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THE POST-GLACIAL SHORE
DISPLACEMENT IN EASTERN BLEKINGE,
SOUTH-EASTERN SWEDEN

WITH THREE PLATES



STOCKHOLM 1964

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WITH THREE PLATES

STOCKHOLM 1964

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ABSTRACT: This paper presents the results, partly preliminary, of an investigation dealing with the Post-Glacial shore displacement in southeastern Blekinge, especially the Karlskrona Archipelago. The studies have been concentrated on the localities of Sörevik, a recent sea bay, and Hallarums mosse, an ancient Littorina inlet. Sections from these places have been pollen- and diatom-analytically investigated. Several horizons in the diagrams have been radiocarbon-dated. The results from these sections have been correlated with levelled shore lines. Finally a curve for the shore displacement is constructed and a comparison made between the Littorina transgressions in Denmark, Scania and Blekinge.

Introduction

An investigation of the shore displacement during Post-Glacial time in the southeastern part of the province of Blekinge was started in 1955. Since it will still take many years to complete this work, some preliminary results will be presented here.

Radiocarbon datings have been made by the Radioactive Dating Laboratory in Stockholm. They have been published in the date lists Stockholm II and V. Two series will be published in Stockholm VII.

Some diatom analyses have been made by Mr. Åke Berg. Most of the diatom investigations have later been performed by Mrs. Hannelore Håkansson. The pollen analyses have been carried out together with Mrs. Håkansson and Mrs. Ingrid Peterson-Kristersson. The diagrams have been drawn by Mrs. Ingallil Schenling. All this assistance is gratefully acknowledged.

The author is indebted to Dr. Tage Nilsson, head of the Institute of Quaternary Geology in Lund, for advice and valuable discussions, to Dr. Maj-Britt Florin for valuable comments as to the interpretation of the diatom analyses, to Dr. Fr. Hustedt for checking some diatom determinations, to Dr. Johs. Iversen for examining the pollen diagrams, especially the zonation within Early Post-Glacial time to obtain correspondence with the Danish pollen zones and to Mr. J. Lepiksaar (Mag. Zool.) for determination of a sub-fossil fish-scale.

The investigation has been supported by grants from the University of Lund, Långmanska Kulturfonden, the Funds of Research in Blekinge and the Royal Physiographic Society of Lund. The radiocarbon datings have been financially supported by the Swedish Natural Science Research Council.

Physico-Geographical Survey

The investigated area comprises the Karlskrona Archipelago and the coast district of the mainland, from the Gö Peninsula in the west to the Torhamn Peninsula in the east (Fig. 1). The largest islands are Hasslö, Aspö, Tjurkö, Sturkö and Senoren. The situation of the area in the south-easternmost part of the Scandinavian Peninsula means that the intensity of the land uplift is very low. According to F. Bergsten (1953) the recent 0-isobase runs from north-western Scania through Sölvesborg and south of the Blekinge coast. The value of the change of level at Kungsholmsfort, 6 km south of Karlskrona, is + 0.04 cm per annum (during the observation period 1887 to 1954, SMHI 1955). The Post-Glacial land uplift is supposed to be the same along the south coast of Blekinge because the isobases on the whole run parallel to this coast line.

This coast area is built of Archaean rocks, in the west coast gneiss and in the east the so-called Tving granite. The rocks have been strongly deformed, probably



in Jotnian time. The area is a continuation of the Pre-Cambrian peneplain but this is intersected by valleys running approximately from north to south. Topographically the mainland is a lowland with rocky hills mostly 5 to 20 m high and with valleys, sometimes forming larger plains. In the archipelago the valleys pass into inlets ("fiords", sw. *fjärd*) of the sea. These are shallow, seldom more than 10 to 15 m deep. Also south of the archipelago the bottom topography is flat. It is a gentle slope down to 40—50 m, which is the greatest depth within the sea map Utlängan—Tärnö. The islands are rather plain, only small areas reach 25—30 m above sea level. The southernmost part does not reach 10 m. As a rule the islands are hilly and intersected by valleys like the mainland. The dominating shore types are flat rock and moraine shores. Flatcoast built of sand is rare.

The coast area of Blekinge lies below the highest shoreline (HK) about 60 to 70 m above sea level. For this reason the soil has been strongly eroded and the bedrock exposed. The washed moraine cap is often thin. The material is sandy to gravelly and rich in boulders. In the valleys the moraine is covered with clays of the Baltic Ice Lake and peat. Areas below 5 m have Post-Glacial sediments.

The salinity of the Baltic Sea water in the archipelago varies around 7 per mille. This value is based on samples collected during one year at six stations (Rodhe 1963).

Methods

The morphology of ancient shore lines has been studied. The most distinct shore marks have been levelled. The stratigraphy of some beach ridges has been investigated, especially those where pollenanalytical dating was possible. In two localities the shore ridges have been dated archaeologically.

When studying the shore displacement a common method is to investigate the sediments of basins which sometimes have been connected with the sea, sometimes isolated. Because of the low intensity of land uplift in this area such localities are difficult to find. Rather recently such basins were found by the author and so far only one has been investigated. The name of this is Hallarums mosse. Corresponding studies were earlier made in recent sea bays. The most important locality of this type is Sörevik. Only fiord sediments are found here. Unfortunately the relative difference in water depth between transgressions and regressions will be very small at such a site, which is unfavourable for diatom

Fig. 1. Map showing the investigation area and the localities described in the paper. Shaded areas are land more than 5 m above the sea according to the topographical map of Sweden. They roughly correspond to the distribution of emergent land during the Littorina time *s. s.* Inset map of southern Scandinavia shows the location of eastern Blekinge.

För spridning godkänd i rikets allmänna kartverk den 28 september 1964.

analysis. The fiord locality Sörevisk yields the best information of shore displacement in Early Post-Glacial and the inlet locality Hallarums mosse in Middle Post-Glacial time. Besides these main localities some other basins have been studied to date their isolation from the sea. — In this paper “transgression phase” means not only culmination of a transgression but also the time before and after the maximum stage.

At all levellings of shore marks, overflow levels etc. a tube-instrument has been employed. The borings have been performed by the Hiller sampler. To get material for radiocarbon dating a core sampler, the so-called clay sampler type “Borro” (with 6 cm core diameter) has been used. This sampler works as the Reissinger type (cf. Faegri & Iversen 1964, pp. 55 ff.).

In the pollen diagrams the sum of calculation includes only trees (*Corylus* excluded). This pollen sum is at least 1 000 (except diagrams in Figs. 9, 15). Only in the survey diagram in Fig. 13 is *Corylus* included. This calculation facilitates correlations with among others the Danish diagrams. Besides the arbor pollen curves only some pollen finds of importance for describing the sedimentation milieu are presented. The group “Herbs I” includes plants characteristic of sea shores, e.g., species of *Chenopodiaceae* and *Artemisia*, and of sea bays, e.g., *Ruppia*. The group “Herbs II” includes plants characteristic of lakes and lake shores, e. g., *Nymphaea*, *Myriophyllum*, *Typha angustifolia*. Among “Other microfossils” there are several characteristic of lacustrine milieu. Besides them there are also the very important marine zooplankton named hystrichosphaerids (cf. Erdtman 1950, 1954, Nordli 1951, Fries 1951). They also occur in recent sea water of the Blekinge coast. Two types have been determined and according to Fries (1962) they are preliminarily named *Hystrichosphaera furcata* (EHRENB.) WETZEL and *Hystrichosphaeridium centrocarpum* DEFL. & COOKS. The latter is the more dominant.

After correlation with Scanian diagrams the Scanian pollen zone system has been used (T. Nilsson 1935, 1961). Broadly speaking, it is possible to compare these zones with corresponding zones in the Danish system (Jessen 1935, 1938, cf. T. Nilsson 1948). It must be underlined that the definitions of the zone boundaries in this paper always refer to Nilsson.

In the diatom diagrams the sum of calculation is the number of all counted shells except species within the genera *Epithemia* (with the exception of *E. turgida* var. *westermanni*), *Melosira* (except *M. moniliformis*), *Fragilaria* and *Tabellaria*. As a rule at least 200 shells have been counted. The diatoms have been divided into ecological groups (cf. Brockmann 1954, Cleve-Euler 1951—52, M.-B. Florin 1944, 1945, 1946, 1957, Halden 1922, 1929, Hustedt 1930, 1931—1962, Mölder 1943, 1962). Groups A, B and C are characteristic of lakes: A of ordinary fresh water, B of highly transparent fresh water (“Ancyclus-forms”) and C includes species which are rather indifferent to the water salinity (but often more or less halophilous). Groups D, E and F are characteristic of the sea: D

of slightly brackish water, E of brackish water and F of marine water. On the whole, diatoms of D, E and F are mesohalobic (Kolbe 1927, Hustedt 1956). Rare diatoms are not mentioned in the diagrams. Frequencies lower than one per cent are marked with +.

In one diagram from the Sörevik locality the plankton forms are separated from the bottom forms and epiphytes (plate I, anal. A. Berg). In this diagram all diatoms are included. A special "bathymetric" diagram from Hallarums mosse (Fig. 12) is based on the occurrence of lagoon, shallow-water and deep-water forms (bottom forms and epiphytes) in a brackish water inlet.

The whole analysis material with numerical values will be published later, the pollen analyses soon in a paper on the vegetational history and the diatom analysis when the changes of level have been studied more thoroughly in Blekinge.

The nomenclature of the plants follows Hylander 1955 (vascular plants) and Cleve-Euler (1951—52) (diatoms). When divergences from Cleve-Euler are found Hustedt (1930) has been followed.

All radiocarbon dates mentioned in this paper are corrected firstly to the international radiocarbon age scale, NBS standard (Stockholm III, age figures in Stockholm I—III are subtracted with 55 years), secondly to the half-life of radiocarbon by multiplying with factor 1.03 (Godwin 1962). Both uncorrected and corrected values of samples from Blekinge will be found in the table p. 46.

A large series from Hallarums mosse containing lacustrine and marine gyttja sediments has been C 14-dated. Also C 13-analyses have been performed on these samples (cf. table p. 46). The latter show that the limnic gyttja has normal C 13-proportion and the brackish and marine gyttja high C 13-proportion, which is characteristic for submerged sea plants (Wickman 1952). It is also known that surface ocean water and marine plants have too low a C 14-activity, which is caused by the delayed carbon dioxide cycle in the sea (Rankama 1963, p. 237 f., investigations by Craig et al.). The apparent age of ocean water is estimated to 400 years (cf. Stockholm V, Atlantic and Kristineberg series). To get knowledge about this source of error in the investigation area recent marine plant material from the southern Baltic will be analyzed¹. Comparisons between radiocarbon-dated pollen zone boundaries in Scania and Blekinge (telmatic and terrestrial peat, T. Nilsson 1964, and Berglund, unpublished) and corresponding boundaries in the marine series of Hallarums mosse show that the uncorrected figures ought to be subtracted with about 400 years. This has also been proposed (table p. 46² and plate III). However, the figures of three brackish and shallow water samples have been reduced by only 200 years. — The marine samples in the series from Inlångans mosse has normal C 13-proportion. At this locality the water depth during the deposition of the marine mud was very low and the distance to the shore and its vegetation very short. This probably led to good

¹Cf. the date list Stockholm VI (in press)

²This correction is abbreviated »sea corr.»



Fig. 2. The bay of Söreвик, Senoren, seen from the southwest. In the foreground dense stands of *Scirpus maritimus*, in the background *Phragmites*. BP I is situated in the middle of the bay, at the right side of the picture. July 1958.

turbulence and supply of organic material from the shore. For this reason no correction has been done of the date figures from this site.

Description of localities

Loc. 1. Långöra

Torhamn parish, 3.5 km south of Torhamn. Submarine pine stumps.

