# Litorina Sea sediments of ancient Vääna Lagoon, northwestern Estonia

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Received 27 May 2008, accepted 22 August 2008

**Abstract.** Vääna Lagoon (59°22′30″N, 24°25′00″E) is located 25 km west of Tallinn in ancient Vääna Klint Bay at a 22 m Litorina Sea isobase. Lagoonal deposits were reinvestigated and new results of pollen, diatom, loss-on-ignition, magnetic susceptibility analyses, and radiocarbon datings were used for the reinterpretation of previous studies. The onset of the Litorina Sea transgression in the region is dated to 8300 cal yr BP and culmination to about 7000 cal yr BP. New material shows a single Litorina Sea transgression and denies the twofold transgression suggested earlier.

**Key words:** Litorina Sea, transgression, diatoms, pollen, radiocarbon dating, Vääna Lagoon, Estonia.

## INTRODUCTION

North and West Estonia are classical areas for the study of the post-glacial shore displacement in the eastern part of the Baltic Sea basin. The elevated position of the different Baltic Sea shorelines along the glacio-isostatically uplifting coastal area has favoured the shore displacement studies in Estonia. In spite of the long tradition of this research, there are several problems waiting to be specified, especially those connected with the development of the Litorina Sea. The Litorina Sea was transgressive due to the general rise of ocean level caused by melting of glaciers during the mid-Holocene thermal maximum (Fairbanks 1989; Yu 2003).

The first clear evidences of the Litorina Sea transgression in Estonia were obtained from sediment sequences of isolated lakes and ancient lagoons (Kents 1939; Thomson 1939; Kessel 1963; Raukas et al. 1965; Kessel & Raukas 1979). On the basis of the location of beach ridges at two different levels (21.67 and 18.77 m a.s.l.) near Vääna, Kents (1939) proposed a twofold Litorina Sea transgression. Biostratigraphical studies carried out by Thomson (1939) and Kessel (1963) at Vääna bog confirmed the presence of marine gyttja deposits rich in brackish-water diatoms, especially *Campylodiscus clypeus*. This gyttja bed rested on calcareous gyttja, which Thomson interpreted as isolation contact sediment (bleke). The clayey bottom bed under the bleke contained freshwater diatoms typical of Ancylus Lake. Thomson (1936, p. 162) mentioned that two transgressions of the Litorina Sea occurred close in time to each other and changes in the *Pinus* pollen graph could be interpreted as twofold sea level alteration. These studies became a benchmark and provided grounds for differentiating two phases in the Litorina Sea transgression in Estonia (Kessel 1963; Kessel & Raukas 1979, 1984). However, later studies in the Pärnu region confirmed only one Litorina Sea transgression in Estonia (Raukas et al. 1995a; Veski et al. 2005).

Studies around the Baltic Sea also show a variable number of the Litorina Sea transgressions. Multiple stratigraphic sequences from southern Sweden revealed five minor transgressions (Yu 2003; Berglund et al. 2005) with rapid sea level rise at 7600 cal yr BP (Yu et al. 2007). In southern Finland only one main Litorina Sea transgression has been recorded (Seppä et al. 2000; Miettinen 2002, 2004), whereas a sediment sequence (Tchernaya Rechka) on the Karelian Isthmus hinted at a twofold transgression (Miettinen et al. 2007). The relative sea level curve along the coast of Western Pomerania suggests two transgressions during the Litorina Sea stage (Lampe 2002). New sea level curves for the southern North Sea also displayed several small transgression and regression waves (Behre 2007). So, the evidences of the Litorina Sea transgressions are still diverse.

Radiocarbon dates from the Vääna Lagoon deposits were absent up to now, while those from other randomly located peat and gyttja layers in Estonia, buried under Litorina Sea sands, vary considerably (Saarse et al. 2006). Numerous dates on the start of the Litorina Sea transgression are available only from SW Estonia (Veski et al. 2005).

We revisited ancient Vääna Lagoon and conducted detailed biostratigraphical and lithostratigraphical analysis of the Litorina Sea deposits. Using accelerator mass spectrometry (AMS) and conventional $^{14}C$ dating, we established a chronology of the studied sequence. Our aim was to determine whether there were one, two or several broad transgressions during the Litorina Sea stage and to provide timing to the Litorina Sea water-level oscillations.

