

Program

***TRAINING SCHOOL: PALAEO-
COASTLINES OF THE BALTIC SEA AND
STONE AGE COASTAL SETTLEMENTS***

September 10.-15.2012

University of Tartu
Institute of Ecology and Earth Sciences
Pärnu 2012

Organized by: The University of Tartu in cooperation with the University of Latvia, Faculty of Geography and Earth Sciences and Klaipėda University.



Supported by: Doctoral School of Earth Sciences and Ecology, University of Tartu, by COST Action TD0902 „Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf“ and by Estonian Science Foundation Project: „Post-glacial coastline changes of the Baltic Sea and its relations with Stone Age settlements in Estonia“.



Program edited by: Hanna Raig, Hando-Laur Habicht, Merle Muru, Alar Rosentau

Training School: Palaeo-coastlines of the Baltic Sea and Stone Age coastal settlements

Takes place in Hotel Strand, Pärnu, Estonia Sept 10-15 2012.

Training school is addressed to doctoral students and early stage researchers (up to 8 years after PhD) of Earth Sciences and Archaeology and is aimed to give knowledge on Stone Age coastal settlements and post-glacial water-level indicators of the Baltic Sea. The training school consists of introductory lectures, poster session and geological-archaeological field-trip. During the field-trip we will travel from the isostatically uplifting coast in Pärnu region (SW Estonia) down to the subsiding coast in Klaipeda-Nida region (N Lithuania) and will examine the past water-level indicators and Stone Age coastal settlements of this transitional zone. We will study inundation and preservation processes of Stone Age coastal settlements which were flooded during the transgressions and later uplifted above the present sea level and will visit archaeological excavations of a Stone Age coastal settlement site. On the field-trip we will introduce relevant geological and archaeological fieldwork techniques including the usage of different coring equipments and geophysical methods.

The training school is organized by the Institute of Ecology and Earth Sciences, University of Tartu and supported by Doctoral School of Earth Sciences and Ecology, University of Tartu, by COST Action TD0902 „Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf“ and by Estonian Science Foundation Project: „Post-glacial coastline changes of the Baltic Sea and its relations with Stone Age settlements in Estonia”.

List of trainers

Prof. Geoff Bailey (University of York, United Kingdom)

Prof. Vladas Zulkus (Klaipeda University, Lithuania)

Dr. Albertas Bitinas (Coastal Research and Planning Institute, Klaipeda University, Lithuania)

Dr. Aldona Damusyte (Geological Survey of Lithuania, Lithuania)

Dr. Lembi Lõugas (Institute of Archaeology, Tallinn University, Estonia)

Prof. Laimdota Kalnina (University of Latvia, Latvia)

Prof. Guntis Eberhards (University of Latvia, Latvia)

Dr. Valdis Berzins (Institute of Latvian History, University of Latvia, Latvia)

Prof. Aivar Kriiska (Institute of History and Archaeology, University of Tartu, Estonia)

Dr. Jüri Plado (Department of Geology, University of Tartu, Estonia)

Dr. Alar Rosentau (Department of Geology, University of Tartu, Estonia)

Prof. Algirdas Girininkas (Klaipeda University, Lithuania)

Program

Monday (Sept 10)

9.00-9.30 Registration

9.30-10.00 Introduction of the program (Alar Rosentau)

10.00-11.00 The Archaeology of sea-level change and submerged landscapes (Geoff Bailey)

11.00-11.15 Coffee break

11.15-12.00 Stone Age coastal settlements in Eastern Baltic (Aivar Kriiska)

12.00-13.00 Lithuanian coast of the Baltic Sea: geological structure, development and recent geological processes (Albertas Bitinas)

13.00-14.00 Lunch

14.00-16.00 Resource utilization by prehistoric people at the coastal zone of the eastern Baltic (Lembi Lõugas)

16.00-18.00 Poster session (participants of the Training School)

Tuesday (Sept 11)

9.15-10.00 Submerged prehistory and SPLASHCOS project (Geoff Bailey)

10.00-11.00 Problems of reconstruction of the Baltic Sea level fluctuation during Late Glacial and Holocene (Albertas Bitinas)

11.00-11.15 Coffee break

11.15-12.00 Relative sea level indicators and reconstructions in Estonia (Alar Rosentau)

12.00-13.00 Ground-penetrating radar in archaeology (Jüri Plado)

13.00-14.00 Lunch

14.00-15.00 Early settlement in Pärnu area (Aivar Kriiska)

15.00-18.00 Stop 1 and Stop 2 Field Trip to visit Stone Age settlements and buried peat layers in Pärnu area (Aivar Kriiska, Alar Rosentau)

Wednesday (Sept 12)

9.00-18.00 Field Trip from uplifting to subsiding coast: Pärnu-Riga-Ventspils

Stop 3. Tolkuse mire and Rannametsa dunes (Alar Rosentau)

Lunch in Lido, Riga

Stop 4. Priedaine Neolithic site and its palaeoenvironment (Valdis Berzins, Guntis Eberhards, Laimdota Kalnina)

Stop 5. Outcrop of buried gyttja and peat layer, hoard findspot at Staldzene (Laimdota Kalnina, Valdis Berzins)

Overnight in Ventspils Seaside Camping

Thursday (Sept 13)

9.00-18.00 Field Trip from uplifting to subsiding coast: Ventspils-Nida

Stop 6. Archaeological excavations of Lapini Mesolithic settlement near Sarnate (Valdis Berzins)

Stop 7. Buried gyttja and peat layer at Baltic Sea Bluff near Sarnate Neolithic settlement (Laimdota Kalnina, Valdis Berzins)

Lunch in Grobina

Stop 8. Litorina and Post-Litorina Sea terraces near Palanga (Aldona Damusite)

Stop 9. Neolithic settlements near Palanga (Sventoji) (Algirdas Girininkas, Vladas Zulkus)
Overnight in Jurate Hotel, Nida.

Friday (Sept 14)

9.00-16.00 Field Trip from uplifting to subsiding coast: Nida

Stop 10. Parnidis dune and lagoon marl exposure (Aldona Damusyte)

Lunch in Nida

Stop 11. Buried soils in the Grey (Dead) Dunes nature reserve (Albertas Bitinas, Nikita Dobrotin)

16.00-18.00 Seminar and closing of the training school (Alar Rosentau)

Overnight in Jurate Hotel, Nida.

Saturday (Sept 15)

Transport from Nida via Riga Airport to Tartu



Stop 1 and Stop 2: Stone Age Settlements and Buried Peat Layers in Pärnu Area

Aivar Kriiska¹, Alar Rosentau²

¹Institute of Archaeology, University of Tartu, Lossi 3, Tartu, Estonia

²Institute of Ecology and Earth Sciences, University of Tartu, Ravila 14A, 50411 Tartu, Estonia

The study area in SW Estonia (Fig 1), on the eastern coast of Gulf of Riga, is characterized by slow post-glacial isostatic uplift (apparent uplift about 1mm/yr) and slowly undulating low topography. Therefore, even small increases of sea-level can easily lead to flooding of substantial areas. The complex deglaciation history of the Baltic Sea area, with up-dammed lakes and early phases of post-glacial seas has, at times, left southwestern Estonia submerged, while at other times, it has emerged as terrestrial land. Therefore, transgressive deposition of water-laid sediments of the Ancylus Lake and the Litorina Sea have led to repeated burial of soil, peat and gyttja deposits and associated settlement layers (Fig. 2.).

The Pärnu area is rich in sites from different prehistoric periods. Coastal habitation is characteristic of the Stone Age. The Pulli, Sindi-Lodja I and II and Jõekalda settlement sites in the lower reaches of the Pärnu River and the Malda, Lemmetsa I and II settlement sites in the lower reaches of the Audru River are important in this context.

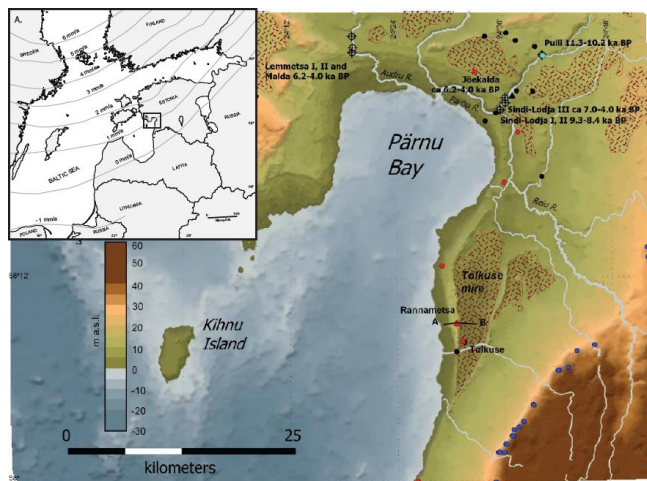


Fig 1. Study area in SW Estonia

Several vertical sections studied in Pärnu area provide high-resolution records for bio-and chronostratigraphical, geological, archaeological and palaeogeographical reconstructions of the interaction of man and environment during the early phases of the Baltic Sea in the area.

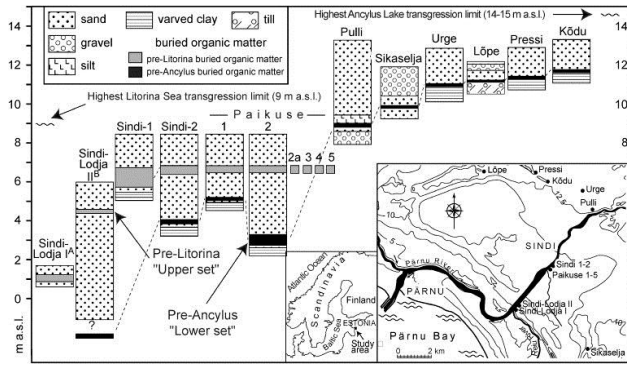


Fig. 2. Location of study sites in the Pärnu area and a simplified geological cross-section. Buried organic matters represent either the pre-Ancylus Lake and/or pre-Litorina Sea lowstand and terrestrial accumulation (peat/cultural layers). Pulli and Sindi-Lodja are Stone Age settlement sites.