The place is situated in the bay or strait between the islands Lilla Långöra and Stora Långöra. The water depth in the northern part is 1 to 2 m, in the southern 0.5 to 1 m. The bottom material is a gyttja layer (about 0.5 m) resting on sand. It has not been possible to penetrate the sand. During dredging in the northern part of the bay several pine stumps were found. They seemed to have been lying about 3 m below sea level, below sandy layers. It has not been possible to date these stumps pollenanalytically. Radiocarbon dating has given

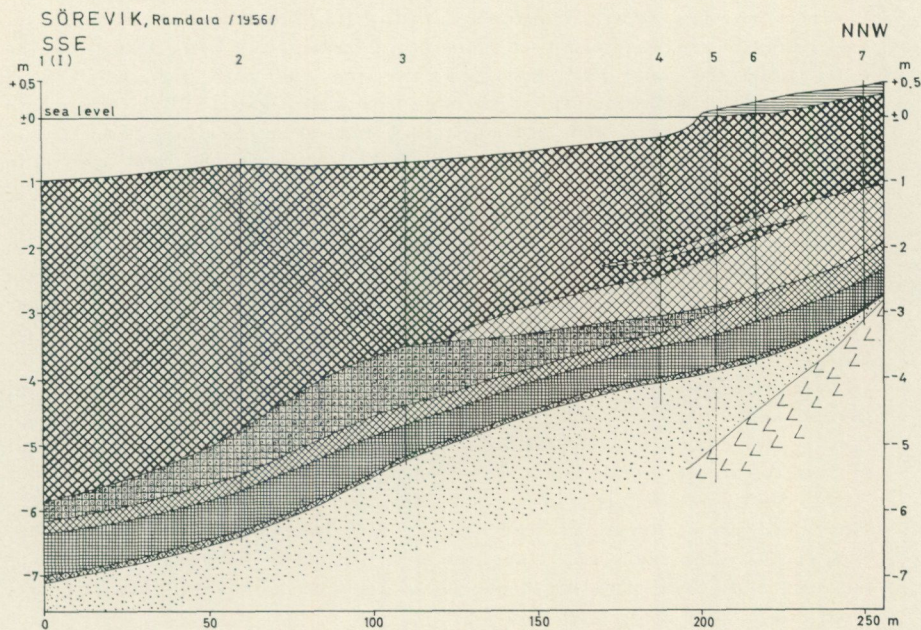


Fig. 3. Longitudinal section of Sörevisk. Legend, see p. 42, description pp. 9—10.

the age 7630 ± 130 B.C. (St—806). The overlying gyttja has been deposited during Sub-Boreal and Sub-Atlantic time (pollen-analytically dated) which suggests that the stumps are found in situ (cf. Lundqvist 1962, p. 6).

Loc. 2. Sörevisk

Ramdala parish, at the island of Senoren, about 500 m southeast of Östernäs. A sea bay with sediments from Early Post-Glacial time. (Photo Fig. 2, section of stratigraphy Fig. 3, pollen diagram plate I, diatom diagrams plates I and II, Figs. 4, 5.)

The bay leads into a fiord in the south and southeast. In the north the bay is continued by a valley on Senoren (the main part of the island in the west and a peninsula in the east). The water depth in the bay varies between 0.5 m and 1.5 m. Based on borings from the middle of the bay to the shore meadow in the north a longitudinal section has been drawn. The borings have been carried out with a Hiller sampler except at BP 5 where a "Borro" sampler has been used. The stratigraphy is as follows:

- A. Terrestrial grass peat, brown-black. A highly humified peat formed from the shore meadow vegetation, existing only above the mean sea level.
- B. Marine fine detritus gyttja, clayey, dark green. This gyttja is much thicker in the outer part of the bay. It contains fragments of algae, leaves of *Zostera marina* and some mollusc fragments (*Bithynia tentaculata*, *Mytilus edulis*).

- b) Coarse detritus gyttja, sometimes as drift gyttja, brown-green to dark brown, found only in the innermost part of the bay. Marine gyttja forms a lobe into the outer part of the coarse detritus gyttja. In the upper part of this there is an erosion contact and the sediment can be characterized as drift gyttja (BP 5). The coarse detritus gyttja contains seeds of *Carex* spp., *Nuphar luteum*, *Nymphaea alba*, *Potentilla palustris*, fruit stones of *Potamogeton*, wood of *Betula*, bark of *Pinus*, and operculi of *Bithynia tentaculata*. At BP 5 (270 cm below sea level) one scale of a cyprinid, probably *Leuciscus erythrophthalmus* (det. J. Lepiksaar) was found.
- C. Gasteropod gyttja, slightly clayey, light green. It is fine detritus gyttja with abundant gasteropods, among others *Bithynia tentaculata*, *Limnaea truncatula*, *Valvata piscinalis*, *V. cf. macrostoma*. These shells are most common in the lower and upper part of the layer.
- D. Clayey fine detritus gyttja, dark green.
- E. Clay gyttja, grey-green to green, in the outer part of the bay blue-black caused by iron sulphide.
- F. Drift gyttja, black-brown. This layer is very thin (about 5 cm). It contains wood of *Pinus* and *Betula* and abundant seeds from *Potentilla palustris*.
- G. Sand, slightly muddy, grey. In the uppermost part wood of *Pinus*.
- H. Clay, grey-green, sometimes brownish, probably Late-Glacial clay with varves. This clay is extremely hard. It has not been possible to confirm the existence of this layer more than below the shore meadow, because layer G could not be penetrated in the bay.

At the outermost boring point, BP 1, a series of samples has been taken. These samples have been investigated with pollen- and diatom analyses. The stratigraphy is the following.

- | | | |
|----|---------------|---|
| | 0.0 — 0.97 m | Sea water. |
| B. | 0.97 — 5.72 m | Marine fine detritus gyttja, clayey. |
| C. | 5.72 — 6.12 m | Gasteropod gyttja, slightly clayey. |
| D. | 6.12 — 6.29 m | Clayey fine detritus gyttja. |
| E. | 6.29 — 6.97 m | Clay gyttja, blue-black, except the lower 20 cm, which are grey-blue to grey. This gyttja is so loose that it was impossible to take samples between 642 and 665 cm (the chamber was not opened). |
| F. | 6.97 — 7.04 m | Drift gyttja. |
| G. | 7.04 — 7.42 m | Sand, slightly muddy. |

The pollen diagram is shown in plate I. Rebedded pollen grains occur especially in layers G, F and the lower part of E. The frequency of *Pinus* is abnormally high within the same layers because these sediments have been formed very near the shore (cf. Faegri & Iversen 1964, p. 121).

The results of the diatom analyses made by Mr. Åke Berg have been summarized in a diagram next to the pollen diagram. These analyses were mainly qualitative. The quantity of the different species was only estimated according to the scale 1 to 5. But as a very large number of species has been determined, these analyses are of great value, especially to illustrate the transition from fresh to brackish water. The diagram has been drawn in such way that the height of a

SÖREVIK BP I, Ramdala / 1956 /

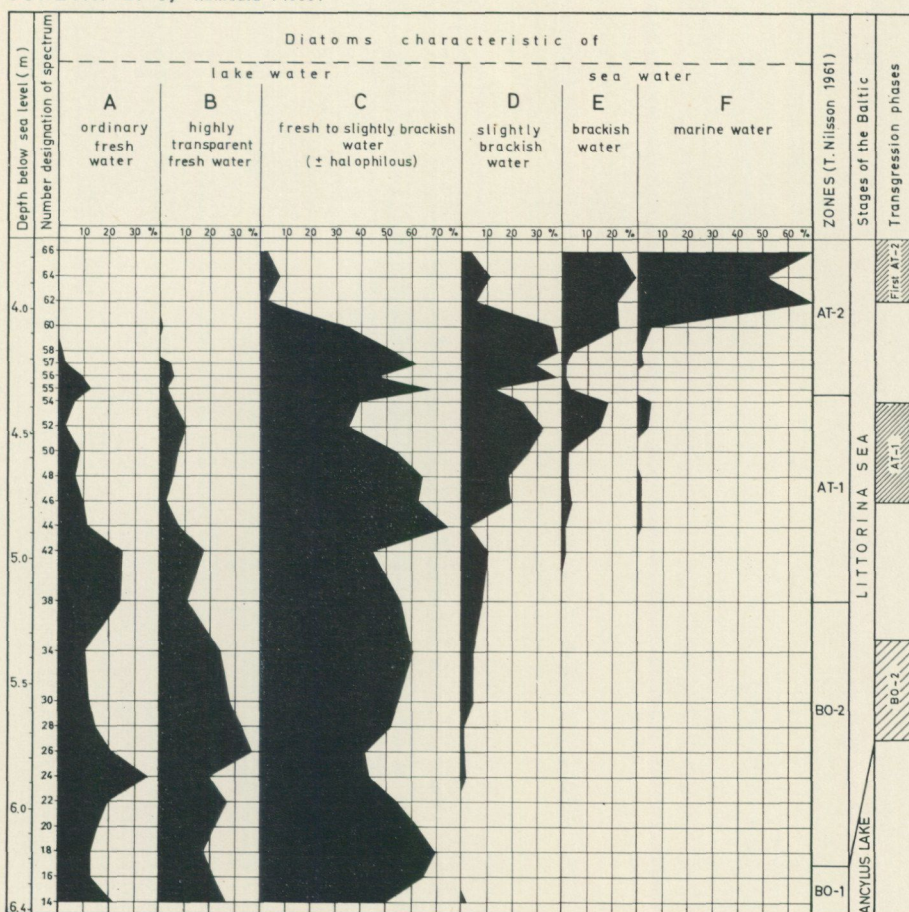


Fig. 4. Diagram showing the succession of the fossil diatom flora at Sörevik BP I. The group A—F are described on p. 6. Detailed diagram in Pl. II.

column is proportional to the figures of frequency. For the layers between 3.8 and 6.4 m below sea level this diagram has been completed with fully quantitative and qualitative analyses (plate II, Figs. 4, 5).

Recently a series of samples was collected from BP 5. Only some preliminary pollen analyses have been made at this point. Later this material will be thoroughly investigated by means of pollen and diatom analyses and radiocarbon datings.

Layer H, the Late-Glacial clay, seems to have been a dry-crust. Layers F and G have been dated pollen-analytically at the beginning of the Early Boreal time. According to the analysis there is a discordance between H and G. Material from layer F at BP 5 has been radiocarbon-dated at 7265 ± 140 B.C. (St—333).

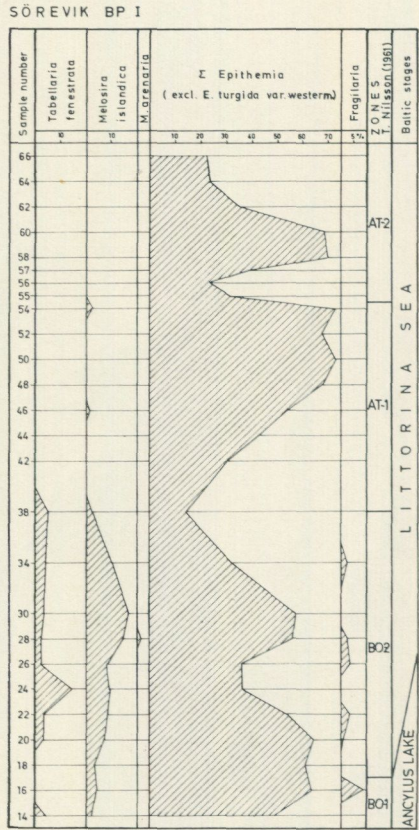
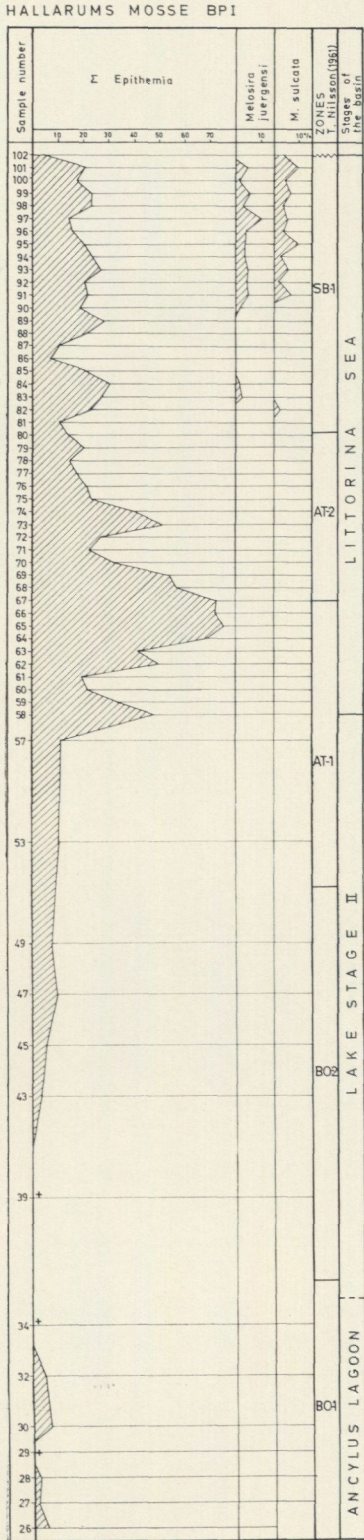


Fig. 5 (above). Diagram from Sörevik BP I showing the frequencies of the diatoms not included in the diatom sum.