## GEOLOGICAL SETTING

Northwestern Estonia deglaciated about 12 700 cal yr BP (Hang 1997; Kalm 2006) and was afterwards flooded by waters of the Baltic Ice Lake, Yoldia Sea, Ancylus Lake, and Litorina Sea. In NW Estonia the Litorina Sea inundated mostly low-lying klint bays. Ancient Vääna Lagoon (ca 25 km west of Tallinn), which was examined lately, lies in one of such klint bays (Fig. 1). Vääna Klint Bay is filled with ca 70–100 m thick glacial, late-glacial, and Holocene deposits (Arold 1971; Raukas & Liivrand 1971), which rest on the Early Ordovician Pakerort age argillite. Several sand ridges extend across the klint bay and cause the Vääna River to wind. Varved clays on the riverbanks are sensitive to landslides and from time to time blocked the water flow to the sea, forcing the river to erode new channels (Treial & Künnapuu 1962). Ancient Vääna Lagoon holds now a raised bog with the convex surface extending to about 4 m above the surroundings (up to 24.7 m a.s.l.). The central part of the bog is being exploited by peat cutting, and is dotted with milling peat piles and crossed by a service road.

The Vääna bog is bordered by the Keila-Joa–Türi-salu klint headland in the west and by the Suurupi klint headland and spit in the east (Tammekann 1940). The spit core consists of cemented crystalline and carbonate rocks and has been interpreted as an islet formed at the beginning of the Litorina Sea transgression (Raukas et al. 1965). The ancient lagoon was located behind the spit and had a narrow threshold near Vahiküla at 18.2 m a.s.l. (Kents 1939). The contact between gyttja containing brackish-water diatoms and peat has been levelled at the same elevation as the lagoon threshold (18.2 m a.s.l.; Kents 1939).

## MATERIAL AND METHODS

Several parallel sediment cores were taken with a Russian peat sampler from the central part of the Vääna raised bog (59°22′30″N, 24°25′00″E). The upper part of the peat layer was removed in the course of peat extraction and a 2.25 m long sediment sequence (from an altitude of 19.10–16.85 m a.s.l.) was selected for detailed laboratory analyses.

Magnetic susceptibility was measured with the Bartington Instruments Ltd. high-resolution surface scanning sensor MS2E. The sediment surface was cleaned with a microscope glass slide, covered with a thin plastic film, and the susceptibility was measured on the sediment surface at 1-cm resolution.

The organic matter (OM) content was quantified by loss-on-ignition (LOI) analysis at 525 °C. The carbonate content was estimated in terms of the difference between LOI at 900 °C and 525 °C multiplied by 1.36 (Heiri et al. 2001). The ignition residue was estimated as a mineral matter content. The measurements were performed on continuous 1-cm-thick subsamples.

Pollen analysis was carried out with the sampling interval of 5 cm. The samples were prepared following standard techniques (Berglund & Ralska-Jasiewiczowa 1986; Fægri et al. 1989). The samples with a high amount of mineral material were treated with fluoride acid and stored in glycerine. A minimum of 500 terrestrial pollen grains were counted in each subsample. The basis for the percentage calculations was the sum of terrestrial pollen, i.e. the sum of arboreal pollen (AP) and non-arboreal pollen (NAP). The percentages of the other identified microfossils were calculated from the basic pollen sum.

Diatom samples were digested in hydrogen peroxide according to Battarbee et al. (2001) and the cleaned subsamples were dried onto cover slips and permanently mounted onto microscope slides using Naphrax medium. At least 350 diatom valves were counted from each subsample (except the lowermost part of the studied sequence where microfossils were rare) under a Zeiss Axiolab light microscope at ×1000 magnification using phase-contrast optics and were identified using standard floras (e.g. Krammer & Lange-Bertalot 1986, 1988, 1991a, b). Chrysophyte cysts were counted as separate categories under microscope and the ratio of chryso-phycean cysts to diatoms was calculated. Diatoms were grouped according to their habitat into plankton and periphyton, the latter including benthic, epilithic, and epiphytic life forms, and into brackish-water, salinity-indifferent, and freshwater taxa according to their salinity preferences. The sediment composition, pollen, and diatom diagrams were plotted with TGView software (Grimm 2004).

Seven $^{14}C$ dates were obtained from the Vääna sediment sequence. Two conventional radiocarbon datings of the lowermost part of the peat were performed in the Institute of Geology at Tallinn University of Technology, and four AMS $^{14}C$ datings of the terrestrial plant remains (in order to eliminate the error caused by reservoir ages of bulk sediment) and one dating of the bulk gyttja sample were carried out in Poznan Radiocarbon Laboratory. The radiocarbon dates were converted to calibrated age (cal yr BP) at one sigma range using the IntCal04 calibration curve (Reimer et al. 2004) and the Calib Rev 5.0.1. program (Stuiver et al. 2005). All ages mentioned in text refer to calendar years BP (0 = AD 1950).