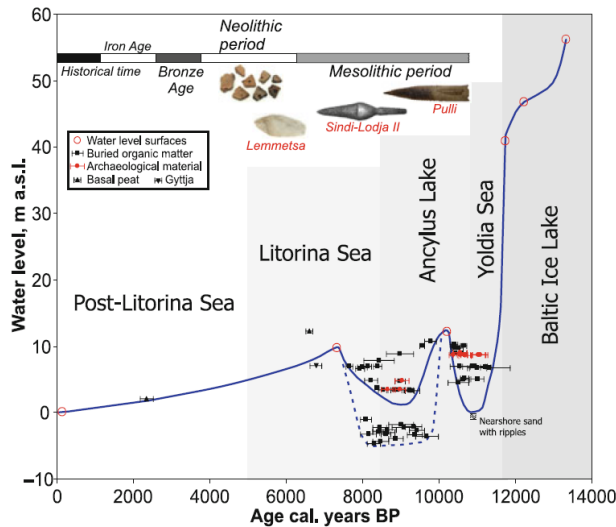
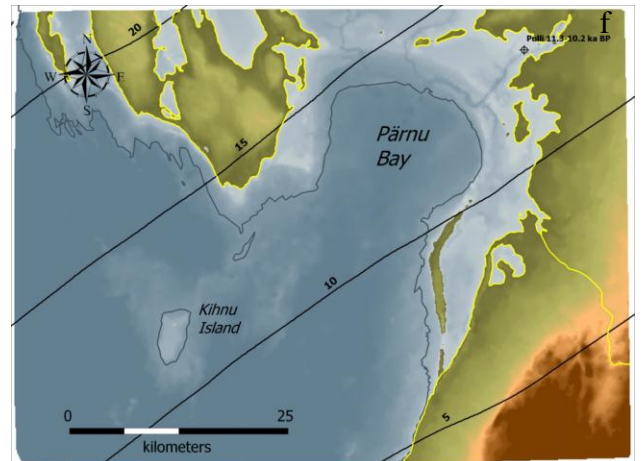
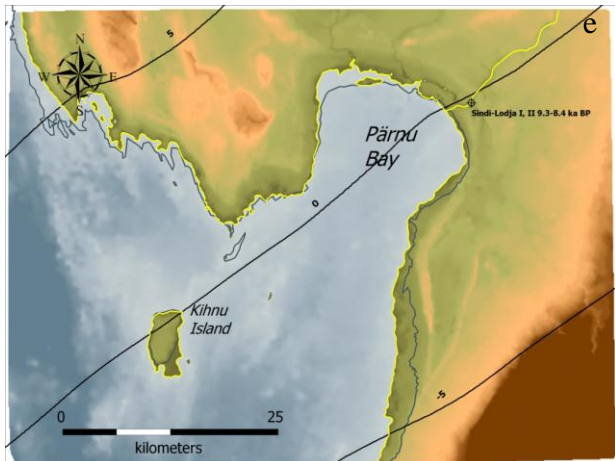
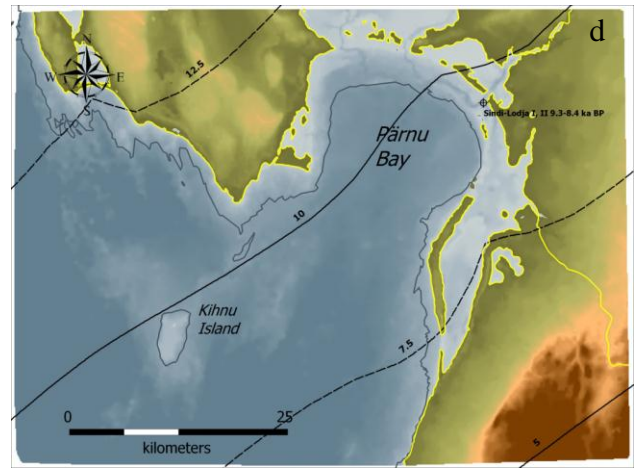
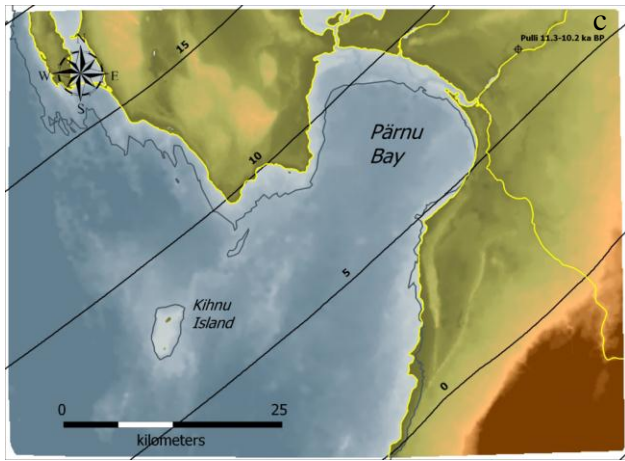
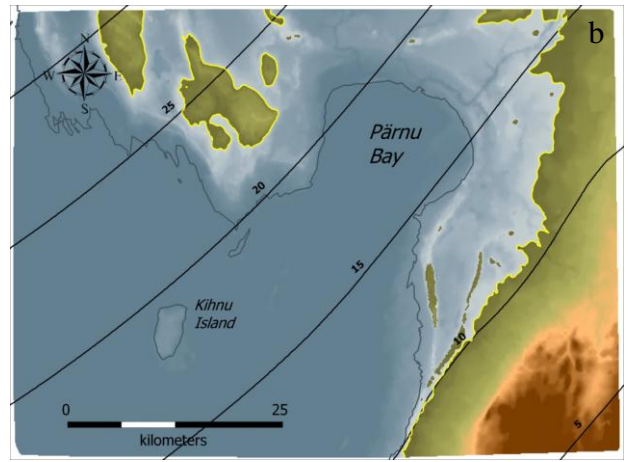
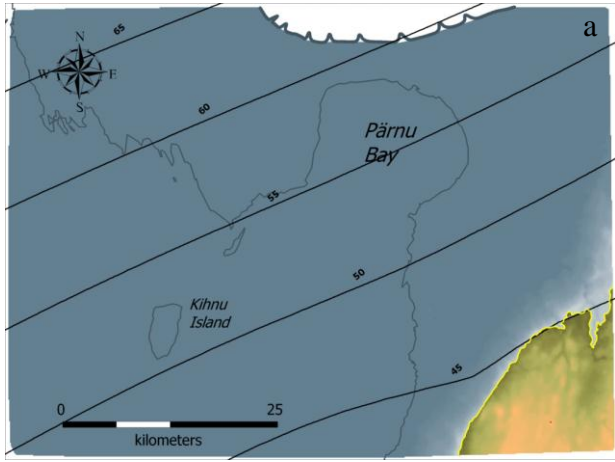


Fig 3. The Holocene shore displacement curve for SW Estonia was constructed on the basis of coastal landform elevations and 14C dated buried peat and soil sequences below Ancylus and Litorina sediments. The curve displays three regressive phases of the past Baltic Sea interrupted by the Ancylus Lake (10.6-10.2 cal ka BP) and the Litorina Sea transgressions (8.6-7.3 cal ka BP) with magnitudes 12 m and 10 m

The use of digital terrain models (DTM) and GIS-based spatial calculations has opened up new perspectives for the reconstruction of palaeo-water bodies in formerly glaciated areas. Palaeoreconstructions are based on spatial calculations in which glacioisostatically deformed water-level surfaces are subtracted from the DTM. Palaeo water level surfaces were calculated for relevant time periods by interpolation in space and time using late glacial and Holocene shoreline databases.

Combination of geological, geodetic and archaeological shore displacement evidence was used to create a temporal and spatial water-level change model for the SW Estonian coast of the Baltic Sea since 13,300 cal. years BP. The Baltic Sea shoreline database for Estonian territory was used for the modelling work and contained about 1,200 sites from the Baltic Ice Lake, Ancylus Lake and Litorina Sea stages. This database was combined with a shore displacement curve from the Pärnu area (Fig. 3) and with geodetic relative sea-level data for the last century. The curve was reconstructed on the basis of palaeocoastline elevations and radiocarbon-dated peat and soil sequences and ecofacts from archaeological sites recording three regressive phases of the past

Baltic Sea, interrupted by Ancylus Lake and Litorina Sea transgressions with magnitudes of 12 and 10 m, respectively.