Fig. 6 (to the left). Diagram from Hallarums mosse BP I showing the frequencies of the diatoms not included in the diatom sum.

Layer H was during Pre-Boreal time situated above the water level. Later it was transgraded and the sand layer formed. The diatom flora is poor and does not indicate whether the sand is lacustrine or marine.

Layer E, the clay gyttja, has been deposited during the Early Boreal time. The diatom flora is lacustrine. Among the species there are several which are characteristic of the Ancylus Lake. The dominant species are *Cyclotella bodanica*, *Cymbella prostrata*, *Gyrosigma attenuatum*, *Melosira arenaria*, *M. islandica*, *Navicula oblonga*, *Opephora martyi*, *Stephanodiscus astraea*. The transgression mentioned above seems to have occurred in the beginning of the Ancylus Lake stage. During its culmination the clay gyttja was formed. This stage falls within the Early Boreal time.

Layers D and C, clayey fine detritus gyttja and gasteropod gyttja, have been formed during Late Boreal time. The boundary to the overlying gyttja lies between the index horizons BO 2 b and c. The diatom analyses show that this is a transition stage between the Ancylus Lake stage and a stage with very slightly brackish water. The fresh water diatoms dominate, but the frequency of the halophilous diatoms increases and the first brackish water diatoms appear. The latter are *Mastogloia smithii*, *Stauroneis salina* and *Synedra pulchella*. The pollen diagram shows, however, that the aquatic and shore vegetation, broadly speaking, is the same as before. Also the gasteropods are fresh water species.

Layer B, marine fine detritus gyttja, includes the end of the Late Boreal time and most of the Atlantic time. Probably sedimentation has continued even later, but such younger sediments have been eroded. The uppermost pollen-analyzed sample is mixed with younger material. Layer B can be subdivided into one lower part comprising Late Boreal and Early Atlantic time and one upper part comprising at least the beginning of the Late Atlantic time.

The lower part of the marine gyttja is characterized by the rich occurrence of fresh water diatoms as well as brackish water diatoms. The aquatic and shore vegetation seems to have nearly the same lacustrine character as during the early part of the Late Boreal time. Among other plants *Nymphaea alba* seems to have been common. Between the index horizons BO 2 a and c several diatoms characteristic of slightly brackish water appear more regularly than earlier: *Cocconeis pediculus*, *Mastogloia smithii*, *Rhoicosphenia curvata* and *Synedra pulchella*. More occasional are *Amphora commutata*, *Campylodiscus clypeus*, *Nitzschia frustulum* and *N. hungarica*. It is possible that there was a transgression at that time. The analyses show at least distinctly that the Late Boreal time was an ingression phase — a period when the salinity very slowly increased.

During Early Atlantic time (between AT 1 c and d) the frequency of the fresh water species decreases and the slightly brackish water diatoms become more common. In the last group *Mastogloia*-species dominate (*M. braunii*, *M. elliptica* and *M. smithii*). Also some ordinary brackish water species occur, among others *Diploneis interrupta*, *Epithemia turgida* var. *westermanni* and *Navicula peregrina*

as well as marine plankton forms, e. g., *Melosira moniliformis*. There was a transgression in the later part of the Early Atlantic time and a regression at the zone boundary AT 1/AT 2. The very beginning of AT 2 is a transition stage to the next period.

The conclusion must be that the layers from the largest part of the Late Boreal and the whole of the Early Atlantic time have been deposited in a sea with very low salinity. Three phases can be distinguished, the first with nearly fresh water up to BO 2 b/c, the second with very slightly brackish water up to AT 1 c/d and the third with brackish water up to the beginning of AT 2.

The upper part of the marine gyttja begins at the index horizon AT 2 f. Within this horizon sea water diatoms are quite dominant. Among them there occur several marine forms, *Grammatophora* spp., *Hyalodiscus scoticus*, *Navicula digitoradiata*, *N. lyra*, *Rhabdonema* spp. and *Synedra crystallina*. The marine zooplankton named hystrichospaerids are met with very often (cf. p. 6). Further, the aquatic and shore vegetation has a marine character — pollen grains of *Chenopodiaceae* and *Artemisia* occur abundantly just above AT 2 f. These plant groups represent a shore vegetation which is characteristic of sea shores. The distinct change at this index horizon is surely caused by a transgression. It is difficult or rather impossible to identify transgressions in the overlying deposits because the relative difference of level between a transgression and a regression must have been very small. However, it is clear that the sedimentation was strong during the Late Atlantic time.

In the inner part of the bay the coarse detritus gyttja, layer b, corresponds to the oldest marine gyttja. Layer b is deposited in shallow water near the shore. Some preliminary analyses have been made on material from BP 5. The gyttja has been dated at the end of BO 2 and the beginning of AT 1. It consequently corresponds to a regression phase during this time. The lobe of marine gyttja in the upper part has eventually been formed during a short transgression, preliminarily dated at BO 2 a (see above).

Loc. 3. Hallarums mosse

Jämjö parish, about 1 km southeast of the village of Hallarum. An ancient Littorina inlet, nowadays a peat bog. (Cf. photo Fig. 7, section of stratigraphy Fig. 8, pollen diagrams plate III and Figs. 9, 13, diatom diagrams plate III and Figs. 6, 10—12.)

Hallarums mosse lies within a basin with rather steep slopes. The outlet of the basin faces the northwest towards the bay of Hallarum. The overflow threshold lies about 5 m above sea level (the upper surface of the moraine has here been levelled to 4.7 m). The peat bog is nowadays drained and partly reclaimed. The easternmost part is most intact. A small brook flows down from the hills in the east.

Based on borings in the eastern part of the bog a section has been drawn. One



Fig. 7. The innermost part of the Hallarum's bay seen from the south. In the background of the picture (the right side) this bay is continued by a valley running into the Hallarums mosse basin. The photo also shows the characteristic coast landscape with valleys and rocky hills. July 1957.

separate boring has been performed in the central part of the bog (BP II). Here the underlying sediments are very thick but too loose for the sampler. All borings have been made with the Hiller sampler except at BP I, where the "Borro" sampler has been used. The stratigraphy is as follows :

- A. Sphagnum peat, brown-black, highly humified. In the central part of the bog this peat is covered with moderately humified *Sphagnum* peat.
- B. Sphagnum peat, moderately humified, brown. Distinct boundary between this layer and C.
- C. Sphagnum peat, highly humified, brown-black.
- D. Carex-Sphagnum peat, moderately humified, dark brown.
- E. Carr peat, highly humified, dark brown. This does not occur in the central part of the bog where layer D lies directly on gyttja.
- EF. Coarse detritus gyttja, dark green-brown. Fruit stones of *Potamogeton* and seeds

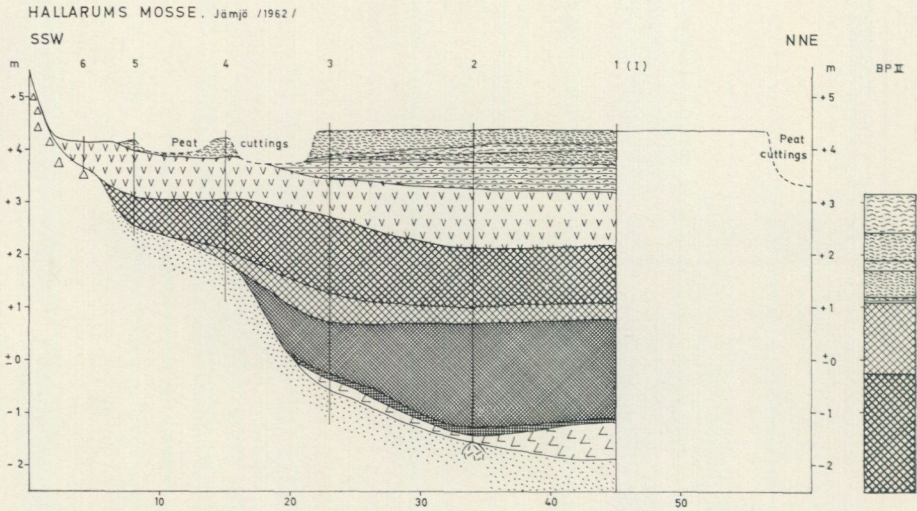


Fig. 8. Section of the eastern part of Hallarums mosse. BP II shows the stratigraphy in the central part of the bog. Legend see p. 42, description pp. 15—17.

of *Nymphaea alba* are numerous. This is a lacustrine gyttja which only is met with in the central part of the basin.

- F. Marine fine detritus gyttja, partly clayey, dark green. In the uppermost part there are abundant remains (roots and stems) of probably aquatic plants. Seeds of *Ruppia*, *Najas marina* and leaves of *Zostera marina* are also found.
- G. Coarse detritus gyttja, dark green-brown.
- H. Fine detritus gyttja, partly slightly clayey, dark green.
- I. Clay gyttja, grey-green. Distinct boundary between this layer and K.
- K. Muddy clay, grey-green.
- L, M. Clay, grey. The lower part varved (M).
- N. Sand, partly clayey.

At BP I a series of samples has been investigated by means of pollen and diatom analyses. This only applies to the sediments and the contact with the terrestrial peat. Material has also been collected for radiocarbon datings. The stratigraphy follows below (the figures indicate height above sealevel) :

- A—C. 4.00 — 3.12 m Sphagnum peat.
- D. 3.12 — 2.80 m Carex-Sphagnum peat.
- E. 2.80 — 1.79 m *Alnus carr* peat. Rich in wood of *Alnus* and *Betula*.
- F. 1.79 — 0.71 m Marine fine detritus gyttja, dark green. Leaves of *Zostera marina* and seeds of *Ruppia* and *Najas marina* are rather common.
- F₁. 1.79 — 1.69 m Slightly clayey gyttja. Abundant plant remains (roots, stems, leaves) from probably aquatic vegetation.
- F₂. 1.69 — 1.40 m Non-clayey gyttja. Partly algae gyttja.