## RESULTS

### Lithostratigraphy, magnetic susceptibility, and sediment composition

The lithostratigraphy from top to bottom of the studied sediment sequence is given in Table 1. The basal part of the core opened up sediments that have deposited in different environments and can be divided into five lithostratigraphical units (Fig. 2). Basal fine-grained sand (core depth 281–325 cm; altitude 16.87–17.31 m a.s.l.) with the OM content <1% is slightly calcareous (11–13%). In calcareous silt (core depth 260–281 cm; altitude 17.31–17.52 m a.s.l.) OM is still low, <6%, but the carbonate content increases rapidly from 10% at the lower limit of the unit to 30% near its upper limit, and that of mineral matter decreases from 83% to 64%. This unit contains few mollusc shells. In calcareous silty gyttja (core depth 237–260 cm; altitude 17.52–17.75 m a.s.l.) $CaCO_3$ and mineral matter are prevailing but the content of OM increases steadily. Mollusc shells, among which *Bithynia tentaculata* is most abundant, are present in substantial numbers at the upper limit of the unit. In the coarse detritus gyttja unit (core depth 192–237 cm; altitude 17.75–18.20 m a.s.l.) sediment composition changes rapidly. At the lower limit of the unit the content of OM reaches 40%, but decreases continuously upwards in the sediment sequence. The content of mineral matter increases upsection and the carbonate content is stable with values around 4%. At a core depth of 192 cm (altitude 18.20 m a.s.l.) a sharp boundary occurs between coarse detritus gyttja and peat, which suggests a possible hiatus in sedimentation.

Magnetic susceptibility varies considerably (Fig. 2) and shows a lowering trend upwards in the minerogenic sediment from $170 \times 10^{-6}$ to $20 \times 10^{-6}$ SI. Magnetic intensities are very low in calcareous silty gyttja and coarse detritus silty gyttja, at an altitude of 17.50–17.90 m a.s.l. In the topmost part of coarse detritus gyttja (altitude 18.15 m a.s.l.) a well-developed peak in magnetic susceptibility was registered (Fig. 2).

### Biostratigraphy

*Diatoms*

The basal sand contains very few diatoms, representing the species that are generally found in large freshwater lakes and are also common in sediments of Ancylus Lake, e.g. planktonic diatoms *Aulacoseira islandica* and *Stephanodiscus neoastraea*, as well as littoral taxa such as *Diploneis domblittensis*, *Gyrosigma attenuatum*, and *Navicula scutteloides* (Fig. 3). A similar diatoms assemblage with a rather high proportion of epiphytic *Epithemia* spp. ranges up to an altitude of 17.55 m a.s.l. A decline in large-lake planktonic diatoms is observed at the same level. In addition, relative abundance of periphytic large-lake diatoms decreases and the importance of diatom species living in small-sized hard-water shallow lakes, such as *Cymbella ehrenbergii*, *Gomphonema angustatum*, *Mastogloia smithii* var. *lacustris*, and *Navicula oblonga*, as well as chrysophyte cysts, increases. Changes in diatom composition and abundance coincide with sediment transition from silt to calcareous silty gyttja. The changes in the stratigraphic record may be explained with the isolation of the basin from Ancylus Lake. At an altitude of 17.95 m a.s.l., in the middle section of coarse detritus silty gyttja, the relative abundance of freshwater periphytic diatoms and chrysophyte cysts decreases distinctly, whereas brackish-water periphytic diatoms, such as *Campylodiscus clypeus*, *Mastogloia baltica*, and *M. braunii* increase towards the upper part of the unit (Fig. 3). Moreover, resting spores of *Chaetoceros* spp., commonly recovered in the sediments of the Litorina Sea stage of the Baltic basin (e.g. Andrén et al. 2000), are present. The diatom composition indicates brackish-water environment and re-opened connection

**Table 1.** Lithostratigraphy of the Vääna sediment sequence

| Depth from sediment surface, cm | Altitude, m a.s.l. | Sediment description |
|---|---|---|
| 0–192 | 18.20–20.12 | *Phragmites–Carex* peat, poorly decomposed |
| 192–237 | 17.75–18.20 | Coarse detritus silty gyttja |
| 237–260 | 17.52–17.75 | Calcareous silty gyttja, at 237 cm abundant mollusc shell fragments |
| 260–281 | 17.31–17.52 | Calcareous silt |
| 281–325 | 16.87–17.31 | Sand |

to the sea, that is to say, the Litorina Sea transgression. However, the diatom assemblage does not imply that deep-water conditions were generated, on the contrary, shallow-water lagoonal conditions existed in the basin.

