deviations from present temperatures in statistical sampling should coincide with the tests used to study dust concentrations. To do this, the number of the tests of temperature anomalies from the international database was preliminarily reduced without damage to the creation of the diagram (Fig. 2) and further calculations.

The authors (Petit et al., 1999) used the same samples (the same depth of ice core sampling) to determine both deuterium concentrations and dust concentrations for the time interval of 208–4.5 thousand years ago. At later intervals, the shifts between the parameters were from 50–120 years (325–208 thousand years ago) to 200–270 years (421.5–330 thousand years ago). These minor discrepancies did not affect the results obtained for all calculations and constructions (see Fig. 1, 2). Figure 1 shows the exact correspondence of all maximal values of dust concentrations to minimal values of temperature anomalies. It is obvious that the dust content of the atmosphere was minimal during the interglacial periods, which was noted by the authors (Petit et al., 1999).

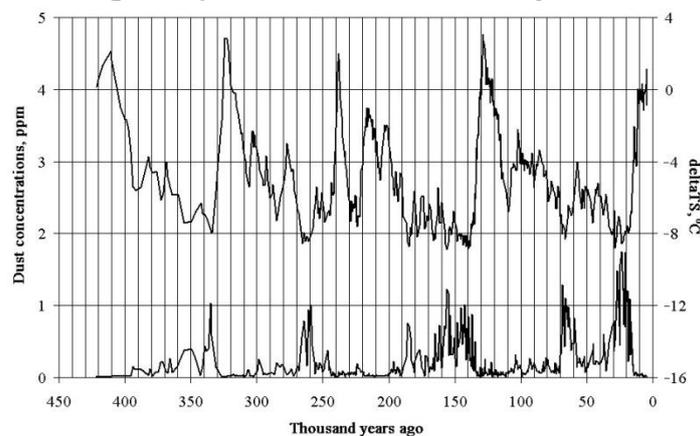


Fig. 1. Deviations of paleotemperatures from present values (upper spectrum) and dust concentration (lower spectrum) in ice cores; 506 values of each parameter from the international database (Petit et al., 1999) were used

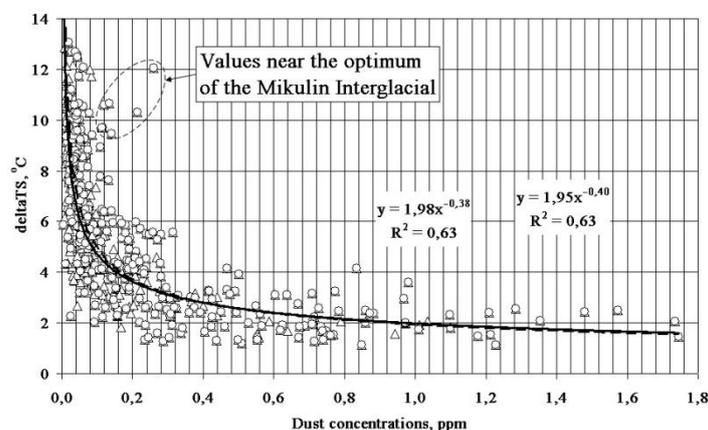


Fig. 2 The dust concentrations and temperature anomalies from ice core data (see Fig. 1); the temperature anomalies are increased by 10 to avoid negative values; the graphs of the power function for the given time intervals practically coincide

The relationship between dust concentrations and temperature anomalies is best described by a power function (see Fig. 2). The constructed models indicate a high sensitivity of the paleotemperatures to the presence of solid suspended particles in the atmosphere in the area of their relatively low concentrations. It is possible that the ingress of large amounts of dust into the terrestrial atmosphere in the past caused not only increased cooling (mainly at the end of the glaciations), but also indirectly affected the subsequent warming due to a combination of positive feedbacks. The sequence of their implementation could be the following: the deposition of dust

from the atmosphere due to gravitation leads to the beginning of a new increase in global temperature, the atmospheric precipitation (increased as a result of the warming) more and more quickly flush the dust from the airspace the of, additional portions of CO₂ enter the atmosphere from the ocean. As a result, there is a sharp increase in global temperature. Deviations from the general dependence are observed, for example, near the temperature maximum of the transition from the Moscow Glaciation to the Mikulin Interglacial (130.9–122.3 thousand years ago) (see Fig. 2), and the weakest statistical relationship between dust concentration and temperature anomalies is noted for the time interval of 129.5-55.4 thousand years ago (Table).

The probability of a dangerous temperature change (decrease) with a relatively small increase in dust concentrations should be taken into account when discussing the proposed (Bewick et al., 2012, 2013) geoengineering concept on the using of "dust cloud" or "dust rings" for protecting the Earth from solar radiation. Problems, first of all, will be maintenance of safe (and effective) dust concentration and stabilization of the manipulative asteroid system, suggested by this authors, at the Lagrange point. However, even more important is the problem of the ethical plan, connected with the risk for the planet of large-scale geoengineering tests. Many specialists, including authors of this concept, recognize this.

Table. Statistical relationship between dust concentrations and temperature anomalies by time intervals

Time intervals by ice cores, thousand years ago	Correspondence to glaciations and interglacials	Approximation	Approximation Coefficient (R ²)
387,804 (388,065)–250,413 (250,501)	Likhvin Interglacial, Dnieper Glaciation	$y = 1,96x^{-0,35}$	0,70
249,148 (249,219)–130,410	Odintsovo Interglacial, Moscow Glaciation	$y = 1,52x^{-0,43}$	0,71
129,545–55,377	Mikulin Interglacial, Tver Glaciation	$y = 3,13x^{-0,27}$	0,38
53,606–12,569	Midle Valday period, Ostashkov Glaciation	$y = 2,22x^{-0,35}$	0,70
387,804 (388,065)–12,569		$y = 2,00x^{-0,37}$	0,60
421,507 (4218,761)–4,509	See Fig. 1 и 2	$y = 1,98x^{-0,38}$	0,63

To prevent unjustified and dangerous actions, it is necessary to take into account the global changes in the past. It is also necessary to keep in mind the differences in climatic changes of the past and present, consisting in the impact on the nature and climate of the current human civilization, which, in turn, should be regarded, according to V.I. Vernadsky, as a powerful geological force.

References:

- Bewick R., Sanchez J.P., McInnes C.R. 2012. The feasibility of using an L1 positioned dust cloud as a method of space-based geoengineering. *Adv. Space Res.* 49(7). 1212–1228.
- Bewick R., Lücking C., Colombo C., Sanchez J.P., McInnes C.R. 2013. Heliotropic dust rings for Earth climate engineering. *Adv. Space. Res.* 51(7). 1132–1144.
- Petit J.R., Jouzel J., Raynaud D. et al. 1999. Climate and Atmospheric History of the Past 420,000 years from the Vostok Ice Core, Antarctica. *Nature.* V. 399. 429–436.

NEW DATA ON THE STRUCTURE OF QUATERNARY SEDIMENTS AND MODERN GEODYNAMIC MOVEMENTS IN LAKE LADOGA

Rybalko, A^{1,2}, Tokarev, M³, Aleshin M.⁴, Subetto D^{5,6} and Belyaev P.¹

¹*Institute of Earth Sciences of St.Petersburg State University, Universitetskaya nab., 7-9, 199034, St.Petersburg, RUSSIA,*

²*Ltd "Center for Analysis of Seismic Data at Moscow State University named MV Lomonosov", Leninskie Gory, ow. 1, building 77, Moscow, RUSSIA,*

³*Lomonosov Moscow State University, GSP-1, Leninskie Gory, Moscow, RUSSIA*

⁴*Split Science Company, Leninskie Gory, ow. 1, building 77, Moscow, RUSSIA,*

⁵*Herzen State Pedagogical University of Russia, Moika, 48, St.Petersburg, RUSSIA,*

⁶*Northern Water Problems Institute, Karelian esarch Centre, Russian Academy of Sciences, Alexander Nevsky 50, Petrozavodsk, RUSSIA*

E-mail: alek-rybalko@yandex.ru

In 2014-2015, the Center for Marine Research of the Moscow State University. M.V. Lomonosov, Institute of Water Problems of the North of the Karelian Scientific Center of the Russian Academy of Sciences and the Institute of Earth Sciences of the St. Petersburg State University conducted seismoacoustic works in the Ladoga Lake in the framework of the "Scientific program for the study of bottom landscapes and paleogeography of the Late Quaternary time of inland water basins along the eastern periphery of the Baltic Crystal Shield". The implementation of these studies is associated with a large break in paleogeographic research in the Great Lakes region of Russia. Field work was carried out with NIS "Ecolog" through a network of regional profiles. At different times, Sparker and Bummer energy sources were used for research. The working frequency of profiling was 1000-2000 Hz. Reception of signals was carried out on a seismic analog sixteen-channel spit in steps of 2 meters between receivers; the seismic acquisition data was collected in the Multichan software package in the SEG-Y format.

Quaternary sediments in Lake Ladoga are typical for all lacustrine and marine basins of the eastern periphery of the Baltic crystalline shield. Their section is represented (from the bottom upwards) by glacial deposits (till) of the last glaciation, the thickness of limno-glacial clays and lake mud, the formation of which occurred in the Late Neopleistocene-Holocene. However, analysis of seismogram has shown that the propagation of till is intermittent. Usually it forms gently sloping ridges on the uplifts of the bedrock. The thickness of the deposits in these ridges changes from the first to 10-15 m. Often described sediments are absent and the bedrock is directly overlapped by the deposits of the periglacial lake.

Special attention was given to interpretation a range of hill-like uplifts that crossed the Lake Ladoga from the mouth of the River Burnaya to the eastern shore of the lake. It was found that these ridges are composed mainly of till. In this case, often in the basis of the ridges lie the protrusions of the root relief, composed of crystalline rocks. The age of this ridge is compared with the Nevsky Oscillation of the retreating Scandinavian glacier, that is, it has an age of about 13,000 years ago. The ridges have an asymmetric shape with a gentle north-west and steep southeast slopes. Their relative height can reach 20-50m. North of the Solovetsky archipelago, these ridges take the form of typical drumlins.

Considerable attention was paid to the study in the southern part of the lake of the relationships of sedimentary rocks composing the basal layers of the platform cover. The data obtained as a result of multi-channel seismoacoustic profiling in the middle part of the lake made it possible to single out a thin Vendian stratum put of argillites and underlying Riphean sandstones. Between them a sharp angular unconformability is fixed. At the same time, glacioidislocations are distinctly observed in the upper part of the Upper Proterozoic section. They are expressed in the form of blocks of bedrock, irregularly lying under the Quaternary sediments, and also often crumpled and dislocated.

Geodynamic postglacial processes are an important problem for the entire Ladoga area. Many researchers pointed to seismotectonic activity in this region in the Holocene (BA Assinovskaya, AD Lukashov, AA Nikonov, and others). The conducted seismoacoustic profiling made it possible to distinguish these phenomena in the structure of quaternary deposits. Structural ridges in the northern part of the lake are their most vivid manifestation. As a rule, they are underwater continuation of similar ridges on land, which separate the fjord-shaped bays. Their relative height can reach 80-100 meters or more. The ridges themselves were previously covered by glacial-lacustrine clay strata, but post-Pleistocene movements led to a sharp shift and rupture of this horizon, which is clearly seen on seismograms. In some cases, the discontinuity of the single horizons extends to the Holocene lake deposits, which allows one to assume the possibility of tectonic shifts during the Holocene period. An interesting fact is also the "squeezing out" of positive, supposedly gravitational blocks composited by glacial deposits and located at considerable distance from the foot of these ridges. It can be assumed that this happened as a result of another seismic event and the subsequent gravitational slip of sedimentary masses from a steep slope. It also became the driving force for the moving of the sedimentary block away from the slope.

Other manifestations of modern geodynamic movements are noted. To the south of Valaam islands the tectonic fault dissects already moraine ridge. In this case, both horizons of glacial-lake clays and lake ooze are displaced relative to each other. The amplitudes of such displacements are up to 5 m, and the glide mirror is fairly gentle (up to 15 degrees). These materials are in good agreement with the previously conducted high-frequency (1-4 kHz) geolocation profiles in western part. Seismograms clearly show disturbances in the horizons of glacial-lacustrine clays, reflecting the "subsidence" of the foundation blocks, which were also accompanied by landslides on the slopes of elongated depressions.

An important fact for paleogeographic reconstructions of the Late Neopleistocene and Holocene is the practical absence of interglacial (Eemian) deposits known in the Leningrad region as Mikulin clays. The seismological section in the western part of the lake is a typical after glaciation cycle beginning with moraine of Ostashkov's age. However, here valley-like negative forms of relief were established. They according to profiling data were filled by essentially sandy deposits. Thickness is about 5-8m. They fill small depressions in a roof of the "acoustic basement" and are probably represented by fluvio-glacial formations.

Thus, seismoacoustic profiling with new-generation equipment have made it possible to clarify the features of the structure of the Quaternary cover in the development of glacial formations and have made it possible to state the widespread occurrence of postglacial geodynamic movements on most of the present-day Onega Lake.

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. 18-17-00176 and 14-17-00766.

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).

DEVELOPMENT OF GLACIAL LANDFORMS IN TRANSITIONAL COLD – WARM BED SUBGLACIAL CONDITIONS IN THE CENTRAL PART OF FENNOSCANDIAN ICE SHEET, IN NORTHERN FINLAND

Sarala, P.^{a,b}

^a *Geological Survey of Finland, P.O. Box 77, 96440 Rovaniemi, FINLAND*

^b *Oulu Mining School, University of Oulu, FINLAND*

E-mail: pertti.sarala@gtk.fi

An airborne LiDAR (Light Detection And Ranging) interpretation has revealed new data and revolutionized the mapping of glacial landforms. Previously detected landforms, such as streamlined landforms, hummocky moraines and end moraine complexes show up in LiDAR based digital elevation models (DEM) in greater detail than ever before. Landforms that are smaller than resolved from topographic maps and earlier DEMs (e.g. 10 m grid) can now be detected and examined with high resolution. This opens new possibilities for landform evolution analysis and glaciodynamic examination in the glaciated terrains. At the moment, the project for LiDAR DEM based glaciomorphological mapping is on-going in Finland (Putkinen et al. 2017) carried out by the Geological Survey of Finland together with the universities.