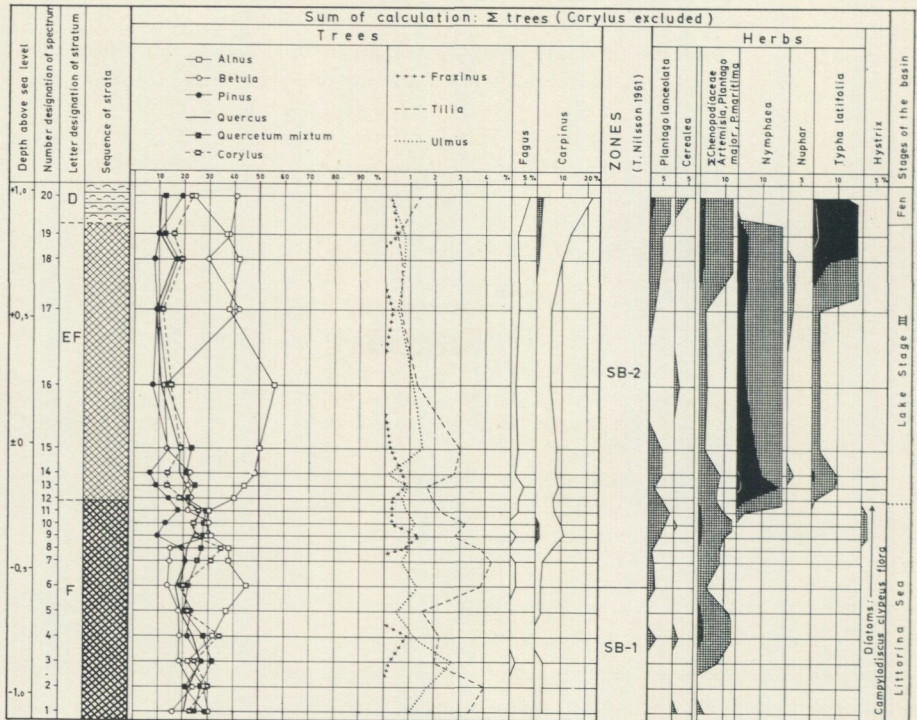
F ₃ .	1.40 —	1.30 m	Clayey gyttja.
F ₄ .	1.30 —	0.93 m	As F ₂ .
F ₅ .	0.93 —	0.71 m	Brackish gyttja, dark green to yellow green. Not clayey. Roots and stems of aquatic plants are rather common. Seeds of <i>Najas marina</i> .
G.	0.71 —	0.41 m	Coarse detritus gyttja, green-brown. Seeds of <i>Nymphaea</i> and fruit stones of <i>Potamogeton</i> are abundant.
H.	0.41 —	—1.43 m	Fine detritus gyttja, dark green. Few macroscopic plant remains.
H ₁ .	0.41 —	0.12 m	Slightly clayey gyttja with some plant fragments.
H ₂ .	0.12 —	—0.92 m	Clayey gyttja.
H ₃ .	—0.92 —	—1.29 m	Slightly clayey gyttja, very dark colour. Partly algae gyttja.
H ₄ .	—1.29 —	—1.43 m	Clayey gyttja, dark grey-green. Diffuse transition to the underlying layer.
I.	—1.43 —	—1.52 m	Clayey algae gyttja. Rather distinct boundary between this and the underlying layer.
K.	—1.52 —	—1.56 m	Muddy clay.
L, M.	—1.56 —	—2.27 m	Clay, varved between 1.63 and 2.27 m (M), grey or brown-grey.
N.	—2.27 —	?	Sand, partly clayey.

The pollen diagram is shown in plate III. It includes above all the marine layers of the basin. The diatom analyses are presented in two diagrams, one connected with the pollen diagram and a separate one which comprises only the limnic part (Fig. 10). A summarizing diatom diagram is shown in Fig. 11 and a survey diagram with both pollen and diatom diagrams is presented in Fig. 13. The transition between the marine and lacustrine sediments in BP II has also been pollen-analytically investigated (Fig. 9).

The pollen curves are normal except in layers D, E and EF where *Alnus* and *Betula* are over-represented. This is caused by local supply of these pollen grains from trees which have been growing in the fen. When it comes to the diatoms there are almost no diatoms in the gyttja layer H₃, but above the boundary H₂/H₃ the diatom flora is very rich.

Layer L is a Late-Glacial clay which has been deposited in the Baltic Ice Lake. At the transition between Late-Glacial and Post-Glacial time (Younger Dryas/Pre-Boreal) the basin was isolated from the Baltic and a small lake formed. During the first lake stage in Pre-Boreal time the layers K, I, H₄ and H₃ were deposited. Suddenly, above a sedimentation boundary the diatom flora becomes very rich. This flora has a mixed composition of diatoms characteristic of highly transparent water ("Ancyclus flora") and ordinary fresh water diatoms. To the latter group belong some alkaliphilous species which are extremely common here, *Navicula graciloides* and *N. laterostrata*. For this reason the diatom spectra will be very different if these species are included or not in the diatom sum (cf. Fig. 11). In the main diagram (Fig. 10) they are included, in the survey diagram (Fig. 13) excluded. The flora is not quite typical of the Ancyclus Lake but,

HALLARUMS MOSSE BP II, Jämjö / 1959/



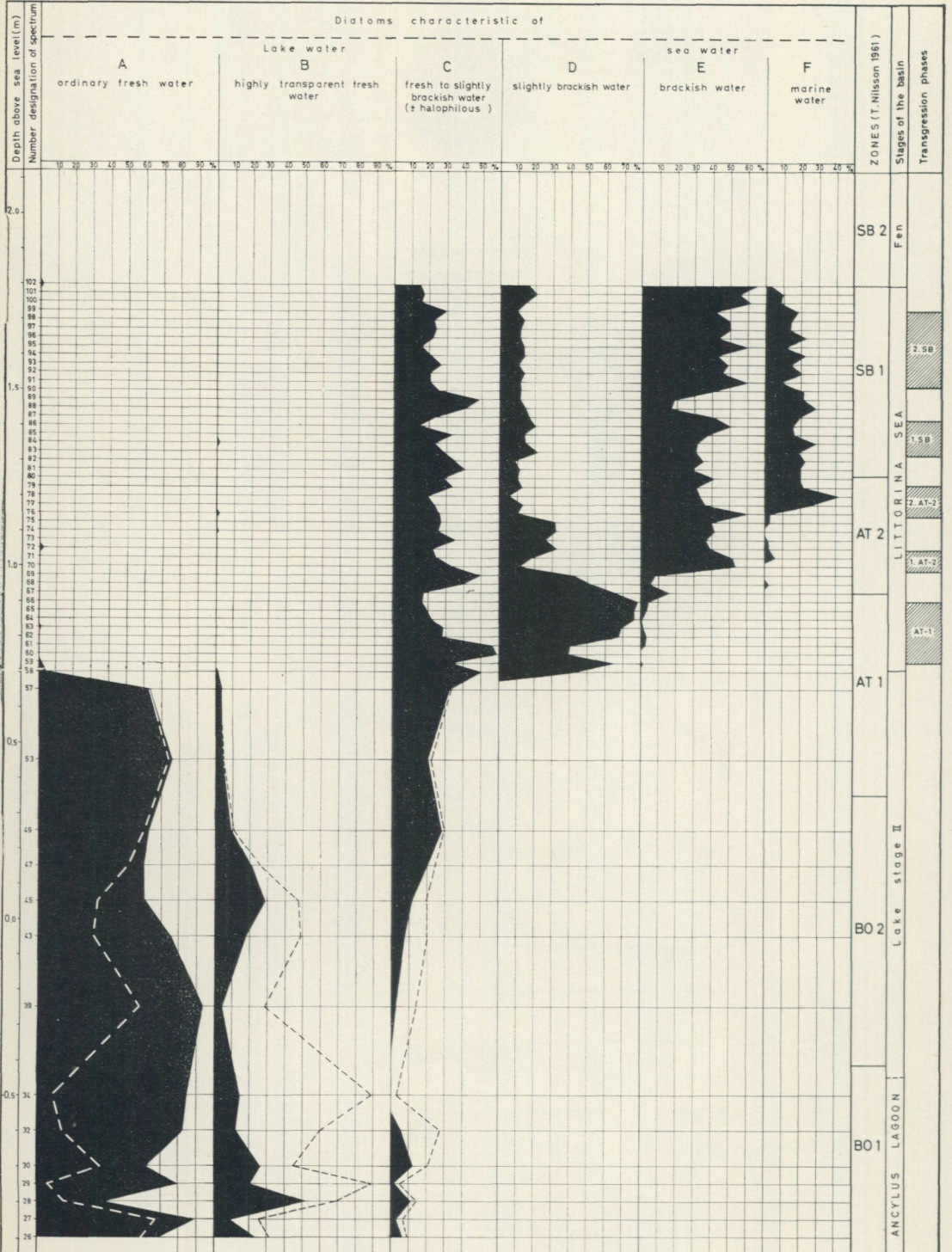
Anal. B. E. Berglund, I. Kristersson 1963-64

Fig. 9. Pollen diagram from Hallarums mosse BP II situated in the central part of the bog. In this diagram the pollen sum is more than 600 arbor pollen. Legend, see p. 42.

broadly speaking, similar to the Ancyclus lagoon floras of Central Sweden (M.-B. Florin 1945, 1946, S. Florin 1948). The upper boundary is rather diffuse. Though it is an aberrant Ancyclus flora it seems possible that the Ancyclus Lake has transgraded the threshold of 5 m. In this case the Hallarums mosse basin formed a shallow inlet or lagoon to the Ancyclus Lake during the Early Boreal time. Probably the sound in the west was narrow and shallow. Another way of explaining the development of the diatom flora during Boreal time is the following. In the beginning there was an eutrophic lake but as a result of filling up and/or lowering of water level the character of the lake was changed. However, several circumstances in the beginning of the Early Boreal time, the change of the sediments to more clayey gyttja, the sudden change of the diatom flora and the character of the diatoms, support the assumption that the Ancyclus Lake really transgraded. But this ought to be verified from other sites.

During Late Boreal time and the beginning of the Early Atlantic time there was again a small lake, Lake Stage II. The increasing frequency of limnophytes (pollen and macrofossils) indicates that the lake was in the process of being

HALLARUMS MOSSE BPI, Jämjö /1962/



filled up. This was stopped by the transgression of the Littorina Sea just above AT 1 c. Up to the zone boundary AT 1/ AT 2 the brackish water flora is dominant, later the flora has a more marine character. During the Early Atlantic time the following diatoms characteristic of slightly brackish water are dominant: *Mastogloia smithii*, *M. braunii*, *Navicula scopulorum* and *Campylodiscus clypeus*. Just above the zone boundary the flora changes suddenly. Species requiring much higher salinity immigrate into the basin. They characterize the flora during both Late Atlantic and Early Sub-Boreal time. The most common species are *Achnanthes brevipes*, *Cocconeis scutellum*, *Navicula peregrina*, *N. pygmaea* and *Rhopalodia gibberula*. When this change of the diatom flora occurs the marine plankton Hystrichosphaeridae also immigrates and pollen of the sea shore plants within *Artemisia* and *Chenopodiaceae* become very common. It is interesting to see that at this point of time there is quite a corresponding change in the flora at the Sörevik locality. Marine plankton forms are common first after the middle of AT 2, then *Actinocyclus ehrenbergii* and marine *Coscinodiscus*-species immigrate. *Melosira sulcata* appears in the middle of SB 1. The macroscopic finds show that also the aquatic spermatophyte vegetation was marine, in the basin occurred e.g., *Ruppia*, *Najas marina* and *Zostera marina*.

The sea water diatoms can be classified into ecological groups if they have special demands of water depth (cf. M.-B. Florin 1945). Some diatoms have been chosen and put into the following groups: a) Littorina lagoon, b) Shallow Littorina bay, c) Deep Littorina bay. The occurrence of these bathymetric groups is presented in Fig. 12. Included in the groups are only bottom forms and epiphytes, but some important plankton forms have been plotted separately in the diagram. On the basis of this it seems possible to distinguish the following transgressions:

The Early Atlantic (in the diagram named AT-1)

The first Late Atlantic (1. AT-2)

The second Late Atlantic (2. AT-2)

The first Early Sub-Boreal (1. SB-1)

The second Early Sub-Boreal (2. SB-1)

The Early Atlantic transgression is characterized by the dominance of the shallow Littorina bay species, the regression afterwards by a maximum of the Littorina lagoon species (*Campylodiscus clypeus*). The first Late Atlantic transgression begins with increasing frequency of the shallow Littorina bay species followed by a culmination of the curve for the deep Littorina bay species. In this part of the diagram the curves are especially easy to interpret and all facts

Fig. 11. Diatom diagram showing the succession of the fossil diatom flora in Hallarums mosse BP I. The groups A—F are described on p. 6. Detailed diagram in Fig. 10 and Pl. III. At the bottom of the diagram the broken lines indicate the frequencies when *Navicula graciloides* and *N. laterostrata* are excluded (cf. Fig. 10).