*Pollen*

Pollen stratigraphy of basal sediments at 17.01–17.31 m a.s.l. opens with high and almost equal percentages of *Betula* and *Pinus*, low *Alnus*, *Ulmus*, *Corylus*, and *Picea*; and high abundance of algae (Fig. 4). Calcareous silt between 17.31 and 17.52 m a.s.l. is characterized by high abundance of *Betula* and *Alnus* and diminished *Pinus*. *Corylus* and *Ulmus* frequencies reach 10%. *Quercus*, *Tilia*, and *Fraxinus* are sporadically present. In calcareous silty and coarse detritus gyttja (altitude 17.52–18.20 m a.s.l.) the proportion of *Quercus*, *Tilia*, and *Fraxinus* in tree pollen has increased. Non-arboreal pollen, as well as aquatics *Typha* and *Potamogeton* appear, and green algae *Pediastrum boryanum* and *Botryococcus* are richly represented in detritus and silty gyttja. At an altitude of 18.20 m a.s.l. a sharp change in pollen composition occurred: Gramineae and Cyperaceae started to flourish, tree pollen decreased, and algae had a peak.

### Chronostratigraphy

The age of Väana sediments is based on five radiocarbon dates (Table 2). The two lowermost AMS dates, namely those on terrestrial plant remains found at 280 cm core depth (17.32 m a.s.l.) in the upper part of sand (3900 ± 40, Poz-24248) and on terrestrial plant remains found at 260 cm core depth (17.52 m a.s.l.) in the upper part of calcareous silt (5090 ± 40, Poz-24247) yielded erroneous (too young) ages. According to diatom stratigraphy these sediments deposited in Ancylus Lake. The dating 8040 ± 50 $^{14}$C yr BP (Poz-24246) of coarse detritus gyttja, which accumulated in the shallow lake, indicates that the Väana basin was isolated before 9000 cal yr BP from the Ancylus Lake basin. Radiocarbon dates associated with the development of the Litorina Sea stage are in good accordance with biostratigraphical evidence. The AMS dating of the terrestrial plant macrofossil at a core depth of 220 cm (17.92 m a.s.l.) yielded a date of 7420 ± 40 $^{14}$C yr BP (Poz-24267) (8310–8190 cal yr BP) and suggests that the water of the Litorina Sea had surpassed the basin threshold between 8200 and 8300 cal yr BP. The AMS sample of the terrestrial plant macrofossil from the uppermost part of coarse detritus gyttja at a core depth of 201.5 cm (18.105 m a.s.l.) dated to 6240 ± 40 $^{14}$C yr BP (7250–7070 cal yr BP, Table 2) indicates the approximate time of the Litorina Sea transgression maximum, confirmed by the maximum occurrence of brackish-water diatoms (Fig. 3). Two conventional radiocarbon dates from the lowermost 10-cm peat layer yielded the dates of 5205 ± 60 $^{14}$C yr BP (Tln-3037) and 5255 ± 60 $^{14}$C yr BP (Tln-3036), respectively, suggesting the onset of peat accumulation around 6000 cal yr BP and a ca 1000-year-long gap between sedimentation of detritus gyttja and peat.

## DISCUSSION

The palaeoenvironmental data from the Väana sediment sequence were used to reconstruct the Baltic Sea history of the region. The reconstruction is primarily based on biostratigraphic evidence of subfossil diatom assemblages and pollen assemblage zones, radiocarbon dating, as well as sediment lithology and composition. The available evidence of the altitude of elevated ancient shorelines is also taken into consideration.

Judging by the diatom assemblages, i.e. taxa common for large freshwater lakes such as planktonic species *Aulacoseira islandica* and *Stephanodiscus neoastraea*, as well as littoral species *Diploneis domblittensis*, *Gyrosigma attenuatum*, and *Navicula scutteloides*, the basal sand of the studied core deposited in Ancylus Lake.

**Table 2.** Radiocarbon dates from the Väana sediment sequence

| Depth from sediment surface, cm | Altitude, m a.s.l. | Age, $^{14}$C yr BP | Lab. No. | Calibrated age at one sigma (cal yr BP) | Material |
|---|---|---|---|---|---|
| 183–187 | 18.29–18.25 | 5255 ± 60 | Tln-3036 | 6175–5935 | Peat |
| 187–192 | 18.25–18.20 | 5205 ± 60 | Tln-3037 | 6170–5905 | Peat |
| 201.5 | 18.105 | 6240 ± 40 | Poz-24245 | 7250–7070 | Plant remains |
| 220–221 | 17.92–17.91 | 7420 ± 40 | Poz-24267 | 8310–8190 | Plant remains |
| 235–236 | 17.77–17.76 | 8040 ± 50 | Poz-24246 | 9020–8780 | Gyttja, bulk |
| 260 | 17.52 | 5090 ± 40 | Poz-24247 | 5910–5750 | Plant remains |
| 280 | 17.32 | 3900 ± 40 | Poz-24248 | 4410–4290 | Plant remains |