One of the key study areas for glacial landforms and dynamics in Finland is the Kuusamo Ice Lobe area close to the Late Weichselian ice-divide zone in southern Finnish Lapland. The glacial morphology of the ice lobe is composed mainly of moraine morphologies such as the glacial streamlined lineations of the Kuusamo drumlin field in the eastern part (Räsänen et al. 2012) and different hummocky and ribbed moraines in the western part, i.e. at the core of the ice lobe (Sarala & Räsänen 2017). The drumlin field was formed under surging type glacial movement during and just after the Younger Dryas while the core part of the glacier remained cold-based. Glaciofluvial deposits (eskers and delta formations) occur as chains representing last deglaciation phase.

Ribbed moraines, a unique morphology type formed of transversal moraine ridges in the centre of last continental glaciers, represent the depositional formations formed under subglacial conditions at the transitional zone between the warm and cold based glacier (Sarala 2005). It forms relative large, uniform ridge fields in the area having also well-formed transitional series with streamlined morphologies such as flutings and drumlins (Fig. 1).

LiDAR based mapping has revealed new knowledge of the formation phases of subglacial moraine formations in the core part of continental glacier. For example, an erosional, subglacial meltwater channel network has cut the ribbed moraine ridges before the deposition of glaciofluvial deposits, such as eskers (Fig 2). At the same time, the surfaces of ribbed moraine ridges were smoothly lineated under gently glacier reworking during a later phase of deglaciation. This means that the formation of the ribbed moraines must be earlier process than drumlin and meltwater channel formation, happened close to cold-based core part.

References:

Putkinen, N., Eyles, N., Putkinen, S., Ojala, A., Palmu, J.-P., Sarala, P., Väänänen, T., Räsänen, J., Saarelainen, J., Ahtonen, N., Rönty, H., Kiiskinen, A. & Tervo, T. 2017. Bulletin of the Geological Society of Finland 89:2, 64–81.

Räsänen, J., Johansson, P., Kejonen, A., Räsänen, J., Sarala, P., Valkama, J. & Väisänen, U., 2012. Ruka - Oulanka: geological outdoor map, guidebook. Rovaniemi, Geological Survey of Finland, 51 p.

Sarala, P., 2005. Bulletin of the Geological Society of Finland 77, 71-104.

Sarala, P. & Räsänen, J., 2017. Bulletin of the Geological Society of Finland 89:2, 82-99.

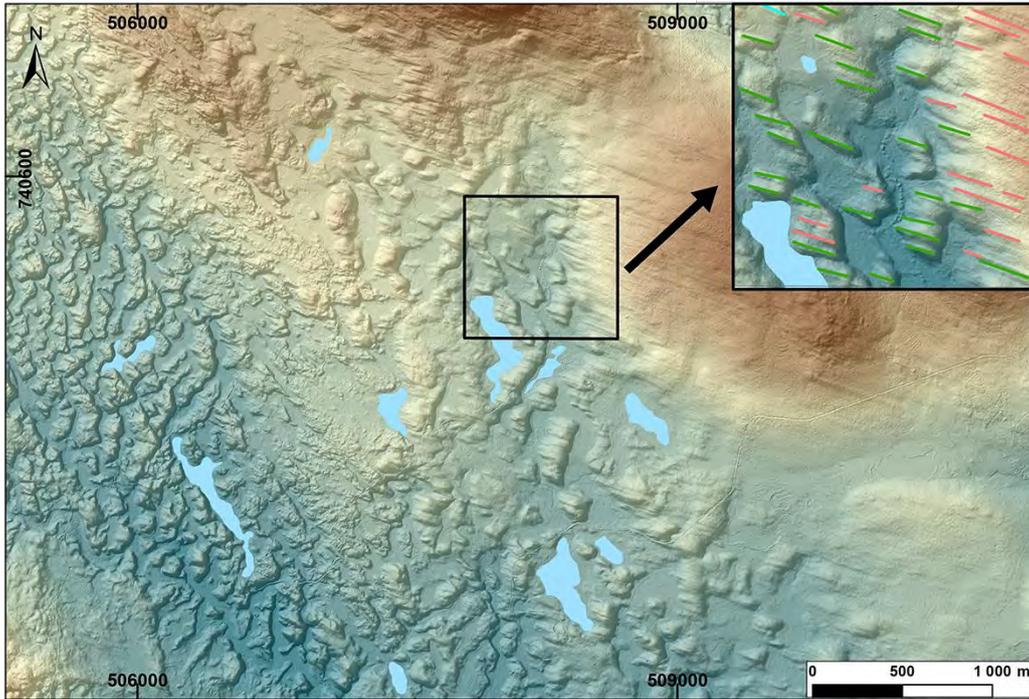


Fig. 1. Ribbed moraine field with transition to flutings and drumlins on the western side of Kemijärvi town. Ice flow direction from west-northwest direction. After Sarala & Räisänen (2017).

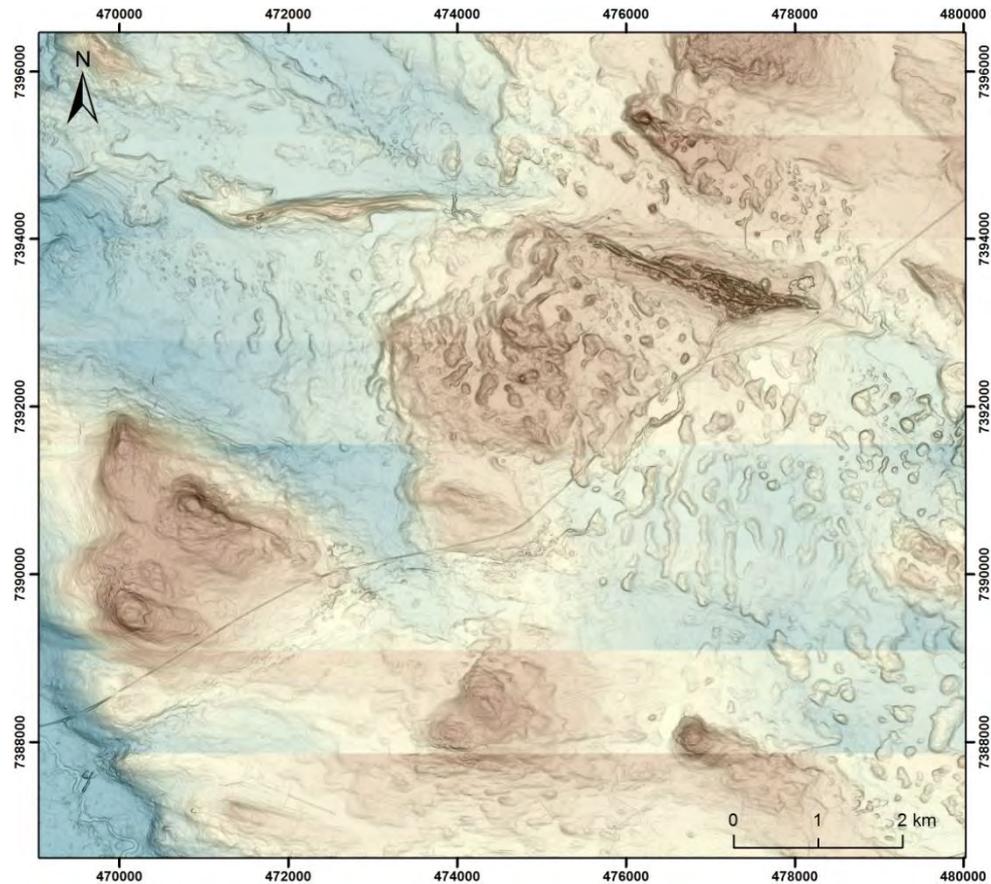


Fig. 2. Well-formed Rogen moraine type ribbed moraine field cut by subglacial meltwater channel filled with glaciofluvial sediments in the core part of Kuusamo Ice Lobe with some streamlined landforms indicating ice flow direction from west to east.

POSTGLACIAL PALEOSEISMODISLOCATION ON MOUNT VOTTOVAARA

Shelekhova, T.S., Lavrova, N.B.

FIC KarRC RAS Institute of Geology, Karelian Research Centre, RAS, Petrozavodsk, Pushkinskaya str., 11, RUSSIA

E-mail: shelekh@krc.karelia.ru

Mount Vottovaara (abs.alt.417.2 m), the highest top of the West Karelian Upland, is a ridge elongated approximately north – south for about 7 km, composed of Jatulian quartzite and quartzitic sandstone and broken by numerous faults probably rejuvenated in Postglacial time. The denudation surface displays a highly rugged topography, the top surfaces are subdued by exaration, and the relative altitude above the surrounding terrain is up to 157 m. Mount Vottovaara bear traces of disastrous geological events that took place here at the Pleistocene-Holocene boundary (Demidov, 1997; Demidov et al., 1998; Lavrova & Demidov, 1997; Lukashov, 2004; Shelekhova, 1999). The crystalline rock surface has been considerably transformed by multiple glaciations during the Quaternary Period. Exaration forms, roche moutonee, glacial grooves, ruts and scars are common to the area. Holocene tectonics has been confirmed by the lithologo-stratigraphic and micropaleontological study of bottom sediments from a small lake located in a seismogenic basin near the mountain top (63° 04' 20" N, 32° 37' 15" E). The lithological composition of the sediments, spore-and-pollen spectra (SPS) and the diatom complex changed markedly at the Preboreal-Boreal boundary, suggesting a break in sedimentation. The SPS display a rapid succession of dominant components and the increasing contribution of hygro- and hydrophytes. Diatom flora evolved gradually up to the Preboreal-Boreal boundary, but the diatom complex changed rapidly after the break (Shelekhova, 1999). Radiocarbon analysis of sapropel, which accumulated in the lake after the break, has shown that their deposition began in Boreal time (8920 ± 60 years ago, SU-2824) y.a. A break in sedimentation in the lake and numerous traces of seismodislocations suggest that they were produced by a violent earthquake. It could have been provoked by the degradation of the Late Valdai glaciations and the rapid removal of the glacial load which contributed to the rejuvenation of old faults of varying rank. Paleoseismodislocations were undoubtedly derived in Postglacial time, as indicated by extensive evidence for dislocations in the form of steep walls with fresh irregular surfaces, traces of rock breaking and the detachment of individual massive rock blocks; numerous dismembered blocks shifted relative to each other; thrown away and shifted blocks; seismogravitational collapses, the distinctive feature of which are blocks similar in the degree of weathering or overgrowing with lichens, rock blocks thrown away from the carp wall so that a niche is formed, clefts; gaping extension joints in the basement; broken roche moutonee, on which the glacially affected surface displays fresh fractures; «fresh» fault scarps; fractures extending along the mire bottom; and a seismogenic pit with a lake in the centre.

Seismodislocations within Vottovaara Ridge could have taken place at the Preboreal-Boreal boundary. This assumption is supported by the occurrence of similar forms in the same seismogenic structure in Lake Pizanetz, 26 km north-east of Mount Vottovaara. (Lukashov, 2004). Mount Vottovaara undoubtedly attracts tourists and scientists who study local paleoseismodislocations of postglacial age.

References

- Demidov I.N. 1997. Mount Vottovaara relief formation in Postglacial time // *Archaeology of the North*, issue 1, KarRC. Petrozavodsk. P. 200-203.
- Demidov I.N., Lukashov A.D., Lavrova N.B., Shelekhova T.S., Vyakhirev S.A. 1998. Paleocology and paleoseismology of the Mount Vottovaara area, Western Karelia, I Late and Postglacial time. Abstracts of presentations at the International Symposium "Paleoclimates and evolution of paleogeographic settings in the Earth's geologic evolution". 27-31 August, 1998. Petrozavodsk, P.28-30.
- Lavrova N.B., Demidov I.N. 1997. Paleocological conditions of sedimentation and evolution of vegetation on top of Mount Vottovaara. // *Problems in Karelia's geocology*. Petrozavodsk. IG KarRC, RAS. P.13-20.

Lukashov A.D. 2004. Neo-geodynamics // Deep structure and seismicity of the Karelian Region and its surroundings. Petrozavodsk: Karelian Research Centre, RAS, P. 150 – 191.

Shelekhova T.S. 1999. Postglacial and Holocene evolution of Vottovaara Landscape Preserve's nature.//Problems in Karelia's geology and ecology. Petrozavodsk, KarRC, RAS, P.39-44.

DEFORMATIONS OF SEDIMENTS AND TOPOGRAPHY OF THE ESKER, AS EFFECTS OF STRONG SEISMIC EVENTS IN LATE GLACIAL (KARELIAN ISTHMUS, SOUTH EASTERN PART OF FENNOSCANDIAN SHIELD)

Shvarev, S.^{a,b}

^a *Institute of Geography RAS, Staromonetny lane 29, Moscow, RUSSIA*

^b *Schmidt Institute of Physics of the Earth, Bol. Gruzinsky street 10, Moscow, RUSSIA*

E-mail: *shvarev@igras.ru, shvarev@ifz.ru*

The research area is located in the Northern part of the Karelian Isthmus between Lake Ladoga and the Gulf of Finland of the Baltic sea. Glaciofluvial landforms of the last glaciation - esker ridges, spatially associated with faults in the crystalline basement, which were activated in late- and post-glacial time. The esker under study is located in the central part of Karelian Isthmus and has length about 40 km. The esker elongated to North-West and in the south part located along the valley of the Vuoksi River. Three cross-sections show different types of deformations in the esker sediments.

