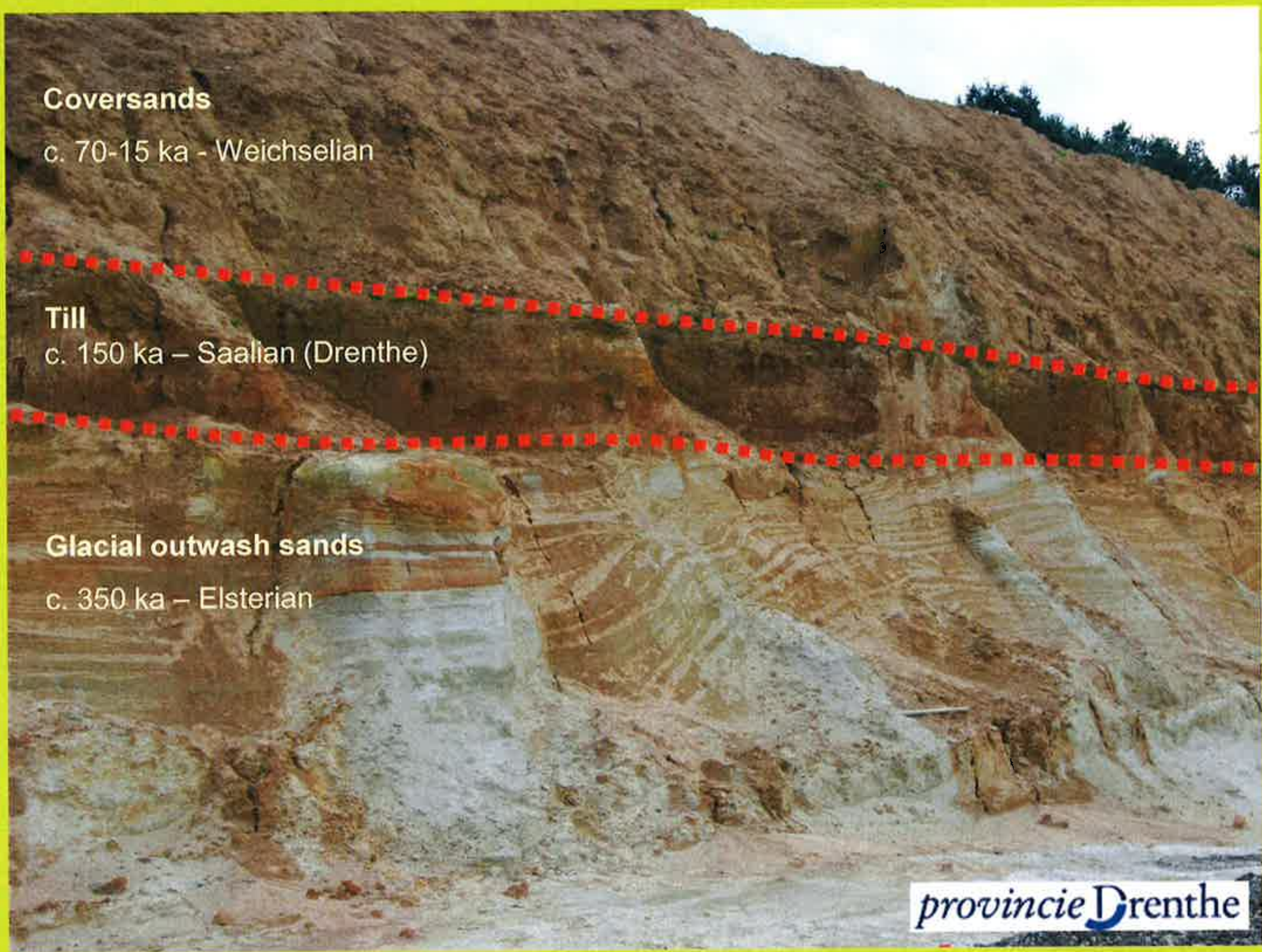
INQUA Peribaltic 2015 Working group meeting & International field symposium

Quaternary Geology and Modern Questions

PROGRAMME & ABSTRACT VOLUME

November, 5 Province House, Assen

The Netherlands | November 2 – 8, 2015 | Utrecht – Assen - Utrecht



Program

Information:

in this guide

in other guide(s)

Mon 2 November - Arrival in Utrecht *icebreaker*

Tue 3 November - Fieldtrip Utrecht – Texel – Assen

Check-out Utrecht Hotel – Check-in Assen Hotel

Visit NIOZ institute. Coastal Stop at Slufter Texel.

Diner at Workum, halfway between Texel and Assen, before check-in

Wed 4 November - Fieldtrip Assen – Drenthe – Assen

Thu 5 November - Conference day Assen

Fri 6 November - Fieldtrip Assen – IJssel – Utrecht

Check-out Assen Hotel – Check-in Utrecht Hotel

Visit Wageningen Univ., glacial and fluvial stops IJssel + Rhine.

Diner at Utrecht, walking distance of hotel, after check-in

Sat 7 November - Visit TNO Geological Survey NL

Sun 8 November - Departure from Utrecht

Lunch and meals are included for Tuesday 3 to Lunch Saturday 7.
i.e.: evenings of Mon 2-11 and Sat 7-11 you care for yourself

Time	What	Who
9:00 – 9:10	**Welcome in Drenthe**	Gjaltema
	Postglacial impact on earth crust, tectonics and hydrology	
9:10 -9:30	Geology, glacial rebound and impact on present landscape functioning	Bregman
9:30 -9:50	New observations of an old fault: preliminary trenching results at the Peelboundary faultzone	Van Balen
9:50 -10:10	Seismicity and Neotectonics in the peri-Baltic region in response tot the glacial loading/de-loading cycle Holocene relative sea-level changes in the Dutch Wadden Sea	Mörner
10:10-10:30	Holocene relative sea-level changes in the Dutch Wadden Sea	Meijles
	Coffee and posters	
	Periglacial Landscapes	
11:00-11:20	Younger Dryas periglacial structures	Dzieduszyńska
11:20-11:40	Pingo remnants – indicators and recorders of Late Weichselian climate and environmental change	Hoek
11:40-12:00	Hondsrug Geopark generates a Pingo Programme in Drenthe, the Netherlands	Verbers
12:00-12:20	Comparison of the Late Weichselian fluvial to aeolian succession between Poland and the Netherlands – similarities and differences	Sokolowski
12:20-12:30	Discussion	
	Lunch	
	Sediments, soil and dating	
13:30-13:50	Lithological properties of glacial sediments in the shallow subsurface of the Northern Netherlands	Harting
13:50-14:10	Perspective of a new cosmogenic (10Be) chronology for the last Scandinavian Ice Sheet recession in Poland – project "DatErr"	Tylmann
14:10-14:30	MIS3 Gleysols and Histols in the nearest periglacial zone of Eastern Europe and Western Siberia: a latitudinal zone of hydromorphic pedogenesis?	Rusakov
14:30-14:50	Catastrophic saltwater inundations in the area of Darlowo (Polish Baltic coast, north Poland)	Piotrowski
14:50-15:00	Discussion	
	Tea and posters	
	Humans in the landscape	
15:30-15:50	An exceptional Middle Palaeolithic site on the Drenthe Plateau (northern Netherlands)	Niekus
15:30-16:10	Šventoji 4 – A key section for understanding environmental conditions and human activities on the SE coast of the Baltic Sea, 6000-2000 cal BC	Vaikutiene
16:10-16:30	The last glaciation in North-western Poland: selected geosites	Relisko-Rybak
16:30-16:50	Geoheritage in Barents Region (Results of ABCGheritage project)	Johansson
16:50-17:00	Discussion	
	Drinks and posters	
18:00	**Diner**	
19:30	**Business meeting**	

INQUA NETHERLANDS
International Union for Quaternary Research

Dear colleagues,

We welcome you all in The Netherlands, the low lands. In the coming days we will share our knowledge about geology, our landscapes and how we connect science to practice in our country. But we also hope to learn from your experience, to hear about new developments in your country and your scientific work. But maybe the main thing is to share friendship as a good basis to start all communication.

We made different guides for the fieldtrip. In every one you will find the program of all days and the daily program with some background information. Separate you will find a booklet about the Geology of The Netherlands, and brochures and some practical stuff.

Our meeting and program was not possible without financial support of the Province of Drenthe and the Dutch Geological Survey. We are grateful for this and the support of people and organizations who will welcome us and will take time to introduce us into their field of working.

Thank you for coming: be warmly welcome!

The organizers,

Kim Cohen

Wim Hoek

Freek Busschers

Enno Bregman

Ronald van Balen

Judith Anneveldt

Lena Smit

INQUA NETHERLANDS
International Union for Quaternary Research

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Abstracts

Oral presentations

Geology, Late Glacial Early Holocene rebound and impact on present landscape functioning, Drenthe, The Netherlands

Bregman, E.P.H.[1,2]*, Smit, F.W.H.[3], Magri, F.[4], Ten Veen, J.[5], Grootjans, A.P.[6,7], Herber, R[6], Elzehawi, S[6], Klootwijk, A.[8], Hoek, W[2], Cohen, K.M.[2,9]

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Keywords: paleaoreconstruction, glacial rebound, differential tectonics, saltdomes, deep- and undeep groundwaterflow, DDC, seepage areas, morphology, peatformation, plantspecies.

Updoming as well as collapse down of Weicselian forbulging caused differential tectonics, landscapeforming processes with impact on morphology as well on the distal and proximal side of the top of the forebulge in the Netherlands and Northwestern Europe[1,2].

Although last (Weichselien) glaciation not reached the Netherlands and North Western Germany we will postulate that the impact of this glaciation on the present landscape and is far more then well known periglacial features which remains in the present landscape, like deposition of coversands and the formation of pingo-ruines. Results of study in one of the key area, the National Park Drentsche Aa show high dynamic impact of Late Glacial Early Holocene differential rebound on morphology and actual landscape forming processes in Drenthe, The Netherlands. These processes had not only a impact on height of glacial deposits and morphology (like river terraces and -patterns). But present (geo)hydrological system, positioning of seepage areas, differentiation of upconing of deep groundwater and even positioning of remains of (thick) peat formations strongly depends on glacial loading and unloading influenced deeper geological structures too. This is the outcome of modeling (2D and 3D). Outcome of hypothesis based on these modeling by Temperature measurements of the groundwater, analyses of macro ions, isotopes and aging confirms the modeling, fits with distributions of (selected) plant species and previous ecological studies[3].

Unraveling of the complex relationship between deep and undeep geology and the thermohaline[4] driven geohydrological system contributes to better insight in the ecological system on the regional, sub-regional and local level. New insights contributes too to a more complete and sustainable mid- and longterm base for nature- and landscape management as well as gives hopefully better insight in potentials for the use of geothermy for heating. Our geological structural 3D model will be the base for further study of geothermal gradients, but also as a base for a multiproxy integration study of subglacial till deposition, loading and tectonics.

Reference:

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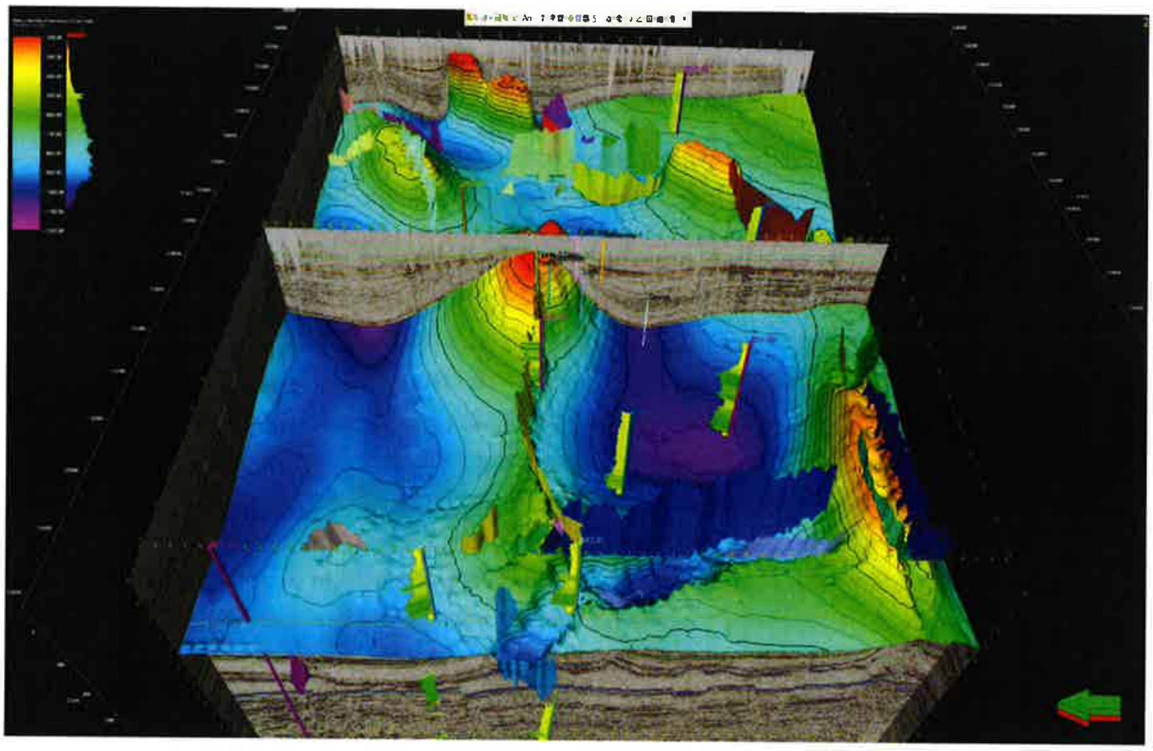
[2] Lehné, R., Sirocko, F., 2007, Rezente Bodenbewegungspotenziale in Schleswig-Holstein (Deutschland) – Ursachen und ihr Einfluss auf die Entwicklung der rezenten Topographie – Z. dt. Ges. Geowiss., 158 (2): 329-347, Stuttgart.

[3] Grootjans, A. P. et al., 2002, Restoration of brook valley meadows in the Netherlands Hydrobiologia, 478, pp.149–170.

[4] Magri, F., 2005, Mechanisms of fluid-dynamics driving saline waters within the North-East German Basin: results from thermohaline numerical simulations. Thesis Freie Universität Berlin



Structural geological elements in the presented study area, looking East. For this study the Anloo diapir (central in the slide)is very important for fluid flow and therefore will be further analyzed . Colered surface is top of Zechstein (red color is near surface). Note the posion of the saltridge of Hooghalen (right wall); note also the mapped faults above the saltdome of Anloo, the Assen graben (frontside, blue wall and faults near the Voorste Diep (on top.) (F.M.Smit & Bregman, in prep)

New observations of an old fault: preliminary trenching results at the Peelboundary Faultzone

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Natural, mild seismicity occurs in the southern Netherlands and adjacent areas. Due to the Roermond earthquake (1992, M_s 5.4, M_l5.8), renewed interest into fault activity, potential magnitudes and recurrence intervals of earthquakes was stimulated. Because of the long recurrence intervals of significant earthquakes, paleo-seismic information is mostly derived from the geological record by means of trenching. A synthesis of the results of such studies showed indications for a period of enhanced fault activity around 15 Ka, possibly related to the process of glacio-isostatic rebound (Houtgast et al., 2005). Last year (2014), a new trench was opened along one of the most important faults in the Netherlands. In this poster we report on the preliminary results.

The trench was made across one of the faults of the Peelboundary faultzone (PBF). The PBF is the northeastern bounding fault system of the Roer Valley Graben (RVG), separating the graben from the adjacent Peel Block. Together, they are part of the Roer Valley Rift System (RVRS), which is an active rift structure in the southern part of the Netherlands and adjacent parts of Belgium and Germany. The current mode of extension of the RVRS started at the Oligocene to Miocene transition and is ongoing (Michon and Van Balen, 2005; Van Balen et al., 2005).

Site selection of the trench was based on regional geology, morphology, augering, and sudden changes in the groundwater level. Faults of the PBF are known to be barriers for horizontal groundwater flow. As a result, groundwater levels are higher at the footwalls, even causing wetlands/swamps at elevated positions in the landscape. Previous research has shown that the reduced horizontal permeability is caused by a combination of factors: clay smearing, juxtaposition, and grain re-orientation. Precipitation of Fe-oxides might play a role at shallow depth levels. At this trench, the groundwater level drop across the fault was nearly 2 meters. The most important faults of the RVRS have fault scarps. A scarp was present at the location of the new trench, however it did not coincide with the change in groundwater level but was created by Medieval aeolian sedimentation.

In the trench evidence was found for one time-period of ~1 m of fault displacement. An intensely convoluted peri-glacial loam is truncated by the near-vertical fault. Faulting was co-eval with the sedimentation of gravelly deposits, which could be the regional Beuningen Gravel bed (BGB; ~18Ka). A Late Glacial soil (Allerød) is apparently non-deformed; it could represent a scarped paleo-landscape. Three clastic dikes were found, indicative of a fluidization event(s). Two small dikes are truncated by the BGB layer. A larger dike intruded along the fault planes, and is only mildly affected by fault displacement. This might imply that two faulting events are recorded in the trench, assuming the fluidization was caused by seismicity.

Houtgast, R.F., R.T. Van Balen, R.T , and C. Kasse, 2005. Late Quaternary tectonic evolution of the Feldbiss Fault. Quaternary Science Reviews 24, 491-510.

Michon, L., Van Balen, R.T. ., 2005. Characterization and quantification of active faulting in the Roer valley rift system based on high precision digital elevation models. Quaternary Science Reviews 24, 457-474.

Van Balen, R.T., R.F. Houtgast and S.A.P.L., Cloetingh, 2005. Neotectonics of the Netherlands. Quaternary Science Reviews 24, 439-454.

Seismicity and Neotectonics in the peri-Baltic region in response to the glacial loading/de-loading cycle

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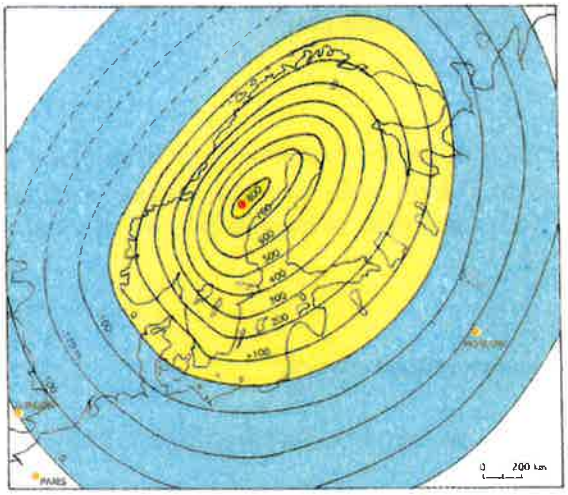
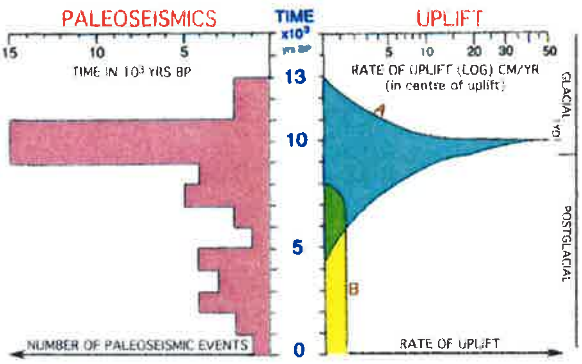
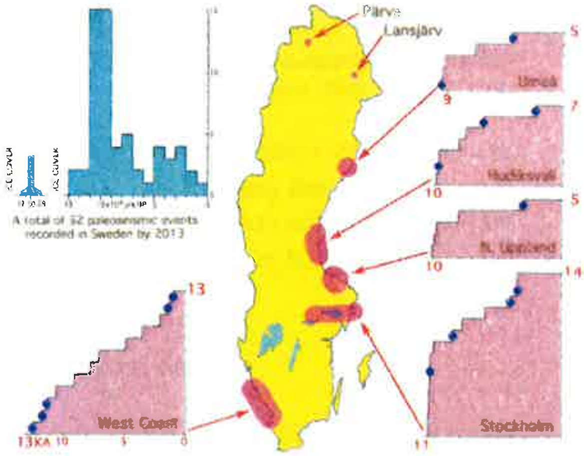
Northwestern Europe was generally held to be a low-seismic region. In the 1970s, it became obvious that some parts had suffered very intensive seismic activity in association with the deglacial period with strong crustal movements as a function of glacial isostatic de-loading. This is not only true for the glaciated parts of uplift but also for the peripheral parts of peripheral subsidence. The notion of a high seismic activity in post-LGM time is important for our interpretation sedimentary structures and landscape morphology. It is also central for our long-term seismic hazard assessments (not least in the case of nuclear waste storage).



