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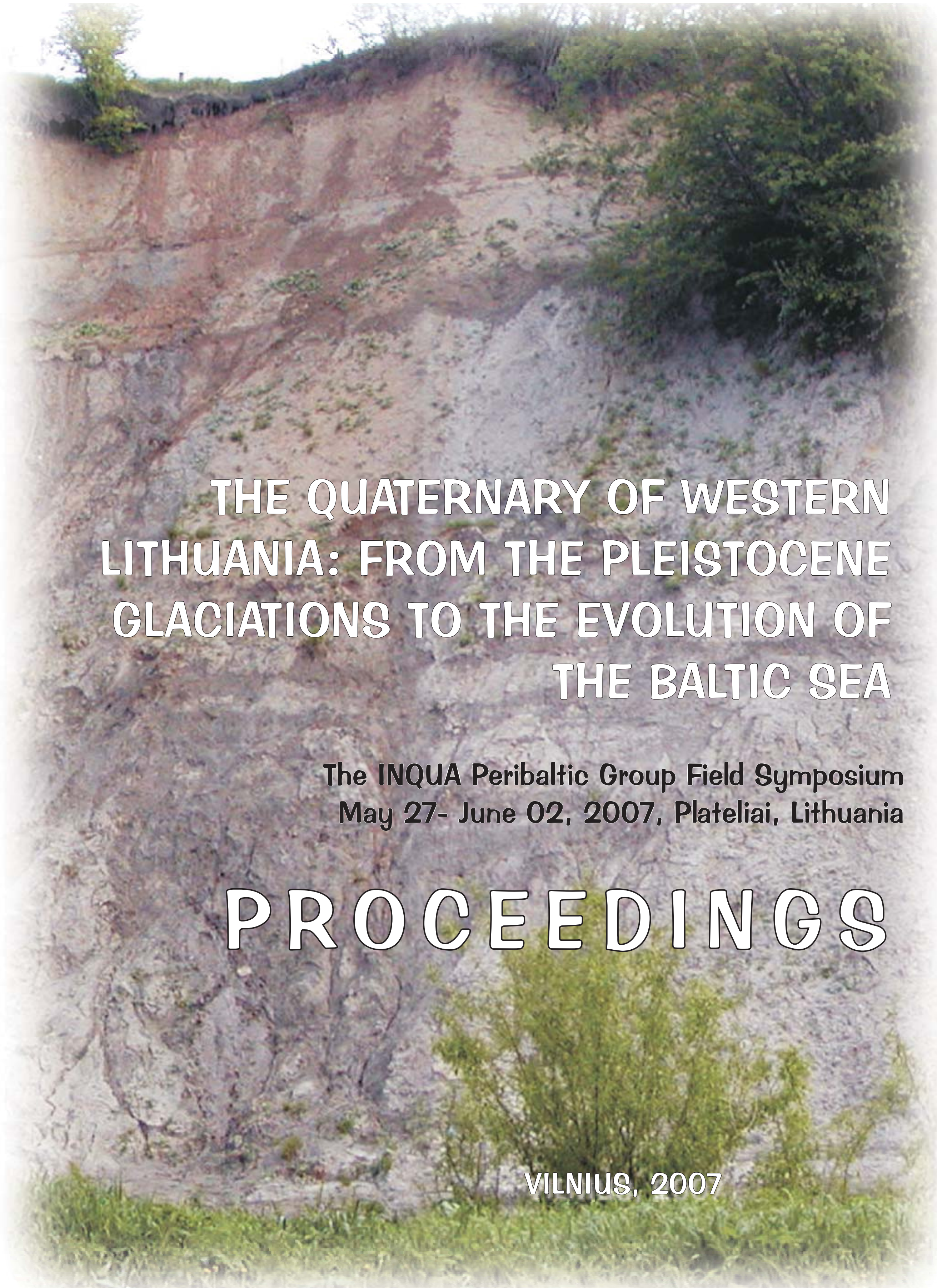

THE QUATERNARY OF WESTERN LITHUANIA: FROM THE PLEISTOCENE GLACIATIONS TO THE EVOLUTION OF THE BALTIC SEA

The INQUA Peribaltic Group Field Symposium
May 27- June 02, 2007, Plateliai, Lithuania

PROCEEDINGS

VILNIUS, 2007

THE QUATERNARY OF WESTERN LITHUANIA: FROM THE PLEISTOCENE GLACIATIONS TO THE EVOLUTION OF THE BALTIC SEA

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The INQUA Peribaltic Group Field Symposium
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UDK [551.79: 551.33: 551.8] (100): 061.3 (474.5)
Qu-09

The Quaternary of Western Lithuania: from the Pleistocene glaciations to the evolution of the Baltic Sea: Proceedings: The INQUA Peribaltic Group Field Symposium, May 27 – June 02, 2007, Plateliai, Lithuania / Eds.: R. Guobytė, M. Stančikaitė; Lithuanian Geological Survey, Institute of Geology and Geography. – Vilnius: LGT, 2007. – 107, [1] p.: iliustr. – ISBN 978-9986-623-45-8

SYMPOSIUM PROGRAMME

May 28th	**Paper and poster session**
May 29th	**Stops 1–2, 4–6, Samogitian Upland**
	Stops 8–9, Venta Plain
May 30th	**Stops 3, 16–19, south-western Samogitian Plain**
May 31st	**Stops 20–24, Curonian Spit**
June 1th	**Stops 7, 10–15, north-western Samogitian Plain**

The Symposium Venue – Hotel LINELIS (Plateliai)

ORGANIZERS:

Section of Quaternary Geology of the Lithuanian Geological Society
Lithuanian Geological Survey
Institute of Geology and Geography
Coastal Research and Planning Institute of Klaipėda University
The Peribaltic Group (INQUA Sub-commission on Glaciation)
Friends of Baltic Quaternary

THE SYMPOSIUM HELD UNDER AUSPICE AND FINANCIAL SUPPORT OF THE:

Baltic Sea Region INTERREG III B Project *Adaptation Strategies to Climate Change in the Baltic Sea Region (ASTRA)*,
Lithuanian State Science and Studies Foundation

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Compiled by: A. Damušytė
Edited by: R. Guobytė, M. Stančikaitė
Layout and cover design: R. Norvaišienė (**Pagramantis outcrop**. *Photo by P. Aleksa*)

Circulation: 100 copies

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LITHIC- AND POLLEN STRATIGRAPHY OF THE MIDDLE NEOPLEISTOCENE IN THE NORTH OF THE EUROPEAN RUSSIA

Andreicheva, L. N.
Institute of Geology, Komi Scientific Centre, Ural Branch of RAS, Pervomaiskaya 54, RUS-167982 Syktyvkar, Komi Republic; e-mail: andreicheva@geo.komisc.ru

The section is situated on the left bank of the Seyda river, 35 km to the north of the mouth, on a sharp northward bend. We visited it together with John Inge Svendsen and Valery Astakhov in 1995. The Seyda section is about 500 m long and up to 30-35 m high. Roughly, the section includes 3 members. The stratigraphy upwards in succession is the following:

1. Lower complex of glacial sediments. It is represented by dark-grey boulder loam, unstratified, very compact, with very high content of coarse rock fragments. The contact with the overlying sediments is gradational. The total thickness from the river level is 8 m.

2. Complex of lacustrine-bog sediments.

1) Blue clay, unstratified, with rare rock fragments – 1.0 m thick.
2) Horizontal interbedding of brown-grey sandy loam with plant detritus and peat – 1.3 m thick.
3) Green loam with plant detritus, unstratified – 0.20 m thick.
4) Dark-brown peat – 0.10-0.15 m thick.
5) Snuff-green-coloured loam the same as in bed 3 – 0.65 m thick.

The contact with overlying sediments is sharp, horizontal.

150 m upstream (clearing no.2) the common thickness of lacustrine-bog sediments is 4.4 m. The bottom of this complex is situated 4.0 m high from the sloping beach, above the lower till. Blue-grey silt occurs on the base of the complex, its thickness is 2.0 m. The contact is horizontal, erosional. The silt is overlied by brown-grey sandy loam with fine plant detritus. The thickness of the sequence is 0.4 m. The contact is rolling. The overyling sequence is dark-brown and black peat with fragments of wood, crumbling in the lower part and foliating in the upper part. The thickness of the peat is 1.0 m. The peat is overlied by a unit of snuff-coloured sandy loam (0.3 m), fine-grained stratified sand (0.3-0.4 m) and muddy-grey silt (0.3-0.4 m). The unit is enriched in fine plant detritus.

3. Upper complex of glacial sediments. It is represented by dark-grey boulder loam, unstratified, dense, containing abundant pebbles and boulders – 22 m thick.

Till horizons have been studied by granulometric, mineralogic and petrographic methods. 75 samples for palinologic analyses were collected from the lacustrine-bog sequence.

Lower till. According to results of granulometric analysis of the lower till it is represented by typical unsorted mixed sediments with sorting coefficient 0.07. It is sandy loam, the average diameter of fine earth is 0.041 mm. The sediment is very compact, probably due to carbonate cementation, its content in the matrix makes up to 17.5 %. The petrographic composition is characterized by the predominance of carbonate rocks, they reach 41 %. The main mineralogic association of the lower till consists of epidote (25.2 %), pyrite (22.2 %) and siderite (17.9 %), the combined content of them make up 65 %.

Upper till. Granulometric analyses of the upper till showed that it differs from the lower till by a finer composition: the main diameter of the matrix is 0.020 mm. This till contains from 5.8 to 7.5 % of carbonate material in the cement. Perhaps, this is the reason why the upper till is less compact. The content of carbonate rock fragments is 26 % only. In comparison with the lower till, the content of igneous and metamorphic rocks is higher (about 28 %) versus 18 % in the lower till. In this group the Urals rocks have been recognized. In the mineralogical composition epidote (28.3 %), pyrite (14.6 %) and ilmenite (12.4 %) are predominant. The content of siderite is unsteady: 9.4-18.8 %.

Fabric analyses were carried out for both till horizons. It is not seen any essential distinctions between orientation of rock fragments in both upper and lower till horizons. Fabric analyses indicated predominating NE-SW orientation of clasts. But some features in petrographic, mineralogic and granulometric composition allowed to draw concluding about different source areas. The clasts from both the Novaya Zemlya and Urals source areas were found on the sloping beach. It suggests that there are two eroding till horizons of different origins.

35 samples from clearing no.2 in the interval from 4.0 to 8.5 m were studied by palynological method by Duryagina D. A. Six fossil pollen complexes reflecting phases of vegetation evolution during that period have been established.

I complex (the interval from 4.0 to 5.0 m). In a pollen composition of spectra the pollen of grass is predominant. It is represented mainly by *Cyperaceae*. Within the arboreal pollen shrub birch (*Betula sect. Nanae*) predominate. Treelike birch (*Betula sect. Albae*), pine (*Pinus silvestric*), alder (*Alnaster)* are of universal occurrence. The complex suggests tundra and forest-tundra existence during sedimentation.

II complex (the interval from 5.0 to 5.75 m). In comparison with the lower complex arboreal pollen is predominant in pollen composition here. But the portion of shrub birch is lower while the portion of treelike birch is higher. Spruce *(Picea)* pollen appears. The pollen spectra indicates a warmer climate. The territory was covered with taiga with rare broad-leaved species *(Ulmus, Carpinus, Corylus).*

III complex (the interval from 5.75 to 6.1 m). Pollen composition shows a decrease in the content of spruce (*Picea*) and treelike birch pollen (*Betula sect. Albae).* The contents of shrub birch (*Betula sect. Nanae*) and *Alnaster,* on the contrary, are higher. The complex reflects a relatively short cold climatic period. Forest-tundra with parts of forest was widespread.

IV complex (the interval from 6.1 to 6.5 m). Contents of *Betula sect. Albae*, *Picea, Pinus* pollen are increased, but the portion of *Betula sect. Nanae* is decreased. The complex suggests middle taiga conditions.

V complex (the interval from 6.5 to 7.4 m). The arboreal pollen (*Pinus, Picea, Betula sect. Albae*) dominates. Pollen of exotic (*Picea sect. Omorica*) and broad-leaved species (*Ulmus, Carpinus, Corylus*) is observed. The complex corresponds to southern taiga with rare broad-leaved and exotic species.

VI complex (the interval from 7.4 to 7.8 m). The share of *Picea* is reduced, but *Betula sect. Nanae* is increased. The complex indicates beginning of a climatic cold period. The area was covered with northern taiga.

Thus, in the lacustrine-bog sequence of the Seyda section, two warm periods (complexes II, IV and V) separated by a cold snap period (complex III) have been recognized. The established variation of the spore and pollen spectra reflects regular vegetation and climatic changes during the interglacial. Similar vegetation and climatic changes with two climatic optima, separated by a cold snap period are typical for both Chirva and Rodionovo interglacials. We suppose this flora belongs to Rodionovo because it is characterized by a more xerophile composition in comparison with Chirva interglacial. Besides, a typical feature of Rodionovo diagrams is a higher content of pollen *Pinus, Betula, Chenopodiaceae, Artemisia* pollen in comparison with Chirva diagram.

Thus, according to the obtained date, we suggest the following:

1. Two till horizons with different lithologic composition were established in the Seyda section. Pre-Quaternary bedrocks are represented by a complex of the Lower Permian limestones, dolomites, marls, carbonate sandstones. This is the reason why the lower till is enriched by carbonate materials of the entire granulometric spectrum. The Lower Permian rocks are widespread in this region. High pyrite and siderite contents, perhaps, are connecting with the Permian sediments, too.

2. The lacustrine-bog sediments have typical palinological spectra indicating the Rodionovo interglacial.

3. The upper till is characterized by a higher content of igneous and metamorphic rocks. Inside this group the Polar Urals rocks have been recognized. The till mays be correlated with the Vychegda till of the Lower Adzva. The influence of the rocks of the Chernyshev Ridge is necessary to take consideration.

THE WEST-EAST CLIMATE GRADIENT IN GLACIAL HISTORY OF EURASIA

Astakhov, V.
St. Petersburg University, Faculty of Geology, Universitetskaya 7/9, RUS-199034 St. Petersburg, Russia; e-mail: val@nb15514.spb.edu

(1) The west-east climate gradient, a well-known feature of the Eurasian landmass, is the cornerstone of the concept of latitudinal asymmetry of Pleistocene glaciation (Gerasimov & Markov, 1939; Velichko, 1980). Other authors ignored this peculiarity, trying to reconstruct Eurasian glaciation based on the North American and west European models (e.g. Grosswald & Hughes, 2002). Hard geological evidence is indispensable for resolving the dilemma. Such evidence was collected in 1993-2004 by Scandinavian, German, American and Russian scientists collaborating in Arctic Russia under the European umbrella program QUEEN (Quaternary Environments of the Eurasian North). Stratigraphic studies in key sections on the dry land and sea floor yielded about two thousand luminescence, radiocarbon, ESR, U/Th datings that allowed to geochronometrically correlate Late Pleistocene glacial events across the continent from Scandinavia to the Lena river (Svendsen et al., 2004). The striking difference in the mode and timing of glaciations in Siberia as compared with the Atlantic seaboard strongly supports the asymmetry, although the Weichselian ice sheets by QUEEN differ significantly from the reconstruction by Velichko et al. (1997). At any rate it became clear that the Atlantic glacial history is not a good model for the world largest continent.

(2) According to the new data Late Pleistocene ice sheets which grew upon the arctic shelves from Taimyr to Timan expanded southward to reach their limit along the Arctic Circle as early as the late MIS 5 ca 80-90 kyr BP. The northeastern terrains, open to the Arctic Ocean, were first to experience the cooling impact of the Ice Age. The next, less extensive, ice sheet that culminated ca 60 kyr BP was largest in the Arkhangelsk region (Larsen et al., 2006). With the increasing continentality through the glacial cycle, i.e. precipitation progressively diminishing along with temperature, Arctic and Siberian ice sheets were waning. By MIS 2 the deeply frozen Arctic and Subarctic were already so dry that glaciers could not survive even in the mountains. E.g., in the Verkhoyansk Range no moraines younger than 50 kyr have been found (Siegert et al., 2006), whilst on the humid Atlantic seaboard the Scandinavian glacial system was growing to reach its peak ca 20 kyr BP. In Western Europe this trend is perceived as a result of progressive cooling. In terms of the entire continent the leading feature of glacial history is the growing aridification of the northern margin. The Late Weichselian ice sheet may be considered as a byproduct of such development that resulted in the lopsided glaciation restricted to the westernmost Eurasian margin. The ice barrier that grew in Scandinavia and on the western Barents Sea shelf must have amplified aridity of the continent.

(3) The W-E gradient is detected in the deglaciation pattern as well. The continental climate and thermal inertia of the deeply cooled Siberian lithosphere led to retarded deglaciation and preservation of fossil glacial ice in the Arctic for tens of kyrs (Kaplanskaya &Tarnogradsky, 1986; Astakhov&Isayeva, 1988). In contrast, thin-skinned permafrost in the Atlantic realm was an ephemeral feature which only sporadically affected glacier behaviour. The short-lived marginal permafrost could not impede the fast deglaciation during Atlantic terminations.

(4) The structure of interglacials is more mysterious, but the strong W-E gradient is evident in warm intervals as well. E.g., the number of known Eemian terrestrial organic deposits, ubiquitous in Western Europe and in central Russia, persistently decreases eastwards. Between the Urals and Yenissei only 3 or 4 Eemian peat lenses are known, whereas the Holocene

peatlands occupy about 400 thousand square kilometers in West Siberia. The rarity of interglacial peat deposits in Siberia cannot be explained solely by the scarcity of investigators, since there is no lack of marine interglacial sites.

(5) The pattern of the Weichselian glacial history taken as a model suggests that ice sheets of previous Pleistocene cycles probably also culminated earlier in the Russian Arctic than in Western Europe. During each cycle the bulk of glacial was gradually shifting westwards. The trend of the westward migration of ice dispersal centres can be used for stratigraphic correlations. E.g., it may account for the well-known fact of no Cromerian tills in Western Europe, whereas the Don glaciation, fed by the growing arctic ice domes, reached the southern drift limit of the Russian Plain already during MIS 16. On the other hand, it seems erroneous to assume a synchroneity of spatially disconnected ice sheets of Eurasia and sum up their volumes to account for the magnitude of the eustatic fall of sea level. Deficient glacial ice needed to balance the global hydrological equation should better be sought elsewhere, probably in the Antarctic and America.

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PECULIARITIES OF THE ENVIRONMENT AND DEVELOPMENT OF VEMBŪTAI PLATEAU AND HILL FORT, WESTERN LITHUANIA

Baltrūnas, V., Karmaza, B., Stančikaitė, M., Pukelytė, V.
Institute of Geology and Geography T. Ševčenkos 13, LT-03223 Vilnius, Lithuania; e-mails: baltrunas@geo.lt, karmaza@geo.lt, stancikaite@geo.lt, pukelyte@geo.lt

Surroundings of Vembūtai plateau with a hill fort situated on the southern part of the Samogitian Heights were formed by the Baltija Stage of the Late Weichselian (Nemunas) Glaciation what had left a hilly moraine as well as kame and plateau relief (Guobytė, 2004, Lietuvos…, 2005). The body of the Vembūtai plateau was formed in a cavity of the melting and cracky glacier. Later on, layers of the very fine grained sand and silt were deposited in a dammed lake covering undulating till surface as an uneven layer (Fig. 1).

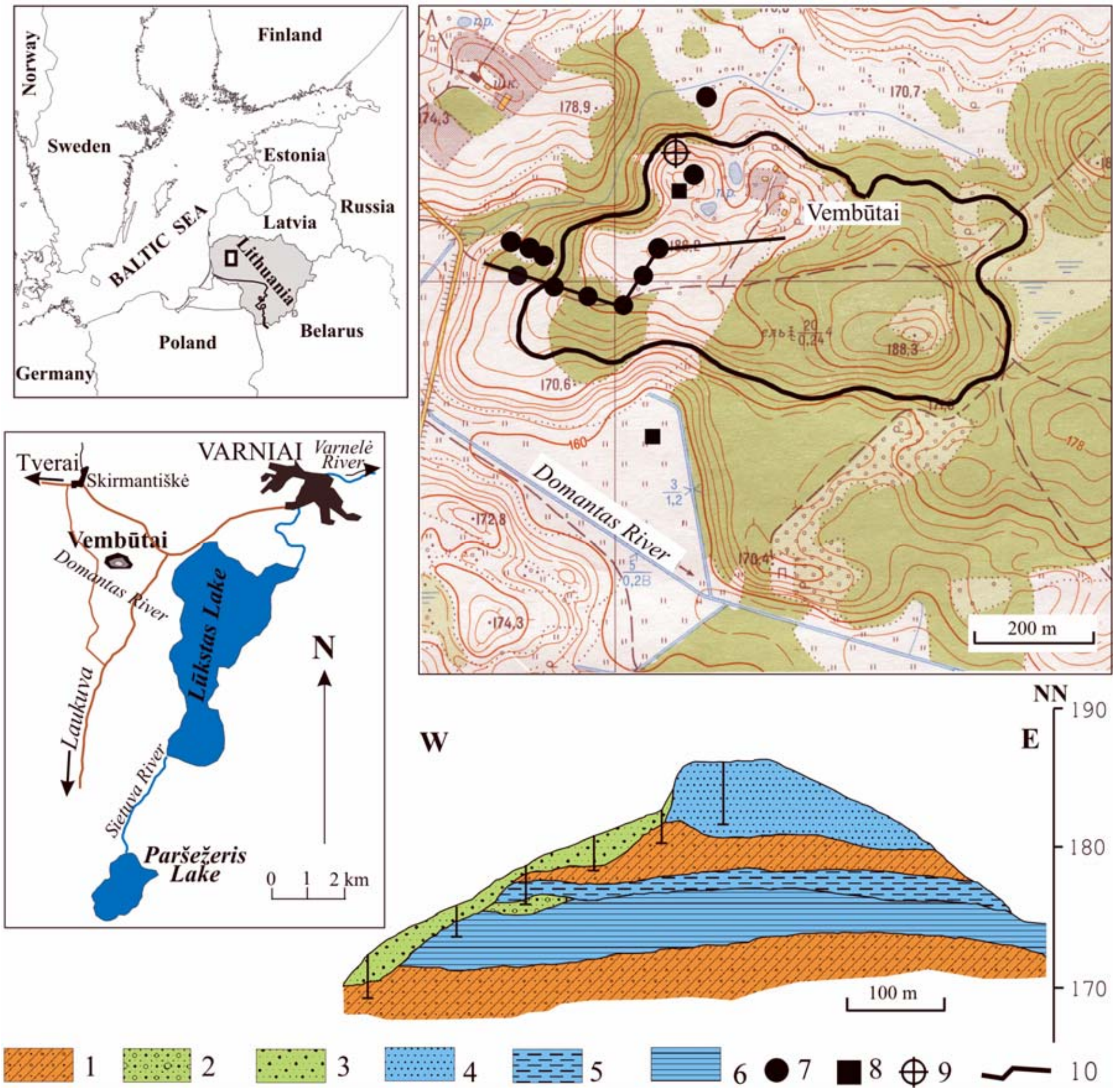

Fig. 1. ***Vembūtai plateau and its internal structure. 1 – clayey and sandy loam, 2 – sand with gravel, 3 – various grained sand, 4 – very fine grained sand, 5 – silt, 6 – clay, 7 – borehole, 8 – test-pit, 9 – Vembūtai hill fort, 10 – line of the geological cross–section***

Afterwards plateau was influenced by the abrasion and accumulation processes caused by the periglacial basins dammed by the retreating glacier. Till beds enriched by rubbles are exposed on the north-western part of the plateau and slopes. Numerous stones and boulders were used for building, defence and cult-related purposes. The northern, eastern and a part of the southern slopes with a plain terraces on the foot where glaciolacustrine level stretches at about +168-+172 m NN reach about 10-15 m in high. Glaciolacustrine level lying at about +160 m NN and crossed by the Domantas rivulet surrounds the south-western slope.

By the means of pollen analysis the composition of the flora was determined. Results of palynological investigations show the minor impact of the human activity dated back to the last millennium. The earlier changes of flora composition had been induced by variations of the climatic conditions only.

Pollen data indicates the composition of the vegetation cover existed in the surroundings of Vembūtai hill fort during the last two thousand years. Radiocarbon data indicates the onset of the sediments formation around the Birth of Christ (Ki-11399, 1980±60 ^{14}C BP, 119BC- AD133) when a dense forest with the remarkable portion of alder (*Alnus*) and hazel (*Corylus*) flourished in area. Such composition of the forest may have been determinated by the wet habitats predominated in the territory under investigation. Low representation of the deciduous trees could be related with the restricted distribution of the fertile soils that, generally, coincides with the geological situation of the area. Simultaneously, number and variety of shrubs and herbs was very low, most probably these occupied shores of the investigated basin.

Subsequent composition of the pollen spectra indicates remarkable changes of the vegetation cover where pine (*Pinus*) and later spruce (*Picea*) gain more ground. Similar changes registered in many pollen spectra all over the western Lithuania took place at the transition from the first to the second millennium AD. As the sings of the human interference, including agriculture activity, are very scarce, registered variations of the vegetation cover were initiated by the climatic factor most likely. Sporadic occurrence of the *Chenopodium*, *Artemisia* and Brassicaceae pollen may be related with the local disturbances of the soil layer then with the systematic activity of the population.

The last stage determinated in the pollen diagram shows intensive destruction of the forest cover and formation of the open landscape with agriculture fields. Human activity is confirmed by the continuous appearance of the cereals (*Cerealia*) and ruderal taxa together with the species typical for the open meadows and pastures where Cyperaceae flourished on the wet plots. Predominance of the pine (*Pinus*) pollen in spectra could be related with the long-transport origin of the pollen grains confirming the predominance of the forest free areas in adjacent vicinities to Vembūtai hill fort.

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DILATANCY IN UNCONSOLIDATED SEDIMENTS

Bruj, M.
Polish Geological Institute, Rakowiecka Str. 4, PL-00975, Warszawa, Poland; e-mail: Malgorzata.Bruj@pgi.gov.pl

Dilatancy, described and defined firstly by Reynolds (1885), plays a significant role in the course of deformation process in unconsolidated sediments. On the basis of ten types of dilatancy designed as A – J, by Brodzikowski (1981), there are presented examples of this phenomenon observed at Bełchatów Quarry (central Poland).

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HOLOCENE PALEOGEOGRAPHY RECONSTRUCTION OF THE UPPER VYCHEGDA RIVER DEPOSITS

Buravskaya, M. N., Golubeva, Yu. V.
Institute of Geology of Komi Scientific Centre of Ural branch of Russian Academy of Sciences, Pervomayskaya 54, RUS-167982 Syktyvkar, Russia; e-mails: buravskaya@geo.komisc.ru, bratushchak@geo.komisc.ru

The Vychegda River is the main right tributary of the Northern Dvina River and flows from the west to the east. It is 1.130 km in length and the basin area is 121.000 km^2. The source of the river lies on the South Timan Ridge between 200 to 300 m above sea level. The basin is densely forested and swamped hilly plain.

Erosional and accumulational processes control the evolution of the Vychegda River valley. They are characterized by river erosion of rocks, material transportation and accumulation of alluvial strata. In Vychegda River basin the complex of such processes can be commonly found. Denudation relief forms are formed together with accumulation relief forms. The Holocene alluvial sediments build up a high flood plain, a low flood plain and the first terrace. Channel, flood plain and oxbow facieses are observed in composition of the alluvial strata.

The channel facies (channel shoal facies) sediments accumulate directly in river bed and on spits in consequence of lateral migration of meandering stream during high waters. In overflowed river bed the speed of river stream increases and transversal circulation flows reach their most intensity. The water subsides to the bottom of undermined bank, which the line of river race depressed to, contributing to river erosion and retreat of the concave shore. From here the water reflows to the opposite bank. Dragging a part of fragmental products to the inner bank, where this products accumulate due to decrease of stream speed. The channel facies sediments comprise light-gray horizontal-bedded medium and fine-grained sand (fraction content is 88.1 %). Psephytic material occurs rarely and the sediments are fine (Sc=0.75 when d_{cp} tends to 0.108 mm). Structures are sharp stratified. Diagonal, agitation ripple and current ripple beddings dominate.

Palynological study and radiocarbon dating are used for sedimentation time determination of channel alluvium. Humic material from interlayer of channel alluvium is studied. The results indicate the dominant role of tundra vegetation. Probably, pollen sequence shows periglacial vegetative complex in the Late Drias (DR-3). This suggestion is confirmed by radiocarbon dating (10 370±90 years BP).

Usually channel sand are overlied by flood plain alluvium, which is formed during high waters and composed of loam, aleurite, not often by sand. Sediments are dense with horizontal bedding and gentle wave-like lamination presented by alternation of sandier and loamy interbeds with rhythmical seasonal pattern. Deposits are middle graded (Sc=0.6 with d_{cp}=0.09 mm). Upper flood plain layers are pierced with plant roots and revised by soil processes. The main factors of sedimentation are that gradual reducing of stream speed during high waters contributes to settling of sandy material and suspended sediments.

Formation of oxbow alluvium takes place in water body isolated from main river bed and which is formed during high waters. In upper Vychegda valley two types of oxbow-lake can be identified: oxbow-lake-meander and oxbow-lake-watercourse. Oxbow-lake-meander deposits accumulate in separated lake as a result of cutoff. Sedimentation of oxbow-lake-watercourse deposits occurs in shallowed watercourse, which is formed as a result of changing of river stream regime. The oxbow-lake composition is similar to lake composition. The oxbow-lake deposits are abundant with organic material dark brown muddy sand, loam and sandy loam, sometimes crowned with peat. Deposits are nongraded (Sc=0.30 when d_{cp}=0.053 mm). Oxbow-lake alluvium forms lenses and occupies intermediate position between channel and flood plain deposits.

Determinate variations of granulometric composition through the alluvium section allow characterizing sedimentation conditions. Formation of channel alluvium facies occurs in consequence of maximum water power. Periodic high waters are sedimentation conditions of flood plain alluvium. The main condition for oxbow-lake alluvium formation is lake condition occurring in swamped drainless water bodies.

WATER CHESTNUT TRAPA NATANS MACROFOSSILS AND POLLEN FROM PLEISTOCENE INTERGLACIAL AND HOLOCENE DEPOSITS IN LATVIA

Cerina, A., Kalnina, L., Zvagina, I.
University of Latvia, Raina Blvd. 19, LV-1586 Riga, Latvia; e-mails: Aija.Cerina@lu.lv, Laimdota.Kalnina@lu.lv, ivetazv@inbox.lv

Waterchestnut *Trapa natans* is rare and endangered species, which has been preserved just in the three lakes in Latvia until nowadays. The growing conditions and development of this plant has been studied both in the past (Gilbert M., 1939; Apinis, 1940) and nowadays. The Pokrata Lake is the northern limit of the distribution of the waterchestnut. Vegetation studies have been done in Pokrata Lake during 2004. The plant societies with *Trapa natans* have been located on the muddy ground in the depth of 0.8-1.5 m. Waterchestnut usually is dominating species and frequently forms pure stand. The latest palynological data from the Pokrata Lake demonstrate that *Trapa natans* in this lake grew since the Late Atlantic Time (Zvagina et. al., 2005). Number of pollen changes in the sediment sequence. Essential decrease or even disappearance has been observed in several intervals. The last one has been noted at the depth 32 cm and probably can be related to the „Little Ice age" during Medieval Time.

The fruits and fragments of the *Trapa* have been found in the Pleistocene interglacial sediment sequences, but only in the western part of Latvia: Pulvernieki (Holsteinian) Pulvernieki section No. 7 and Jaunskieri outcrop (Cerina, 1999), as well as in Eemian interglacial sediments of the Satiki section (Kalnina et al., 2004).

Finds of the waterchestnut remains in the Stone Age settlements are of interest of archaeologists as important food resource (Past human..., 2004).

The fossil *Trapa* fruits in the Holocene sediments have been found in the Stulve Lake peat (Valters, 1926) and in gyttja of the Gipka lagoonal Lake (Galenieks M., 1928). On large amount of gathered *Trapa* fruits from the Sarnates Stone Age settlement have been reported by the archaeologist E. Sturms (Gilbert, 1939).

According paleobotanical data the waterchestnut grew in the Holocene since the beginning of the Atlantic Time. *Trapa* sp harpoon has been found in the 10th sample of the Zvidze settlement cross section (1982, place B, A profile, Kv. e), but in the 11th sample from the same section - 5 nut fragments. The depth interval of the samples 10 and 11 correspond to the interval of pollen zone AT1 divide by I. Jakubovska (Jakubovska, 1998), where pollen of *Trapa natans* have been found. Both charred and fossil *Trapa natans* nut shells have been found in the samples from the Zvidze settlement cross section. There was found large number of seeds, which were not only burned but also mineralised with limonite and gypsum. Therefore, it was necessary to analyse also heavy (submerged) plant macroremain fraction.

Since cultural layer has been formed on the gyttja and grass peat in the coastal area of lake, it is very difficult to determine: are no charred *Trapa* nuts remains gathered by people or were growing in the lake during sediment formation. The only charred *Trapa natans* nuts is clear evidence of the gathering and used for food, which remains have been found in several settlements - Zvidze, Abora I, Piestina and Abora in Lubans Plain (Jakubovska, Loze., 1982).

The cultural layer of the Ica settlement has been formed on the sandy sediments at the small island, therefore both remains of charred and fossil *Trapa natans* nuts found at the settlement can be considered as resource for food. The number of no charred nuts remains is 4 - 5 times larger than charred, but water chestnut was not growing on the island. It seems that nuts have been gathered from the lake nearby.

Plant macroremains, including Trapa natans has been studied also in the sediments from the Littorina Sea lagoonal sediments at the Purciems. The charred remains have been found in the Stone Age settlement sediments from the lagoon shore. The remains of the Trapa natans fruits from the archaeological excavations from the 1950ties have been studied also from the collections of the National History Museum of Latvia.

The first special studies of the Trapa natans pollen have been carried out in the Gipka lagoonal sediments by A. Presnikova (Presnikova, 1956). Since that time waterchestnut pollen have been found in the large number of lake sediment sections throughout Latvia. Trapa natans pollen have been found in almost all sections of the Stone Age settlements at the ancient Lubans Lake area, where studies have been carried out in the collaboration with archaeologists. It is very important to carry out pollen studies in the undisturbed lake sediments with aim to clear time of the distribution of the waterchestnut in the lake. Such investigations have been carried out in the areas of ancient Lubans and also of Burtnieks Lake close to the important Stone Age settlement Zvejnieki (Kalnina, 2006). There were found also Trapa natans macroremains during investigations in 2006.

Pollen of Trapa natans has been found in the sediments of Lielais Mire, where shallow lake bays existed during the Atlantic Time. Sphagnum-Scheuchzeria peat started to form during the Subatlantic Time in this former bay of the Lubans Lake. The pollen of Trapa natans have been found in almost all sections from the Lubans Lake former area (Malmuta Mouth, Eini settlement etc.). Trapa natans pollen have been found in the deepest basin sediments (Eini Lake) formed during the Late Atlantic Time and beginning of the Subboreal.

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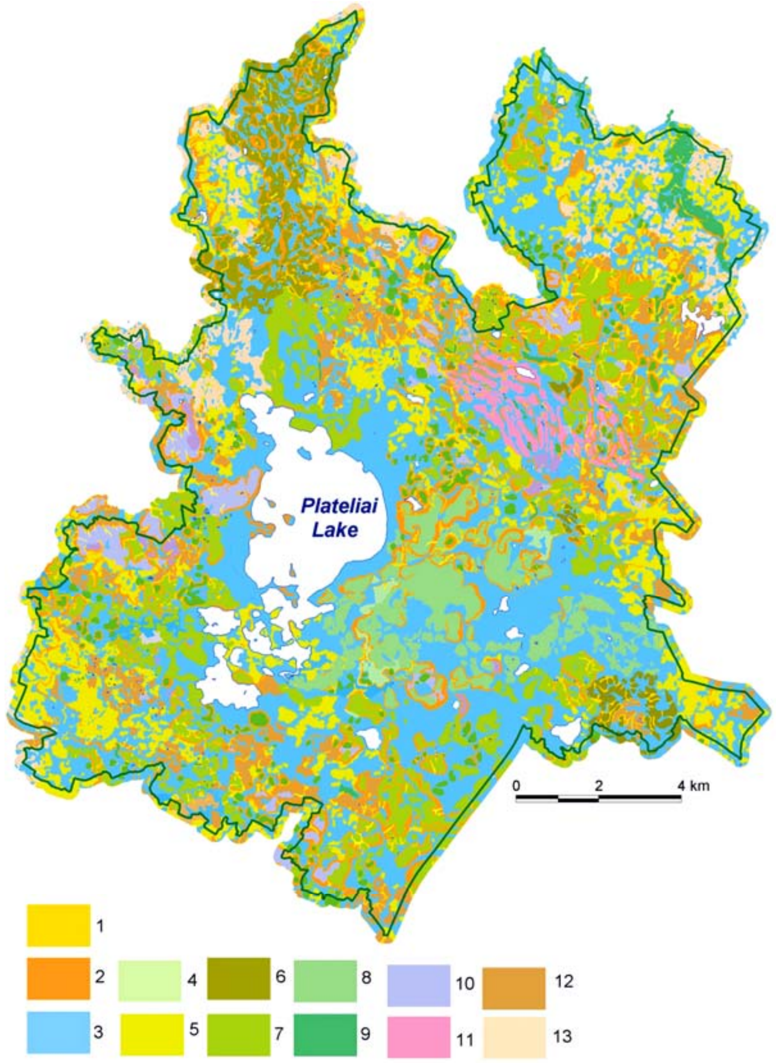
THE MISTIC "BURBOT'S CITY" IN THE PLATELIAI LAKE: UNDERWATER OUTCROP OF INTERGLACIAL SEDIMENTS

Damušytė, A.[1], Guobytė, R.[1], Grigienė, A.[1], Šeirienė, V.[2]

[1]Lithuanian Geological Survey, S. Konarskio 35, LT-03123 Vilnius, Lithuania; e-mails: aldona.damusyte@lgt.lt, rimante.guobyte@lgt.lt, alma.grigiene@lgt.lt

[2]Institute of Geology and Geography, T. Ševčenkos 13, LT-03223 Vilnius, Lithuania; e-mail: vaida.seiriene@geo.lt

The Plateliai Lake is situated in northwest Lithuania, in the Žemaičiai Upland. The present lake occupies an area of 1200 hectares of the surface depression in the Plateliai glacioelevation and is the largest one in Žemaitija. Post-glacial Lake Plateliai (Fig. 1, coloured in blue) had occupied a wide depression between the plateau-like hills, glaciofluvial massifs and kames.