The first cross-section (southern) shows complex of opposite oriented normal faults forming a graben-like structure, oriented to NW and coinciding with orientation of the esker ridge and main morphologically expressed lineaments. Vertical amplitude of the graben is about 1 m, and amplitudes of faults reach to first decimeters. Important properties of this deformational structure is that some thrust-faults located in the central (axial) part of graben and asymmetry of graben with steep (mainly quazi vertical) NE side and gentle SW side. Therefore, the structure forming process consisted of two stages, the first is stretching and the second is compression. These stages coincide to process of tectonic movement. Upper layers are horizontally bedded sands and gravel lightly lowered above graben and dissected near bottom by thrust faults from lower deformed part. It is evidence that first stage of stretching was accompanied by flow with coarse depositions (gravel). Second stage of compression occurred when the gravel deposition was not finished.

The second cross-section (middle) includes two main parts as previously. The upper part is horizontally bedded sands, gravel and pebbles. The lower part is sands and partly silt dissected by normal faults oriented orthogonally the esker ridge, but coincides to morphologically expressed lineaments, crossed the ridge. Amplitudes of faults reach to first decimeters usually, but the master fault amplitude is about 1.9 m. Some layers in this depositional complex include soft-sediment deformational structures. Some species of the upper layers of deformed part represent fragments of varved clays which are considered as depositions of Baltic Ice Lake (BIL) which was here between 13.0-11.6 cal. kyr. BP. Therefore we can state that traces of several seismic events was found here. Horizontal upper layers and abrasion surface we can connect with the activity of the BIL on the last stage. This feature of cross-sections are characteristic as for this location, so for the first site of investigation. Thus observed traces of seismic events we can connect with the early stage of BIL.

The third cross-section (northern) is most interesting and intricate. First of all, the surface of the esker in orthogonal (NE-SW) cross-section represents two lengthwise ridges and shallow hollow between them. Left (NE) part is binomial. Lower layers are deformed sands and silt with large boulders which "swimming" in liquefied matrix. Upper layers are horizontally bedded sands, gravel, pebbles and very good rounded boulders near the surface. Central part represents gentle inclined to central axis parallel bedded sands and gravel. The border between left and central parts consist of several (mainly three) parallel normal faults. The master fault amplitude is more

than 3 m, secondary faults amplitudes are more than 2 m and about 0.3 m respectively. Thus the summary displacement reaches more than 5 m. Right (SW) part is binomial as left. But it is very thin upper horizontal undeformed part of layers here. The thickness of this part is about 0.5-1.m. Lower part includes three main deformation types: 1) inclined sands and gravel dissected by normal faults; 2) horizontal bedded sands, silt and gravel dissected by thrust faults; 3) quazi vertical and steep inclined layers of silt and sands located between 1 and 2 types at the same level. All fault surfaces inclined to SW and strike lines of fault oriented to NW along the esker. Some layers of deformed part are typical soft-sediment (SSD) deformation species or “event horizons”. These horizons consist of varved clays fragments which can be connected with the time of existence of the BIL. Thus it can be detected traces of several different seismic events. The sequence of these events includes: 1) two earthquakes at the early stage of BIL (SSD horizons in varved clays); 2) phase of stretching and appearance of normal faults with the formation of half-graben structure, which was filled quickly by sands and gravel; 3) phase of compression and appearance of thrust faults which was accompanied by steep folding of varved clays horizon. The last two events happened at the latter stage of BIL before it lowering and traces of these events in topography not leveled under the influence of basin accumulation or abrasion.

Based on the analysis of the dislocations found here, several main conclusions can be drawn:

1) The esker after formation in the Late Glacial time was transformed as a result of several stages of erosion and re-deposition during the existence of the Baltic Ice Lake, partially associated with presumable vertical displacements in the crystalline basement and in the body of the esker ridge;

2) Deformations have several types and generations, interconnected with each other and with the activated structures of the crystalline basement;

3) Kinetic types, spatial and temporal relations of deformations testify to the rapid alternation of tectonic extension and compression (normal faults and thrust faults respectively) with conjugated folding) and seismogenic character of displacements;

4) The presence of the deformed varved clays of the Baltic Ice Lake, post-sedimentation folds and faults determines several strong seismic events in the time period between 13-11,6 kyr. BP.

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SEDIMENTATION CONDITIONS OF TAURAGNAI GLACIOFLUVIAL DEPOSIT

Šinkūnė, E.^{a,b}, Aidukas, T.^b and Šinkūnas, P.^b

^a *Lithuanian Geological Survey, S. Konarskio str. 35, Vilnius, LITHUANIA*

^b *Institute of Geosciences, Vilnius University, M. K. Čiurlionio str. 21/27, Vilnius, LITHUANIA*

E-mail: egle.sinkune@lgt.lt

A sedimentological study was carried out in the terminal moraine complex of the Last Glaciation at the Baltic Uplands in East Lithuania. The terminal moraine complex there is expressed by end moraine ridges, which consist mainly of till, and only in areas associated with tunnel valley systems, the glaciofluvial deposits typically having undulating and hummocky surface expression are distinguished. The glaciofluvial sediment sequence that was outcropped in Tauragnai gravel quarry shows its binary structure. The lower part of the sequence consists of trough cross-bedded sand, while in the upper part a sequence of rhythmical layered sand, gravel and cobbles prevail. The architecture of the sequence upper part also is complicated with layers of poorly sorted cobble and boulder-rich gravel.

At the lower part of the sediment sequence, the various grained sand with some gravel admixture composes trough cross-bedded 0.2-0.6 m thick layers, lenticular beds or thick short lenses incised one into another. Current ripple laminated fine sand layers and lenses are present in

some places. The dip directions of cross-laminae are dispersed in a wide sector to the south. These sand beds fill an incision of north-south direction eroded into the top surface of underlying till bed. This incision nearly prolongs the tunnel valley stretching from northwest to southeast which is occupied by lakes Ilgis, Klykių and Politiškių. The sand beds are considered to be deposited by flows and braided streams of moderate hydrodynamic activity as the result of the subglacial ice melt water discharge from the tunnel valley mouth. Fan-shaped sand deposits probably had been formed at the valley mouths, along the outer side of the glacier margin (Lelandais *et al.*, 2016).

The upper part of the sediment sequence from the lower one is separated by a boulder-rich horizon and is of a completely different structure. Extensive bodies of horizontal to low-angle stratified pebble, usually matrix-supported, horizontally stratified sometimes cross-bedded granules interspersed in coarse sand and various grained sand beds make sheet shape arranged rhythmites. These coarse-grained rhythmite sheet beds with interspersed outsized clasts have a slight or in some places quite high inclination to the east-southeast. The measured sand cross-laminae have the same preferred direction of dip. It may represent a sheetflow deposition from the ice margin. The sandy gravels, massive to crudely laminated occurring in thick boulder/cobblerich beds and massive gravel or gravel-sand sheets indicate cohesionless debris or grain flows in some places. Such structure of the upper part of the glaciofluvial sediment sequence infers a formation of the end moraines constituted of coalesced fans at the ice margin by redeposition of supraglacial material (Krzyszowski & Zielinski, 2002).

References:

Krzyszowski, D. & Zielinski, T. 2002. The Pleistocene end moraine fans: controls on their sedimentation and location. *Sedimentary Geology* 149, 73-92.

Lelandais, T., Mourgues, R., Ravier, É., Pochat, S., Strzeczynski, P. & Bourgeois, O., 2016. Experimental modeling of pressurized subglacial water flow: Implications for tunnel valley formation. *Journal of Geophysical Research: Earth Surface* 121, 2022-2041.

AVAILABLE FORMS OF HEAVY METALS IN BOTTOM SEDIMENTS OF THE SMALL LAKES OF URBAN AND NON-URBAN AREAS, REPUBLIC OF KARELIA

Slukovskii, Z.I.

*Institute of Geology, Karelian Research Centre of the Russian Academy of Science,
Pushkinskaya Str., 11, 185910, Petrozavodsk, RUSSIA
E-mail: slukovskii_z@igkrc.ru*

Heavy metals are excellent indicators of negative anthropogenic influence to water objects. Bottom sediments of water objects are the main reservoir of heavy metals and play the role of secondary sources of anthropogenic pollution of the water environment. The analysis of heavy metals concentrations in bottom sediments is an important element of the complex environmental assessment of any waterbodies. Especially when the detection of different forms of heavy metals is needed during indicated investigations.

In this report, data on the concentrations of available forms of heavy metals in bottom sediments of the four small lakes of the Republic of Karelia are represented. All lakes are located in different parts of this region (fig. 1). Chetyrekhverstnoe Lake is located in Petrozavodsk city territory. Other researched lakes are located in non-urban (background) areas of the Republic of Karelia.

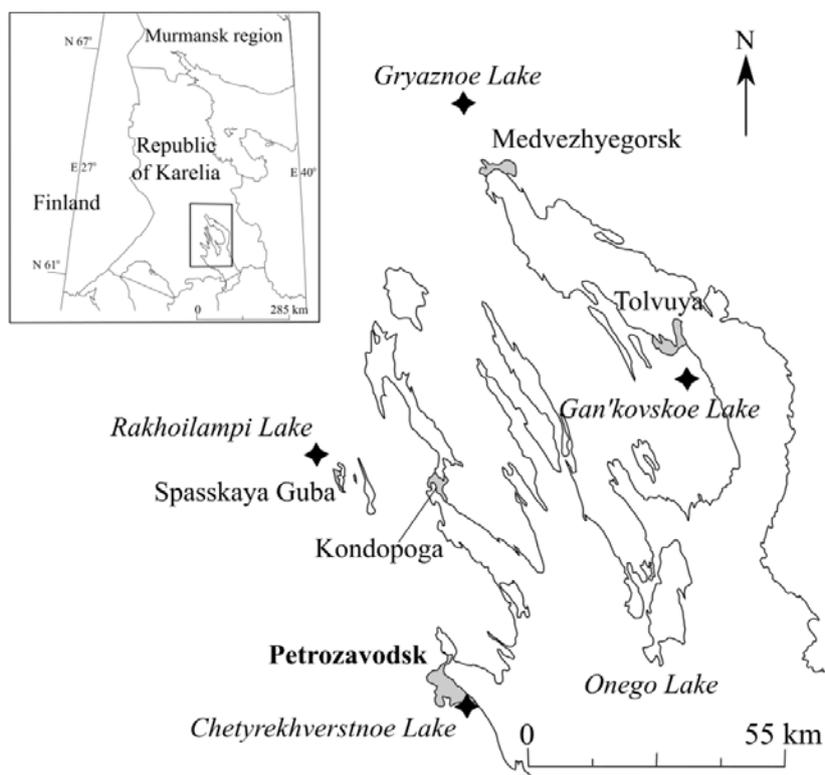


Fig. 1. Map of studied area (Created by Novitsky D.)

Samples were collected from the upper layers of the lake bottom sediments by the Ekman Bottom Grab Sampler. Extraction of microelements from previously dried samples of bottom sediments were done using $\text{CH}_3\text{COONH}_4$ (pH 4,8). Concentrations of heavy metals were measured by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in the analytical center of the Institute of Geology Karelian Research Centre of the Russian Academy of Science.

The sediments of all researched lakes are of the same type of sediments that are rich in organic matter (it is sapropel). The concentrations of heavy metals in bottom sediments of all studied lakes are taken in Fig. 2. It is shown that the content of all elements in deposits from Chetyrekhverstnoe Lake is higher than in other researched lakes. Especially the bottom sediments from the urban lake have the highest concentrations of Zn, Co, Ni, Cd, and Pb, which exceed concentrations of the same metals in sediments of non-urban lakes by 3 to 42 times. The main sources of anthropogenic pollution of this urban environment are emissions of machine-building enterprises, emissions of road and rail transport, household waste and traces of global air pollution in Northern Europe.

Thus conducted researches have shown the significant impact of large industrial cities of the north of Russia to contaminate the water environment. The concentrations of available forms of heavy metals in polluted bottom sediments exceed similar concentrations in bottom sediments of the lakes of background territories.

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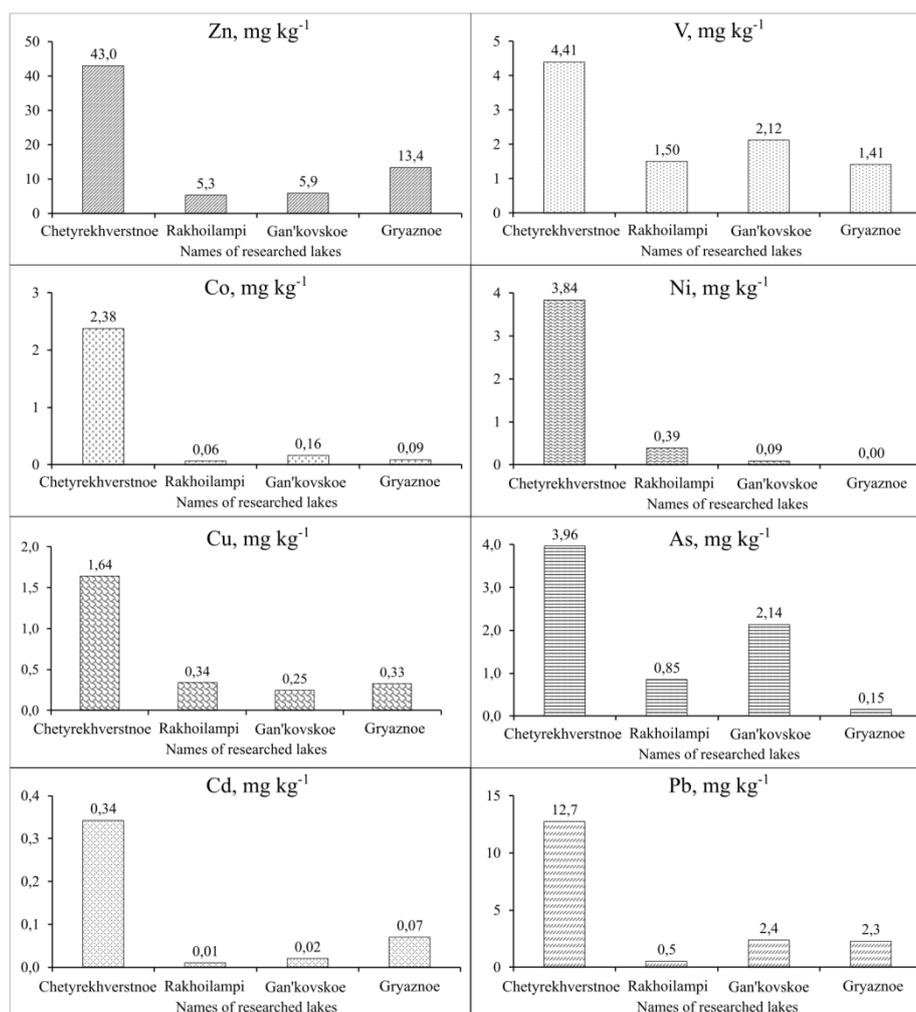