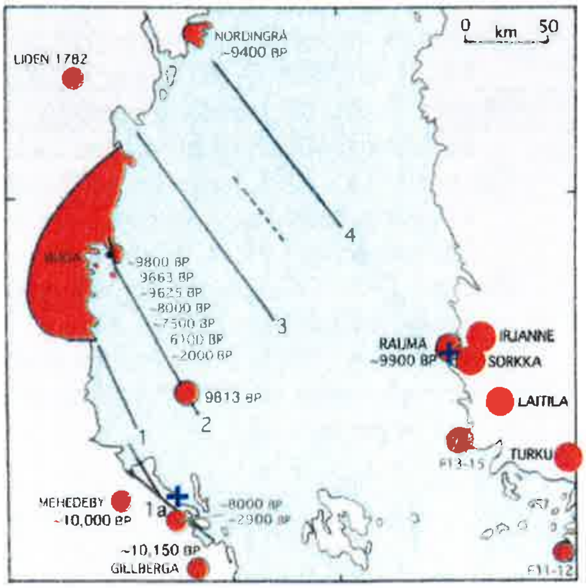
Post-LGM uplift of Fennoscandia (yellow) and subsidence (blue) of the peripheral collapsing forebulge region. The uplift cone was characterized of vertical, radial and tangential extension with peak rates of uplift of ~15-40 cm yr^{-1} = 0.4-1.1 mm day^{-1} and strain rates of 10-24 s^{-1}, i.e. quite remarkable rates almost bound to generate fault reactivation and fault new inducement.



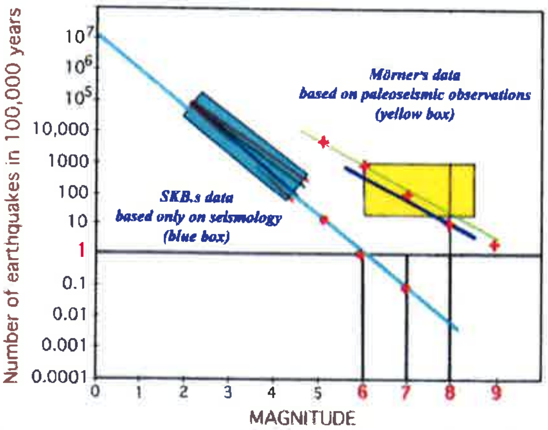
In view of the high rates of glacial isostatic uplift recorded, it is not surprising that there is a good agreement between the changing rates of uplift (right) and the number of paleoseismic events recorded in Sweden (left).



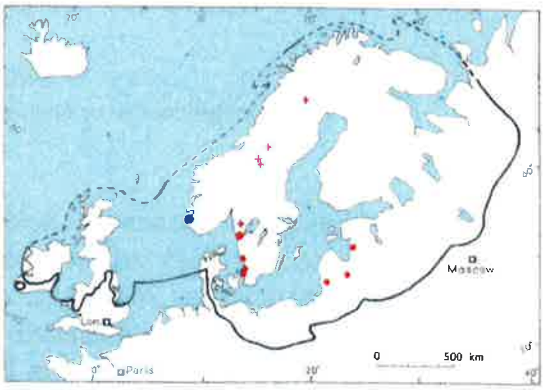
We are even able to identify recurrence diagrams for five areas of Sweden. Blue dots mark tsunami events recorded.



In the region of the nuclear waste storage sites (blue +) in Finland (Olkiluoto) and Sweden (Forsmark) the paleoseismic activity was exceptionally high. This can only be understood by paleoseismic analyses.



In Sweden, the nuclear industry chose to limit their seismic hazard assessment to seismic data (blue: giving an illusive maximum of 1 M 6 event in 100.000 years). A use of available paleoseismic data (yellow box) completely change the picture, which invalidates a "safe" storage in the bedrock.



The finding of multiple sites of paleoseismic activity at around 30.000 BP invalidates the use of loading models for long-term hazard assessment as further discussed in Mörner (2013)

In conclusions, evidences of a higher paleoseismic activity in the past have now been found in the east and south parts of the Baltic, to the south in Poland and Czechian, and in Germany and the North Sea coast, even in the Mid North Sea – and still, in most areas, we are just in the initial phase of paleoseismological studies.

Some selected references to the authors work

Mörner, N.-A., 1985. Paleoseismicity and geodynamics in Sweden, *Tectonophysics*, 117, 139–153.

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Holocene relative sea-level changes in the Dutch Wadden Sea

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Holocene relative sea-level reconstructions provide information relevant to coastal evolution, differential land movements, paleo-landscapes, paleo-ecology and occupational history of coastal areas. To assess future impacts of climate change, regional knowledge of the recent geological past is also required.

Currently there are sea-level curves available for most coastal areas in The Netherlands and bordering regions. There is a long history of sea-level research for the western Netherlands which resulted in a thoroughly tested and reliable sea-level reconstruction. Other well-established curves have been constructed for the southwestern Netherlands, the western coastal plain of Belgium and the inland area of the central Netherlands (Flevo area). For the German Wadden sea region, several curves are available, of which the most recent has received some critical reviews. However, no Holocene relative sea-level curve for the Wadden Sea area in the northern Netherlands is available, although several hypotheses have been put forward as to its position relative to neighbouring curves. Based on a geophysical modelling approach, Kiden *et al.* (2002) posited the Northern Netherlands curve to be lower and steeper than the curves to the south, due to larger postglacial isostatic subsidence in the north. Recent work by Kiden & Vos (in prep.) also points in this direction. This is at variance with Van de Plassche (1982) who, based on a limited number of reliable sea-level index points available at that time, suggested that the Western and Northern Netherlands curves were similar.

Here we present a sea-level reconstruction for the northern Netherlands based on index points from the base of the basal peat. A dataset was compiled from literature and unpublished archive sources comprising all radiocarbon-dated basal peat samples that were taken in the area from 1961 (Jelgersma, 1961) until now. In total, this dataset contains 51 dates of the base of the basal peat. After careful evaluation, 25 samples were selected as reliable sea-level index points and used to create a relative sea-level curve for the Wadden Sea region from 8000 to 500 cal a BP.

The results show that the Wadden Sea curve has a lower and steeper trajectory than the Belgium and Zeeland curves, which may be attributed to a larger postglacial glacio-isostatic subsidence to the north. In the early Holocene, the relative sea level in the northern Netherlands plots below the curve for the western Netherlands. From 7500 cal a BP however, the mean sea-level error bands overlap, suggesting a relative sea level rise similar to the western Netherlands. The Wadden Sea curve tends to be slightly higher from 5300 to 3800 cal a BP, but the error bands of both curves coincide to a great extent and thus we interpret the curves to be not significantly different.

As basal peat may grow well above mean sea level but not much below, the relative sea-level curve for the northern Netherlands presented here should be considered as an upper limit, i.e. sea level may be below it but not (much) above. This may be a possible explanation for the overlap with the western Netherlands sea-level error band since 7500 cal a BP. Not all samples used for this sea-level

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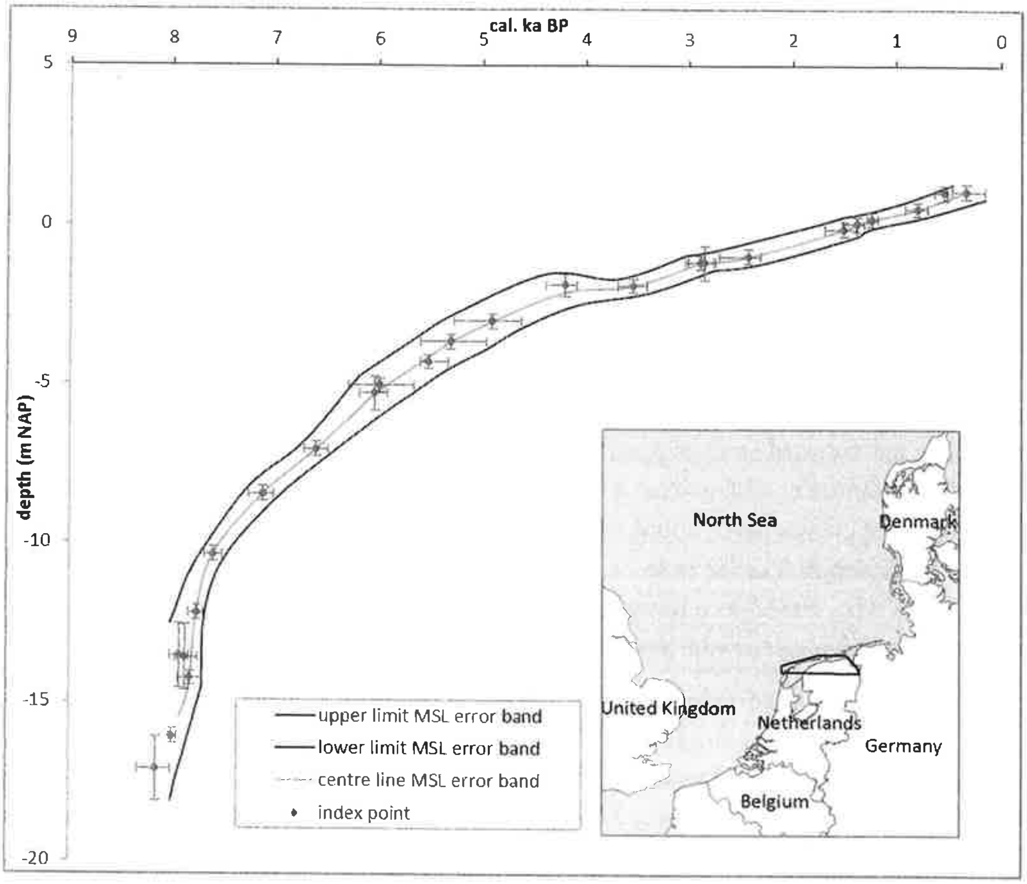
reconstruction were originally meant to be used for sea-level reconstruction. To further analyse the curve's position in respect to curves of neighbouring coastal regions and to further test the validity of the Wadden Sea curve presented here, we suggest to collect additional samples of the base of the basal peat, located at carefully selected sites with a sloping Pleistocene substratum to minimise local groundwater influence on basal peat growth, as suggested by Kiden (1995).

The significance of the Wadden Sea curve with respect to differential patterns of glacio-isostatic rebound during the Holocene remains to be studied in more detail. The relatively small vertical differences through time between the Wadden Sea and western Netherlands curves, if real, may suggest that the position of the zone of maximum postglacial subsidence might extend further south than previously expected.



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- Kiden P, Denys L, Johnston P. 2002. Late Quaternary sea-level change and isostatic and tectonic land movements along the Belgian–Dutch North Sea coast: geological data and model results. Journal of Quaternary Science 17 (5-6): 535–546. DOI: 10.1002/jqs.709.
- Van de Plassche O. 1982. Sea-level change and water-level movements in the Netherlands during the Holocene. Mededelingen Rijks Geologische Dienst 36 (1): 1-93.

Younger Dryas periglacial structures

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The Younger Dryas cooling, ending the Lateglacial, in Central Poland is distinguished by a significant decrease in temperature, especially of the coldest month, decrease of humidity and changes in vegetation towards opening of forest communities. During this period, with near glacial conditions (Björck et al. 1998), a remodelling of Weichselian periglacial realm into temperate was stopped for ca. 1100 years. Climatic and biotic disturbances caused activation of morphogenetic processes in various sedimentary environments. Some of these processes might have been promoted by the reactivation of permafrost, at least of a sporadic or discontinuous nature.

In Central Poland, similar to the Northwestern European territory, final permafrost degradation occurred in the Alleröd. The return of permafrost in response to the Younger Dryas cooling is commonly suggested by the investigators, however direct evidences are scarce. The question arises whether the effect of cooling was not too small to cause the re-establishment of the permafrost. So far, only from the Bełchatów brown coal outcrop, epigenetic ice wedge casts of Younger Dryas age were reported by Kasse et al. (1998). Most probably the presence of the frost structures is either a proof of seasonal frost or/also due to specific local conditions. Permafrost conditions may be inferred from involutions (cryoturbations after Vandenberghe 1988); however it should be remembered that they are not conclusive indicators of frozen ground (Kasse 1999).

The area of the present study is situated in the old morainic area, in central section of the valley of the Warta River. The fluvial history of the Weichselian indicates prevailing its aggradation tendencies (Petera 2002). In the Alleröd/Younger Dryas transition, the stable conditions on the floodplain resulted in the deposition of organic series of a thickness of up to 50 cm. The accumulation of this series is radiocarbon dated at ca. 12,900-11,600 cal BP. The series is underlain with the thick sandy deposits. At the boundary between these units at a depth of 2-2.5 m, a range of deformation structures was registered. Among them are: load casts, including drop-like and flat-bottomed structures, cryohydrostatic pressure involutions and frost cracks, which originated in the active layer during the Younger Dryas. Most involutions are relatively regular, symmetrical of amplitudes generally of about 20-30 cm; locally irregular structures are present as well. According to Vandenberghe (1988) they belong to type 3a and type 6.

The load cast structures are represented by a system of regular folds or pocket-like structures, which in many places became drop-like structures. The mature stadium of that kind of deformations has a form of flat-bottomed structures. Loading of organic-mineral series into sandy deposits was possible thanks to oversaturation of the active layer of permafrost. Vandenbreghe (1988) pointed that the most prominent circumstances appear during the permafrost degradation. From palaeogeographical point of view the most important are flat-bottomed structures, which could developed downward up to a solid bottom of the active layer.

The cryohydrostatic pressure involutions have a form of diapirs, which appear either as single structures or in groups – in that case they take form of irregular involutions. Cryohydrostatic pressure developed in the active layer between two fronts of freezing at the beginning of winters and are results of injection of sediment, even if the sediment has very low plastic and liquid limit.

The frost cracks documented in study area are very thin and 1 to 1,5 m deep. In the lower part the finger-like structures are visible, which suggests that fissures existed more than one season. The permafrost is not necessarily to form frost cracks; deep seasonal freezing is sufficient, but in this case the important indicator of periglacial environment are finger-like structures.

Indirect evidence of the frozen ground presence is provided from the study on the functioning and destruction of the riparian forest at the Younger Dryas beginning carried out at Koźmin Las site. The well-preserved remains of pine and birch trees (trunks, in situ stumps with lateral root systems) stand on the previously described organic series. The multiproxy studies indicate that forest grew in unfavourable weather conditions (narrow-ringed wood, reactionary wood). There are hints to conclude that trees lost their stability in effect of boggy substratum caused by an increase of groundwater level over the active layer of the reactivated permafrost (Dzieduszyńska et al. 2014).

The development of deformation structures in the terrace deposits of the Warta River and the history of the riparian forest were determined by the climate, but also significant was lithology. The organic layer, locally with peat, could hamper thawing of frozen ground and thereby facilitate periglacial events.

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Pingo remnants – indicators and recorders of Late Weichselian climate and environmental change

Wim Z. Hoek and many others

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Pingos are known from present day permafrost regions in Alaska, Canada and Siberia and occur under permafrost conditions with sufficient groundwater, leading to the formation of ice lenses in the sub-surface. In the Netherlands, the remains of hundreds of pingos have been recognised over the last decades, especially in the Province of Drenthe. These pingos presumably originated as a result of hydrostatic pressure, under conditions of discontinuous permafrost during the Weichselian Pleniglacial (GS-2). As temperature rose at the onset of the Lateglacial interstadial (GI-1, round ca. 12,500 ^{14}C BP or 14,700 cal BP), permafrost most likely started to disappear from that time onward resulting in the development of pingo remnants – isolated depressions with or without a rampart.

The presence of these pingo remnants with a diameter of 50 to 300 meters and in depth varying between 5 meters in the southern Netherlands to 20 meters in the northern Netherlands indicates a minimum thickness of permafrost in the order of those values. Melting of the permafrost layer, which was several meters thick, presumably lasted hundreds of years. Implications for the disappearance of permafrost during the Lateglacial in The Netherlands are given by the basal organic infilling of pingo remnants, dated to begin between 12,500 and 12,300 ^{14}C BP. The fills of the pingo remnants in the Netherlands form a unique record of environmental change since the last deglaciation containing for instance plant macro-fossils, pollen, chironomids, aeolian sand, tephra. Some of these depressions are filled with calcareous gyttja, implying that hydrostatic pressure and groundwater exfiltration continued after the decay of the ice-body. Within the isolated lakes clear water level changes occurred which can be used to reconstruct changes in effective precipitation. The pingo remnant fills can be regarded as an environmental history record in which also archaeological information has been stored.

Recent studies with MSc students in Germany and Denmark indicate that similar pingo remnants also occur in these regions, though not in such high amounts as in the Province of Drenthe.

A PINGO PROGRAM IN DRENTHE, THE NETHERLANDS

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A pingo is a permafrost landform, an earth-covered ice hill formed by an ice lens that pushes the overlaying sediment upwards while growing. After climate change the ice lens melts and the sediment slides mainly side wards. Thus a remnant of the formed ice hill and sediment is formed: a circular depression surrounded by a rim.
In the present time the northern part of the Netherlands covers the biggest amount and concentration of pingo remnants in Europe and they form an important part of the glacial landscape scenery.
Until today most pingo remnants have got open water and most of them have got Late Glacial – Holocene infillings of lake sediments and peat which strongly reflect environmental conditions of the past and the present. They are valuable for earth- and nature science and most of them have got ecological, archeological and cultural values. Anthropogenic impact already started in Mesolithic and Neolithic times. Later on they were used for washing sheep and many people in northern Netherlands learned swimming and skating in pingo remnants nearby their villages.
Despite all the values pingo remnants are not recognized as such. In general they are poorly studied and get minor attention in landscape- and nature education and landscape management. Exposure for tourists fails and thus also chances to tell a unique attractive story to visitors of the province of Drenthe and therefor also at Hondsrug Geopark. An exception is the pingo remnant 'Mekelermeer', which has been well studied recently and is a geological monument since the first of October this year.
In order to get more awareness and better management an integrated approach is initiated by the Geopark organization together with the province of Drenthe, landscape- and nature organizations and the Universities of Utrecht and Groningen. The first outline of this approach, the Pingo Program Drenthe, will be presented at the conference. We will focus on the way we integrate several fields of interest to an integral plan and will zoom in at the Hondsrug Geopark as a showcase how to work out the Pingo Program on a regional level.