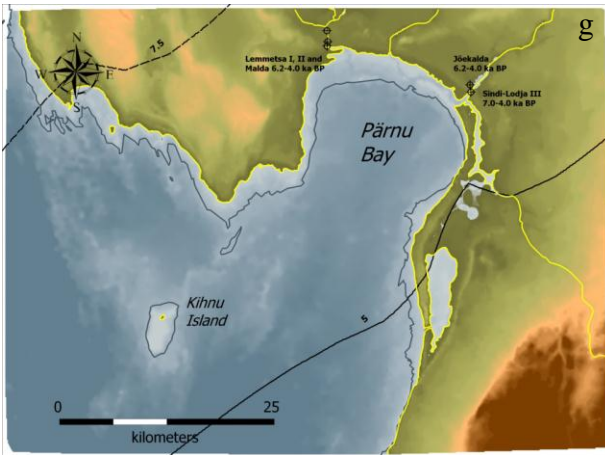


Fig 4. Palaeogeographical reconstructions of the Baltic Sea coastline during different stanges:

(a) the Baltic Ice Lake during the deglaciation of the Pärnu area and formation of the end-moraines of the Pandivere-Neva ice marginal zone at about 13,300 cal. years BP, (b) the Baltic Ice Lake after the Billingen drainage at about 11,600 cal. years BP, (c) Ancylus Lake at the beginning of the transgression and during the Pulli settlements at about 10,500 cal. years BP, (d) Ancylus Lake during its maximum in the Pärnu area at about 10,200 cal. years BP, (e) the Litorina Sea before the transgression and during the Sindi-Lodja I and II settlements at about 9,000 cal. years BP, (f) the Litorina Sea during its maximum in the Pärnu area at about 7,300 cal. Years BP, (g) the Litorina Sea after the

transgression and during the Lemmetsa, Malda, Jökalkalda and Sindi-Lodja III settlements at about 6,000 cal. years BP

Pulli is the oldest known human occupation in Estonia and it is dated to the Early Mesolithic 11.3-10.2 cal ka BP. Pulli was situated on the ancient Pärnu River, a few km from the Ancylus Lake but is now 15 km from the present sea shore. By the character of soil and find material it is assumed, that Pulli was a seasonal hunting and fishing camp. Bone material is well preserved and typical of the hunter-fisher-gatherer economy with dominance of elk and beaver bones. Pulli site was buried under the transgressive Ancylus Lake sediments.



Fig 5. Pulli settlement site

The site of Sindi-Lodja II is located on the left bank of the Pärnu River, approximately 400m upstream from the mouth of the Reiu. The cultural level, alternating with layers of sand, is located on the steep river-bank, about six metres lower than today's ground level. The find material obtained from the small area excavated was relatively rich. It is not clear, if the site was inhabited seasonally or year-round. Compared to Pulli, ringed seal is more represented in the bone material, indicating the growing importance of seal hunting. The radiocarbon dates obtained from the wood gathered from the cultural layer gave a result of 9.3-8.4 cal ka BP, i.e. the Middle Mesolithic. Sindi-Lodja II was buried under the transgressive Litorina Sea sediments.



Fig 6. Sindi-Lodja II settlement site

Most tools found in the Stone Age sites in Pärnu area are made of flint. At Pulli, the flint is of high quality, often (brownish) black. It is most probably from southern Lithuania, Belorussia or the Ukraine. During Middle/Late Mesolithic also local, low quality Silurian flint tools were used.

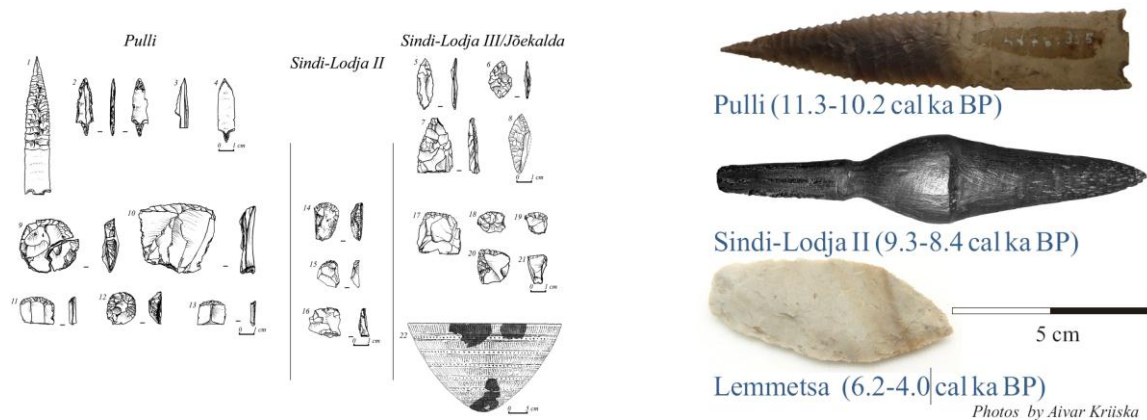


Fig 7. Different artefacts from sites in the Pärnu area.

References

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& Oja, T. 2011: Palaeogeographic model for the SW Estonian coastal zone of the Baltic Sea. *In* Harff, J., Björck, S. & Hoth, P. (eds.): *The Baltic Sea Basin*, 165–188. Central and Eastern European Development Studies, Springer-Verlag, Berlin.

Veski, S., Heinsalu, A., Klassen, V., Kriiska, A., Lõugas, L., Poska, A. & Saluäär, U. 2005: Early Holocene coastal settlement and palaeoenvironment on the shore of the Baltic Sea at Pärnu, southwestern Estonia. *Quaternary International* 130, 75–85.

Stop 3. Tolkuse Mire and Rannametsa Coastal Landforms: Holocene Water-level Changes on the Slowly Uplifting Coast of SW Estonia

Alar Rosentau, Tiit Hang, Marko Kohv, Hando-Laur Habicht

Institute of Ecology and Earth Sciences, University of Tartu, Ravila 14A, 50411 Tartu, Estonia

Geological data from Rannametsa coastal landforms and Tolkuse mire reflects the Holocene water level change history of the past Baltic Sea and will be discussed together with other shore displacement evidences from SW Estonian coast during the excursion (Fig 1).

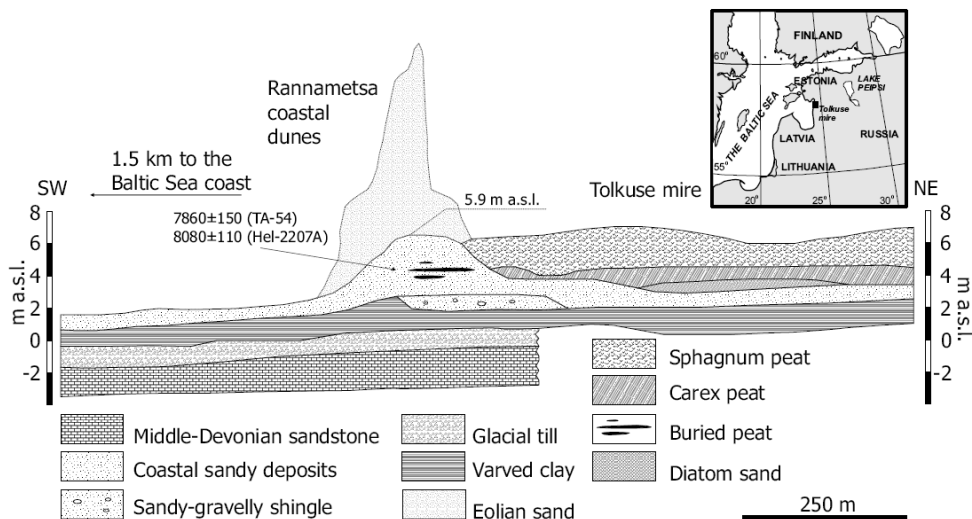


Fig 1. Geological cross-section of the Rannametsa coastal landforms with datings (uncalibrated ^{14}C years) and Tolkuse mire (after Hyvärinen et al., 1992).

The Tolkuse mire (5500 ha) is located between the Ancylus Lake and the Litorina Sea (Rannametsa) coastal ridges (Fig. 1). An 8 m long sediment core from the southern part of the mire, was investigated and preliminary results of lithostratigraphy, loss-on-ignition, diatom analysis and radiocarbon dates were used and applied with digital terrain model to reconstruct

the evolution of the area. We discovered a 0.20 m thick peat layer buried under the layer of fine sand and gyttja which is covered by *Carex* peat (Fig. 2). Two radiocarbon dates from the buried peat layer indicate the pre-Litorina Sea lowstand at about 8.8-8.2 cal ka BP. This is the lowermost known buried peat layer in SW Estonia reflecting the pre-Litorina Sea low water level stage. Diatom analysis confirms that the silt layer below the peat contains large lake diatoms, such as *Ellerbeckia arenaria* and *Aulacoseira islandica*, typical to the Ancylus Lake freshwater environment. The sandy deposits above the peat contain already diverse assemblage of the littoral brackish-water diatoms indicating deposition in the Litorina Sea shallow lagoon (Rosentau et al., 2010). The sandy deposits are interbedded with thin peat layers characteristic to the transgressive sediments of the Litorina Sea found elsewhere in SW Estonia. Transgressive sands are covered by thick layer of gyttja deposits containing a mixture of planktonic and littoral brackish-water and marine diatoms suggesting basin with deeper water column and higher salinity. The gyttja is overlain by younger *Carex* type peat. The onset of peat formation is dated to ca. 4.2 cal ka BP (Fig. 2).

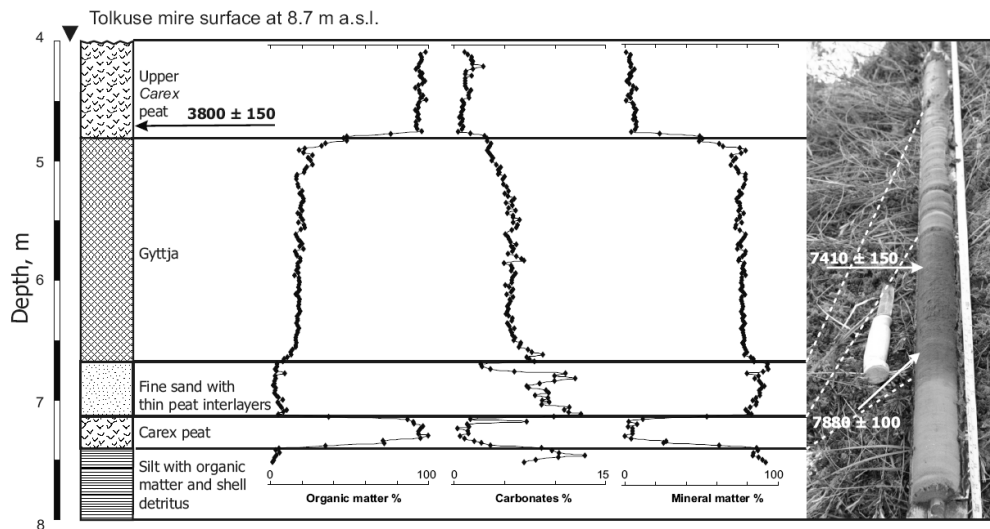


Fig 2. Buried peat layer and results of LOI and radiocarbon dating (uncalibrated ^{14}C years) from the Tolkuse sediment core of 2009.