HALLARUMS MOSSE BP I, Jämjö / 1962 /

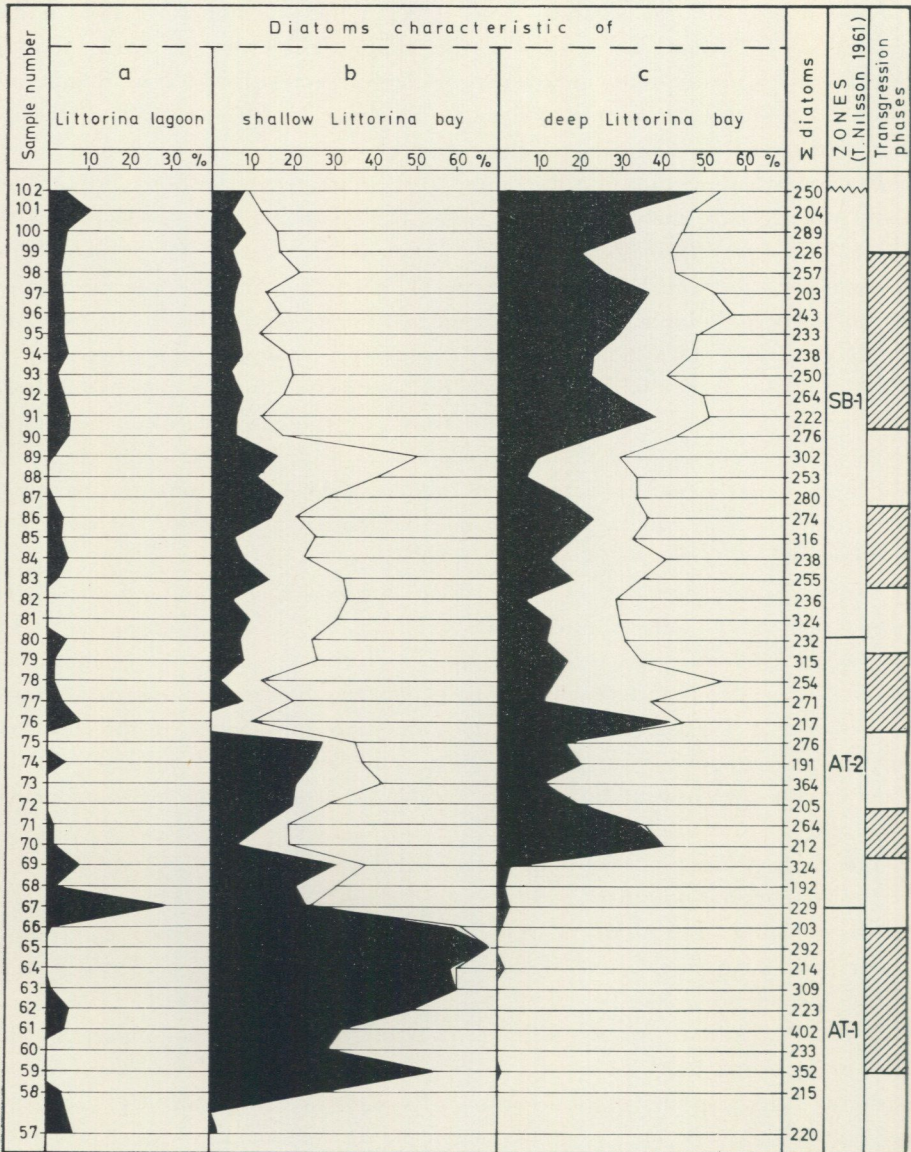


Fig. 12. Diagram from Hallarums mosse BP I covering the brackish and marine sediments. It shows the frequencies of diatoms with different water depth requirements. Bottom forms and epiphytes in solid black, plankton forms separated (white field). Group a) Littorina lagoon include: *Amphora mexicana* var. *major*, *Anomoeoneis sculpta*, *Campylodiscus clypeus*, *Nitzschia circumscuta*, *N. scalaris*, *N. tryblionella* and *Surirella striatula*. Group b) Shallow Littorina bay include: *Amphora commutata*, *A. holsatica*, *Mastogloia braunii*, *M. elliptica*, *M. smithii*, *Navicula scopulorum*, *Rhoicosphenia curvata*, and the plankton form *Cyclotella meneghiniana*. Group c) Deep Littorina bay include: *Achmanthes brevipes*, *Campylodiscus bicostatus*, *Cocconeis scutellum*, *Diploneis didyma*, *D. interrupta*, *D. smithii*, *Grammatophora marina*, *Navicula peregrina*, *Synedra affinis*, *S. crystallina* and the plankton forms *Actinocyclus ehrenbergii*, *Coscinodiscus* spp., *Hyalodiscus scoticus* and *Melosira sulcata*.

indicate that it certainly is a question of real transgressions of the Baltic. Later the sea level was higher and the difference between transgressions and regressions is not expected to be so distinct. The Late Atlantic and Early Sub-Boreal transgressions are marked by a maximum of the deep *Littorina* bay species while the regressions are marked by a maximum of the shallow water species. The first Sub-Boreal transgression can be distinguished in the sediments as a more clayey mud. The higher clay proportion eventually depends on a higher sea level with more erosion and stronger inflow of clay and silt from the Hallarum's bay.

Between the marine gyttja and the fen peat there is a small erosion-hiatus, which corresponds to the later part of SB 1. The diagram from BP II (Fig. 9) shows, however, that there has been a continuous sedimentation in the central part of the basin. The marine gyttja with *Littorina* lagoon flora reaches to the transition SB 1/ SB 2. It is probable that the hiatus in BP I (according to radio-carbon datings its duration was about 700—800 years) corresponds to a regression as well as a transgression, the third Sub-Boreal (cf. locality Inlängen p. 31).

From the diagram in Fig. 9 it can be seen that the basin after the isolation from the *Littorina* sea was a lake, Lake Stage III. This stage was very short. Already in the Late Sub-Boreal time the lake was overgrown with telmatic fen vegetation.

Loc. 4. Sandbäcksviken

Sturkö parish, 300 m northeast of Sandbäcksviken. Beach ridge formed during the Post-Glacial transgression maximum. (Section Fig. 14, pollen diagram Fig. 15.)

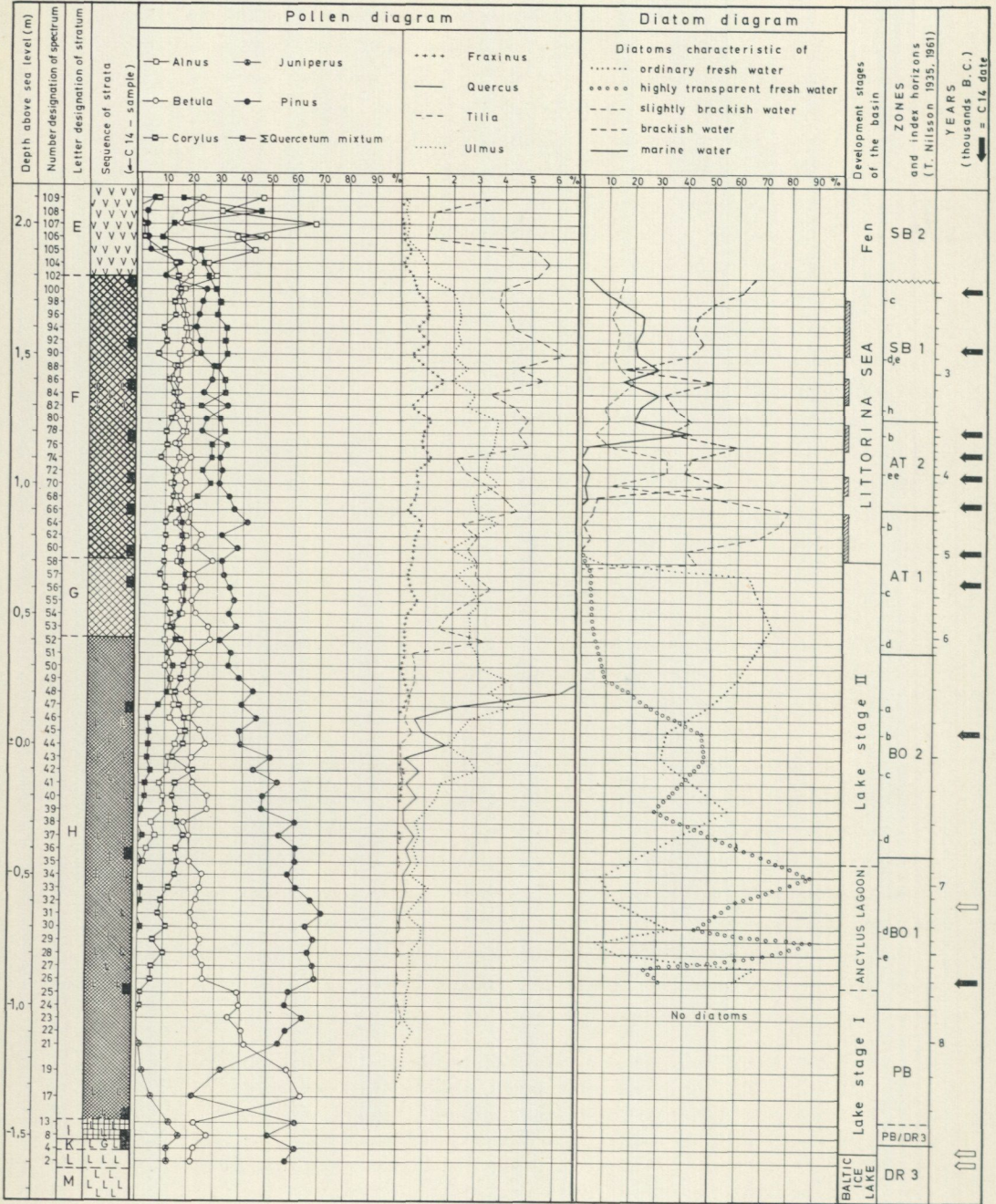
The place is situated in a valley running from the southwestern shore of the island of Sturkö to the center of the island. It is exposed towards the southwest. The beach ridge is mainly built of sand, covered with a thin layer of aeolic sand. Its top has been levelled to 8.2 m above sea level. This is the highest Post-Glacial transgression limit here. There are no distinct shore lines below this level. The proximal slope towards the sea is gentle (about 2°), the distal slope being much stronger. Northeast of the beach ridge there is a reclaimed fen.

Diggings have been performed on the distal slope of the ridge. At DP 2 and 4 the organic soils have been pollen-analytically investigated. DP 4 showed the following stratigraphy (the figures indicate height above sea level).