Comparison of the Late Weichselian fluvial to aeolian succession between Poland and the Netherlands - similarities and differences

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The succession of sediments representing the evolution of the depositional systems from fluvial to aeolian is a common finding in western and central Europe. The classic sequence has been described primarily in the profiles from the Netherlands, where the lithostratigraphic and temporal scheme comes from (Vandenberghe et al., 2013, and the works cited therein). This succession is generally tripartite. It starts with fluvial deposits, transiting into fluvio-aeolian deposits. The upper part of the succession is formed of aeolian deposits of sand covers and/or dunes.

The researches on the fluvial to aeolian succession carried out since the beginning of the 1990s on Poland's territory have shown a similar pattern of the facies succession (Bohncke et al., 1995). This allowed the correlation of the profiles of the Netherlands and Poland. These findings prompted the conclusion regarding a very similar nature and course of the sedimentation processes at the turn of the Late Weichselian.

In recent years the researches on the fluvial to aeolian succession have been undertaken in the area of Poland and western Ukraine. They showed similar (tripartite) development of the deposits compared to outcrops in the Netherlands. In the profiles exposed in the river valleys the lower unit of the succession is built of fluvial sediments, resulting mostly in an environment of sand-bed braided river in the conditions of continuous permafrost. Its central section is formed of fluvio-aeolian deposits with an increase of aeolian components and incidental flows. Their bottom border is usually of the erosion type, occasionally underlined by a deflationary pavement. The top of the middle unit is usually a tundra-gley fossil soil. The uppermost segment of the succession consists of two series of aeolian sediments (sand cover and/or dunes), separated by a level of initial podzolic soil (Usselo type) or colluvial soil.

Dating of the sediments age by different methods (TL, OSL OSL IR, ^{14}C) conducted in several profiles showed significant differences in the stratigraphic position of the deposits of the fluvio to aeolian succession in Poland and western Ukraine (Zieliński et al., 2015 and works cited therein). This applies particularly to the end of the deposition of the lower (fluvial) and central (fluvio-aeolian) units of the succession. Some of these differences result from local conditions of the depositional processes at different sites (valley size, orientation of the valley axis). However, compared to the results obtained from the Netherlands, a few differences can be noted: (i) deposition of the fluvial unit lasted longer, up to about 16-14 ka; (ii) erosion surface between the lower and middle succession unit (17-15 ka) - correlated with the Beuningen Gravel Bed - is younger; (iii) deposition of the fluvio-aeolian unit started later and lasted shorter, and locally the permafrost cover still existed during its deposition; (iv) permafrost degradation in the area of Poland and western Ukraine took place later by about 4 ka.

Similarities in the development of the fluvial to aeolian succession indicate a similar scheme and succession of depositional processes. In contrast, differences in the timeline mainly stem from a different course of climate change and the degree of climate continentalism.

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Lithological properties of glacial sediments in the shallow subsurface of the Northern Netherlands

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The Dutch shallow subsurface is extensively being used for natural aggregate resources, groundwater extraction and construction works. This makes that insights into the composition and heterogeneity of the subsurface and its physical and chemical properties are of vital importance for Dutch society (Vernes *et al.* 2010, Van de Meulen *et al.* 2013). Although a large amount of physical and chemical data of the subsurface has been collected in the past, issues like discontinuous sample distributions and/or differences in analysis techniques, have limited their helpfulness for applied research (Harting *et al. 2014*).

We present new results from an analysis of a vast nation-wide data set of lithological properties from the shallow subsurface of the Northern Netherlands that were collected, measured and analysed in a systematic and uniform way (Bosch *et al.* 2015). The dataset, which is managed by the Geological Survey of the Netherlands, contains a large number of parameters that were collected from undisturbed sediments taken from 75 continuous boreholes with a depth up-to 40m. Since the cores have an excellent geographical distribution and the samples are measured on *in situ* samples with a standard set of techniques, the data overcomes the data density and measurement inconsistencies known from previous studies.

In this presentation we will focus on the lithological properties of the Boxtel, Drente, Drachten and Peelo Formations in the northern Netherlands that were deposited under periglacial, glacial, eolian and glacial to glacio-lacustrine conditions respectively. We found that Weichselian (Boxtel Fm.) and early Saalian (Drachten Fm.) eolian sediments are nearly identical, suggesting comparable sedimentary processes during deposition. In several cores we newly identified a Elsterian till belonging to the Peelo Formation, which is very different from the Saalian till belonging to the Gieten Member of the Drente Formation. This difference may be related to the sediment sources available during formation of the till. Finally, we describe a new type of bedded till from the Saalian Gieten Member, strongly contrasting with the well-known massive till.
With these examples, we show that using our lithofacies based approach (Harting *et al. 2014*) is a strong and powerful tool to study and better understand heterogeneity in these sediments (Bosch *et al.* 2015).

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Perspective of a new cosmogenic (^{10}Be) chronology for the last Scandinavian Ice Sheet recession in Poland – project "DatErr"

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Terrestrial cosmogenic nuclide dating (TCND) has been successfully used for direct dating of the last SIS recession, providing valuable data for the chronology of late Pleistocene glacial phases in Europe. However, the decay of the last SIS`s southern sector is still a matter of debate, including its absolute time frame, dynamics of ice-margin fluctuations and style of deglaciation. We suggest that North Western (NW) Poland is the key region to resolve this issues. Project "DatErr" will provide a new set of ^{10}Be ages that bridges the existing gap between the records available further west and east (Fig. 1). The exciting perspective to build a comprehensive chronology for the demise of the SIS along its entire southern margin will allow us to understand its dynamic with respect to readily available paleoclimate records.

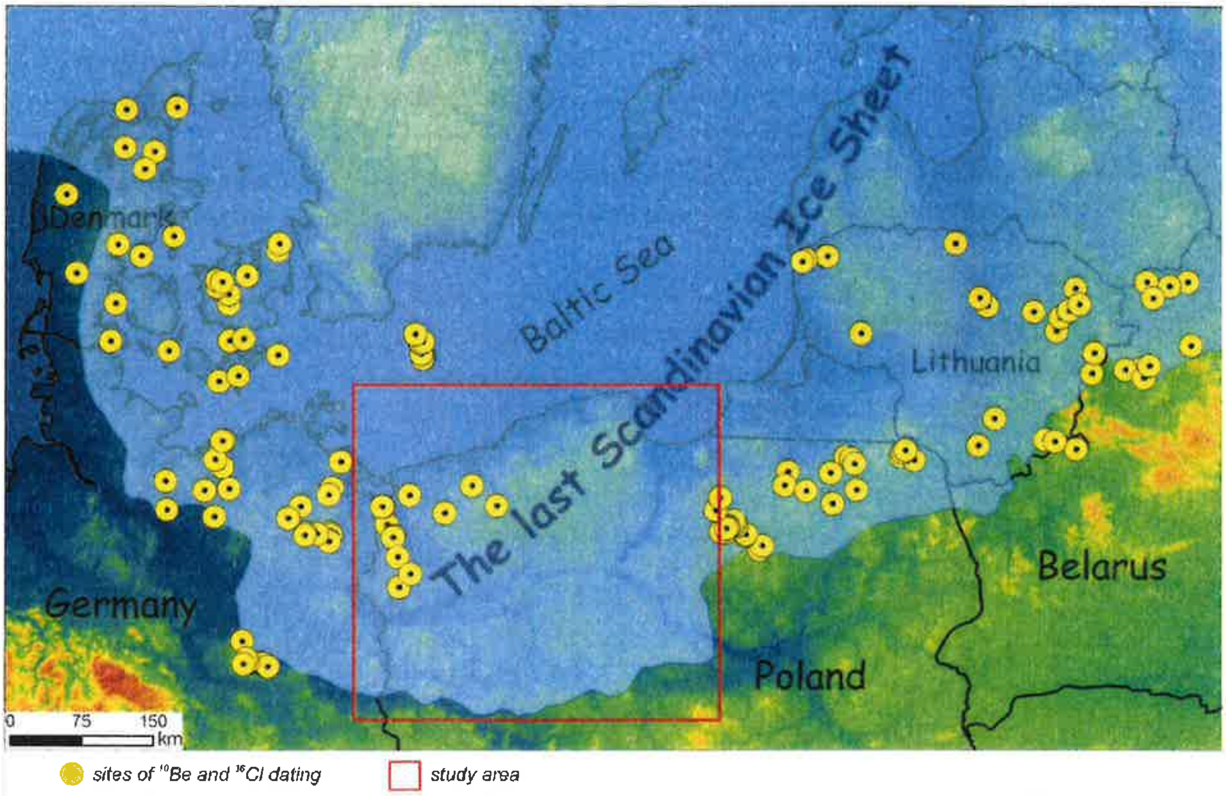

Fig. 1. Surface exposure ages (^{10}Be and ^{36}Cl) of erratic boulders and bedrock available for the southern front of the last Scandinavian Ice Sheet (Dzierżek & Zreda 2007, Houmark-Nielsen et al. 2012, Rinterknecht et al. 2005, 2007, 2008, 2012, 2014) and study area of "DatErr" project.

"DatErr" focuses on the recession of the last SIS in NW Poland and erratic boulders resting in-situ on moraine surfaces. Seventy large, well preserved boulders were selected for investigation. The project covers marginal belts in NW Poland correlated with successive glacial phases of the late Weichselian (Brandenburg, Frankfurt, Pomeranian and Gardno). Cosmogenic nuclide ^{10}Be dating of these erratics will lead to constructing a robust chronology of paleo ice-sheet retreat. During the Late Weichselian NW Poland was covered by a significant part of the southern sector of the last SIS that responded but also influenced the Late Pleistocene climate. Direct dating of the SIS retreat in NW Poland and compilation of a new ^{10}Be dataset with existing geochronological data for this part of the last SIS will allow to reconstruct the past ice sheet dynamics with respect to climate variations.

Our research will result in: (1) the first direct dating of the last SIS maximum extent in Poland, (2) getting the first surface exposure ages of Poznań (Frankfurt) Phase of the last SIS recession in NW Poland, (3) the first complete ^{10}Be chronology of the last SIS recession from the local Last Glacial Maximum to the final deglaciation of NW Poland, (4) bridging the gap between the "western" and the "eastern" Peribaltic regions in terms of surface exposure ages of the last SIS recession.

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MIS3 Gleysols and Histosols in the nearest periglacial zone of Eastern Europe and Western Siberia: a latitudinal zone of hydromorphic pedogenesis?

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The MIS3 paleosol units comprise a prominent element of the loess-paleosol sequences throughout the Eurasian Loess Belt. To the north of the loess regions the findings of MIS3 paleosols were few: it was supposed that geomorphic processes related to the extensive ice cover of the LGM destroyed the earlier soil mantle. Recently much smaller extent of continental ice in the east of Northern Europe and ice-free West Siberian Plain during MIS2 has been hypothesized, supposing preservation of MIS3 and earlier paleopedological records.
We discovered in the center-north of European Russia (56.7°–58.5° N, the Upper Volga basin) and Western Siberia (Middle Ob basin) MIS3 paleosols within the Late Pleistocene sedimentary sequences.

The paleosols studied in the northern central European Russia are developed within nearest periglacial zone of East European Plain (the Upper Volga River basin). These paleosols are strongly formed: 1) on Moscowian (Riss II) moraine or moraine-like deposits and 2) on ancient (Riss II) lake clayey sediments. The buried profiles are represented by system of horizons Agb-Gb, Hb-Gb(Ghb); pedocomplex consisted of: 1) the paleohumus and paleogley (2Atgb-2Gtb-3Atgb) and 2) paleohumus (3Atgb-3AtGb) horizons. These pedostratigraphical units were classified as the Umbric Gley and Histosols. The14C age of the paleosol humus and peat horizons varied between 46,700–24,350 yr BP thus corresponding to the second half of MIS3.

In Western Siberia paleosols were studied in the upper reach of the right-hand tributary of the Middle Ob' river, that is the Sabun-Vakh River system. The recent soil on the surface is a well-developed Podzol formed on the sandy alluvial sediments. The first buried paleosol level was encountered at a depth of about 4 m on the parent substrate of a half-meter thickness with alternating clayey, loamy and sandy-loamy layers. It consists of a grey strongly gleyed horizon formed in such a mostly loamy stratum underlain and overlain by sandy sediments. The calibrated radiocarbon age of this paleosol is 25,000–27,000 Cal. Yr. BP. In other sites of the Vakh River system, several other paleosol levels were found in the middle and basal parts of that terrace correspondingly. It also formed in loamy sediments and strongly gleyed, its profile consists of well developed dark-grey A horizon and bluish-grey G horizon. The radiocarbon dating of humus from this paleosol produced a date older than the lower limit of the method; anyway the calculated radiocarbon age of those paleosols is more than 40,000 Cal. Yr. BP. All paleosols were defined as Gleysols.

Although located far away from each other, the paleosols of the Upper Volga and Middle Ob basins demonstrate clear similarities: they are represented by hydromorphic profiles with Histic horizons and gleyic colour pattern. Conspicuously they are developed in the well drained geomorphic positions, where modern soils are non-gleyic; to our opinion, permafrost could be responsible for blocking of percolation and water logging. We reconstruct a northern zone of MIS3 Gleysols and Histosols different from synchronous Cambisols and Chernozems formed within loess sequences to the south.

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Catastrophic saltwater inundations in the area of Darłowo (Polish Baltic coast, north Poland)

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There are records of unusual catastrophic events in the chronicles: "The Baltic Sea holds its own weather, which has no connection with the weather on land. Sometimes a submarine storm occurs in the Baltic Sea. Under a clear and calm sky, thunder can be heard rolling along the Pomeranian coast, and dead or half-dead marine or coastal fish are thrown onto land. The local people call that phenomenon the Sea Bear (Seebaer)" (Brüeggemann, 1779).

In this paper we present the first results of the geological investigation carried out along a 10 km section of the Southern Baltic coast near Darłowo, Poland (Fig. 1), where two historical catastrophic saltwater inundations (CSI) events were recorded on the 8th of September in 1497 and the 1st of March in 1779. The aim of the study was to verify historical information about peculiar waves at the Southern Baltic coast.
The first stage of the research was focused on finding potential CSI layers and identifying their inland extent, morphology and thickness. As Morton et al. (2007) indicated, these features can serve as criteria to distinguish CSI layers related to tsunami events from storm deposits. Two sand layers separated by a very thin bed of peat were found near Darłowo. The boundary between them is clearly defined by organic deposits (peat), while the organic deposits below the lower layer are underlain by lacustrine silts. ^{14}C dating of samples taken from the organic deposits underlying both layers confirmed that they are related to the CSI events from the 15th and 18th centuries.

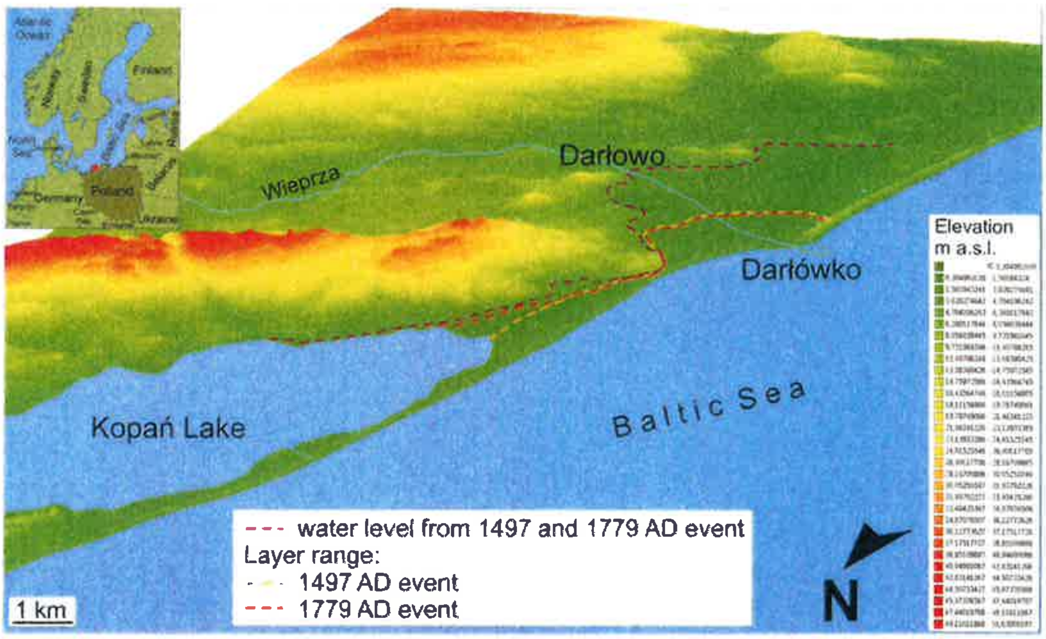

Fig. 1 Water level and layer range from CSI events in the study area.

Their morphology follows the palaeotopography. The maximum inland extent of the lower layer is 700 m, while the upper one stretches up to 400 m from the coast (Fig. 1). Their thickness varies from several centimetres to 40 cm (average of 20 cm). Historical maps indicate gradual coastal recession during the recent centuries, and the primary extent of the CSI layers has been estimated to be 150 to 490 m greater. At some sampling points, several factors made it difficult to identify the CSI layers, their inland extent and thickness: the accumulation of CSI deposits in the lake environment and on sandy deposits; later aeolian processes; precipitation of Fe and Mn compounds related to groundwater fluctuations; plant roots; compaction of the underlying deposits; agricultural activities; and mass movement processes.

Acknowledgements:
The research was funded by the National Science Centre, Poland (project No. ST10/07220).

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An exceptional Middle Palaeolithic site on the Drenthe Plateau (northern Netherlands)

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Introduction

In 2007 a very important Late Middle Palaeolithic site was discovered in the northern Netherlands, not far from the city of Assen, the capital of the province of Drenthe (Niekus *et al.* 2011). The open-air site is located on the Saalian till plateau and was discovered during systematic field surveys by students and (amateur) archaeologists. In total the site has until the summer of 2015 produced little over 450 artefacts. It is, therefore, by far the largest site postdating the Saalian glaciation (MIS 6) in the northern part of the country. Over the years most artefacts were found scattered over an area measuring approximately 40 x 30 meters but recently a second concentration was discovered, approximately 500 meters from the main concentration. Other finds, including isolated bifaces or handaxes and Levallois-cores are known from the wider area. Another important Middle Palaeolithic site is located in the same valley, a few kilometres to the southeast. At the latter site several preforms of Mauern-type leafpoints were found, testifying to the presence of a group of Late Neanderthals during the Middle Pleniglacial (Stapert *et al.* in press).