Palaeogeographic reconstruction shows that the study area has been flooded by transgressive waters of the Ancylus Lake at about 10.2 cal ka BP. and the palaeocoastline was located east of the Tolkuse mire at an altitude of 10-7 m a.s.l. During the Ancylus Lake regression the coastline retreated to the west from the Tolkuse mire and stopped probably close to the present-day shoreline (Fig. 1). Hyvärinen et al. (1998) described a section of peat and clayey gyttja (3-4 m a.s.l.) buried under the sandy deposits of the Litorina Sea at Rannametsa (Fig. 1). Earlier radiocarbon dates from Rannametsa and our dates from Tolkuse mire show the simultaneous formation of the buried peat deposits at about 9.0-8.2 cal ka BP and indicate the emergence and formation of wetland in Tolkuse area. The Litorina Sea transgression in the study area started at about 8.2 cal ka BP. During the transgression the coastal ridges at Rannametsa formed, damming up the Tolkuse lagoon. Sandy deposits alternating with thin peat layers formed in the lagoon in shallow water conditions with active wave regime and erosion of older organic deposits. Stabilized shoreline position at Rannametsa during the transgression initiated probably the dune

formation on top of the coastal ridge. At the time of the culmination of the Littorina Sea at about 7.3 cal ka BP, 20 km long and 5 km wide lagoon developed in Tolkuse area. The water-level in the lagoon was about 8 m a.s.l. in the north and about 6 m a.s.l. in the south and the water depth was up to 5 m. Our reconstructions show that Tolkuse lagoon had two passages: one in the north and another in the south. The northern passage was about 2 km wide and functioned initially as a main connection route with the Baltic Sea basin. Palaeogeographic reconstructions show that the northern passage was the first to close at about 6.0 cal ka BP due to the more intense land uplift. Radiocarbon dates from our sediment core suggest, that brackish water lagoon existed in Tolkuse area for 4000 years and terminated before 4.2 cal ka BP.

References

- Hyvärinen, H., Raukas, A., Kessel, H. (1998) Mastogloia and Littorina Seas. In: Raukas, A. and Hyvärinen, H. (eds.) *Geology of the Gulf of Finland*, pp 296–312 (in Russian with English summary)
- Rosentau, A.; Hang, T.; Heinsalu, A.; Kohv, M. (2010). Holocene development of the Baltic Sea in Tolkuse area, SW Estonia. In: . (Eds.) Lorenz, S.; Lampe, R. *Ice, water, humans - Quaternary landscape evolution in the Peribaltic region: 12th Annual meeting of the INQUA Peribaltic working group*, Greifswald, Germany, 13-17 Sept 2010., 2010, 64 - 65.

Stop 4. Priedaine Neolithic Site and its Palaeoenvironment

Valdis Berzins¹, Guntis Eberhards² and Laimdota Kalnina²

¹University of Latvia, Institute of Latvian History, ²University of Latvia, Faculty of Geography and Earth Sciences

Geology

Priedaine Stone Age settlement is located on the slope and the foot of flat dune wall, approximately 1.3 km to the east from Priedaine railway station and 0.6 km from right bank of Lielupe River (Fig. 1). Dune ridge from the mainland has border with Littorina Sea Babītes - Spilves meadow lagoonal plain and Slēpere Mire from the east. There are two peculiarities of the relief according the geological structure at the Priedaine Stone Age settlement: dune ridge and lagoonal plain.

Palynological investigations of sediments in core 20 in the locality of Priedaine Stone Age settlement (Kalnina at al., 2009) shows organic sediments accumulation in lagoon start at the middle part of the Holocene about 6500 years ago. Landscape was relatively open during that time – area mainly covered with sedge and grass, but in the dry places broad-leaved and alder forest was distributed. Accumulation conditions have been changed in Priedaine lagoon. Gytja with sand and silt layer and presence of salty water diatom species indicates frequent sea water

indicates that sea water didn't flow into lagoon anymore during next phase of lagoon development and water became less salty and unsuitable for growing of these plants.

Ic – aquatic plants *Nymphaea alba*, *Zannichellia palustris*, *Najas marina*, *N. flexilis* and increase of mire plant remains (end of climatic optimum, beginning of the Late Holocene).

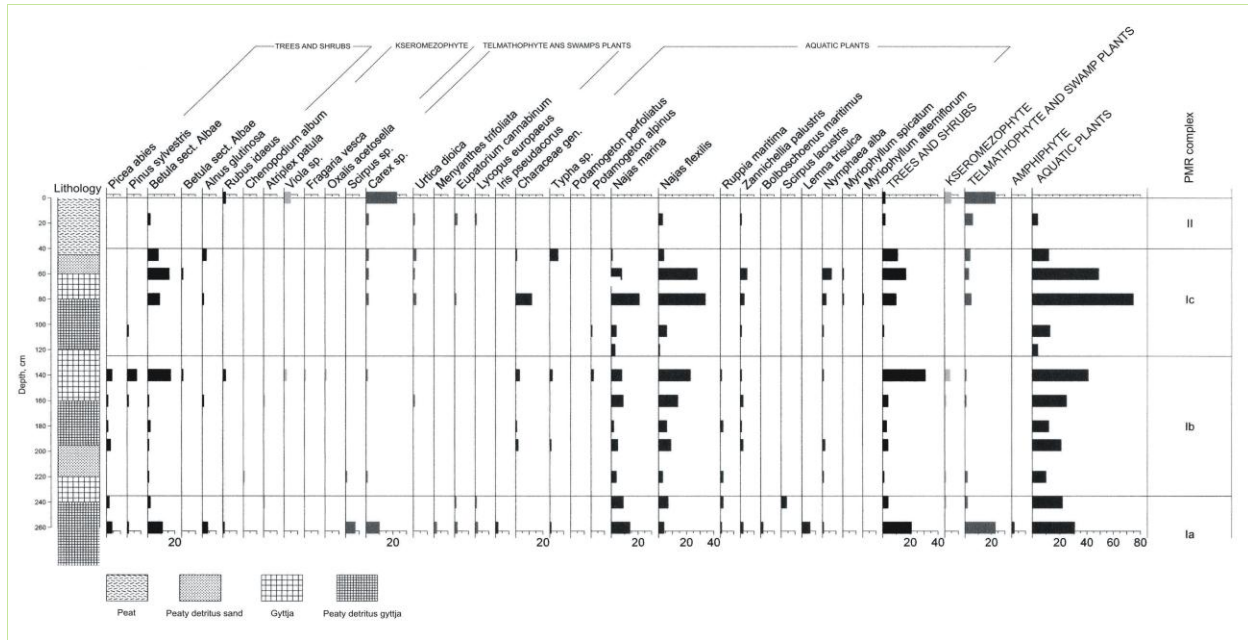


Fig. 2. Plant macroremain diagram from Priedaine site. Analysed by Aija Cerina.

II – dominance of terrestrial plant remains (end of SB, SA). Sharp decrease of aquatic plant species and plant remains as well increase of mire, wet meadow and other terrestrial plants can be observed in the upper part of section (0.6 – 0.17 m). That point on rapid paludification of area and overgrowing of water basin. Only two aquatic plant remains have been found in depth interval 0.45 – 0.17 m, but above this interval just mire plants.

Data of both pollen and macroremain analysis indicate Priedaine lagoon development since the middle part of the Holocene climatic optimum until end of it. Lagoon became as lake during the first part of the Late Holocene and continues to fill in and mire has been developed in the area of the former Littorina Sea lagoon during the Late Holocene.

Archaeology

Already in 1975, the local museum in the seaside town of Jūrmala was given some Neolithic artefacts found in the woods at Priedaine. However, it was not until many years later that the site came to the attention of Stone Age researchers. In 2007 the first trial excavation was conducted at the site by the Institute of Latvian History under the direction of Valdis Bērziņš (Fig. 3).

Twelve test-pits were excavated on the slope of a dune and at the edge of the adjacent boggy plain. In the test-pits on the dune slope, a Neolithic occupation layer was found in the sand

layers, and in Test-pit 12, at the foot of the slope, archaeological material was recovered in a layer of sandy fen peat.

The finds include sherds of Comb Ware, flint tools and debitage, two amber pendants, worked and unworked pieces of amber, a miniature stone chisel, a whetstone and two unworked pebbles, probably used as net sinkers. In Test-pit 12, wooden laths and the tip of a stake were found – thought to be remains of Neolithic fishing gear (Fig.4).

Excavation continued in 2008 in collaboration with the Roman-Germanic Commission of the German Institute of Archaeology (Frankfurt), this time focusing attention on the wet part of the site at the foot of the dune slope. Test-pit 12 was extended into a small excavation area (2×3 m). This area was excavated in 5 cm spits, and all the excavated earth was wet-sieved. It turned out that the steep slope of the dune continues under the peat. The stratigraphy in the excavated area consisted of peat layers that had accumulated in the course of terrestrialisation of a former lake, alternating with layers of peaty sand, i.e. sand eroded from the upper part of the sandy slope and redeposited at the edge of the bog. The area was excavated to a maximum depth of 0.9 m. The finds continued in the gyttja layer beneath the peat, but the rapid inflow of water and time shortage prevented complete excavation.

Structural remains were not observed (only the end of one pile), but there were fragmentary artefacts scattered in the peat and sand layers. It was concluded that the settlement itself had been further upslope, and that the wetland part of the site represents the former shore zone of the lake, where occupation refuse accumulated.