Legend: *1– ravine, dry valley, 2 – slopes, 3 – post-glacial lakes, 4 – glaciofluvial plain, 5 – glaciofluvial hills, 6 – glaciofluvial massifs, 7 – glaciofluvial kames, 8 – kame massifs, 9 – eskers, 10 – plateau-like hills, 11 – end moraine ridges, 12–13 – hummocky moraines*

Fig. 1. ***Palaeogeographical map of post-glacial Lake Plateliai***

Archaeologists of Klaipėda University (KU) under the guidance of V. Žulkus have studied the Plateliai lakehores and islands. New data was obtained from the recent underwater investigation of the lake bottom. In 2003 layer of gittja, named "the town of burbots", was discovered by the archaeologists-divers (leaded by diver-instructor V. Krisikaitis) on the slope of Nalija deep, 18–24 m depth. Three sites on the lake bottom were sampled for the palaebotanical study: 1st site in the Nalija deep, depth 20–24.2 m, 2nd site at a depth of 20–25.5 m, and 3rd site at the Pilis Island, 16.0–20.0 m depth (Fig. 2).

The sequences were investigated by the means of pollen and spores analysis. Pollen analysis was performed on 23 samples of gyttja from the site 2, on 13 samples of silt from the sequence from the site 1 and three samples from the site 3 sequence.

Results of pollen survey. **Site 2:** Sediments are rich in pollen. *Pinus* (pine) pollen comprises some 55 %, *Picea* (spruce) reaches up to 10–25 %. The percentage values of broad-leaved trees are low, except *Quercus* (oak) (up to 13 %). Herbaceous pollen constitute 5–7 %. Spores of *Osmunda* were noted.

According to palinological data gyttja were accumulated in posttemperate stage of the Merkinė (Eemian) Interglacial.

Site 1. The pollen frequence is low. Three local pollen assemblage zones (LPAZ) have been distinguished in the pollen diagram.

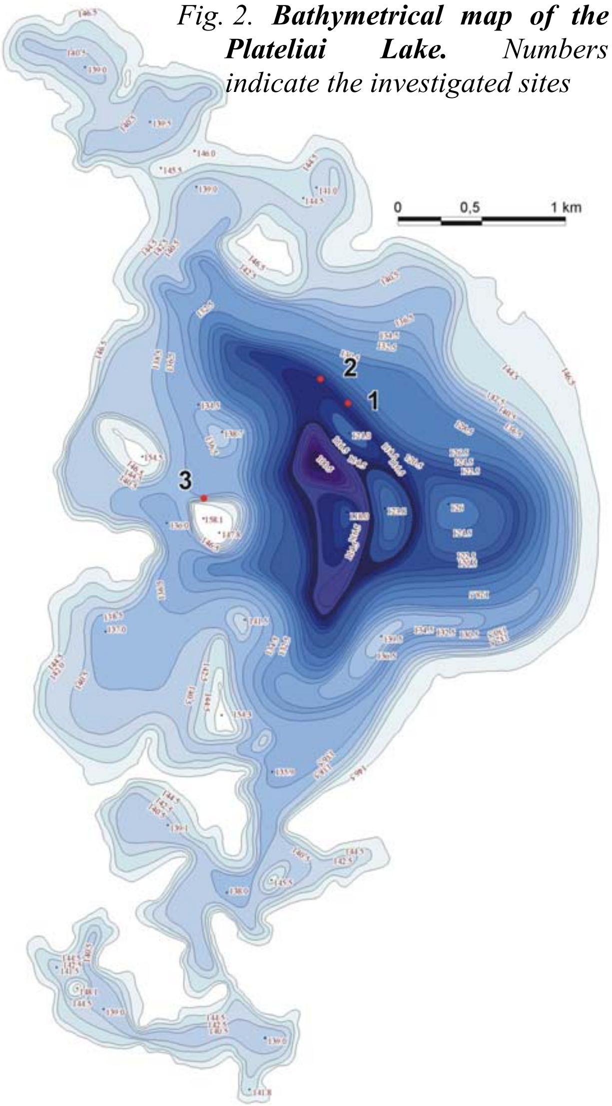


Fig. 2. ***Bathymetrical map of the Plateliai Lake.*** *Numbers indicate the investigated sites*

1. *Picea–Quercus* LPAZ (24.20–24.05 m): only one sample represents this zone. *Picea* (spruce) constitutes 15 %, *Quercus* (oak) occurs at about 10 %. *Alnus* (alder) is also represented by high frequencies. A few spores of *Osmunda* were noted.

2. *Pinus–Artemisia* LPAZ (24.05–21.80 m): the percentage values of herbaceous pollen increase and reache up to 20 % of the total pollen sum. *Artemisia* and Chenopodiaceae predominate. A few pollen grains of *Helianthemum* were identified as well as spores of *Botrychium* and *Lycopodium selago*. *Betula nana*-type appears with 3 %.

3. *Pinus* LPAZ (21.80–20.50 m): the herb values drops down and the percentages of tree pollen increase. *Pinus* (pine) pollen show a clear maximum forming up to 90 % of the total sum.

The development and changes of the vegetation cover show that the silt was accumulated during the end of the Merkinė (Eemian) Interglacial and Early Weichselian stadial / interstadial.

The pollen composition from sequence **Site 3** is similar to that indicated in Nalija deep.

Results of diatom survey. **Site 2.** Freshwater diatom complex consisting of 81 taxa was identified in the sediments studied. Diatom composition is not very changeable throughout the section. Epiphytic and benthic species prevail in the sediments that are consistent with shallow water conditions. Species of *Fragilaria* genus (*Fr. construens*, *Fr. pinnata, Fr. leptostauron* var. *martyi*) are the most abundant among epiphytic ones. Most of them have high requirements for oxygen and dissolved mineral materials. High content of benthic species (up to 40 %) indicates good transparency of the water. Slightly rising water level was registered at 22.5 and 24.3 depth, were plankton species such as *Aulacoseira granulata, Cyclotella radiosa*, *Stephanodiscus rotula* and etc. appear. The presence of brackish-fresh water species e. g. *Cocconeis disculus, Mastogloia smithii*, *M. smithii* var. *lacustris* points on the higher content of dissolved chloride or some input of brackish water. In the uppermost part of the section the increase in acidophilous *Navicula jarnefeltii* is noticed. It might be related with slight acidification of the water or the beginning of overgrow of the lake. Most species identified are strict to nutrients, oxygen and calcium. The continuous presence (~10 %) of north-alpine species reflects cold water conditions.

Concluding, the diatom record indicates the sedimentation in freshwater mesotrophic-eutrophic lake with low water level. No stratigraphicaly significant species were recorded in the sediments.

Acknowledgemets: We are very grateful to persons who helped us to take samples from underwater outcrops: V. Krisikaitis, V. Žulkus, A. Malinauskas, A. Krisikaitis, G. Žilinskas, A. Žigeu, B. Drungilas, M. Andriulis, R. Polovcevas, Ž. Soraka.

SEDIMENTATION CONDITIONS OF THE UPPER DNIEPER VALLEY IN THE LATE GLACIAL AND HOLOCENE (ORSHA-ROGACHEV PLOT, BELARUS)

Drozd, A., Badiay, V.
Institute of geochemistry and geophysics NAS of Belarus, 7 Kuprevich str., BY-220141, Minsk, Belarus; e-mails: drozd@igig.org.by, badiay@igig.org.by

The formation of the Upper Dnieper valley occured in a different geodynamic and paleogeographic conditions. They changed during upper Oligocene – Quaternary more than once. A local sedimentation conditions were connecting with features of a geological structure, relief and climate, so each of them correspond to appropriate alluvial series. Receiving geological and palynological data allow to generalize vast materials of study this type of sediments in the Upper Dnieper valley on a plot from Dybrovno up to Rogachev during Late Glacial and Holocene.

Late Glacial alluvial deposits submitted by fine-grained sand, aleurite, sandy loam, loessial loam. They were uncovering in sections Kobeliaki, Selische, Zabolotie et. al (Yelovicheva, 1995, 2001; Drozd, Yelovicheva, 2003). The investigated deposits include layers poor by pollen and layers with abundance of macrofossils. Rarefied vegetation (grassy associations with prevalence of Chenopodiaceae, Poaceae, Artemisia, Cyperaceae etc.) developed on the initial Late Glacial stage. Later it has replaced by rarefied birch woods with a fur-tree and pine, rare arctboreal and steppe flora elements. The taiga vegetation with mesophilic and thermophilic species has received wide development in the end of the Late Glacial. At this time there was a change of the braided Dnieper channel on a meandering once. The rests of multichannel Dnieper were investigated near Shklov. They are located at a first terrace level (Kalicki, 1999; Badiay, 2006).

Holocene is important paleogeographic boundary. It characterized by the increase of warm and humidity. It has caused radical changes of natural conditions of region. It is subdivided on early (PB, BO), middle (AT, SB) and late (SA) stages. The sediments of Early Holocene are met in sections Zabolotie, Buroje, Adrov, Malaya Aleksandriya, Staraya Trosna (Yelovicheva, 1995, 2001; Drozd, Yelovicheva, 2003) etc. They submitted by sand, sandy loam, loam and peat. Birch, pine, mixed pine-birch and birch-pine woods with a fur-tree and broad-leaved species received mass development in landscapes during Early Holocene.

The sediments of the Middle Holocene are met in sections Zabolotie, Buroie, Adrov, Malaya Alexandria, Kholstov (Yelovicheva, 1995, 2001; Drozd, Yelovicheva, 2003; Drozd, 2004). They are submitted by peat, sand, sandy loam, loam. The beginning of a stage coincides with climatic optimum and characterized by universal development of broad-leaved woods in all researched territory, which once have replaced pine, mixed pine-birch and birch-pine woods with broad-leaved species, alder and nutwood at the end of the stage.

The deposits of the Late Holocene are met in sections Zabolotie, Buroie, Adrov, Malaya Alexandria, Malinovka, Kholstov (Yelovicheva, 1995, 2001; Drozd, Yelovicheva, 2003; Drozd, 2002, 2004). They are submitted sandy loam, sand, peat. At this time wide development have received coniferous (fur-tree), pine, mixed pine-birch and birch-pine woods with broad-leaved species, alder, nutwood. There is a pollen of cultural plants in associations of grassy vegetation. The role of grassy groupings in landscapes grows.

So, it is know that the formation of sandy deposits occurred in Late Glacial. At this time, there was an intensive outflow of melted glacial waters by the Upper Dnieper valley. The heightened erosion and glacioisostasy movements have resulted in destruction of considerable amount of Lower and Middle Pleistocene alluvial sediments of the Dnieper.

In the beginning of the Holocene the hydrological regime of the Upper Dnieper was fixed at a level close to modern. Normal sedimentation with prevalence of lateral channel migration has received development. Therefore, aleurite, sandy loam, loessial deposits accumulated in the Dnieper valley. The marsh processes also received development in the beginning of Holocene. However, gradual increase of humidity together with tectonic movements has resulted in rise of a water level in the Atlantic period and increase of intensity of erosive processes. The sandy deposits collected primarily at this time. They were uncovering in a number of sections, but do not contain vegetative microfossils. The stabilization of the described processes has taken place already by the end of Middle Holocene, that is proves by accumulation of sandy loam and loam. Peat formatted on the Late Holocene stage, which were replace by modern soil processes.

The publication is prepared within the project X06M-154 of BRFFR.

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APPLICATION OF MACROSCOPIC IDENTIFICATION METHODS OF INDICATOR ERRATICS TO LOCATE SOURCE AREA OF ŁUKÓW JURASSIC GLACIAL RAFTS

Gałązka, D.
Polish Geological Institute, Rakowiecka 4, PL-00975 Warsaw, Poland; e-mail: dariusz.galazka@pgi.gov.pl

Despite the long-term research designed to explain the origin of Callovian rafts in numerous glacial rafts, to date their alimentation area has not been identified unambiguously. Recently, an attempt was undertaken to define the transgression directions of continental glaciers responsible for the transport of Jurassic rafts, using the method of macroscopic petrographic analysis of indicator erratics (Gałązka, 2004) from the boulder clays accompanying the rafts of Jurassic sediments. The Jurassic rafts in the area of Łuków (as many as 5!) are the largest and best known. The ammonite shells have been preserved in the smallest detail; their colour is natural and their chemical composition has not changed. According to Ruszczyńska-Szenajch (1976), the exceptional dimensions of Łuków rafts and the delicate fauna remains perfectly preserved in them and practically intact are evidence to the transport of Callovian clays by the continental glacier in a frozen state.

New geological investigations of the bottom of the Baltic Sea – an area from which, theoretically, the Jurassic sediments occurring in Łuków rafts could have originated (Kramarska, 1999) – indicate a much smaller range of the occurrence of Jurassic sediments north of the Gulf of Gdańsk than the one suggested several years earlier (Ziegler, 1990). The main area of their occurrence is delineated from the north by the 20^{o} meridian (in older studies, it reached as far as the 18^{o} meridian); hence, most probably, the source area of Callovian rafts is rather situated in Northern and/or Western Lithuania. Indeed, in the Pleistocene the range of the outcrops of Callovian rafts must have been different from the present one; however, since Cretaceous sediments were found to lie directly in the basement of Quaternary sediments in the area of the Gulf of Gdańsk (Kramarska, 1999), outcrops of Jurassic rocks cannot have existed in this area in the Pleistocene. One of the probable source areas of Jurassic clays occurring in glacial rafts was already localised by Jentzsch (1900), who described the drilling profiles in the area of Klaipėda (*ger. Memel*) with Callovian clays of the *lamberti* zone. Their colours vary from black and brown to dark grey and they include numerous ammonite remnants, e.g. *Quenstedtoceras lamberti, Cosmoceras* sp., belemnites, snails, foraminiferans, corallites and molluscs. The thickness of the *lamberti* zone varies from 2 to even as much as 51 m. They underlie directly Quaternary sediments, which reach in this area the maximum thickness of 80 m. Jentzsch (1900) noted distinct similarities between the formation of sediments in the area of Klaipėda and the stratotypic site at Papilé. The most recent descriptions of the Jurassic sediments at Papilé known to the Author come from 1991 (Paškevičius, 1991). The layers denoted by symbols **q, r, s1** (Paškevičius, 1991), with their thickness reaching only 2.1 m, were included in the *lamberti* zone.

Comparison of the determinations performed for the indicator erratics from sites in the area of Łuków with the results of analysis carried out in Belarus (Astapova, 1993; Astapova, Vinokurov, 2001; Halicka, 1986; Halicki, 1939; Jaroszewicz-Kłyszyńska, 1938; Szempel, 1979) indicates that the only element which can contribute to localising the alimentation area of Jurassic rafts is the presence of erratics from Smäland (Southern Sweden) in a glacial tills co-occurring with Callovian clays in the area of Łuków. This fact unambiguously indicates the advance of the ice sheet through the Mazurian ice stream and, thereby, the area of Klaipėda as the source area of the Łuków Jurassic rafts. The area of Papilé, within the impact zone of the Riga ice stream, must be excluded as the source area of Łuków rafts, since to date Southern

Swedish indicator erratics have not been found in the glacial sediments of the last three glaciations within the range of the Riga glacial globe.

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NEOTECTONIC FAULTING EXPRESSED IN THE QUATERNARY LANDSCAPE IN DENMARK

Jakobsen, P. R.
Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350 Copenhagen K, Denmark; e-mail: prj@geus.dk

Morphological indications of tectonic activity within the glacial landscape was pointed out by Milthers (1916, 1948), as he described and interpreted conspicuous valley systems in Central Jylland as fault generated features. He named the most pronounced valley system the Hvorslev valleys, after a local village, and he classified them as crevasse valleys. The systematic geological mapping of the area and a re-interpretation of a seismic line crossing the valley system have added new documentation and allows a well founded interpretation of the tectonic origin of the valleys. With this example of fault related valleys as type example, other examples of fault related morphological features are demonstrated within the Danish glacial landscape.

In the Hvorslev area the valleys stretch in north-south direction with spacing of 125 m to 250 m. This system has a length of 9 km and it is 800 m wide. The individual valleys have an undulating floor in the longitudinal direction, and they cut hills and erosional valleys. In places the transverse profile of the valleys show a steep eastern flank and a gently dipping western flank. Air born laser scanning of the Hvorslev area resulted in a high-resolution altitude model (Torp, 2001) (fig. 1).

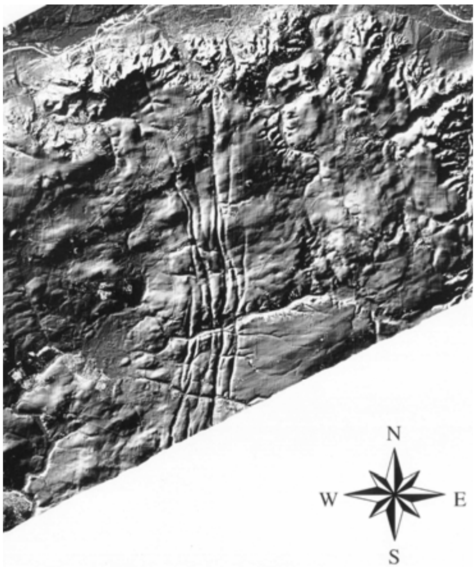

Figure 1. ***High resolution altitude model of the Hvorslev area. The crevasse valleys are the N-S trending lineaments in the eastern part of the area*** *(from Torp, 2001).*

For location, see fig. 2.

During the geological mapping of the area the fault morphology of the valleys was confirmed and, in places, a displacement of the top till was recognised. Furthermore, a seismic line is crossing the Hvorslev lineaments and it reveals a fault zone which is situated exactly below the valley system.

Other examples of a faulting controlled landscape feature in Denmark are presented as well. The location of the morphological features mentioned, are shown on fig. 2. North of the Hvorslev valleys the Gravlev valley cuts through the highest parts of the region. The valley also cuts into the pre-Quaternary chalk and limestone. Based on seismic profiles a tectonic model is interpreted to explain the formation of the valley (Pedersen & Jakobsen, 2005).

Another example is Horsens Fjord (Lykke –Andersen, 1981). A deep seated salt pillow just north of the Horsens Fjord introduced a graben structure limited by normal faults, and the Horsens Fjord is situated just inside this graben.

In the south-eastern part of Denmark a straight and narrow valley cuts across the island Lolland. Based on borehole information a series of faults are recognised and this valley is situated above one of the prominent faults.

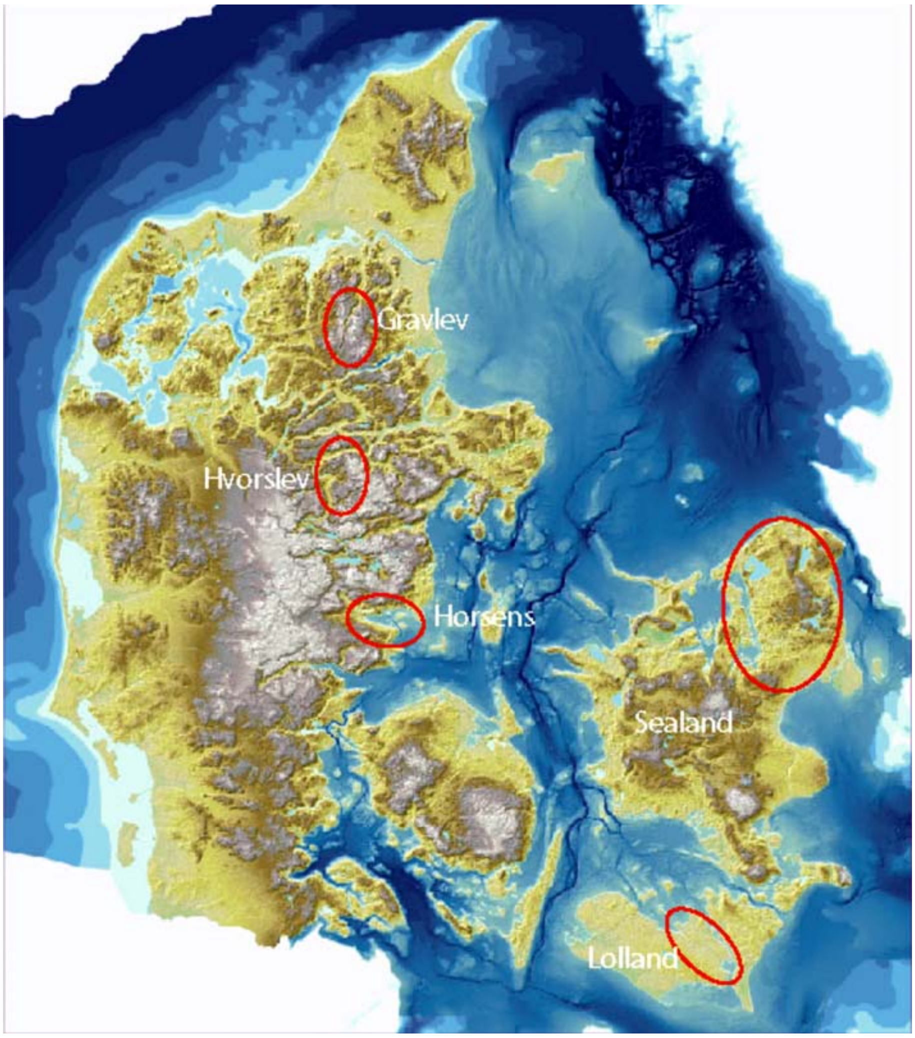

Figure 2. ***Terrain model of Denmark. The localities and regions mentioned in the text are indicated on the map***

In the North-eastern part of Sealand large fault systems related to the Fenno-Scandian Border Zone seem to have an impact on the morphology in the region. Some of the lakes and the Roskilde Fjord are controlled by deep seated faults. Resent seismic records show that the faults in this region are still active.

At present GEUS is working on a new digital morphological map of Denmark, and neotectonik fault related valleys or crevasse valleys will be a new morphological element in the classification of the glacial landscape in Denmark.

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THE DIVERSITY OF MELTWATER CHANNELS REPRESENTING DIFFERENT STAGES OF DEGLACIATION ON THE FELLS OF OUNASSELKÄ, FINLAND

Johansson, P., Lehtinen, K. & Sarala, P.
Geological Survey of Finland, P.O. Box 77, FIN-96101 Rovaniemi, Finland; e-mail: peter.johansson@gtk.fi

The fells of Ounasselkä consist of remnants of an approximately 2-billion-year-old fold mountain. The surrounding rock types have eroded more quickly than the quartzite, conglomerate and amphibolite of the fells, which have formed a residual mountain. The current relief of the fell range was formed during the preglacial era by millions of years of erosion. The landscape and landforms were later shaped and eroded by several glaciations and the action of meltwater.

The fell tops are often bedrock outcrops as a result of glacial erosion. The slopes are mainly till-covered. The extensive bedrock outcrops on the slopes and in the valleys were mainly the result of the rinsing action of unchannelised supraglacial meltwaters flowing from the ice sheet. The sub-, en- and supraglacial meltwaters channelised in valleys to form different types of erosional forms. These can be classified into five main types based on their location, form and origin: subglacial gorges, proglacial overflow channels, lateral drainage channels, marginal channels and extramarginal channels.

In the subglacial tunnel, the meltwater stream could flow independently of the bedrock morphology. Under the influence of hydrostatic pressure, it overcame even major obstacles, such as fell ridges functioning as watersheds. North of the Pallastunturi fells, for example, is the subglacial gorge of Pahakuru, a rocky labyrinth of steep rock cliffs and deep gorge lakes. This was formed by the erosional action of the subglacial meltwater stream flowing through the fell range at the final stage of the last glaciation.

The proglacial overflow channels are visible as sharp gashes in the fell ridges. They are connected with the initial phase of the deglaciation, when the fell tops just broke the surface of the thinning glacier to form nunataks. Meltwaters collected around the fell tops to form marginal ice lakes, from which the waters flowed supraglacially via the lower spots of the fell range towards the ice margin. The flowing water wore away a channel through the glacier into the till and eventually deep into the rock underneath. This is how for example the Lumikuru gorge, an approximately 10-metre-deep gorge with a V-shaped section, was created.

Lateral drainage channels mainly occur in the southern part of the Ounasselkä fell range. Dozens of meltwater channels can be found on the till-covered fell slopes of Ylläs and Lainiotunturi. Each channel of these groups runs parallel, one after the other, descending gradually along the fell slope. Channels range in length 100 m to 1.5 km and it is often hard to discern where they begin and end. As they generally score the till-covered slope to a depth of less than two metres, they seldom extend as far down as the rock surface. The lateral drainage channels formed between the edge of the melting ice sheet and the fell slope. As the channels usually occur at regular intervals, their spacing makes it possible to determine the gradient of the surface of the ice and to calculate its annual thinning and retreat rates. In the Ounasselkä area, the gradient of the surface of the glacier varied between 2.6–4 metres over a hundred metres, with an annual thinning rate of 2.0–3.3 metres and an annual rate of retreat of 160 metres on average.

Steep-sloped marginal channels, running parallel with the glacier margin for several kilometres, formed on the lower fell slopes and the surrounding low altitude areas, as well as lower-gradient, steep-sloped but flat-bottomed extramarginal channels, the location of which was influenced by the ice margin and morphology. The shape of the channels shows that large quantities of meltwater flowed along them for decades, either from ice-dammed lakes or from the glacial rivers. The length of the marginal channels is usually 1–3 kilometres, whereas the extramarginal channels may be tens of kilometres long. Like the lateral drainage channels, the marginal and extramarginal channels show the location of the margin of the continental ice sheet, but within an area that is much larger than that shown by the lateral drainage channels. Therefore, mapping them and establishing their chronological order are major tools for studying glacial hydrography and the retreat of the ice margin in the supra-aquatic area of northern Finland.

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THE STRATIGRAPHY AND PALAEOENVIRONMENT OF THE NORTHERN PART OF THE CURONIAN SPIT BASED ON NEW POLLEN, DIATOM, MOLLUSCS AND CARBONATE ANALYSIS DATA

Kabailienė, M.[1], Vaikutienė, G.[1], Damušytė, A.[2], Rudnickaitė, E[1].
[1]*Vilnius University, Dept. of Geology and Mineralogy, Čiurlionio 21, LT-03101 Vilnius, Lithuania; e-mails: meilute.kabailiene@gf.vu.lt, giedre.vaikutiene@gf.vu.lt, eugenija.rudnickaite@gf.vu.lt*
[2]*Institute of Geology and Geography, Lithuanian Geological Survey, S. Konarskio 35, LT-03123 Vilnius, Lithuania; e-mail: aldona.damusyte@lgt.lt*

Presented geological investigations of the Lithuanian Baltic coastal zone are linked with detailed geological mapping (scale 1:5000) of Klaipeda seaport, dislocated in the Klaipeda Strait which conect Curonian Lagoon and Baltic Sea. The key section (borehole 65a, NN 6.14 m) is located on the northern part of the Curonian Spit on the coast of the Klaipeda Strait. The lithological composition of sediments varies from fine-grained or medium-grained sand and gravel until gyttja: depth 0–410 cm fine sand; 410–680 cm – fine sand with organic; 680–1070 cm – fine sapropelic sand; 1070–1240 cm – various sand with molluscs; 1240–1320 cm – gyttja; 1320–1610 cm – various sand; 1610–1700 cm – various sand, gravel and sandy loam (redeposited till?); 1700–2350 cm – fine sand with organic and peat nodules and 2350–2610 cm – aleurite with organic.

The pollen composition and sequence have been described in terms of local pollen assemblage zones (LPAZ) and correlated with chronozones (Mangerud et al., 1974, Kabailienė, 1998). The pollen diagram from the site 65a is divided into 11 LPAZ. According to pollen composition this pollen diagram can be splited into two parts: lower (depth 1320–1860 cm) and upper (depth 60–1320 cm). The lower part of diagram includes deposits of the Late Glacial (Older Dryas(?), Alleröd and Younger Dryas chronozones) and Preboreal layer of dark fine sand.

In these deposits (especially in layers of Older(?) and Younger Dryas) herbs pollen thrive (up to 30–35 %). Poaceae and Cyperaceae prevailed over the rest species of the herbs. *Artemisia*, Chenopodiaceae have been found as well. *Salix*, *Juniperus* pollen, *Selaginella selaginoides* and *Botrychium* spores fixed in the deposits. All such species are typical for the cold climate, nonstabile soils, open habitats. Trees pollen (mainly *Pinus* and *Betula*) have been found too. Probably part pollen of these trees is of the long distance origin. On the depth of 1500–1590 cm herbs pollen decrease up to 15–18 %, *Pinus* is dominant. These deposits are of Alleröd age. Mentioned chronozones coincide with the Baltic Ice Lake stage. Freshwater planktonic diatoms *Aulacoseira granulata*, *A. islandica*, *A. ambigua* prevaile in the sediments of this period. Freshwater epiphytic and benthic diatoms (*Opephora martyi*, *Fragilaria brevistriata*, *Navicula scutelloides*) make only 20 % of total diatom sum.

Betula is dominant in the depth 1320–1380 cm and it is characteristic for Preboreal chronozone. Diatoms were very sparce in the sediments of this period. It coresponds to the Yoldia Sea stage. Single diatoms could be redeposited, because water level was lower during the Yoldia Sea stage. Content of carbonates was very low in the sediments of mentioned interval.

The upper part include deposits of 60–1320 cm interval. There have been single out Early and Late Boreal (prevail *Pinus* and *Corylus*) at the depth 1230–1320 cm. There were found maximum values of carbonates comparing to whole holocene sediments. Planktonic freshwater diatoms (mainly *Aulacoseira granulata*, *A. islandica* and *Stephanodiscus rotula*) make 60–90 % of total diatom amount. Epiphytic freshwater diatoms (*Opephora martyi*, *Fragilaria* sp.) had less abundant. This period was confirmed by results of radiocarbon dating of gyttja as well: depth 1240–1260 cm – 10 040±120 cal yr BP; depth 1270–1290 cm – 9 800±170 cal yr BP.

Early Atlantic (*Alnus* maximum and the spread of *Ulmus*) and Late Atlantic (broad leaved trees *Quercus*, *Tilia*, *Ulmus* maximum) chronozones were distingquished in the depth 700–1230 cm. Amount of carbonates was variable. Content of carbonates increased at the middle and the end of Atlantic period. Planktonic freshwater (*Aulacoseira granulata*, *A. islandica*), epiphytic (*Opephora martyi*) and benthic (*Navicula scutelloides*) prevaile in sediments of the lower part of Atlantic chronozone. Freshwater epiphytic (*Fragilaria inflata* et var. *istvanfyi*, *F. construens* var. *binodis*, O*pephora martyi*) and brackish (*Grammatophora marina*, *Diploneis didyma*) diatoms are characteristic for the upper part of Atlantic. The largest amount of well preserved subfossil mollusc fauna have been found in the depth 1070–1100 cm: *Cerastoderma glaucum, C. edule, Macoma balthica* and *Mytilus edulis*. Such community of molluscs confirm that sedimentation occured in brackish water, i.e. in the Litorina Sea. Content of determined species is characteristic for littoral zone of brackish sea basin with salinity 5–10 ‰ and depth up to 5–10 metres.

Early Subboreal (spread of *Picea* and *Pinus*), Late Subboreal (*Picea* decline, *Pinus* prevailed, herbs pollen increased) and Early Subatlantic (increase in *Betula* and herbs pollen) chronozones were defined at the depth 0–700 cm. Amount of carbonates was small and did not changes in high range. Freshwater benthic diatoms (*Navicula gastrum*, *Neidium iridis* f. *vernales*, *Stauroneis anceps*, *Pinnularia* sp.) became dominant at the beginning of Early Subboreal. There were found only a few diatoms at the upper sediment layers.

During the Older and Younger Dryas on the shore of the Baltic Ice Lake open herb communities spread everywere birch and pine spread in warmer Alleröd. The forest was of an open type. The depth of the Baltic Ice Lake was relatively high because planktonic freshwater diatoms were prevailed in sediments. Birch and pine forests spread on the studied territory during Preboreal and Boreal. Low content of carbonates at Preboreal sediments means that climate was cold. Yoldia Sea water level was low and did not reach studied area. Climate was warmer during Boreal because values of carbonates were significantly higher. The Ancylus Lake water level could reach the studied area, because there were found freshwater planktonic and epiphytic diatoms in the sediments of Early Boreal. Investigated area could be like a shallow lagoon which water level decreased at the end of the Ancylus Lake stage. The climate became warmer and humid during Atlantic period. The surrounding forests were dominated by broad leaved species, especially elm with lime and oak. Alder and hazel occurred everywere. The Litorina Sea deposits contain mainly freshwater benthic diatom flora. Benthic diatoms prevail among brackish diatom species too. Studied area was a shallow littoral zone during the Litorina Sea stage. Water salinity could be low due to freshwater river run-off. The Litorina Sea water level fluctuated in low ranges and decreased at the end of Litorina Sea and the beginning of Postlitorina Sea stage. Increases of carbonates amount are closely related to the Litorina Sea water salinity increases. Later there were unfavourable conditions for diatom living and accumulation. The Curonian Spit formation started after regression of the Litorina Sea and people settled on the southeastern coast of the Baltic Sea. Burried soils in the eolian sands could be revealed by small carbonate content increases.

Researches were partly supported by Lithuanian State Science and Studies Foundation.

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THE NORTH LITHUANIAN ICE MARGINAL MORAINE RIDGE: STRUCTURE, ORIGIN AND RELATIONSHIP OF SURFACE FORMS WITH PRE-QUATERNARY STRUCTURES

Karmazienė, D.
Lithuanian Geological Survey, S. Konarskio str. 35, LT-03123 Vilnius, Lithuania;
e-mail: danguole.karmaziene@lgt.lt

The North Lithuanian ice marginal moraine ridge, or so-called Linkuva ridge was formed by Žiemgalos Ice lobe what advanced at the end of glaciation through the Gulf of Riga. This ridge is considered as the North Lithuanian recession phase of the Upper Nemunas Baltija (Pomeranian) stage. B. Doss was the first who described this important geological, geomorphological object in 1910. Linkuva ridge stretches for 130 km as a bow-shaped ridge marking the boundary of active ice lobe.

A geological mapping of Linkuva ridge and surrounding areas was carried out at a scale of 1:50 000 in 1998–1999 and 2002–2006. The mapped territory covers 1867 km^2. Quaternary geological and geomorfological maps and a few geological cross-sections were compiled.

As established by geological mapping, the Quaternary deposits are laying on an uneven sub-Quaternary surface formed by Upper Devonian rocks. The sub-Quaternary surface was formed by glacier and melt water erosion. The difference in the solidity and resistance to erosion of the Upper Devonian rocks had the biggest influence for this process.

An obvious relationship was established between surface relief forms and pre-Quaternary structures. It was found that the Linkuva ridge corresponds to uplift of the pre-Quaternary rocks. The uplift is cut apart by paleoincission. Tectonic foults in pre-Quaternary rocks detected by data of electro-tomography are linked with distinct lineaments zone. The localization of glacier edge and accumulation of glacial deposits, Linkuva ridge and adjoined limnoglacial kame terrace, dislocation of eskers are linked with uplifts in sub-Quaternary relief (Fig. 1). The steps of the sub-Quaternary surface influenced the dynamic of the glacier, formed propotious conditions for the dead fields' accumulation, in one of which fluvio-kames group was accumulated.

There was found two groups of subglacial forms to the south and to the north from Linkuva ridge. The author interprets these forms as drumlin-like ridge. The orientation allows to consider they are drumlins. More detail structural, textural research, which let us to solve that problem, are not done because of bad cropping out. An analysis of drill core data do not allow to make solution, having one meaning. The pre-Quaternary structure evidently had a direct influence on the formation of drumlin-like ridge field. Several peculiarities of drumlin-like ridge seam exposure were revealed. The relationship between the sub-Quaternary surface and the present relief is one of the most evident: the altitude of the sub-Quaternary surface almost always corresponds with drumlin-like ridge crest and vice versa.

It is possible to distinquish at least three ice advances on the 52 km long and 20 m height section of Linkuva ridge on the proximal slope of ridge. It shows what the Žiemgalos ice lobe deglaciation has an oscilatory character.

In the cause of geological mappping in northern Lithuania it was discovered that the till of the North Lithuanian ice marginal moraine, which composes major part of the Linkuva ridge, has physical and mechanical properties different from the Mid-Lithuanian marginal till as well as from North and Middle Lithuanian basal tills. The Linkuva marginal till looks like a clay because of a great amount of fine (clayey) particles. Moreover, the input of gravel is negligible, less than 2 %. An outstanding feature of this till is its micro-layering. The till delaminates into 1–2 mm thin layers when breaking it. Such the micro-layered till could form only because of regelation, i. e. was caused by periodical thawing and freezing events within a moving glacier.