Excavation

In 2011 a trial excavation was carried out at the main artefact concentration. For the first time in northwestern Europe Middle Palaeolithic artefacts were found *in situ* in boulder sand, the erosional residue of glacial till. The finds comprise flakes, blades, cores and retouched tools. The latter category consists predominantly of handaxes, but a few side-scrapers and backed knives are also present. Apart from locally available erratic Baltic flint, of which most artefacts are made, raw materials include quartzitic sandstone, quartzite and, remarkably, *hälleflinta* ('rock-flint'). Before 2011 there were only three handaxes made from this raw material known from the Netherlands. The 'Assen' site has produced several dozen artefacts of *hälleflinta*, including a few backed knives and handaxe thinning flakes. One of the reasons for Neanderthals to frequent this location, which is situated near a stream valley close to the confluence with a small tributary, might be the presence of relatively good quality flint nodules and fairly large slabs of *hälleflinta* (Niekus *et al.* 2015). Besides 'Assen' there is only one other Middle Palaeolithic site in northwestern Europe where this raw material was knapped.

Activities

The assemblage is also exceptional because of the many handaxes that dominate the tool spectrum, leading us to suggest that butchering activities played a major role in the formation of the assemblage. The tip of some of the handaxes is missing, probably as result of use. Several *refits* point not only to on site knapping of flint and *hälleflinta* but also to the finishing and/or resharpening of handaxes. An interesting aspect of the site is the presence of at least five small 'handaxes' and several cores which were worked in an inadequate way. These pieces show a lot of steps and hinges, too deep scars, etc. Moreover, they are in most cases too small to have been of any use. Our interpretation is that these are workpieces left behind by one or two apprentices in the art of flintworking, i.e. children.

One of the handaxes found during the excavation in 2011. It is a (sub)triangular specimen with a bifacially worked cutting base. The tip is missing, most probably as a result of butchering. Note the small resharpening flake that fits to the handaxe (right). Photo: F. de Vries (ToonBeeld/Stiens).

Dating

'Assen' is one of the northernmost Middle Palaeolithic occurrences in the Netherlands, as well as in Europe, and most likely dates to MIS 3 or MIS 5a/5c of the Weichselian. The presence of many relatively small (sub)cordiform and (sub)triangular handaxes indicates a cultural affiliation with the Mousterian of Acheulian Tradition, Type A. The site is situated near the northern limit of the occupation range of Middle Palaeolithic hominins, and the lithic assemblage is comparable to that from several other sites in the northern part of the North European Plain. The 'Assen' site is a small yet significant step forward in understanding the different strategies employed by hominins in the exploitation of these northern territories.

Future prospects

Presently plans are being developed for a full excavation of the main concentration since the find layer is in severe danger of destruction by agricultural activities. The recently discovered second concentration, which consists mainly of cores and flakes and probably represents a location for flintworking instead of butchering, will also be the subject of further investigation. It is not sure (yet) if both concentrations are contemporaneous. Last but not least a coring campaign followed by a trench in the stream valley is needed to search for organic occupation debris.

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Šventoji 4 – a key section for understanding environmental conditions and human activities on the SE coast of the Baltic Sea, 6000-2000 cal. BC

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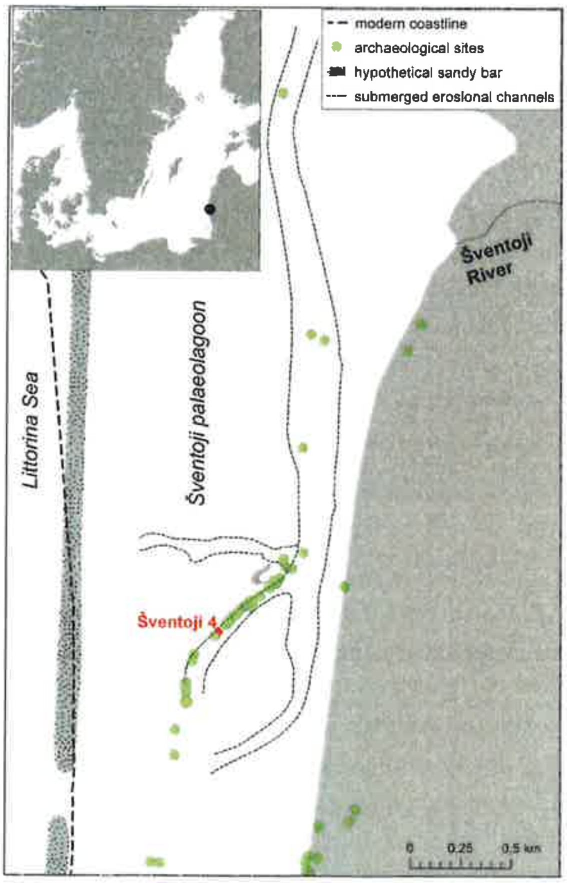

Fig. 1. Site Šventoji 4 and reconstruction of the eastern Littorina Sea coast.

The Šventoji archaeological complex, NW Lithuania, is famous due to wetland sites, which usually produce astonishing pieces of every day and ritual life, propose very favorable perspectives for interdisciplinary paleoenvironmental studies. Today Šventoji is one of the best archaeologically investigated areas in Lithuania. Šventoji sites are situated on the banks, littoral parts and beds of former lagoons, lakes, erosional channels and rivers Fig. 1). These sites are interpreted as dwelling zones, amber workshops, refuse layers and fishing stations (Rimantienė 2005; Piličiauskas et al., 2012).

Site Šventoji 4 is special because of the large amount of fishing equipment and other human waste deposited within mainly freshwater sediments/gyttja. In 2014 a trench 18 m in thick and 2 m in width has been investigated as a part of archaeological project 'Neolithisation of coastal Lithuania'. Three cultural layers are thoroughly registered during excavations as well as 223 wooden and 123 ceramic artefacts, 17 mammal and bird bones. Many burnt water chestnuts and hazelnuts are recovered as well.

Finally, thousands of fish bones and teeth have been wet sieved through 1 mm mesh sieves. Sediment sequence of 3 m in thickness is dated by 15 AMS dates, ten samples analyzed for diatoms, nine–for plant macro-remains. In addition molluscs and all wooden artefacts have been identified. The idea of this multidisciplinary study is to understand better both the Baltic Sea paleogeography and cultural development, to find out new information about changing coastal landscapes and human response to them.

A profile of archaeological trench of 2014's provides a basement for a further research and findings. Šventoji 4 section is of key importance for understanding cultural and economical development of coastal people during the transitional period from the Subneolithic to the Neolithic. At the same time the section research provides a valuable data on ancient landscapes, which has already been used in refining curve of relative sea level changes for the southeastern Baltic (Piličiauskas et al., 2015). Until ~5500 cal BC an investigated area probably was a dryland covered by forests and bogs. However, ancient palaeosoil has been eroded during maximal transgression of Littorina Sea. This period is reflected by fine sand at the bottommost part of the profile and muddy sand above it with remains of molluscs *Macoma balthica, Cardium edule, Mytilus edulis.* Littorina Sea regression started 4750–4500 cal BC in the eastern part of the recent Baltic Sea. Shallow bay emerged and one meter thick of banded muddy sand and gyttja with plant remains have been deposited in the investigated area. Prevailing freshwater–brackish benthic diatoms (*Epithemia turgida, E. adnata*) indicate mainly freshwater, shallow, calm sedimentary environment. A few percent of brackish benthic *Diploneis smithii* f. *rhombica, Campylodiscus clypeus* diatoms mean that this bay had connection with the sea and existed small brackish water inflow. It well coincides with plant macrofossil data. The species of shallow-water habitats are dominating among macrophytes. Some of them are halophytes (*Ruppia maritima, Salicornia europaea*), which spread in the brackish water bodies or marshes in coastal areas.

It is highly probable that during Littorina regression sea coast retreated till a modern coastline or even more westward. Then, somewhere around 3400 cal BC a channel 50–250 m in width, not less than 4 km in length and up to 3 m in depth has been suddenly sculptured within lagoonal and marine sediments by mighty flow of water. Most likely it was caused by an abrupt drainage of the large lagoonal lake, which has been formed above Littorina Sea level because of ongoing post–glacial movement in the earth's crust. There are almost no alluvial deposits left by this event with exception of thin and discontinuous gravel interlayer, intruded in–between marine sand and lacustrine gyttja. Very soon after then, probably Littorina Sea transgression started again and accumulation of mainly freshwater gyttja started within erosional channel as well as on it's banks, because sea level was high enough to cover them also. An age–depth model has been compiled for a gyttja 2 meters thick with an assumption of a constant sedimentation rate. According to it gyttja sedimentation took place around 800 years, 3290/3130–2490/2370 cal BC. *Trapa natans* as well as *Bithynia tentaculata, Sphaerium solidum* and *Unio sp.* are indicators of a shallow and warm freshwater basin, while few lenses of coarse or gravely sand imbedded within a lower part of gyttja points to occasional flows. Predominant freshwater–brackish plaktonic (*Aulacoseira ambigua, A. granulata*) and epiphytic (*Frafilaia brevistiata*) diatoms confirm shallow almost freshwater sedimentary environment. Fresh water inflow prevailed in to the lake, but small amount of brackish benthic diatoms in the sediments indicate permanent although insignificant inflows of brackish water from the sea. All halophytes disappeared from macroflora. *Nymphaea alba, Najas marina* and *Potamogeton perfoliatus* prevailed among water plants. At the same time plants of shores (*Typha latifolia, Schoenoplectus lacustris*) and plants of dampish nutrient rich habitats (*Urtica dioica, Persicaria lapathifolia*) started to spread. It is possible that small muddy islands existed in the shallow littoral. Littorina Sea regression (till 0.4 m b.s.l.) started around 2400 cal BC and the lake was abruptly and totally drained. After than peat layer formation started in the area of the former lake.

Three cultural layers have been distinguished within gyttja dated to 3110/3000–2700/2620 cal BC. Lowermost two layers belong to the Subneolithic (pointed bottom vessels) while the uppermost–to the Neolithic (Globular Amphora Culture vessels). The most intriguing is a gap of 200 years (3020/2930–2800/2720 cal BC) between the oldest and the middle one, which has been detected here and also at the other sites in Šventoji. No signs of any dramatic environmental change are known for this period. Therefore, a pause in fishing activities could be caused by destructive impact (war or deceases) of Corded Ware Culture (CWC) stock breeders to local fishermen and seal hunters. First wave of CWC is dated to 2900–2800 cal BC in the Eastern Baltic. Freshwater fish, i.e. cyprinids (*Cyprinidae*), pike (*Esox lucius*) and pikeperch (*Sander lucioperca*) clearly prevails among zooarchaeological material of each cultural layer. Seals (*Phocidae*) are represented as well. Pine laths (up to 2–2.5 m long) were used as the main building material for stationary fishing gear. However, poles and stakes have been made mostly of hazel (*Corylus*).

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The last glaciation in North-western Poland: selected geosites

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In 2009, the Polish Geological Institute – National Research Institute (PGI-NRI) established the Central Repository of Geosites in Poland (CRGP), a popular science service maintained to promote preservation of the geological heritage of Poland. It operates as a part of the Central Geological Database coordinated by PGI-NRI, and includes information gathered in the field by PGI as well as by other public and private organizations.

Currently, the online database contains over 3700 sites spread across Poland. The sites were added by PGI in two phases: 1500 sites between 2009 and 2012 and 1350 between 2012 and 2014. The remaining sites were included by external organisations. The geosites are divided into nine categories: sedimentary landforms, denudation forms, natural and man-made exposures, historical mining sites, places of special interest due to accumulation of fossils as well as minerals and rocks, hydrographical forms and others. Since 2015, information collected in the database during the first phase has been verified and updated.

There are unique sites in Northwestern Poland (Fig. 1), where the Weichselian ice sheet reached its southern most point, leaving a large variety of landforms and features. Thus, the major group of geotourism points are moraine margins, ice-marginal valleys, glacial sedimentary and denudation forms, erratics, glacitectonic structures and historical mining sites.

In Northwestern Poland, natural (such as coastal cliffs) and man-made exposures not only document the complexity of depositional processes in glacial environments but also show their scale. They reveal, for example, glacitectonic processes which deformed glacial deposits and in some locations pushed Cretaceous chalk, Miocene lignite and Oligocene clay to the surface. Many of them were extensively mined from the mid 19th century (Figs. 2 and 3).

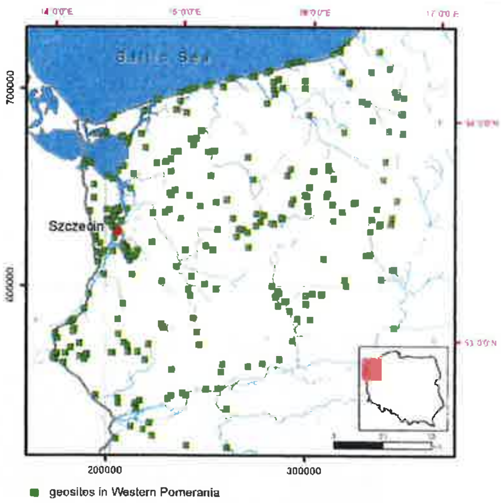

Fig. 1. Map showing distribution of geosites in Northwestern Poland

Fig. 2. Lake Szmaragdowe, in Bukowe Hills near Szczecin, a historical mining site extracted by the local cement factory

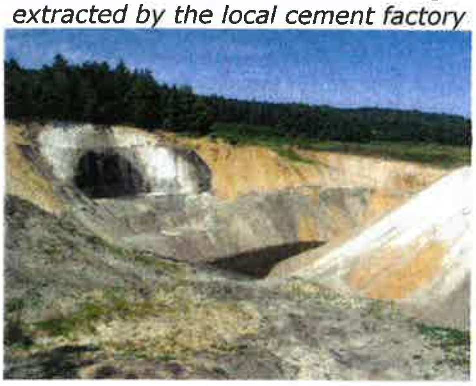

Fig. 3. Sieniawa, an open pit quarry where glaciotectonic processes folded the Miocene lignites

The large-scale forms include the Toruń–Eberswalde ice-marginal valley, a west-east trending valley several kilometres wide that was carved by dynamic meltwater flow during the Weichselian. Distinct glacial uplands, such as those surrounding Szczecin, or near Łagów (Fig. 4), are also included in the database as geosites.

Fig. 4. Glacial hills near Łagów and the subglacial valley cutting their southern edge

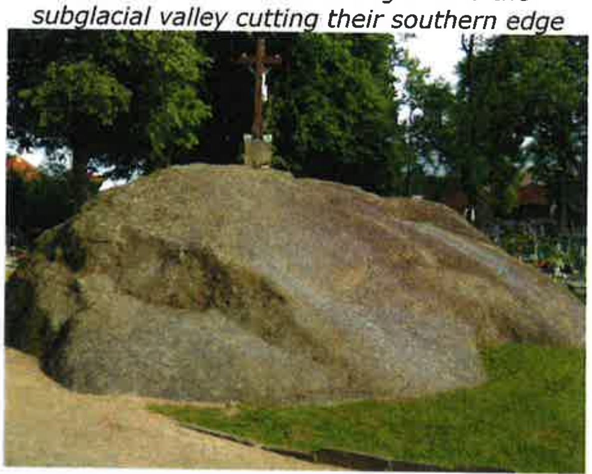

Fig. 5. Triglav, a dark-grey gneiss, transported from Sweden.

Fig. 6. Libbert's Rocky Gorge, a landscape-geological reserve preserving a valley with late-Pleistocene sandstone exposuresdeeply incised by meltwater

Another group of geotourism points includes large boulders. They were intensively used as building material from the Neolithic period, and there are many megalithic structures scattered across Western Pomerania, which are also included in the database. Thus, only a fraction of boulders remain, including Triglav (Fig. 5), the biggest erratic in Poland. Triglav is a dark-grey gneiss boulder with an impressive circumference of 50 m, length of 13.7 m, width of 9.3 m and total height of 7.8 m. Its weight is about 2000 t (Słomka, 2012). It was transported by the ice sheet from Uppsala, Sweden.

The only geological reserve in this part of Poland – Libbert's Rocky Gorge - preserves a unique late-Pleistocene sandstone and conglomerate formation, outwash sediments cemented by calcium carbonate solution (Piotrowski et al., 2010, Słomka, 2012). Later, the rocks were weathered and eroded by water that also deeply incised the valley, thus forming elaborate rock structures (Fig. 6).

Apart from serving the general public, the Central Repository of Geosites in Poland provides information on geodiversity to the central and local governmental organisations, as well as environmental organisations. Thus, information necessary for sustainable development and geoconservation is available to all concerned.

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Geoheritage in Barents Region (Results of ABCGheritage project)

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The Geological Survey of Finland and the Geological Institute of the Kola Science Centre of the Russian Academy of Sciences have already worked in the Barents Region for several years with the clear aim of spreading knowledge about geological heritage to the public, the tourism sector, and to educational institutions. The work was carried out within the Arctic Biological, Cultural and Geological Heritage (ABCGheritage) project between 2012 and 2015. The purpose of the project was to preserve and protect the biological, cultural and geological heritage of northern regions and harmonize them for instruction and cross-border nature tourism. The project was funded by the Kolarctic ENPI CBC programme of the European Union.

Eight different actions were planned for implementation in the geological part of the project. Concurrent with geological field work, valuable natural sites were mapped. The main result of the project was the Barents Tour for Geotourists -book. It is a guidebook about the nature, landscape history and geological sights of northern Fennoscandia. The area includes northern Norway, northern Finland and north-western Russia. The book is based on information collected in 2012–2014 as a part of an inventory of interesting bedrock and Quaternary geological localities: e.g. rare rock types and minerals, potholes, gorges, eskers, glacial meltwater channels, raised beaches and palsa mires. The route comprises 26 localities of which 14 are located in Finland, 4 in Norway and 8 in the Kola Peninsula. The localities are situated along a circular route that traverses Finnish Lapland, continues to the Sør-Varanger area in Norway and from there to Petchenga, Khibiny and White Sea coast in Russia and back to Eastern Finnish Lapland. The geological information on the sites is published in four languages: English, Finnish, Russian and Norwegian.

As a result of the data collection, a geological outdoor map and a guide book of the Khibiny Tundra in the Kola Peninsula were published. The earlier experiences of the production techniques were used in this action, as already 11 similar maps had been successfully published for the most important national parks and nature recreation areas in Finland. On the map, geological sites and information are depicted in different colours and symbols, and in the guidebook an explanation is given of the geological history of Khibiny Tundra. The guide book is published in Russian, English and Finnish. Other geological activities included collecting rock samples and other geological materials for nature exhibitions, the production of educational and information materials for schools, excursions to the geological sites, seminars and lessons of geoheritage and meetings focusing on geology and geotourism. Nature trails and information panels of the geological demonstration sites were also created. The information on the sites has been published on the Internet and can be downloaded onto mobile devices for use on personal hikes or guided tours.

According to the Kolarctic ENPI Action Plan, the purpose of this project was to increase regional knowledge, particularly where school children are concerned, but also to develop cross-border nature tourism and present geological development, fascinating shapes of landscape, rock types and valuable mineral deposits as new tourist attractions. It will increase the sustainable use of protected and recreational areas. The project also aims to increase awareness of geological sights among school children, students, local people and nature tourism business owners. Personnel working in education and tourism will get new targets and background data for their clients. In addition, it promotes the consistent long-term development of nature tourism in the Barents region.