Some unusual wooden artefacts were discovered: one of them was a long, very regular stick of semicircular section, with oblique grooves cut into the rounded side, whereas the other side was flat. Its function remains unknown, since no archaeological or ethnographic parallels have been identified.

Many sections of pine wood laths were also recovered, two of them wound with birch bark strips. These are evidently remains of fish fences, such as have been found at many other Neolithic sites in north-eastern Europe.

The pottery recovered at Priedaine includes sherds from mineral-tempered and shell-tempered vessels, decorated with comb, wound cord and other impressions. The pottery shows strong Comb Ceramic influence, but also features going back to the Early Neolithic ceramic tradition of the East Baltic.

Food remains include hazelnut and water chestnut (*Trapa natans*) shells, fish scales and some poorly preserved animal bone.

Five AMS radiocarbon dates have been obtained from macrofossil samples taken from the wetland part of the site. They cover the period approximately 3970–3520 cal. BC, i.e. the earlier part of the Middle Neolithic. The shoreline at this time would have been about 1 m above present sea level.

Fieldwork and analysis was supported by Jūrmala Town Council, the Culture Capital Foundation of Latvia and the Roman-Germanic Commission of the German Institute of Archaeology.



Fig.3. Excavation at Priedaine, 2008



Fig.4. Finds from Priedaine: wooden artefact of unknown function, amber pendant, Comb Ceramic sherd.

Stop 5. Outcrop of buried gyttja and peat layer, hoard findspot at Staldzene

Laimdota Kalnina¹ and Valdis Berzins²

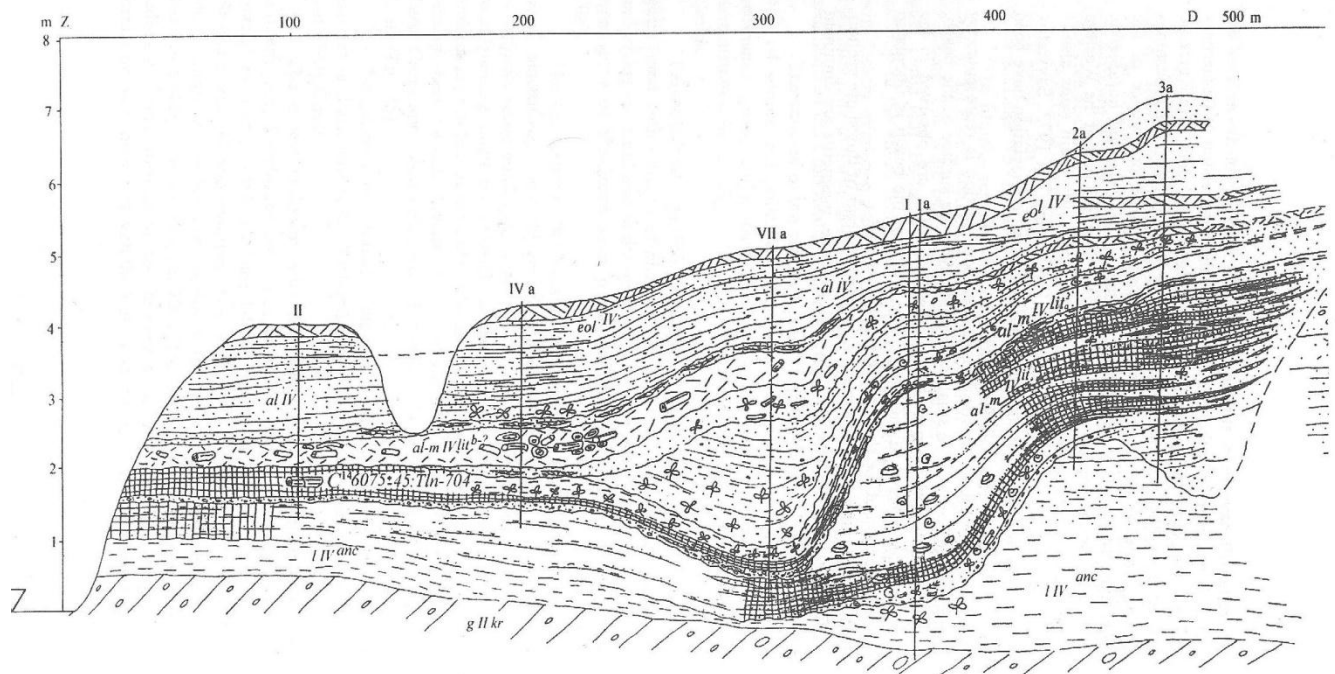
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Geology

The Staldzene outcrop is located at the Baltic Sea is typical abrasion cliff, length about 4 km from accumulative shore near Ventspils harbour to the Busenieks Lake at the north. The abrasion cliff outcrop has the altitudes 8-12 m above sea level. It occurred in the result of along coastal stream erosion activity, which increases after construction of the Ventspils harbour jetty. Nowadays each storm takes away several meters of deposits from outcrop. Therefore earlier investigated sections already are washed away by sea, which have been investigated by I. Veinbergs (1999), Z. Meirons (Meirons et al., 1985), A. Cerina, E. Bulgakova (1985).

The sediment sequence at the outcrop southern Staldzene site are formed under conditions of the different Baltic Sea stages and overlie grey till of the last glacial (Fig. 1). Sediment structure can be characterised as follow: bluish-grey silt, silty clay and fine sand, large bed of the lacustrine deposits represented by the gyttja, peat and eolian sand (Cerina, Bulgakova, 1985; Savvaitov, A. et al., 1998).



A. Cerina, J. Bulgakova, 1985

Fig. 1. Geological longitudinal section of the Staldzene outcrop.

Sediment sequence has been analysed by lithological, paleobotanical methods (Veinbergs, 1996), as well as dated by ^{14}C . The underlying sediments of the Ancylus Lake contain *Selaginella selaginoides* (L) Link. The remains of *Zannichellia palustris* L. have been found among plant macrofossils in the Ancylus Lake sediments. There have been found the plant macroremains of *Betula alba* L., *Pinus* sp., *Picea* sp., *Potamogeton filiformis* Pera, *Carex* spp., *Alnus glutinosa* (L) Gaertn., *Rubus idaeus* L., *Menyanthes trifoliata* L. etc. These sediments contain the remains of the wood, fossils and plants. The wood was dated at 10850 cal years (9440 ± 90 ^{14}C years Tln 706) BP. This date allow to suggest that characterized sediments were formed at the beginning of the Ancylus Lake transgression. Palynological data indicate that the bed of the organic deposits (peat, gyttja, sand with remains of plants) formed during the climatic optimum and its ending part, but underlying sand and bluish-grey silt and silty clay - during the before climatic optimum, probably during Ancylus Time. The wood from gyttja of Staldzene outcrop was radiocarbon-dated at 6873 cal. years (6075 ± 45 ^{14}C years) BP.

Gyttja from the Staldzene outcrop contain diatoms, predominantly represented by freshwater planktonic species: *Aulacosira ambigua*, *A. granulata*, *Stephanodiscus astrae* var. *minutulus*, and *S. astrae* var. *intermedia*.

In the section have been found also large diverse of benthos species, however in small amounts. *Opephora marthyi*, *Fragilaria brevistriata*, *F. construens* var. *construens* et var. *binodis*, et var. *venter*, *F. inflata*, *Cocconeis placentula*, *Epithemia zebra*, *E. sorex* u.d.c. has been found more frequently. There have been found also species characteristic for gyttja *Cocconeis disculus disculus* et var. *diminuta*, *Synedra parasitica*.

In small numbers (17 species, 7% from total amount) have been found very well preserved brackish species like *Navicula forcipata*, *Diploneis smithii* var. *smithii* et var. *rhombica*. These data allow suggesting frequent sea water inflow in the basin. In the silt above gyttja have been stated 14 mesohalobous taxa, including some species for the first time: *Nitzschia scalaris*, *Campylodiscus clipeus*, *C. echeneis*, *Synedra tabulata*, *Diploneis interrupta*, *Navicula humerosa*, *N. paregrina*. Marine species like *Diploneis smithii* var. *smithii* et var. *rhombica* and *D. didyma* have been found in significant amounts, which allow suggesting that silt overlying have been formed under conditions of frequent marine water presence. The most possible it can take place during a transgression of the Littorina Sea. Nowadays lagoonal and alluvial sediments appear at the coastal outcrop due to coastal erosion, which increase after building of Ventspils harbour jetty.



Fig.2. Gyttja and peat layers at the Staldzene site and waterfalls

Archaeology

The stormy weather of early November 2001 eroded part of the coastal sand cliff at Staldzene, revealing a large number of bronze artefacts: the Staldzene Hoard. This is the largest deposit of Bronze Age artefacts ever discovered in the territory of Latvia. When all the material was brought together, there was an impressive array of finds: 174 bronze artefacts and fragments (around 80 items after refitting of the fragments), a total of 5.6 kg of bronze. In the Bronze Age, bearing in mind that the territory of Latvia was far from the metallurgical centres of the time, bronze reached the area in limited amounts, and such an amount of metal represents as an immense quantity, possibly even a priceless treasure. Up to the finding of the Staldzene Hoard, only 165 bronze artefacts from the Bronze Age had been found in Latvia.

Judging from the artefact forms, we may conclude that they were made at the end of the Bronze Age, around 800–600 BC. Bronze – the ‘precious metal’ of the time – was a material used to make ornaments as weapons that served as a special indicator of wealth and social status.

The largest section of the hoard consists of ornaments broken already in antiquity – neck-rings, armband-like rings, armbands, a so-called belt box, a brooch, dress-pins etc. Predominant in the hoard, also in terms of weight, are 32 cast rings resembling armbands with open terminals, which have not been further worked. These can only nominally be classed as ornaments. It has been suggested that they served as a means of payment: these valuable bronze castings were used in the exchange process and as a form for storing the metal.