The 22 km long and 0.5–1.0 km width glaciolacustrine kame terrace on the distal part of Linkuva ridge was mapped and investigated in detail. Such deposits were developed between the glacier and a neighbouring valley slope. Geological structure of Linkuva ridge indicate that this ridge and adjoined kame terrace were formed between active ice lobe and field of died ice dislocated at front.

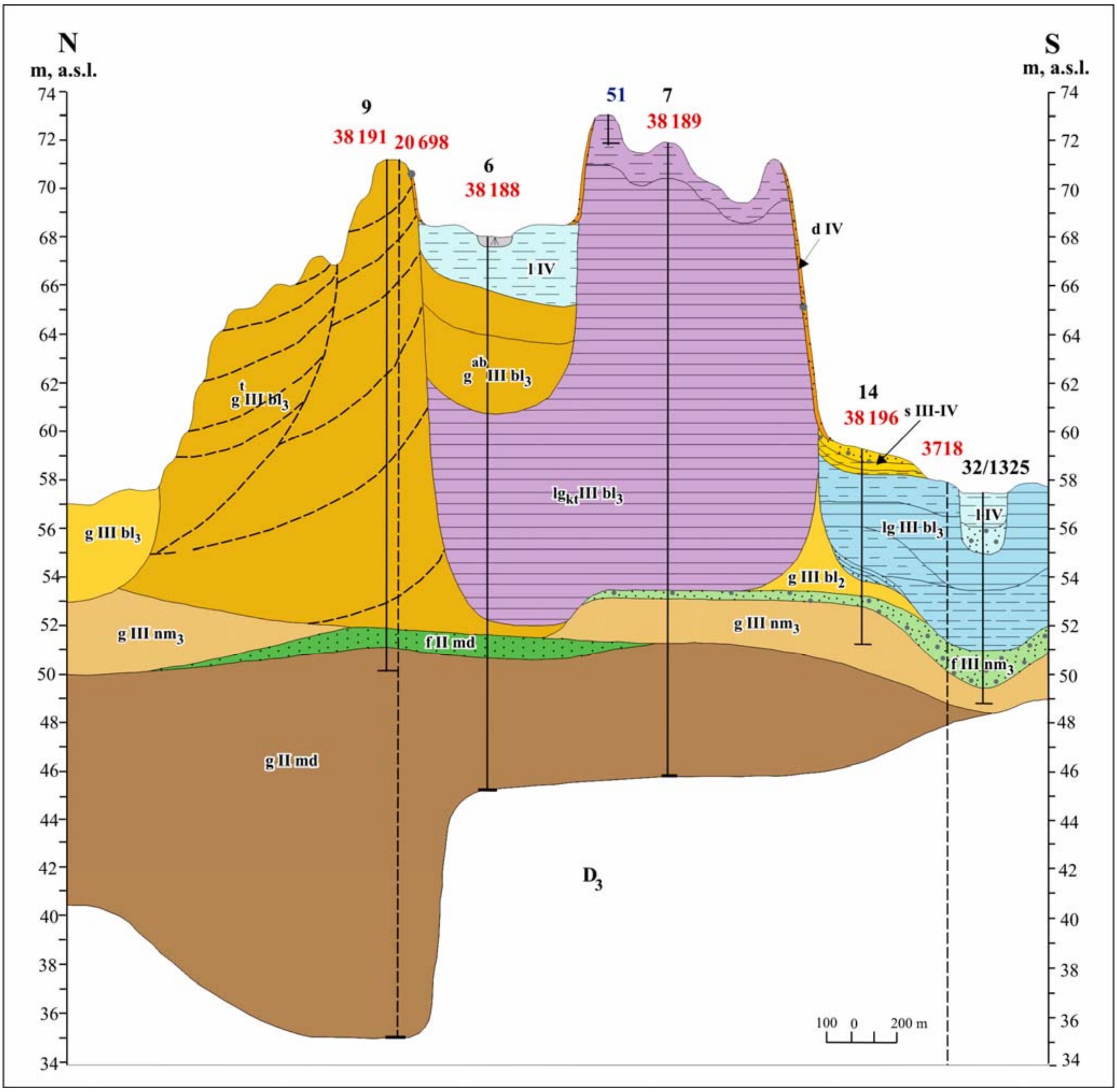

Fig. 1. ***Geological structure of Linkuva ridge near the Judiškiai hollow***

GEOTECHNICAL PROPERTIES OF GLACIODYNAMIC STRUCTURES AT OUTCROP OF ULMALE

Karpovičs, A., Lūse, I.
LU faculty of Geography and Earth sciences, department of Applied Geology, Lielā Street 2, LV-3001 Jelgava, Latvia; e-mails: andris.karpovics@lu.lv, ilze.luse@llu.lv

The outcrop of Ulmale is located near the similarly named village by the sea bluff between Pāvilosta and Ventspils. This particular bluff has been of interest to many researchers ever since the thirties of previous century (as for A. Dreimanis), later examinations in seventies and eighties were carried out by J. Straume, V. Segliņš and others, but still quite a lot of different explorations have been made in the last years (Kalvāns *et al* 2004, Dreimanis *et al* 2004, Segliņš *et al* 2007 and others).

Previous studies in the mentioned region of the bluff revealed the presence of diapirs and their complexes. Diapirs of dark grey clay or clayey silt are observed here overlain by fine sand and grey till, which often has been washed off and covered by sandy sediments of the Baltic Ice Lake, and boulder pavement in some places. Diapirs are slightly stretched in the direction of glacier movement, and their northern slope is steeper than the southern one. Several of diapirs are complicated with small-scale overthrusts and dike structures (Kalvāns *et all* 2004).

In year 2006 a set of studies were carried out to explore the distribution of glaciodynamic structure geotechnical properties in the contact zone between diapir clay aleirite and fine-grained sand. Thus measurements of cone resistance, vane tests, as well as natural humidity were taken, using portable instruments. Also the grain size distribution of fine grained sediments was obtained in laboratory, using the Analysette 22 COMPACT sedigraph.

Measurement results show that the mean values of cone resistance are quite alike for silty clay – 1.3 MPa, and for fine sand – 1.1 MPa. But the vane shear resistance and humidity values differ significantly, vane shear resistance and humidity for silty clay is 97 KPa and 48.2 % respectively, and for fine sand the values are 38 KPa and 6.9 % respectively. In its turn, the series of measurements of cone resistance after every 2 cm in direction from aleirite to the sand show a decrease of resistance roughly by 40 % around the contact zone. Measurements in the silty clay diapire surface, present an expanded zones of decreased sediment consolidation (mean 0.7 MPa).

Further researches are involving *in situ* measurements of mentioned above geotechnical properties and grain size analysis. Thereto estimation of overconsolidation ratio (OCR) will let us know more about stress history of the region.

The research has been carried out thanks to the financial support from ESF.

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TRACE FOSSILS AND SEDIMENTATION OF UPPER PLEISTOCENE GLACIOLACUSTRINE CLAY IN LITHUANIA

Kazakauskas, V.[1], Uchman, A.[2], Gaigalas, A.[3]

[1]*Institute of Geology and Geography, T. Ševcenkos str. 13, LT-03223 Vilnius, Lithuania; e-mail: kazakauskas@geo.lt*

[2]*Jagiellonian University, Institute of Geological Sciences, Oleandry str. 2a, PL-30063 Krakow, Poland; e-mail: fred@ing.uj.edu.pl*

[3]*Department of Geology and Mineralogy, Vilnius University, Čiurlionio str., 21/27, LT-03101 Vilnius, Lithuania; e-mail: algirdas.gaigalas@gf.vu.lt*

The sediments of glaciolacustrine basins are widely spread in Lithuania. They are generally composed of clayey and silty laminated sediments that formed in proglacial lakes dammed near the margin of the receding ice-sheet of the Last (Nemunas) Glaciation. Development of glaciolacustrine basins and laminated clay sedimentation in Lithuania were closely connected with the course of ice-cover retreat during Daniglacial time from 16 000 to 13 000 years BP. The sedimentation of laminated sediments in proglacial lakes of Lithuania went on for about 3 000 years. The largest glaciolacustrine basins in Lithuania are as follows – Simnas-Balbieriškis (South-Lithuania phase of Baltija stadial of Nemunas Glaciation), Kaunas-Kaišiadorys and Jūra-Šešupė of South-Lithuania phase and Mūša basin of North-Lithuania phase. The distribution of them in the territory of Lithuania was closely related to the character of the retreat of the ice-sheet at the end of Last Glaciation, the topography of the deglaciated territory and climatic variations. Mostly these factors caused the sediments' formation of different series, which reflect the dynamic conditions of glacier degradation. According to the varve/year counting, the Simnas-Balbieriškis glaciolacustrine basin existed for about 440 years (based on varve counting in Balbieriškis section), Kaunas-Kaišiadorys glaciolacustrine basin – about 250 years (Girininkai section) and Mūša glaciolacustrine basin – about 166 years (Joniškėlis section).

Ichnological observations, carried out in six sections of glaciolacustrine sediments, show that the bottom of the proglacial lakes was not an arctic desert but was habitat for different invertebrate animals. Relatively common trace fossils *Gordia, Helminthoidichnites, Glaciichnium* and less frequent *Cochlichnus, Warvichnium* and *curved ridges* occur in the Upper Pleistocene laminated sediments of Balbieriškis (I and II) outcrops and Girininkai, Krūna, Tauragė and Pašaminė quarries. *Glaciichnium and Warvichnium*, produced by crustaceans, show a great variety of preservational variants, which were probably controlled by substrate consistency. Abundance of particular ichnotaxa varies from locality to locality. They occur in single laminae every one or two decimetre in clayey laminae packages and are absent in laminae rich in carbonates. The investigations of trace fossils in Pašaminė quarry show that their occurrence in some laminae is very stable over a long distance. The other laminae show rather patchy distribution of trace fossils. It is not clear whether such a distribution in isolated laminae resulted from rare occurrences of proper preservational conditions or from incidental colonization of the lakes floor. Commonly, the colonized laminae contain only one ichnota.

MARINE AND LAND DEPOSITS IN THE SOUTHERN BALTIC AND ORLOWO CLIFF (GDANSK BAY) ON THE LIGHT OF QUARTZ GRAINS SEM STUDIES

Kenig, K.
Polish Geological Institute, Rakowiecka 4, PL-00975 Warsaw, Poland; e-mail: krystyna.kenig@pgi.gov.pl

The objective of the current work was to characterize the microtexture of quartz grains that occur in deposits of the contemporary Baltic Sea bed, specifically the case where marine deposits (Holocene) are derived from the deposits directly underlying them (Pleistocene). It was assumed that the degree of transformation of land sediment into marine sediment could be traced, and the percentage of land-type grains in marine sediments could be quantitatively estimated. A detailed description of the method used was presented in earlier paper (Rywocka-Kenig 1997). The classification also refers to the literature (Krinsley, Doornkamp 1973, Mahaney 2002).

Marine and land deposits from the sections in southern Baltic on the Odra Bank, Slupsk Bank, and South Middle Bank, (Geological map … 1989-1995, Geological atlas 1995) and from an exposure in the Orlowo Cliff (Gulf of Gdansk), were selected for SEM investigation of quartz grain microtexture.

The SEM investigation was mainly concerned with quartz grains of the 1.0-0.5 mm fraction and the 0.5-0.25 mm fraction. In several cases grains of the 0.1-0.05 mm fraction were also investigated (Rywocka-Kenig 1997).

Marine sediments of the Baltic Sea are characterized by the presence of rounded quartz grains, with only a small percentage of angular grains. Most often, grains are shine, both polished and the angular ones. On these grains, common microtextural features include v-shaped pits of varying intensity, with are marked by peaks on the diagram (Fig. 1a). These features, considered typical for a high-energy coastal environment (Krinsley and Doornkamp 1973), were observed by on beaches from various places in the world. On grains redeposited from the beach environment into other deposits. Closely connected with this feature is the appearance of arch shaped incisions on the same grains. These two features are strongly correlated (Rywocka-Kenig 1997). Simultaneously, on conchoidal fractures that limit the shape of angular grains, initial stages of coastal working are visible, as indicated by a small number of v-shaped pits. The low frequency of chemical etching characteristics indicated that these sediments were deposits in sea water for only a relatively short time, in quite warm conditions and at level of chemical aggression on quartz grains.

Quartz grains from sandy deposits in the investigated profiles of the Southern Baltic banks show significant variability in microtexture features. Besides the average characteristics, which show a general trend of frequency of subaerial genesis features and the distinct influence of marine sedimentation deposits (among others, an average 10 % presence of beach environment features), each of the lithodynamic areas must therefore be considered separately.

Thus, maximum concentrations of subaerial features are marked in sediments from sample 2 S-192, from the northern part of Odra Bank. Typical grains with characteristics of aeolian abrasion of varying intensity are present.

It should be stressed that there are distinct differences in the frequencies of grains with analyzed features of microtexture in till of connecting the lower (older) till from Orlowo with a till in the Baltic Sea bottom (in the Slupsk Bank and the South Middle Bank) into one lithostratigraphic horizon. Quartz grains from the Orlowo lower till, are characterized by a predominance of abrasive and aeolian features. Also, a larger number of post-sedimentary features are present suggesting frost processes in a water-saturated environment. A significant point is the lack of grains with earlier marks of littoral environment. On the other hand, on quartz grains from the upper till, significant participation of redeposited grains from an earlier littoral environment is visible. Abrasive, including aeolian features, are slightly less intensity of cryogenic and chemical processes is also distinctly reduced, with may by considered a confirmation of the young age of the deposits. This characteristic is in agreement with observations of the variability of features in stratigraphic formulation concerning deposits of different origin (Rywocka-Kenig 1997).

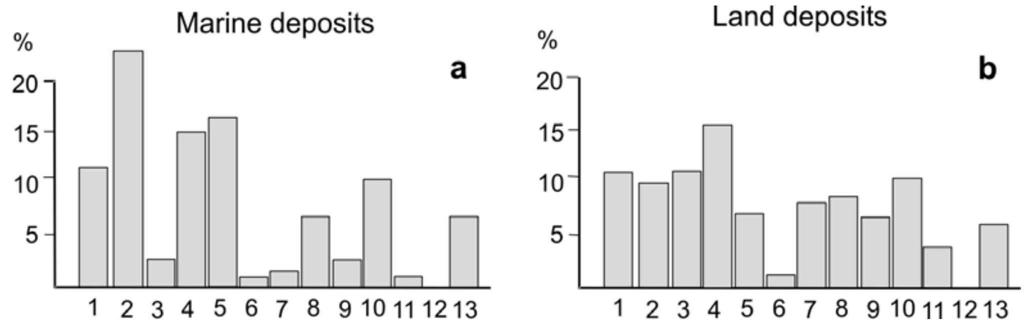

Fig. 1. ***Frequency of occurrence of quartz grains with particular microtextural features***

1. Conchoidal fractures, 2. Subaqueous v-shapes pits, 3. Abrasion v-shaped pits, 4. Triangular form (abrasion), 5. Arch shaped incisions, 6. Cracs, 7. Aeolian pitting, 8. Granular disintegration, 9. Exfoliar disintegration, 10. Effects of silica dissolution, 11. Effects of silica precipitation, 12. Crystallographically oriented chemical etching, 13. Secondary minerals (after Kenig in: Geological atlas southern Baltic…1995)

The use of this specific method of sedimentological investigation – SEM quartz grain microtextural analysis – allowed the characterization of the grains from genetically different environments. The determination of the degree of transformation of the previously defined deposits was also possible (fig. 1), as well as its recognition on the base of SEM.

On the surface of quartz grains from marine deposits, the most frequently seen are subaquaently v-shaped pits and arch shaped pits. Quite often, chemical features such as the effects of silica dissolution and secondary minerals, are present.

In the land deposits underlying the marines ones on the Banks of the Southern Baltic, one can mainly see abrasive features such as: v-shaped pits, triangular forms and aeolian pitting (Fig. 1b). Simultaneously, proper marine environments are present (for example, subaqueous v-shaped pits and arch shaped incisions), arising as a result of the mixing of land and marine deposits on the littoral zone. In the same land deposits, higher differentiation of features is occurring.

An interpretation of the type, amount and relationship of characteristics of quartz grains microtextures allowed the tracing of the history of deposits, taking into account changes in the conditions of the deposition.

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STRATIGRAPHICAL PROBLEMS OF THE PLEISTOCENE SEDIMENTS IN THE PAJŪRIS LOWLAND, WEST LITHUANIA

Kondratienė, O.

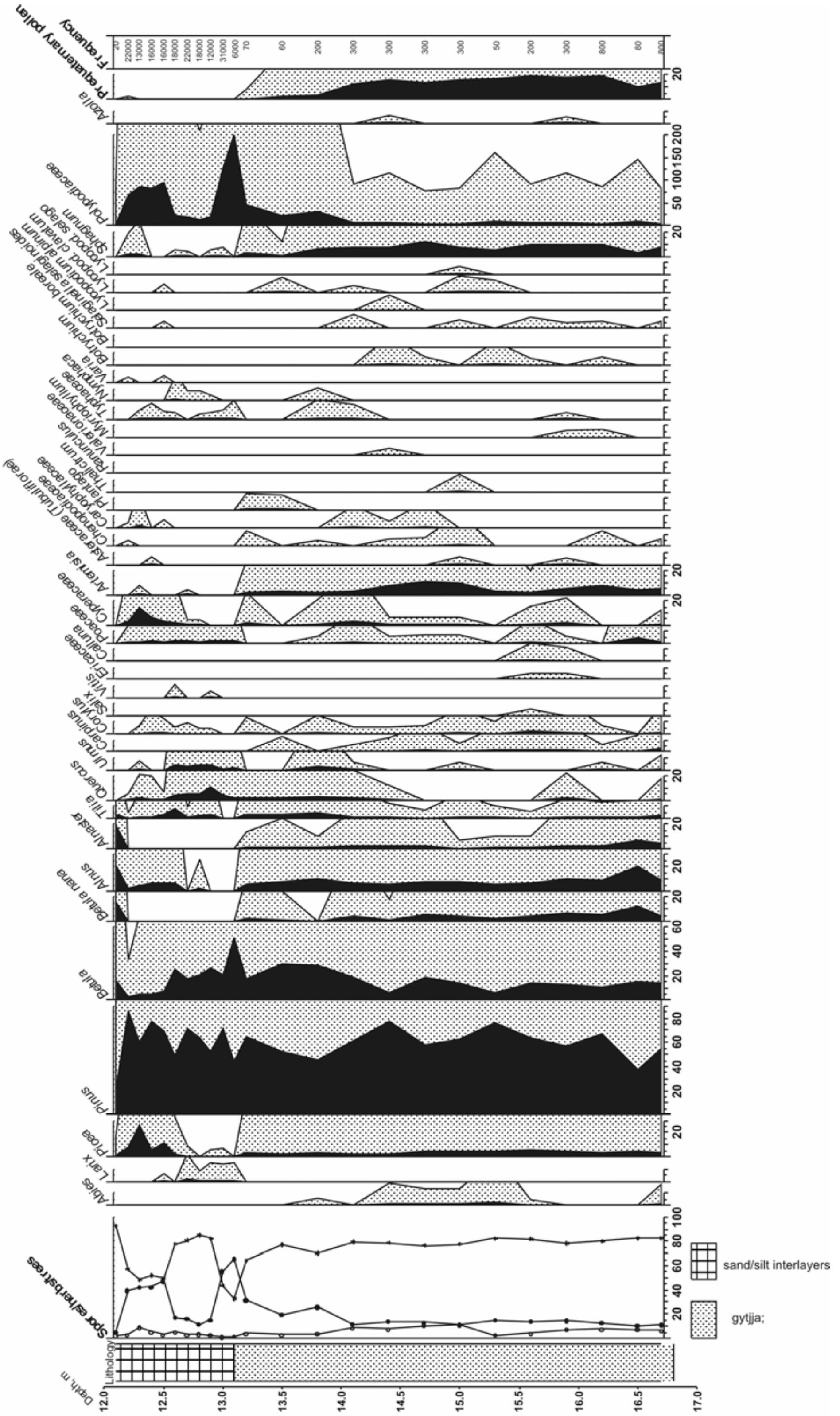
Institute of Geology and Geography T. Ševčenkos 13, LT-03223 Vilnius, Lithuania; e-mail: o.kondratiene@gmail.com

In the biggest part of the Pajūris Lowland, west Lithuania, sediments of the Pleistocene age forms a stratum reaching up to 60-70 m. Within the palaeoincisions thickness increases and shows up to 100 m. The structure of the above mentioned stratum is rather simple e.g. two layers of the tills deposits are separated by the intertill layer (up to 20-30 m) composed of the sand and silt with the lenses of peat and gyttja (reaches up to 1 m). The altitude of the intertill layer varies from +15 m NN to -15 m NN.

Although the scientific investigations of the above mentioned intermoraine (intertill) deposits started in the second half of the XIXth century, stratigraphical position of the bed stays unclear until now and similarly, formation of the layers are under discussion as well. According to the different authors the age range includes nearly the whole Pleistocene. Herewith the age of the underlying and overlaying till deposits is unknown.

A new pollen data obtained from seven cores, developed in the area of the Klaipėda port, indicates:

- ✓ only a small part, of the intermoraine (intertill) sediments that reaches up to 3 m, were formed during the interglacial. Other part of the investigated sediments was deposited during the early- or late-glacial conditions.
- ✓ onset of the organogenic sedimentation varies from the end of the lateglacial to the interglacial optimum.
- ✓ due to the intensive destruction the upper most part of the pollen spectra (up to 0.5 m) can't be used for the reconstruction of the vegetation composition.
- ✓ sedimentation hiatus existed between the formation of the organogenic layers and deposition of the overlaying sandy/silty beds.
- ✓ peculiarities of the forest composition indicated according to the pollen spectra (Fig. 1) of the intertill sediments are in a good correlated with the lower part of the pollen spectra from the Buivydžiai Outcrop (East Lithuania) that makes the conclusion about the deposition of the investigated sediments at the beginning of the Snaigupėlė Interglacial, possible.
- ✓ throughout the final part of the Žemaitija (Saalian) Glaciation, large fresh water basin covered the area of the Pajūris Lowland. Due to the fast degradation of this basin at the beginning of the climatic optimum of the Snaigupėlė Interglacial sedimentation was interrupted here.



The percentage pollen diagram for the core 36916

MORPHOTECTONIC PATTERN OF THE KOLA PENINSULA

Korsakova, O. P., Kolka, V. V.
Geological Institute of Kola Science Sentre, RAS, Fersman St. 14, RUS-184200 Apatity, Russia;
e-mails: korsak@geoksc.apatity.ru, kolka@geoksc.apatity.ru

There are opinions (Nikonov, 1977, Mel'nikov, 2002, and others) that the Kola Peninsula has a block-structure pattern. Morphological expression of separate tectonic blocks depends on their geodynamic. Highest tectonic activity was established in Khibina and Lovozero massifs and these mountains are as a key object for analysis of morphotectonic pattern of the Kola Peninsula. The block structure is conditioned by the development of the multirange discontinuities. They are caused by the interaction of main geodynamic processes: continental drift, tectonic activity, and elastic resistance of rocks. These factors define hierarchic field of natural tensions and cause destruction of the massif due to disconnection and displacement along the structural discontinuities of different orders that segregate the Kola Peninsula and form tectonic blocks of different range.

To establish morphotectonic pattern of the Kola Peninsula the morphometric and fieldwork methods were applied to study the relief and composition of the rocks. Based on decoding of the aero- and satellite images, and on the morphometric analysis, the sketch map of the multi-ordered lineaments (tectonic zones) was compiled. Spatial position and order of lineaments was defined in accordance with the order of the river valleys developing along the tectonic zones. During the field work, a verification of distinguished lineaments was done and landscape features of tectonic zones beyond river valleys were defined.

It is established that the erosion systems of the Kola Peninsula are represented by the valleys of seven orders. Based this concept, it is possible to distinguish the morphotectonic structures of the seven ranges. The boundaries of the 1st range blocks were defined by erosion valleys of the highest seven order. They represent the zones in width from tens to a few hundreds meters. Hence the Kola Peninsula is divided on three morphotectonic blocks (western, northern and southern) of the highest range (Fig. 1).

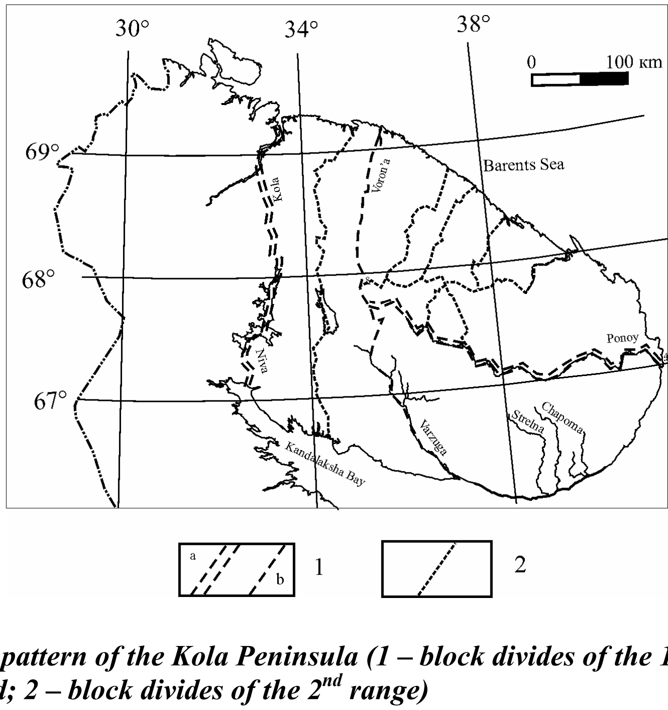


Fig. 1. ***Morphotectonic pattern of the Kola Peninsula (1 – block divides of the 1st range (a – established, b – inferred; 2 – block divides of the 2nd range)***

The block divides trace the valleys of the Kola and Niva rivers, and inferably the Varzuga and Voronja rivers. The third block divide corresponds to the valley of Ponoj river. The every block consists of sections, which represent the blocks of 2nd order, etc. By this way, the blocks of five lowest ranges are established in Khibina mountain massif, and blocks of fore ranges – in Lovozero massif.

This work was supported by the Russian Foundation for Basic Research (project 05-05-97501), the Research Program of the Presidium of the Russian Academy of Sciences "Evolution of the relief and deposits of the Kola Region in Holocene".

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SILICEOUS ROCKS AS RAW MATERIAL OF PREHISTORIC ARTEFACTS IN ENVIRONS OF BIRŽULIS LAKE, WESTERN LITHUANIA

Kulbickas, D.
Vilnius Pedagogical University, Faculty of Natural Sciences, Department of General Geography, Studentu 39, LT-08106, Vilnius, Lithuania; e-mail: kulbickas@yahoo.com

Silicites are sedimentary rocks of chemical and biochemical origin, which are mostly composed of opal and chalcedony or, in rarer cases, by quartz: tripoli, diatomite, gaize, flint, jasper and others. Articles made of solid, shelly and razor-edge silicites usually referred to as "flint" abound among archaeological artefacts. The first Lithuanian postglacial (Late Paleolite) inhabitants used flint for production of arrowheads, knives, burins, scrapers, borers, axes, etc. The natural bedding form of silicites is variable. The Cretaceous flint concretions (with a typical concentric structure) and Devonian siliceous nodules (silicified rounded rock concretions) are sized 2–30 and even 70 cm. The Upper Cretaceous gaize and thin interlayers (lenses) of its silicified varieties lying in the carbonaceous rock mass are known in Lithuania. Silicites were scattered over a large territory by advancing glaciers in south-western, southern and south-eastern directions. It was observed that the network of finding sites of Palaeolithic and Mesolithic flint artefacts almost coincides with the distribution of flint concretions in the Upper Cretaceous carbonaceous sediments.

The grey gaize and its strongly silicified varieties sometimes referred to as flint attracted attention when studying the evolution of the cultural landscape of Žemaičiai Upland. These flint artefacts are genetically related with the erosion relicts of the Late Cretaceous Campanian rocks in the sub-Quaternary surface, which were used as a tool material in the Stone Age. A preliminary survey of flint artefacts in the Lithuanian National Museum showed that a rather wide spectrum of rocks with similar properties is referred to as „flint". Their colour (blackish, bluish, grey, white, and brown) and natural contacts with other kinds of rocks show that rocks of different age and genesis are often classified into one group of "flint". According to the available data of visual observations, the artefacts uncovered in the Žemaičiai Upland (e.g., in the Daktariškės, Pabiržulis, Dreniai, Šernelė and other settlements) are made of the local raw material white silicified gaize, which is not found in other localities.

Biržulis area is situated in the Middle Žemaičiai Upland and includes strand of Biržulis Lake, Dreniai, Kalniškiai and Ožnugariai archaeological settlements whose flint artefacts were geochemically analysed. The area also includes Šūkainiai and Jonikaičiai localities from which samples of gaize and its silicified varieties were taken. The sub-Quaternary surface is lying at a depth of 150–314 m. Terrigenous Upper Jurassic and Lower Cretaceous sediments (sand, silt and clay) predominate. The present northern boundary of the spread area of Upper Cretaceous carbonaceous sediments (chalk and chalk marl) runs south of Biržulis Lake. At the time of the first glaciations, this boundary might have been north of the studied area. This is proved by rare glacial erosion relicts of these sediments further north. The Upper Cretaceous Campanian rocks (chalk and marl with gaize patches and interlayers) 10–15 km north of Biržulis Lake represent one of such "islands". Advancing glaciers eroded these sediments reworking gaize and its silicified varieties (whitish flint). These varieties represent a consecutive succession of siliceous rocks. Unevenly silicified interlayers in the Cretaceous chalk marls are also known in West and South-West Lithuania.

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VARYING PRESSURES OF THE ICE SHEETS AS A FACTOR OF THE PLEISTOCENE ACTIVITY OF THE POLOTSK-KURZEME AND THE SMALAND-BLEKINGE DEFORMATION ZONES

Kurlovich, D. M.
Faculty of Geography, Belarusian State University, Leningradskaya 17, BY-220050 Minsk, Belarus,
Department of Geology, Lund University, Sölvegatan 12, SE-22362 Lund, Sweden; e-mail: kura_geo4@mail.ru

Continental topography is at the interface of processes taking place at depth in the Earth, at Earth's surface, and in the atmosphere above it. During the last 20 Ma plate-tectonic and other geodynamic processes in the Earth's interior have caused many changes in the Earth's surface topography. The impact of Solid-Earth processes on surface topography at plate boundaries has been known for several decades, but their influence in intraplate areas is only just being appreciated. One of the examples of the influence of processes in the deep Earth to Earth' surface is the correlation between faults of the crystalline basement and topolineaments.

Topographical maps, airphotos and satellite images suggest a remarkable linear arrangement of landforms here called lineaments. Those lineaments are often related to fault zones of the crystalline basement. A good example of this relationship is the Polotsk-Kurzeme Deformation Zone (PKDZ), which extends from Moscow across the northern part of Belarus, to Latvia and Lithuania and its possible continuation across the Baltic Sea into the Småland-Blekinge Deformation Zone (SBDZ) and Bornholm Island (Fig. 1). Those from one of the numerous fault zones in the Precambrian crust of the East European Craton (EEC), which was formed at ca. 1.5-1.4 Ga. On the surface, the PKDZ and the SBDZ are reflected as linear landforms and by hydrography. The character of the Quaternary sediments (glaciodislocations, declining glacial and interglacial layers, changing thickness of sediments), seismic activity, all indicate neotectonic and recent movements along these lineaments.

The influence of Mesoproterozoic faulting on the Paleozoic, Mesozoic, Cenozoic and recent evolutions of the Precambrian crust has been assessed using 3D reconstructions of paleosurfaces, GIS (=Geographical Information Systems) -models of basement-cover correlation and topolineaments identification (Fig. 2 and 5). The key target areas of this study have been the Polotsk part of the PKDZ in northern Belarus and the eastern part of the SBDZ in southeastern Sweden (Figure 1). Geologically the key areas are sufficiently different. The crystalline basement in the Polotsk area lies under the mostly thick sedimentary cover. The present topography was formed by accumulation activity of the repeated Pleistocene glaciations. Only the thin layer of the Quaternary deposit covers the crystalline basement surface in the eastern part of the SBDZ area. There are a lot of bedrock outcrops. The present topography was shaped by the melted dead ice of the last Scandinavian Ice Sheet.

The 3D upper paleosurfaces of the crystalline basement, the Ectasian-Stenian, Ediacaran, Ordovician, Devonian and Quaternary sedimentary deposits and the present landform surface for the Polotsk key area as well as the 3D upper paleosurfaces of the crystalline basement and the present landform surface for the eastern part of the SBDZ key area have been performed with ArcGis 9.1 software. A series of maps showing correlation coefficients between the upper paleosurface of the crystalline basement and all the various Phanerozoic deposits has been produced for the key target areas. We have also profiled the Quaternary deposits in the Polotsk area (Fig. 3 and 4).

As a result of the study, two main stages of activity of the PKDZ have been identified in the Polotsk area. In the Mesoproterozoic, the major EW- and linked NS-trending fault systems developed in conjunction with orogenic processes at the southwestern margin of the EEC. In the Cenozoic, the activity of this belt was caused by both neotectonics and varying pressures of the ice sheets with attendant Pleistocene deformation of the sedimentary cover within the Polotsk area. In the eastern part of the SBDZ key area the Mesoproterozoic-Phanerozoic activity has been identified.

In consequence, we find that the application of modern GIS-technologies to the study of the PKDZ and the SBDZ allows evaluating the effect of the Precambrian tectonics on the Phanerozoic and recent evolutions of the crust.

Funding from the Visby Programme of the Swedish Institute is highly acknowledged.

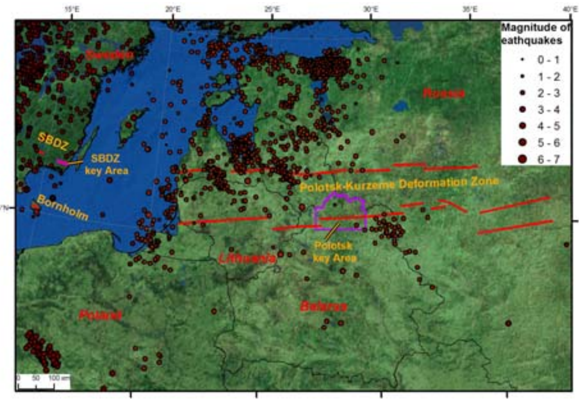

Figure 1. ***The seismic activity in the region of the PKDZ and the SBDZ***

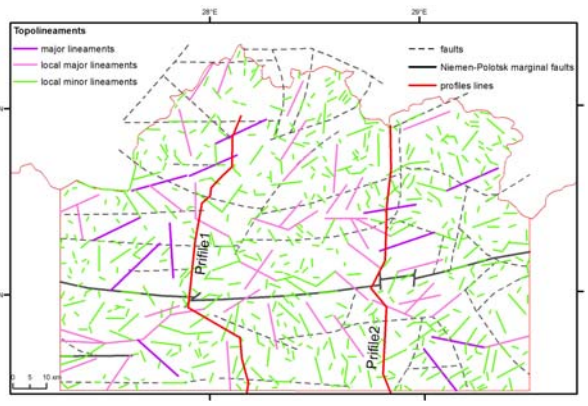

Figure 2. ***Faults of the PKDZ and topolineaments in the Polotsk area. Location of the geological profiles***

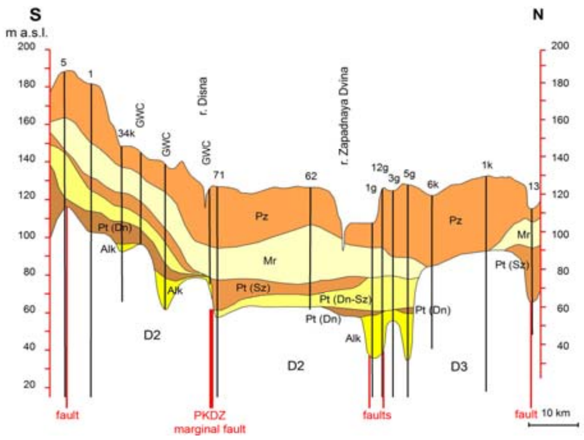

Figure 3. ***Profile 1***

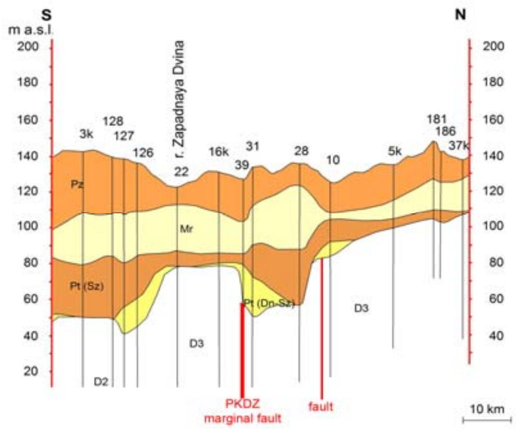

Figure 4. ***Profile 2***

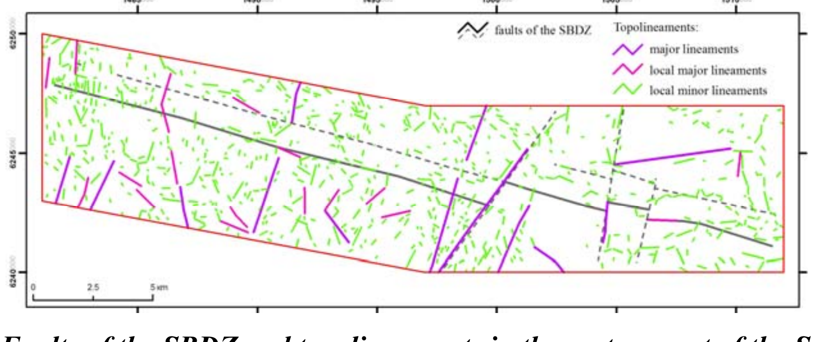

Figure 5. ***Faults of the SBDZ and topolineaments in the eastern part of the SBDZ area***

THE GLACIATION HISTORY OF THE BELARUSIAN POOZERIE AREA (AS BASED ON 3D GIS-MODELS OF THE GLACIAL/INTERGLACIAL PALEOSURFACES)

Kurlovich, D. M.[1, 2], Kurlovich, O. A[1].
[1]*Faculty of Geography, Belarusian State University, Leningradskaya 17, BY-220050 Minsk, Belarus,*
[2]*Department of Geology, Lund University, Sölvegatan 12, SE-22362 Lund, Sweden; e-mails: kura_geo4@mail.ru, ferrari_86@mail.ru*

The present-day landscape of Belarus was shaped by repeated Pleistocene glaciations. Five major ice sheets affected the country during the Pleistocene: the Narev, Berezina, Dnieper, Sozh and Poozerian glaciations. The sequence of glacial/interglacial deposits reaches a maximum thickness of 325 m, with an average thickness of 75-80 m (*Matveyev, 1995*). The last advance of the Scandinavian Ice Sheet in Belarus occurred during the late Pleistocene Poozerian Glaciation (*Karabanov et al., 2004; Matveyev, 1995*). The ice covered only the northern part of the country. The territory, which is situated within the last glacial maximum in Belarus, is named the Belarusian Poozerie Area.