Fig. 2. Content of available forms of heavy metals in bottom sediments of the small lakes of urban and non-urban Karelia areas

AN INFLUENCE OF CLIMATE COOLING ON FLUVIAL PROCESSES - A CASE STUDY FROM OSŁONINO SITE, NORTHERN POLAND

Sokołowski, R.J.^a, Hrynowiecka, A.^b and Woronko, B.^c

^a Department of Marine Geology, University of Gdańsk, Al. Piłsudskiego 46, 81-378 Gdynia, POLAND

^b Polish Geological Institute - National Research Institute, Marine Geology Branch, 5 Kościarska Street, 80-328 Gdańsk, POLAND

^c Faculty of Geology, University of Warsaw, Al. Żwirki i Wigury 93, 02-089 Warsaw, POLAND

E-mail: r.sokolowski@ug.gda.pl

The Bładzikowo formation was previously established by Skompski in 1997 in the Pomorze Gdańskie region, north Poland. It is a fluvial complex deposited during the Eemian Interglacial and composed of channel, sandy series. It was correlated with other fluvial series of the Eemian age described from the Lower Vistula region, north Poland. Recent studies of the Bładzikowo formation from the Mrzezino key site gave a new interpretation of it. It is older fluvial series deposited during Marine Isotope Stage (MIS) 7d under interstadial (boreal) climate conditions (Sokołowski et al., 2017).

One of key sites where the Bładzikowo formation was described by Skompski (1997) is the Osłonino site. It is an outcrope in the cliff section along the Gulf of Gdańsk, north Poland. The outcrope reaches 15 m height and more or less 300 m length. The thickness of the Bładzikowo formation is from 5 to 14 m. It is covered by the Rzucewo clays and the till from the Weichselian glaciation.

The sedimentological (including lithofacial, quartz grains and heavy minerals analysis) and palynological studies were performed. The detail sedimentological studies confirmed the fluvial origin of the sediments. The sediments were deposited in the sandy, meandering river. The material was transported towards NW. However, the textural analysis suggests that fluvial series is bipartite. Therefore two subunits were distinguished.

The lower subunit, identified mainly in the northern part of the Osłonino site, was deposited in mild, boreal climate conditions as a result of redeposition of glacial material (predominance of weak minerals as amphiboles, pyroxenes and epidotes). The upper subunit is present in the central and southern part of the outcrope. In the sediments were observed numerous syn-genetic ice-wedge casts (up to 2 m of length) in at least three levels, peat layers and load-cast structures in a big scale (>0.6 m) in the top part. The analysis of quartz sand grains shows high intensity of aeolian processes with multiple redeposition in the aeolian environment. It is confirmed by heavy minerals analysis, where dominates garnet and zircon (minerals resistant for mechanical abrasion). The palynological analysis suggests the dominance of treeless open landscape. The climate was severe with steppe-like plant cover. Numerous periglacial structures let to interpret it as cold conditions with continuous permafrost and important role of aeolian processes on the exposed parts of a valley.

The stratigraphic position of the Bładzikowo formation based on recent research, is difficult to prove. The results from nearby Mrzezino site suggest older age, at least the for lower part of fluvial succession in the Osłonino site. The open question is the age of the upper part. Nevertheless, the palaeoclimate reconstructions suggest more severe conditions, than during MIS 7. At this moment we can assume that the deposition took place during older part of the MIS 6, but it needs further studies.

References:

- Skompski, S., 1997. Eemska formacja bładzikowska pod Puckiem. *Przegląd Geologiczny* 45, 1279-1281.
Sokołowski, R.J., Janowski, L., Hrynowiecka, A., Molodkov, A., 2017 Causes of fluvial system evolution during the late middle Pleistocene (Marine Isotope Stage 7) – a case study from the Bładzikowo Formation, N Poland. *Quaternary International*, <https://doi.org/10.1016/j.quaint.2017.09.042>

DEFORMATION STRUCTURES IN THE QUATERNARY SEDIMENTS OF THE EASTERN PART OF THE BALTIC SHIELD: MORPHOLOGY, POSSIBLE GENESIS AND CONNECTION WITH PALEOSEISMICITY

Sorokin, A.A.^a, Gorbatov, E.S.^a, Kolesnikov, S.F.^b

^a *Schmidt Institute of Physics of the Earth IPE RAS, 123242, Moscow, B. Gruzinskaya, 10, b.1, RUSSIA.*

^b *Moscow State University of Geodesy and Cartography (MIIGAiK), 105064, Moscow, Gorokhovskiy per., 4, RUSSIA.*

E-mail: aas@ifz.ru; e.s.gor@mail.ru; sfkol@yandex.ru

In recent decades, more attention has been paid to the study of disturbance of stratification in loose sediments of the Northwest of Russia, with a tendency to classify a significant part of the detected structures as traces of paleoearthquakes, especially in the case of soft-sedimentation structures (Biske et al., 2009). At the same time, in most cases, seismic genesis of these structures

has not been sufficiently proven by a set of generally accepted criteria, developed in detail in seismically active regions (Bowman et al., 2004). Thus, our studies of Khibin band clay did not confirm the seismic genesis of previously revealed intralayered fold deformations (Gorbatov & Kolesnikov, 2016). In connection with this, the tasks of this work were: 1) the systematization of deformation structures in the loose sediments of the region; 2) evaluation of their significance as indicators of paleoseismicity.

During field work in the summer of 2017, in the area of the St. Petersburg – Murmansk highway between 60.7° and 67.5° N, 17 quarries were inspected. Typical undisturbed glacial deposits in the study area are represented by sandy-loamy moraines, fluvio-glacial deposits with lenticular and cross-bedding stratification and sandy-silty limnoglacial deposits. Glacial dislocations, clastic dikes and convolutions were detected in 9 sections, the first two types of disturbance being typical for all three genetic types of deposits, and the third type only for limnoglacial sediments.

Small (5-7 cm) convolutions (flame structures, ovoid), having a sedimentary nature, were found in sandy-silty sediments near the railway station Polar Circle. Larger (10-60 cm), but irregular structures of introduction on the border of silt covered with sands, were identified in a quarry near Petrozavodsk. The most interesting outcrop 70 m long with large and regular convolutions, very similar to the seismic, is described in the southern side of the sand and gravel quarry in the area of the settlement Louhi. Here under the lens of gravel-pebble deposits lies a layer of silts with fine-grained sands in the roof, wedged out in the western part of the section, where the gravel material is underlain by cross-bedded coarse-grained sands. In the marginal parts of the silt layer, a horizon of convolutions 0.5-1 m thick and up to 6 m in length, overlapped and underlain by undisturbed sediments is revealed (Fig. 1). Convolutions consist of narrow antiform folds of ascending penetration with an amplitude of 10-40 cm, separated by broad synform folds. In the roof of the convolute horizon, pseudonodules in the form of pillows and drops, up to 40 cm in diameter, formed as a result of lowering heavier sand deposits in the liquefied silt were also detected.

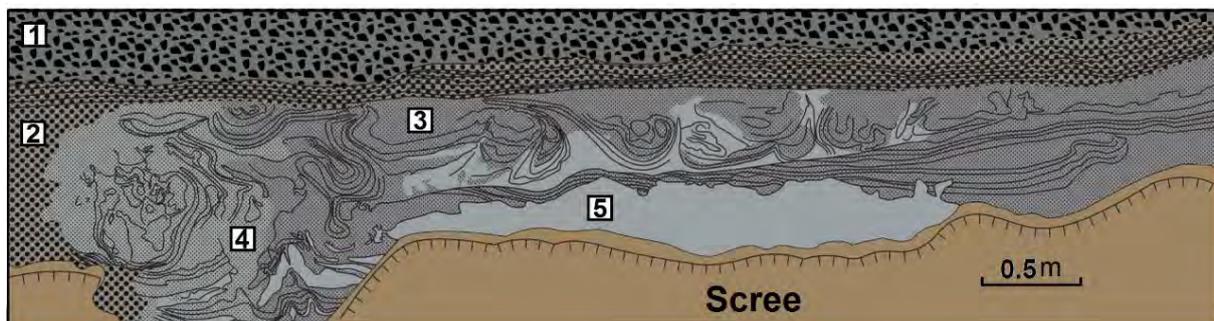


Fig. 1. Fragment of the horizon of large seismite-like convolutions (load casts) in the roof of a layer of late Pleistocene sandy-silt sediments, discovered in the area of the settlement Louhi. Lithological composition of sediments: 1 – gravel; 2 – coarse-medium-grained sand; 3 – fine-grained sand; 4 – mixed sandy-silt sediments; 5 – silts.

Standard schemes for the formation of seismogenic convolutions in the form of load cast assume that similar structures arise at the boundary of two liquefied layers with inversion of densities (Alfaro et al., 1997). Depending on the ratio of the viscosity of the adjacent layers, the lower layer is embedded in the upper layer in the form of either a dome or a pointed diapir. Since the revealed convolutions in limnoglacial sediments correspond to diapiriform morphologies, it can be concluded that they originated in the system "less viscous soils on more viscous". Another model is E.V. Artyushkov (1963) shows that in two-layer systems with inversion of densities with a more viscous lower layer, polygonal convection cells with central subsidence arise. At the second stage of convection development, similar narrow antiform and broad synform folds are formed in such cells, which can subsequently lead either to the formation of pseudonodules from the upper layer or to the rupture of the upper layer along the anticline axes with the formation of injection dikes. It is important to note that such convective structures are diagenetic in nature and can be formed in slow processes without seismic liquefaction. Thus, it is premature to draw a

conclusion about the seismic genesis of the revealed convolutions only on the basis of their morphological similarity with the seismites.

The glaciadislocations include intensive disturbed in sandy-silt strata lying in the front of the moraine. Such violations were found in the area of Lake Nilmozero and at the turn on the station Polar Circle. The supposedly glacial dislocations also include intensive structures mixing in the sand layer, as well as protrusions at the boundary of pebbles and sands, identified in fluvio-glacial deposits in the southern foothills of the Khibin. Also during the field work, injection dikes of an unclear nature found in non-disturbed moraine (Chupa) and fluvio-glacial deposits (Malinovaya Varakka settlement) were found. Conclusions:

1. The observed convolute horizons are morphologically very similar to seismites, but some may be the result of slow post-sedimentation redistributions of weakly consolidated lacustrine sediments under inversion of densities.

2. In all three sections, convolutions arise when sands are deposited on silt, while the size of the folds is directly dependent on the thickness of the layers on the boundary of which they arise.

3. As a rule, the formation of convolutions involves more or less narrow anticlinal folds interspersed with sufficiently wide synclinal folds, indicating a greater viscosity of the underlying deposits.

4. In order to clarify the genesis of convolutions, it is necessary to establish the rates of sediment accumulation and deformation, the relationship between the physical properties of deformed and enclosing sediments, the physical conditions of sedimentation, in particular the presence or absence of cryogenesis.

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References:

1. Alfaro, P., Moretti, M., Soria, J.M. Soft-sediment deformation structures induced by earthquakes (seismites) in pliocene lacustrine deposits (Guadix-Baza Basin, Central Betic Cordillera) // *Eclogae geol. Helv.*, 1997, v. 90, p. 531–540.

2. Bowman, D., Korjenkov, A.M., Porat, N. Late-Pleistocene seismites from Lake Issyk-Kul, the Tien Shan range, Kyrgyzstan // *Sediment. Geol.*, 2004, v. 163, p. 211–228.

3. Artyushkov, E.V. Basic Forms of Convective Structures in Sedimentary Rocks // *Dokl. AN SSSR*. 1963. v. 153. № 2. p. 412–415. (in Russian).

4. Biske, Yu.S., Sumareva, I.V., Sheetov, M.V. Late Holocene paleoseismic event at southeastern coast of Lake Ladoga. I. Principles of research and deformation structures // *Bulletin of St. Petersburg University. Ser. 7*, 2009. v. 1, p. 3–25. (in Russian).

5. Gorbatov, E.S., Kolesnikov, S.F. Deformation structures in glaciolacustrine deposits of Khibiny and assessment of their seismogenic potential // *Seism. Instrum.*, 2016, v. 53, № 3, p. 224–233.

ACCUMULATION AND DISTRIBUTION OF RARE EARTH ELEMENTS IN LATE
PLEISTOCENE BOTTOM SEDIMENTS OF ICE ONEGA LAKE (DATA FROM THE
SMALL LAKE POLEVSKOYE).

**Strakhovenko, V.¹, Subetto, D.², Tiit, H.³, Ovdina, E.¹, Gurbich, V.², Kirichenko, I.¹,
Potakhin, M.²**

¹ *The V.S. Sobolev Institute of Geology and Mineralogy of the Siberian Branch of the Russian Academy of Sciences (IGM SB RAS), Acad. Koptyug ave., 3, Novosibirsk, 630090, RUSSIA;*

² *Institute of water problems of the North-a separate subdivision of the Federal research center "Karelian research center RAS", Petrozavodsk, Republic of Karelia, Russia;*

³ *Tatty University, Tatty, Estonia*

E-mail: strahova@igm.nsc.ru

Lake Onega, Europe's second largest lake, is located on the boundary of the Baltic crystalline shield and the Russian Plate. During the Quaternary period, the Lake Onega basin underwent significant changes related to the degradation of the Valdai glacier and the development of the glacial water body. The authors obtained data on the stratigraphy of the samples of bottom sediments (BS) of Lake Polevskoye, which may indicate that this core of BS can be considered as representative e.g. Gurbich et. al., (2017). The aim of this research is to investigate of the distribution of the rare earth elements (REE) in recent and the Late Pleistocene bottom sediments (varved clays) of the relict Ice Onega Lake and the analysis of their inherent systematics REE for better visualization of the formation.