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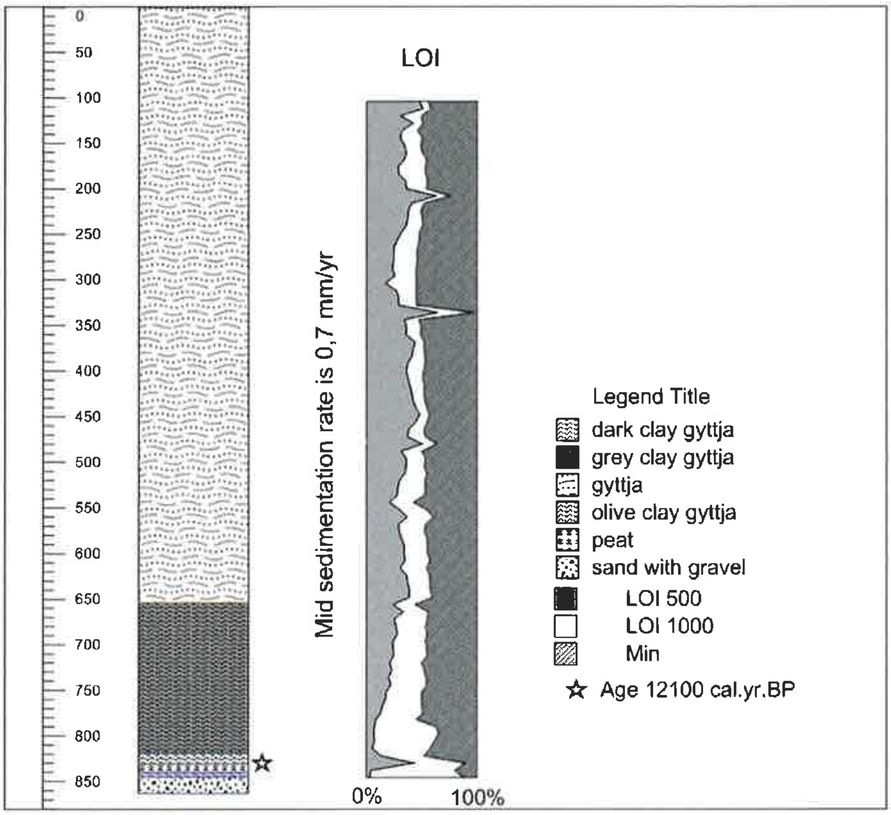

Figure 2. Analysis of bottom sediment of lake Protochnoe.

Acknowledgements:

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Abstracts

Posters

The peri-Baltic region as a test area of present sea level changes (i.e. regional eustasy)

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The sea level data preserved along our northwest European coasts – uplifted around Fennoscandia and subsided along the North Sea coast – provide a unique database for the definition of the eustatic component. This was quite successfully done for past sea level change in the Late Glacial and Holocene. Having established the isostatic uplift (in Fennoscandia) and subsidence (in the North Sea coast) in great details, we are also able to handle the delicate issue of present-to-future sea level changes in a much better way than elsewhere in the world.

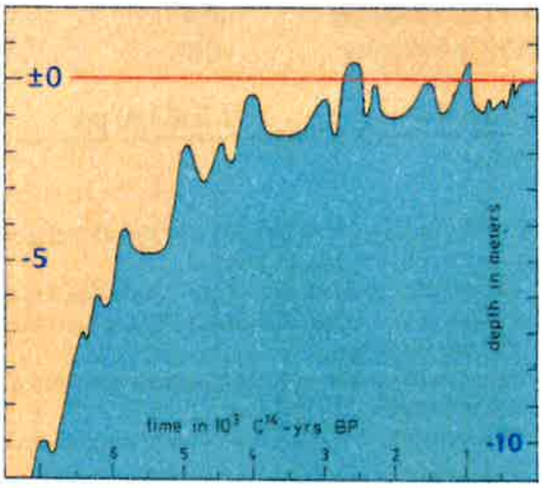

Fig. 1. Eustatic curve of the Kattegatt –North Sea region.

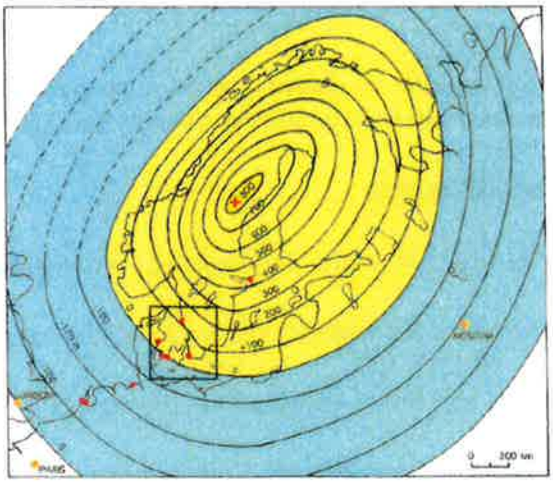

Fig. 2. Uplift (yellow) and subsidence (blue), sites discussed (red dots) and area of Fig. 3 (square).

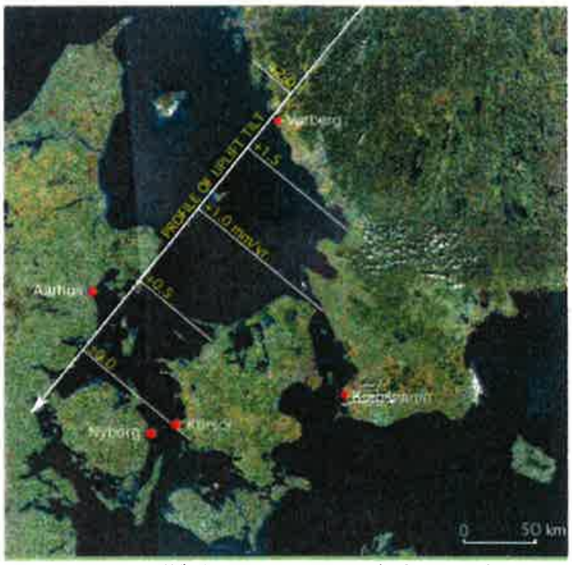

Fig. 3. The uplift in the Kattegatt is known in great details. The location of the zero isobase (or axis of tilting) has remained stable for 8000 years in the Great Belt area. Knowing the rate of absolute uplift and the relative sea level in the five tide gauge stations used (red dots), the eustatic factor can be determined with high precision at +0.9 mm/yr.

Knowing the crustal component of uplift or subsidence and reading the relative rate of sea level changes from tide gauges (red dots in Fig. 2), it easy to calculate the regional eustatic component (Table 1). For the North Sea region and Stockholm it becomes +1.1 mm/yr. In the Kattegatt, we have a very carefully determined uplift diagram (Fig. 3), where the axis of tilting has remained fixed at the Great Belt region for the last 8000 years. The Kattegatt tide gauges give a very strict eustatic component of +0.9 mm/yr (Fig. 3, Table 1).

Table 1. Measured tide gauge changes and known crustal component for a site (Figs. 2-3) give values of the eustatic component involved: 1.1 mm/yr in the North Sea and 0.9 mm/yr in the Kattegatt.

Locality	*Relative sea level Tide gauge data*	*Crustal component subsid(+), uplift(-)*	*Regional eustasy (mm/yr)*
Mediterranean:			
Venice	+2.3 in 140 yrs	+2.3 in 300 yrs	±0.0 in 140 yrs
North Sea:			
Brest	+1.0 in 160 yrs	~0.0 in 9500 yrs	~1.0 in 160 yrs
Amsterdam	+1,5 in 100 yrs	+0.4 in >5000 yrs	~1.1 in 100 yrs
Ijmuiden	+1.6 in 80 yrs	+0.4 in >5000 yrs	~1.2 in 80 yrs
Cuxhaven	+2.5 in 160 yrs	1.4 in >170 yrs	~1.1 in 160 yrs
Kattegatt:			
Korsör	+0.81±0.18 in 125 yrs	±0.00 in 8000 yrs	~0.8 in 125 yrs
Sliphavn	+1.01 ±0.16 in 125 yrs	+0.10 in 8000 yrs	~0.9 in 125 yrs
Aarhus	+0.63 ±0.11 in 125 yrs	-0.28 in >3000 yrs	~0.9 in 125 yrs
Varberg	-0.86	-1.75 in >1000 yrs	~0.9
Klagshamn	+0.6	-0.30 in 8000 yrs	~0.9
Baltic			
Stockholm	-3,8 in 150 yrs	-5.1 in 1000 yrs	1.1 in 150 yrs

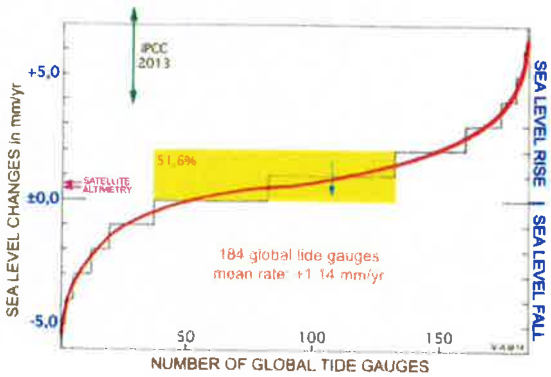

Fig. 5. Distribution of rates of 184 global tide gauges with a mean rate of 1.14 mm/yr.
The eustatic components of the North Sea coast of 1.1 mm/yr and of the Kattegatt of 0.9 mm/yr fit well with the mean rate.
The revised satellite altimetry records give about 0.5 mm/yr (Mörner, 2015b).
All indicating that the mean global eustatic component is in the order of 0.0 to 1.1 mm/yr.

Conclusions: Only in the "peri-Baltic" region are we able to obtain a good measure of the true eustatic component: +1.0 ±01 mm/yr. Higher rates can here be proven directly wrong.

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Evolution of the Odra River valley based on multidisciplinary study near Cedynia, NW Poland

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The Hohensaaten-Cedynia Basin is a 10 km-wide stretch of the Lower Odra Valley near Cedynia located about 100 km south from the Baltic coast. Until the mid-19th century, this was a swampy part of the valley. Its bottom part is currently at the sea level, and since the last glaciation the valley evolution has been closely linked with the sea level changes. Based on information known from boreholes, approximately 13 thousand years ago this section of the Odra valley was deeply incised to a level of 70 m below the contemporary sea level. This was followed by gradual deposition of sand and gravel by melt water flowing to the south. The recession of the ice sheet and the subsequent rapid rise of the base level resulted in gradual fluvial accumulation. The whole area also experienced steady isostatic subsidence (Piotrowski, 1991).

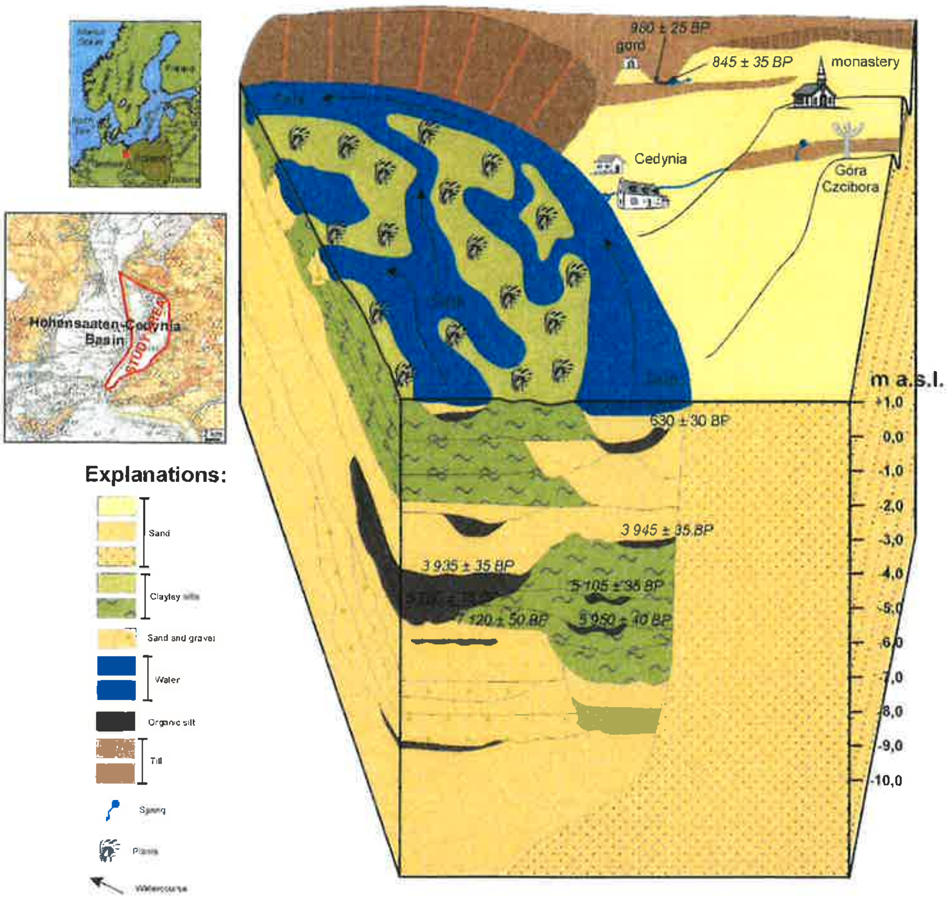

Fig. 1 Geology of Hohensaaten-Cedynia Basin in vicinity of Cedynia (Piotrowski et al., 2012)

Vibrocoring at several locations to a depth of 10 m and radiocarbon dating of organic beds identified within series of channel fill and overbank deposits provided new information about the evolution of Hohensaaten-Cedynia Basin during the Littorina Transgression (Fig. 1). Initially when the ice was still blocking the exit of the Odra valley, the river had a low gradient and a meandering character. After that the base level suddenly dropped transforming the river into a braided system. Around 7 thousand years ago, the fluvial system responded to the raising sea level and decreasing river gradient adopting the current anastomosing style. Such river pattern is depicted on historical maps and drawings of this area. The study showed that during the recent 7 thousand years, the average rate of accumulation in the Hohensaaten-Cedynia Basin was 1.0–1.3 m/ka which was related to the base level rise influenced by the Baltic Sea.

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Stratigraphy, sedimentation paleoenvironments and paleogeographical expression of the Pleistocene sediments at the site of Łęczyce near Lębork

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Compared to the rest of the Polish Lowland, the area of the Gdańsk Pomerania has few interglacial fluvial and organic series described in the literature. This makes the creation of a reliable stratigraphic-paleogeographical reconstruction for this area difficult. A chance for at least partial change in this situation can be a sedimentation profile at the site of Łęczyce.
The Łęczyce site is located within the northern slope of the Łeba valley, about 1.6 km SW of the town of Łęczyce, N Poland. The outcrop developed during the construction of a large-diameter pipeline ditch in 2014. The earthworks uncovered the profile of the Miocene and Pleistocene deposits with a total thickness of about 60 m and the hypsometric position from 30 to 90 m a.s.l. The thickness of the Pleistocene deposits is almost 50 m.
As a result of the geological studies, eight informal lithostratigraphic units have been delimited in the outcrop (U1-U8)
The profile starts with the Miocene deposits (unit U1). These are sands and sandy silts with inclusions of carbonaceous substances of large-scale diagonal stratification. These deposits formed in the environment of a sand-bed meandering river.
On the Miocene layer there is a layer of Scandinavian rock boulders of up to 1 m in diameter. Above there are medium- and fine-grained sands of a diagonal medium- and large-scale tabular stratification up to 9 m thick (unit U2). They are overlaid by coarse sand transiting upwards into gravels of cross channel stratification (unit U3). These deposits are covered by a 1 m thick layer of deformed clays, fine sand and lacustrine chalk (unit U4).
On the sediments of the unit U4 there are sands of diagonal large-scale bedding up to 5.5 m thick (unit U5). The deposits of the unit U5 are covered by glacial till of the unit U6 up to 4 m thick. This till is overlain by organic deposits with a 9 m thick clay insertion (unit U6). They start with mineral brown gyttja with organic laminae. Upwards the gyttja transits into packed, black organic silt about 5 m thick, covered by peat with sandy laminae and wood fragments (1 m thick). Above there are horizontally laminated gray-brown clays. The unit U6 ends up with a peat layer with traces of weathering, of up to 0.3 m thick.
The organic sediments are covered by the second glacial till 8 m thick (unit U7). In its lower part there is an enclave of deformed Miocene sediments. They are covered by sands and gravels of diagonal

medium- and large-scale channel stratification of a thickness of 3 m (unit U8). In the bottom of these deposits there is a layer of boulders, which includes periglacial structures (post ice wedge pseudomorphs).

Sandy sediments of the units U8, U5, U2 and U3 were sampled: in total 16 samples were collected in for the luminescence dating. So far the dating was performed using the TL method. Closed dates were obtained for the samples of the unit U8 (10-11 ka), unit U5 (211-250 ka) and unit U3 (220-225 ka). All samples obtained from the unit U2 gave open results. It can be assumed that in terms of their age the sediments of the unit U2 reach beyond the scope of the TL method.

The preliminary palynological analyses of the samples from the bottom of the unit U6 indicate that we are dealing with the ascending phase of the Eemian. This suggests that the upper part of the profile represents the remainder of this warming, and presumably lower part of the Weichselian glaciation.

The erosion pavement between the units U1 and U2 can be regarded as the residue of the glacial till, presumably of the San I or San II glaciation. The units U2 and U5 were deposited in fluvial environments: deep, sand-bottomed braided river (U2) and sandy meandering river (U5). The unit U3 was supposedly deposited within an outwash and can be regarded as an indirect trace of the following glaciation. The clay-organic sediments of the unit U4 are a record of sedimentation in a reservoir. These deposits were post-sedimentologically deformed, presumably as a result of periglacial processes. Tills of the units U5 and U7 developed during the two advances of the Scandinavian ice sheet. They were separated by a period of warm climate, which can be interpreted as the Eemian Interglacial. The deposition of the Eemian sediments occurred in a deep and fertile lake basin. The deposits of the unit U8 formed during the deglaciation of the research area during the last ice age.

The whole of the Pleistocene sediments in the Łęczyce site is a unique record in a superposition of different sedimentary terrestrial environments: fluvial, limnic, and finally glacigenic. Completion of multidisciplinary research at this site will bring new information regarding deposition and stratigraphy as well as paleogeographical and climate change in the area of the Gdańsk Pomerania.

Schmidt hammer testing of erratic boulders in north-west Poland – preliminary results

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Schmidt hammer (SH) testing is a simple method for measuring the hardness of rocks. If the lithology of rocks is uniform, differences in rock surface resistance may be related to degree of its weathering, which is a function of time. Therefore, the SH testing is often used as a relative dating method of rocks exposure time (e.g. Matthews & Winkler, 2011). Poster presents preliminary results of SH testing of glacial erratic boulders in north-west Poland (Fig. 1).