There are a lot of geological materials related to the Quaternary period, collected by Belarusian geologists during the last decades. The aim of the present work is a reconstruction of the glacial history of northern part of Belarus (the Belarusian Poozerie Area), using the results of drillings in Quaternary deposits. The main instrument of the study is geographical information systems (GIS). GIS are getting a special significance in the current development of geology and geomorphology as GIS-technologies allow to visualize landforms and geological data, as well as to carry out different kinds of geomorphological and geological analysis and modelling (three-dimensional models of landforms and geological paleosurfaces).

The results of interpretation of drillings in Quaternary deposits and description of natural outcrops *(Levickaya, 1990)* have been used for reconstruction of the glacial history of the Belarusian Poozerie Area. These geological materials include information about position (latitude/longitude) of drilling wells (or natural outcrops) and interpretation of drilling/outcrop logs (depth in m a.s.l. of the Quaternary layers). The used material is also maps of Quaternary sediments of each glacial and interglacial in the scale of 1:500 000. The spatial information of the position of drilling wells and natural outcrops has been transformed in digital form according to its coordinates using the software of the geographical informational system ArcGis 9.1 (ESRI, USA). The upper paleosurfaces of pre-Quaternary (Devonian) sediments and all glacial/interglacial complexes have been constructed using the interpretation of drilling/outcrop logs (see the examples as Figures 1-6). These paleosurfaces have been created with the interpolation function (Spline method with option of tension) in Spatial Analyst of ArcGis 9.1. The maps of pre-Quaternary and Quaternary sediments *(Levickaya, 1990)* have also been transformed in digital form, using the special function of georeferencing in ArcGis 9.1. These maps have been corrected, taken into account the latest investigation in the Belarusian Poozerie Area. Finally, corrected information has been put in digital form as maps of pre-Quaternary bedrock and sediments of each glacial and interglacial.

In consequence, we find that the application of modern GIS-technologies in the study of glacial/interglacial patterns of the Belarusian Poozerie Area allows constructing GIS maps of pre-Quaternary and Quaternary upper paleosurfaces and sediments. The obtained results of GIS-modelling as well as geological data of the latest field investigation enable summarizing the glacial history of the northern part of Belarus.

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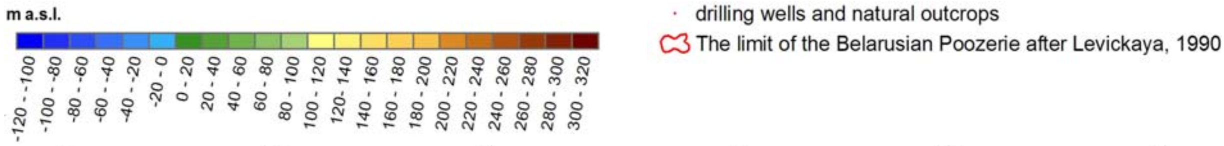

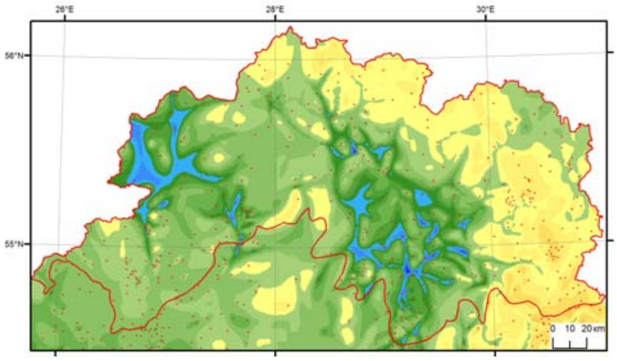

Figure 1. ***A model of the upper paleosurface of the pre-Quaternary (Devonian) sedimentary deposits***

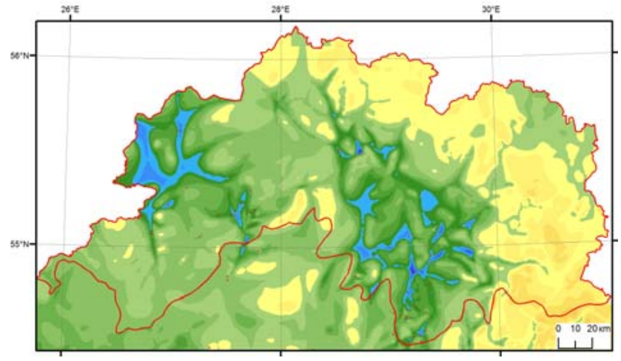

Figure 2. ***A model of the upper paleosurface of the Narev (a stadial of the Waalian) glacial complex***

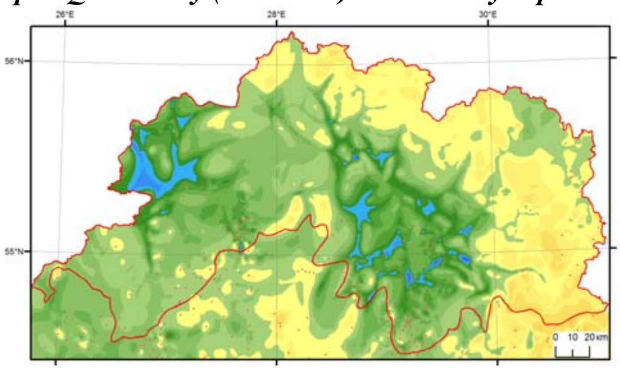

Figure 3. ***A model of the upper paleosurface of the Berezina (Elsterian) glacial complex***

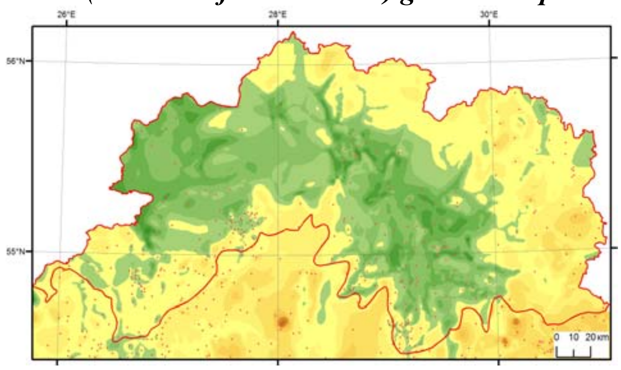

Figure 4. ***A model of the upper paleosurface of the Dnieper stadial of the Pripyat (Saalian) glacial complex***

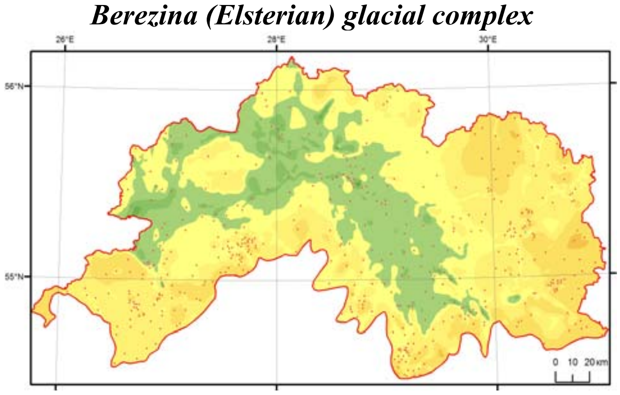

Figure 5. ***A model of the upper paleosurface of the Sozh stadial of the Pripyat (Saalian) glacial complex***

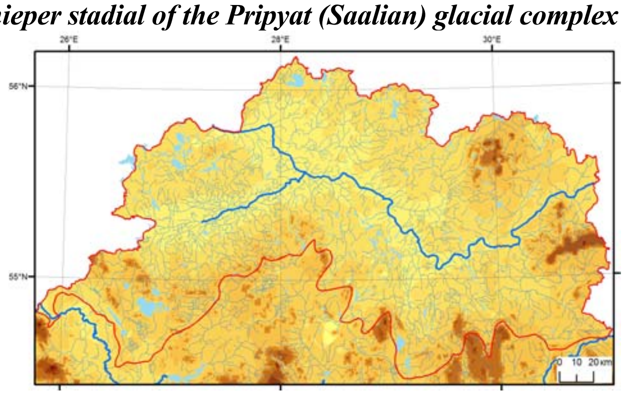

Figure 6. ***The digital terrain model (the upper surface of the Poozerie (Weichselian) glacial complex)***

EVALUATION OF NEOTECTONIC MOVEMENTS IN ANTARCTICA

Lastochkin, A. N.[1], Krotova-Putintseva, A. Y.[1, 2]

[1]*Saint-Petersburg State University V. O. 10th line, 33, 199178, Saint-Petersburg, Russia*

[2]*VSEGEI, Sredny pr., 74, 199106, Saint-Petersburg, Russia; e-mail: avacha2001@rambler.ru*

We report on balance method of quantitative evaluation of neotectonic movements in Antarctica. This method based on model of relief formation in the Antarctic and estimation of correlation between mineral and ice masses' volumes in lower structural stage. This method can not be applied for subaerial or submarine relief, or for those areas of the Antarctic where Cenozoic sedimentation took place (Ivanov & Kamenev 1991).

According to general model of relief formation in the Antarctic, lifetime of ice cover is commensurable with the neotectonic period of earth crust evolution. In a general way neotectonic movements defined the height and depth amplitude of modern relief, morphology and contrast of its forms. The latter were preserved from lithodynamic processes and they are the most objective indicators of concurrent tectonic movements.

The whole ice cover of the Antarctic (Fig. 1) divided into two structural stages: glaciosphere – free from the influence of bed relief, and lower stage (Lastochkin 2006). The dynamics of ice in the lower stage is influenced by the relief of subglacial bed. Thicknesses of strata between them are estimated: H_1-H_2 («free» glaciosphere), H_2-H_3 (glacial strata of the lower stage of ice cover), H_2-H_4 (lower structural stage, including overall thickness of glacial and mineral masses), H_3-H_4 (mineral strata of the lower structural stage, experience maximum influence from ice cover and subglacial water).

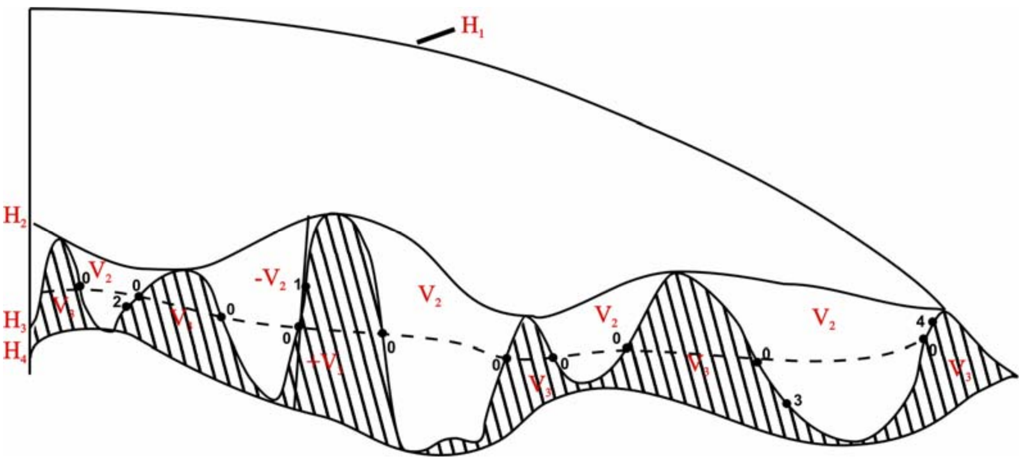

Fig. 1. ***Assessment of the earth crust differentiated movements by balance method***

Surfaces: the day surface of ice cover (H_1), polyapexial (H_2), subglacial-submarine (H_3), polybasis (H_4); lower structural stage's strata of: glacial (V_2) and mineral (V_3) masses. At points 0–4 – balance values, reflecting differentiated movements: at point 0 – zero balance ($-V_2 = +V_3$); at points 1, 4 – positive balance ($V_3 > V_2$); at points 2, 3 – negative balance ($V_2 > V_3$). Dash line – location of original planation surface (balance value is equal to zero).

The essence of balance method – total thickness of the lower stage can be represented by balance $S=V_2+V_3$. Its value is defined by ratio of income ($+V_3$) and outcome ($-V_2$) at each point of subglacial-submarine surface (Fig. 1).

We present map of differentiated neotectonic movements of Antarctica based on the balance method (Fig. 2). This method allows identifying peculiarities of morphotectonic plan which were not revealed during morphotectonic zoning and structural-morphometric investigations. The main goal of balance method is evaluation of differentiated neotectonic movements, their amplitude and direction; revealing areas of elevation and depressions (for interpretation of this map see Lastochkin 2006).

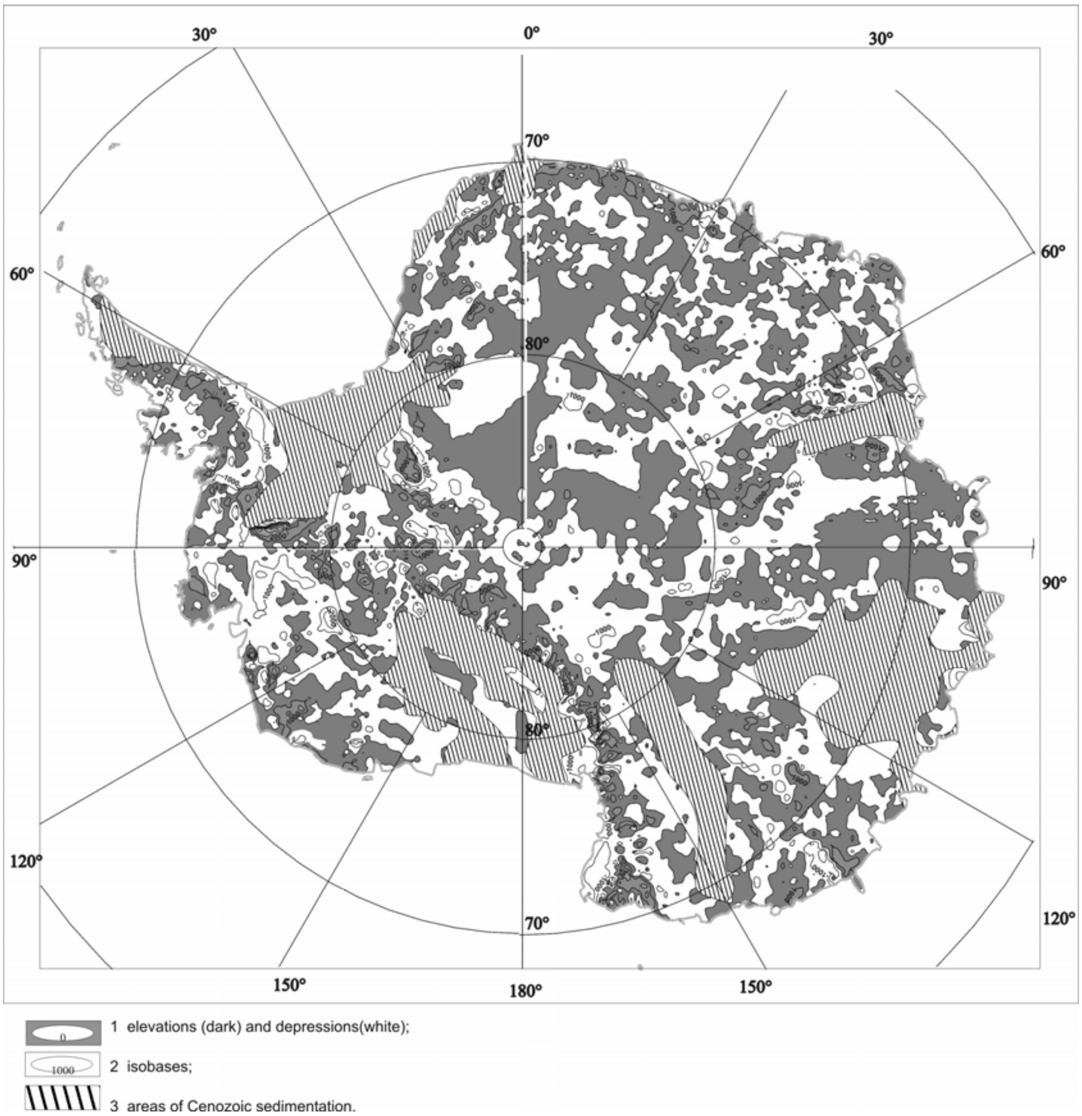

Fig. 2. ***Map of differentiated neotectonic movements of Antarctica (based on balance method)*** *(authors: Krotova-Putintseva A. Y., Lastochkin A. N.)*

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A NEW PALAEOENTOMOLOGICAL AND PALAEOBOTANICAL DATA FROM THE LATE GLACIAL DEPOSITS IN THE RAUNIS SECTION

Lukševica, L.[1], Lukševics, J.[2], Cerina, A.[2], Kalnina, L.[2], Barševskis, A.[3]

[1]*Natural History Museum of Latvia, K. Barona Street 4, LV-1050 Riga, Latvia; e-mail: ligita.luksevica@ldm.gov.lv*

[2]*University of Latvia, Rainis Boulevard 19, LV-1586 Riga, Latvia; e-mails: citplanetietis@inbox.lv, caija@inbox.lv, Laimdota.Kalnina@lanet.lv*

[3]*University of Daugavpils, Vienibas 13, LV-5400 Daugavpils, Latvia; e-mail: beetles@dau.lv*

Late Glacial in Latvia has been subdivided into several chronozones, namely Raunis, Early Dryas, Böling, Middle Dryas, Allerød, Late Dryas, which correspond to respective palynozones (Seglinš, 2002). It is considered that the Raunis Beds represent the oldest deposits of the Late Glacial corresponding to the Raunis interstadial proposed by A. Dreimanis (Seglinš, 2002). In accordance with the newest data the Raunis Beds should be considered as deposited during the North Lithuanian phase (Zelcs, Markots, 2004).

Application of animal fossils for the Quaternary stratigraphy of Latvia until recently was limited because the remains of vertebrates and mollusks are rare and very often poorly preserved whereas insect remains have been recorded in several sections, but their fossils were never studied in details. In this paper we present the results of palaeoentomological study of palynologically and paleocarpologically well-studied stratotype section of the Raunis Beds for interpretation of paleoecological aspects of the Late Glacial. A new material provides new data on the entomofauna of the Late Glacial and characterizes distribution of insect remains in the section, as well as adds information on distribution of plant macroremains.

The Raunis Beds, overlying the Latvian till, in stratotypical section consist of limnic and mire deposits with the high content of organic matter. Two sharply differing spore and pollen assemblages were established within the Raunis Beds by palynological data (Danilans, 1973). Deposits enriched in plant remains and herb pollen (20-30 %) dominated by Cyperaceae, and pine dominating among pollen of trees, are characteristic for the lower part of the section. New data collected during last years significantly add the assemblage of plant macroremains from the lower part of the Raunis Beds, where oogonia of charophytes (Characeae), some stone-fruits of pondweed *Potamogeton filiformis* Pers., rare megaspores of *Selaginella selaginoides* (L.), and seed of *Picea*, as well as remains of dwarf trees *Betula nana* un *Dryas octopetala* have been found (Cerina *et al*., 1998; Cerina, Kalnina, 2000). During this study, stone-fruits of the bird-cherry *Padus avium* have been found for the first time. Radiocarbon dating of the plant remains from the lower assemblage shows 13 390±500 years (Danilans, 1973).

The upper part of the Raunis Beds consists of silt and clay deposits with the low content of organic matter. Wormwood *Artemisia* dominates the herb pollen, and birch tree dominates among the tree pollen (Danilans, 1973). During recent study remains of only water-plant, charophytes and several species of pondweed, have been gathered.

Recent palynological study demonstrates that the lower part of the section contains pollen of pine, as well as few of birch and alder, which compose about 65-70 % of all pollen. The other portion of material contains pollen of vascular plants and spores. Pollen of *Betula nana* and *Dryas*, as well as spores of *Selaginella selaginoides* also have been found from this interval. In the upper part of the section the content of these remains increases, while the pollen of trees other than pine gradually disappear. The content of spores and pollen indicate the subarctic depositional environment of the Raunis Beds.

The remains of insects in Raunis section have been found only in the lower part of the Raunis Beds. They are well preserved, though mainly disarticulated parts of skeletons such as forewings, abdominal segments, rarely heads or complete skeletons were gathered. The main part of the determined insects belongs to the genus *Notiophilus* of the family of ground beetles Carabidae. Nowadays members of this genus belong to the entomofauna of the temperate zone. *Notiophilus aguaticus* (L.) and *N. palustris* (Duff.) are characteristic for the Holarctic ecozone and today are widely distributed in Latvia. Significant is finding of *Notiophilus biguttatus* (F)., which is xerophytic and heliophylic organism (Barševskis, 2003). In the lowermost part of the section trans-Palearctic ground beetle *Bembidion gilvipes*? Sturm, nowadays distributed in the Central and Eastern Europe including Eastern Latvia, and Siberia until the Lena River, has been recorded. Interestingly the ground beetle *Bembidion unicolor* Chaud. until now has not been found within the modern entomofauna of Latvia. The ground beetle *Agonum viduum* (Duff.), which is now widely distributed in the whole Latvia, is found a bit higher in the section. This species is living along the banks of basins and other wet or boggy places.

Agrilus sp. is only representative of the jewel beetles Buprestidae. Nowadays these insects also live in Latvia. The larva of this jewel beetle bore through bark of various types of trees and shrubs.

Interesting finding is subfossil of the alder leaf-cutting beetle *Agelastica alni* from the middle part of the section, below the layer with the water-plant remains. This species belongs to the leaf beetle family Chrysomelidae. Nowadays *Agelastica alni* exists in wet forests and consumes only leafs of the black alder *Alnus glutinosa*. Apart the afore-mentioned species, indeterminable remains of weevils Curculionidae, leaf beetles Chrysomelidae, and rove beetles Staphylinidae have also been found.

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MORPHOLOGY, INTERNAL STRUCTURE AND GENETIC INTERPRETATION OF THE MORAINE RIDGE AT CĒRE, CENTRAL PART OF THE NORTHERN KURSA UPLAND, NW LATVIA

Markots, A., Strautnieks, I., Zelčs, V.
University of Latvia, Rainis Blvd. 19, LV-1586 Rīga, Latvia; e-mails: Aivars.Markots@lu.lv; Ivars.Strautnieks@lu.lv; Vitalijs.Zelchs@lu.lv

The moraine ridge at Cēre is the dominant glacial landform in the up to 7.5 km wide depression that occupies the central part of the Vanema Heights, the highest part of the Northern Kursa Upland. Here subparallel, elongated ridges alternate with 0.5-1.0 km wide hollows. The Cēre Ridge is about 6 km long, 3 km wide and ca. 40-55 m high (up to 107 m a.s.l.). It has an asymmetric cross-section with some inclination of the flat-topped surface to SE. The W and N slope is steeper and higher, in some places abrupt. In addition, the N slope is intersected by two step-like ascents that reflect heterogeneity of the lithological composition of Upper Devonian bedrock, influencing on the erosional processes.

The Cēre Ridge is located on a relatively flat, slightly convex bedrock surface elevated 40-50 m a.s.l. and complicated by small and low topographical highs built by Devonian terrigenous rocks (Juškevičs et. al, 1999), supposedly traces of glacial erosion. The structure and stratigraphy of the Pleistocene deposits are very similar to those occurring in the entire Vanema Heights. The only difference is in the thickness of the Pleistocene deposits, which is on average only about 40 m and reaches up to 50-60 m in the highest part of the Cēre Ridge. The covering layer of the Upper Weichselian till is 0-4.5 m thick. The small rafts or clasts of reddish sandstone and inclusions of particoloured marl and aleurolite occur in the Late Weichselian till and, as well, in the uppermost part of disturbed glacioaquatic deposits, particularly along the edges of the ridge. In surrounding hollows the Quaternary cover is thinner than 20 m.

The surface of the Cēre Ridge is complicated by two assemblages of numerous subparallel ridges. The ridges, that have same general geomorphic trend as the entire elevation, are dominant. Individual ridges of this assemblage are several hundred meters long, up to a hundred meters wide and a few meters high. The landforms of the other assemblage have a transverse orientation and are also not expressed morphologically so well.

The Cēre Ridge itself and assemblages of landforms that complicate its surface are mainly composed of deformed outwash sediments, covered by till. In comparison to those in the western part of the Vanema Heights, sand and gravel have a more important role in composition of glacial landforms. Outwash is parallel stratified, but cross-bedding, as well as filling-in of meltwater channels occur occasionally. Outwash also contains silty intercalations with minor flow folds or dewatering structures that are encountered on flanks of the major folds and at the basal part of some imbricate thrusts. Internal shearing and rotation appear in the interlayers of the banded diamicton. Granulation of pebbles and occurrence of crush breccia are common along the thrust planes, dipping to the NNW or NW along the W edge and to the NE, E and even SE in the E part of the ridge. The OSL dates of the underlying fine grained sands in a depth 6.0 and 12.0 indicate age of 45±3 and 115±10 cal kyr B.P. (Risø Nos. 04 46 56 and 04 46 57). It rather seems that these dates are in contradiction with regional context (Meirons, Zelčs, Markots, 2004). It is possible that the material is mixed with different sand populations.

Major folds with amplitude up to 6 m are the landforming structures of the small drumlin ridges. In many instances these folds superimpose preceding shear and thrust planes. Contemporary minor folding and shearing also occur along the flanks of these landforming anticlines. Successively, the drumlin-forming folds are altered by subsequent folding shearing and overthrusting by acting stress directed from NNE. Commonly this stress direction is in good agreement with NNW and NNE maxima of the fabric lineation in the covering till, but conclusions regarding such a relationship and some other features of macrofabric lineation are under consideration.

In the W part of the Cēre Ridge macrofabric lineation measured in diamicton, pebbles, gravel and pebbles interlayers are complicate but mainly dispersed in NW-SE and NE-SW sectors with dip angles correspondingly on average from 20° to 30°, and from 5° to 10°. Along the western flanks of folds longitudinal axes of pebbles dip to the NW, NNW or even the SW, in the eastern flanks – mainly to the NE or E. Occasionally pebbles with maxima in the NE have also conjoint maxima in the SW.

In the E gravel pit fabric strikes from N to S, NE-SW; SSE-WNW, but at the lower section along displacement planes striking to NW, pebbles lineation from SW-NE is dominant.

The Cēre Ridge has been treated as an interlobate spur-like massif by J. Straume (1979). The morphology and, as described above, internal structure of the Cēre Ridge are analogous to the Waldelwitz-Johannistal hills, classified by J. Piotrowski (1997) "…as a mega-drumlin, which surface is formed into secondary ridges running parallel to the axis of the mega-drumlin". Most likely the transverse, small ridges are superposed landforms, some like recessional or ribbed moraine.

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MICROELEMENTS OF QUATERNARY SEDIMENTS –MAIN SOIL – FORMING ROCKS OF THE NORTH-WEST RUSSIA

Matinian, N. N.
St.Petersburg State University, University emb. 7/9, RUS-198504 St. Petersburg, Russia; e-mail: Natalym101136@yandex.ru

Investigation of microelemental content of quaternary sediments - main soil-forming rocks of the northwest of Russia is important for a scientifically sound development of soil manipulation aimed on their increased fertility. It also allows to forecast possible environmental changes under the influence of an ever-increasing technogenic pressure.

The territory of the northwest of Russia is one of the young surfaces on Russian plain, which in late pleistocene has been still under the last Valday (Bürm) glacial cover. It is characterized by young low density quaternary sediments which are represented mainly by actually-glacial (moraine loams, sandy loams) and aqueoglacial (limnoglacial sands, clays, and fluvioglacial sands).

Moraine loams cover about 45 % of all territory of the region, while 30-40 % of territory is covered by the aqueoglacial sands. Among all limnoglacial clays, the best represented are varve clays that overlay the bottoms of postglacial reservoirs, and unstratified clays (zvontsy), encounted on elevations of monticulate morainic relief.

The microelement composition of quaternary deposits is determined by the nature of underlying bedrock and by the duration of hypergene changes in the sediments, that were left behind by glacier in its retreat. Quaternary deposits are significantly poorer in microelements content than their underlying crystalline rocks. Deposits concentrate only Nb, V, Co, Zn, Cu.

Based on the microelements concentration coefficient in the quaternary deposits relative to the crystalline rocks, limnoglacial clays accumulate V, Nb, Co, Zn, Cu. The values of the coefficient for Cu ,V, Nb are especially high. V, Co, and Zn are concentrated in the morainic sediments, Sr and Sn - in the limnoglacial sands, Co, Zn, Cu– in the fluvioglacial sands.

In comparison with the regional background (average content of microelements in the regional rocks) limnoglacial sands contain the least amounts of microelements among all the quaternary rocks. They are enriched by Sr and Sn only. Fluvioglacial deposits exhibit elevated concentrations of Cu, Zn, Sn**.** Zvontsy clays are the richest in almost all microelements (except for Mo, Sn). Varve clays concentrate V, Nb, B and Y, although overall, the total amount of microelements is comparable with regional background content. In these deposits clay interlayers are enriched by Ni, Co, Pb, and Cu; the sandy- dusty interlayers – by Zn, Sr, and Mn, whose concentration gravitates to clastic minerals.

Among the morainic deposits noncarbonate moraine is the one most enriched by microelements such as Mo, Ni,Co, B, V, Ba, V, and Zr. Concentration of these microelements there significantly exceeds the regional background.

All types of quaternary deposits are encountered in different geomorphological and geochemical conditions of region, that determines the distribution of microelements and the direction of soil formation.

Among the lowlands where varve clays are spread, the clays of Karelian isthmus are marked by the elevated content of all microelements (except for Nb and Mo). The highest concentrations are for Ni and Sr. Enrichment of Karelian clays by microelements is due to the introduction and redeposition in interselga depressions of slight weathered products of rich in primary minerals of crystalline rocks. Carbonate varve clays of southern lowland (along the river Velikaya) contain microelements below the regional background concentrations (except for Nb). The high concentration of microelements (Cu, Zn, Nb, Pb, Ni, and V) in unstratified clays (zvontsy) was detected in the monticulate morainic relief between the rivers Lovat' and Velikaya.

High coefficients of microelement concentration were detected in shore sands of Finnish gulf and Ladoga lake. Some samples contained the highest concentrations of Cu (1500 mg/kg) and Zn (210 mg/kg).

Among fluvioglacial deposits sands of morainic lowland adjecent to the Valday upland (preValday destrict) are characterized by high concentrations of V, Mo, B, Nb, Cu, Ni, and Co. Those sands located on the south-west of region are the poorest in microelement content.

Microelemental content of carbonate moraines is lower than in noncarbonate ones. Carbonate moraines of Ordovic plateau and along the Chudskoe lake are poorest in that respect. Carbonate and non-carbonate moraines of PreValday district are the most enriched by microelements. In these moraines nearly all microelement content is higher than the regional district background.

Accumulation of microelements is characterized for all quaternary deposits of Prevalday district - territory located on element migration pathways towards the main depression of the northwest Russia - Ilmen lowland.

Soils that form on quaternary deposits inherit the microelemental content of these sediments.

IR-OSL DATING OF DEPOSITS FROM THE NEW LATE PLEISTOCENE SECTION AT THE VOKA SITE, NORTH-EASTERN ESTONIA

Molodkov, A.

Research Laboratory for Quaternary Geochronology, Institute of Geology, Tallinn University of Technology, 5 Ehitajate Rd., EE-19086 Tallinn, Estonia; e-mail: molodkov@gi.ee

In this paper a series of results obtained from the new late Pleistocene section at the Voka site, NE Estonia, are presented. This site is situated in the eastern part of the southern coast of the Gulf of Finland where a steep cliff – the North-Estonian Clint – is interrupted by an about 2.2 km wide clint bay filled with thick Quaternary deposits (Molodkov et al. 2007).

The deposits studied are exposed in two neighbouring outcrops V1 and V3 located approximately 60 metres from each other. The sandy to clayey sedimentary sequence comprises at least two lithostratigraphic units, A and B. The boundary between these units is marked by a gravel bed at the base of unit A (Fig. 1). The deposits forming the upper part of unit A of the V3 section are characterised by a high uranium content (up to about 23 ppm), which is due to the considerable amount of uraniferous Ordovician Dictyonema argillite (black shale). Besides the high uranium content deposits of this unit are characterised in V3 by the high degree of inhomogeneity due to the laminated structure of the sediments. The expected age of the deposits was between about 14 370 and 12 200 cal. years ago.

Fifteen samples from unit A of the V3 section were measured with IR-OSL and the time scale for the dated part of unit A was constructed on the basis of the best-fitting age-depth model shown in Fig. 1. From the regression equation follows that the sedimentation lasted from about 39 to 31 kyr BP. In the exposure V1 where the uranium content in unit A deposits is much lower (up to about 4–9 ppm) and the deposits are considerably more homogeneous consisting basically of fine-grained sands, the same range of ages from about 44 to 33 kyr BP was obtained. It can be interpreted as indicative of the fact that deposits of unit A in two neighbouring sections are chronostratigraphycally identical despite the obvious visual differences between them, and hence were contemporaneously formed during the time predating the LGM.

Single age estimates of the deposits from the underlying unit B indicate that these deposits span the period from at least about 110 to 70 kyr BP (V1) and from about 115 to 90 kyr BP (V3). This proves the presence in the Voka section of the deposits of the last interglacial *s.l.* (MIS 5).

It can be concluded from the present study that despite the extremely unfavourable sedimentary environment (high uranium content in the deposits, high degree of inhomogeneity) the dispersion of the dates obtained is surprisingly low, and there is good agreement between stratigraphy and succession of the IR-OSL ages in two different sections. It demonstrates the potential of the luminescence dating of sedimentary deposits with even very complicated structure and sedimentation history.

The study is supported by Grant No. 6112 of the Estonian Science Foundation.