One of the largest and most impressive ornaments is a spiral armband with 25 windings, with terminals rolled back in an S-shape. (A second similar spiral armband is preserved in fragmented form.) There are also several broken ornate neck-rings with broad oval terminals, decorated with an unusual linear design. Most of these ornament forms have never been found in Latvia before. These include the dress-pins with circular and flat spiral terminals, a spectacle-shaped brooch, neck-rings twisted in opposed directions etc. Other unusual artefacts include a dress-pin with a

solid, realistically formed ram's head and fragments of hollow circular objects, regarded as parts of an ornate harness.

Almost all the ornaments that are unique in Latvia have direct parallels in the Scandinavian countries, particularly in Denmark and Sweden. The character of the hoard suggests that the artefacts were being brought over for re-melting. The impression is that worn out and broken ornaments, which were still valuable because of the bronze they were made of, were brought here by Scandinavians as a valuable raw metal.

The artefacts are now kept in Ventspils Museum.



Fig. 3. Artefacts of the Staldzene Hoard

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Stop 6. Archaeological Excavations of Lapini Mesolithic Settlement Near Sarnate

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University of Latvia, Institute of Latvian History

On September 6–22 an excavation directed by Valdis Bērziņš and Inga Doniņa from the Institute of Latvian History will be undertaken at the Lapiņi complex of archaeological sites in the forest north of the village of Sārņate. A new forestry road was built here in 2011, and in the course of survey work flint artefacts were found in the ditches along the road, indicating that this is a Mesolithic site. In further survey work, a number of burnt bronze and iron objects (fragmentary neckrings, armbands, brooches, axes) were also discovered: it turns out that on this same site there is a Late Iron Age / Medieval cremation cemetery, a typical burial site of the Couronians, a Baltic group. The main aims of the excavation are: to determine the extent of the site and the state of preservation of the Stone Age occupation layer and the cremation graves, to obtain radiocarbon samples for dating the Stone Age occupation and to study the Couronian burial practices.

The Mesolithic site Lapiņi I is located at a height of approximately 10 m above present sea level. If it is a shorebound site, then it must correspond to a high transgression phase of the Littorina Sea (or Ancylus Lake?). Another site, Lapiņi II, which has so far produced only two flints, lies at a height of 8 m above present sea level. These sites are on a spit of land that separated the open waters from the Ventspils Lagoon – presumably an advantageous site for fishing and seal hunting.



Fig.1. Bronze jewellery and iron axes from the Couronian cremation graves at Lapiņi

Stop 7. Buried Gyttja and Peat Layer at Baltic Sea Bluff Near Sarnate Neolithic Settlement

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

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

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



Fig. 2. The water-escape structures of sand and silt covered by organic deposit layer at the Baltic Sea Cliff near the Sarnate.

The pollen analysis show that well decomposed wood-grass peat layer had a pollen spectrum (significant amount of *Alnus*, *Corylus*, *Ulmus*) that characterised the early part of the Holocene Climatic Optimum, which is confirmed by the ^{14}C dates (Fig.2). *Hypnum*-sedge peat accumulated, providing pollen spectra characteristic of the vegetation of the climatic optimum with highest amount of broadleaved trees - *Ulmus*, *Tilia*, *Quercus*. The very upper part of this layer probably was formed at the end of the Climatic optimum Time what has proved by pollen spectra with significant proportions of *Quercus* and *Alnus* pollen, and *Carpinus* is also recorded. Pollen spectra from the very upper grass peat layer indicate that probably peat has been formed during the Late Holocene, because of decrease of warm demanding plant pollen in comparison with lower layer and maximum of *Picea* pollen. The organic deposit layer in depth interval 2.7 to 2.2. m from the surface contains pollen anthropogenic indicators *Plantago major/media*, *Chenopodium album*, *Polygonum aviculare*, *Urtica* and *Rumex acetosella*.

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

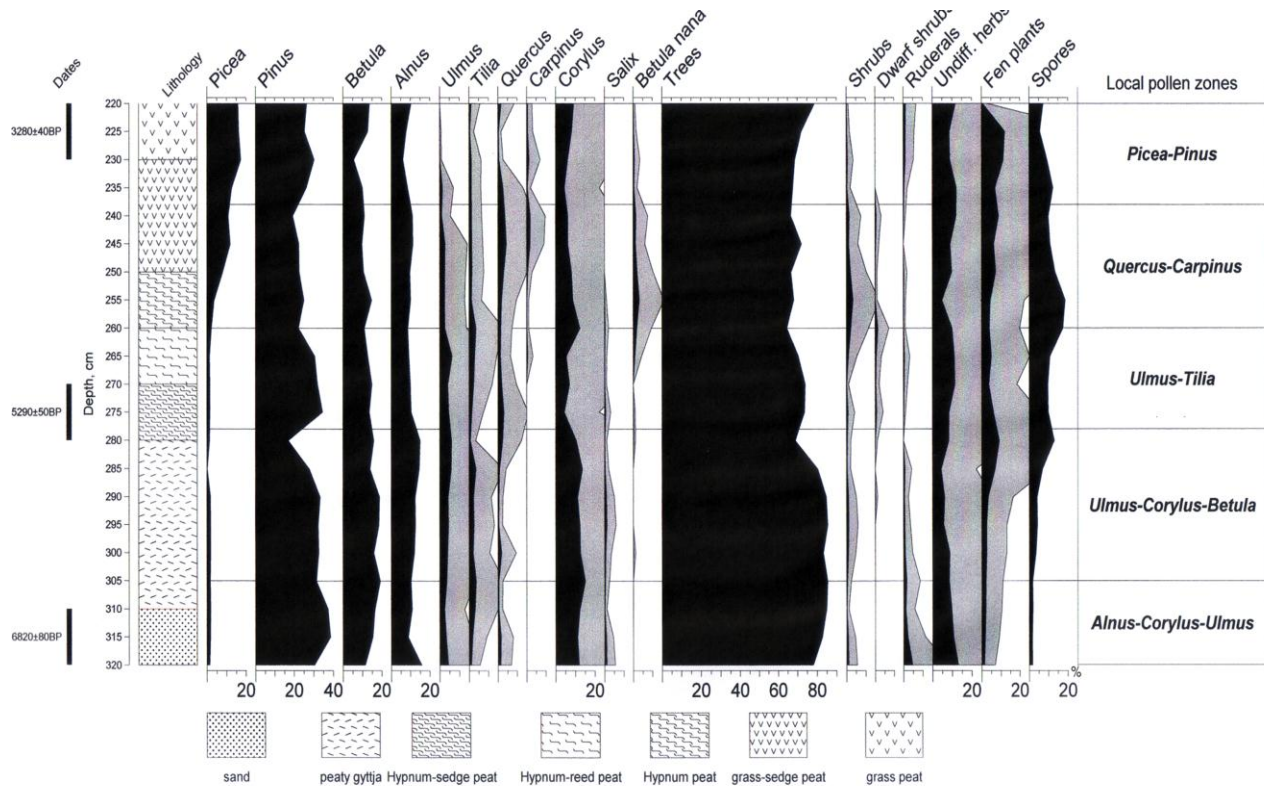


Fig. 2. Generalised pollen percentage diagram from Sarnate outcrop sediments.

Stop 8 and 9. The Baltic Sea Terraces and Neolithic settlements in the Northern Part of Lithuanian Coastal Area Near Palanga (Sventoji)

Aldona Damušyte¹, Albertas Bitinas², Algirdas Girininkas², Vladas Zulkus²

¹Lithuanian Geological Survey

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The best expressed geological records of the Baltic Sea development – terraces of the Baltic Ice Lake, Litorina Sea and Post-Litorina Sea – are developed in the northern part of the Lithuanian Maritime region, north from Palanga resort (Fig. 1) A number of investigations associated with geomorphological and geological structure of mentioned terraces as well as problems of development of the Baltic Sea basin have



been done in the mentioned coastal area (Gaigalas 1996; Gudelis, 1979, 1997; Kabailienė, 1959 and others). The Lithuanian coastal area was situated in the transitional position concerning to general tectonic situation of the entire Baltic Region during lateglacial and Holocene: the northern part was uplifted due to glacioisostatic rebound while the southern part experienced submerging. Presently the mentioned terraces indicating the different stages of the Baltic Sea development has an obvious regional trend – uplift towards to the north (Gudelis, 1979). Thus, the surface of the Baltic Ice Lake terrace increases from about +9.5 – +10 m a.s.l. in the vicinity of Palanga to +12 – +14 m a.s.l. close to the Lithuanian–Latvian state border. In some localities the flat surface of the mentioned terrace was influenced by aeolian processes: a few meters-high dunes are developed. According to the results of optically stimulated luminescence (OSL) dating the aeolian activity started about 8-10 kyr BP.

The prominent 1.5–2.5 m high and up to 200 metres wide beach ridge marks the maximal limit of the Littorina Sea transgression. The Litorina Sea terrace is situated at the altitude +6 – +8 m a.s.l., gently inclining westwards. This terrace is better presented northwards from Šventoji River. The Post-Litorina Sea terrace is situated from +4 m a.s.l. northwards to Palanga up to +0.3 m a.s.l. in the vicinity of the Šventoji resort.

The detailed morphological investigations carried out in the northern part of Lithuanian coastal area indicate that terraces of the Baltic Ice Lake, Litorina Sea and Post-Litorina Sea have not only regional trend (Gudelis, 1997), but have local deformations as well. The terrace surface of the Baltic Ice Lake has about 2–2.5 meters difference in altitude comparing to the flat surfaces of the terrace at both sides of the Šventoji River. The surface of Litorina Sea terrace is deformed as well: the relative difference in the altitudes of terrace surfaces at both sides of the river reaches up to 1-1.5 m (Bitinas, Damušytė, 2004). Šventoji River concurs with the Early Palaeozoic Akmenė Fault in this part of the coastal area (Šliaupa et al., 2005). No obvious local deformations were detected in the Post-Litorina terrace, while then terrace have an opposite trend – southwards uplift. All these deformations could be related with the neotectonic activity of the Earth's crust blocks during the Holocene. These movements probably have an oscillatory character.