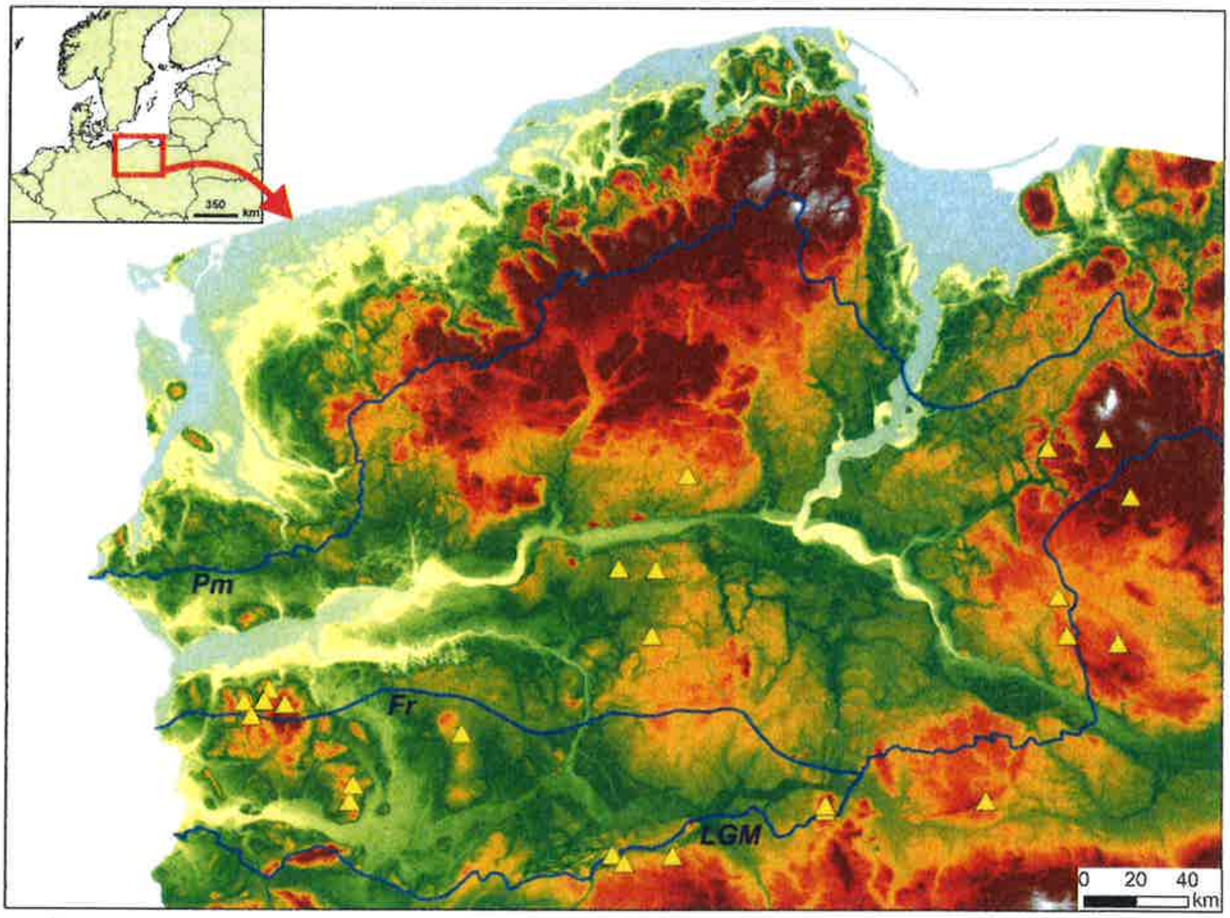

Fig. 1. Distribution of massive erratic boulders in north-west Poland investigated in this study. The last Scandinavian Ice Sheet limits according to Geological Map of Poland 1:500 000 (Marks et al. 2006) and Kozarski (1995).

The idea of our studies is to test if there is a relation between hardness of erratics surface and potential duration of its exposure in north-west Poland. Twenty eight massive erratic boulders resting in-situ on moraines were selected to testing. Six of them are located outside the LGM limit (on the Saalian

moraines) and twenty two of them within the last Scandinavian Ice Sheet maximum extent. Selected erratics are located close to the LGM limit, between the LGM limit and the Frankfurt Phase limit as well as north of the Frankfurt Phase limit (Fig. 1). This allows us to trace the relationship between potential exposure-age of investigated erratics and their response to the SH impact. Upper surface of boulders was tested with 40 SH readings per one erratic. In the case of 16 erratics (3 on the Saalian moraines, 5 close to the LGM limit and 8 on the Frankfurt moraines) control readings on fresh rock surface of a boulder have been possible to conduct. Whole dataset of the SH readings was analysed in order to detect trends in erratics resistance and its relationship with exposure age.
This study was financed by UG grant no 538-G240-B894-14 to Karol Tylmann.

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Periglacial landscapes of the southeastern border of LGM and their hydrology

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This study is focused on the palaeoenvironment of LGM (especially its southeastern flank) and some features of palaeohydrology of its periglacial area.

1) One of the controversial problems of the LGM palaeoenvironment is the formation of proglacial lakes and their extension in the North Dvina – Vychegda - Kama fluvial system. The existence of overdeepened transition valleys on the Vychegda-Kama-Pechora interfluve area was first proposed by I.I. Krasnov (Krasnov, 1948); according to then existed conceptions of LGM border he proposed the formation of proglacial lake and the overflow of the North Dvina – Vychegda waters into the Kama basing *via* huge Keltma spillway and the "first-order" rearrangement of drainage pattern in the SE periglacial zone of the LGM. Indeed, a wide channel is well seen on cosmic photographs between the North and South Keltma river headwaters.

Then D.D. Kvasov proposed the existence of an immense LGM-lake in the European North-East (Kvasov, 1975), whose idea is now shared by a number of scientists (Lavrov, Potapenko, 2005; Lysa et al., 2011; 2014; Larsen et al., 2013). It is based upon the hypothesis that the SE lobe of last Scandinavian ice sheet entered the Sukhona and Vychegda valleys *via* North Dvina river (Larsen et al., 2013). The level of such a lake was supposed to have risen up to 130-135 m a.s.l. that resulted in the outburst of the waters southwards.

An opposite hypothesis of the limited extent of the LGM-lake (Sidorchuk et al., 2001; Zaretskaya et al, 2014) is based upon the results of QWEEN project, where the limits of NE flank of Scandinavian ice sheet have been established between the Vychegda and Vaga river outflows (Svendsen et al., 2004), and our recent field studies. We studied a series of sections within the Vychegda river valley, comprising deposits synchronous to LGM and adjacent time. These were sections of Vychegda river terraces, with radiocarbon dated horizons underlying LGM deposits. Radiocarbon dates fall into the interval of 26 – 25 ^{14}C kyr BP and mark the last period of pre-LGM warming. The LGM-associated deposits are represented by alluvial sands in all studied sections.
The low terrace in the Vychegda valley which provides both pre- and post-LGM ^{14}C dates demonstrates clear features of fluvial morphology and leaves no space for occurrence of lacustrine environments during LGM. Based on the elevation of this terrace at the Vychegda mouth, the level of proglacial lake may be thought to have not exceeded 60 m a.s.l., which is far below the 135 m a.s.l. level of the Kel'tma spillway where the hypothetical outflow into the Kama River basin could have occurred. We consider that the LGM proglacial lake did not exceed the Vychegda river mouth, but the accumulation of its terrace had probably been promoted by the backwater effect from the lake. The extension of the LGM proglacial lake was not more than ~200-250 km spreading upstream from the SE margin of the last glaciation (boundaries according to Svensden et al., 2004 etc.). Also the proposed glacio-isostatic forebulge is reconstructed crossing the lower reaches of Vychegda (Bylinskiy, 1990) which could block the expansion of the LGM-lake upstream.

The Keltma spillway more likely has been formed much earlier, in the pre-Quaternary time (Krasnov, 1948) but it could be active during the Saalian glaciation which covered the most of North Dvina – Vychegda fluvial system (Svendsen et al., 2004) and could cause the proglacial lake formation in the Vychegda upper reaches (Kadam-Donty depression) and the rearrangement of outflow southwards into the Kama basin.

2) Another type of drainage pattern "second-order" rearrangement (abandoned channels) took place within the Vychegda basin, in the Kadam – Donty depression, at the end of the LGM during the deglaciation period. The abandoned Vychegda channel – the Don-ty lake – is located in the northern part of the depression and has been formed due to catchment of Vychegda river bed by Northern Keltma river. The Don-ty lake topography is repeating the Vychegda river bed pattern. The age of organic deposits at the lake bottom is 12000-11600 cal BP, that is the catchment could take place during the Younger Dryas or earlier. This rearrangement could be caused by emptying of the proglacial lake in the middle reaches of the North Dvina river and the decrease of the erosional base level of the fluvial system.

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Middle Pleistocene and periglacial landscapes in the Arctic and Sub-arctic of European Russia

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The current regional stratigraphic and correlation Quaternary schemes are multivariant. Some investigators believe that there was only one the Middle Pleistocene glaciation. In this case Moscow glaciation is considered as the second phase of the first – Dnieper (Middle Pleistocene) glaciation (Schick, 2014). Others believed that during the Middle Pleistocene there were two glaciations, and the upper, corresponding to the Dnieper, they divide into two stages (Velichko, 2012). Results of our investigations prove the existence of two warm interglacial periods and two cold – glacial periods during the Middle Pleistocene in the Arctic and Subarctic of European Russia (Andreicheva, Sudakov, 2014). In the stratigraphic sequence the following regional horizons stand out: interglacial Chirva (Likhvin), glacial Pechora (Dnieper), interglacial Rodionovo (Shklov) and glacial Vychegda (Moscow). The contradictory nature of existing points of view was caused by absence of integrating and unity of methodical approaches in the research of Quaternary sediments. The sediment stratigraphy is usually carried out by means of only one – the palynological method, which is not the main method for the Quaternary stratigraphy.

Water-glacial and periglacial alluvial deposits lay at the bottom of Pechora horizon. The central part of the horizon is represented by till with lithological characteristics, caused by the influence of distant, transit and local distributive provinces. Dark-colored limestones from the Polar Urals and Pai-Khoi Ridge dominate in the petrographic composition of coarse material. Underlying terrigenous rocks are also numerous. In northern and western parts of the region the main part of debris consists of bedrock rocks – Cretaceous and Jurassic sandstones and siltstones (30-46% of all the debris). In the eastern part (in the valleys Adzva, B. Rogovaya, Seyda and the middle Pechora) – Permian and Triassic gravelstones and siltstones make up 35-40% of debris material. Fragments of index marble limestones of crinoids and bryozoans from Novaya Zemlya are constantly present. The strip of their distribution elongates in the direction of movement of the Pechora glacier from the Novaya Zemlya, where there are outcrops of the south-south-west, up to the lower Vychegda. Pyrite and siderite comprise up to 31% of the till heavy fraction, and glauconite makes up a light fraction – these minerals are characteristic for the underlying Lower Cretaceous and Jurassic rocks. Epidote and ilmenite – minerals that are typical of the Northeastern provenance. The stable south-south-west direction of Pechora glacier movement – 340-60°, is an important feature of Pechora glaciation in the Timan-Pechora-Vychegda region. It is consistent with the characteristics of the material composition of the till. Fluvioglacial, limnoglacial and periglacial sediments overlying till are formed in the final stage of the Pechora glaciation. Periglacial alluvium contains teeth of collared lemming with negative index of evolutionary level (PES) minus 4.4 – minus 4.8 (Kochev, 1984). Moreover, the age of Pechora deposits is determined by their position between Chirva and Rodionovo horizons which are palynologically characterized in detail. The micromammalian fauna consists 98% of lemmings. This reflects the harsh conditions of the Arctic tundra, timed to periglacial zone of the Pechora ice sheet. Landscapes like shrub tundra probably dominated during this interval and the boundary of the taiga zone shifted much to the south. The lower part of the Vychegda horizon is also represented of periglacial alluvium with teeth of collared lemming. This suggests cold climate caused by the onset of the Vychegda glaciation and the distribution of Arctic tundra in the study area. PES = 1.5-3.1 of

lemming's remains indicate the Vychegda age of overlying till. In addition, the Vychegda age of the till is also confirmed by the results of lithological study. This made it possible to lithologically substantiate the presence of two distributive provinces of till formation.
The main part of the study area is overlapped by glaciation of Fennoscandinavian center in the Vychegda time. The elongated fragments of rocks in till (clast fabric) are oriented from west-northwest along the azimuth 270-360°. The carbonate rocks predominate in the petrographic composition of coarse material and light colored limestones dominate in this group. The content of index rocks from Fennoscandia and northern Timan Ridge is significant. They are represented by nepheline syenite, basalt with agates and granites, gneissose granite, amethysts. In addition, connection of the Vychegda till with Fennoscandia is confirmed by the potassium-argon isotopic dating of crystalline rocks boulders in the range 1345-2015 Ma. In the valley of Shapkina River thermoluminescent dating of marine sands, lying under the till, showed up to 230±20 ka, lacustrine sands and silts overlying till were dated 130±12 ka. These dates clearly indicate the Vychegda age of till by its position between the dated sequences. Pomegranates and amphiboles – typical minerals of Northwestern terrigenous mineralogical province, comprise up to 63% of the till heavy fraction. The Vychegda age of till is also confirmed by its geological position between Rodionovo and Sula horizons with relevant palynological spectra.
The Extreme Northeast of the Pechora lowland and valley of middle Pechora in the Vychegda time have been covered by a glaciation from the Polar and Circumpolar Urals center. The material for the Vychegda till moved from the east-northeast along the azimuth 40-105°. The concentration of Uralian igneous and metamorphic rocks represented by Devonian and Lower Ordovician quartzites and quartzitic sandstone, quartz-epidote rocks, amphibolites, peridotites, pyroxenites, various shales, including phyllites, is 26-32% in the petrographic composition of boulder-pebble material.
The accumulation of fluvioglacial sediments and periglacial alluvium containing lemming remains showing PES 13.5 (Kochev, 1993) occurred during the degradation of the Vychegda Glaciation after the outburst of small ice-dammed lakes. Arctic complex of small mammals suggests distribution of the Arctic tundra landscapes.
Thus, glaciations in the Middle Pleistocene were independent. The Pechora ice sheets moved from Pai-Khoi-Ural-Novaya Zemlya glaciation center. North-western and central parts of the region overlapped by Fennoscandinavian ice sheet during the Vychegda time. North-eastern and eastern parts of the Pechora lowland overlapped by the glacier centered in the Polar and Circumpolar Urals.

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Summary of ^{230}Th/U ages of the Mid-Late Pleistocene (MIS-3,-5,-7) organic-rich sequences in Russia and adjacent regions

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Geochronology of the mid-late Pleistocene of the Russian Plain and Siberia are based mostly on paleobotanical studies, the ^{14}C-dating of organic sediments and plant remains, the TL and OSL dating of sands and loams as well as the ESR dating of mollusk shells. However, the accumulated evidence did not conclusively resolve, for example, the problem of the status of the Karganian (Middle Würm) time in Siberia: is it an Interglacial or Interstadial time? The Mikulinian (Eemian) deposits on the Russian Plain are well distinguished by the pollen spectra but have yet to get a numerical age. The Middle Pleistocene chronostratigraphic position of Glacial, Interglacial and Interstadial deposits in the territory of the Russian Plain is debatable at the present time. It is connected with discussions concerning the rank and ages of the pre-Eemian (pre-Mikulinian) Interglacial sediments. Some researchers relate these deposits to the Oxygen-Isotope Stage 7 (MIS 7), others - to the MIS 9. Accordingly, the notions of an even earlier Interglacial age also vary between the MIS 9 and MIS 11.

During the past three decades, the uranium-thorium (^{230}Th/U) radioisotope method has been used for dating terrestrial Interglacial (Interstadial) organic-rich deposits with ages up to 300-350 kyr. However, the basic theoretical requirements for its practical use for the dating of organic-rich sediments such as buried peat and gyttia are not always completely fulfilled. Therefore, in the mid-90s of the last century we initiated comprehensive radiochemical, chrono- and biostratigraphical studies of organic-rich deposits to substantiate the capabilities and limitations of the ^{230}Th/U-method for their dating.

The ^{230}Th/U method is based on the established fact of the disturbed radioactive equilibrium in the U-series in buried peat or gyttja deposits. With time, from the parent uranium, a daughter ^{230}Th isotope is accumulated while the ^{230}Th/^{234}U ratio is a measure of the sample age. The principal issue of the ^{230}Th/U dating of these natural objects is caused by inclusion of the mineral fraction with a certain quantity of thorium isotopes, including ^{230}Th (so-called primary ^{230}Th), whose content should be excluded in the age calculation. Therefore, we applied the isochronous approach for ^{230}Th/U age calculation. Our version of isochronous approximation is based on agreement of isochronous-corrected ages obtained for the same coeval samples analyzed by the two analytical techniques based on: (1) acidic extraction of sample - “leachate alone” technique (L/L-technique), and (2) “total sample dissolution” technique (TSD-technique).

Up to now we have obtained a number of ^{230}Th/U age data for the Upper and Middle Interglacial/Interstadial buried deposits from the East European Plain and Siberia The peat layer from the key section Mikulino (Smolensk Province, the Russian Plain) was dated 109.5±6.2 ka (Kuznetsov & Maksimov, 2012). Other ^{230}Th/U ages corresponded to MIS-5 were obtained for the organic-rich sequences from the East-European Plain including Belarus, Lithuania and European Russia as well as from Siberia in the range from ~90 kyr to ~140 ka (Astakhov et al., 2005; Laukhin et al., 2008; Kuznetsov & Maksimov F.E. 2012, Boerner et al., 2015; Rusakov et al., 2015; et al.). The two MIS-7 dates of 195.2±9.9 ka (L/L-technique) and 204.1±15.0 ka (TSD-technique) were obtained for the Krivosheino Site (Western Siberia), as well as 218.1±25.9 ka (L/L-technique) and 182.8±24.9 ka (TSD-technique) for the Mardasavas Site (Lithuania) (Gaigalas et al., 2005; Maksimov et al., 2012).

From the viewpoint of precision and reliability of radioisotope dating, the most preferable organic deposits are those that can be examined by both the ^{14}C and the ^{230}Th/U methods. We studied the buried peat bog from the Tolokonka section located in the North-West of Russia on the right bank of the Severnaya Dvina River. The good agreement between ^{14}C ages in the range of 37.5-42.8 cal ka BP and $^{230}Th/U$ ages in the range of 39.7-45.2 ka (TSD-technique) and 31.5-45.7 ka (L/L-technique) were obtained. The ^{14}C age in the range of 43.6-41.6 cal ka BP corroborated the $^{230}Th/U$ dates 47.8±2.3 ka (L/L-technique) and 42.8±4.0 ka (TSD-technique) obtained for the buried soil from the Kur'jador Site located on the right bank in the upper reaches of the Vychegda River (North-Western Russia) (Maksimov et al., 2011; 2015).

All the $^{230}Th/U$ ages obtained and related references are reported.

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Quaternary correlation charts: the last 2.7 Ma, the last 270 Ka

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Two international stratigraphical correlation charts for the Quaternary will be presented. They differ by one order of magnitude in the time/depth represented and the resolution at which correlations are made.

The first chart spans the last 2.7 Ma, resolved to the nearest 10,000 years, and has global coverage. This chart dates from 2004 and has since been revised semi-annually (e.g. Gibbard & Cohen, 2008). The second chart covers the last 270 Ka, resolved to the nearest 1,000 years. It illustrates the North Atlantic and Europe north of the Mediterranean. A prototype of the latter chart was first exhibited at the 2011 INQUA Congress, then further developed, and prepared again for the 2015 INQUA Congress.

The differences in time/depth and resolution echo the difference in preservation with increasingly younger records. Directly related to this, the charts reflect the differences in detail of study and level of understanding attainable. Because different regions hosted different Quaternary environments, regional division schemes differ between countries and between land and sea. These divisions are therefore based on different criteria and definitions. The many environmental sequences shown in both charts emphasise the shared, dominant glacial-interglacial cyclicity.