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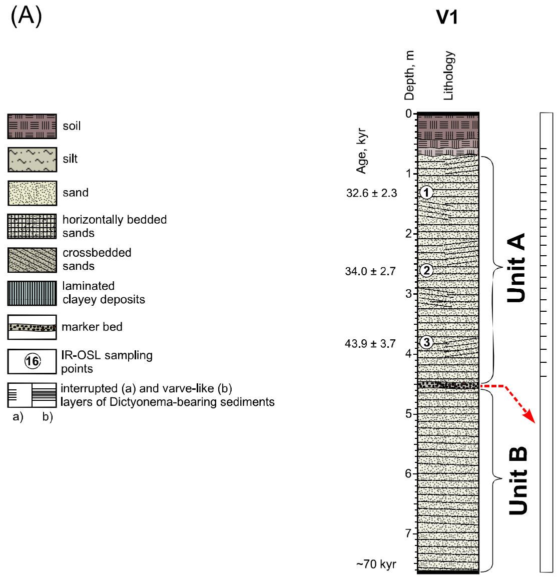

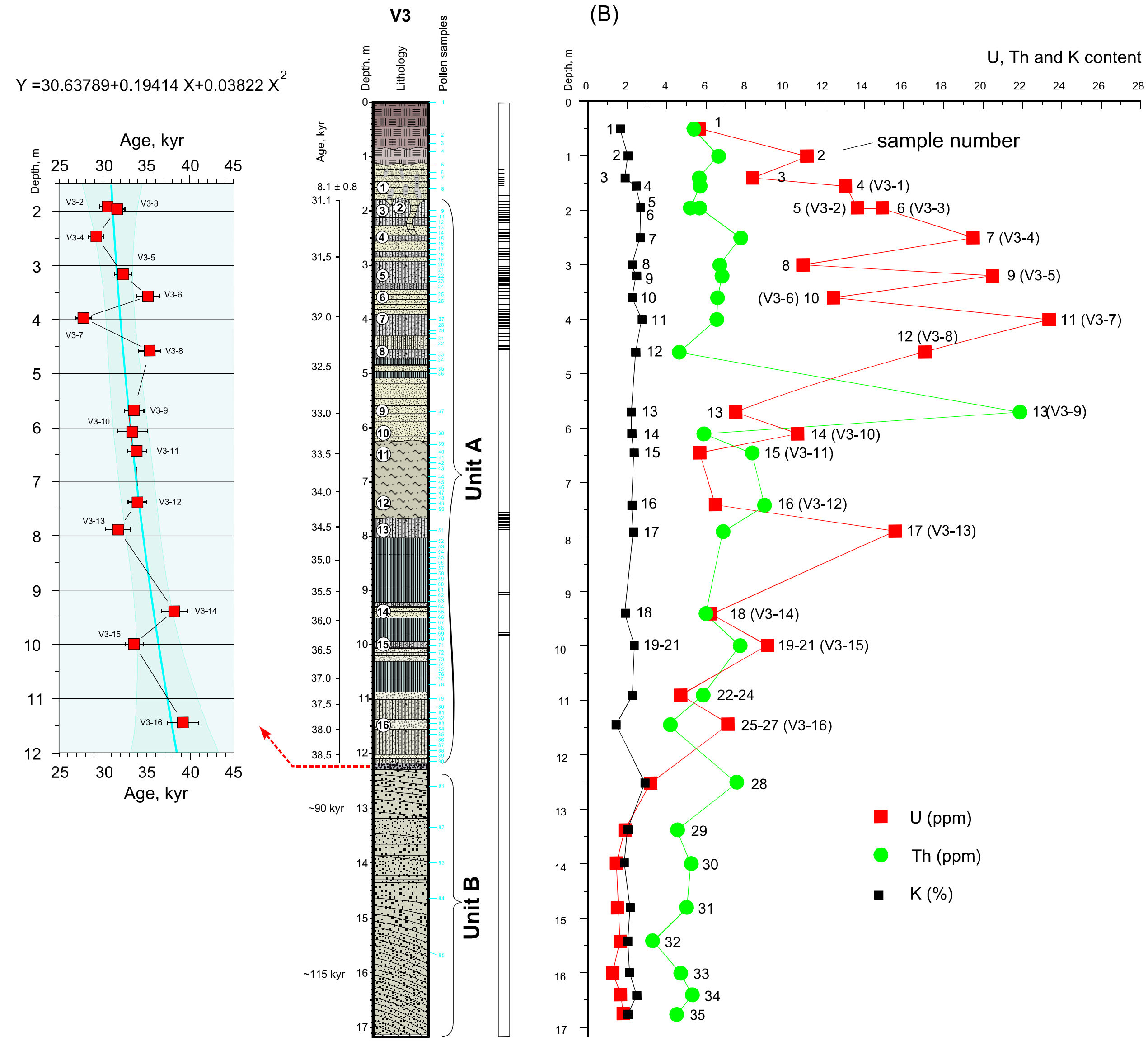

Fig. 1. (A) Stratigraphic columns of the V1 and V3 sections at the Voka site. The numbered circles show the location of the IR-OSL sampling points. Shown to the right of the columns are the position of pollen sampling points and the variations with depth of the Dictyonema argillite distribution in the deposits along the sections. Calendar time scale for unit A of the V3 section and IR-OSL dates from this unit (red squares) are indicated on the left. The best-fitting line (blue) for these data and 95% confidence contours (thin solid lines) with respect to this line are also shown. From the regression equation above follows that the sedimentation lasted from about 39 to 31 kyr BP.

(B) Uranium, thorium and potassium content determined by laboratory gamma-spectrometry down the V3 section. The numbers in the

FACIES AND DEPOSITIONAL HISTORY OF THE LATE WEICHSELIAN TILL AT THE SECTION KOZŁOWO, THE LOWER VISTULA VALLEY, NORTHERN POLAND

Narloch, W., Wysota, W.
Department of Geology and Hydrogeology, Institute of Geography, Nicolaus Copernicus University, Gagarina 9, PL-87100 Toruń, Poland; e-mails: wnarloch@stud.umk.pl, wysota@uni.torun.pl

The Kozłowo section is located in the middle part of the Lower Vistula valley, about 100 km to the south of Gdańsk. It reveals a thick (above 30 m) sedimentary complex of the Middle and Late Weichselian glaciation (Makowska, 1976, 2004). Four major lithostartigraphic units were distinguished in a exposing succession (from the bottom to the top): fluvial series (up to 20 m thick), glaciolacustrine silts (3 m thick), the till member (up to 6.6 m thick) and overlying it varved clays (few metres thick). The till member is a signature of the first ice sheet advance and its decay during the Late Weichselian (Wysota, 2002, 2007; Piotrowski et al., 2005).

Nine lithofacies (from A to I) have been distinguished in a vertical succession of till member (Narloch, 2006; Narloch and Wysota, 2006). Till lithofacies are generally concist of massive diamicton, excepting F and I lithofacies which reveal stratified nature. The lowest A lithofacies occur locally and consist of a silty, homogenous diamicton, 0.1 m thick. The contact between the diamicton and underlying glaciolacustrine silts is sharp. B lithofacies consist of a sandy diamicton, 3.5 m thick, that either overlies A lithofacies or rest upon glaciolacustrine silts and fluvial sands of substratum. The contact between lithofacies B and A is gradual, but ploughing marks and sedimentary prows can be observed. Minor folds and shear planes were recognised in glaciolacustrine silts just beneath the diamicton. In places, interfingering of till and the underlying silt material can be found, but a sharp contact is dominant.

The upper part of the till member consists of various lithofacies (C – I). The thickness of individual beds ranges from 0.1 to 0.8 m. They characterise different lithology (from clayey to sandy matrix) and colour. Isolated stones with striation on the upper surfaces and gentle overdraping clast structures have been found in C lithofacies. D lithofacies show thin intrabeds of sorted deposits (sand and clay) that are strongly disturbed. Lying above E lithofacies, consist of dark brown, massive clays, 0.1 m thick. Generally, contacts between lihofacies are sharp and conformable. However, gradual contacts can also be found between lithofacies G and H, and locally C and D.

The till fabric strength is generally high, with S_1 values ranging from 0.47 to 0.89. Mean vector shows NNE direction of ice flow.

The till member was formed by complex subglacial and supraglacial processes. A–D lithofacies in the lower and middle part of the till member were produced under an active ice, mainly as a result of combination of subglacial deformation, lodgment and ploughing. These processes were interrupted by episodes of melt water sedimentation (sorted intrabeds) during a periodical basal decoupling of ice from its bed (Jørgensen and Piotrowski, 2003; Piotrowski et al., 2005). E–H lithofacies were also formed under subglacial conditions by direct melt-out processes during a stage of a stagnant ice (Shaw, 1982; Munro-Stasiuk, 2000). The upper I lithofacies are interpreted as a flow till, and were accumulated probably both subaquatic and subaerial environments.

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DEVELOPMENT HISTORY OF THE GLACIAL LAKES IN NORTHERN VIDZEME, LATVIA

Nartišs, M., Zelčs, V.
University of Latvia, Rainis Blvd. 19, Rīga, LV-1586, Latvia; e-mails: maris@gmail.com, Vitalijs.Zelchs@lu.lv

The history of development of the glacial lakes in northern Vidzeme is complex. Due to the uneven topography with the alternating of interlobate areas, local highs and depressions, and the common inclination of the land surface of glacial lowlands towards the retreating glacier, the meltwaters could not drain freely forming ice-dammed lakes along the retreating margin of the Middle Gauja and Burtnieks ice lobes. The study concludes that shore displacement of glacial lakes was regressive. Outlet erosion and retreat of the ice lobes resulted in reducing the level of the lakes, and the abrupt opening of new outlets. Therefore the drainage brought episodes of rapid drawdown of theses lakes. As a result, in watershed areas deeply incised (up to 60-65 m in a depth) drainage spillways, smaller hanging or braided drainage channels were formed. Meltwater drainage caused also formation of erosion scarps, eroded surfaces marked by boulder concentrations, terraces and thresholds of drainage channels, levels of dry hanging gullies, and deposition of sediments either as deltas in proglacial lakes or occasional glaciofluvial fans in supra-aquatic areas.

The development of the glacial lakes started with formation of ephemeral lakes with elevation of 115-130 m a.s.l. in depressions between chain of end moraines and northern slope of the Vidzeme Upland at the first onset of the Linkuva (North Lithuanian) stade. Probably at the same time in the territory of the Middle Gauja Lowland the earliest phases of the Middle Gauja meltwater basin began. This early high-level stage is only recorded as levels of the River Gauja terraces between the townships of Ranka and Velēna (Āboltiņš, 1971), meltwater drainage at 125 m to Eastern Latvian Lowland, and the highest delta levels of the River Vaidava at Ape.

A few radiocarbon ages have been published from the study area, taken from the lake sediments that were deposited upglacier of the end moraine and outcropped in the upper part of the right bank of the Raunis River (Vinogradov et al., 1963; Punning et al., 1968; Stelle et al., 1975). These sediments reveal an existence of discontinuous ice-dammed lakes at altitude of 106-83 m a.s.l., and provide a minimal time of deglaciation of the Linkuva stade sometime between about 13 250 and 13 390 ^{14}C yr (about 15.3 cal kyr) B.P. The corresponding stage of the Middle Gauja meltwater basin can be traced from delta levels of the rivers of Gauja and Tirza at Lejasciems (Āboltiņš, 1971) and the lowest levels of the River Vaidava delta at Ape. Probably during this phase the connection through the Piusa and Hargla valleys to the glacial lake of Peipsi had emerged.

The Smiltene glacial lake was formed gradually during the glacier ice retreat to the line of Vaidava-Trikāta-Vijciems-Sēļi. The lake occupied wide area along the Vidzeme Upland and Aumeistari interlobate heights, including the lower NW corner of the Middle Gauja lowland. The fragments of the highest shorelines and upper levels of river deltas are fixed at 72-78 m a.s.l. Most likely the glacial lake was drained to WSW through the Mārsnēni-Middle Rauna depression and lower stretch of the River Rauna. As a result the junction of the spillway valley of Gauja between this tributary and Silciems ice-dammed lake was created. According to Rosentau et al. (2004) the connection of the glacial Lake Peipsi through the Võhandu and Hargla valleys was most likely strait-like rather than fluvial, due to its relative shallowness and because of horizontal glaciolacustrine terraces in the Hargla valley at an altitude of 79–73 m a.s.l. Both mentioned above connections were closed by the lowering of the Smiltene proglacial to 65-70 m a.s.l. which is reflected by the level of the delta of the River Mustjõgi (65 m a.s.l. by Āboltiņš, 1971), and levels of shorelines and aeolian accumulation. During this phase the drainage route was shifted from the Rauna River conduit to the direction of Valmiera, and the connection Miegupe-Gauja spillway valley was developed. It also seems that the proglacial damming of meltwaters in depressions and along southern slope of the Sakala Upland occurred concurrently with the development of the Smiltene glacial lake.

The Strenči proglacial lake came into being after the drainage of the Smiltene glacial lake, and the recession of the glacier ice from line Vaidava-Trikāta-Vijciems-Sēļi. Transition from the Smiltene glacial lake to the Strenči proglacial lake are marked by the development of flat-topped surfaces of morainic landforms and formation of new thresholds. The Strenči glacial lake disappeared with the beginning of the formation of the River Gauja valley in the Valmiera stretch. It also seems that the loss of the connection between Strenči and Vörtsjärv proglacial lakes in the Valka depression at 50 m a.s.l. (Rosentau et al., in press) caused formation of the Seda drainage valley, and establishment of the connection between the palaeolakes of Strenči and Burtnieks.

This study is based on investigation of the coastal landforms and and proglacial glacioaquatic sediments. Currently, improvement of the numerical database of palaeo-morphological data and field works on geologic and geodetic mapping of the glacial basins, investigation of glaciolacustrine deposits, and related drainage pattern features (shorelines, deltas etc.) are ongoing in the territory under consideration. The creation of more precise DTM is also in progress. The study was founded by Latvian Science Council Grant No. 05.1498.

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ENVIRONMENT DYNAMICS IN THE LATEST PHASE OF THE EEMIAN (MIKULINO) INTRGLACIAL IN THE CENTRAL AND NORTH-WESTRN OF THE EAST EUROPEAN PLAIN

Novenko, E. Yu., Faustova, M. A., Chepurnaya, A. A.
Institut of Geography RAS, Staromonetny 29, RUS-119017 Moscow, Russia; e-mail: lenanov@mail.ru

The last interglacial (Eemian, Mikulino) attracts a close attention of a wide range of Quaternary researchers, being a possible analogue to the advances stage of the global warming. Short-term oscillations characteristic for the transitional parts of the climatic macrocycle (transitions from glaciation to interglaciation and *vice versa*) reveal the highest natural rates of the landscape components' response to the climate change. Despite the succession of forest communities, typical for the Eemian (Mikulino) Interglacial is well investigated allover Europe, a question abut Interglacial\Glacial boundary is still open. In East regions Grichuk (1961) had attributed pine zone (M8) to the beginning of the Early Valdai glacial epoch and considered this phase as a transition from warm to cold epochs. In the most European schemes pine zone is included in the Eemian (Menke & Tynni, 1984; Mamkowa, 1989).

The object of represented work is the spruce zone (so-called "upper maximum of spruce"), described by Grichuk (1961) as one of diagnostic features of the Mikulino pollen diagram. The plant cover during this phase could be characterized as interglacial vegetation, but progressive cooling has been determined in spatial structure of landscapes. The reconstruction of plant cover (fig. 1) based by about 60 published pollen diagrams allowed us to determine three vegetation belts within the boreal forest zone on the eastern European Plain. The south and south-west regions (subzone 1) were occupied by spruce-beech forests with participation of elm, lime and oak and swamped forests of alder. Spruce forests with admixture of beech and rare oak and lime were spread over the vast area from the north-west of European Russia to the upper Volga basin and far to the east up to the Ural Mountains (subzone 2). Alder and hazel took part in the plant communities but were not abundant. The eastern part of the considered territory was covered by spruce forest and pine-birch ones (subzone 3). Alder continued to play a conspicuous role in vegetation; beech, oak, lime and hazel could grow in spruce forests on fertile soil, like in the modern south taiga.

Temporal dynamics of spruce phase were considered using results of pollen analysis on the complete Eemian and Early Weichselian sequence (fig. 2) in the Central Forest State Reserve (Valdai Upland, Russia). To obtain additional information about vegetation dynamics pollen analysis was carried out for buried organic sediments in small forest mires where peat accumulation began in the last 100-150 years (in modern epoch). The buried peat horizons lied at the depth 1.5-2 m and separated from modern ones by loess-like sediments. Detail analysis of these horizons shows that the most active process of swamp development occurred in spruce phase of Eemian Interglacial. Pollen assemblages of the first part of spruce zone are characterized by the highest values and concentration of Picea pollen. The second part is marked by increase of amount of pollen of broad-leaved trees, the some peaks are noticed on *Carpinus*, *Alnus* and *Corylus* curves; the content of spruce pollen reduced (see fig. 2). Probably, the progressive climatic cooling in this phase were interrupted by a short relatively warm interval before the finally transition to Early Glacial time. Some ambiguity of spruce phase is not unique situation for the Central Forest Reserve. Similar dynamics have been recognised in several profiles in Lithuania, Belorussia and in central and north-west region of European Russia (Kondratene, 1996; Savchenko, Pavlovskaya, 1999; Grichuk, 1982).

This work was supported by RFBR grant № 05-05-64479.

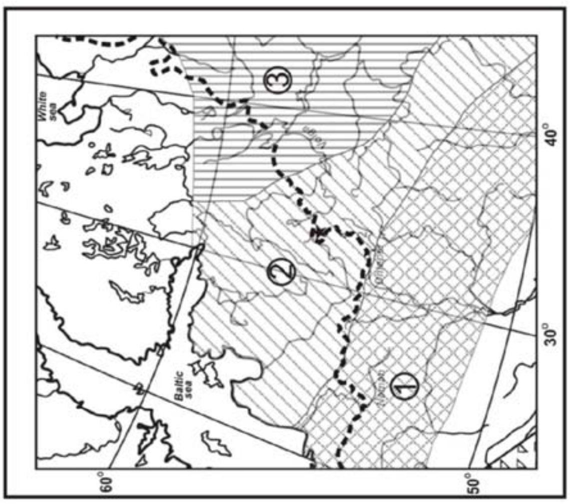
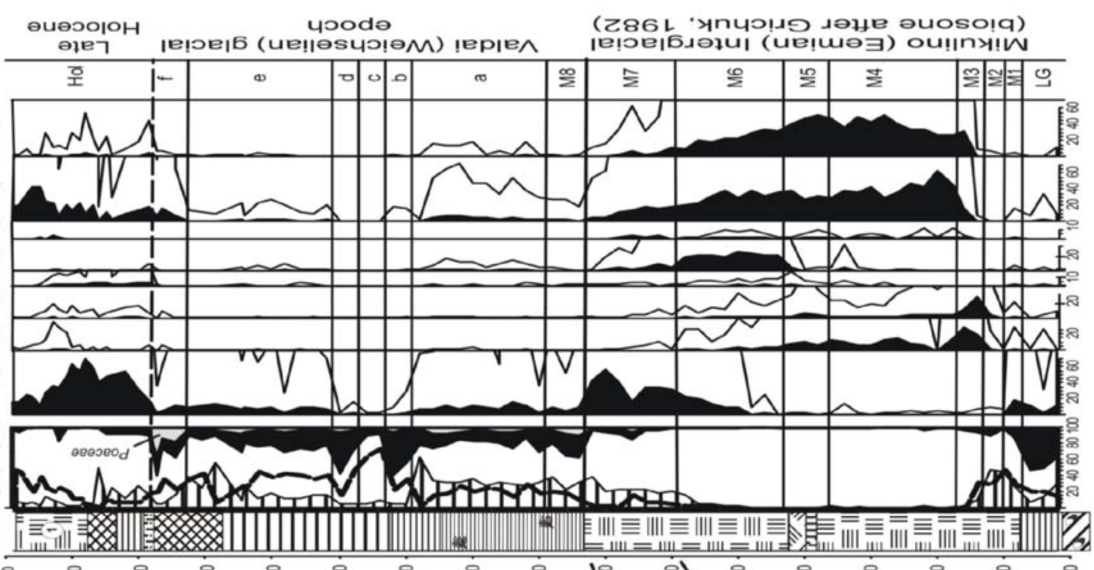


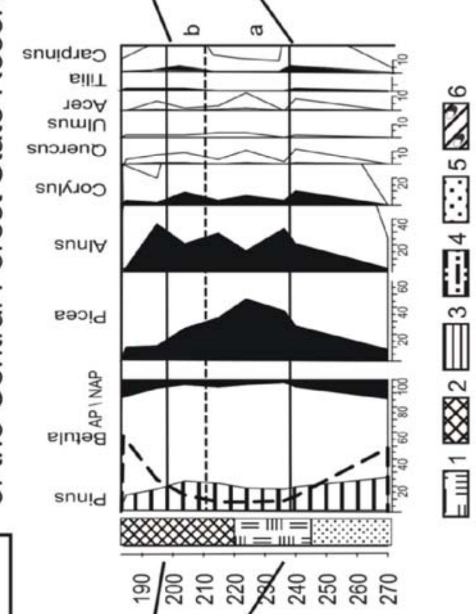
Fig.1. Vegetation during spruce phase

① Vegetation zone

Boundary of the Late Weichselian ice sheet (after Velichko et al.,2004)

★ Location of the Central Forest State Reserve





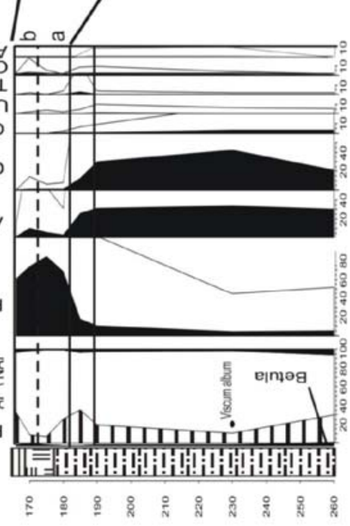


Fig.2. Pollen diagrams of the Central Forest State Reserve

Lithology: 1 - peat, 2 - gittja, 3 - clay, 4 - sand with caly, 5 - sand, 6 - till.

SUBGLACIAL TUNNEL SPACING INFERRED FROM THE DISTRIBUTION OF BEDROCK VALLEYS IN ESTONIA

Rattas, M.
Institute of Geology, University of Tartu, Vanemuise 46, EE-51014 Tartu, Estonia; e-mail: maris.rattas@ut.ee

Bedrock valleys, open as well as buried, are very important components of the overall evolution of the drainage system in Estonia. The origin of these valleys has been a matter of controversy and in many cases a composite origin should be considered. A number of them are inherited from the pre-Quaternary river drainage, but definitely, they have been re-used as subglacial drainage pathways and preferentially eroded repeatedly during several glaciations. In addition, the direct glacial quarrying is considered to have played the important role on their formation. The sedimentary infill of deeper buried valleys consist of several till beds stratified with aqueoglacial deposits, may be as old as Elsterian, and only in few places the interglacial deposits. Shallow valleys often contain only meltwater deposits lying directly on the valley floor and being relatively coarse grained in the lower unit reflecting more proximal ice-margin, deltaic or subglacial sedimentation.

In northern Estonia, in the area of Ordovician and Silurian carbonaceous rocks, individual valleys can be characterized as rectilinear to slightly sinuous, mostly orientated parallel or near parallel to the direction of ice movement, i.e. N-NW to S-SE. Occasionally they are with abrupt, up to 90° angel bends, which appear to be related to the bedrock fracture zones. In the fore-klint area they are deeply incided into the Ediacarian and Cambrian poorly consolidated terrigeneous rocks. Maximum valley depths are about 150 m (to about -150 m a.s.l.), almost reaching to the Precambrian basement and the width may range up to 2 km. On the carbonate plateau the valleys are typically 200-600 m in width and up to 40 m deep. The cross-sections of valleys are mostly U-shaped with rather steep sides and flat floors. In southern Estonia, in the areas of more permeable Devonian siliciclastic rocks, the complicated jointed valley networks occur, distinctly of different generation with various preferred orientations. The valleys are slightly sinuous, occasionally showing abrupt high-angle bends. Valley slopes in general vary in steepness, from rather gentle slopes (<10°) to steep slopes of 30° or more. Deeper valleys reach to the Lower Silurian carbonate rocks, incised to altitudes of -100 m or more a.s.l.

The re-usage tendency of bedrock valleys can be preferentially attributed to differences in hydraulic conductivity of bed, which also controls tunnel formation beneath glaciers. The morphological characteristics of some valleys or valley branches suggest strong erosion by pressurized water in tunnels; their longitudinal profiles are slightly irregular with multiple lows and thresholds. Some valleys appear to begin and terminate rather abruptly. In addition, some valley terminates into small outwash plain in front of recessional line or continues as esker. Based on morphological characteristics it is suggested that some of valleys are subglacial tunnel valleys. It is, however, difficult to assess the relative importance of the different processes for the re-usage of pre-existing valleys; also because of sparse and poor infill lithologic and sedimentologic data.

The study is supported by the research grant No 6962 and the target financed project SF0182530s03 from the Estonian Science Foundation.

WHEN AND HOW THE CONTINENTAL ICE RETREATED FROM ESTONIA?

Raukas, A.
Institute of Geology at Tallinn Unversity of Technology, 5 Ehitajate Rd., EE-19086 Tallinn, Estonia; e-mail: anto.raukas@gi.ee

The territory of Estonia was freed from the continental ice in Gotiglacial time which was characterized by high activity of the glacial streams and lobes and a highly variable glacial morphogenesis. Glaciers left behind different landforms and deposits up to 200 m thick. Glacial accumulation was concentrated to interlobate subglacial uplands and, as a result, several accumulative insular heights were formed. During the course of the thinning of the ice sheet, the movement of its individual lobes was controlled by the underlying subglacial topography and had a considerably specific dynamics. It complicates the correlation of ice-marginal formations. Depending on interior dynamics of the glacier and the nature of the subglacial topography, the deposits and relief forms of the same marginal belt may be of a diachronous character, especially on different sides of ice shed lines.

The deglaciation history in Estonia has been dated using the ^{14}C method, varve chronology, palynology, ESR, thermoluminescence (TL) and optically stimulated luminescence (OSL) methods and 10Be techniques, but the results obtained are rather controversary. The most promising is the radiocarbon method but it has also limited application due to the lack of good interstadial sections for dating. Often interstadial and interphasial sediments are contaminated by redeposited older organogenic material and the dates are inconsistent with each other. On the other hand, in several cases anomalously high ages have been obtained due to the “hard-water” effect.

In the study area traditionally five ice-marginal belts have been distinguished: Haanja, Otepää, Sakala, Pandivere and Palivere. They were formed either as a result of standstills of the ice margin or, in some cases, as a result of readvances. Observations at sites where till-covered, interstadial-type sediments (e.g. Viitka, Petruse, Kaagvere) occur provide in some cases evidence for events of ice front oscillations. But rather often organic deposits of different composition (fragments of peat, remains of plants, subfossil mollusc shells a.o.) do not form clear layers and are located in older sediments in the form of nests as a result of glaciokarst in the stagnant ice. Therefore such sections cannot date a new readvance of the active glacier.

In front of the ice-edge in all Baltic States and in the Gulf of Finland were located huge ice-dammed lakes and it gives some hopes to use varve chronology with the simultaneous study of secular variations of geomagnetic field. But in reality, as proglacial lakes were isolated from each other and many caps exist between the neighbouring territories, the accuracy of the estimated rate for the ice recession in the areas where glaciolacustrine sediments are absent is extremly disputable. The varve chronology combined with the magnetostratigraphy gave an approximate age some 12 000 – 12 500 yr BP for the beginning of glaciolacustrine sedimentation in North-East Estonia.

To improve the situation and wishing to establish more accurate deglaciation chronology, during the last years we have paid much attention to using the most modern techniques, including the OSL, ESR and ^{10}Be. For OSL dating we used samples from all genetical varieties of glaciofluvial deposits: from sandurs, glaciofluvial deltas, eskers and kames and ancient valley fillings. The results did not prove satisfactory. Alongside reliable dates between 11 000 – 15 000 OSL yrs BP, a lot of entirely unreliable dates from 8 000 to 114 000 OSL yrs BP were obtained. It is understandable. As glaciofluvial deposits exhibit a wide range of sedimentary characteristics the assumption that the TL signal is completely zeroed prior to final deposition is not only arguable but in many cases impossible and, what is also important, even the errors of dating in OSL years are often bigger than the duration of the whole deglaciation history of the investigated territory. To my mind the possibilities of the OSL method in dating glaciofluvial sediments are highly overestimated. Especially complicated is the dating of intermorainic deposits of unknown genesis.

In Estonia there are lot of gigantic boulders up to 58 m in perimeter and up to 930 cubic metres in volume. They are good objects in determining exposure ages using cosmogenic beryllium. Unfortunately the usage of the ^{10}Be method for establishing boulder exposure ages on the top of end moraine belts also gave great variations from 5 464±515 to 16 251±1121 yrs BP. It is normal, because we do not know how long time the investigated boulders have been in the forest, under snow cover or below the waters of the Baltic Sea.

In the light of pollen analytical interpretations, the retreat of the ice margin from the Haanja zone (the oldest in Estonia) began in Bølling, whereas Estonia was finally ice-free in the second half of the Allerød chron. According to the classical methods the ice-cover began to retreat from the south-eastern part of Estonia some 13 000 years ago, from the Otepää belt about 12 600 years ago and from the Pandivere belt about 12 200 years ago. Probably about 11 200 radiocarbon years ago a new temporary advance of glaciers took place, which led to the formation of the Palivere marginal zone, with a lot of rapakivi boulders from SW Finland, which are absent in the Pandivere zone and show different ice movements during the mentioned two stadials.

In conclusion we can say that despite the great number of analyzes and publications devoted to the deglaciation history and marked improvements in study methods, many problems of topical interest have still not been solved yet, especially due to the lack of good direct dating methods. Even using of most modern physical dating methods could not help to improve existing stratigraphical charts for the late-glacial period.

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DEVELOPMENT OF THE BALTIC ICE LAKE IN ESTONIA

Saarse, L.[1], Vassiljev, J.[1], Rosentau, A.[2]

[1]*Institute of Geology Tallinn University of Technology, Ehitajate Rd. 5, EE-19086 Tallinn, Estonia; e-mail: Leili.Saarse@gi.ee,*

[2]*Institute of Geology University of Tartu, Vanemuise St. 46, EE-51014 Tartu, Estonia*

In the history of the Baltic Ice Lake (BIL) five main phases have been distinguished in Estonia; of those BIL I and III are considered transgressive and the remaining three regressive. The reason why so many different phases are distinguished is grounded in the fact that raised beaches and terrace surfaces occur at five different levels (Pärna, 1960). In the current study we will focus on phases BIL I–III.

BIL I coastal formations were formed on the distal shore, when the ice margin stagnated at the First Salpausselka ridges (Ss I) about 12 300–12 100 cal BP. The age of the formation of Ss I ridges is based on varve counts, ^{14}C AMS dates and palaeomagnetic measurements (Saarnisto and Saarinen, 2001). According to Sauramo, south of Salpausselkä the ice retreated at a rate of ca 60 m yr^{-1} and north of it at a rate of ca 260 m yr^{-1}. Okko suggested that by the time Ss I started to form, the ice sheet had retreated some 30 km beyond the Ss I position. According to Rainio, it could have retreated even as much as ca 80 km (Donner, 1995). The geological evidence presented by Lunkka *et al*. (2004) supports the ice retreat and re-advance from and to the Ss I position. Assuming that the ice margin started to retreat from the surroundings of Tallinn at about 12 700 cal BP and reached ca 50 km north of Ss I at 12 300 cal BP, with the distance between these points being ca 245 km, the speed of ice movement must have been ca 61 m yr^{-1} , which is quite similar to the average rate of recession proposed by Sauramo.

BIL I formations in Estonia have been registered at 61 sites along ca 360 km coastline. Abrasional and accumulative terraces, beach ridges, benches, spits, dunes and boulder fields mark the maximal distribution of BIL I, which at the northern slope of the Pandivere Upland reached up to 68–70 (Pärna, 1962) and at the slope of the Sakala Upland up to 42–45 m a.s.l. (Lõokene, 1959). In north Estonia, BIL I distal coast fringed along the proximal edge of the Kemba glaciofluvial delta forming a 10–12-m-high bench.

BIL II formations (42 points) locate quite close to the BIL I formation, positioning only 2–3 m lower elevations, between 68–32 m a.s.l. BIL II shoreline is well developed along the coast starting from Narva, bordering the Pandivere and Sakala uplands and reaching the Estonian-Latvian frontier. On the western coast of Estonia several islets emerged. As the simulated coastline verges almost exactly that of BIL I, a question arises about their synchronicity. During heavy storms the water level could rise 2–3 m, abrade and transport a lot of material like the last heavy storm on January 9, 2005 when the water level rose 300 m in the Pärnu area.

During the ice margin standstill at the Second Salpausselkä ridges (Ss II) about 11 800–11 600 cal BP (Saarnisto and Saarinen, 2001) a well developed coastline of BIL III was formed along the slopes of the Pandivere and Sakala uplands at 65.5 and 32.5 m being most expressive between Kohila and Rapla where the openness of the coast to the westerly stormy winds and the tilt of the glacial topography towards the same direction favoured the development of different beach formations. BIL III level seems to be slightly transgressive in Estonia. The magnitude of transgression near Hageri was about 3–5 m concluded from the beach formation. In the Rabivere mire (Kõrgsoo) the basal sand of the Younger Dryas age is covered by 1.2-m-thick silt intercalated with *Bryales* peat serving as an evidence of this transgression (Kessel, 1972). Another region with geological evidence indicating transgression is Kunda Hiiemägi, where the glaciofluvial deposits are covered by coastal ones.

Simulation of the BIL III stage shoreline shows that it was quite indented with several bays, especially on the northern and northwestern slopes of the Pandivere Upland. Lower reaches of several rivers, including the Narva, the Kunda, the Loobu and the Valgejõe, were submerged. The area of Lake Peipsi had considerably decreased and only a small water body was left in the northern part of the Peipsi depression. This is in good accordance with the earlier reconstruction made by Pärna and the water level curve, presented by Hang et al. (1996), which confirms a low lake-level in Peipsi during the late glacial. At the same time, only the north-eastern part of the Võrtsjärv Lowland was inundated by water and Lake Võrtsjärv was most probably dry or very shallow. The total water level lowering from BIL I to Yoldia level in Estonia is estimated at 40 m on the Tallinn isobase. At the end of the Younger Dryas about 11 600–11 500 cal BP, BIL lowered rapidly or even catastrophically and left behind a few scattered beach formations between 58.35–45 m. In Estonia, these formations have been connected with the BIL IV and V phases (Pärna, 1960).

This study was supported by ETF Grant 6736.

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END MORAINES IN THE SOUTHERN PYHÄ-LUOSTO FELL AREA, NORTHERN FINLAND

Sarala, P., Johansson, P. and Valkama, J.
Geological Survey of Finland, P.O. Box 77, FI-96101 Rovaniemi, Finland; e-mail: pertti.sarala@gtk.fi

Finnish Lapland has repeatedly situated in the central region of the last Scandinavian glaciation. Glacial deposits indicate several glacial phases with separate till units and variable striae and till fabric datasets. Glacial morphology, instead, is indicating only the last deglaciation phase when the ice divide zone situated in the Central Lapland area crossing it with west-east orientation. Ice-flow directions were towards the south-east on the southern side and towards the north or north-east on northern side of the ice divide. The edge of glacier was divided into ice-lobes of which flow directions are seen on the orientation of streamlined drumlins and esker chains. The Central Lapland area was mainly on supra-aquatic position during deglaciation although large, time-transgressively developed ice-lakes were common.

The Pyhä-Luosto fell area situates in the southern part of Sodankylä municipality, about 80-100 km to the north from the Arctic Circle and Rovaniemi (Fig. 1). It is locating on the southern side of the last ice divide zone. The Geological Survey of Finland (GTK) was mapped surficial geology and deposits of the area during the 2005-2006. During the work surficial deposits and glacial landforms were mapped covering the whole Pyhä-Luosto fell area (ca. 750 km^2).

The studies concentrated on southwest-northeast oriented moraine ridges, which are oriented perpendicular to the latest ice-flow direction on the southern side of the Pyhä-Luosto fell area. They seem to form incoherent chains which length was several kilometres. Most of the ridges (height 3-5 m, length 100-500 m and width 5-10 m) are clearly distinguishable from the surrounding terrain because of the steep slopes (Fig. 2). Some of them are following each others in the ice-flow direction with intervals of about 30-50 m having an arched shape. On the south-eastern parts of the hill chain occur drumlinoids and flutings with direction of about 300°.

Three of the ridges were studied carefully using test pits and trenches (depth 3-4 m). The till stratigraphy and structures show that these are composed of two till units which both have a sandy matrix and quite rounded pebbles indicating long transportation of till material. The lower till is composed of grey and homogeneous basal lodgement or melt-out till unit. An orientation of pebbles is about 280° with low dips (5-20°). The upper one, instead, is grey or brownish grey, more heterogeneous till unit where the stratification, colour bands, shear structures, faults and ice-wedges are common. Pebble orientation is about 300° (dip 0-20°). Sheared and deformed, 10-50 cm thick, sandy/fines layer occur in between the till units.

An orientation of the hills with inner structures, and their chain-like occurrence indicate marginal processes during the deposition. Ice margin has retreated towards the northwest and the hills are oriented perpendicular to that. Because of the sharp form and steep slopes the deposition before the last deglaciation was hardly possible. That is why we interpret these forms to be end moraines, which were deposited by the oscillating ice-lobe during the retreat phase. Deposition has happened most probably about 10 300-10 400 years ago after glacier's margin was reached the fell area and the glacier was divided into separate ice-lobes flowing on both sides of the fell chain towards the east or south-east.