NB! During this stop we will have a short presentation about submerged forest in Lithuanian coastal waters at University of Klaipėda.

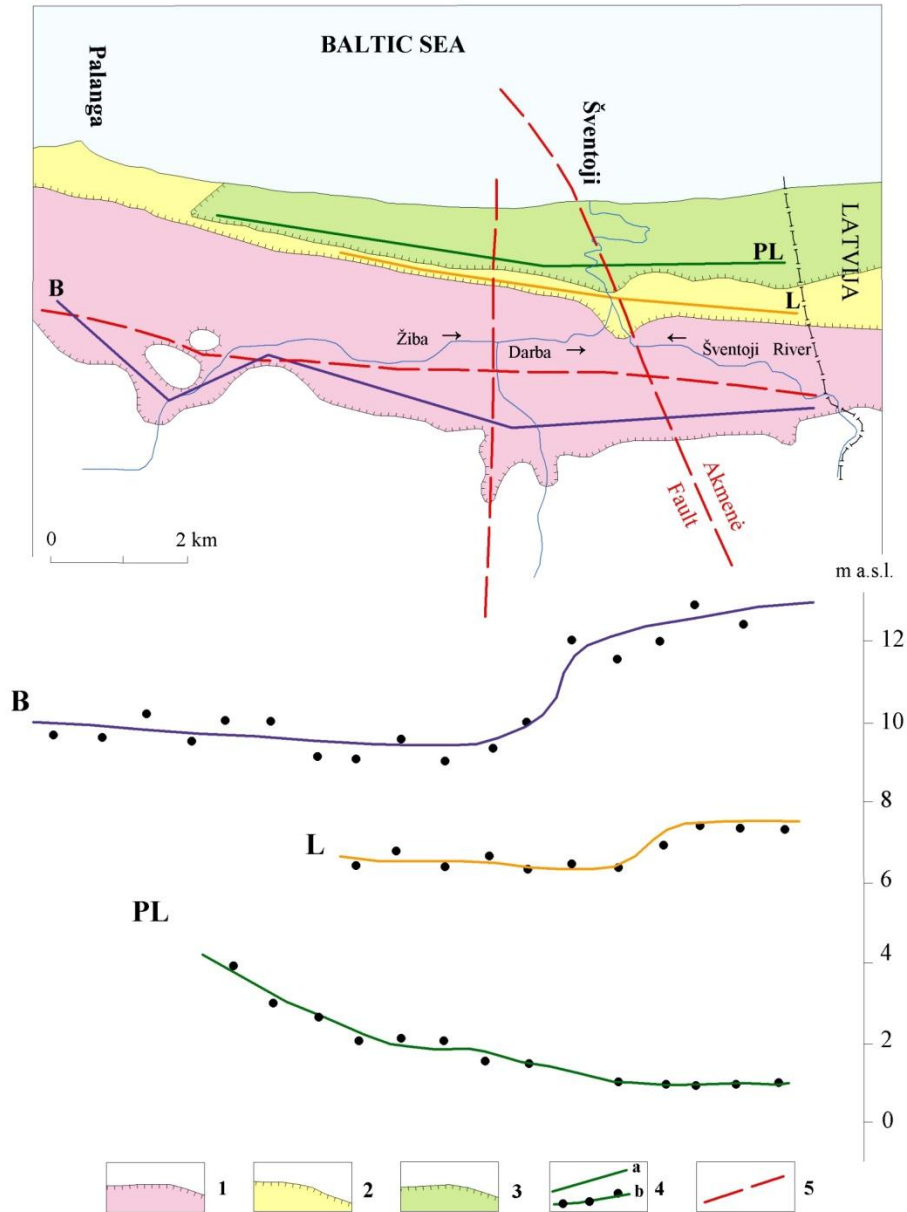


Fig. 1. Baltic Sea terraces in the northern part of Lithuanian Maritime region. Terraces: 1 – Baltic Ice Lake (B), 2 – Litorina Sea (L), 3 – Post-Litorina Sea (PL), 4 – longitudinal profile of terrace: a – location of profile; b – morphology of terrace surface; measured altitudes of terrace surface indicated by black dots, 5 – tectonic fault

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Stop 10. Parnidis Dune and Lagoon Marl Exposure

Curonian Spit

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The spit of Kuršių Nerija (Curonian Spit) is a 98 km long and 0.4–4.0 km wide sandy barrier in the South–Eastern Baltic separating the lagoon of Kuršių Marios (Curonian Lagoon) from the Baltic Sea. The area of Curonian Lagoon is 1584 km² with 413 km² belonging to Lithuania. The largest depth reaches 5.8 m in the southern part of lagoon, while the average depth is 3.8 m.

Administratively the northern half of the Curonian Spit (50 km) belongs to Republic of Lithuania, the southern one (48 km) is in the Kaliningrad region of the Russian Federation. In both parts of the Spit National Parks were established; in 2002 the whole Curonian Spit was included in the UNESCO World Heritage List as an object of cultural landscape with many natural and cultural heritage values.



The Curonian Spit being a unique natural heritage area represents:

- ✓ natural geomorphological (physiographic) features of the great dune ridge: diversity of dune forms at different stages of formation; separate dune peaks, diversity of blown sand plains, capes and small bays, which are valuable from aesthetic and scientific point of view;

- ✓ sandy beaches, the Baltic Sea coastal dune ridge, and great dune ridge host numerous natural and seminatural habitats of threatened species of animals and plants; the old forests habitats are of outstanding universal value from the scientific and conservational points of view.

The Curonian Spit landscape being created not only by natural processes but also by human activities represents the combined work of nature and man. It illustrates the evolution of fisherman society and their settlements over the time: the influence of the physical conditions and opportunities presented by nature on one hand, and further development of natural areas by humans on the other hand. Cultural properties in the Curonian Spit represent:

- ✓ sites (fishermen settlements) where works of man and nature are of outstanding universal value from the ethnocultural, historic and aesthetic point of view;

- ✓ monuments: architectural works, which have an universal historical, aesthetic and scientific value.

The Parnidis Dune: Formation of Curonian Spit and Aeolian Activity

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The Curonian Spit is an inimitable part of Lithuania's landscape without which it would be impossible to imagine the coast of Lithuania. The geology and geomorphology of the Curonian Spit, Curonian Lagoon and adjacent region had been studied by numerous researchers: J. Schumann (1859), G. Berendt (1869), H. von Wichdorff (1919), O. Pratje (1931), V. Gudelis (1959, 1961 and 1976) and others. Detailed investigations of the Curonian Spit and Curonian Lagoon origin and development during Lateglacial and Holocene by pollen and diatom methods started only in the second



half of 20th century (Brockmann, 1954; Kabailienė, 1959, 1967, 1990, etc.). These investigations continue until the present-day.

In the northern, Lithuanian part of the Spit, the deposits of the Last Glaciation (Late Weichselian) are presented by till and glaciolacustrine clay occurring at altitudes of -25 – -30 meters, while in the southern part the till deposits lay at about -2 – -4 meters, and in the vicinity of Rasytė (Rybachyj) they are a few meters above the present sea level. Most probably, the formation of the Curonian Spit started during the transgression of Ancylus Lake, when the water level was a few meters lower than present, and continued during the Litorina and Post-Litorina Sea stages. Thus, the Curonian Spit is a sandy bar composed generally by marine sand. Eroded coasts of the Semba Peninsula served as a source area for the marine sand. Later the major part of the Curonian Spit surface was occupied by an aeolian sand plain called here “palvė”. Along the western margin of the Spit there is a protective dune ridge, 6–12 m high and mainly human-made, and a beach which is still forming. A long range of high dunes, Great Range, is stretching along the eastern margin of the Spit.

The dunes are typical for the entire Lithuanian coast, but only in the Curonian Spit the dunes clearly dominate the surface. Since the early beginning of the Spit existence, the aeolian processes play a very important role for its development. They formed the largest and the highest dune formations in North Europe. The dune tops rise up to 60–70 m; the official highest point in Lithuanian part of the Spit Vicekrugo Hill is 67.2 m high (forested dune). The other similar dune (alive, moving) named Sklandytojų /Glider Flyers/ also reaches 67-68 m height. The average height of the dunes is about 40 m. Great Range consists of dunes of a few generations: ancient parabolic dunes covered by ancient soils, and new very high, migrating, longitudinal dunes above the first ones. The Juodkrantė and Nida parabolic dunes remained since the end of the Litorina Sea time, i.e. Atlantic period. Now they are overgrown by forest, and their shape is not easily observed. The very interesting and distinctive dunes are situated between Juodkrantė and Pervalka, where they were not affected by human activity. There are several soil horizons and tree remains buried by the sand. Dunes in this part of the Spit are practically stable, whereas the area close to Nida with the Parnidis Dune is an excellent example of moving dunes. The eastern shoreline of the Spit is very uneven: there are numerous sand peninsulas called by Lithuanians “ragas” /horn/. The most impressive is Grobšto Ragas with a picturesque Vienišoji /solitary/ Dune.

For long centuries, the dunes in the Curonian Spit were freely driven by wind. Only in 19th century the forestation and stabilization of dunes started. Thus, finally, the sand transport from the Baltic Sea side has been interrupted; hence, dunes started to become smaller.

Parnidis Dune – Lagoon Marl Exposure. Phenomenon of “Dune Tectonics”

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Southwards from Nida at the bottom of high dune ridge descending into the Curonian Lagoon at the coves of Parnidis Dune and Grobšto Ragas a clayey gyttja is exposed. Since 19th century German researchers used to call these sediments “haffmergel”. Analogically, the Lithuanian specialists named it “marių mergelis” meaning lagoon marl. The lagoon marl is a general name for the mentioned beds because these deposits are not homogenous. The lithological composition varies according to the proportion of organic matter, carbonates and clay particles from clayey gyttja so gyttja clay.