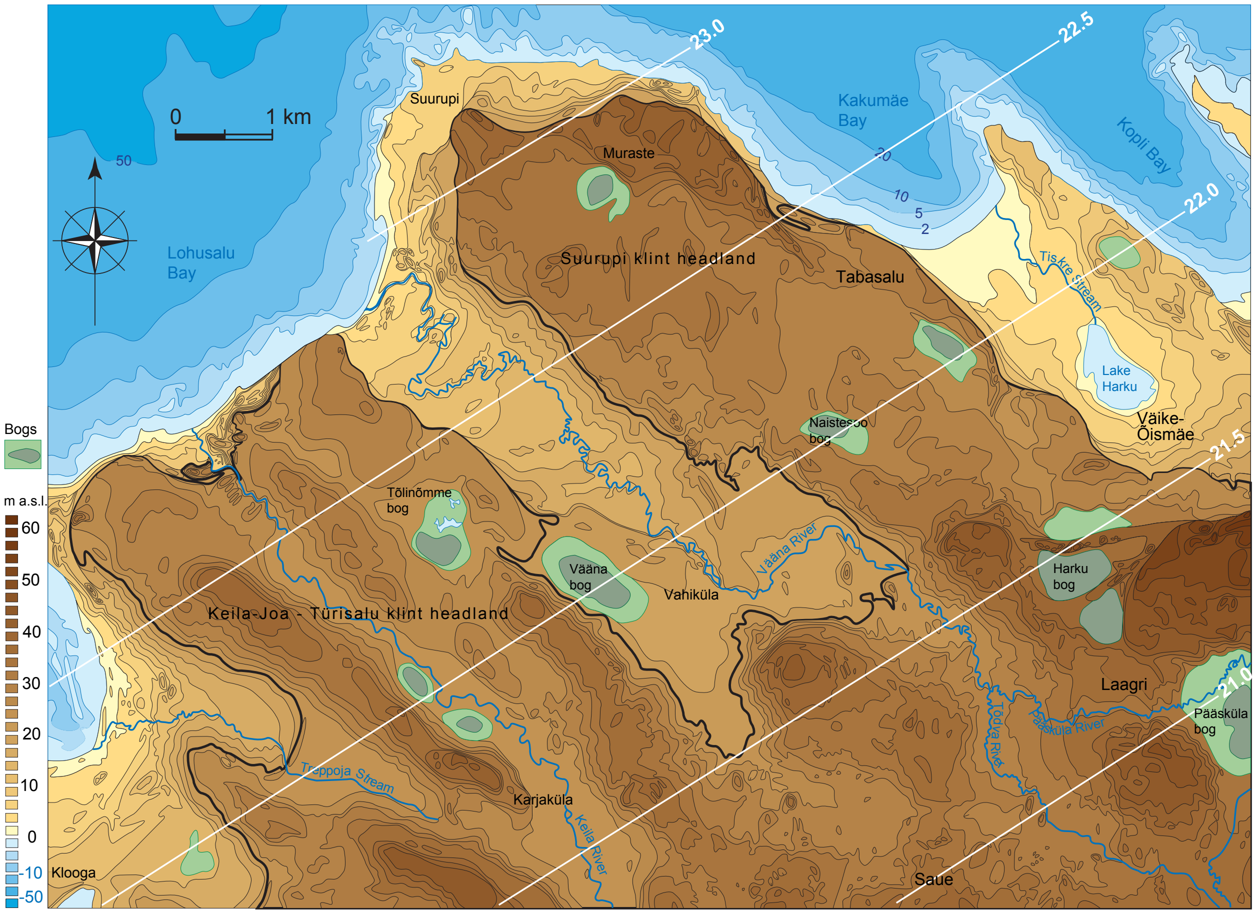


**Fig. 1.** Location of the study area, spatial distribution of the Litorina Sea maximum shoreline (bold black line), and the Litorina Sea shoreline isobases (white lines). Numbers indicate the Litorina Sea shoreline elevation in m a.s.l.