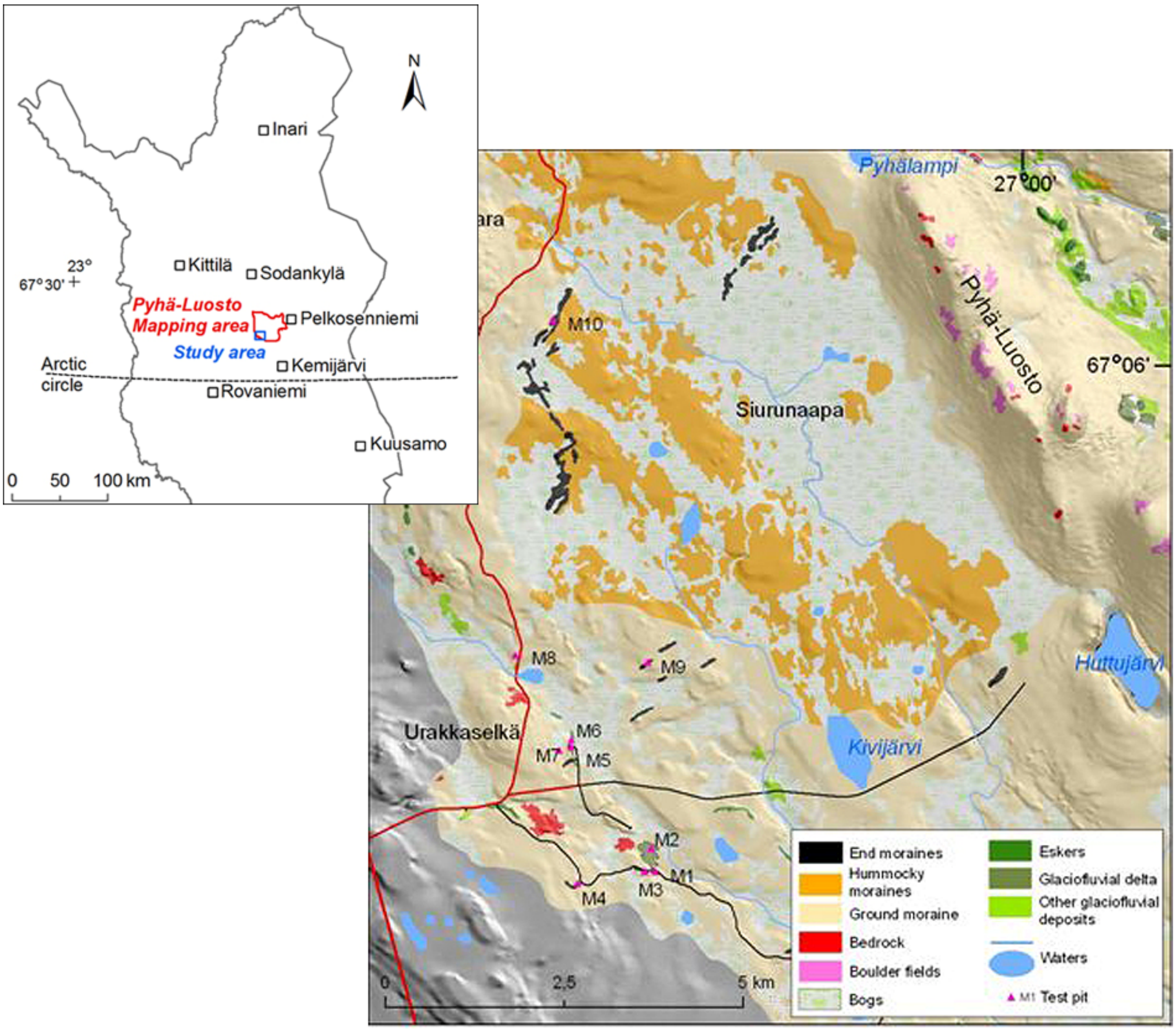

Fig. 1. ***A location of the study area in northern Finland. An occurrence of the end moraines and other surficial features is also shown in a map. Elevation data and topographic features © National Land Survey of Finland, permission number 27/LA/07***

Fig. 2. ***A view from the end moraine ridge to the Pyhä-Luosto fell chain in the north. Sandy till material from the test pit M4 (cf. Fig. 1) is seen on a top of the ridge. Photo P. Sarala***

PLENI-WEICHSELIAN SEQUENCES IN THE VENTA RIVER VALLEY AND VICINITIES (NORTH-WESTERN LITHUANIA), EXEMPLIFIED BY THE PURVIAI OUTCROP

Satkūnas, J.[1], Grigienė, A.[1], Jusienė, A.[1], Damušytė, A.[1], Mažeika, J.[2]

[1]*Lithuanian Geological Survey, S. Konarskio 35, LT-03123, Vilnius, Lithuania; e-mails: jonas.satkunas@lgt.lt, alma.grigiene@lgt.lt, asta.jusiene@lgt.lt, aldona.damusyte@lgt.lt*

[2]*Radioisotope Research Laboratory, Institute of Geology and Geography, T. Sevcenkos 13, LT-03223, Vilnius, Lithuania; e-mail: mazeika@geo.lt*

The Middle Weichselian (Oxygen Isotope Stage 4) is characterised in Lithuania by nonglacial plaeoenvironment, however this interpretation was based mainly on data from South-Eastern Lithuania (sections Jonionys, Medininkai, Mickunai, Rokai) (Satkunas *et al* 2003, Satkūnas & Grigienė 2000). It was noted, that the upper part of the Middle Weichselian (Pleni-Weichselian) only very tentatively could be subdivided into thermomers and cryomers due to slight climatic changes on the background of general climatic deterioration (Satkūnas 1999), therefore, each section with Middle Weichselian sediments is very important for climatostratiphic subdivision of the Pleni-Weichselian time span. The investigations of the Purviai outcrop in Venta river valley were carried out in order to determine paleogeographical conditions and precise stratigraphical position of the lacustrine sediments, known in the area and according to the previous researchers (e.g. Kondratienė 1988) interpreted as Middle Weichselian.

The area under discussion geomorphologicaly is located in the glacial plain of middle course of the Venta river valley formed during retreat of continental ice sheet of the Late Nemunas glaciation. According to data of the geological mapping (Jusienė *et al* 2003, Grigiene & Jusiene 2004) the Middle Nemunas (Middle Weichselian) lacustrine deposits are overlying Medininkai (Saalian) till and are covered by Upper Nemunas (Upper Weichselian) glacial deposits.

The Purviai outcrop is located in the valley of Venta river, 11 km downstream from Papile town, in the Venta Regional Park. Starting from the level of water in river Venta, the following layers were identified in the outcrop: sandy silt with organic matter (0.0-0.12), peat (0.12-0.17); sandy silt with organic matter (0.17-0.34); gravel with organics and mollusca shells (0.34-0.73); sandy silt with lenses of gytjja (0.73-0.96); sandy silt with with lenses of sand (0.96-1.71), fine sand upwards getting coarser and basal gravel at the upper contact (1.71-2.71), brown sandy loam (till). The section was sampled for pollen and spores analysis, determination of mollusca from the layer of gravel, and radiocarbon dating (two samples).

The pollen diagram has been divided into two (I – II) local pollen assemblage zones (LPAZ): In the Ist LPAZ herbaceous plant reach the highest values up to 85 %. Cyperaceae with 80 % predominate. *Artemisia* and Poaceae are less common. A few pollen of *Salix*, *Juniperus* and *Ericales* were noted. In the IInd (upper) LPAZ: *Pinus* is the most common tree pollen, reaching over 80 % of the total pollen sum. *Betula* pollen comprises some 20 % of the pollen flora. *Picea* appears with 15-20 %. Pollen of *Alnus* and broad-leaves are reworked from older sediments. *Betula nana* values increase and reach maximum with 2 % in the lower part of the zone. A rich herb pollen flora was noted e.g. Apiaceae, Asteraceae, *Artemisia,* Cyperaceae, Chenopodiaceae, Poaceae, *Rumex*, Rosaceae, Ranunculaceae. A few pollen of *Helianthemum* were identified as well as spores of *Botrychium* and *Lycopodium selago*. Among the aquatic plants *Typha*-*Sparganium* and *Potamogeton* have been observed. Spores of Polypodiaceae and *Sphagnum* reach up to 15 %.

The sedimentional environment is interpreted on the basis of lithological composition of sediments: lacustrine (silt, sandy silt, wetland or peatbog (peat), alluvial (gravel with the *Margaritifera margaritifera),* glaciofluvial (sand with basal layer) and glacial (till).

According to the pollen data during the deposition of the sandy silt and peat (0.08-0.25 m) the main composition of the local vegetation were Cyperaceae and *Artemisia*. The pollen record (LPAZ I) shows a cold, severe, however wet periglacial conditions, where landscape was open and only sedges communities have grown in the territory. Therefore the lowermost interval of the Purviai outcrop (interval 0.0-0.34 m): sandy silt, peat and sandy silt, most probably were accumulating in shallow changing lacustrine-wetland environment in open landscape under the severe climatic conditions. However, the occurrence of compacted peat (interval 0.12-0.17 m) with pieces of wood indicates, that presence of single poor trees or shrub vegetation was possible. Radiocarbon age 34 250±500 yrs BP (Vs-1630) leads to conclusion that the interval, corresponding to the I LPAZ could correlated with Huneborg interval, which takes place in Western Europen stratigraphy between the classic pollen-based Hengelo Interstadial (38-36 ka) and the so-called Denekamp Interstadial Complex (32-26 ka) (Huijzer & Vandenberghe 1998).

The overlying units – gravel and sandy silt (0.25-1.54 m) - corresponding to II LPAZ - contain pollen of *Pinus*, *Picea*, *Betula* and NAP. The variety of herbaceous plant pollen as well as pollen of *Helianthemum, Botrychium* and *Lycopodium selago* spores show still cold climatic conditions, however this interval marks climatic improvement and thus could be interpreted as thermomer. During the sediments accumulation, the territory was covered by park tundra with birch, pine and some admixture of scattered spruces, dwarf birch and juniper. It is interesting to note that, the layer of gravel (interval 0.34-0.73) contains fragments of mollusca shells of *Margaritifera margaritifera* - the freshwater pearl mussels that live buried or partly buried in coarse sand and fine gravel in clean, oligotrophic, fast-flowing and unpolluted rivers and streams.

The similar intervals to the II LPAZ, described in the Purviai outcrop, according to the pollen and spores data were identified in the Medininkai 117P section and in Mickunai site in Eastern Lithuania and interpreted as Mickunai 3 thermomer and tentatively correlated with the Denekamp Interstadial (Satkūnas *et al* 2003, Satkūnas & Grigienė 2000, Satkūnas 1999).

However, it must be admitted that the radiocarbon date 34 690±650 yrs BP (Vs-1676) from the gravel layer (mollusca shells) does not corresponds to the geochronological span of 32-26 ka of the Denekamp Interstadial Complex in The Netherlands as recognized by Huijzer & Vandenberghe (1998), or 32-28 ka according to Caspers & Freund (2001). This discrepancy leads to wider discussion on long distance correlations of climatostratigraphic events. The transition noted in the outcrop Purviai, however confirms assumptions that climatostratigraphic events during Pleni Weichselian are not expressed as sharp climatic fluctuations on the background of generally progressing global climate cooling.

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A NEW DATA FROM THE OUTCROP AT THE COASTAL CLIF OF THE BALTIC SEA NEAR TO SARNATE

Saulīte, A.[1], Kalniņa, L.[2], Stinkulis, Ģ.[2], Ceriņa, A.[2]
[1]*Natural History Museum of Latvia, K. Barona Str. 4, LV-1050 Riga, Latvia; e-mail: anita.saulite@ldm.gov.lv*
[2]*University of Latvia, Rainis Blvr. 19, LV-1586 Riga, Latvia; e-mails: laimdota.kalnina@lu.lv, grts.stinkulis@lu.lv, caija@inbox.lv*

The area of Sarnate site has been studied both by geologists (Dreimanis, 1947; E. Grinbergs, 1957; Doluhanovs 1977; Mūrniece, et. al 1999) and archaeologists (Šturms, 1940; Vankina, 1970; Berzins, Kalnina, 1998) because of interesting geological object and the Neolithic Age complex of European importance.

Silt and silty sand with a small amount of organic matter was laid down in the area of the present-day Sarnate Mire area during the Younger Dryas, with the fall in the level of the Baltic Ice Lake. The area contained one or more shallow coastal lakes, which were cut off from the open water of the lake on the western side by a narrow (0.3-0.5 km wide) spit of land during the Ancylus Lake, when sea level was about 4-5 m higher than present one. The freshwater lime accumulated in some places of lakes, and on their shores thin peaty layers of gyttja were formed. During the Littorina transgression at the beginning of the Atlantic Time, seawater entered the low-lying area in the surroundings of Sarnate and other stretches of the coastline with lower topography, and reached a height above present sea level of 5-6 m. This formed a large, shallow lagoon, which was cut off from the sea through the process of long-shore drift. The water level during the Littorina transgression fell and the lagoon rapidly divided into separate lakes, which became overgrown, and mires were formed.

Organic sediment layers formed in Sarnate area during the Holocene nowadays become revealed due to coastal erosion. It allows studying these sediment sequences at the coastal cliff of the Baltic Sea. The lowest part of the outcrop is represented by sandy and silty sediment layers, which have particular water-escape structures (Fig. 1). Large water-escape structures are present in alternating silt and sand beds, up to 2 m thick. These structures occur in 2-3 levels and their maximum vertical amplitude reaches 1 m. These structures probably have formed under pressure of glacier, which extruded pore-water from sediment and initiated its upward migration together with loose material.

The water-escape structures have been overlaid by organic deposit layer represented mainly by peat of different decomposition level. The lowest part (3.20-3.1 m) represented by various coarse sand with very well decomposed wood-grass peat, containing fragments of wood (some charred pieces), as well as remains of grass and Bryales. The admixture of sand decrease in the peaty gyttja in the section upwards (3.1-2.8 m). It contains wood remains, as well as *Carex* nuts and *Menyanthes trifoliata* seeds. In the upper part seeds of *Potentilla* and other plants increase. This layer is covered by low decomposed *Hypnum*–sedge peat (depth 2.8-2.7 m) with pressed structure and contains *Carex* sp. nuts and seeds of *Menyanthes trifoliata*. The deposit layer at the depth 2.7-2.6 m is represented by low decomposed *Hypnum* – reed peat, which upwards (2.6-2.5 m) covered by *Hypnum* peat with wood and reed remains and seeds of *Menyanthes trifoliata.* The peat layer at the depth interval 2.5 – 2.3 m is medium decomposed grass-sedge, which contains *Carex* sp. nuts and some *Menyanthes trifoliata* seeds. The very upper layer of organic deposits (depth from surface 2.3-2.2 m) represented by well decomposed grass peat contains nuts of *Carex* sp., seeds of *Cladium mariscus*, *Menyanthes trifoliata*, *Potentilla* and large number of insect remains. This peat layer is covered by eolian sand.

The pollen analysis show that well decomposed wood-grass peat layer had a pollen spectrum (significant amount of *Alnus, Corylus, Ulmus*) that corresponds to the early Atlantic Time, which is confirmed by the ^{14}C dates (see Table 1). *Hypnum*-sedge peat accumulated, providing pollen spectra characteristic of the vegetation of the climatic optimum with highest amount of broadleaved trees - *Ulmus*, *Tilia*, *Quercus*. The very upper part of this layer probably was formed at the end of the Atlantic Time what has proved by pollen spectra with significant proportions of *Quercus* and *Alnus* pollen, and *Carpinus* is also recorded. Pollen spectra from the very upper grass peat layer indicate that probably peat has been formed during the Subboreal time, because of decrease of warm demanding plant pollen in comparison with lower layer and maximum of *Picea* pollen. The organic deposit layer in depth interval 2.7 to 2.2 m from the surface contains pollen anthropogenic indicators *Plantago major/media, Chenopodium album, Polygonum aviculare, Urtica* and *Rumex acetosella*.

The plant macroremain, pollen and ^{14}C dates indicate that layer of organic deposits from the cliff at Sarnate has been formed during time span from the early Atlantic Time to the Subboreal and are some part of former Littorina Sea lagoon.

Figure 1. ***The water-escape structures of sand and silt covered by organic deposit layer at the Baltic Sea Cliff near the Sarnate***

Table 1. ^{14}C dates of peat layer at Baltic Sea Cliff near the Sarnate

Sample	Depth, m	Date	Calibrated (OxCal 3.10)	Lab index
Sarnate 1	2.3-2.2	3280+-40 BP	3560-3450 BP	Ta-2895
Sarnate 2	2.7-2.8	5290+-50 BP	6130-5990 BP	Ta-2896
Sarnate 3	3.1-3.2	6820+-80 BP	7730-7580 BP	Ta-2897

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GEOLOGICAL STRUCTURES AT SLAMPE IN DETAILED STUDIES

Seglins, V., Sitchoff, G.
University of Latvia, 10 Alberta Str. LV-1010 Riga, Latvia; e-mail: valdis.seglins@lu.lv

Late – Weichselian geological structures of Latvian Northwest (North Kurzeme) are studied from thirties century before (V. Zans), much more in details by Z. Meirons, J. Straume, V. Juskevics and S. Murniece during and geological mapping exercises in scale 1 : 200 000 and 1 : 50 000. Regarding area of particular interests – Central part of Eastern Kursa Upland – several more studies are provided mainly by I. Veinbergs, O. Aboltins, and latter by I. Strautnieks, V. Zelcs. This is area of Eastern slopes of uplands and borderland with Middle Latvia lowlands nearby the Tukums City around vicinity of Slampe.

The area around 35 km^2 is concentrating several geological problems to be studied in relations to deglaciation history of the area and interaction with early stages of Baltic Ice Lake development. Here by geological mapping were recognized flat moraine plain with some undulations of current landscape within 1-3 m, and main section consist from massive and sandy one layer glacial till from the last glaciation. And besides palaeogeographical reconstructions of I. Veinbergs demonstrate here costal formations of Baltic Ice Lake first stage (Blb I) and very complicate development history of Abava River hydrographical network.

Studies during the 2005–2006 demonstrate much more complicate basic palaeogeographical events in the study area. Detailed analysis of aerial photos, some leveling, studies of borings and outcrops and tests of sediments were supplemented by examinations of ground penetration radar (GPR).

Currently there are two moraine layers up to 1.5-2.5 m thick representing the least events of deglaciation history split by 5-7 m relatively fine sorted sand and gravel delta formations of ancient streams. Sand and gravel formation is southeast and southwards directed and there can be recognized several main sedimentation bodies. Only upper part of this section member is slightly deformed directly under the upper till layer. Character of deformation demonstrates soft interaction between dry sandy and gravel deposits and the least glacial activity. Probably these are reflected activities of North Lithuania Stage or local, next to it. Besides, there no any signs of ancient local basin interaction with the Baltic Ice Lake introductory phases, at least in this area, and this sedimentation basin could be part of elder large Zemgale Basin.

There are substantial difference between earlier studies determined here moraine plain with corresponding extremely limited possibilities to find out useful minerals and our studies with prospecting 5-8 m thick sand and gravel formations in the depth of 1-2.5 m. Therefore GPD studies were applied at this stage to evaluate separate observations to recognize geological section aerial changes. Was applied georadar ZOND-12c supported by antenna complex with fixed impulse frequency of 75MHz and study was realized by several crossing profiles.

Most of the Slampe vicinity areas were studied by GPR, and the best results was reached near the gravel pit Kazoki (Fig. 1.), around 12 km southeast of Tukums City. Here most of

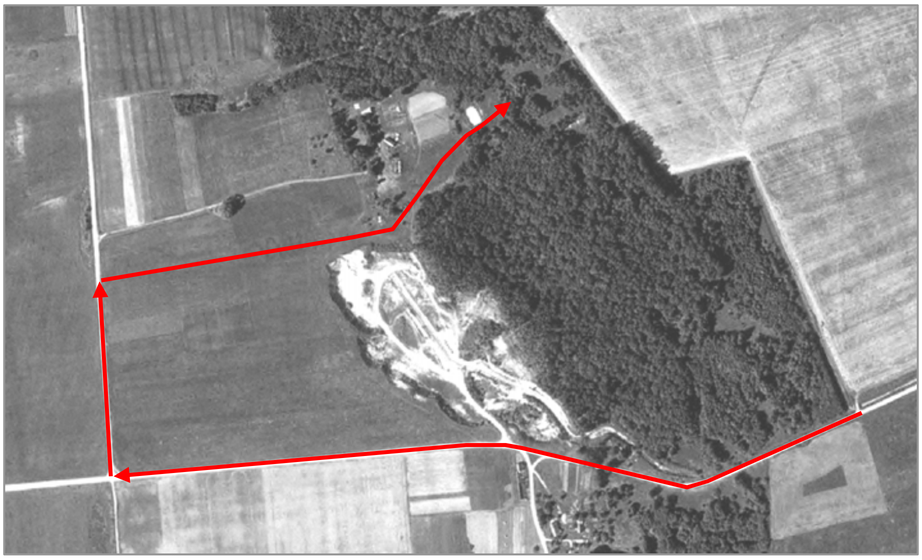


Figure 1. ***Location of GPR profiles near the Kazoki gravel pit. The red lines – GPR profiles***

GPR profiles demonstrate expanded possibilities to apply the method in complicate multilayer geological conditions in depths of 20 m (Fig. 2).

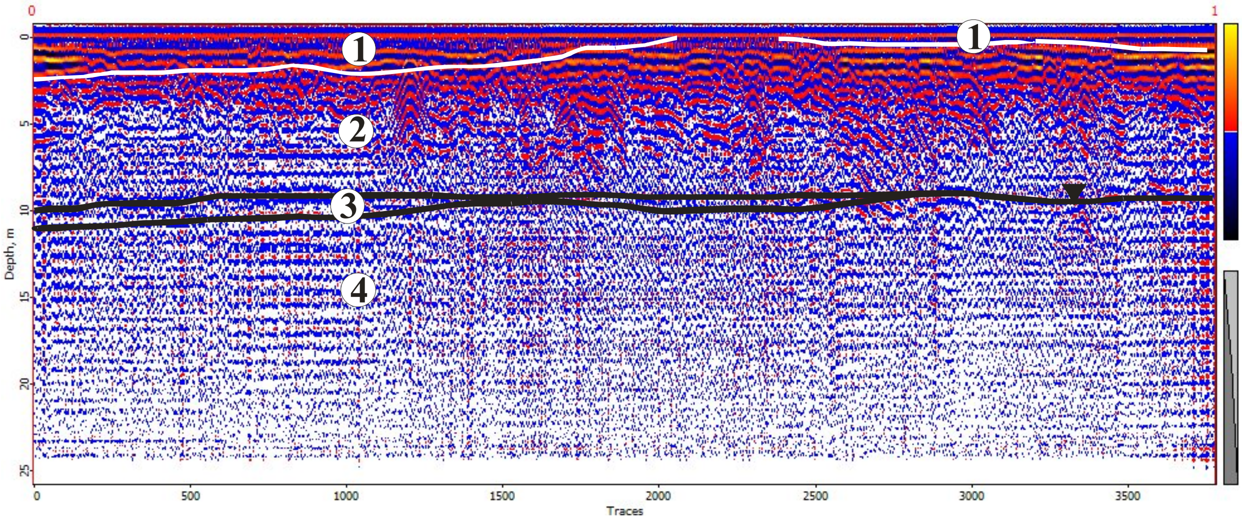


Figure 2. ***Shortest GPR profile from south to north (sample).*** *Vertical section is 25 m, horizontally – approximately 210 m. Legend: 1- upper till, 2- sand and gravel, 3- lower till, 4- Devonian dolostone, black triangle – ground water table*

Profile illustrate section where the top layer of massive silty till at the beginning (1.3-2.2 m) latter is replaced by sandy till and not present between marks 2100 and 2500, latter heavy till is presented only fragmentary. Deeper there are sandy and gravel deposits with presence of stones at the top until the continuous line of groundwater level close to the 10m depth with some variations from mark 3000. There fine sand deposits cover directly Middle Devonian dolostone and argillaceous dolomite (mudstone) with rock gypsum interlayer. Only in the southern part till deposits split dolomite from the sandy deposits (from mark 0 to 2100).

Therefore studies demonstrate several stages of the least deglaciation in the area, revisions needed for restoration of the Baltic Ice Lake first stages and substantial new prospects for sand and gravel exploration in the area.

ENVIRONMENTAL CHANGES AND EUTROPHICATION FROM SEDIMENT RECORDS IN TWO LAKES OF EAST LITHUANIA

Šeirienė, V.[1], Kasperovičienė, J.[2], Mažeika, J.[1], Kabailienė, M.[3]

[1]*Institute of Geology and Geography, T. Ševčenkos 13, LT-03223, Vilnius, Lithuania; e-mail: seiriene@geo.lt*

[2]*Institute of Botany, Žaliųjų ežerų 49, LT-08406 Vilnius, Lithuania; e-mail: jurate.kasp@botanika.lt*

[3]*Vilnius University, Department of Geology and mineralogy, Faculty of Natural sciences, Čiurlionio 21/27, LT-30101, Vilnius, Lithuania*

Sediment sequences retrieved from the two Lakes Baltys and Lydekis (east Lithuania) were analysed for diatoms, pigments, pollen, isotopes and geochemical parameters. Age control was provided by ^{14}C measurements. The main aim of the studies was to identify natural and anthropogenic changes during the Late Glacial and Holocene. These studies were a part of the project "Lake sediments – the chronicle of natural and antrophogenic changes", supported by Lithuanian Science and Studies Foundation.

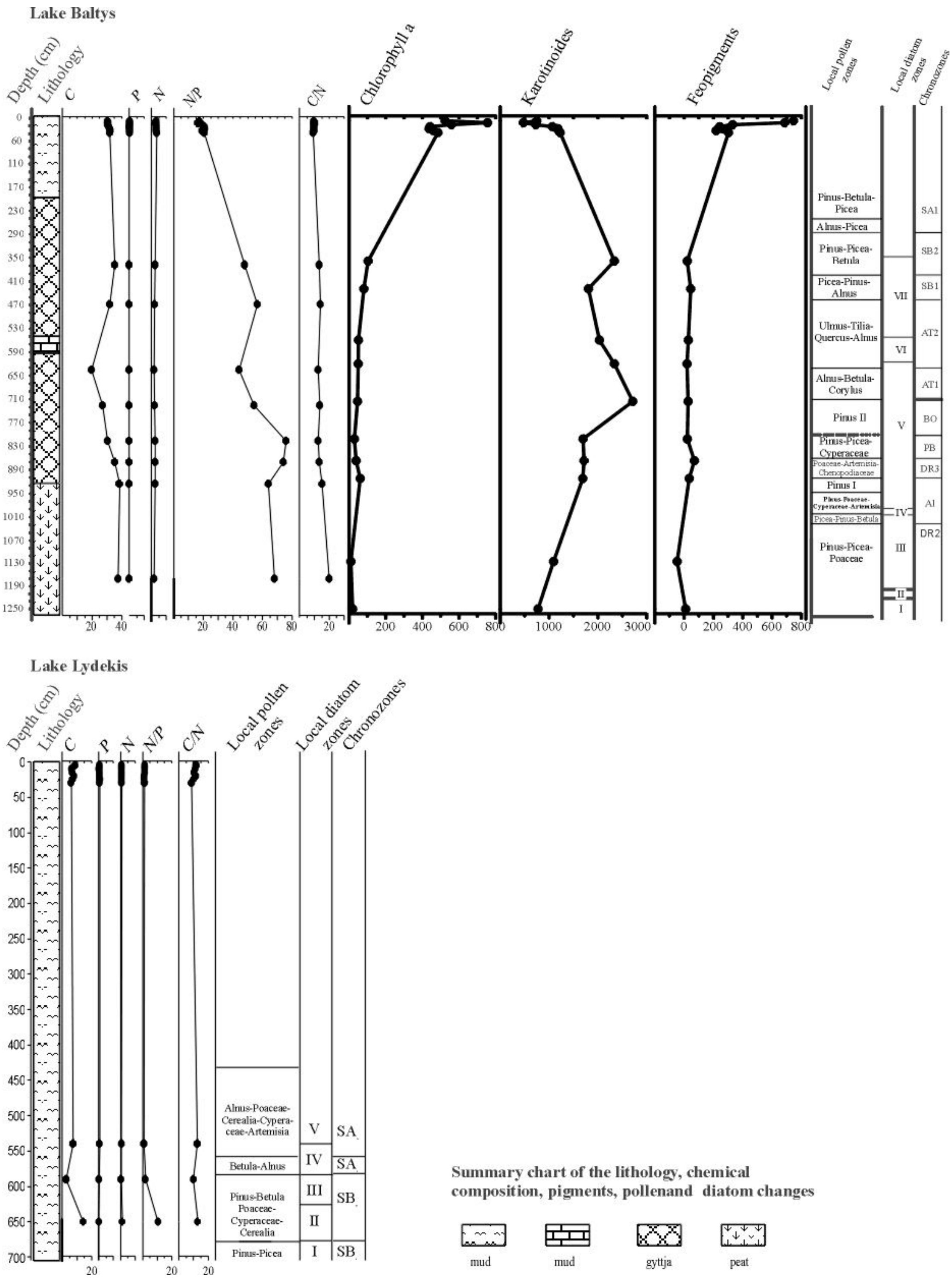
Sediments of Lake Baltys were investigated in 12.5 m core. According to pollen and radiocarbon investigations sedimentation took place during the Older Dryas (DR_2) period and continued till the Early Subatlantic (SA_1). Concentration of diatoms is very changeable throughout the section and in some samples decreases to single frustules. Epiphytic and benthic diatom species prevail in the sediments indicating relatively low water level and mesotrophic-eutrophic water conditions. The highest water level registered during the Late Atlantic period.

Sediments of Lake Lydekis were investigated in 6.85 m core. According to pollen and radiocarbon investigations sedimentation took place during the Early Subboreal (SB_1) - Late Subatlantic (SA_2) periods. Diatom flora is prevailed by epiphytic and benthic alkaliphilous species and indicates eutrophic water conditions. Highest water level registered in the upper part of the section during the Late Subatlantic period. In the uppermost part of the section a numerous frustules of extinct (Eocene) diatom species reached about 50 %. Possibly they are redeposited from the outcrops of Vyzuona River.

The complex isotope studies allowed ascertaining the sedimentation parameters: sedimentation modulus (g/cm^2/years) and linear accumulation rate (mm/years). The modulus of the recent sedimentation according to ^{210}Pb and ^{137}Cs studies in Lake Baltys is 0.05-0.07 g/cm^2/year and in Lake Lydekis–>0.5 g/cm^2/year. Other sedimentation parameters – linear rates are changing subject to density and moisture of a material. According to ^{14}C measurements the mean accumulation rate of sediment thickness in Lake Baltys is 1.1 mm/year and in Lake Lydekis – 1.5 mm/year**.**

In both investigated lakes eutrophication processes are in progress:

An increase in organic carbon concentration is registered in surface sediments and indicates the rise of organic material input; phosphorus and nitrogen concentrations differently slowly but steadily increase upward, thus causing the ratio N/P to decrease; chlorophyll a and carotene concentrations increase slightly but remain higher values recorded in the upper layers. Those data register an increase of the productivity of the lakes. It is confirmed by the rise of variety and frequency of diatoms.



Summary chart of the lithology, chemical composition, pigments, pollenand diatom changes

DIFFERENCES IN POLLEN SPECTRA OF HOLOCENE DEPOSITS FORMED WITHIN UNPOPULATED WOODLAND AND NEAR THE SETTLEMENTS OF THE STONE AND BRONZE AGE (BELARUS)

Simakova, G. I.[1], Mihailov, N. D.[1], Vlasov, B. P.[2]
[1]*Institute of Geochemistry and Geophysics, National Academy of Sciences of Belarus, Kuprevicha 7, BY-220141 Minsk, Belarus; e-mails: sim@igig.org.by, mihailov@igig.org.by*
[1]*Laboratory of Limnology of Belarusian State University; e-mail: vlasov@bsu.by*

Seven archaelogical sites were found on sandy hills within peaty flood-plain of lake Vecheria (52° 05´ N, 28° 10´ E). The thickest cultural layer was recognized in the site Ozernoe 1, where materials of the Stone, Bronze and Iron Ages were revealed (Kryval·cevič, Simakova, 2004). Pollen diagram of anthropogenic impact derived from peat deposits of the profile Ozernoe 3 (near Ozernoe 1 archaelogical site) showed significant content of herbs (up to 10 %) and sharp peaks of ruderal pollen in the Boreal. That was conditioned by open landscapes and by the presence of mezolithic hunters and fishers near the lake shores (Fig. 1). In the middle of the Atlantic single grains of Cannabaceae and Cerealia (including *Triticum*) were present against the background of a new increase of other anthropogenic indicators values. *Artemisia* permanently presented and amount of *Urtica* grew among ruderal plants. The content of *Rumex acetosa/acetosella* L. increased among pastural land indicators. The total sum of anthropogenic indicators reached 5 %, the content of NAP increased up to 6-7 %, and the content of Poaceae grew up to 2-3 %. Early Subboreal section of the pollen diagram indicated a drastic change of plant associations due to climatic, pedogenic, anthropogenic and possibly to pathogenic factors. The curves of *Artemisia,* Chenopodiaceae, *Rumex,* Asteraceae showed major peaks, *Urtica* occued frequently, and *Polygonum aviculare* L. appeared for the first time. The contents of *Secale* and later of *Triticum* became significant. The total sum of pollen indicators of human impact reached the maximum values of 7-8 %, and the contents of NAP increased to 9 % against the background of rapid increase of *Betula, Alnus, Picea, Salix,* fluctuating values of *Pinus* and disappearance of *Ulmus.* Another culmination of anthropogenic pollen as well as maximum contents of *Betula, Alnus, Picea* are characteristic of the Subatlantic.

By the contrast to the diagram from Ozernoe 3 profile, the human impact pollen diagram derived from sediments of lake Sviatoe (in 35 km to the east from lake Vecheria, within hydrological reserve) did not show marked peaks of main components of pollen spectrum and revealed more abundant and miscellaneous pollen of shrubs and broad-leaved plants, as well as lower contents of NAP, *Picea* and *Pinus* (Fig. 2). Now only 2.9 % of the area of reserve (3.1 hectars) is used for agricultural purposes (1.5 and 1.6 hectars are occupied by arable lands and hayfields respectively). Ninety three percents (98.1 hectars) are covered by woodland. It is obvious that almost twofold reduction of *Ulmus* at the Atlantic/Subboreal transition occured due to natural causes. According to pollen data the influence of economic activity on the landscapes of the lake basin can be recognized during the last millenium only. Rational limits of *Secale, Rumex,* cultivated and pastural lands indicators, as well as the first appearance of *Fagopyrum* date to the beginning of Subatlantic 3 (1 000 years ago). At this time the contents of NAP, *Poaceae, Picea, Pinus, Betula, Salix* and the total sum of anthropogenic indicators increased at the expense of *Ulmus, Corylus, Quercus, Tilia* and *Fraxinus*.

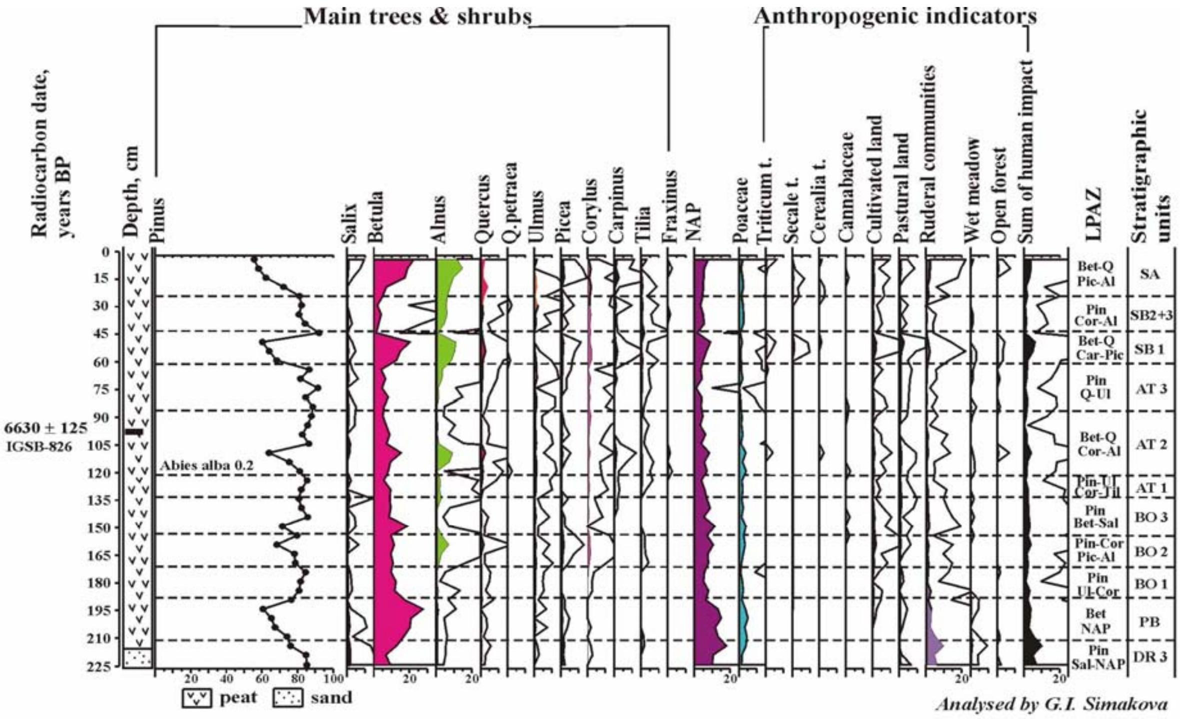


Fig 1. Human impact pollen diagram derived from bog deposits, profile Ozernoe 3

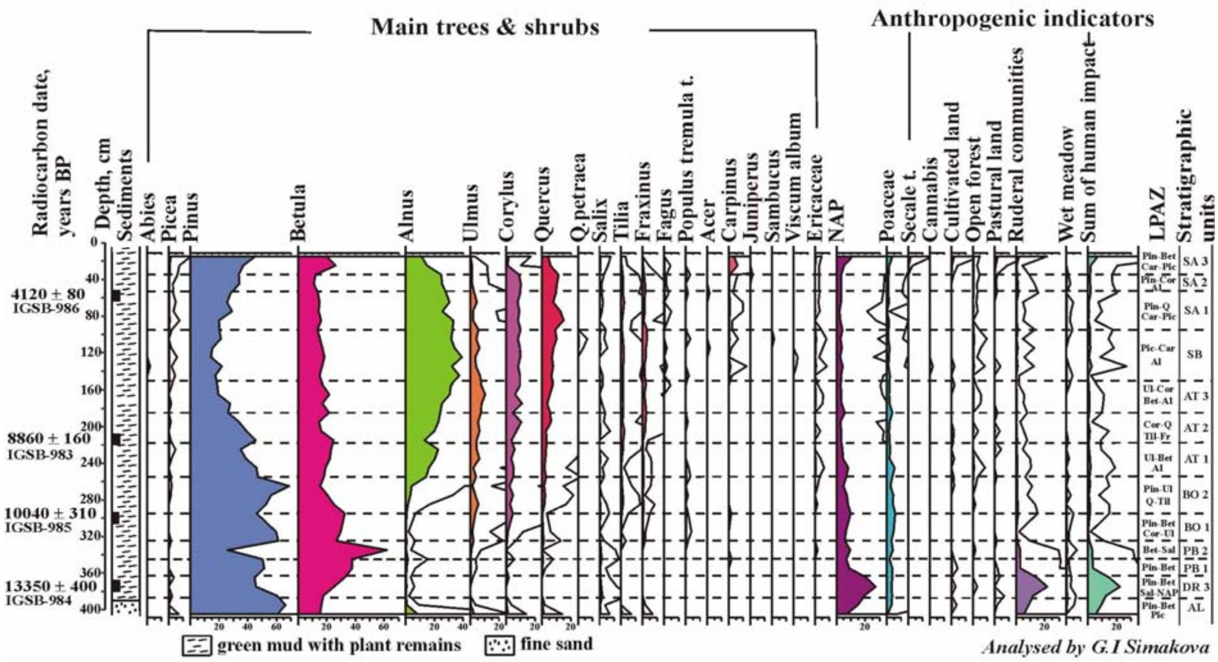


Fig 2. Human impact pollen diagram derived from sediments of lake Sviatoe Radiocarbon dates (conventional ^{14}C years BP) indicate the ages which are 1500-2000 years too old compared to the ages inferred from traditional pollen based chronology.