Though discovered in many localities along the Curonian Spit lagoon, the marl is known mainly in northern half of the Spit. According to the data of boreholes, as well as results of investigations by ground-penetrating radar (GPR), the lagoon marl occupies an area of at least several square kilometers in the vicinity of Nida. The top of the lagoon marl unit occurring *in situ* is fixed at a depth from -6.8 to -8.9 m NN. It is overlain by barrier sands up to 7–10 m thick. The bottom of the lagoon marl dips down to -14.5 meters below the sea level, i.e. the thickness of these sediments varies from 5.4 to 9.0 m. The integrated investigation (pollen, diatom, and molluscs analyses, ¹⁴C dating) show that the lagoon marl beneath the present-day Curonian Spit was deposited in a freshwater lagoon. Its sedimentation started, probably, after the Ancylus regression, i.e. more than 9.0 ka BP. The sedimentation continued until the second half of Subboreal.



Fig 1. Lagoon marl exposure close to the Lithuanian–Russian state border

Some lagoon marl sediments are squeezed out above the surface from under the sandy dune (“dune tectonics”) at the base of Parnidis Dune, to the south of Nida. The second and biggest exposure of the lagoon marl is located farther to the south, close to the Lithuanian-Russian state border. The length of this formation reaches up to 700 m, height is 3.5 m, and width is 50–60 m. There are lagoon marl outcrops as several belts (ridges) extending parallel to the dune ridge.

Examples of so-called “dune tectonics” are quite rare in the coastal or inland dunefield areas and are governed by the interaction of two main factors: 1) presence of lagoon marl layers beneath ground water table and 2) active development of aeolian processes, i.e. migration of massive sand dunes. The exposures of lagoon marl are caused by a large mass of the dune sand. The ridge of aeolian sand is slowly moving eastwards and pressing the coast and bottom of the Curonian Lagoon. This caused the deformation of the clayey marl beds occurring under the sand and making their exposures at the surface. The part of the lagoon marl in exposures is eroded by lagoon waves, but the significant part remains for many years, until the dune bottom approaches it and buries later. Then a new belt of marl is being pressed out in the other place of the eastern coast of the Curonian Spit. At present, this geological process is becoming less intensive: the dune height and the rate of migration are decreasing due to lack of sand caused by insufficient sand supply from the seaward sources. The reason is that during the last two centuries the massifs of active dunes and the sea coast were separated by the artificially planted forest along the entire length of the Curonian Spit.

In 1964 the outcrop of lagoon marl beneath Parnidis Dune, representing this rare geological-geomorphological process, was declared as Lithuanian geological monument protected by law.



Fig 2. Lagoon marl outcrop beneath Parnidis Dune, to the south from Nida (photo by J. Satkūnas)

Stop 11. Buried Soils in the Grey (Dead) Dunes Nature Reserve

The Naglis Nature Reserve: aeolian sedimentation and history of human and nature interaction

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The Curonian Spit separating the Curonian Lagoon from the Baltic Sea is a unique place by its development and human history. Moving sand forms dominated in the relief since the earliest periods of the spit existence. An interaction between the nature and man has played a dominant role in the development of flora and fauna, as well as the Curonian Spit itself.

The unique monument of the Curonian Spit development has been found in the sand dune ridge, extending between Rasytė (Rybachyj) and Juodkrantė. A few buried soil horizons corroborated the theory concerning the development of the Curonian Spit relief, human influence in to environment and palaeoecological conditions during the second part of the Holocene period. German naturalist J. Schumann (1859) was the first who has mentioned this fact. G. Berendt (1869), H. von Wichdorff (1919), F. Mager (1938) had prolonged the investigations of the ancient soil horizons. Significantly more data about the development of the dune ridges was given by scientists of Lithuanian Academy of Sciences. V. Gudelis was an initiator of the investigations. Numerous articles in various publications examined this phenomenon (Gudelis 1960, 1986, 1989–1990, Gaigalas *et al.* 1991, and others).

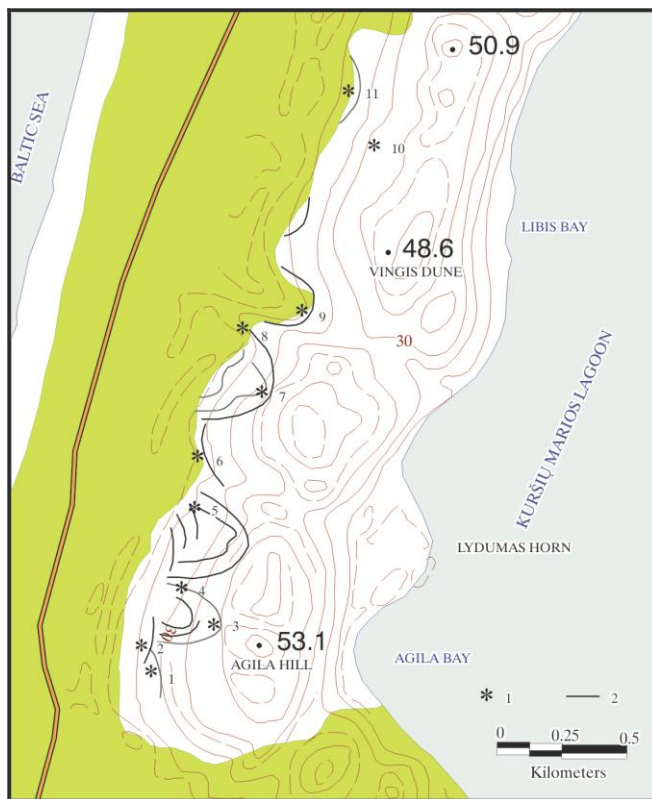
Now the major part of the dune ridge is overgrown by grass and forest and only a few places with open sand afford an opportunity for investigations of the buried soil horizons. These horizons are found northwards from Pervalka between Agila Hill and Vingis Dune on the windward (western) slopes of the dune ridge. Only one soil horizon has been mentioned by H. von Wichdorff (1919), but later up to 7 layers have been excluded. 3–4 horizons are most widely spread and have a stratigraphic significance. The dune ridge in the Curonian Spit is composed of two eolic sand complexes. The lower dunes had been formed as parabolic, the so-called “ancient buried parabolic dunes,” and the ones had been formed during 18–19th century. Soil horizons overlay the surface of the ancient buried parabolic dunes. The buried soils stretch along the western slope of the dunes in the north-south or west-east directions. The slopes of the dunes have been influenced by the wind and part of the sand has been eroded.



The configuration of the soil layers reflects the shape of the ancient dunes. Even stumps and trunks of huge trees have been found in some places. The high amount of charcoal in soils shows the big fires in the Curonian Spit. The shape of the old dunes, formed by wind was very changeable, and the belts of soil horizons confirmed that.

The ancient soil layers are composed of the forest litter of various thickness, podzol horizon, which is composed of grey fine sand, and illuvial horizon which is of reddish or brownish colour due to high content of iron and manganese.

The pollen analyses and results of the radiocarbon dating of the soil horizons and pieces of wood confirmed the stratigraphical relationship of the soil layers with the type of flora flourished at the time of the soil formation. Palynological investigations of the soil horizons have been carried out by N. Savukynienė and M. Kabailienė.



A sketch map of the distribution of exposed soils in the Kuršių Nerija Spit at Pervalka (according V. Gudelis & N. Savukynienė, 1995)
1 – exposed soils, 2 – fossils

According the results of investigations, three flora complexes have been distinguished. The lowest soil horizon contains the high amount of broad leaf trees pollen. Pollen of *Tilia* reached up to 12–40 %. *Pinus* (20–30 %) was a typical tree in forest communities. *Betula* and *Alnus* thrived on wet places. Hazel and oak flourished in the territory, *Calluna vulgaris* pollen are typical for the spectra as well. The forests were luminiphylous with diverse herbs, ferns, and *Lycopodium* (Gudelis and Savukynienė, 1995).

The middle complex contains the high amount of pine (60–70 %) and spruce (10–20 %). The amount of birch, elm, broad leaf trees pollen has decreased. The diversity of herb species in comparison with the older complex has increased. Various spores have been found as well.

The upper pollen complex (the youngest one) is very similar to that of the present vegetation. Pine reached up to 90 %, but birch and elm have been diminished from the habitats (10 %). The amount of the spruce pollen is only 3 %. Herbs and spores thrived.

The results of the radiocarbon dating show the following periods of soil formation: 4 630–4 035 uncal. yr BP, 3 470–2 960 yr BP, 1 200–1 040 yr BP, 500–290 yr BP (Gaigalas *et al.* 1991).

The earliest traces of humans have been detected in Juodkrantė and Nida, and it was attributed to the Middle Neolithic (Rimantienė 1989). The Entire Curonian Spit was populated only during the Late Neolithic, the period of Corded Ware Culture. Since the beginning of the Subboreal period, the plant cover in the Curonian Spit has been destroyed several times. After the distinction of vegetation cover, the sand started to move and layers of sand have been formed between the soil horizons. The high amount of charcoal in the sediments confirmed the presumption that big fires had caused the decrease of vegetation. An origin of the ancient catastrophic fires is under discussion. Few presumptions exist: the fires were caused by lightning during dry summers or were initiated by man. Since the 15th century, forests were devastated by man. The wood – cutting in 16–17th centuries caused the catastrophic consequences, when 14 villages have been covered by wind – driven sand. In order to stop the movement of dunes, the afforestation was initiated in 19th century. G. D. Kuvertas, a head of the post office in Nida, has initiated the afforestation that was finished in 1902.