The object of research –BS of Lake Polevskoye, which was previously part of a large Ice Onega Lake (IOL). The selection the core of the BS was carried out using the Russian Corer in the winter time with an ice (2017) (the thickness of the recovered sediments is 13 meters).

The core samples were studied layer-by-layer with intervals of 1–2 cm. The sediment was studied using a set of geological, geochemical, petrographical and mineralogical methods at the multi-element isotopic research centre of Siberian Branch of RAS in Novosibirsk (atomic absorption, X-ray diffraction, IR spectroscopy, scanning electron microscope, ICP-MS and others).

The upper part of the sediment core is composed of sapropel layers (Loss on ignition (LOI) is 32%). Below by the core massive homogeneous gray sandy clay silt with interlayers (<1mm) of black (pyrolysis, goethite) and green (vivianite) colors are replaced. Following layers are the varved clays (LOI 98%). It's coloured by greenish-gray, and in the lower part of the section (from 12.05 m) pink-brown varve with layers (up to 1 cm) of black (shungite), formed in the Late Glacial period. On granulometric structure of the BS are of predominantly by pelit and silt fractions. The mineral composition of these BS (quartz, feldspar, mica, amphibole and chlorite) was determined by X-ray diffraction analysis. Dolomite is added to this set of minerals at the bottom of the core (below 12 m). Usually a black (pyrolusite, shungite and/or goethite) layers, bright green color and honey (vivianite - siderite, rhodochrosite) are abundant across the whole width of varved clays. In the BS accumulated in the IOL emerged "pink" marker horizon can be followed from the cores of the BS of Lake Onega to the lakes of the Zaonezhye e.g. Demidov (2006). In Lake Polevskoye, the "pink" layer in the width of varved clays is also present, with clear, sharp contact at a depth 10,37 m, and the top gradual to a depth of 10.08 m. According to the obtained geochemical data (48 elements) significant differences in contents of "pink" in the horizon relative to higher and lower lying layers have not been identified.

Data of rare earth elements (REE) are actively used for the reconstruction of formation conditions and the evolution of various geological processes. The content of REE in the BS of Lake Polevskoye with different depths (sapropels, homogeneous clay, varved clay layers ("pink horizon", upper, below contact with the "pink horizon" and varve clay with shungite layers) and their distribution pattern are fixed (fig.1). For comparison, the contents REE in the modern BS of

Lake Onega (excluded data from the Petrozavodsk Bay of Lake Onega, as the distribution in it is sharply different from other areas of the lake) and varve clays of the Baltic Ice Lake e.g. Kunzendorf, Valius (2004) are also presented in fig.1.

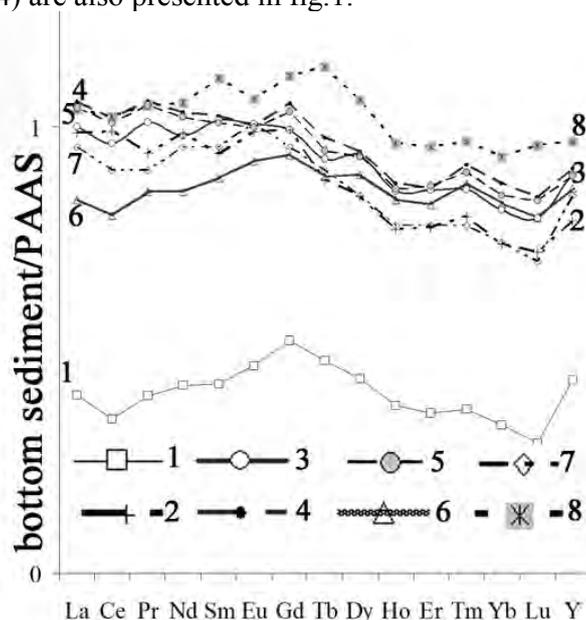


Fig. 1. The PAAS normalized spectra of REE distribution in Holocene (1,2) and Late Pleistocene bottom sediments of Lake Polevskoy (3-6); in recent bottom sediments of Lake Onega (7) and varve clays of the Baltic Ice Lake (8): 1 - sapropel layers, 2 - massive homogeneous gray sand-clay silt, 3 - varved clays upper “pink” layer, 4 - in the varved clays “pink” marker horizon, 5 - 3 - varved clays lower “pink” layer, 6 - pink-brown varve with interlayers of the shungite.

Average REE content in layers of BS of different age does not differ significantly, except for sapropel part of core, in which REE concentration is much lower, due to dilution with organic matter. General character of REE distribution in the BS of Lake Polevskoye is no different from the BS of Lake Onega. In the layers of varve with shungite interlayers Σ REE are ranges from 142 to 148 g/t (Σ LREE/HREE from 3.2 to 3.5); in varve, including in the “pink layer” - Σ REE from ~180 to ~256 g/t (4.6-5.2); in homogeneous clays - Σ REE from ~130 to ~176 g/t (4.5-5.1); in sapropel layers - Σ REE from ~51 to ~54 g/t (3,5-3,8); in modern BS of Lake Onega- Σ REE from ~ 84 to ~136 g/t (3.6-5.6); in modern BS of the Petrozavodsk Bay of Lake Onega - Σ REE from ~242 to ~439 g / t (15-26), which corresponds to the continental lithogenesis. The PAAS normalized REE distribution in BS of Lakes Polevskoye and Onega characterized by rather low angle slightly MREE oriented shape and the following peculiarities. A weak negative (Ce/Ce*)PAAS (0,89-0,92), except the Petrozavodsk Bay BS of Lake Onega (2,56 -4,33) and varying values (Eu/Eu*)PAAS: a significant negative for the sapropels (0,56), mild negative for all horizons of varved clays (0,92-0,99), and clearly manifested a positive for varved clays with interlayers of shungite (1,66) and slightly positive for the “pink” layer (1,1). The general feature of BS of all layers indicate the expressed similarity with distribution of REE in crystalline rocks of Archaean and Proterozoic of the Baltic Crystalline Shield. BS of Lake Onega are characterized by the size Nd (t) from -21,98 to -25,9, which also corresponds to the model age of crystalline rocks of Archaean and Proterozoic Baltic shield.

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References:

- Gurbich V., Potakhin M., Subetto D., (2017) / Astrakhan herald of ecological education No. 3 (41) p. 4-13. Earth science (in Russian).
 Demidov, I.N., 2006. Geologiya i poleznyye iskopayemye Karelii 9, 171–182 (in Russian).
 Kunzendorf H., Valius H., 2004. Baltica, Vol. 17(2), pp. 53-62. Vilnius

VARVED CLAYS AND A CLAY-VARVE CHRONOLOGY OF THE PERIGLACIAL LAKE ONEGO, NW RUSSIA

Subetto, D. ^{a, b}, **Hang, T.** ^c, **Gurbich, V.** ^a, **Strakhovenko, V.** ^{a, d}, **Potakhin, M.** ^a, **Belkina, N.**

^a

^a *Northern Water Problems Institute, Karelian Research Centre of Russian Academy of Sciences, Alexander Nevsky 50, Petrozavodsk, RUSSIA*

^b *Herzen State Pedagogical University of Russia, Saint-Petersburg, RUSSIA*

^c *Tartu University, Tartu, ESTONIA*

^d *The V.S. Sobolev Institute of Geology and Mineralogy of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, RUSSIA*

Periglacial Lake Onego (PLO) developed in front of receding Late Weichselian ice margin in the Russian Karelia. Widely spread glacial varves formed in PLO have been earlier studied by means of palaeomagnetism, varve counts and ¹⁴C AMS dates from the northern Lake Onego area and from the bottom of the lake. Changes in magnetic parameters and similar stratigraphy of varve record together with the existence of basin wide marker interval of pink colored varves have been used for core to core correlation and palaeogeographic interpretations (Saarnisto, Saarinen 2001). Unfortunately, there are missing varve to varve correlations between the cores. We will present a 1100 yrs long local varve chronology based on 3 parallel cores from two small lakes in the Zaonezsky Peninsula of the northern Lake Onego area. Varve counts and correlation of varve series was provided from digital images. Thickness changes exhibit rapid upward thinning from several tens of mm to 5-15 mm within first 150 yrs which can be interpreted as rapidly increasing distance to the retreating ice margin. The slightly fluctuating varve thickness then decreases to 3-10 mm for the period 150-500 yrs above the bottom indicating rather stable retreat of the ice margin. In 'pink horizon' with 108 varves the thickness is 3-5 mm with decrease down to 2-3 mm at the end of the period. Color change from dark grey to pink is synchronous but the upper boundary of the interval is transitional. Above 'pink horizon' a sudden decline in varve thickness down to 1 mm and less takes place and continues within following ca 250 yrs. Considering earlier AMS chronology by Saarnisto and Saarinen (2001) which places the deglaciation of Lake Onego basin between 14.250 and 12.750 cal yrs BP, this interval of micro varves may have been climatically controlled during the Greenland Interstadial 1b. The final slight thickening of varves (ca 350 yrs) indicates increased erosion due to the lowering of ice lake level. Ca 100 km south of our study area Saarnisto and Saarinen (2001) reported 200 more varves compared to our results. Visual correlation of graphs place these extra varves to the proximal part of the series which indicates rapid deglaciation of the main Lake Onego basin with the ice recession rate ca 500 m per annum.

This work is supported by a Russian Science Foundation grant (project, 18-17-00176).

References

Saarnisto M., Saarinen T. Deglaciation chronology of the Scandinavian ice sheet from east of Lake Onega basin to the Salpausselkä end moraines // *Global and Planetary Change*. Vol. 31, 2001. P. 387-405.

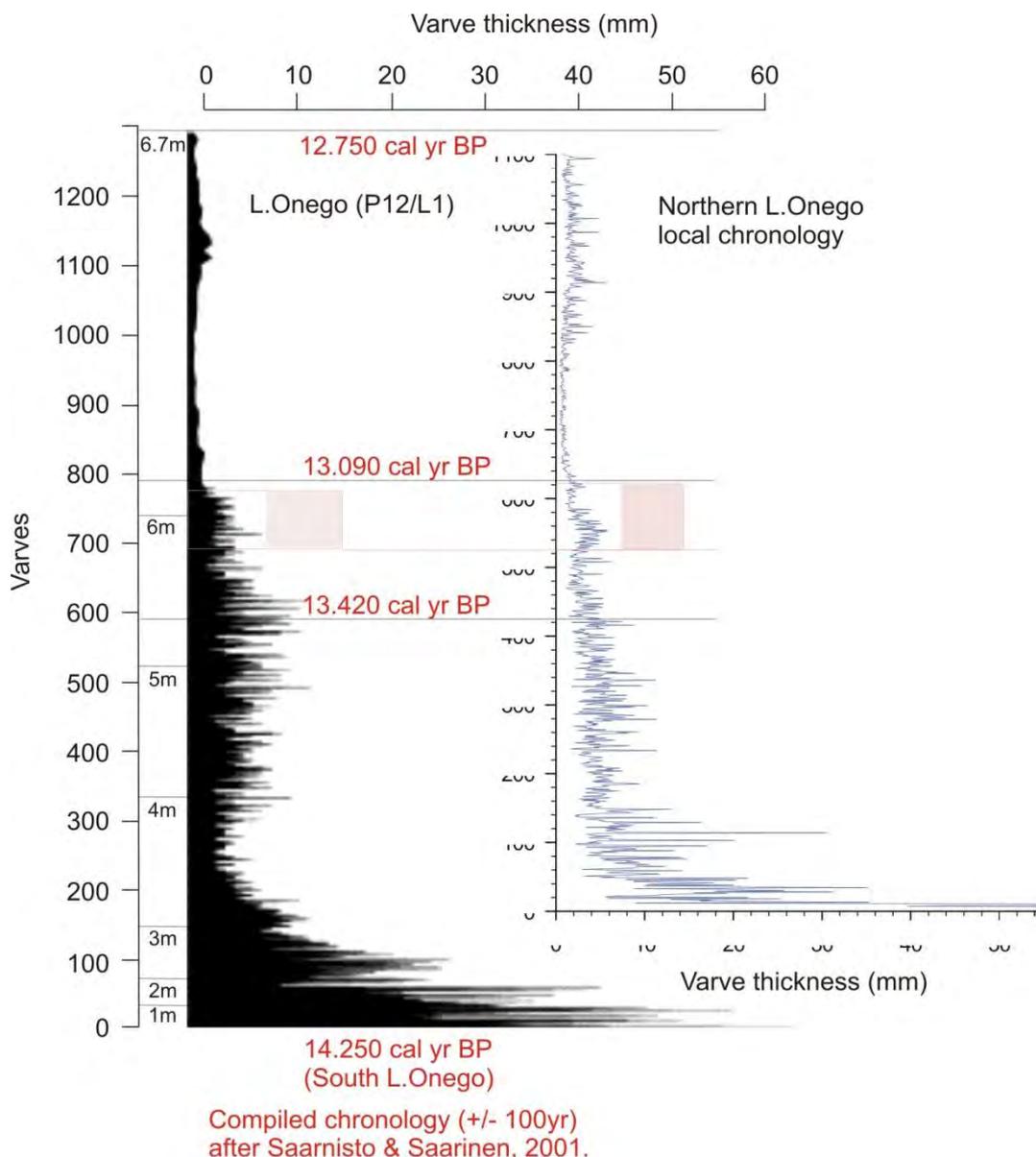


Fig. Correlation of our local varvo-chronology with chronology of Saarnisto & Saarinen (2001)

THE TRACE ELEMENTS CHEMISTRY OF THE "MARCIAL WATERS" SPRINGS, CENTRAL KARELIA

Svetov, S., Svetova, E.