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M. M. Kryval'cevič, G. I. Simakova. Mikroregion jeziora Večera (Białoruskie Pryedpolesie): główne etapy adaptacji i wykorzystania w epoce brązu na podstawie danych archeologicznych i palinologicznych // Pruthenia Antiqua, vol. I, Olsztyn 2004, p. 91–101.

FORMATION OF KVESAI GLACIAL TUNNEL AND CHANNEL MOUTH DELTA, CENTRAL LITHUANIA

Šinkūnas, P.[1], Jurgaitis, A.[2], Januševičiūtė, E.[1]

[1]*Department of Quaternary Research, Institute of Geology and Geography, T. Ševčenkos 13, LT-03223, Vilnius, Lithuania; e-mail: sinkunas@geo.lt*

[2]*Department of Hydrogeology and Engineering Geology, Vilnius University, M. K. Čiurlionio 21/27, LT-03101 Vilnius, Lithuania*

General aim of the research was to establish the structure and sedimentation conditions of Kvesai glaciofluvial delta deposit (Fig. a) and to relate it to the ice retreat stages of the Last Glaciation and the development of proglacial basin. The study was carried out within the frame of the IGCP 518 project and supported by Lithuanian National Science and Studies Foundation (V - 07040).

Kvesai glaciofluvial delta is situated in Central Lithuania, NW from Kaunas Town near Vilkija settlement (Fig. b). The fan of glaciofluvial delta is spread close to the distal slope of marginal ridge formed during Middle Lithuanian phase of the last recession stage (Baltija) in Lithuania of the Last Glaciation ice (Fig. c). The deltaic deposits cover the surface of glaciolacustrine sediment plane and had formed the source of fine grained sand for the large parabolic dune field in distal part. From southeast to northeast a Nemunas River valley crosses the distal part of the delta sediment body. Deltaic sediments are also eroded close to the valley slopes on the plateau. A large sand and gravel quarries are situated in area of the deltaic sediment body. The fast extraction of gravel had created the good conditions to study a sediment structure and bedding during several years. Deltaic sediments in Kvesai glaciofluvial delta were studied by A. Mikalauskas (1985) and others as well.

The distribution of lithofacies was analysed according to the description of sediment logs of a large number of boreholes (Fig. d) to compile the spatial model of deltaic deposit. The spatial model of delta deposit is based on about 200 borehole logs and database of bedding element absolute level measurements compiled and analysed using computer program STRATOS 98. The character of sediment bedding and structure were analyzed in quarries as well; the dip directions of bedding were measured. The deltaic deposit bed of 7-10 m thick of sand and gravel in some places reaching up to 15 m cowers the silt and clay beds of glaciolacustrine deposits up to several meters thick underlain by till. The prevailing dip directions of sediment bedding are 180-270 degree.

Kvesai glaciofluvial delta was formed in proglacial and terminoglacial subenvironments. Glaciofluvial delta topset, foreset and bottomset units were distinguished after complex sedimentological research. Lithofacies of parallel laminated sand, sand and silt of massive structure, ripple bedded sand, climbing ripple bedded units are characteristic of Kvesai glaciofluvial delta bottomsets, however the bottomsets are merely expressed. Foresets of parallel sand and gravel crossbeds form the main part of delta sediment body. The upper part of topset lithofacies are developed under subaerial conditions, while sedimentation of the lower part took place underwater. The pointbar and channel filing sediments represent the topset lithofacies of glaciofluvial delta consisting mainly of through and tabular cross stratified and flow ripple bedded sand.

The buried valley of west-southwest direction (Fig. d) was established in bedding surface under the modelling of spatial distribution of deltaic lithofacies. The valley stretches transversely underneath of the glaciofluvial deltaic sediment body indicating the origin of it self taking place before the final surge of the glacial lobe when water level of proglacial basin was considerably lower. The ice melt water flow has inherited the primary valley as subglacial after the final surge of glacial lobe to the limit of marginal ridge. After the water level of proglacial basin had elevated under the ice lobe melting the conditions for delta sedimentation formed. The level marked by the boundary between deltaic foreset and topset lithofacies points to the proglacial basin water level during the Kvesai glaciofluvial delta development.

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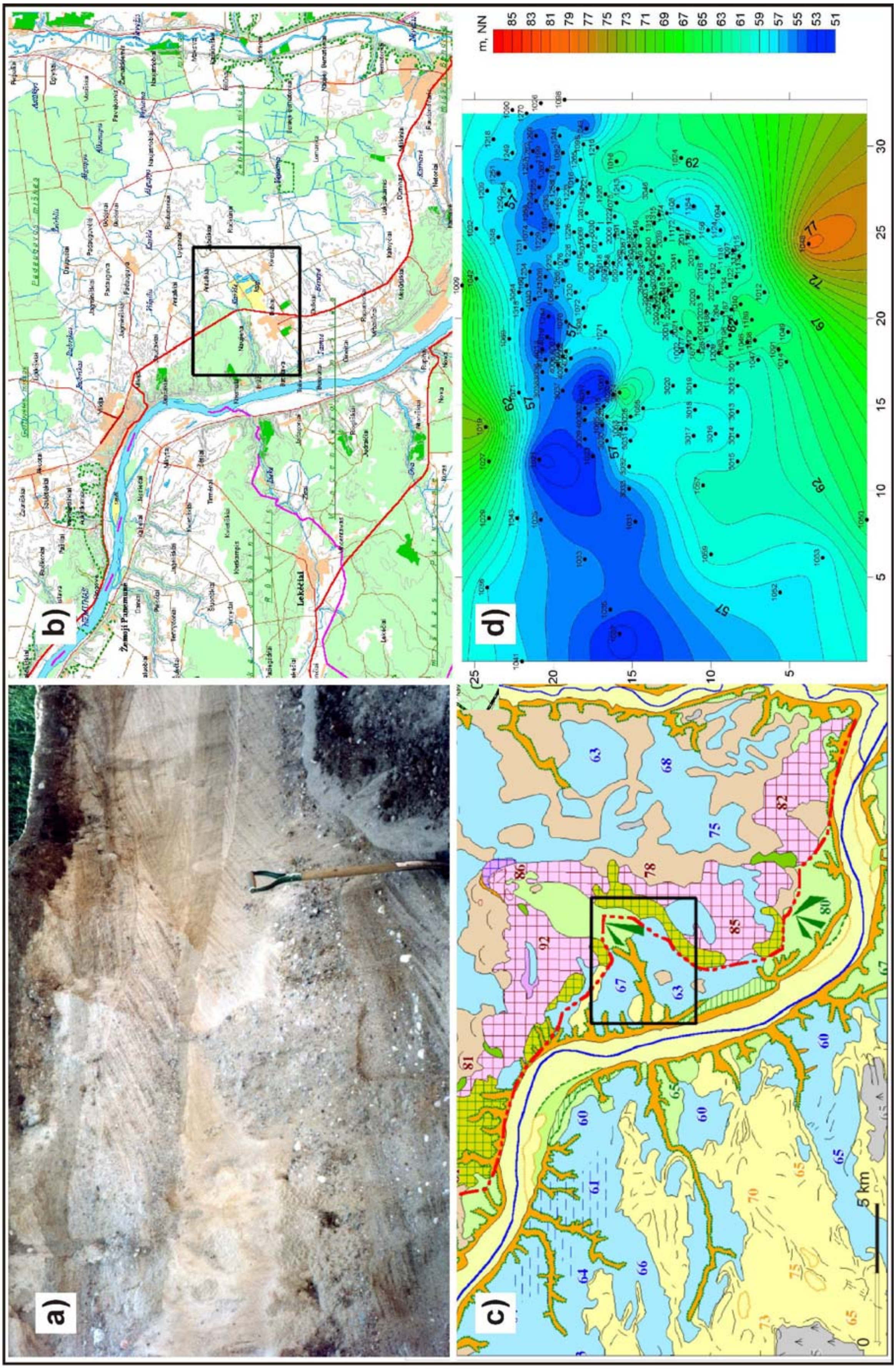

Fig. ***Kvesai glaciofluvial delta: a) sediment bedding, b) topographical and c) geomorphological (after R. Guobytė) setting and d) bedding surface***

NEW DATA ON SUBMERGED COASTLINES LOCATION IN THE EASTERN PART OF GDANSK BASIN

Sivkov, V., Dorokhov, D., Chestnova, M.
Atlantic Branch of Shirshov Institute of Oceanology, RAS, Prospect Mira 1, RUS-236000 Kaliningrad, Russia; e-mail: sivkov@baltnet.ru

The Baltic Sea had a very complicated history before it had got recent shapes. Its surface level raised and went down several times. Due to it location of the coastline had changed. Ancient coastlines on land are easy for study because of their visibility and there are a lot of investigations in Scandinavia and other Baltic countries. Ancient coastlines which are situated below recent sea level are investigated considerably worth.

Existing knowledge on submerged coastlines near Kaliningrad Region (Blazhchishin et al., 1982; Kharin, 1986; Gelumbauskaite et al., 1991; Blazhchishin et al., 1998; Emelyanov & Romanova, 2002) are incomplete and conflicting. The reasons of it are primitive echosounders and rough positioning of profiling data.

New data on bottom relief collected in 10 cruises of r/v "Professor Shtokman" (2004-2007) by echosounder ELAC with acoustic speed corrections of depths and GPS positioning were used for clearing this matter. The conclusions of Uscinowicz study (2003) were used for interpretation of our data (examples at fig. 1). The generation of some terraces has no explanation. So the terrace at depths 73-77 m (profiles 1, 3) is obviously mistakenly associated by Kharin (1986) and Emelyanov & Romanova (2002) with Baltic Ice Lake. Hypothetically this terrace is associated with structure of bedrocks and activity of bottom currents at halocline level during Litorina Stage.

Two symmetrical sequences of small terraces defined at Sambian Peninsula underwater slope and Curonian-Sambian underwater plateau have an especial interest (profile 2). The whole profile looks like submerged river valley. Genesis of these small terraces requires additional investigations. Probably they argue about stepped nature of the first Litorina transgression.

Northward of Sambian Peninsula at depth about 30 m was discovered submerged channel (?) which apparently was created as a result of transportation of material of coastal abrasion and bottom erosion by alongshore currents. This channel can play an important role in sedimentary matter balance of sedimentary system "Sambian Peninsula – Curonian Spit – Curonian-Sambian Plateau".

New data let specify earlier created maps of submerged coastlines.

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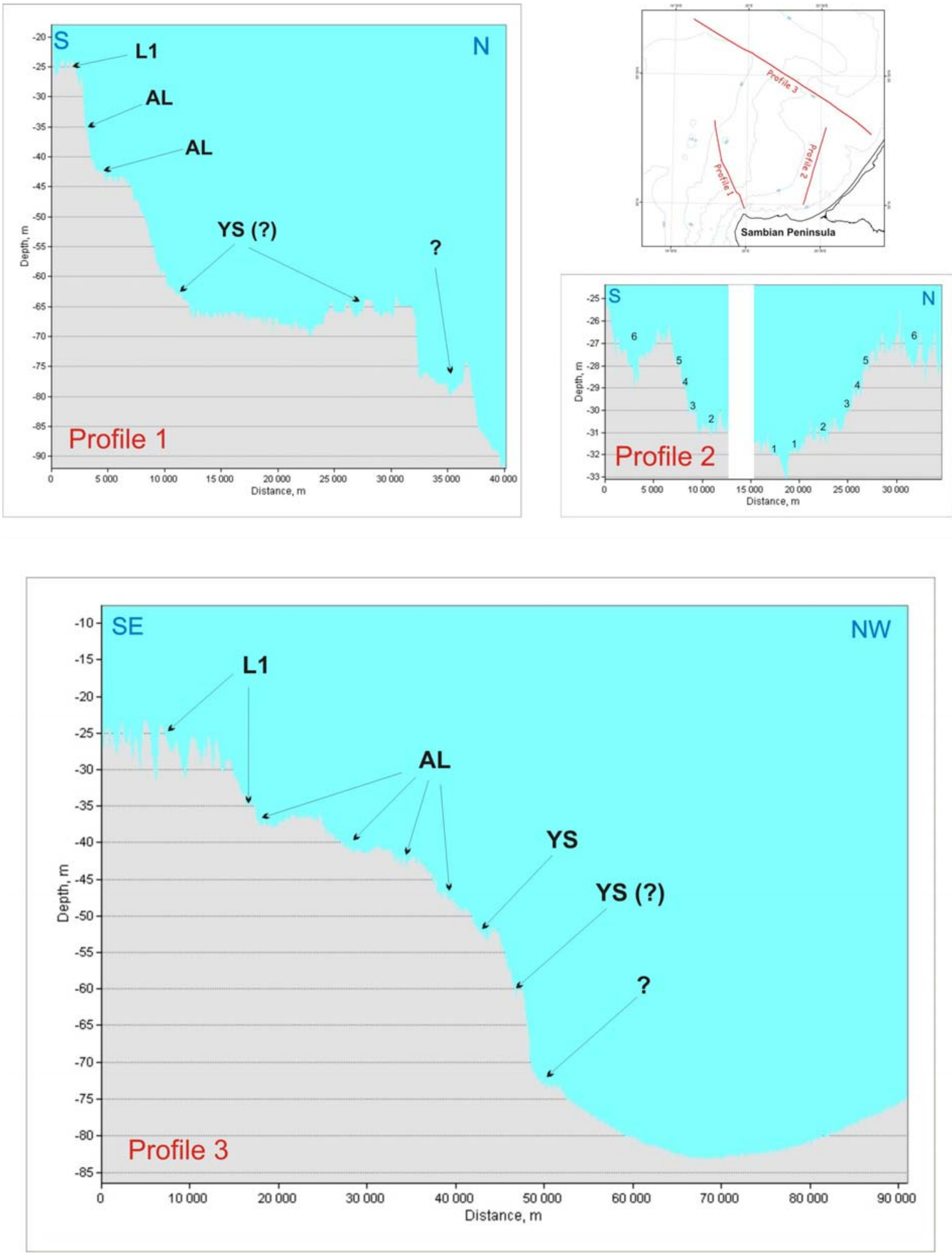

Fig. 1. ***Examples of echosounder profiles of r/v "Professor Shtokman" (2004-2007) with determined submerged coastlines (the Baltic Sea stages: YS – Yoldia Sea, AL – Ancylus Lake, L1 – first stage of Litorina transgression)***

T-LINE CONCEPT AND PLASTICITY OF OVERCONSOLIDATED MORAINIC TILLS IN KLAIPĖDA SEA PORT

Šlauteris, A.
UAB "Geoprojektas" ir Ko, Trilapio 10, LT-92191 Klaipeda, Lithuania; e-mail: info@geoprojektas.lt

Adoption of ISO and EN standards as LST standards of the Republic of Lithuania is very important for the companies involved in engineering, geological and geotechnical investigations and geotechnical design. However, the international European standard LST EN ISO 14688-2:2006 "Geotechnical investigation and testing. Identification and classification of soil – Part 2. Principles for classification" that was adopted as a Lithuanian standard does not satisfy the practical needs in the field of geotechnical investigations and design, as it takes till as a natural ground. This newly approved standard indicates that there exist volcanogenic grounds in Lithuania, but it ignores the concept of the continental glaciation. Thus, the basic standardization requirement is violated: according to the common agreement the regulations of the national standard must be adopted to the geographical and geological conditions of the country.

On the other hand, the regulations of this standard state that the geological genesis of the grounds has to be estimated only as a side feature. The genesis of the grounds is considered to be the main feature for distinguishing taxonomic units even in the Russian standard GOST 25100-95, 1996 version.

This is very important for the current identification of the morainic till soils. Units and terms describing soil deposits are used in the USA and Canada. According to J. E. Bowles (1997), the terms "glacial till" or "morainic till" are quite acceptable there from the geotechnical point of view, as they mean "a mixture of material that may include sand, gravel, silt and clay deposited by glacial action". The term "till" is usually used to describe materials precipitated out of ice, but the user must check the context of usage, as the terms are used interchangeably.

Thus, identification of the classification unit of glacial till (morainic till) in the Lithuanian standard would provide with a possibility to reason the identification of the taxons of lower level – morainic till and morainic loam – according to the Boulton's T-line concept. The use of plasticity parameters for the classification of morainic grounds would enable to relate the data of earlier engineering geological investigations with the data of the recent investigations. The provided diagram shows that Medininkai morainic grounds of Klaipėda seaport match with the segments of Bolton's T-line concept from the point of view of classification aspect. Thus, it can be stated that there opens a possibility for a local classification of morainic grounds that enables to identify taxonomic units (taxons) of glacial clayey till and glacial loam till levels. The recent practice of engineering geological and geotechnical investigations reveals that such classification of morainic grounds can be prepared even now.

THE COASTS OF LAKE PEIPSI AND THEIR CHANGES DURING LAST DECADES

Tavast, E.

Institute of Geology at Tallinn University of Technology, Ehitajate tee 5, EE-19086 Tallinn, Estonia; e-mail: tavast@gi.ee

Shore types. The first data concerning the coasts of Lake Peipsi were presented by Helmersen (1864). The recent studies of the coast of Lake Peipsi (Tavast 1984, Raukas, Tavast 1996) allow to differ scarp (cliffed, sandy, morainic, peaty) and flat (till, sandy, peaty, silty) coasts. The flat shores are usually swampy, reed and bulrush grow on the foreshore and bushes occur on the backshore. This kind of shore mainly spreads in the western part of the lake. The scarp sandy beach is prevailing in the northern part of the lake. Like the majority of lakes in the Northern Hemisphere (Klinge 1889), Peipsi has a more open eastern and a more swampy and overgrown western bank.

Shore changing factors and forces. Shoreline changes and beach erosion have been caused by several geological (initial rocks and sediments, tectonic movements, slope gradient) and hydrometeorological (hydrology, wind regime, wave action, ice-push) factors and human activity.

Neotectonic and contemporary movements of the Earth's crust. The northern part of the Peipsi depression is rising faster than the southern part, what is highly affecting to the evolution of the coast. According to recent land uplift maps (Zhelnin 1966), the northern Lake Peipsi area is rising at a rate of 0.2–0.4 mm/yr, while the southern part is sinking at a rate of up to 0.8 mm/yr.

The steady southward advancement of the lake has already caused severe damages to inhabitants. The chronicle of Pskov records that in 1458 a church was built on the Ozolitsa Island. The remains of this church are now submerged beneath 0.4–2.5 m of water.

Hydrological regime. The small depth and rather large surface and drainage areas make Lake Peipsi extremely sensitive to climatic fluctuations and other environmental changes occurring in their drainage basins. Distinct rhythmicity is observed in lake-level fluctuations (Jaani 1973). During 1959–1977 the water level in lake was low. In the water-rich period 1986–1991, it was 0.5 m above the long-term average. Since 1992 the water level has been constantly lowering. In 1996 and 2006 the water level was extremely low and in some places the lake floor was exposed for hundreds metres. A new high-water period is expected in lake somewhere around 2010 (Jaani, Reap 2001). It is understandable that the erosion and damages on the coast depend on the water level. During the low-level periods no erosion will be noted and a broad, up-to–a–kilometre-wide foreshore plain will emerge. When the water level rises, the lake shores will be subject to intensive erosion and serious damages.

Generally, the wave action is most intensive in the autumn–winter period when the water level is relatively high and great water masses are piled up. Under high-water conditions the surge can reach 2–3 m and cause severe damage to the coast. At the end of November 1987, intensive erosion was registered over practically the entire length of the northern coast. The coast retreated 3 m in some places.

Ice-push action has caused extensive changes on the coasts Lake Peipsi. Ridges of pressure ice up to 10 m high are generated by persistent winds and are pushed forward against the shore with an enormous force. These play a significant role in shaping the lake shore, breaking trees, moving erratic boulders and redepositing beach sediments, piling up several metres high and tens of metres long accumulations of loose material on the beach. The effects of ice-push are greatest on sandy beaches on the northern coast of Lake Peipsi where deep furrows are often formed on the beach and coastal slope under the compressing and ploughing influence of the ice. In March 2002 ice ridges damaged the till shore near Nina Village on the western coast of the lake and endangered the buildings.

Human impact. As a result of intensive agriculture, the 1970s and 1980s were characterised by high loads of different polluting substances carried into lake. This caused an intensive growth of reed and bulrush, which sometimes form up to 150 m wide belts on the foreshore. Due to the encroaching vegetation, the area of beaches suitable for recreational use is notably reducing. Long stretches of coastal areas, which some dozens of years ago attracted numerous holidaymakers, are now swampy and people have to dig canals to reach the open water. The northern coast of the lake exhibits irreparable traces of man's carelessness for nature (mistakes in the building politics, trampling down up etc.). During the last decade, after land reform, several prominent people have unlawfully changed the shore profile near their summer cottages. Ignoring the law, they have erected new buildings close to the shoreline and constructed landing places for their boats.

Rapid changes on the coast of lake are important from both geological and social points of view. Therefore, coastal monitoring of lake and study of coastal processes has fundamental importance for better understanding of the future, including human-induced processes on the lake shores.

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INVESTIGATIONS OF AGRICULTURAL IMPACT ON SHALLOW GROUNDWATER QUALITY IN MONITORING STATIONS IN LATVIA

Vircavs, V.

Latvia university of Agriculture, Department of Environmental Engineering and Water Management, Academy street 19, LV-3001 Jelgava, Latvia; e-mail: valdis.vircavs@llu.lv

There is a noticeable intensification of agricultural activity during the eve of the previous and the dawn of the present century. That is associated with increased use of agrochemicals and organic fertilizers, which in turn can cause groundwater quality decline from source and diffuse contamination.

One of the main environmental protection goals in agriculture is to reduce now and limit in the future the groundwater pollution, including pollution with nitrates. The risk of polluting the groundwater and especially the shallow groundwater is one of the main factors in determines the impact of agricultural land use areas on the environmental quality in Latvia.

In order to evaluate the impact of diffuse contamination from agricultural activity on the quality of groundwater several monitoring boreholes must be made. The arrangement of the monitoring boreholes depends on the location or the hydro geological conditions of the territory, such as: the form of groundwater feeding, direction and speed of groundwater flow, groundwater level which depends on the physical characteristics of the ground and conditions of bedding.

In the end of the year 2005 ten stationary boreholes were created in three different monitoring stations (Auce, Bērze, Mellupīte). The boreholes are 6.0 to 10.0 meters deep and located in loam and sandy loam sediments. In the summer of 2006 a data loggers were installed in the boreholes, to register the fluctuations of the water level and temperature as well as the changes in the water balance. The instruments perform the measurements every hour automatically.

The regularity of the groundwater sampling depends on the season, but the annual amount of samples taken is at least four. Significant water level fluctuations are key-factor when deciding the moment the sample should be taken. It is necessary to state the moment when the groundwater level starts raising again, after a long-lasting drop in groundwater level during the vegetation period. During the rise of the water level, it is possible to obtain representative samples from the groundwater horizon that represent the quality of the groundwater.

The pollution of groundwater is characterized by the increased concentration of nitrates, phosphorus, heavy metals and organic substances. It is necessary to regard hydro geological, as well as hydro meteorological conditions, when evaluating the influence of the agricultural caused diffuse contamination on the groundwater quality indicators (pH; K; Ca; Mg; NO_3^-; NH_4^+; N_{tot}; PO_4^{3-}; P_{tot}).

THE RESULTS OF THE HYDRO-ACOUSTIC INVESTIGATIONS OF THE LITTORAL FORMATIONS DURING TRANSGRESSION – REGRESSION PERIOD OF SOUTHEASTERN SIDE OF KLAIPEDA–VENTSPILS PLATEAU

Visakavičius, E.[1], Blažauskas, N.[2], Gulbinskas, S.[2], Michelevičius, D.[3]

[1] *Klaipeda University, H. Manto 84, LT-92292 Klaipėda, Lithuania; e-mail: erikas.visakavicius@gmail.com*

[2] *Coastal Research and Planning Institute, Klaipeda University, H. Manto 84, LT-92292 Klaipėda, Lithuania; e-mails: nb@geo.lt, gulbinskas@geo.lt*

[3] *Faculty of Natural Sciences, Vilnius University, M. K. Čiurlionio 21/27, LT-03101 Vilnius, Lithuania*

From the geologic-geomorphologic point of view, the research area belongs to the Klaipeda-Ventspils plateau. Area of ~ 42 km^2 in the Northern part of the Lithuanian EEZ, in the depths of 25-31 m, covers the moraine Palanga ridge and the fragments of old marine terrace adhering to it. The site of complex geomorphological and ambiguous genetic origin has been investigated using up-to-date hydro-acoustic methods such as side-scan sonar, multi-beam echosounder and subbotom profiler. The ground-trouthing of the data obtained during remote sensing phase was made using vibro-coring and grab-sampling devices. Main aim of the research was to assess the possibility to use the old marine terrace sediments for beach nourishment works in highly eroded Lithuanian beaches. The data have been collected during three research campaigns. On July, 2005 the first geological and geophysical investigations has been arranged on the polish R/V "Nawigator XXI", which belongs to Szczecin Maritime University. Additional geological sampling was organized in September, 2005 on the Fisheries research laboratory vessel "Darius" and the last geophysical and geological expedition took place on July, 2006 on the R/V "IMOR", belonging to Gdansk Maritime Institute, Poland.

During the first stage of the research ("Nawigator XXI", July 2005), preliminary maps of seafloor morphology and lithology were compiled based on the side scan sonar (Edge Tech 272-TD) and multi-beam echo-sounder (Elac MKII) survey on the 20 predefined profiles. Five different litho-complexes have been distinguished after interpretation of acoustic sonograms and grab samples lithological analysis. The glacigenic sediments – brownish till, are exposed in the western part of the research area. Further to the east, the areas represented by characteristic mixture of the washed out sediments consisting of various grained gravel and sand have been identified. Two complexes of sandy deposits (fine and medium grained as well as fine and very fine sand), the most interesting and promising for the beach nourishment purposes, are spread in the most part of the research polygon. Just silt deposits are located very episodically in the eastern corner of the study domain. This, preliminary map of the superficial sediments distribution in the combination with seafloor bathymetry model, served as an base map for the planning of next – more precise geological-geophysical investigations, organized on the R/V "IMOR" (June, 2006). Additional full-covering side scan sonar, multi-beam echo-sounder surveys have been planned together with sub-bottom profiling (deeper seafloor geology reconstruction tool) in order to detail map sandy sediments distribution and evaluate the volumetric of the suitable sandy material. 10 seismo-acoustic profiles and 18 vibro-cores were made during second phase of field works. As a result, detail lithological map, high resolution bathymetrical chart and 3D model of sandy deposits distribution and volume have been compiled. As the same time as the preparation of the geological-geophysical model of the area, quality analysis of the sandy deposits have been made in order to identify and classify the sand according to the physical (grain size distribution, sorting parameters an other) and sanitary (chemical and mineralogical composition) requirements for the beach treating works.

Thanks to the combined scientific and applied investigations using modern remote hydro-acoustic and classical geological research methods, high resolution maps of seafloor morphology, sediment distribution as well as shallow sub-bottom structure models has been generated. During the research complex geomorphological structure and shifting sedimentological conditions of the research are has been revealed.

CHRONOLOGY AND EXTENT OF WEICHSELIAN ICE ADVANCES IN POLAND

Wysota, W.[1], Piotrowski, A. J.[2], Murray, A. S.[3] and Bateman, M. D.[4]

[1] *Department of Geology and Hydrogeology, Institute of Geography, Nicolaus Copernicus University, Gagarina 9, PL-87100 Toruń, Poland; e-mail: wysota@umk.pl*

[2]*Department of Earth Sciences, University of Aarhus, C. F. Møllers Allé 120, DK-8000 Århus, Denamark; e-mail: jan.piotrowski@geo.au.dk*

[3]*Nordic Laboratory for Luminescence Dating, Risø National Laboratory, DK-4000 Roskilde, Denamark; e-mail: andrew.murray@risoe.dk*

[4]*Sheffield Centre for International Drylands Research, Department of Geography, University of Sheffield, Winter Street, Sheffield S10 2TN, UK; e-mail: m.d.bateman@sheffield.ac.uk*

One persistent problem of the Weichselian glaciation in the Polish Lowland is the chronology and the extent of the Scandinavian Ice Sheet (SIS) advances. It concerns particularly the lower Vistula (Weichsel) River in central Poland, which is a key area to study the major fluctuations of the southern margin of the SIS (Marks, 2002, 2004; Wysota, 2002).

The model builds upon studies in the lower Vistula River which consider three ice advances during the Early, Middle and Late Weichselian, separated by ice-free interstadials (e.g. Makowska, 1976, 1992, 1994; Mojski, 1980, 1995). This three-part glaciation hypothesis was subsequently adapted for the central and eastern part of northern Poland (Marks, 1988; Lindner & Marks, 1995). In western Poland (the Great Poland Lowland), assumes just one advance of the SIS in the Late Weichselian, up to the maximum extent position during Leszno (Brandenburg) phase, followed by ice retreat with several local re-advances (Kozarski, 1980, 1988; Stankowski, 2000).

The paper presents the results of optically stimulated luminescence (OSL) dating of Weichselian sediments in central and northern Poland. In 2004-2007, a total 93 OSL samples were dated from 25 sites, located in the area between the maximum extent the Weichselian glaciation and the Pomeranian phase. 73 OSL dates were obtained from the Nordic Laboratory for Luminescence Dating in Risø (Denmark) and next 20 OSL dates from the Sheffield Centre for International Drylands Research (UK). The OSL method was supported by radiocarbon dating (6 samples).

The ages obtained do not yield support for the SIS advance in the Early Weichselian. The dating results suggest occurring of glacial sediments of the Middle Weichselian advance (c. 55–50 kyr) at the Kurzętnik site, but it demands further investigation. The results show two advances of the SIS along the lower Vistula River during the Late Weichselian (MIS 2).

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CONDITIONS OF FORMING THE DEPOSITS WITH THE REMAINS OF WOOD ELEPHANT (*PALAEOLOXODON ANTIQUUS*) ON BELARUS

Yelovicheva, Y.[1], Drozd, A.[2]
[1]*Belarussian state university, Nezavisimostj av. 4, BY-220050 Minsk, Belarus; e-mail: yelovicheva@yandex.ru*
[2]*Institute of geochemistry and geophysics NAS of Belarus, Kuprevich 7, BY-220141 Minsk, Belarus; e-mail: drozd@igig.org.by*

The lens of ancient lacustrine deposits was uncovering in 2006 when was built one of tunnels of the underground in Minsk on the crossing of the Nezavisimosty avenue and the Shafarnianskaya street. It lies on a depth about 10 m from a surface and consist of the 1.05 meter's layer of sand and sandy loam which are underlying by the grey marl. In the thickness of sandy loam were found the rests of the wood elephant (*Palaeoloxodon antiquus*) for the first time in Belarus. 21 samples from layer of sandy loam were studied. 6 palynocomplexes (PC) are defined in the palynological diagram (figure).

The content of AP pollen is 94-97 %, NAP pollen – 2-3 %, Spores – 1-5 % in the lower part of a section (PC-1-4). The group of arboreal pollen is composed mainly *Pinus sylvestris* (74-88 %). The other species have the next maxima: ПК-1 – *Larix* (12 %)+*Betula sect. Albae* (12 %)+*Salix* (1 %); ПК-2 – *Betula sect. Albae* (4-9 %); ПК-3 – *Larix* (13 %); ПК-4 – *Picea sect. Eupicea* (7-17 %). The of pollen of *Alnus, Carpinus betulus, Picea sect.* ***Omorica, Betula sect.*** *Nanae****,*** *Betula sect****.*** *Fruticosae****,*** *Selaginella sp****.*** *(aff. Sibirica)*, terrestrial herbs and water-bog plants and *Osmunda cinnamomea* are represented by rare findings. The pine forests, with a birch, larch with of ferns, bracken in soil cover was received the development at a moderate-warm climate conditions of the end of Muravian (Eemian) Interglacial. A fur-tree and a willow are settled on the humidified places, while the sphagnum, moss, dwarfish birch, sometimes a grape-fern, osmunda took up one's residence in paludification sites.

The content of AP pollen is 33-53 %, NAP pollen – 33-52 %, Spores – 1-5 % in the upper part of a section (PC-5-6). Tree species are represent by *Pinus sylvestris* (48-70 %), *Picea sect. Eupicea* (1-14 %), *Betula sect. Albae* (18-40 %), *Q.m.+Carpinus* (1-11 %; *Alnus* – 1-8 %, *Quercus robur* – 1-7 %, *Tilia cordata* – 1-2 %, *Ulmus laevis* – 1-3 %, *Carpinus betulus* – 1-3 %), shrubby – *Corylus avellana* (1-3 %), *Cornus* (1-3 %), *Salix* (2-3 %), *Ephedra distachya* (2 %), *Alnaster*, *Betula sect****.*** *Nanae, Betula sect****.*** *Fruticosae*. The herb plants are includ *Chenopodiaceae* (1-16 %), *Artemisia* (45-82 %), *Poaceae* (2-16 %), *Polygonaceae* (1-11 %), *Asteraceae* (1-4 %), *Brassicaceae* (1-4 %), *Ranunculaceae* (1-13 %), *Caryophyllaceae* (1-7 %), *Apiaceae* (1-3 %), *Cichoriaceae* (1 %), *Dipsacaceae* (1-2 %), *Violaceae* (1 %), *Cyperaceae* (1-4 %), *Phragmites* (1 %), *Ericaceae* (1-9 %), *Pyrolaceae* (1 %), *Typha latifolia* (1,5 %), *T. angustifolia* (1,5 %). Spore-bearing species dominated by *Sphagnum* (63-91 %), *Polypodiaceae* (9-32 %*), Lycopodium* (1-6 %), *Selaginella selaginoides****, S.*** *helvetica* (4-9 %), *Botrychium lunaria* (2-3 %), *Osmunda cinnamomea* (2 %). Rarefied bright-coniferous forests with birch, fern and grape-fern in a grassy cover, mosses in soil cover are dominated in the vegetation at a cold climate conditions connected with the beginning of Poozerian (Weichselian) Glacition. The open spaces occupying of the diverse terrestrial herbs was received the great development in the landscapes. The sphagnum, sedge, heather grew on the paludification sites, and a coastal part of water basins were marked by reed mace, reed, lady's thumb.

It is also important, that a role of redeposition of coal particles, calloused bodies, mesophilic and thermophilic flora elements grew gradually from the end of Muravian Interglacial to the beginning of Poozerian Glacition.

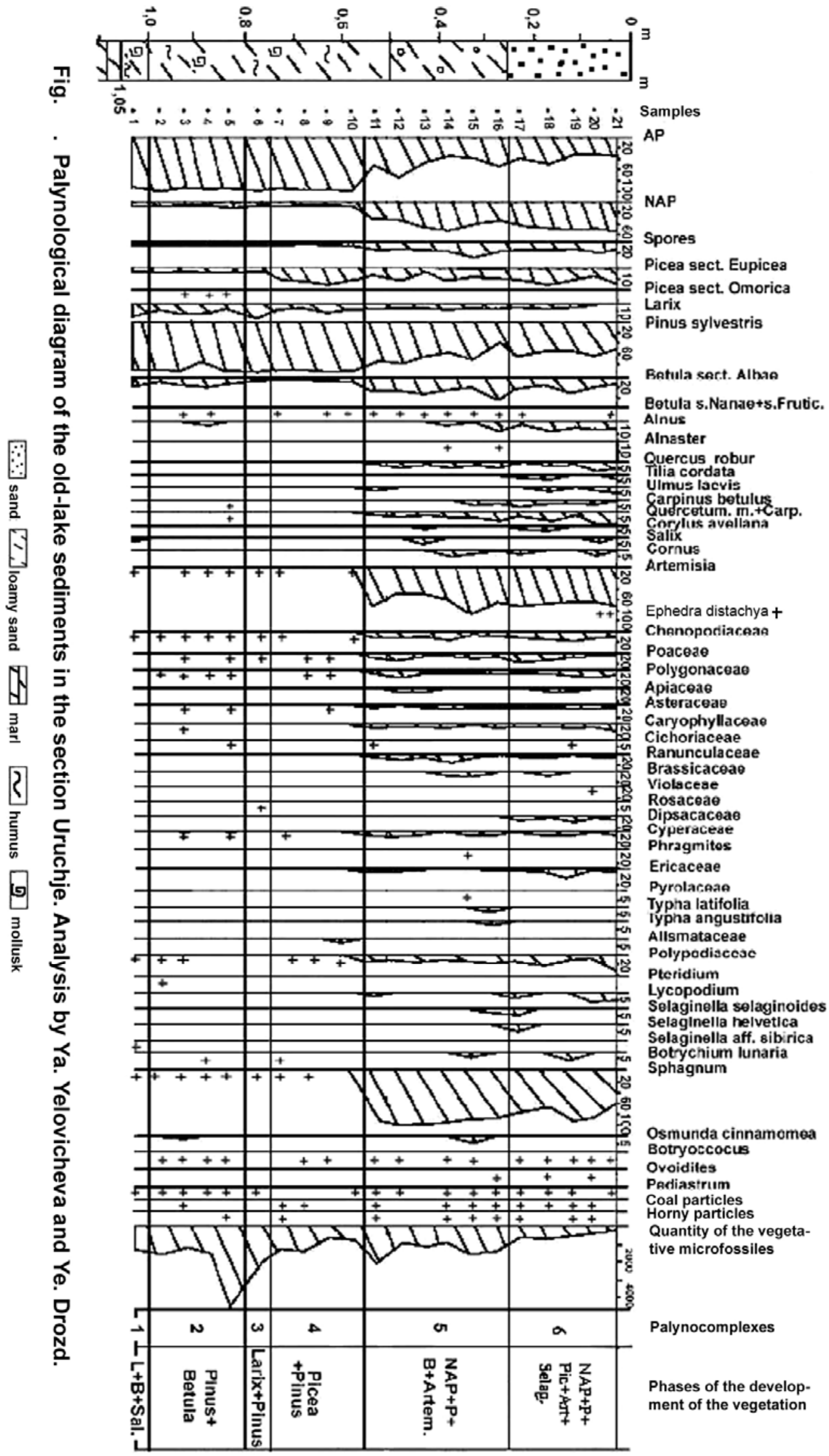

Fig. . Palynological diagram of the old-lake sediments in the section Uruchje. Analysis by Ya. Yelovicheva and Ye. Drozd.