The principal application of the charts is to provide a ready reference for the widely used stratigraphical terms for similar periods in different areas, environments and schemes. In addition, the 1,000-year resolution of the last 270,000 years chart also encourages cross-comparison and testing of alternative correlations between records for this critical interval, providing a vital tool for modern Quaternary science. Also, just as the present is a key to the past for understanding processes, the recent geological past is a key to the more distant past. Understanding the loss of resolution and preservation of record over the youngest climatic cycles for various environments and geographical positions, is vital for linkage of chronostratigraphical definitions in the Quaternary, to those of the rest of the geological chart (e.g. Cohen et al. 2013).

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The oldest evidence for human habitation in the South-eastern Baltic Sea region

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We report the discovery of the oldest evidence for human presence in the South-eastern Baltic Sea region (Druzhinina *et al.*, submitted). The Riadino-5 archaeological site was discovered in 2006 during a survey of the partly preserved third terrace in the lower course of the Šešupė River. Archaeological investigations were supplemented by a set of palaeogeographic studies including IRSL dating of the site sediments. Luminescence ages were determined using the multiple-aliquot additive-dose technique, applied to sand-sized potassium feldspar. Four of the six samples collected at the site represent cultural deposits and two the geological environment for the archaeological layer.

Chronological data obtained for the culture-bearing sediments from the Riadino-5 Palaeolithic site indicate human occupation of the site between at least 50 ka and 44 ka ago, during the first half of MIS 3. Existing data on the palaeoenvironment of MIS 3 confirm the possibility of colonization of the Baltic area by groups of archaic humans during this time period. The flint artefact collection from the Riadino-5 site is quite extensive and includes various kinds of tools. Therefore, new studies are underway to gain more knowledge about their cultural attribution.

The dates obtained place the Riadino site among the most ancient sites of the Middle to Upper Palaeolithic transitional period in Europe.

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New data on palaeoseismicity in the Eastern Baltic region (Šešupė River Valley, Kaliningrad Oblast of Russia)

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We present new data on geological structures, which have been interpreted as palaeoseismic sedimentary deformations. They were identified in the northeast of the Kaliningrad region, in the lower reaches of the River Šešupė. Tongue-shaped and dome-shaped diapir-like structures indicate liquefaction-induced features caused by water saturation and ground shaking during seismic event. The earthquake could be caused by active faults and related to structural crust movements, as indicated by the location of the study area within the system of tectonic faults: the Neman fault and several faults stretching in a NW-SE direction. Seismicity of the territory could be also connected with postglacial rebound which triggered seismic activity at the end of Late Pleistocene, Early Holocene up to the present in the Baltic ice marginal zone. A preliminary date for the seismic event, based on the field observations and radiocarbon (^{14}C) date covers the period from early Medieval up to the present time.

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Sediment record from the Kamyshovoe Lake, Kaliningrad Region, Russia: results of 2014 - 2015

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The results of a study of the Kamyshovoe Lake (Vishtynetskaya highland) are presented. A pollen and diatom survey, LOI and radiocarbon dating of the bottom sediments were applied to reconstruct the history of local vegetation during Lateglacial – early Holocene. The deposition of limnic sediments began during the Allerød. Pollen records show the formation of birch-predominating forest at the beginning of the chronozone and the flourishing of pine towards the second half of the chronozone. The transition to the Younger Dryas led to the development of patches of shrublands with *Juniperus* and communities of steppe herbs. Amelioration of the environmental regime enabled birch and pine woods to spread during the second part of GS-1 event and the Preboreal. The Late Preboreal time is marked by the appearance of *Populus* and an increase in the role of grasses in the vegetation cover, which can be correlated to similar open vegetation phases deduced from other pollen records in Europe. During the Boreal *Corylus* had its maximum value, *Alnus, Tilia* and *Quercus* appeared and spread while the birch-pine forests retreated. Diatoms appeared in the basin during the second part of the Younger Dryas. Also of note is the transition to the Preboreal-Boreal, marked by a rise in the diversity of diatom species. Water level and eutrophication of the lake began to increase at the boundary of the Boreal-Atlantic.

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Weichselian decline reflected in frequency distributions of ^{14}C dates (Łódź region, Central Poland)

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For the Łódź region (Central Poland Lowland) ^{14}C dates covering the time from the first symptoms of warming of the Late Weichselian (termination of MIS 2) to the Holocene beginning (about 6500 calendar years, between 18 and 11.5 ka cal BP) were gathered. The radiocarbon dates were calibrated using the OxCal v. 4.2 Programme (Bronk Ramsey 2009), Calib programme (Stuiver and Reimer 1993) and the calibration curve IntCal 13 (Reimer et al. 2013). The obtained individual distributions were summed up and the probability density functions (in calendar timescale) were constructed. On the basis of the obtained dataset, an attempt to detect its usefulness in determining palaeoenvironmental changes was made.

The analysis is based on a set of 175 ^{14}C dates from 55 localities of the Łódź region, made till the end of 2014 in 5 radiocarbon laboratories. The database contains dates gathered through query of scientific literature and of archives from the Radiochemical Laboratory of Archaeological and Ethnographical Museum in Łódź. Only geological samples are included in the analysed set (organic mud, peat, gyttja, wood, fossil soil, plant macrofossils and choarcoal). Most dates contributed in the present analysis were stratigraphically determined by investigators.

Conclusions on the qualitative aspects of the phenomena occurring in the discussed time period time are based on assumptions derived from previous studies of a similar nature (e.g. Michczyński and Michczyńska 2006). According to these authors maxima and minima of the probability density function are the result of the shape of the calibration curve and preferential sampling.

The discussed time interval was characterized by alternating warm and cold periods of a global nature (e.g. indices of the Greenland ice cores). In land areas chronology of environmental events is recorded, for instance, in annually laminated sequences. In old morainic area of the Łódź region, which lacks of high resolution lacustrine record, stratigraphic subdivision of the analysed time period is defined on the basis of dune-formation processes, palaeosoils and multiproxy palaeoecological investigations carried out mostly in peatbogs. The course of palaeogeographical changes is well reconstructed from fluvial environment where from about 18 ka cal BP transformation of the size and type of river channels started as a result of changes of vegetation and the reduction of sediment load.

Warmings and coolings clearly reflect the shape of the probability density functions. Very clearly we see also environmental changes on the calibration curve, and its shape directly models the form of the constructed summary probability density distribution. Concentrations of dated samples in the set of real values, additionally strengthen or weaken the variability of the calibration curve. Determined intervals of environmental changes, illustrated by significant changes in slope of the curve, register $^{14}C/^{12}C$ isotope ratios change in the atmosphere. Increased amplitude of changes on a curve about 18–17.5 ka cal BP years marks the onset of the gradual transformation of the environment towards temperate conditions. Two peaks for the time period ca. 14.2–12.6 ka cal BP are correlated with the Late Glacial warming of Bölling (ca. 14.2–13.45 ka cal BP) and Alleröd (ca. 13.2–12.6 ka cal BP), with inter-Alleröd climatic deterioration in between. The fall of the function between these warmings coincides with the Older Dryas (ca. 14.2–13.45 ka cal BP). There are no separate peaks on a graph of simulation probability density distribution, which indicate to the local nature of this cooling. The distinct decrease of the value of the probability function at ca. 12.6 ka cal BP marks the Younger Dryas.

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Dynamics of the Younger Dryas vegetation changes in Central Poland

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Pollen data are an integral part of the palaeoenvironmental interpretation. Within the framework of the topic, pollen diagrams from the Łódź Region (Central Poland) were collected. The aim of the study is an attempt to reconstruct the Younger Dryas vegetation cover of the area. Conditions in Central Poland during the Younger Dryas were favourable for development of forest-tundra-steppe communities (Madeyska 1998).

17 available pollen diagrams were analysed, 14 of them investigated in the past few years, 3 profiles elaborated a few decades ago, including 1 (Witów) which is a stratotype for the Late Glacial of overregional importance. Most data come from peatbog sequences, on which interdisciplinary comprehensive analyses were carried out. The diagrams illustrate the Younger Dryas period with varying clarity, but in each case the age assignment does not raise major doubts. The following data were took into account in the undertaken study: AP/NAP relation, percentage of Pinus nad Betula pollen and the presence of indicator plant species: *Helianthemum*, *Artemisia*, Chenopodiaceae, *Selaginella selaginoides*, *Ericaceae*, *Empetrum*, *Betula nana*, *Ephedra distachya*, *Gypsophila fastigiata*, *Bupleurum*, *Juniperus*. Moreover, the sites were considered in the geomorphological context.

Among the analyzed diagrams, particular attention was paid to the Koźmin Las profile, located on the low terrace low of the Warta River valley. The organic series was there accompanied by remains of riparian forest from the Younger Dryas beginning. Based on pollen results, other biological proxies (cladocera, chironomid, diatoms, dendrology) and chronological methods (radiocarbon dating, dendrochronology), a sequence of environmental events as response to climate cooling was reconstructed (Dzieduszyńska et at. 2104). The time of the forest existence and its destruction were registered. The results seem to be promising to contribute in a debate about the dynamics of change of vegetation during the Younger Dryas and varied reactions of plant communities, resulting from a combination of global conditions and local site factors.

To compare of the several pollen percentages of different sites, the similarity index of structures (*wp*) was used, according to an algorithm proposed by Pawłowski et al. (2014). The use of this method depends on the presence of clusters with the same shape and with roughly the same number of observations. The values of this similarity index are expressed as a percentage. The greater the incidence of the 100% value of this ratio, the greater the similarity of the structures. An index value equal to 100% indicates that the structures are identical. However, because of high skewness of probability distributions of the palynological data the standard statistical procedures, which assume normality, are inappropriate here. Mann-Whitney U test is considered to be especially useful

Last Glacial stage as reflected in sedimentary successions of the Łódź Region (Central Poland)

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For the Łódź Region there is a rich research material which allows for the reconstruction of environmental variability and relief evolution in both periglacial and glacial zones during the Vistulian (Weichselian). Borderline location of the study area offers comprehensive research on the time and processes due to well developed sedimentary environments, retaining their diversity.The most valuable archive of extraglacial zone is provided from organic series filling post-Eemian closed depressions, whereas data of glaciated area is derived from geological and geomorphological evidence. For the extraglacial part of the study area the stratigraphic division of the Vistulian is based on palynological premises introduced in the Netherlands by Zagwijn; this includes: Early Vistulian (MIS 5d-a), Lower Plenivistulian (~ MIS 4), Middle Plenivistulian (~ MIS 3), Upper Plenivistulian (~ MIS 2) and Late Vistulian (~ close of MIS 2). Stratigraphy established for glaciated areas is used for the part of the last ice sheet advance.

In the area outside the last Scandinavian ice sheet extent, a particularly long record of palaeoclimate changes is provided from the Rudunki and Kubłowo subfossil flora profiles. Amersfoort, Brörup, Odderade, Oerel and Ebersdorf interstadials were registered. Tendencies of the peramfrost behaviour are reconstructed from a wide range of geological data, including the presence of well developed ice wedge casts and sand wedges, and sedimentological traces of slope processes, indicative for movement over frozen ground (slopewash, congelifluction). Cold conditions promoted the formation of the autochtonic Aeolian stone pavement (on the plains) and the allochtonic pavement (on the slopes and in the dry valleys). Fluvial tendencies are reconstructed for the whole Vistulian. They register the adjustment for a global climatic trend, but additionally give insight into the local control of the processes, both erosion and accumulation and changes in channel patterns. Cold Vistulian periods promoted aeolian processes reflected in an increased amount of wind-abraded grains in alluvia, while in the Late Vistulian (Older Dryas) in the common dune formation.

The northern part of the region has been embraced by the Płock ice-lobe during the Last Glacial Maximum (MIS 2). No plant succession has been recorded for that period. A palaeogeographic reconstruction for the glaciated area based on abiotic proxies: geomorphology, analysis of sedimentary facies and depositional environments, litho- and kinetostratigraphy and also luminescence datings. The Płock ice-lobe reached its maximum extent between 22.9 and 18.7 OSL ka BP and left a separate basal till of individual petrographic characteristics. Dynamics of the Płock ice-lobe was influenced by local conditions – topography, subglacial hydrology and ice base thermics. Derived from geological evidence, the ice-sheet featured a warm base system. Dominant in the mechanism of the ice movement, prior to the subglacial channel drainage build-up and stabilizing the ice front at the LGM line, was a basal sliding resulting in an apparent acceleration of ice speed and a pervasive subglacial deformation. It has been proved that the ice travel geometry in the Płock lobe was of a fan-like character. Elaborated parameters for the dynamics and geometry of the ice-masses inflow admit to accept as valid that the Płock lobe evolved at the end of the fast moving ice stream and was intensively fed from its hinterland. That distinctive element of the LGM margin contour has featured the main ice flow artery in the distal part of the Vistula palaeo-ice stream.

Antropogenic impact or natural environmental change: new data based on palaeobotanical and geochemical analysis of Dūkštelis lake sediments

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The studies show that soil and sediment mechanical composition may vary even over short distances and depends on their formation period, sedimentary environment, biogenic matter, erosion and other factors, which, in turn, influence the geochemical results. Abnormal content of elements may be erroneously defined as a result of anthropogenic pollution and such misinterpretation can lead to unnecessary costs for cleaning anthropogenically non-contaminated lakes or other areas. Thus, it is important to assess a local geochemical background of the environment in a certain period of sedimentation.

Willing to see if there are any links of paleobotanical and geochemical data to environmental change, an assessment of bogged up part of Dūkštelis lake sediments was carried out. New data reflects palaeoecology of the environment over 13000 cal. y BP and a human impact. Complex studies of 7 cores have been performed. The complex of one core consisted of spore-pollen analysis, LOI, magnetic susceptibility, determination of sediment absolute age (^{14}C, AMS), $\delta^{18}O$ and $\delta^{13}C$ isotopic studies and geochemical sediment analysis (determination of As, Ba, Cr, Cu, Mn, V, Zn, Ca, Fe, K, Rb, Sr, Zr, Ti, S by Thermo Scientific Niton XL2 XRF spectrometer). The complex of other 6 cores consisted of geochemical analysis and studies of magnetic susceptibility. The changes of element contents in lake sediments over the course of time were recorded and their inter-dependence analyzed. The comparison of all borings on horizontal and vertical cross-sections of the lake bottom sediments was established according to lithology, magnetic susceptibility and the contents of the following group of chemical elements (Ba, Ca, Cr, As, Mn, Fe, K, Rb and others) (Fig. 1.). Palynological data from laminated core sequence were interpreted with respect to vegetation and climate change in the region and on the basis of a chronostratigraphical model and archaeological evidence recorded in the region. The results of geochemical analysis were compared with the background levels of trace elements in 4 types of lake sediments of Lithuania (Kadūnas, Radzevičius, 2003), Neris River sediments (Kadūnas et al., 1999) and with maximum permissible concentrations (MPC) given in hygienic standard HN 60:2004 aiming to explore if the sediments are suitable for introduction to soil.

The onset of the sediments formation was coincident with the Lateglacial according to the data obtained. The conclusion about their age, i.e. 12307 – 12631 cal. yr BP, is proven by Poznan radiocarbon dating laboratory (Poz-63651). At that time, the environmental conditions were unstable, vegetation poor, the fine terrigenous substance predominated in the abiotic environment as the soil was in the process of formation in most places. At the beginning of early Holocene the climate stabilized. Development of the plant cover prevented erosional processes in area. Favorable environmental conditions were followed by the introduction of deciduous trees including the broad-leaved species i.e. elm, alder, oak and lime. More and more nutritives were getting into the lake which led to its eutrophication, while the decrease of oxygen content slowed down the mineralization of organic substance. A shift towards temporally anoxic conditions is indicated by lower Fe, Mn fluxes, which are soluble and mobile as reduced species and, therefore can be removed from sediments. The geochemical analysis of the sediments of Lateglacial and early Holocene allowed to detect the chemical elements exceeding the background values – As, Ba, Cr, Cu, Mn, Rb, Sr, V, Ti, Zn, Zr. Also the anomalies of As, Ba, Ni and Mn exceeding MPC from HN 60:2004 were observed in several samples taken from different depths. At the end of the middle Holocene the investigated part of the lake bogged up. The discovered pollen spectra (such as Poaceae, Plantaginaceae) allow us to maintain the opinion that in 3700 – 4400 BC (Early Neolithic) people settled in the territory. A sudden rise to very high terrigenous input reflects the intensification of human pressured and further spreading of deforested and agricultural land. This period of deforestation and establishment of cultural landscape is also reflected in the pollen diagram by a steady increase of NAP-value and human impact indicators. A positive correlation of pollen data with the record of geochemical tracers for soil erosion and human impact is evident. To conclude, the human activity is proven in surface layers of sediments by increased contents of some chemical elements. Though they do not exceed the background values of sediments in the Neris River, but the contents of Cu, V, Ti and Zr exceed the background values in lake sediments (Kadūnas, Radzevičius, 2003).

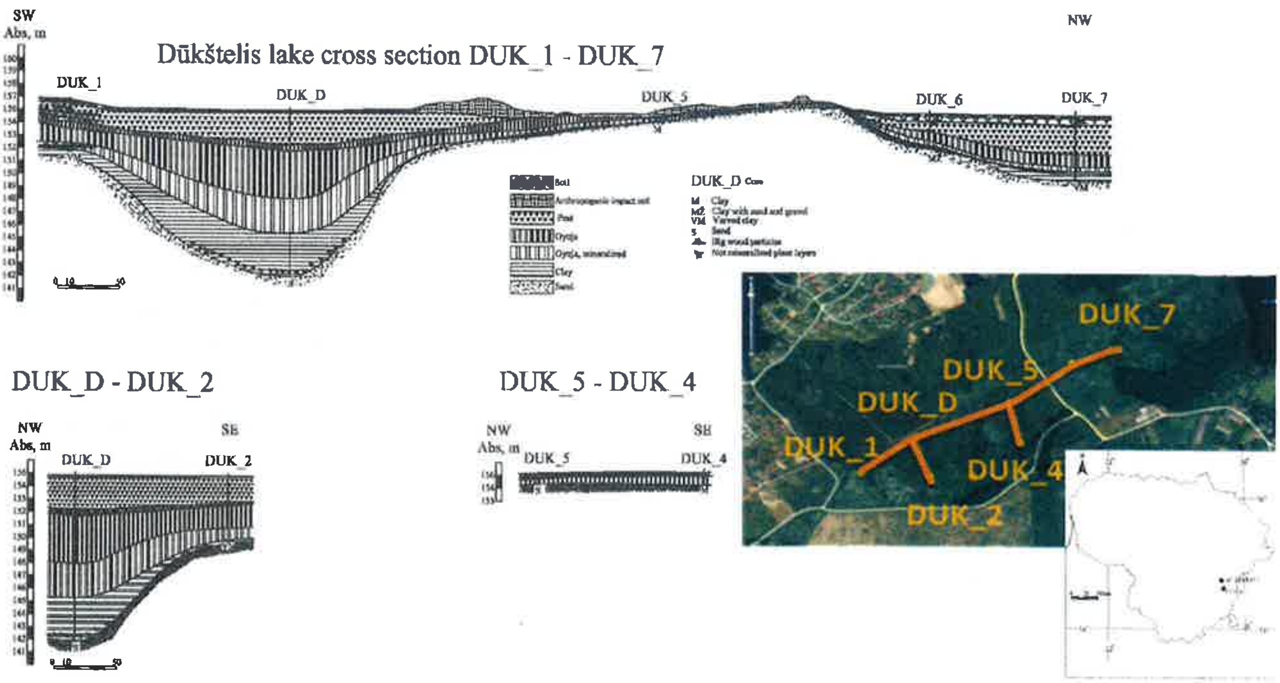

Fig.1. The location of site and cross sections schemes of the Dūkštelis lake.