*Institute of Geology Karelian Research Centre, Russian Academy of Sciences, 11
Pushkinskaja St., 185910 Petrozavodsk, Karelia, RUSSIA
E-mail: ssvetov@krc.karelia.ru*

The first Russian spa resort "Marcial Waters" is located 54 km to the north of the Petrozavodsk (Republic of Karelia). The variations of trace elements content in ferruginous water from the resort sources are discussed.

"Marcial Waters" springs are confined to the denudation-tectonic valley of the Gabozero Lake (Onega structure). The territory is formed by Paleoproterozoic volcanogenic-sedimentary rocks (graphitic schists, siltstones) and intruded by intrusive gabbro-dolerites (the rock age is estimated at ~1.9 Ga) [Tokarev et al., 2015; Onega Palaeoproterozoic..., 2011]. The rock association has

tectonic dislocations and sulfide mineralization in the contact zones with schist [Svetov et al., 2015]. The complex is covered by Quaternary sandy-argillaceous sediments.

The water mineralization is the result of the surface waters interaction, penetrating into tectonic dislocations zones to volcanic-sedimentary unit and causing oxidation of volcanogenic massive sulfides (VMS) on contact with gabbroids, which is represented mainly by pyrite [Tokarev et al., 2015]. Water discharge is carried out by upward filtration through loose sediments in the Raudargiya stream valley and the Gabozero Lake basin.

Four spouting water springs are located on the resort currently. The spring №4 is represented by high-ferruginous sulfate waters ($\text{Fe}^{2+} \sim 100$ mg/l). Other three springs reflects the varying degree of high-ferruginous waters contamination by the sandy horizons waters of Quaternary sediments. As a result, these springs have hydrocarbonate-sulfate composition with lower mineralization and Fe^{2+} content of 10–50 mg/l. Average springs characteristic: pH value range from 6.3 (spr. №4) to 6.0 (spr. №1–3), Eh (mB) range from +213 (spr. №4) to +200 (spr. №1–3), total dissolved solids from 0.8 (spr. №4) to 0.24 (spr. №1–3) g/l [Tokarev et al., 2015].

Trace element content in Marcial water was analyzed in June 2015, November 2016 and March 2017. Acidified samples (5% v/v ultrapure HNO_3) were collected in high density polyethylene bottles for analysis. Trace elements were measured by ICP-MS (X-Series 2 Thermo Fisher Scientific) in the analytical laboratory of the IG KarRC RAS. Cation analyses calibration were performed using international standards IV-STOCK-1643. The trace and rare earth element contents were measured directly in solution without pre-concentration and precision was better than 2%.

The carried out research has shown:

1) Marcial springs water contains a wide range of trace elements with concentrations from 0.001 to 200 ppb;

2) The high divalent ferrum concentration in waters, connected with pyrite oxidation process leads to accompanying element transport from magmatic sulfides (VMS). The concentration of this elements has high values: Mn (280–620 ppb), Zn (40–200 ppb), Ni (30–180 ppb), Co (9–40 ppb), As (30–70 ppb), that can be result of interaction between water and polymineral sulfide system (included arsenopyrite, sphalerite, millerite, cobaltite);

3) The springs are characterized by high concentration of Sr (40–70 ppb) and Ba (3–15 ppb) because of interaction between water and silicate minerals (sodium-calcium feldspar) probably; by lower concentration of Li (9–12 ppb), B (18–28 ppb), P (45–115 ppb), Rb (2–5 ppb), Mo (1–4 ppb), Cu (0.7–3 ppb); <1ppb for Be, Ti, V, Cr, Se, Y; <0.2 ppb for Zr, Nb, Ag, Cd and by lowest concentration of Sn, Sb, Te, Cs, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re, Tl, Bi, Th, U < 0.05 ppb. Presence some of these elements can be explained through its transporting from sulfides and accessory minerals (apatite, monazite and other).

4) The data on water composition for the period 2015–2017 years have shown water stability for Zn, Mn, Ni, As, Ba and variability for Cu, Cr, Mo, Cd, Be, Pb, Sb, Tl, Ag.

5) REE distribution for all springs has a LREE depleted type and various spectrum configurations, that allowed to separate two spectrum types. The first type is corresponds to spring №1, it has lowest REE level, positive Eu ($\text{Eu}/\text{Eu}^* \sim 1.58\text{--}2.46$) and weak negative Ce anomalies ($\text{Ce}/\text{Ce}^* \sim 0.65\text{--}0.76$). The second spectrum type with enrichment in HREE and Eu anomaly absence ($\text{Eu}/\text{Eu}^* \sim 0.63\text{--}0.98$) corresponds to composition of water springs №2, №3, №4.

The studies of trace elements distribution of the Marcial waters springs have shown relatively stable water composition (except for Cu, Cr, Mo, Cd, Be, Pb, Sb, Tl, Ag). Spring water are formed as a result of infiltration waters interaction with ore and silicate minerals, which controlled the chemical composition specificity. In spite of the close pH and Eh water values, the REE distribution indicates different mechanisms of their accumulation, that allows to separate two contrasting water types formed as a result of mixing of high-ferruginous waters of the springs №4 with infiltration water differences.

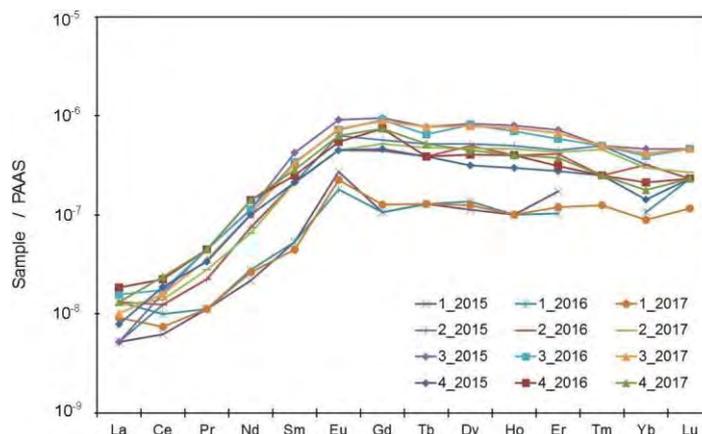


Fig. 1. REE distribution in Marcial water springs normalized to PAAS (Taylor, McLennan, 1985). Legend: 1, 2, 3, 4 – springs number; 2015, 2016, 2017 – sampling years.

References:

- Omega Paleoproterozoic structure (geology, tectonics, deep structure and mineralogy). 2011. Responsible editors: L.V. Glushanin, N.V. Sharov, V.V. Shchiptsov. Petrozavodsk. 2011. 489 p. (in Russian).
- Svetov S.A., Golubev A.I., Stepanova A.V., Kulikov V.S. 2015. Paleoproterozoic volcano-plutonic complexes of the Omega structure. Geological field guide for the XII Russian petrographic conference. Russia, Petrozavodsk: Karelian Research Centre, 2015. P. 28–54 (in Russian).
- Taylor S.R., McLennan S. M. The continental crust, its composition and evolution : an examination of the geochemical record preserved in sedimentary rocks. Oxford; Melbourne: Blackwell Scientific Publications, 1985. 312 p.
- Tokarev I. V., Borodulina G. S., Blazhennikova I. V., Avramenko I. A. Origin conditions of ferruginous mineral water mineral waters according to isotope-geochemical data ("Marcial waters" Resort, Karelia) // Geochemistry, 2015. №1. Pp. 88–91 (in Russian).

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PALAEOCLIMATIC AND PALAEOENVIRONMENTAL CHANGES AT THE LATE PLEISTOCENE–HOLOCENE TRANSITION IN THE SE BALTIC REGION (KALININGRAD DISTRICT, RUSSIA)

**Syrykh, L.^{a,b}, Nazarova, L.^{c,d}, Kublitskiy, Y.^b, Druzhinina, O.^d, Subetto, D.^{b,e,f},
Stančikaitė, M.^g, Vaikutienė, G.^h, Kulkova, M.^b**

^a Kazan Federal University, Kremlyovskaya str., 18, 420018 Kazan, RUSSIA

^b Herzen State Pedagogical University of Russia. 191186, Emb. Moyki, 48, St. Petersburg, RUSSIA

^c Potsdam University (The Institute of Earth and Environmental Science), Am Neuen Palais 10, 14469 Potsdam, Germany, GERMANY;

^d Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Research Unit Potsdam, Telegrafenberg A43, 14473 Potsdam, Germany

^d Museum of Nature and History, A. Nevsky 14, Kaliningrad, 236038, RUSSIA

^e Northern Water Problems Institute, Karelian Research Centre of the RAS. 185030, A. Nevskogo Avenue, 50, Petrozavodsk, Republic of Karelia, Russia

^f Immanuel Kant Baltic Federal University, A. Nevskogo str. 14, Kaliningrad, 236016, RUSSIA;

^g Nature Research Centre, Institute of Geology and Geography, Akademijos Str. 2, 08412, Vilnius, LITHUANIA

^h Vilnius University, M. K. Čiurlionio 21/27, LT-03101, Vilnius, LITHUANIA

E-mail: lyudmilalsd@gmail.com

The climatic and environmental changes at the transitions from the Late Pleistocene to the Holocene are well-established for wide parts of the northern Eurasia, however quantitative temperature reconstructions were not performed for the SE Baltic region yet (Björck et al. 1998; Peyron et al. 1998). Aquatic organisms especially chironomids (Insecta: *Diptera*) are the best biological indicators for quantifying past changes in air temperature or lake chemistry (Brooks and Birks, 2000; Syrykh et al., 2017; Nazarova et al., 2017).

We investigated a sediment records from Kamyshovoe Lake (Kaliningrad region, Russia) to perform a quantitative reconstruction of mean July air temperature using statistical chironomid-based inference models (Nazarova et al., 2011, 2015) and to reconstruct the palaeoclimate and palaeoenvironmental conditions during the Late Pleistocene–Early Holocene transition in the SE Baltic region.

The period ca. 16000-14300 cal BP characterized deglaciation processes and significant environmental changes. In the chironomid assemblages were dominated by taxa indicated of cool to moderate temperatures and acidic conditions. At the same time, was noted the unstable water level of the lake. The reconstructed mean July temperatures of this period were close to the modern parameters.

Analysis of the chironomid assemblages showed changes of the taxonomic composition around 14400-11900 cal BP that was caused unstable climatic conditions. At the middle of the period were reconstructed a sharp decrease of the July temperature from 13 to 11 °C. Thereafter, we observed warming climatic conditions, which reflected in abundance of chironomids: increase a number of thermophilic taxa (*Endochironomus* and *Cladopelma* genera and others). A gradual general warming trend continues until 7500 cal BP.

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References:

- Björck, S., Rundgren, M., Ingolfsson, O., Funder, S. 1997: The Preboreal Oscillation around the Nordic Seas: terrestrial and lacustrine responses. *Journal of Quaternary Science* 12, 455–465. [http://doi.org/10.1002/\(SICI\)1099-417\(199711/12\)12:6<455::AIDJQS316>3.0.CO;2-S](http://doi.org/10.1002/(SICI)1099-417(199711/12)12:6<455::AIDJQS316>3.0.CO;2-S)
- Brooks S.J., Birks H.J.B. Chironomid-inferred late-glacial and early-Holocene mean July air temperatures for Kråkenes Lake, western Norway // *Journal of Paleolimnology*. 2000. № 23. P. 77–89.
- Nazarova, L., Herzschuh, U., Wetterich, S., Kumke, T. & Pestjakova, L. 2011: Chironomid-based inference models for estimating mean July air temperature and water depth from lakes in Yakutia, northeastern Russia. *Journal of Paleolimnology* 45, 57–71.
- Nazarova, L., Self, A., Brooks, S.J., van Hardenbroek, M., Herzschuh, U., Diekmann, B. 2015: Northern Russian chironomid-based modern summer temperature data set and inference models. *Global Planetary Change* 134, 10–25.
- Peyron, O., Guiot, J., Cheddadi, R., Tarasov, P., Reille, M., de Beaulieu, J.L., Bottema, S., Andrieu V. 1998: Climatic reconstruction in Europe for 18000 yr B.P. from pollen data. *Quat Res Volume* 49, Issue 2 March 1998, pp. 183-196. <https://doi.org/10.1006/qres.1997.1961>
- Nazarova L., Bleibtreu A., Hoff U., Dirksen V., Diekmann B. 2017. Changes in temperature and water depth of a small mountain lake during the past 3000 years in Central Kamchatka reflected by chironomid record. *Quaternary International*. 447: 46-58
- Syrykh L.S., Nazarova L.B., Herzschuh U., Subetto D.A., Grekov I.M. Reconstruction of palaeoecological and palaeoclimatic conditions of the Holocene in the south of Taimyr according to the analysis of lake sediments. *Contemporary problems of Ecology*. №4. 363-369

DEVELOPMENT OF THE PALAEO LIMNOLOGICAL DATABASE PALAEO LAKE

Syrykh, L.^{a,b}, Subetto D.A.^{b,c}

^a *Kazan Federal University, Kremlevskaya, 18, Kazan, Russia*

^b *Northern Water Problems Institute, Karelian Research Centre of Russian Academy of Sciences, A. Nevskiy prospect, 50, Petrozavodsk, Russia*

^c *Herzen State Pedagogical University of Russia, Saint-Petersburg., Russia*

E-mail: lyudmilalsd@gmail.com

In recent years, the interest to palaeogeographical studies, especially palaeoclimatic and environmental reconstructions, has grown significantly, which is primarily due to the problem of global climate change (Climate Change, 2007).