- | | | |
|----|---------------|---|
| A. | 7.25 — 6.77 m | Aeolic sand, yellow-white. |
| B. | 6.77 — 6.57 m | Fen peat, sandy, with dy. black-brown. |
| C. | 6.57 — 6.49 m | Muddy sand, with gravel grains, brown-grey. |
| D. | 6.49 — 6.10 m | Gyttja, sandy and clayey, black-grey. The upper part less sandy, like drift-gyttja. Contains fresh water diatoms. |
| E. | 6.10 — 5.25 m | Sand with gravel, grey-yellow. |

Layer A disappears nearer the fen, whereas B and D disappear closer to the top of the ridge. The sand layer C is a distal continuation of the shore sand

HALLARUMS MOSSE BPI, Jämjö / 1962/



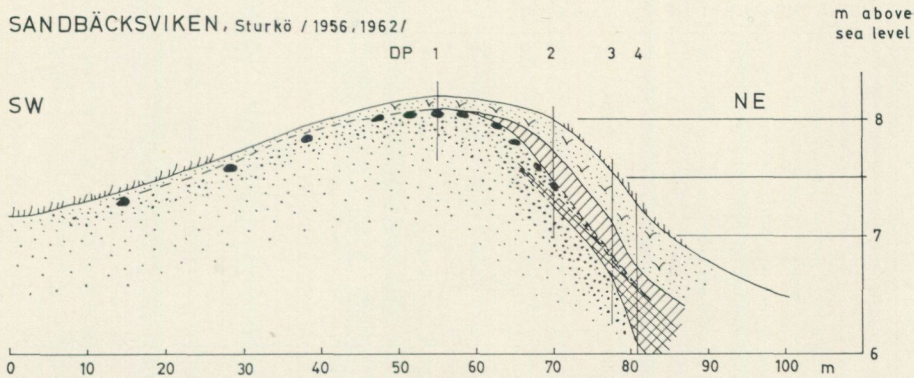


Fig. 14. Transversal section of the Littorina beach ridge at Sandbäcksviken, Sturkö. At DP 1 to 4 pits have been dug. Legend, see p. 42.

from the top of the ridge. The gyttja has been deposited near the shore of a lagoon with fresh water. The pollen diagram is difficult to interpret, but careful comparison with the standard diagrams of the district shows that the gyttja layer can be dated at an early part of the Early Sub-Boreal time. Radiocarbon dating of layer D at DP 2 has given too young an age, probably caused by downgrown roots (St—1003, Stockholm V).

The development at this shore ridge can be summarized in the following way. The underlying sand layers indicate that there was one older shore ridge. At a new rising of the ground water level caused by a sea transgression a lagoon was formed. The transgression probably culminated when the sand layer C was formed. This occurred in the beginning of the Early Sub-Boreal time. Accordingly, the highest Littorina transgression falls, at this point of time.

Loc. 5. Bäck

Aspö parish, along the road between the villages Bäck and Kroken. A complex beach ridge. (Photo Fig. 16, levelling profile Fig. 17.)

The shore ridge is exposed towards the south. It is built up of sand. Three different ridges (the upper two most distinct) can be distinguished. The levels of the ridge tops are 9.4, 8.1 and 6.3 m. There is almost no aeolic sand (the area is surrounded by forests). The slope towards the sea is even and gentle

Fig. 13. Survey diagram of Hallarums mosse BP I covering the development from the Younger Dryas to the Sub-Boreal time. The pollen sum varies between 1000 and 1500. *Corylus* is included in the sum. In the diatom diagram *Navicula graciloides* and *N. laterostrata* are not included (cf. Figs. 10, 11). The absolute age scale to the right is based on radiocarbon datings of the zone boundaries by T. Nilsson (1964). The centuries between these dates are estimated. The C-14 dates of samples from Hallarums mosse are marked with arrows, white if the statistical error is ± 170 or more.

There is no inversion in the sequence of the C 14-dates. Cf. table p. 46.



Fig. 16. The upper two beach ridges at Bäck, Aspö. At the edge of the woods a road follows the uppermost ridge. July 1956.

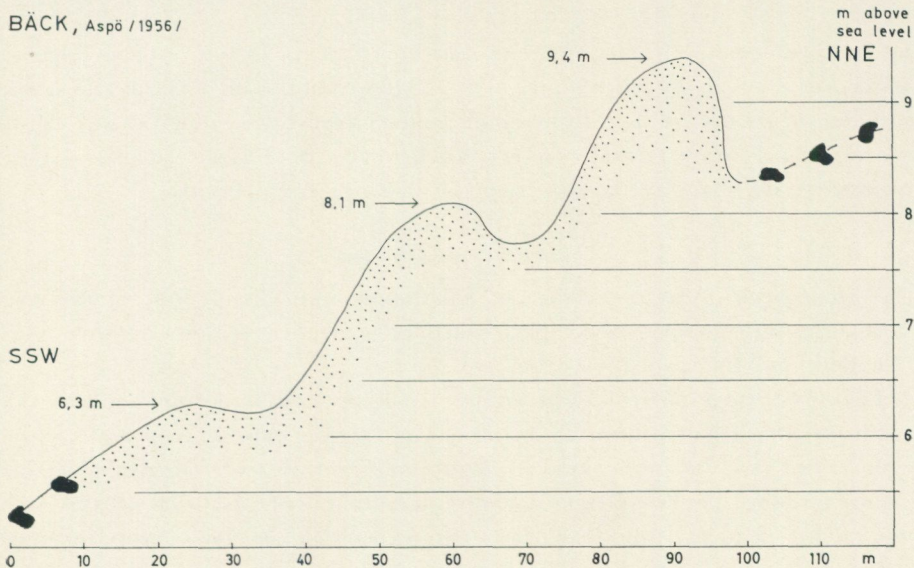


Fig. 17. Levelling cross profile of the beach ridges at Bäck, Aspö.



Fig. 18. Boulder field at Inlängen, Torhamn, seen from the southwest. The lowest Littorina beach ridge in the foreground, the middle is partly destroyed and the highest on the top of the hill at the sailing mark. July 1956.

height in the southern part of 8.7 m and in the north of 8.3 m. The slope towards the sea is more gentle than at the boulder field, both towards the north-east and the southwest. This formation is called crown ridge though it is a slightly aberrant type (formed distally from a beach ridge). Both Post-Glacial and Late-Glacial crown ridges are known from the Blekinge Archipelago.

Loc. 7. Pyslingebacken

Torhamn parish, in the village of Sandhamn, immediately east of the road Torhamn—Kristianopel. A complex beach ridge, with a neolithic culture layer. (Cf. Berglund 1960.)

The beach ridge on which the coast road is situated runs from southwest to northeast. It is exposed towards the east. The ridge is built of sand and covered with a thin layer of aeolic sand. Two different ridges are distinguishable, one higher forming the Post-Glacial transgression limit with the level of the ridge top 8.0 to 8.3 m and one lower, covered with a boulder layer, with the level of the ridge top 7.3 to 7.4 m. The slope is very gentle east of the complex ridge.

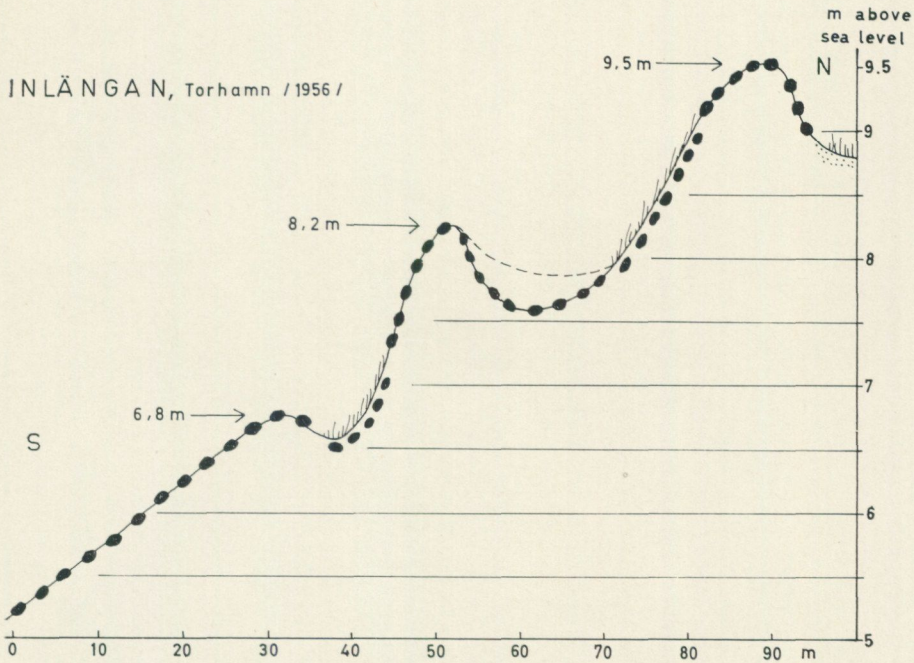


Fig. 19. Levelling cross profile of the beach ridges at Inlångan, Torhamn.

At Pysslingebacken a well-known neolithic settlement is situated. It was investigated by Lund University's Historical Museum in 1957. It was found that the culture layer lay on the surface of the lower beach ridge, below the aeolic sand and above the boulder layer. The archaeological investigation of the artefacts showed that the settlement is of the pitted-ware culture belonging to the stadium Säter III (Nerman 1911, Bagge 1937, 1951), i.e., from the latter part of the Middle Neolithic time or the last part of the Early Sub-Boreal time (cf. T. Nilsson 1948, p. 39). Accordingly the lower beach ridge is somewhat older. Some facts indicate that the settlement at this site ceased before the next transgression. If this is so the transgression must be slightly younger than the culture layer.

Loc. 8. Björkärr

Torhamn parish, between the villages Gisslevik and Torhamn. A complex beach ridge with neolithic culture layers. (Section Fig. 20.)

The locality is situated immediately northeast of the cross-roads Grebbegården—Torhamn—Möckleryd. The place was investigated by Lund University's Historical Museum in 1963. In the western part there is a gravel pit, while in the eastern part the shore ridge is almost intact. Here the top of the ridge is covered with pine forest. Within this area a transversal section was made, based on 15 dug

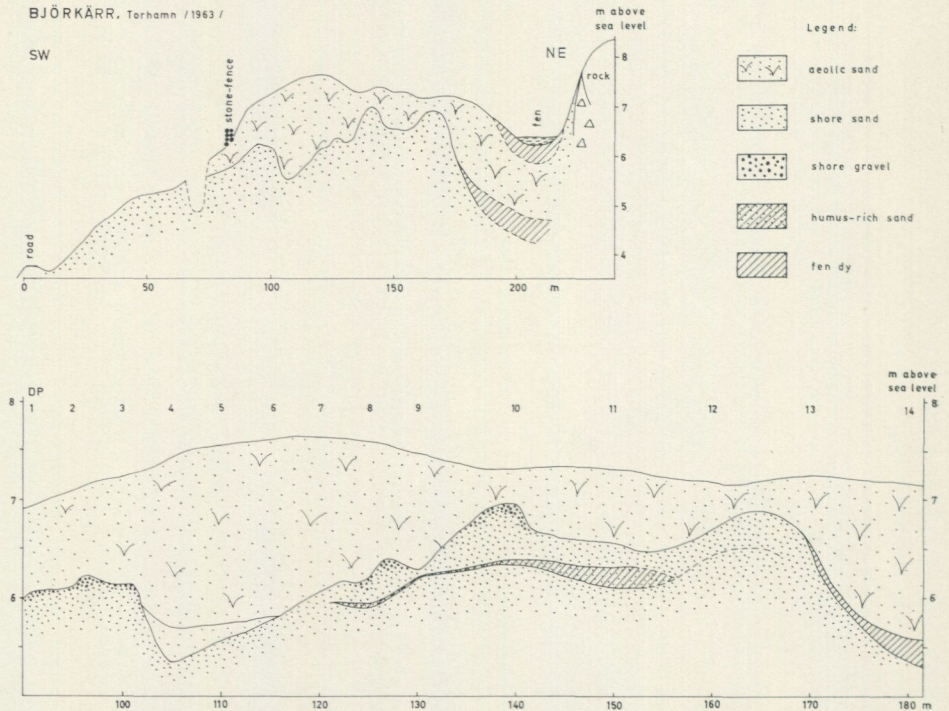


Fig. 20. Transversal section of the Littorina beach ridges at Björkär, Torhamn. DP 1 to 15 are dug pits. The lower section is an enlarged detail of the upper, from 90 to 185 m. Description, see the text.

pits (about 1×1 m and 1 to 2 m deep) with a distance from each other of five or ten meters. The complex beach ridge is covered with aeolic sand. By means of these pits the original surface of the shore ridge was discovered: a lower ridge top about 6.3 m above sea level and an upper doubled ridge with its top about 7.0 m above sea level (in the walls of the gravel pit one can also see a washed gravel zone about 5 to 5.5 m above sea level).¹ The highest ridge forms the maximal Post-Glacial transgression limit within this area. It is a complex ridge formed during the highest Littorina transgression. Through later aeolic activity it has been denuded. This ridge covers a lower and consequently older, also complex ridge. They are separated from each other by a humus-rich sand layer. Also the composition of the sand is different in the two ridges. The lower beach ridge (level: 6.3 m) has been formed during a younger transgression than that which formed the transgression limit.