According to the archaeological investigation taken in 2012-2015 on the bank of Dūkštelis Lake there are at least two episodes of human inhabitance which can be determined by flint find typology. The flintknapping tool making technique is partly typical for Early Mesolithic and later reuse of their flint flakes in Late Neolithic or Bronze Age can be seen. Most probably the impact of the Early Mesolithic humans was not highly expressed, whereas later inhabitants might have had a greater influence to the landscape formation. Some archaeological structures associated with living place and food making have been unearthed and it seems likely the greater part of them should be assigned to the end of the Middle Holocene, Subboreal period, when more sedentary people where living on the shore of Dūkštelis lake. One of the discovered structures is considered to be a hearth which was used more than several times as the surrounding ground is burnt quite heavily. Meanwhile two oval structures in the southern part of the site might be associated with the first inhabitants of the site, showing some food preparation process, as there was a significant concentration of burnt bones. To sum up, there is a big consideration if the banks of the Dūkštelis Lake had overtaken a human impact which would change the landscape. There probably were only few temporary huts built in the very beginning of Holocene, in Early Mesolithic. Whereas after some thousand years in Late Neolithic-Bronze Age more archaeologically defined human inhabitance processes can be recognized. People might have had a settlement they used for a longer period of time and so the lake could have been a more important part of their site-catchment than for their predecessors.

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Vegetation change during Late Glacial and Holocene in the North of the Timan-Pechora-Vychegda region, Northeastern European Russia

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We summarized the results of palynological research of Late Glacial and Holocene sediments in northern Taiga subzone of the Timan-Pechora-Vychegda region (Fig. 1). Analysis of spore-pollen data combined with radiocarbon dating allowed to correlate the synchronous spectra and reconstruct chronologically the landscape and climate change (Fig. 2).

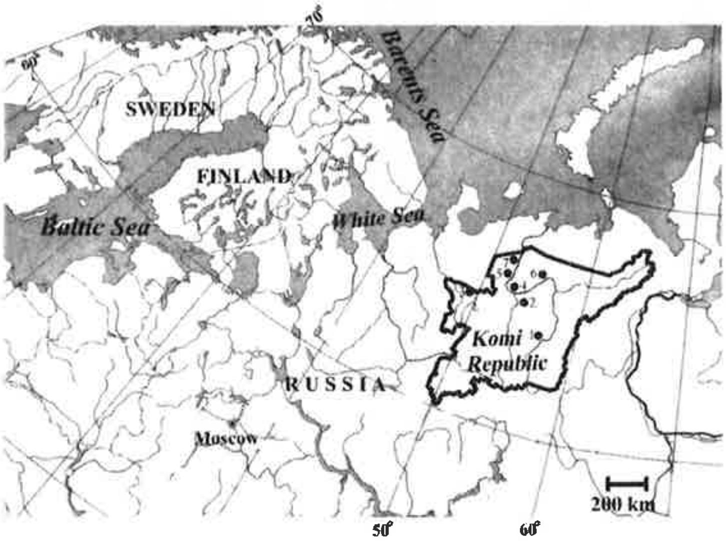

Fig.1 Location of the Holocene sediments sections: 1-Dutovo; 2-Izhma 5; 3-Pizhma 6; 4-Karpushovka; 5-Okunyov nos; 6-Denisovka; 7-Markhida.

Preboreal period (9300-10300 BP).
In the first half of the period (PB 1) in the northern regions (Pechora basin) forest formations were widespread. Open spruce, birch and larch (*Larix sibirica*) woodlands grew in the Middle Timan. Later, during the Holocene, larch was constantly present in composition of the woodland in this area. Areas in the Pechora valley were occupied by open spruce and birch woodlands. There periglacial landscapes with tundra elements and wormwood, wormseed and grameneous communities remained dominant. In the second half of the period (PB 2) periglacial vegetation partially recovered: forest formations were replaced by thickets of dwarf birch, wormwood and wormseed communities. Tundra-type landscapes expanded to the latitudinal section of the Pechora and the Peza valley.

Boreal period (8000-9300 BP).
Warming of climate in the beginning of the period (BO-1) has contributed to distributing of coniferous forests with pine, birch, alder and willow in the Vym valley. The spectra composition of the second half of the period (BO-2) indicates light-coniferouse north-taiga birch forests spread in the watershed of the Mezen and Pechorskaya Pizhma (Marchenko-Vagapova, 2014).

Atlantic period (4600-8000 BP).

Early of the period (AT-1) dark coniferous spruce forests with pine, birch and fir sprawled in the watershed of the Mezen and Pechorskaya Pizhma. In the middle of Atlantic period the north of the region was covered by dark coniferous forests, the participation of birch has increased significantly. Pollen of broad-leaved trees in the spectra was not observed. At the end of the period (AT-3) southern taiga coniferous forests extended.

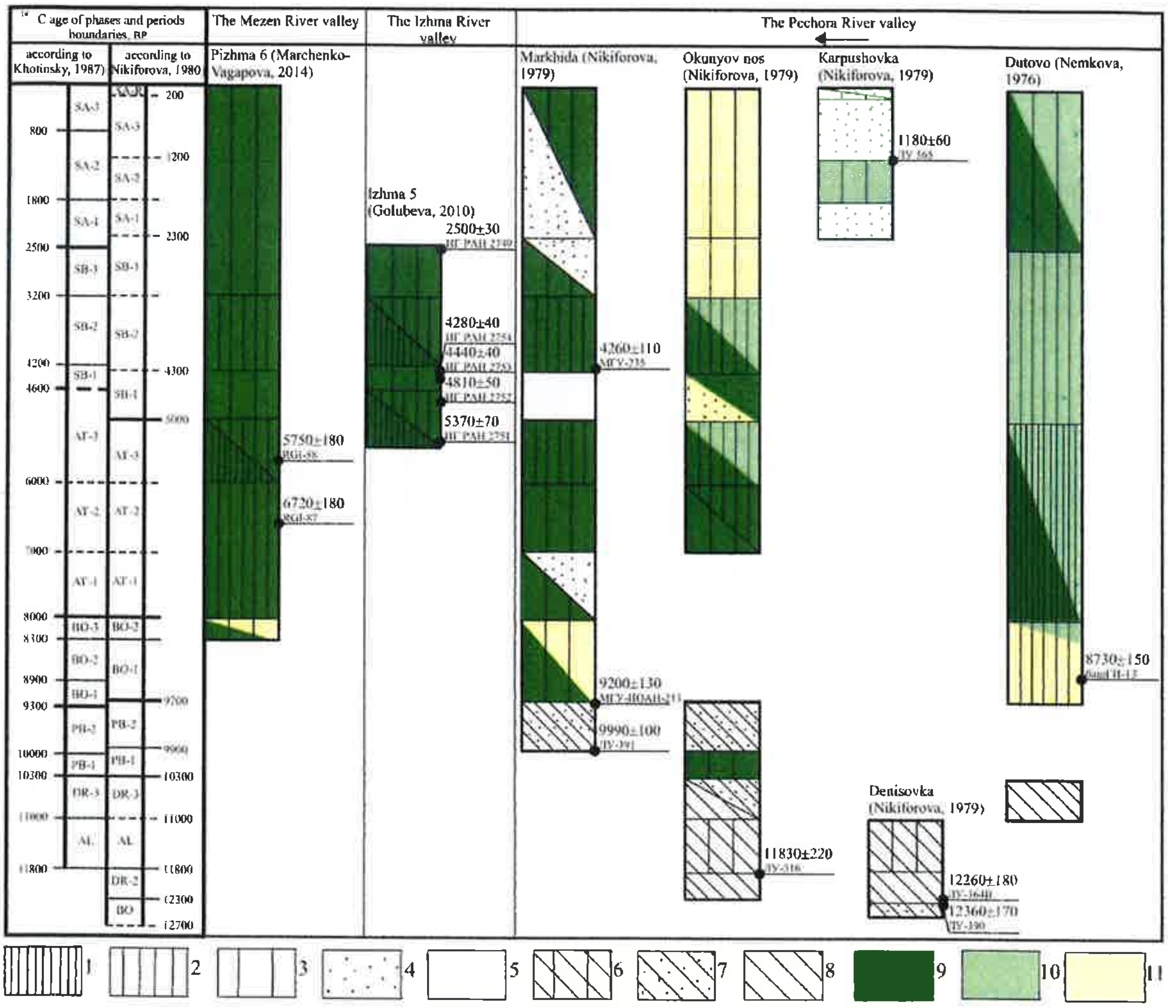

Fig. 2. Correlation of vegetation change during Late Glacial and Holocene in northern Taiga subzone of the Komi Republic: 1 - southern taiga; 2 - middle taiga; 3 - northern taiga; 4 - forest-tundra; 5 - tundra; 6-8 - periglacial landscapes: 6 - with open woodlands; 7 - with forest-tundra elements; 8 - with tundra elements; 9 - dark coniferous forests; 10 - light coniferous forests; 11 - small-leaved forest.

Subboreal period (2500-4600 BP).

At the beginning of the period (SB-1) birch and spruce forests dominated in the Izhma river basin. According to L.D. Nikiforova (1980), thickets of dwarf birch and alder sprawled in the Pechora valley. Tundra communities became dominant. In the middle of Subboreal (SB-2) dark coniferous forests occupied the Mezen and Izhma valleys and the watershed of the Mezen and Pechorskaya Pizhma rivers. Nemoral flora (elm, oak and linden) was present in the composition of the forests. The presence of broad-leaved trees pollen in the spectra indicates the location of the northern boundary of southern taiga in the area. At the end of Subboreal (SB-3) in the Izhma valley the content of broad-leaved trees, cedar and fir decreased (Golubeva, 2010).

Subatlantic period (2500 BP - present).
Early of the period (SA-1) spruce content decreased in the forests composition, pine and birch content increased. In the middle of period (SA-2) dark coniferous forests expanded. The end of the period (SA-3) is characterized by increasing of birch. Areas, occupied by forest communities, were ousted by birch open woodlands with fern thickets in the Mezen valley.

Acknowledgements:
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High-resolution 3D mapping of Saalian glacial till in the northern Netherlands

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One of the key sediment units from the northern Netherlands is the Saalian glacial till (in Dutch: "keileem"). Its shallow occurrence, lithological heterogeneity and generally high hydraulic resistance make it an important unit to be considered in regional and local groundwater models. As such, it is incorporated in the regional groundwater model MIPWA that is used by a large consortium of water partners (provinces, water boards and public water companies) from 2007 onward. In 2013, TNO – Geological Survey of the Netherlands completed a new high-resolution 3D model of the glacial till, encompassing geometry, lithological composition and hydraulic resistance (Vernes *et al.,* 2013). To construct this model, nearly all available borehole data from the DINO database and other relevant data sources was used, resulting in c. 140,000 data points in the model area, of which 36,653 data points contained till. Although data density varies over the model area, the data density generally permits the till model to be used on a sub-regional to near-local scale.

Besides the direct application in the MIPWA groundwater model, the construction of the till model has resulted in several geologically relevant observations. This presentation discusses new insights regarding the geometry and heterogeneity of the Saalian glacial till. We show the exceptional variation in till depth and thickness over very short distances (in the order of meters to tens of meters) that can now be studied at a regional scale, including the directionality present in the till geometry. Also, lithological variation of the till can now be studied over a range of local to regional scales. Furthermore, model construction has led to the identification of a second, older Saalian till in the south-eastern part of the Province of Drenthe, separated from the primary till by several meters of heterogeneous fluvioglacial sand.

Associated research into small-scale heterogeneity of the glacial sediments has led to the inclusion of the results of cryoturbation processes in the calculation of the hydraulic characteristics of the till. Cryoturbation processes have generally resulted in the fragmentation of the originally continuous till layer. By incorporating the results of cryoturbation, present-day variation in the lithological composition and hydraulic resistance of glacial sediments is better acknowledged.

Reference:

Vernes R.W., Bosch J.H.A., Harting R., Maljers D. & Schokker J., 2013. Data-inventarisatie, kartering en parametrisatie van keileem in het MIPWA-gebied, TNO-report 2013 R10107. (in Dutch)

Using the model of sedimentation rate and LOI data for determination of the features of sedimentogenesis of Vishtynetskaya highland lakes (Kaliningrad area)

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Key words: Vishtineckaya highland, sedimentation, nature-climate variability, LOI, model of sedimentation rate

The article describes the reconstruction of the sedimentation rate of Kamishovoe Lake, correlated with lithology and LOI, and calculation of average rate of sedimentation of lakes Kamishovoe and Protochnoe. Periods of high sedimentation rate relate to warm and humid periods, due to growing bio-productivity and surface runoff for allochthonous material. Protochnoe Lake has a higher sedimentation rate due larger catchment area.

One of the lead direction in paleogeography is paleolimnological reconstruction of nature and climate changes, because for understanding present climate changes we need thoroughly investigate climate changes at the past. Bottom sediment of lakes is a unique material for investigation of paleogeographical situations, as they not only conserve a pollen, diatoms and organic macrofossils, but their lithological composition are reliable material for studying the processes of sedimentation and changes in the hydrological regime of water basin.

Kamishovoe lake (54º22'531''N, 22º42'750''E, 189 a.s.l.) locate at Vishtinec highland, in south-east part of Kaliningrad district (pic. 1). The lake is located in the mid kame valley [1], in area of South Lithuania glaciation stage [6]. The thickness of selected deposits in 9.6 m, represented from bottom to top by clayey silt, clay gyttja organogenic and gyttja. On the basis of 23 radiocarbon dates [2] was made up of sedimentation velocity model with dedicated periods of intense sedimentation, lithological descriptions and LOI data (Fig.1). The average sedimentation rate is 0.6 mm / yr.
The first period of high sedimentation rate (9685- 9685 calendar years ago (cal.yr. BP) characterized by the fact that the proportion of biogenic material does not exceed 25%, which excludes the participation of the leading role of organic matter in sedimentogenesis. This period is referred to the period of transition from Boreal to the Atlantic, accompanied by high humidity, resulting in a body of water supplied in large quantities allochthonous mineral substance.
The next period of intense sedimentation stands out in the time interval 6853-5245 cal. BP, which correlates with the Atlantic climatic optimum. Warm and humid conditions favor the increased bio-productivity of the ecosystem of the lake and the surrounding landscape. High values of the LOI - more than 40%, point to the leading role of a biogenic component in the process of sedimentation.
The period from 4035 - 4258 cal. BP characterized by intense sedimentation associated with high biological productivity of the basing.
The period from 1411-1432 cal. BP is also characterized by high rates of sedimentation. This period refers to the Sub-Atlantic, as known as "viking warming" [4]. The content of biogenic substances

reaches its maximum in the history of the Holocene - 56%.
Using data from the LOI and sedimentation rate can be recovered leading factors affecting the ecosystem of the lake. Periods of intensive sedimentation rate, as a rule, are warm and humid periods, due to bio-productivity of the reservoir and bringing allochthonous material. High sedimentation rate with a predominance of allochthonous mineral substances characteristic of glacial lakes as the extremely low biological productivity is not developed soil cover, easily eroded. The relatively low rate of sedimentation is characterized by cool and dry conditions of the Holocene.

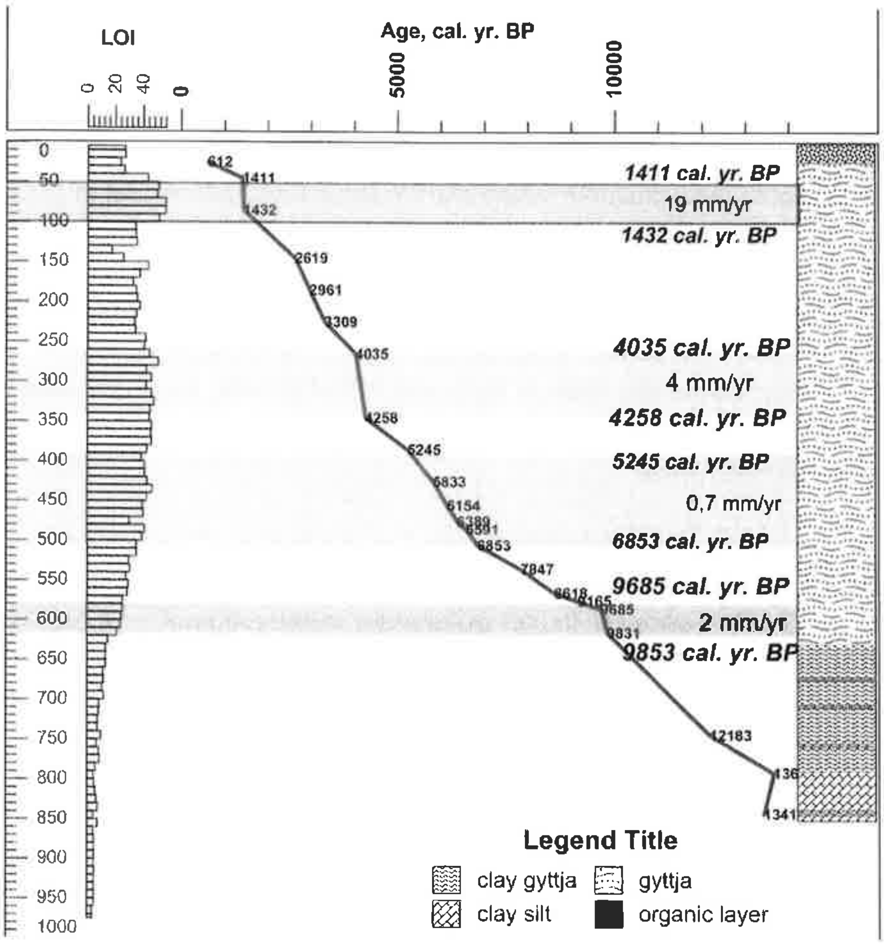

Figure 1. Model Kamishovoe lake sedimentation rates and an analysis of the lake sediments Flowing.

Protochnoe lake (Borovikovo) (52 ° 59`38`` N, 23 ° 55`50`` E, 154 m above sea level) located in Vishtineckaya highland, at 7 km north-east from the Kamishovoe lake. The thickness of selected deposits is 8.7 m, represented from bottom to top by sand, peat, clay and organogenic gyttja [3].
On the basis of a radiocarbon dating and LOI data it is not possible to build a full reconstruction of the intensity of the sedimentation, so we calculated the average sedimentation rate for the whole section - it was 0.7 mm / year. Figure 1 shows that the dynamics of the LOI has both similar and distinctive features of the dynamics of the LOI to the Kamishovoe lake.

If you compare the sedimentation rate of the two lakes, it can be stated that the rate of sedimentation of Protochnoe Lake at 0.1 mm / year more than the rate of sedimentation of Kamishovoe Lake. This is probably due to the lower hypsometric position of the Protochnoe lake and with a larger catchment resulting in lake demolition allochthonous material than in the Kamishovoe lake.

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