Drawing upon a variety of existing data, information and maps the database PalaeoLake was developed to systematize the data on the sedimentation and on the genesis of lakes located on the East European (Russian) Plain (Subetto and Syrykh, 2014; Syrykh et al., 2014). The database (DB) contains the information on over 200 lakes that were studied using palaeolimnological methods.

DB was constructed in MS Excel files. It includes in the structure the following categories: geographical such as the name of the lake, geographical coordinates, altitude, the region where the lake is situated; morphometric - mean and maximum depths, area; palaeolimnological – type of sediments and the thickness of sediments, type of sediment sampling, dating methods, the sedimentation time interval, types palaeolimnological methods that were carried out with the samples. The sources of the PalaeoLake database consists of publications, references, fundamental monographs, international and national journals, proceedings of conferences, authors' own field data.

Mostly the "palaeolimnologically studied" lakes are located on north-west of the Plain, here it was used as high-resolution records of Pleistocene and Holocene to multi-proxy research of climate change and environmental evolution, while the south-eastern regions are studied as objects showing development extra glacial areas, especially anthropologically transformed areas. The analysis of the DB can show synchronize and asynchronous palaeogeographical processes on those territories. This research is the continuation of the previously started studies on lake zoning and on the reconstruction of the stages of the development of lakes during the postglacial time and changes in the level regime of lakes in northern Eurasia (Harrison et al., 1996).

The study is financed by RFBR grant № 18-35-00624 mol_a

References:

Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change // Cambridge University Press, Cambridge, UK, 2007. 982 pp.

Harrison S.P., Yu G., Tarasov P.E. Late Quaternary lake-level record from northern Eurasia // Quaternary Research. 1996. V. 45. P. 138-159.

Subetto, D.A. and Syrykh, L.S., RF Inventor's Certificate no. 2014621070, 2014.

Syrykh L., Subetto D.A., Grekov I. Paleolimnological database for lakes of Russian plain // Proceedings of the II PAST Gateways International Conference and Workshop. 2014. P. 74 – 75.

MIS 3/2 LOESS PALEOSOLS IN AUSTRIA

Terhorst, B.^a, Meyer-Heintze, S.^a, Sprafke, T.^b

^a *University of Wuerzburg/Germany*

^b *University of Bern/Switzerland*

Loess paleosols in Austria differ strongly due to their geographical position. As the northern Austrian climate changes from more humid in the west to dry and warmer conditions in the east, modern and past soils have been influenced widely by the climatic gradient.

Based on a W–E transect we present paleopedological studies in three loess–paleosol sequences (Gunderding, Krems-Wachtberg, and Stillfried B locus typicus). Our study concentrates on the time span around the MIS 3/2 transition with its fast changes from interstadial to stadial periods. The chronostratigraphic frame is generated by OSL- and ¹⁴C-ages, accompanied by pedostratigraphy and locally, by archeological horizons.

In general, Austrian loess–paleosol sequences record a cooling trend from MIS 3 to MIS 2, which is also known from numerous paleoclimatic archives. However, in all sequences, processes related to permafrost were active during the late MIS 3 as well as during the MIS 2. The three main sequences are in line with the general trend of a reduced intensity of pedogenic and cryogenic features from western to (south-)eastern Europe, which can be explained by lower Atlantic moisture influence towards the east. Interstadial cambic horizons are well developed in the MIS 3 sequence of western Austria, whereas the eastern loess profiles only show weak pedogenesis. The studied MIS 2 records are characterised by tundra soils with reductaquic horizons, which is a clear sign for prolonged phases of permafrost. On the spatial scale, the sedimentation rate increases in the eastern loess regions and particularly the Krems-Wachtberg sequence in the center of the transect experienced an exceptionally high sedimentation rate and can thus be seen as one of the most important high resolution records for the MIS 3/2 transition in European loess regions. The results of field, laboratory as well as micromorphological investigations prove that paleopedogenesis, frost processes, and sedimentation rates differ in their spatial occurrence in the loess belt of Austria.

LATE WEICHSELIAN CATASTROPHIC GLACIAL FLOODS IN NORTH POLAND: GEOMORPHOLOGIC SIGNATURE AND PALAEOGEOGRAPHIC IMPLICATIONS

**Wysota, W.^a, Weckwerth, P.^a, Adamczyk, A., Joeck M.^a, Sobiech M.^a, Krawiec, A.^a and
Dąbrowski, M.^a**

^a *Faculty of Earth Sciences, Nicolaus Copernicus University in Toruń, Lwowska 1, 87-100
Toruń, POLAND*

E-mail: wysota@umk.pl

Catastrophic glacial floods have been discovered in many formerly glaciated terrains on Earth (Carling et al., 2009). The unique example of such megafloods are known from the ice-dammed Lake Missoula in the eastern Washington State (USA) (Bretz, 1923; Baker, 2009). Cataclysmic floods were also recognized in other areas of North America (Teller, 2004; Clayton, Knox, 2008; Wiedmer *et al.*, 2010) and in the mountains of Siberia and Central Asia (Carling, 1996; Rudoy, 2002; Herget, 2005, 2012; Komatsu *et al.*, 2016).

Within the area of the last Scandinavian Ice Sheet extension to the European Lowland a wide range of landforms related to glacial meltwater flows, such as tunnel valley systems, eskers, sandur fans and plains, and ice-marginal valleys were documented (Woldstedt, 1955; Galon, 1964). However, no unequivocal geomorphological signatures of cataclysmic glacial outburst floods have been discovered up to now.

The main aim of our research was to recognise signatures of glacial megafloods in the area of northern Poland that had been covered by the Late Weichselian Ice Sheet. The detailed geomorphic analyses of outwash plains in the area of north-eastern Poland revealed suits of landforms which proves their origin may be related to catastrophic glacial floods. The results of the investigations on sandur areas in northern Poland make it possible to distinguish features originated from Late Weichselian catastrophic glacial floods. The megafloods traces comprise large spillways, meltwater erosional surfaces, ice-contact outwash fans, pitted outwashes and obstacle marks, linear clusters of kettle holes and megadunes. Paleohydraulic estimations (calculated on the base of geomorphometry of flood-originated landforms) in the area of NE Poland (Suwałki and Wigry Lake) suggest flood discharge amounted from 0.5×10^6 to $2.2 \times 10^6 \text{ m}^3 \text{ s}^{-1}$.

It is supposed that catastrophic glacial floods in north Poland may have been one of the main causes of the formation of the European Lowland's system of ice-marginal valleys (pradolinas), which transferred significant quantities of glacial meltwaters to the Atlantic Ocean in the Late Weichselian.

References:

- Baker, V.R., 2009. The Channeled Scabland: A Retrospective. *Annual Review of Earth and Planetary Sciences* 37, 393–411.
- Bretz, J.H., 1923. The channeled scablands of the Columbia Plateau. *The Journal of Geology* 31, 17–649.
- Carling, P.A., 1996. Morphology, sedimentology and palaeohydraulic significance of large gravel dunes, Altai Mountains, Siberia. *Sedimentology* 43, 647–664.
- Carling, P.A., Burr D.M., Johnsen T.F. & Brennand, T.A., 2009. A review of open-channel megaflood depositional landforms on Earth and Mars. In: Burr D.M., Carling, P.A., and Baker V.R. (eds.) *Megaflooding on Earth and Mars*, Cambridge University Press, 33–49.
- Clayton, J.A., Knox, J.C., 2008. Catastrophic flooding from Glacial Lake Wisconsin. *Geomorphology*, 93, 384–397.
- Galon, R., 1964. On the geomorphology of the Northern Poland. *Geographia Polonica* 1, 23–39.
- Herget, J., 2005. Reconstruction of ice-dammed lake outburst floods in the Altai mountains, Siberia. *Geological Society of America, Special Paper 386*, Geological Society of America, Boulder, 118 pp.
- Herget, J., 2012. Ice-dammed lake outburst floods in the Altai Mountains, Siberia – a review with links for further readings. *Tomsk State University Journal of Biology* 1(17), 148–168.
- Komatsu, G., Baker, V.R., Arzhannikov, S.G., Gallagher, R., Arzhannikova, A.V., Murana, A. & Oguchi, T., 2016. Catastrophic flooding, palaeolakes, and late Quaternary drainage reorganization in northern Eurasia. *International Geology Review* 58, 1693–1722.
- Rudoy, A.N., 2002. Glacier-dammed lakes and geological work of glacial superfloods in the Late Pleistocene, Southern Siberia, Altai Mountains. *Quaternary International* 87, 119–140.
- Teller, J. T., 2004. Controls, history, outbursts, and impact of large late-Quaternary proglacial lakes in North America. In: Gillespie, A., Porter, S. & Atwater, B. (eds.) *The Quaternary Period in the United States*, INQUA Anniversary Volume, Elsevier, 45–61.
- Wiedmer, M., Montgomery, D.R., Gillespie, A.R. & Greenberg, H., 2010. Late Quaternary megafloods from glacial Lake Atna, Southcentral Alaska, USA. *Quaternary Research* 73, 413–424.
- Woldstedt P., 1955. *Norddeutschland und angrenzende Gebiete im Eiszeitalter*. K.F. Kochler, Stuttgart, 464 pp.

THE LATE PLEISTOCENE - HOLOCENE HISTORY OF THE NORTHEASTERN WHITE SEA COASTAL AREA

Zaretskaya, N.^a, Repkina, T.,^b Shilova, O.^b

^a *Geological Institute of RAS, Moscow, Russia*

^b *Faculty of Geography, Moscow State University, Moscow, Russia*

E-mail: n_zaretskaya@inbox.ru

The northeastern part of the White Sea, including the Gorlo (Gorge) strait and Belomorsko-Kuloiskoe (Kuloi) plateau (Fig. 1), comprises the traces of glacial, marine and tectonic history of Late Pleistocene – Holocene of the northeastern side of the peri-Baltic region. We performed the studies of the southern shoreline zone of the Gorlo strait (Zimniy coast), including geomorphological and GPR survey of different coastal levels, lithostratigraphic investigations of outcrops and drilling cores, radiocarbon dating and diatom analysis (Repkina et al., 2017). The main goal was the reconstruction of the White Sea coastal zone development in the Holocene, but the results embrace a wider time span and range of questions related to the Late Quaternary history of the European Northeast.

The main problem of the geological history of any coastal area is the correlation between marine and terrestrial archives which are often obtained from different institutions, research groups, equipment and data resources. Geological history of the White Sea and its terrestrial surroundings supports this statement completely. Concerning the Gorlo area, there are some controversies in the interpretation of Late Pleistocene glacial record.

The Eemian deposits are widespread both within the Gorlo strait and in the coastal zone (Sobolev et al., 1995; Demidov et al., 2007; Rybalko et al., 2017) and are mostly marine sands and silty sands with shells and shell detrital matter. The luminescent dating results are 160-110 kyr BP (Sobolev et al., 1995). In the coastal outcrops of Zimniy coast these deposits are presented by binary layer of dark-grey massive clays covered by light-grey sands (horizontally layered, with ripple marks, gravel and loam lenses etc.). Usually these deposits are directly covered by LGM diamicton (massive brownish silt with clasts and boulders of crystalline rocks).

The early Weichselian deposits are not identified in the Gorlo strait neither on its southern shore (Sobolev et al., 1995; Demidov et al., 2007; Rybalko et al., 2017). Then according to Demidov et al. (2007), the Barents Sea glaciation blocked the Gorlo strait ca 70-65 kyr BP and crossed the Zimniy coast near Inzy cape (Demidov et al., 2007). On the other hand, according the marine record of the Gorlo strait, the Late Weichselian deposits (glacial and glacio-marine) cover directly the Eemian layers and no other glacial deposits are identified between them. Our observations confirm this statement; we assume the Barents Sea glaciation not reaching the Gorlo strait.

The middle Weichselian interstadial deposits were identified in one section of Zimniy coast (Tova river lower reaches) and are presented by sands and gravels interlayered with silts and loams. One radiocarbon date is 28 ka BP (State..., 2012), and an OSL date from the bottom part is 77±8 (Demidov et al., 2006). Probably another section of interstadial sands was observed in the coastal scarp eastwards of Inzy cape.

Late Weichselian (LGM and deglaciation) tills are the most widespread in this area (Sobolev, 1995; Demidov et al., 2006; 2007; Rybalko et al., 2017). LGM tills cover the Zimniy coast, forming the gently undulating uplands with blanket bogs. The thickness of till layer varies from 1 to 8-9 m, and sometimes is overlying the rhythmically layered sandy-clay unit probably deposited in proglacial conditions of early LGM stages.

The deglaciation of this area left the well expressed marginal landforms. On the Zimniy coast, the moraine ridges of Neva deglaciation stage (Older Dryas) are identified both in the coastal area (Demidov et al., 2006; State..., 2012) and within the Gorlo strait (Sobolev et al., 1995; State ..., 2012; Rybalko et al., 2017). Their NE orientation influenced significantly the further Holocene coastal dynamic.

Marginal moraine ridges partially processed by basin activity form the upper level of the modern coastal zone pattern. The absolute height of the level is 6-20 m and it was formed during the Late Glacial – early Holocene as a result of filling of depressions among the moraine marginal ridges by deposits of a basin with weak hydrodynamic activity (sands and silts); diatom analysis still does not allow confirming their marine or freshwater origin. Basin deposits are covered by gyttja and peat with the age of ~10.8-7.6 cal BP. The GPR profiles of mires covering the ridges show the practically undisturbed moraine surface.

The surface level of 4-5 m a.s.l. was formed in the active marine depositional/erosional environment of the Holocene climatic optimum ~7.2-4.7 cal kyr BP, with higher relative sea level and sedimentary influx. The marine terrace of this level is mostly composed of beach ridges and sands interlayered with lagoon and peat deposits with abundant salt and brackish water diatom species. The transition to the lowest level is marked by abrupt abrasional scarp. GPR profiles show the flat terrace surface under the peat cover.

The lowest (3-0 m a.s.l.) coastal level was formed from SB (4.5 cal kyr BP) till now during the relative and very slow marine regression. Large sandy beach ridges were forming on the wave-exposed coasts (Inzy cape, fig. 1) and spits alternating with offshore mud and laidas – in the river estuaries.