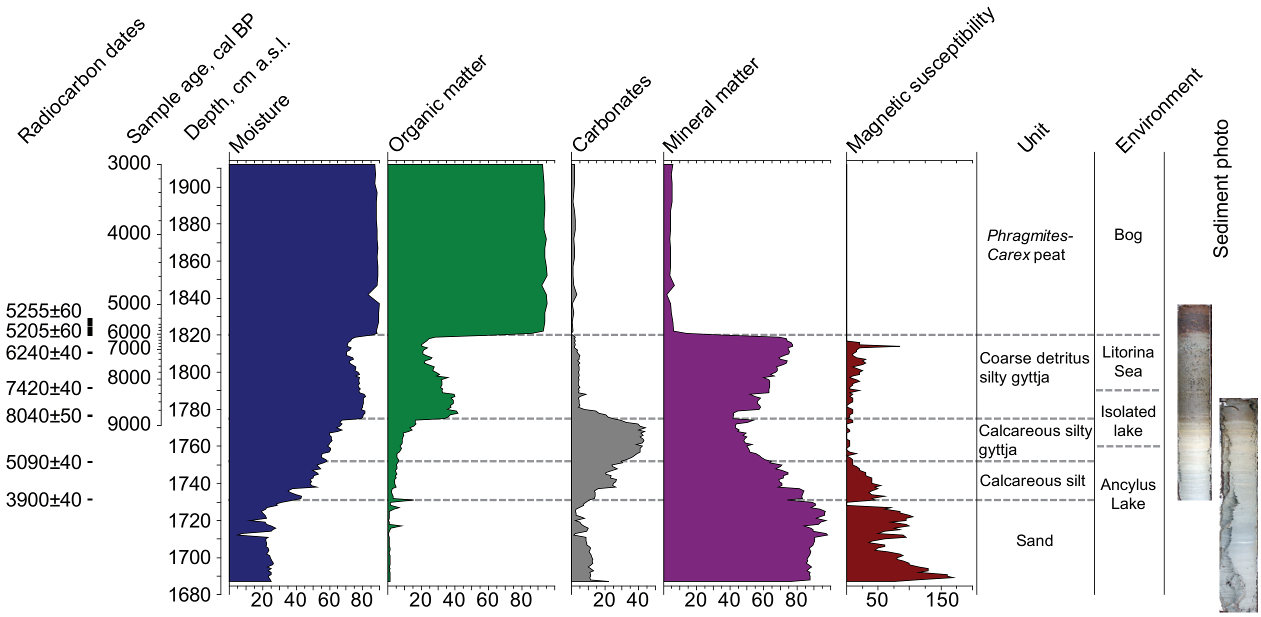


**Fig. 2.** Loss-on-ignition, magnetic susceptibility and $^{14}$C dating results, environmental conclusions, and photos of the studied cores from Vääna.