¹The locality descriptions show that the beach ridges on the Torhamn Peninsula are consequently lower than corresponding ridges in the archipelago. This fact can be explained by the rather plain ground at the eastern and southern coast of this peninsula. Besides this the aeolic activity has been much stronger in this area (sandy areas in the archipelago have been wind-protected by forests). It is impossible to decide whether there have been Post-Glacial tectonic movements.

During the archaeological investigation the pitted-ware culture layers in the area west of the section in Fig. 20 were studied. This settlement had been situated on the aeolic dunes which form the western continuation of the large dune between the points 1 and 8 in the section, i.e. just above the lower beach ridge. The settlement is consequently also here younger than the next highest Littorina ridge (cf. loc. 7 Pyslingebacken). The artefacts also belong to the same group of the pitted-ware culture (Säter III is dominant) as at Pyslingebacken.

Loc. 9. Ekenäs

Ramdala parish, on the island of Senoren, immediately east of the road Sturkö—Ramdala, about 400 m northeast of Knarrholmen. A grave field with Late Neolithic cists. (Cf. Berglund, Petré & Salomonsson 1964, p. 23.)

At this place there are several cists, probably of Late Neolithic age (nowadays they are destroyed). They are situated on a sandy ridge formed during the highest Littorina transgressions. The level above the sea is 6 to 8 m, the lowest cist has been found at 5.5 to 6 m. The mean level of the sea must have been lower than 5 m when the cists were built.

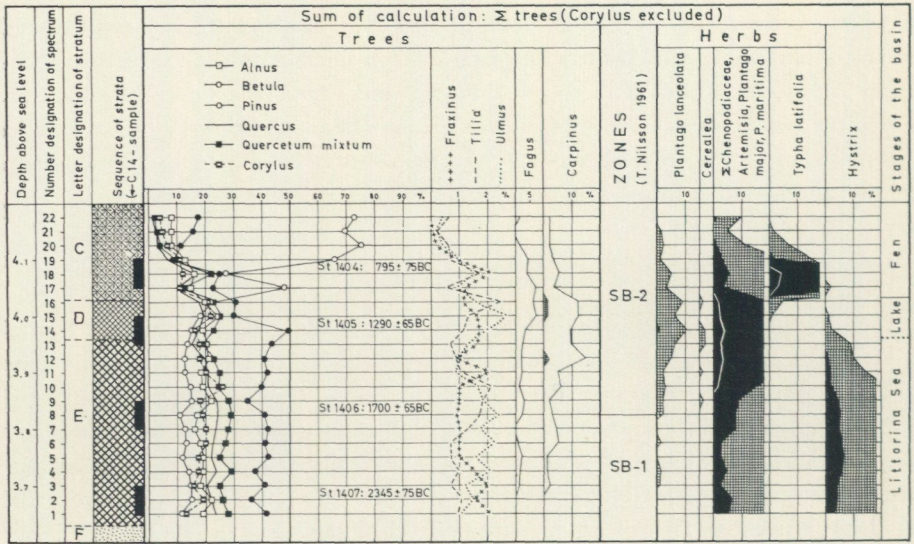
Loc. 10. Inlångans mosse

Torhamn parish, on the northern part of the island Inlångan. Fen with isolation horizon. (Pollen diagram Fig. 21.)

The fen is situated within a plain rocky area. Its overflow threshold lies about 5 m above sea level (or between 4.5 and 5 m). Several borings along longitudinal and transversal lines have been made. Two sections have been pollen-analytically investigated. The stratigraphy at the deepest section is the following (figures indicate height above sea level) :

- | | | |
|----|---------------|---|
| A. | 4.80 — 4.50 m | Fen dy, black-brown, containing an abundance of down-grown roots in the upper part. |
| B. | 4.50 — 4.20 m | Carr peat, brown-black. Wood of <i>Alnus</i> and <i>Betula</i> occurs abundantly. |
| C. | 4.20 — 4.03 m | Drift gyttja, brown-black, containing in the upper part wood of <i>Alnus</i> and <i>Betula</i> , in the lower roots and stems of <i>Phragmites</i> and <i>Dryopteris</i> . |
| D. | 4.03 — 3.96 m | Coarse detritus gyttja, green-brown, containing down-grown roots from overlying layer and fruit stones of <i>Potamogeton</i> . |
| E. | 3.96 — 3.63 m | Marine, slightly clayey fine detritus gyttja, dark green. Fruit stones of <i>Potamogeton pectinatus</i> and seeds of <i>Zannicheilia</i> occur abundantly. Diatom lagoon flora with <i>Campylodiscus clypeus</i> . The transition towards the underlying layer is rather diffuse. |
| F. | 3.63 — ? m | Sand, partly muddy. |

INLÄNGAN BP II, Torhamn / 1963 /



Anal. B. E. Berglund, I. Kristersson 1963-64

Fig. 21. Pollen diagram of Inlängen BP II. The pollen sum is more than 1000. Radiocarbon datings are indicated. Legend, see p. 42.

The pollen diagram in Fig. 21 shows the vegetational development for the layers F to C. The *Pinus* frequency in the marine part is abnormally high (cf. Faegri & Iversen 1964, p. 121).

The sedimentation of the marine gyttja began during the later part of the Early Sub-Boreal time — radiocarbon-dated at about 2300 B.C. The zone boundary lies in the upper part of layer E. It has been dated at 1700 ± 65 B.C. This age agrees very well with Nilssons (1964) dating of a corresponding boundary in Scania: 1700—1800 B.C. The basin has been isolated from the sea in the very beginning of the Late Sub-Boreal time, i. e., at the same time as the ancient lake of Hallarums mosse was isolated. The levels of the overflow thresholds are also very similar. The marine gyttja in Inlängans mosse is probably a transgression sediment, deposited during the third Sub-Boreal transgression at the end of the Early Sub-Boreal period and the beginning of the Late Sub-Boreal period.

Loc. 11. Öppenskär

Torhamn parish, on the southern part of the island of Öppenskär. Fen with isolation horizon.

The overflow threshold of the fen lies about 2 m above sea level. The history of the fen is similar to that of Inlängans mosse. Marine organic sediments have been deposited only during the Late Sub-Boreal time. The basin has been isolated from the sea at the transition between Late Sub-Boreal and Early Sub-Atlantic time.

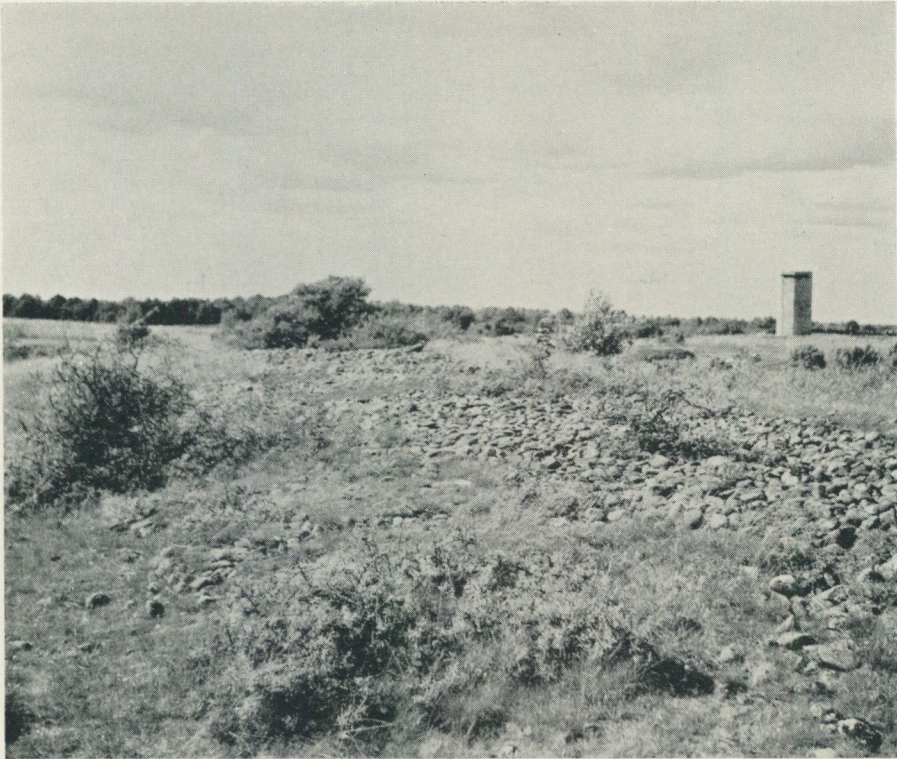


Fig. 22. The highest Littorina beach ridge at Hasslö. It is a boulder ridge with its top 9.5 m above sea level. This ridge runs circularly around the highest point of the island. July 1956.

Loc. 12. Torhamns udde

Torhamn parish, 500 m northwest of the triangulation point "Torhamns udde", the distance from the sea about 80 m. Grave field from the Iron Age.

On a rather plain ridge running from north to south there is a small grave field with several monumental stones. Probably it can be dated in the Late Iron Age. Between the shore and this place there is a rather plain meadow. The lowest levelled stone is situated about 2.2 m above sea level. When the grave field was used the shore could not have been higher than the level where the transition between the meadow and the ridge is nowadays, i.e., about 1.0 m above sea level.

In this paper only some of the most important localities have been described. Other similar localities have also been investigated. It has been shown that a stratigraphy similar to that described from Sörevik is common in sheltered places of the archipelago. The Post-Glacial transgression limit has been studied in several places, e.g., on the southern part of the islands of Hasslö (boulder ridge, top at 9.5 m above sea level, Fig. 22), Tjurkö (boulder ridge, top at 9.8 m), Senoren (beach ridge built of sand, sheltered position, top at 8.0 m), and Häst-

holmen (boulder ridge, top at 8.4 m). A beach ridge built of sand with its top lower than those described above has been levelled at Tång on the island of Hasslö (top at 4.0 m) and on the southern part of Torkö (top at 3.3 m). Pollen- and diatom-analytical investigations of an ancient brackish water lagoon at the ridge on Hasslö preliminarily date the latter to Late Sub-Boreal time.

The Shore Displacement

The results concerning the Post-Glacial shore displacement have been put together in a diagram (Fig. 23). The graph of this diagram illustrates the ancient mean water level of the Baltic in relation to the present water level. It has been supposed that the tops of beach ridges lie 1.0 to 2.0 m, dependent on exposition, above the corresponding mean water level (cf. Lundqvist 1928). The absolute ages of the pollen zone boundaries are the same as given by T. Nilsson (1964), which are based on radiocarbon datings from Scania. Nilsson's results are very similar to those from eastern Blekinge (cf. Fig. 13). Only the age of the boundary AT 1/AT 2 has been changed, from c. 4600 to c. 4500 B.C.

The Baltic Ice Lake

The highest shore line (HK) in southeastern Blekinge was formed during the Baltic Ice Lake stage immediately after the ice recession, i.e., during the beginning of the Alleröd time (cf. Munthe 1940, E. Nilsson 1953, 1960). This shore line is not easily followed in this area but at the esker delta of Bredåkra it has been fixed at 60–67 m above sea level (O. Andersson 1927), at the esker delta of Rödeby at 63–65 m above sea level (Bergdahl 1955), and in the parishes of Augerum and Ramdala at 60–65 m (cf. also unpublished investigations by B. Ringberg). The investigated coast area lies consequently below the highest shore line.