Tectonic impact was not significant in the Holocene.



Fig. 1. Topographic map of the White Sea with local names and study area.

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References:

Demidov, I.N., Houmark-Nielsen, M., Kjær, K.H., Larsen, E., 2006. The last Scandinavian Ice Sheet in northwestern Russia: ice flow patterns and decay dynamics. *Boreas* 35, 425-443.

Demidov, I.N., Larsen, E., Kjær, K.H., Houmark-Nielsen, M., 2007. The Stratigraphy of the Upper Pleistocene of southern part of the White Sea basin // *Regional Geology and Metallogeny*, 30-31, p. 179-190 (in Russ.).

State Geological Maps of 1:1 000 000 scale, 2012. The third generation. Baltic series of sheets. Sheet Q-(35), 36 with water area (Apatity). Explanatory Notes. MAGE, VSEGEI, St. Petersburg, 440 p. (in Russ.).

Sobolev V.M., Alioshinskaya Z.M., Poliakova E.I. 1995 New data on the White Sea palaeogeography in the Late Pleistocene – Holocene. Correlation of palaeogeographical events, p. 120-130 (in Russ.).

Repkina T.J., Zaretskaya N.E., Shilova O.S., Lugovoy N.N., Sadkov S.A., Zverev F.V., Volovinskiy I.V., Gurbich V.A., 2017. Morphodynamics of the Wite Sea Gorge near Inzy cape in the Holocene. In: *Geology of Seas and Oceans (Proceedings of 22 International conference of Marine geology)*, v. 3, p. 274-279 (In Russ.).

Rybalko, A.E., Zhuravlev, V.A., Semenova, L.R., Tokarev, M.Yu., 2017. Quaternary deposits of the White Sea and the history of development of the modern Belomorian basin in the late Nenopleistocen-Holocen, in: *The White Sea System. Vol. IV. The processes of sedimentation, geology and history* (Ed. by A. P. Lisitzin). Scientific World, Moscow, pp. 84-127 (in Russ.).

THE WATERSHED RECONSTRUCTION OF THE ONEGO PALEOLAKE WITH GIS

¹Zobkov M., ^{1,2}Subetto D., ¹Potakhin M.

¹*Northern Water Problem Institute of the Karelian Research Center of the RAS, Alexander Nevsky 50, Petrozavodsk, 185030 Russia.*

²*Department of Geography, Herzen State Pedagogical University of Russia, emb. Moika 48, Saint-Petersburg, 191186 Russia*

The GIS paleoreconstructions of the shoreline, surface area and volumes of lakes are currently in the area of interests of wide scientific community including geologists, sedimentologists, archeologists, paleogeographers etc. However, the aspects of watershed formation and evolution are only formally entertained during the lake development assessment in spite of their key role in water chemistry and bottom deposits formation.

The Lake's Onego watershed evolution during and after the Last Glacial Maximum termination from ca. 14.5 ka BP to present was reconstructed in 0.5 ka increments. Reconstructions were based on ICE-6G paleo-topography model (Argus et al, 2014), modern digital elevation terrain model (Ferranti, 2017), 125 DEMs of lakes depressions situated in the Onego lake region and general Ice margins positions (Demidov, 2006). ArcGis 10.2 software with Spatial Analyst, Geostatistical Analyst and 3D Analyst packages were applied to delimitate and calculate the watershed area, Lake surface area and paleo streams pathways.

The strong variations of the watershed area and its configuration were identified in conjunction with Earth's crust glacioisostatic adjustments (fig). The area of the watershed was assessed to be from $160 \cdot 10^3$ km² 13.5 ka BP to $76 \cdot 10^3$ km² 3.0 ka BP. High glacial rebound and lake watershed allocation close to ice sheet peripheral lithosphere forebulge resulted in turning many of modern rivers backwards and redirection of their drainage in north-west direction below the ice shield. From 14.5 ka BP to 10.0 ka BP the watershed was at least twice larger compared with modern one ($62.8 \cdot 10^3$ km² (Onezhskoe ozero, 2007)), extended more than 300 km southward out of the modern watershed border and included modern Beloe Lake, Kubenskoe and Sheksninskoe water reservoirs. Surface discharge and ancient rivers inflow redirected into the Onego Lake drained from $60 \cdot 10^3$ km² to $30 \cdot 10^3$ km² of the area of the Russian Plate beginning from 14.5 ka BP and ending 2.5 ka BP, when the Beloe lake subwatershed was bestrunked and Onego Lake watershed generally came to the current borders.

The fundamental difference in the geological structure and lithology between the Russian Plate's sedimentary rocks and the Baltic Crystalline Shield's magmatic and metamorphic rocks that are mainly drained currently, can cause significant differences between the past and the modern hydrochemical conditions and sedimentary environments in the lake.

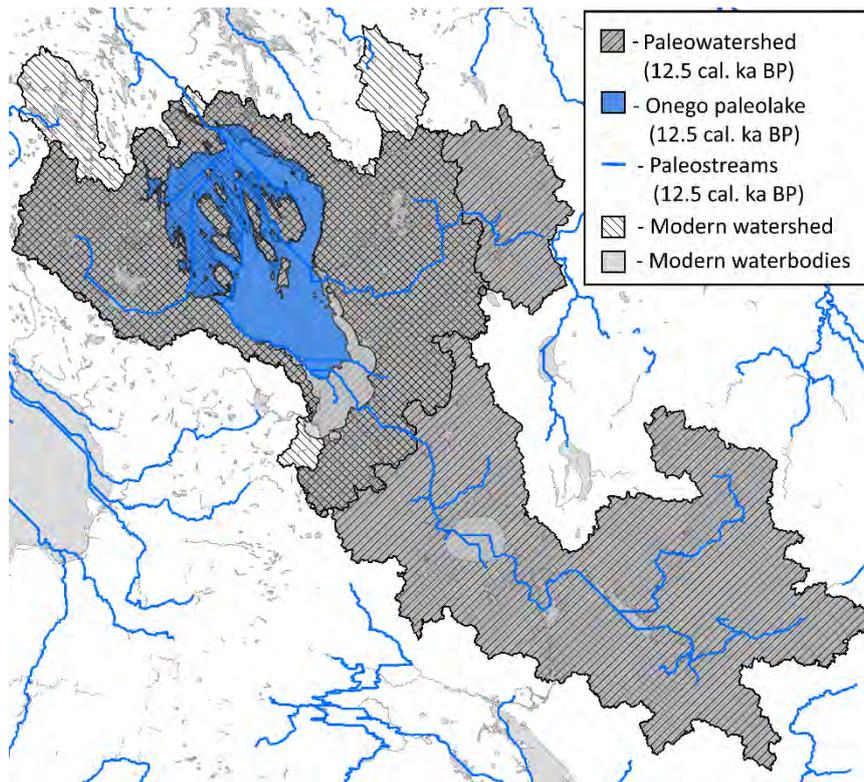


Fig. The Onego lake watershed at 12.5 cal. ka BP and present.

The study is financially supported by the Russian Science Foundation (#18-17-00176).

References:

1. Ferranti J. Digital elevation data. <http://www.viewfinderpanoramas.org/> [Accessed November 15, 2017].
2. Demidov IN (2006a) O maksimalnoj stadii razvitiya Onezhskogo priljedniskogo ozera i izmenenii ego urovnya i glyacioizostaticeskome podnyatii poberezhij v pozdnelednikove. *Geologiya i poleznye iskopayemye Karelii* 9: 171-182 [On a maximum stage in the evolution of periglacial Lake Onego, variations in its water level and glacioisostatic shore uplift of the shore in the Late Glacial Period, in Russian]
3. Argus, D.F., Peltier, W.R., Drummond, R. and Moore, A.W. (2014) The Antarctica component of postglacial rebound model ICE-6G_C (VM5a) based upon GPS positioning, exposure age dating of ice thicknesses, and relative sea level histories. *Geophys. J. Int.*, 198(1), 537-563, doi:10.1093/gji/ggu140.
4. Onezhskoe ozero. Atlas (2010) Filatov NN (red). Petrozavodsk, 151 p [Lake Onego. Atlas, in Russian].

STUDY OF CONTEMPORARY VERTICAL LITHOSPHERIC MOVEMENTS IN THE AREA OF SZCZECIN, NW POLAND

Zygmunt, M.^a, Piotrowski, A.^b, Cacoń, S.^a

^a *Maritime University in Szczecin, Wały Chrobrego 1, 70-500 Szczecin, Poland*

^b *Polish Geological Society, Wieniawskiego Street 20, 71-130 Szczecin, Poland*

The contemporary geodynamic processes we observe, indicate the need for monitoring of vertical movements of the Earth surface. Monitoring of mass-movements in Szczecin area was carried out in 2016 and 2017 by the Polish Geological Institute. However, apart from mass-wasting, the origin of lithospheric deformations in the Szczecin area has not been fully explained. Vertical movements are dominant, and their character will be demonstrated based on descriptions from several places where land deformations have been highlighted before. The geology of Szczecin will be linked to elevation changes of monitoring points known from recent years. Thus

stable areas can be identified, and will serve as reference points for further measurements of lithospheric movements.

Szczecin area is underlain by horst and graben structures and superficial deposits. The latter are formed by glacitectonically pushed up deposits and organic strata. The elevation of the Mesozoic bedrock is very diverse ranging from 80 m below sea level (b.s.l.) in Szczecin and Krakowko Horst and 20 m b.s.l. in Gryfino Horst to 200–400 m b.s.l. in graben areas (Fig. 1). Because plastic Zechstein salt is deformed forming salt pillows, swells and crests (such as the Maszewo-Marianowo Crest), horsts are pushed up by salt intrusions underlying them.

As salt tectonics has had strong influence on the evolution of topography, the whole Szczecin Graben is slowly subsiding. Figure 2 shows the general outline of the geology of Szczecin as well as the main fault zones including the Lower Odra fault zone. The city was intensely developed during the second half of the 19th century which also modified its topography. Elevated areas were incised by excavations while large road and rail embankments were built in valleys including the Odra valley; particularly the harbour was developed placing embankments and piled foundations.

The current study will be based on many methods supplementing each other (Cacoń S., 1998). Periodical measurements of the ground level movements will be referred to stable reference points located in the area of Szczecin. We are planning to collect new satellite measurements using Interferometric Synthetic Aperture Radar (InSAR) to supplement similar data from MELA EU project (Piotrowski, 2007) as well as drone 3D photogrammetry (Zygmunt, 2017).

Constant monitoring using multiple methods is justified by the need for identifying and predicting hazards associated with lithospheric movements. Due to the complexity of geodynamic processes, the following aspects should be taken into account such as vertical lithospheric movements, ground settlement, mass movements, changes in groundwater level, backwater from the Baltic Sea as well as vibrations from transportation and industry.

References:

CACON S. 1998. The measurements and monitoring systems with GPS-the basis for reliable data on deformation of an engineering object, Proceedings of XXI International Congress FIG, Commission 6, Brighton UK, 1998, s. 530-540.

Piotrowski A. 2007. Morphotectonics of the Lower Odra Valley. In: Abstracts, 1 st. MELA Conference “Living morphotectonics of the European Lowland”, 28-30 Aug. 2006, Cedynia, Poland. Polish Geol. Inst., Szczecin: 124-131

Zygmunt M., Hałaburda R., Borczyk K., Stępień G. 2017. Analiza tworzenia Numerycznego Modelu Terenu metodami fotogrametrycznymi z kamerą ustawioną pod kątem 90 i 80 stopni. Praca w redakcji kwartalnika Infrastruktura i Ekologia Terenów Wiejskich.

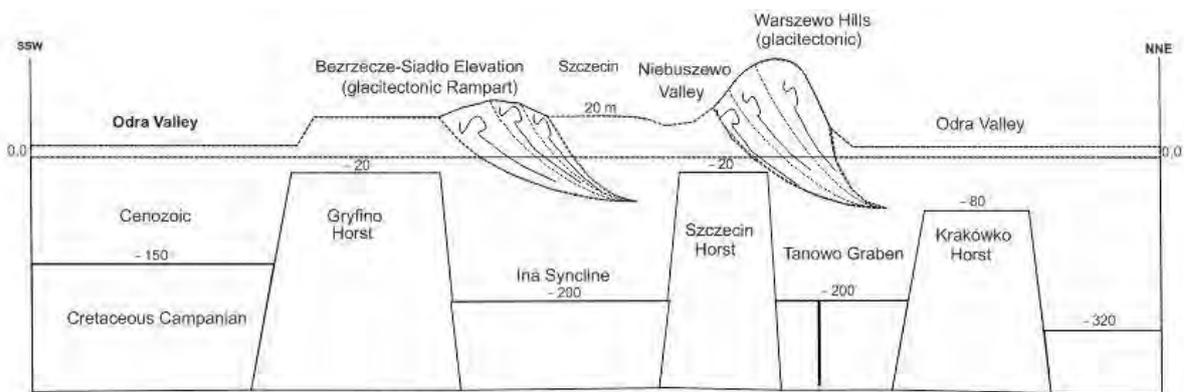
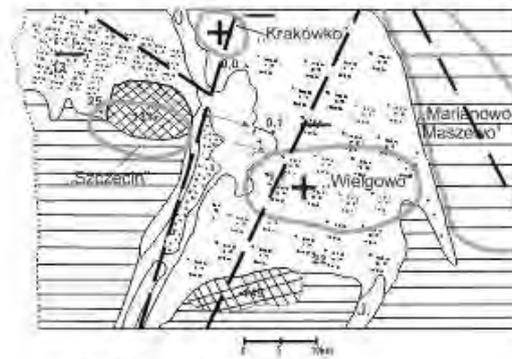


Fig. 1. Schematic geological cross section (Piotrowski A., 2007)



Rys. 2 Geological structure Odra plains area (Piotrowski A., 2007).



Fig. 2. Geological structure Odra plains area (Piotrowski A., 2007)

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