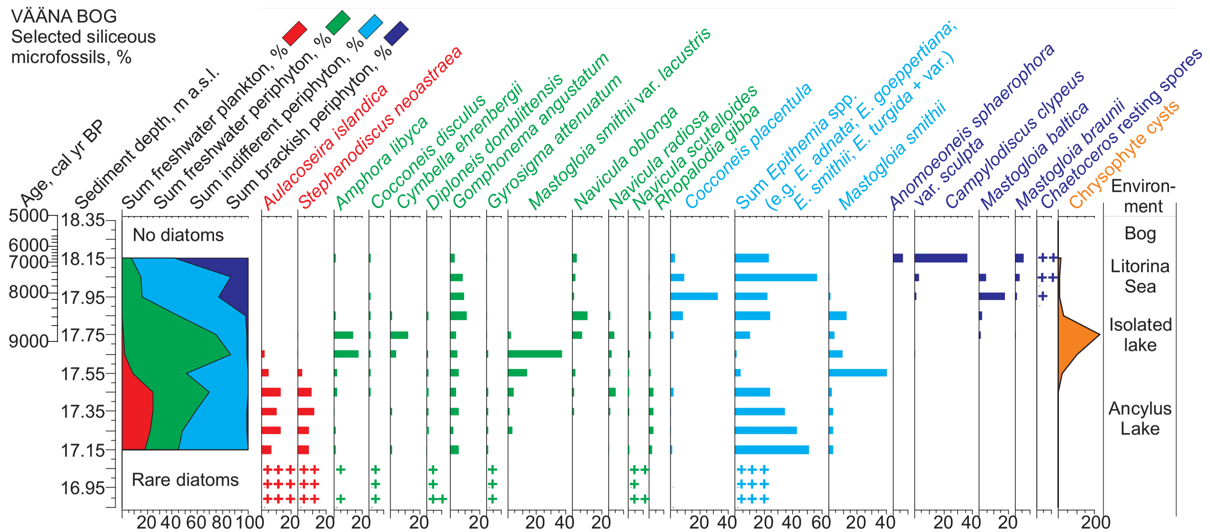


**Fig. 3.** Diatom diagram from the Vääna sediment sequence (analysed by A. Heinsalu).

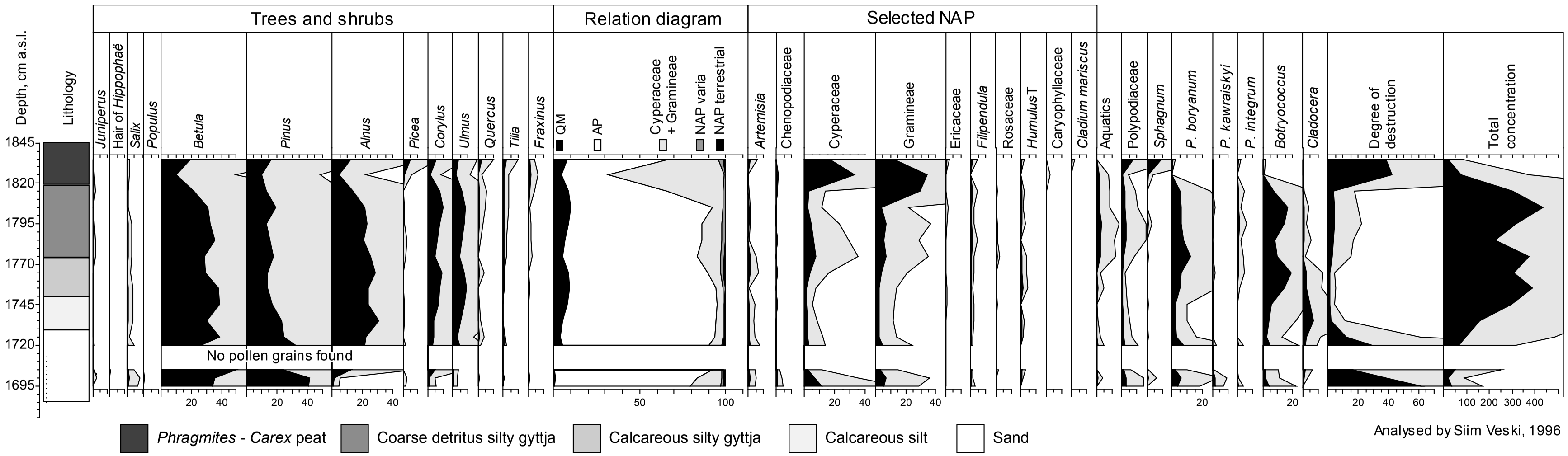


**Fig. 4.** Pollen percentage diagram of the Vääna sediment sequence. AP, arboreal pollen; NAP, non-arboreal pollen; QM, *Quercetum mixtum*; *P*, *Pediastrum*. NAP terrestrial includes herbs preferring dry habitat, NAP varia includes herbs indifferent to habitats (excluding Poaceae and Cyperaceae). Degree of destruction – % of corroded tree pollen of *Alnus*, *Betula*, *Corylus* indicating oxidation and/or corrosion.

*Betula–Pinus–Ulmus* and *Corylus* forest spread in the surroundings of Vääna. The other broad-leaved taxa have not surpassed their rational limit yet. Pollen diagrams compiled by Thomson (1939) and Kessel (1963) display similar changes in tree pollen taxa. According to Estonian Holocene stratigraphical chart (Raukas et al. 1995b), such pollen composition corresponds to the Early Holocene.

Sand is characterized by rather high magnetic susceptibility (Fig. 2). This is in good accordance with the elevated percentages of $Fe_2O_3$ (4.35%; Kiipli et al. 2000) in the Early Ordovician Pakerort age argillite, which forms the bedrock around the lagoon and may have served as a possible source for Holocene sands in the study area. The decline in large-lake planktonic diatoms and domination of diatom taxa that with respect to life-form preferences constitute a benthic and epiphytic community show that the upper part of calcareous silt and the lowermost part of calcareous silty gyttja deposited in the regressive Ancylus Lake basin.

Diatom and lithostratigraphic records provide evidence that an isolated independent lake existed for about 1000 years between the Ancylus Lake and Litorina Sea stages (Figs 2, 3). This is indicated in diatom stratigraphy by diatom species and chrysophyte cysts living in small shallow hard-water lakes. According to extrapolation, the isolation of Vääna Lagoon from Ancylus Lake has been timed to ca 9300 cal yr BP and this small coastal lake occurred at ca 8200–8300 cal yr BP (Figs 2, 3).

*Betula* and *Alnus* were the dominant taxa at that time with an increased share of herbs (Gramineae, Cyperaceae) which covered the emerged areas near the coastal lake. The high abundance of *Alnus* pollen could result from the alder rim around the small isolated water body.