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THE MOUNTAIN GLACIER OF THE LOVOZERO MOUNTAIN FOOTHILLS DURING THE LATE PLEISTOCENE AND HOLOCENE, NW RUSSIA

Yevzerov, V., Nikolaeva, S., Krivoruchko, E.
Geological Institute of Kola Science Center RAS, Fersmana str. 14, RUS-184209, Apatity, Russia; e-mails: yevzerov@geoksc.apatity.ru, nikolaeva@geoksc.apatity.ru

The Lovozero nepheline syenite intrusion located in the central part of the Kola Peninsula forms a low-mountain massif covering the area of 650 km^2. It uplifts above the surrounding plain for 500-950 meters and has a plateau-like surface. The slopes of the massif are indented by river valleys whose upper parts are occupied by cirques. The northern slopes of the massif are highly rugged, while the southern and eastern ones are characterized by a lesser degree of relief ruggedness. The central part of the massif is occupied by the extensive steep Seidozero depression with numerous creek valleys.

The Lovozero massif has rather sharp contacts with the country rocks composed mainly by Archean granites and gneisses and can be traced, according to the geological-geophysical data, down to a depth of 10 km (Arzamastsev et al., 1998). The Lovozero Upper Devonian volcano-sedimentary suite that previously formed the top of the intrusion may presently be observed as xenoliths at the top and marginal parts of the massif.

The relationship between the Scandinavian ice sheets and local mountain glaciers in the Lovozero massif is scrutinized in (Yevzerov&Strelkov, 1969). The deposits of autochthonous and allochthonous glaciers can surely be separated from each other by the morphology of the resulting landforms and petrographic composition of coarse fragments. The pebble fraction of the mountain glacier's deposits consists by 75-100 % of nepheline syenite fragments, while the same fraction of the Scandinavian moraine contains less than 30 % of the fragments from the Lovozero area. The above-mentioned authors have revealed that the mountain glaciation occurred prior to the first stage, between the first and second stages and after the second (last) stage of the Valdai glaciation. Modern points of view are inclined to consider these stages to take place most likely during Early and Late Valdai.

This review represents the data collected by the authors and describes the deposits of a mountain glacier in the western part of the Lovozero massif northern foothills. The area studied is shown in Fig. 1 large cirques and a canyon along the Ilmajok River indent here the mountain slope. Two large ridges are articulated to the cliffy mountain slopes west and east of the Sergevan' River valley. Together with the sub-latitudinal ridge, these form an arc facing north with its prominence. The ridges are also found inside the arc, some 300-500 m west of the Sergevan' River. All the ridges mentioned are visible in the relief. Their height varies from 3-5 to 20-25 m, and width - from 50 to 200 m. The ridges are composed of unsorted boulder - pebbles material, sometimes with admixture of inequigranular sand, gravel and gruss. The petrographic composition of the pebbles fraction is shown in circle diagrams. Everywhere pebbles of the Lovozero nepheline syenite dominate (from 64 to 98 %), regardless the fact that the sights of studying the pebble composition are located outside the massif of nepheline syenite. In other words, the pebbles quite definitely are the result of the activity of a mountain glacier descended from the Lovozero Mountains.

The data represented show that at the concluding stage of the glacial evolution on the Kola Peninsula in the western part of the Lovozero Mountains northern foothills, a submountain glacier was active. It was formed by two initial ice tongues from cirques and valleys of the Ilmajok River. The ridges located somewhat west off the Sergevan' River represent a typical medial moraine. The authors disagree with the viewpoint of C. Hättestrand and V. Kolka who consider the western ridge to be a marginal formation of the Scandinavian ice sheet and compare it only according to the morphological similarity with the marginal formations of the Bölling situated 9 km north-east of the northern end of the western ridge (Korsakova& Kolka, 2005).

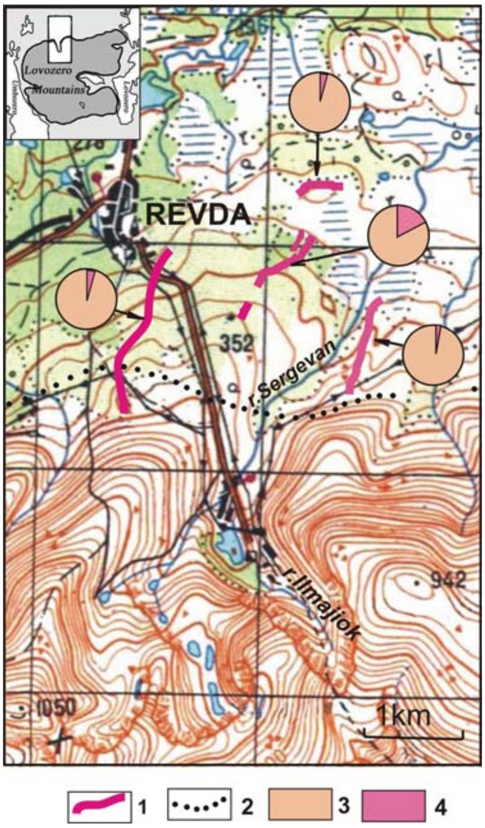

Fig. 1. ***Position of the submountain glacial deposits and petrographic composition of their pebble fraction. 1 - ridges of marginal and medial moraines of submountain glacier, 2 - contact of the Lovozero massif, 3 - content of pebbles in the nepheline syenites of the Lovozero massif, 4 - content of pebbles in the acid and basic rocks of the basement***

This research was supported by programme 16-2 of the Presidium of the RAS, project 5.5 "Evolution of the relief and deposits of the Kola Region in the Holocene" and by grant RFBR number 07-05-96906.

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EVOLUTION OF THE ICE SHEET AND MOUNTAIN GLACIERS DURING THE LATE PLEISTOCENE AND HOLOCENE IN THE SOUTHERN PART OF THE KHIBINY MOUNTAINS, NW RUSSIA

Yevzerov, V., Nikolaeva, S., Semenov, R.
Geological Institute of Kola Science Center RAS, Fersmana str. 14, RUS-184209, Apatity, Russia; e-mails: yevzerov@geoksc.apatity.ru, nikolaeva@geoksc.apatity.ru

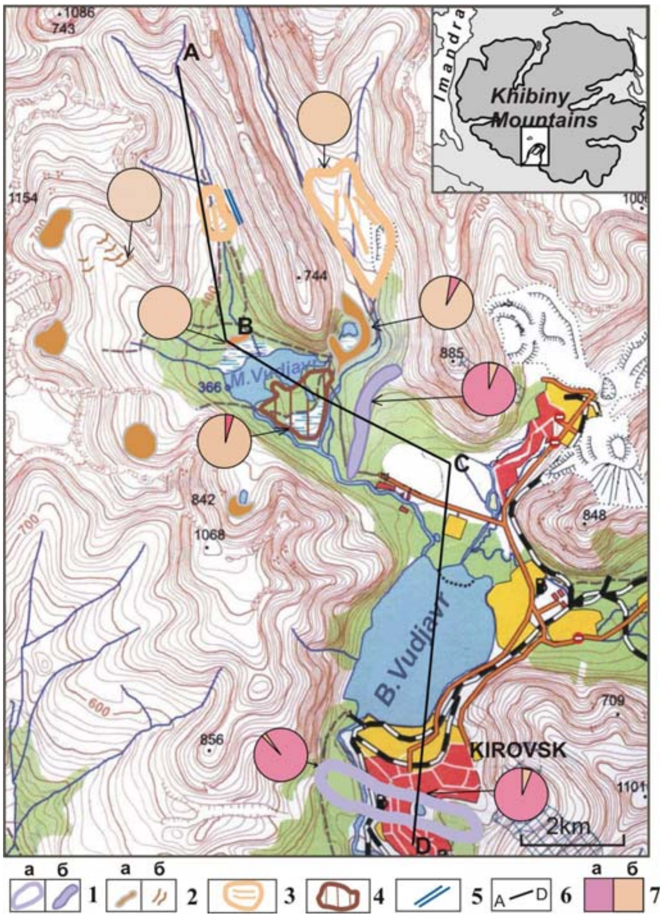

Figure 1 shows the area of the Khibiny Mountains that was covered with glaciers and an ice sheet during the Late Pleistocene and Holocene. The deposits of the glaciers and their melt water are represented by end moraines, De Geer moraines (?), sandur, glaciofluvial deltas and ice-dammed lake terraces. The deposits are characterized by a very high content of the Khibiny nepheline syenite fragments. In the pebble fraction it ranges from 93 % to 100 %. The sediments of the ice sheet formed a marginal belt during the Allerød - Younger Dryas. The belt consists of two bands of marginal ridges: an inner band - a dump moraine, and an outer band - a push moraine (Yevzerov, 1998; Yevzerov&Nikolaeva, 1999). The content of granite, gneiss, gabbro and others non-Khibiny rocks' pebbles varies from 89 % to 95 % in tills and glaciofluvial deposits of ice sheets.

Fig. 1. ***Scheme of glacial formations distribution in the southern part of the Khibiny massif***

1 - ice sheet marginal moraines: a-dump moraine, b-push moraine, 2 - end and circus moraines of local glaciers (a), De Geer moraines (b); 3 - glaciofluvial delta deposits; 4 - sandur; 5 - shoreline of ice-dammed lake; 6 - profile line; 7 - content of pebbles of acid and basic basement rocks (a), and pebbles of the Khibiny nepheline syenites

Figure 2 illustrates the evolution of the glaciers from the Allerød to the Early Holocene. The sedimentation in the Lake Kupal'noe started ca. 9 thousand years ago (Korsakova&Kolka, 2005) that completely corresponds to the proposed scheme of the evolution. Ascribing the deposits of the glaciers and ice sheet to different stages of a sheet glaciation (Korsakova&Kolka, 2005) does not agree with the given material, especially considering the fact that glaciers still exist in the Khibiny Mountains (Zyuzin, 2006).

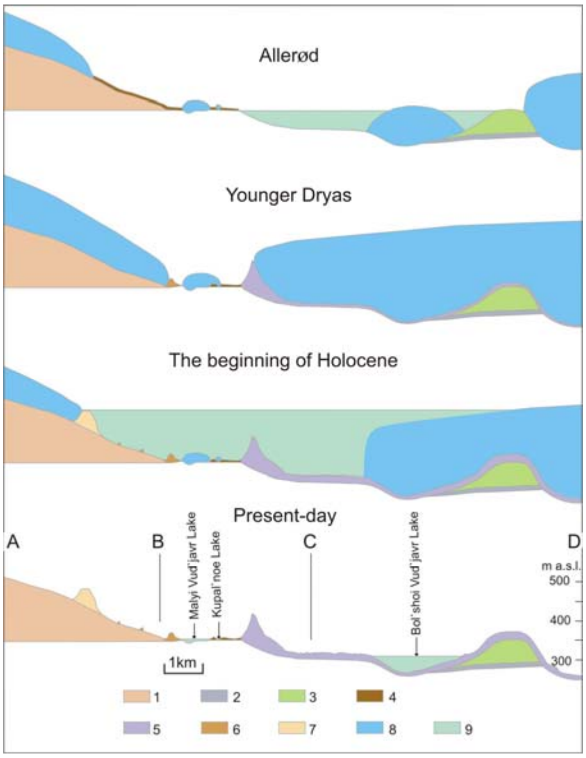

Fig. 2. ***Scenario of glacier and ice sheet evolution in the Late Pleistocene-Holocene***

Bedrock: 1 - nepheline syenites of the Khibiny massif. Deposits of ice sheets: 2 - till and glaciofluvial deposits of the Older Dryas (?); 3 - glaciofluvial and glaciolacustrine deposits of the AllerØd; 4 - till and glaciofluvial deposits of the Younger Dryas. Deposits of local glaciers: 5 - sandur of the AllerØd; 6 - end moraines and De Geer moraines (?) of the Younger Dryas; 7 - glaciofluvial delta of the Early Holocene. Other signs: 8 - active and dead ice; 9 - water of modern and ice-dammed lakes.

This research was supported by programme 16-2 of the Presidium of the RAS, project 5.5 "Evolution of the relief and deposits of the Kola Region in the Holocene" and by grant RFBR number 07-05-96906.

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EARLIEST INHABITANCE OF THE TERRITORY OF LATVIA IN THE LATE GLACIAL ENVIRONMENT

Zagorska, I.
Institute of History of Latvia, Latvian University, Akademijas sq.1, LV-1050 Riga, Latvia; e-mail: lvi@lza.lv; izagorska@yahoo.com

During the last, Weichselian, glaciation only the south-eastern part of Lithuania was ice-free. The rest of the east Baltic gradually became free of the continental ice sheet. South-eastern Latvia was the first part to become free of ice, followed later by the rest of the territory. At the same time Baltic Ice Lake coastal lines were formed, which are still clearly visible in the relief of western end central Latvia. The ice-free areas were covered by tundra vegetation, step by step changing into park-tundra (Eberhards et al, 2002, 85-86).

Most characteristic element of the Late Glacial fauna in eastern Baltic was reindeer. The remains of the reindeer in Latvia were dated to the period from 11 565±80 BP (Hela-606) to 9 980±70 BP (Hela-607) (Ukkonen et al, 2006, 227). Some mammoth bones from Estonia were dated to the very end of the glaciation (Lõugas et al, 2002). Recent analyses of some of mammoth bones from Latvia confirmed the same late existence of this big animal in our territory as well (information by I. Zupins, Nature Museum of Latvia).

Of archaeological importance is the dating of a reindeer antler from Olaine, close to Riga. Paleozoologist L. Lõugas (Tallinn) suggests that this robust antler, which still has part of the scull attached, might indicate that animal had been killed by hunters. If so, then we can regard the period around 10 780±90 BP (Hela-603) as being the time of the earliest known settlement in the territory of Latvia.

Archaeological evidence characterizing the ancient reindeer hunters are preserved in Latvia only from the Younger Dryas onwards. Testifying to the presence of the earliest inhabitants of this area are stray finds of flint tools, archaic forms of bone and antler harpoons and settlement sites with a rich flint assemblages. Archaeological material of a similar kind, representing the final palaeolithic Swidry culture and distant influences of the Ahrensburg culture, has been obtained south of the East Baltic, in the basins of the Vistula, Pripet and Nemunas. Mainly it was the territory of Lithuania, from which during the Younger Dryas the ancient hunters reached nowadays territory of Latvia.

The distribution of the artifacts and likewise that of the sub-fossil reindeer bone remains clearly indicates the routes of arrival of the first hunters in our area.

Thus, reindeer bone finds concentrate in western Lithuania, close to the present day coast, and spears and an arrowhead made from reindeer bone and antler have been found at Klaipeda (Rimantiene, 1994, 33). This may indicate one of the routes taken by ancient hunters: following the coast of the Baltic Ice Lake. So far, there is little data from western Latvia, but it is possible, that more intensive research in this region, which has begun in recent years, will yield new evidence (Fig. 1).

Although in the Late Glacial the extensive Zemgale Gulf extended far into the Lielupe basin, nevertheless the upper course of the River Lielupe had already formed, downstream of the confluence of the Rivers Musa and Memele, coming from the Lithuanian territory. It could be the second route of reindeer hunter arrival. At least four occupation sites along the River Lielupe have produced artifacts of Late Palaeolithic appearance. A large number of reindeer bones also have been recovered by the shore of the Baltic Ice Lake around the former mouth of the River Lielupe.

Figure 1. ***The Baltic Ice Lake coast today, western Latvia, near Kapsede***

However, most of the evidence of human presence in Latvia in the Late Glacial period is connected with the River Daugava valley. It is the largest river of the present-day Latvia, flowing through the eastern and the central regions of the country. After the retreat of the ice it was one of the first river valleys to develop, partly using the elder river bed (Eberhards, 1996, 35-41).

Suitable locations for settlement could be found on the high terraces of the Daugava, the former islands in the river and the former ice-marginal basins, which had develop into lakes. So far, five ancient find spots are known along the left bank of the Daugava and nine along the right bank. The River Daugava valley the groups of ancient hunters could reach via the River Dviete valley, a tributary of Daugava, coming from the eastern Lithuania, where the earlier inhabitance has been observed. Rapids and shallow streches of the river are still present today near the sites occupied by the ancient reindeer hunters. It seems, that in Late Glacial too, these places could be used by the reindeer hunters to ford the river. The situation during the Late Glacial time was similar in the Lithuania as well (Daugnoras et al, 2005, 132).

Aknowledgement:
These thesis are prepared by the support of the Latvian States programme „Letonika".

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THE PLEISTOCENE FLUVIAL SERIES IN THE MIDDLE VISTULA VALLEY, CENTRAL POLAND

Żarski, M.

Polish Geological Institute, Rakowiecka 4, PL-00975 Warsaw, Poland; e-mail: marcin.zarski@pgi.gov.pl

The study area is situated in the Middle Vistula river valley between Kazimierz Dolny and Maciejowice (Żarski, 2002). The Vistula gap is located in the south part of the investigated area and the width of valley is 1 to 3 km. Below the gap, the width of valley increases to17 km. The Vistulian sands and gravels build four overbank terraces and the Holocene sands and silts build two flood plains in the valley. Lithological/petrographic, palynological, micropalaeontological and TL ages investigations were made. Samples were taken from search boreholes. The genesis, facies, composition and age of investigated sediments were determined basing on these analysis. The course of the present-day Vistula valley and buried valley is not the same (Fig. 1). The buried Vistula runs from the Nowy Janowiec region to Wojszyn and Puławy, north of

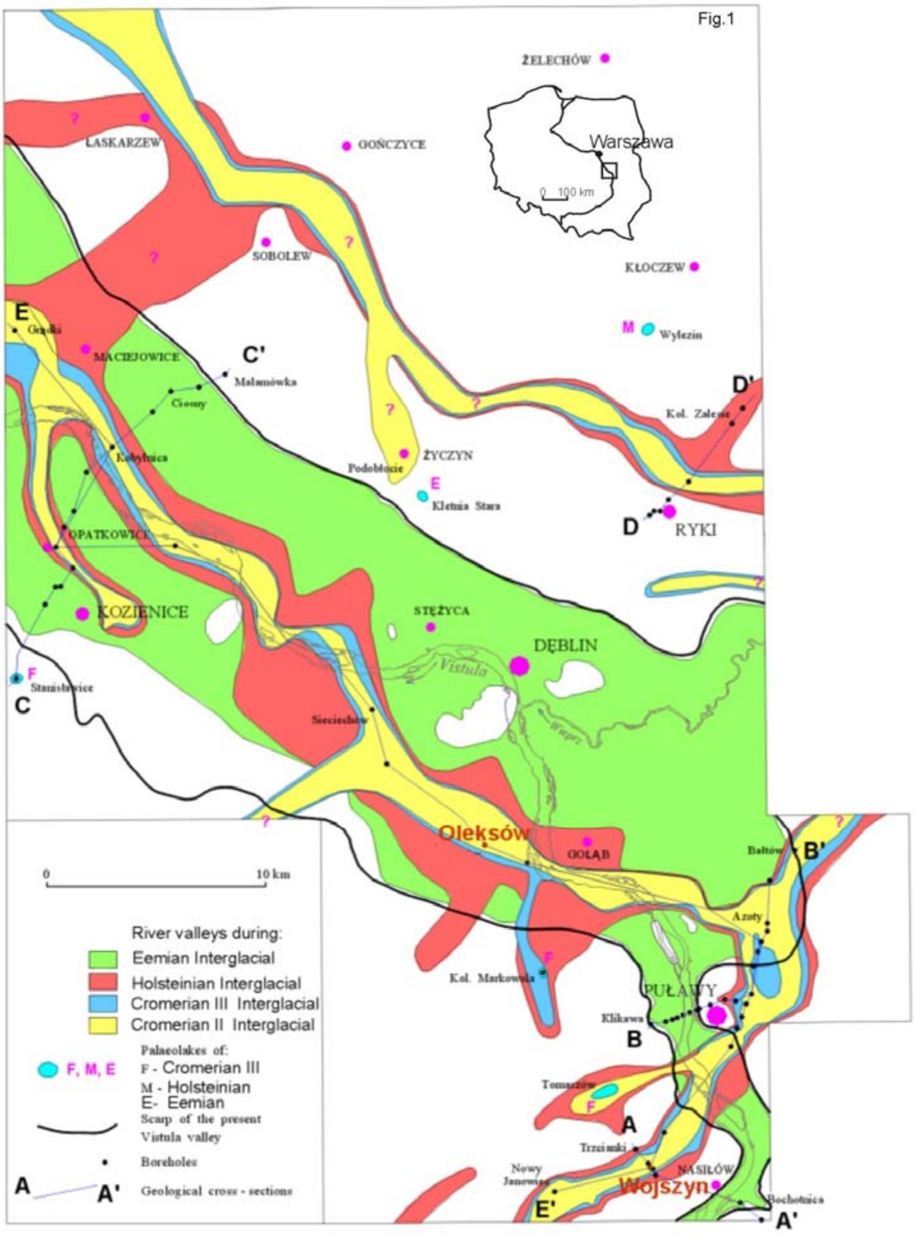

Fig. 1. ***Buried river valleys*** *(after Żarski, 2002)*

contemporary Vistula valley. North of Puławy, the buried Vistula valley is concordant with the contemporary valley. The course of the Vistula had changed after the Saalian Glaciation, which was the latest glaciation at this area. The buried Vistula valley is filled with the Cromerian II, Cromerian III, Holsteinian and Eemian sediments (Pożaryski *et al.*, 1999). The fluvial sediments of these interglacials usually are in contact with one another. Glacial strata or pavement separate the deposits of various interglacials in valley peripheries. During the Cromerian II Interglacial the width of the buried Vistula valley did not exceed 4 km, during Cromerian III – the width of valley reached 5-6 km, during the Holsteinian Interglacials was about 8 km and during the Eemian – 16 km. The valley gradient for the Cromerian II, Cromerian III and Holsteinian buried valley is about 0.57 ‰ but for the Eemian Interglacial as well as the Vistulian and the Holocene valley is about 0.30 ‰. The change of gradient was the result of tectonic movements stopped after the Holsteinian Interglacial. The smaller gradient was a main reason for developing strong lateral erosion and increasing the width of valley. Thickness of sediments filling the buried Vistula valley in the Cromerian and Mazovian is about 40 m but in the Eemian Interglacials, Vistulian and Holocene is about 20 m. Sediments filling the buried Vistula valley during various interglacials have usually different petrographic composition and content of heavy minerals. The Wojszyn borehole is located on postglacial plateau about 2 km from the present-day Vistula valley (Fig. 2). This borehole documents 3 fluvial series from the Cromerian II, III and

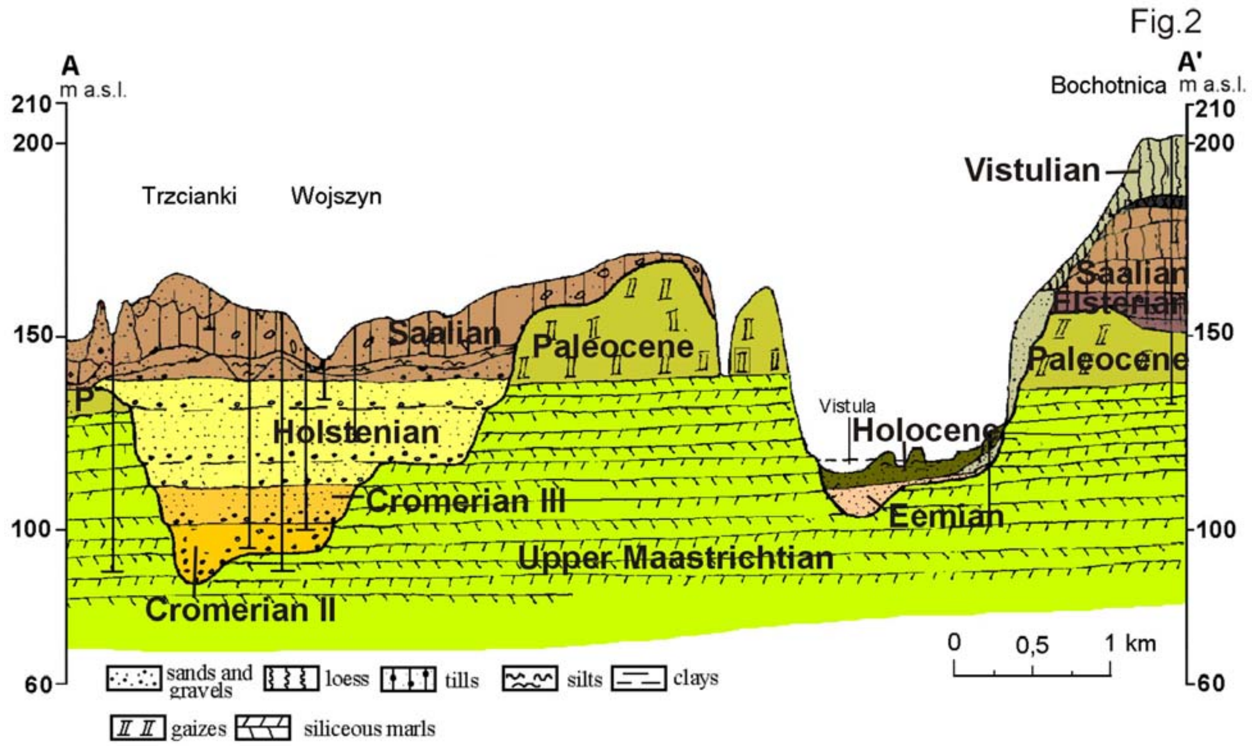

Fig. 2. ***Geological cross-section A-A' between Wojszyn and Bochotnica*** *(after Żarski, 2002)*

Holsteinian Interglacials which fill the buried Vistula valley. The thickness of them is 45 m. Fluvioglacial sediments and the Saalian tills occur above them. The buried valley cuts the limestone of the Upper Maastrichtian and Lower Paleocene. Gravels of diameter 5-10 mm occurring in various interglacials have similar petrographic composition. These gravels are represented by pebbles of gaizes, limestone, marls and siliceous rocks (81.8–91.2 %) originating from surrounding area and the South Polish Uplands. The content of Scandinavian rocks is about 10–20 %. These rocks are represented by granite, limestone and sandstone. The content of local rocks in fluvioglacial sands is about 42.9 % but in tills is 7.5 % to 12.0 %. The content of Scandinavian rocks in fluvioglacial deposits is 57.1 % but in tills – about 90 %. Similar petrographic composition in various fluvial interglacials is connected with occurring of local rocks in the Vistula gap. The content of heavy minerals in fluvial series is following: garnet – over 60 %, tourmaline – 30 %, amphibole – 5 %. It is typical content for fluvial sediments. The content of amphiboles (mineral weathering non-resistant) in fluvioglacial sediments is about 45 % and in tills – 60 %. Analysis of minerals content in sediments are very important to determine genesis of investigated sediments. The content of calcium carbonate in fluvial sediments is 3.1-6.1 % but in fluvioglacial sediments – 29.6 %. The TL age of the Holsteinian sediments from sample taken in Wojszyn profile is about 400 ka.

The Oleksów borehole is located on the flood Vistula valley about 15 km north of Wojszyn borehole. The lower Palaeocene rocks are bedrock of the Quaternary deposits. The thickness of fluvial series filling the buried Vistula valley is 44 m. These sediments represent the interglacials of Cromerian II, III, Holsteinian, Eemian, and the Vistulian and Holocene. The gravel petrographic composition is different in various interglacials. The content of local pebbles decreases in deposits of younger interglacials but Scandinavian gravels increases. The content of local rocks in Cromerian II and III is 93.2 %, in the Lower Holsteinian cycles is 81.8 %, in the upper Holsteinian cycles is 48.6 %. The difference of contents of local gravels in sediments of lower and upper cycles was probably caused by glacial episode. The content of local rocks in sediments of the Eemian is about 57 %. Garnet and tourmaline among heavy minerals are predominant over the rest of heavy minerals. The lithological/petrographic investigations are very helpful to determine genesis and stratigraphical division in the Quaternary sediments.

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STRATIGRAPHY OF LATE GLACIAL AND HOLOCENE DEPOSITS IN BELARUSIAN POOZERIE

Zernitskaya, V.[1], Makhnach, N.[1], Kolkovskij, V.[2]
[1]*Institute of Geochemistry and Geophysics, National Academy of Sciences of Belarus, Kuprevicha str. 7, BY-220141 Minsk, Belarus; e-mail: vzern@igig.org.by*
[2]*Centre of Geophysical Monitoring, National Academy of Sciences of Belarus*

The territory of the geographical province Poozerie occupies the northern part of Belarus and lies within the area of the last glaciation (Fig. 1). Glacial accumulations form the lower marker horizon underlying postglacial sediment series.

The Late Glacial (the Naroch) horizon is composed of solifluction deposits (sand, clay, sandy and silty loam), deluvial and proluvial deposits (sandy, gravel and peblle material, sand, clay, sandy and silty loam, mud), lake deposits (sand, clay, silt, marl, lime, carbonate gyttja, mud) and eolic deposits (sand). Initial accumulation of bog sediments was connected with thermokarstic processes mainly. For instance, a peat layer overlain by gyttja in the bottom of the profile Lozovoki dates to 13 740±850 conventional ^{14}C years BP (IGSB-464).

Fig. 1. ***Location of the study sites*** *(1 – Naroch, 2 – Mezhuzhol, 3 – Dolgoe, 4 – Lozoviki, 5 – Osveja, 6 – Tserkovnoe, 7 – Krivoe, 8 – Teklits, 9 – Volosovo)*

Deposits of the Holocene (the Sudoble horizon) are presented by alluvial deposits (channel, flood-plain and ox-bow facies), lake deposits (siliceous, carbonate, mixed, fine- and coarse detritus gyttja as well as marl, lime, clayey and siliceous mud), bog deposits (peat of eutrophic, mesotrophic and oligotrophic types), spring (mainly calcareous) deposits and sandy eolic deposits.

Within Poozerie, 70 profiles were palynologically studied. However, radiocarbon dates were available from 9 profiles only (1-10 dates for each profile). Up to date, the most detailed investigation of Holocene deposits (palaeontological studies, radiocarbon chronology, oxygen and carbon stable isotopes composition) was carried out for the profile Lozoviki (Fig. 2), where 10.5 m thick deposit (peat, carbonate gyttja, fine-detritus gyttja, peat) was revealed. Because of that this profile may be considered as the stratotype section of the Holocene in Poozerie. The investigation of Late Glacial section of the profile allowed to suggest some new ideas. Formerly, sediments of the Allerød interstadial were usually recognized by the maximum contents of *Picea*, and the sediments of the Younger Dryas were thought to be consistent with the maximum of NAP and with increased contents of *Betula*. As a result of the study of Late Glacial sediments at 5-cm depth resolution it was noted that the maxima of *Picea* and NAP were synchronous and corresponded to the age range between 10 000 and 11 000 BP, characterizing Younger Dryas sediments.

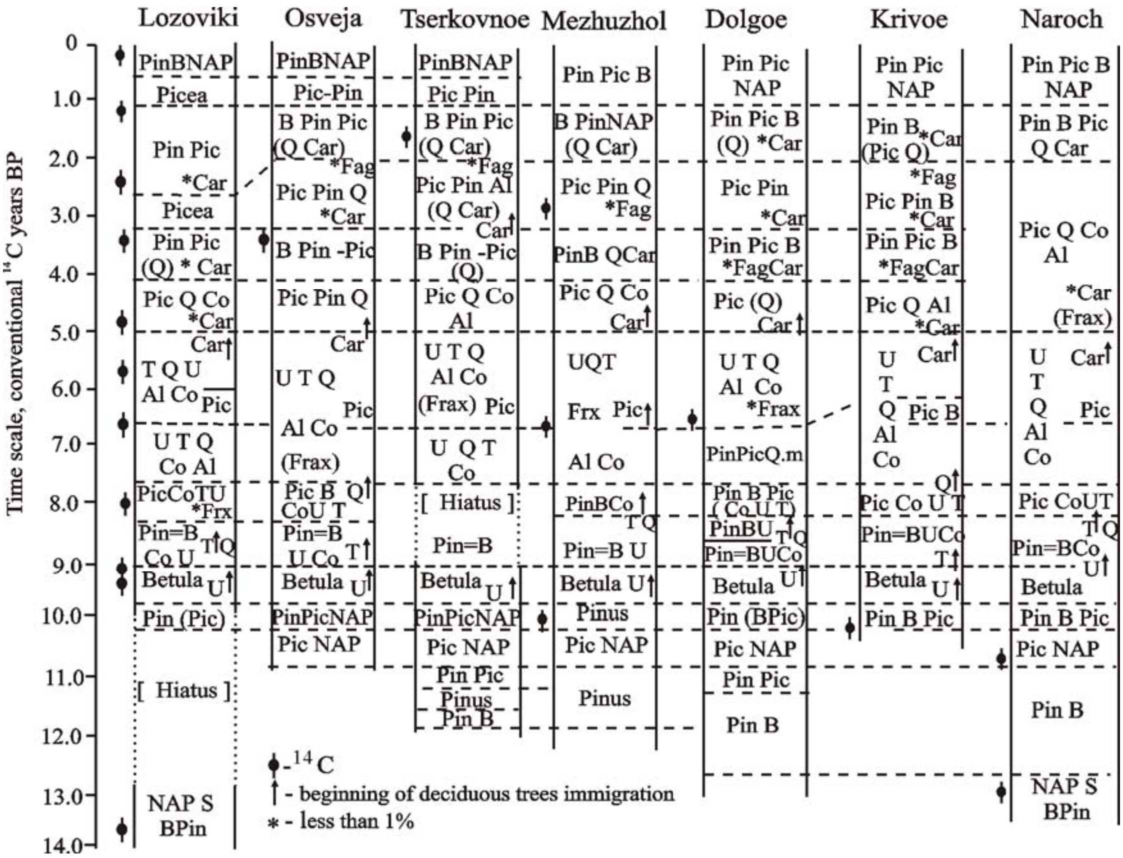

Fig. 2. ***Correlation of local pollen assemblage zones recognized in several profiles from Poozerie***

Correlation of local pollen assemblage zones revealed in several diagrams enabled presentation of pollen stratigraphy of the Late Glacial and Holocene as follows: before 12 700 BP, *NAP – Betula* (*B. nana* L., *B. humilis* Schrank., *Alnaster*); 12 700–11 800 BP, *Betula – Pinus - NAP*; 11 800–11 300 BP, *Pinus* (with *Ephedra, Juniperus*); 11 300–10 900 BP, *Pinus - Picea - Betula*; 10 900–10 200 BP, *Picea* (20–40 %) – *NAP*; 10 200–9 800 BP, *Pinus* - (*Picea*) - *Betula* - *NAP*; 9 800–9 000 BP, *Betula* - (*Pinus*); 9 000–8 600 BP, *Pinus* = *Betula – Corylus* – (*Ulmus*); 8 600–8 400 BP, *Pinus - Corylus - Ulmus* -(*Tilia-Quercus*); 7 800–8 400 BP, *Pinus - Corylus - Q.m - Picea*; 7 800–6 600 BP, *Ulmus - Corylus - Tilia - Quercus - Alnus*; 6 600–6 000 BP - *Ulmus - Tilia - Quercus - Corylus - Alnus* - (*Picea - Betula*); 6 000–5 000 BP, *Quercus - Ulmus - Tilia - Alnus - Corylus*; 5 000–4 200 BP, *Picea - Quercus* - (*Corylus - Carpinus*); 4 200–3 200 BP, *Pinus - Picea - Quercus* - (*Carpinus*); 3 200–2 700 BP, *Picea - Pinus - Betula* - (*Quercus*); 2 700–2 000 BP, *Pinus - Picea - Quercus* - (*Carpinus - Alnus*); 2 000–1 000 BP, *Pinus - Picea - Betula* (*Quercus – Carpinus*); 1 000–500 BP, *Picea - Pinus - Betula - NAP*; 500–0 BP, *Pinus - Betula* - (*Picea*) - *NAP*.

This research was carried out with financial support from the Belarusian Republican Foundation of Fundamental Investigations (grant XO7MC-018).