The small lake was reconnected to the Baltic Sea during the Litorina Sea transgression, when the waters surpassed the threshold of Vääna Lagoon and filled the basin with brackish water. This is confirmed by the occurrence of littoral brackish-water diatoms, such as *Campylodiscus clypeus*, *Mastogloia baltica*, and *M. braunii* and the decline of freshwater taxa, indicating a shallow bay or lagoonal environment. In addition, the OM content decreased gradually and that of mineral matter increased probably due to more intensive shore abrasion during the Litorina Sea transgression. Kessel (1985) has found mollusc shells, namely *Littorina littorea*, *L. saxatilis*, *Ceratoderma glauccum*, etc., typical of the Litorina Sea, in the beach ridges and lagoonal deposits of nearby sites. The start of inundation coincides with the decline in *Betula* pollen and slight increase in *Pinus*.

Diatom composition and interpolated radiocarbon dates suggest that the Litorina Sea transgression in the Vääna area culminated around 7000 cal yr BP (Fig. 3). A well-developed peak in magnetic susceptibility that occurs simultaneously with the highest abundance of mineral matter in coarse detritus silty gyttja and the highest values of brackish-water diatoms obviously referred to a culmination of the Litorina Sea level.

However, the studied sediment record does not allow distinguishing the termination of the transgression. The very sharp boundary between coarse detritus silty gyttja and peat suggests an about 1000-year-long hiatus in sediment stratigraphy (Fig. 2, Table 2). The general diatom-stratigraphic feature for identification of the isolation contact from the Litorina Sea, the dominance of small-sized *Fragilaria* spp. during the isolation event, which has been recorded in several investigations around the Gulf of Finland (e.g. Eronen 1974; Seppä et al. 2000; Miettinen et al. 2007), is missing in the Vääna sediment sequence due to the absence of corresponding sediments.

Our study revealed only one transgression, which reached an altitude of ca 22 m a.s.l., consistent with the elevation of the beach ridge near Vahiküla (21.67 m a.s.l.). No evidence of the existence of any short-term fluctuations during the Litorina Sea transgression was found. Judging from the levelled threshold, the altitude of beach formation, and thickness of sedimentary beds, the Litorina Sea transgression magnitude in the Vääna area was ca 4–5 m. The two slight peaks in the *Pinus* pollen curve, which Thomson (1939) interpreted as indications of the double Litorina Sea transgression, are not supported by the new data.

## CONCLUSIONS

- New results of pollen, diatom, loss-on-ignition, magnetic susceptibility analyses, and radiocarbon datings, covering the time span 9300–7000 cal yr BP, give an improved temporal picture of the development of the Baltic Sea history in the Vääna area.
- The isolation of Vääna Lagoon from Ancylus Lake has been timed to ca 9300 cal yr BP and a small coastal isolated lake existed in the depression up to ca 8200–8300 cal yr BP.
- The intrusion of saline water into Vääna Lagoon started between 8200 and 8300 cal yr BP and the transgression culminated at ca 7000 cal yr BP.
- New bio- and chronostratigraphical data indicate a single Litorina Sea transgression in the study area and do not yield any evidence of other sea-level fluctuations during the Litorina Sea. The amplitude of the transgression is estimated to be 4–5 m.

**Acknowledgements.** PhD L. Kalnina and an anonymous reviewer are acknowledged for critical remarks and suggestions. The study was supported by Estonian Target Financing project SF0332710s06 and Estonian Science Foundation grant 6736.

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## Litoriinamere setted Vääna laguunis Loode-Eestis

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Vääna klindilaht, milles asus Litoriinamere laguun, nüüdisaegne Vääna raba, on keeruka arengulooga. Pärast mandrijää taandumist oli klindilaht pikka aega Läänemere vete poolt üle ujutatud. Maakoore neotektoonilise kerke ja Antsülusjärve veepinna alanemise tagajärjel umbes 9300 aastat tagasi isoleerus merest rannajärv, milles settis karbonaadirikas järvemuda. Litoriinamere transgressiooni käigus, mis algas umbes 8200–8300 aastat tagasi, ujutati klindilaht uuesti üle ja sinna kuhjusid rannavallid ning maasäär. Viimane eraldas avamerest laguuni, kus settis riimveelise diatomeeflooraga jämedetriitne järvemuda. Tuginedes uudsele biostratigraafilisele andmestikule, on väidetud, et Vääna ümbruses esines ainult üks Litoriinamere transgressioon, mis kulmineerus umbes 7000 aastat tagasi.