After several drainages during the Alleröd time the Baltic Ice Lake was definitively drained at the northern end of Mount Billingen. According to E. Nilsson (1960) this occurred in 8315 B.C. i.e., 290 years before the deposition of the first symmict varve in the vicinity of Stockholm, which is dated at 8025 B.C.¹ This caused a strong regression in southern Sweden which is established in most basins within the investigated area (with outflow thresholds at 5 to 20 m above sea level). The isolation contact is characterized by a clayey sand or a gravel layer at the transition from minerogenic to organogenic sedimentation, i.e., about the zone boundary between the Younger Dryas and the Pre-Boreal time.

The transition from the Late-Glacial to the Post-Glacial time reflects an important climatic change which ought to correspond to the Gothi-Finiglacial boundary of 8300 B.C. (Lundqvist 1961, cf. T. Nilsson 1964, p. 29). Radiocarbon

¹According to the last revision of the Swedish time-scale (Järnefors) the first symmict varve is dated to 8015 B. C. New investigations by E. Nilsson (GFF 1964) indicate that the drainage of the Baltic Ice Lake occurred in 8213 B. C.

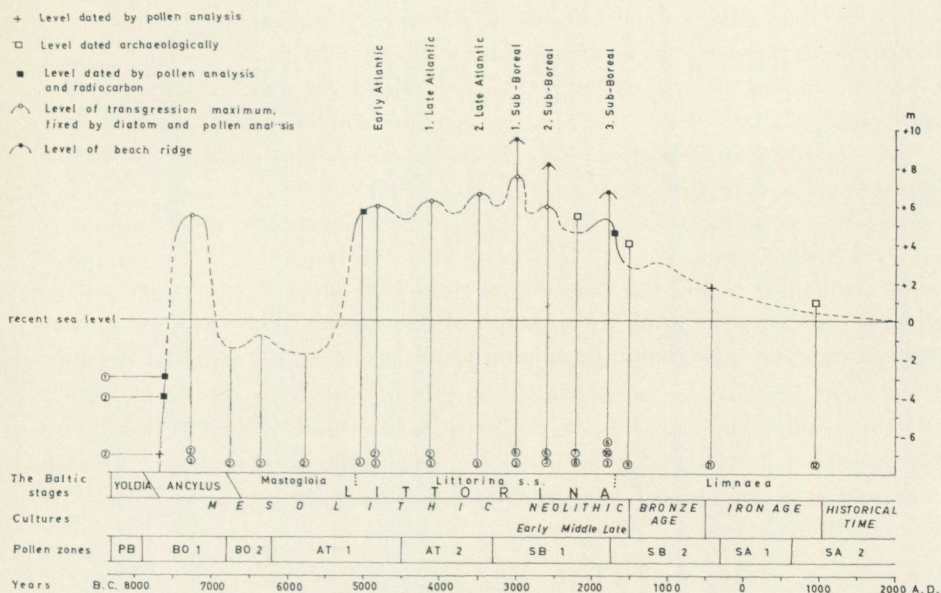


Fig. 23. Diagram illustrating the shore displacement in southeastern Blekinge. The graph indicates the ancient mean water level of the Baltic in relation to the present water level. The figures in circles refer to the numbers of the localities described in this paper. Cf. text, p. 34.

datings from Scania show that the age 8300 B.C. is a probable mean value for the pollen zone boundary DR/PB (T. Nilsson l.c.). Datings of the same boundary in Blekinge have given corresponding results (Hallarums mosse, St—1336, 1337). Consequently the transition DR/PB coincides with the end of the Baltic Ice Lake stage.

The Yoldia Sea

The drainage of the Baltic Ice Lake at Billingen marks the beginning of the Yoldia Sea which was connected with the ocean through the sounds of Central Sweden. In Blekinge the Yoldia time was a regression period.

Of great importance are those results concerning the bottom conditions south of the Blekinge coast which Kullenberg (1954, verbal communication) has obtained by means of borings with the Kullenberg sampler. At Bornholm there is a continuous stratigraphic sequence below 44 m below sea level. The sea bottom south of Blekinge and east of Scania is characterized by wide sandy areas. Between 20 and 35 m depth there is a clay which seems to be a dry-crust (very small proportion of water). Besides this a *Pinus* stump was found at about 40 m water depth south of Karlskrona Archipelago. The radiocarbon age of this stump is 7365 ± 120 B.C. (St—120). This may be compared with the date of the Kåseberga stumps found at 35 to 37 m depth south of Scania, 7605 ± 120 B.C.

(St—179). The Långöra locality has been described above (p. 8). The *Pinus* stumps found there at 3 m depth have been dated at 7630 ± 130 B.C.

The indications of an Early Post-Glacial regression are also supported by the stratigraphy of the bays in the Blekinge Archipelago. Already Gerard de Geer (1882) described an important sequence at Ronneby. This sequence shows that there was a river bed at least 12 m below present-day sea level. During the present investigations it has been found that a transgression sequence is rather common in the Karlskrona Archipelago, e.g., at Sörevik. The Pre-Boreal time is not represented by sediments. Sandy layers rest on a Late-Glacial clay, the upper part of which constitutes a dry-crust. Over the sand there is drift gyttja with *Pinus* wood and over this clay gyttja. The drift gyttja is formed in the beginning of the Early Boreal time. Possibly the radiocarbon dating from Sörevik at 7300 B.C. is somewhat too young. The clay gyttja is deposited in the Ancyclus Lake. Consequently there is a very distinct and, as it seems from the radiocarbon datings, a sudden transgression at the transition Yoldia Sea/Ancyclus Lake. This boundary may preliminarily be dated at 7500—7700 B.C.

The Ancyclus Lake

This stage begins with the transgression described above. The clay gyttja at the bottom of the sequences of the sea bays is a transgression sediment formed during the Early Boreal time. It contains fresh water diatoms and among these several characteristic of the Ancyclus Lake. However, the flora is somewhat different from the corresponding one known from Central Sweden (M.-B. Florin 1944, 1945, 1946, S. Florin 1948). The character of the sediments indicates that the water depth must have been rather great. The locality of Hallarums mosse (overflow threshold 5 m above sea level) affords a better possibility to determine the water level during the transgression maximum and to date the transgression phase. The diatom analyses have been interpreted in the following way. The basin was transgraded by the Ancyclus Lake in the beginning of the Early Boreal time shortly after Sörevik was transgraded. Certainly the water level was very low over the pass-threshold and the Hallarums mosse formed an Ancyclus lagoon. In this basin the transgression seems to have lasted from 7600 to 7000 B.C.¹ The basin was again isolated from the Baltic at the end of the Early Boreal period.

The shore line formed during the Ancyclus transgression cannot be distinguished in the field because it has later been overtransgraded by the Littorina transgressions. At Olsäng on the east coast of Blekinge Munthe (1902) believed that the Ancyclus beach ridge was somewhat higher than the highest Littorina ridge (the tops of both these ridges lie about 10 m above sea level). Recently started investigations of this area will more exactly date the complex beach ridges in

¹ Lundqvist (1957) has radiocarbon-dated peat below Ancyclus ridges on Gotland: 7790 ± 140 B.C. (Mölner) and 7460 ± 130 B.C. (Fröjel). This peat must have been formed before the transgression maximum.

this area. Holst (1899) supposed that the Ancyclus transgression reached about 8 m above sea level at the south coast of Blekinge. In this paper its mean water level during the transgression maximum has been estimated at about the same, c. 6 m.

The diatom analyses suggest that the Baltic during this stage was separated from the sea and formed a real Ancyclus Lake. In other localities within the Baltic basin with deep water sediments, one may find salt water diatoms as relics (cf. Strøm 1957, 1961). The Ancyclus sediments described in this paper have been deposited near the shores in rather shallow water.

The Ancyclus stage was of short duration, 700—1000 years. Broadly speaking, it comprises the Early Boreal time. Most researchers have supposed that this stage lasted much longer (cf. Munthe 1940 and literature cited in that work). In Finland the investigations by Sauramo (1954, 1955, 1958) have shown that the Ancyclus Lake stage existed only during the Early Boreal time. Similar results were obtained by Thomasson (1927, 1935) during investigations in Småland, southeastern Sweden.

The Littorina Sea s. 1.

THE MASTOGLOIA SEA

The stratigraphy of Sörevik shows that the water level during the Late Boreal and the beginning of the Early Atlantic time was somewhat lower than the present-day sea level. In the main it was a distinct regression period. Probably there was a small transgression at the end of the Late Boreal period.

It is in this connection of interest to compare the Sörevik sequence with some localities from the Lister Peninsula in western Blekinge. Holst (1909) describes the stratigraphy of Istaby mosse situated near the sea. Below the Littorina sediments there is a peat and a shell gyttja layer. The "peat" is an algae gyttja according to Holst. This layer corresponds rather well to the regression sediments of Sörevik. Sundelin (1924) describes a similar sequence from Fuglasjökarret also situated near the sea (there is no discernible pass-threshold). Below the Littorina gyttja there is *Amblystegium* and *Cladium* peat between 0.8 and 1.8 m below the present-day sea level. Sundelin's pollen-analytical dating indicates that these telmatic peat layers are of the same age as the coarse detritus gyttja of Sörevik.

Recently Königsson (1964) has published mollusc finds from northern Öland which according to him indicate a very low water level within the Ancyclus stage. However, nothing contradicts the hypothesis that the layers in question derive from the regression period of the Mastogloia stage.

During the beginning of the Late Boreal time some diatoms appear which are characteristic of slightly brackish water. Though the mollusc fauna and the macrovegetation are characterized by fresh water species the following conclusions

may be drawn from the diatom-analytical results: the Baltic has been connected with the ocean through very narrow and shallow sounds between the Danish islands. Probably neither the *Ancylus* water nor the sea water at this point of time reached the basins in the Great Belt described by Krog (1960). Here the beginning of the Late Boreal time is regarded as a transition stage between the *Ancylus* Lake and following real sea stage.

In the middle of the Late Boreal time the number of sea water diatoms increases, int.al. *Mastogloia smithii* appears though it is rare. But fresh water diatoms are still common and the macrovegetation has the same character as earlier. The diatom flora is the same also in the beginning of the Early Atlantic time up to AT 1 c. The water has been only slightly brackish; the salinity approximately < 5 permille (cf. Mölder 1943). This stage may be included in the Littorina Sea Stage *s.l.* (cf. Munthe 1940). It is regarded as a separate stage named Early Littorina time or *Mastogloia* time (cf. studies along the Swedish East Coast by Sundelin 1919, Thomasson 1927, 1935, S. Florin 1948).

In the southern Baltic (Scania) marine influence has not been verified east of Darsser Schwelle, the lowest overflow level of the Danish sounds, before the transition between the Boreal and the Atlantic time (T. Nilsson 1935, cf. 1948). Recently two sequences of fresh water layers situated at 28 and 23 m water depth respectively in the northern part of the Great Belt have been investigated (Krog 1960). In these basins a rise of the water level has occurred during late Early Boreal and Late Boreal time; peat below gyttja is radiocarbon-dated at about 6900 B.C. It has not yet been shown whether this change is caused by an eustathic rise of the sea or by outflow water from the *Ancylus* Lake. Nor has it been found out when Öresund became a sound between the Baltic and the Kattegat.

THE LITTORINA SEA *s. s.*

This stage comprises the later part of the Early Atlantic, the Late Atlantic and the Early Sub-Boreal time. The stage begins with a very distinct transgression, a rise of the sea level about 7 m during a very short time (the Hallarums mosse basin was transgraded). The water level seems to have been oscillating between 5 and 7.5 m above the recent sea level during the whole stage. Six transgressions have been identified within this period. They have been named after Blytt—Serander's terminology according to the suggestion by Iversen (1937). These denominations are very practical since corresponding names are now used for the pollen zones (T. Nilsson 1961). The transgression phases and their places in the pollen diagrams are as follows.

AT 1 c—AT 1/2	the Early Atlantic transgression
AT 2 ee—f	the first Late Atlantic transgression
AT 2 b	the second Late Atlantic transgression
SB 1 g—h	the first Sub-Boreal transgression (about 7.5 m above sea)

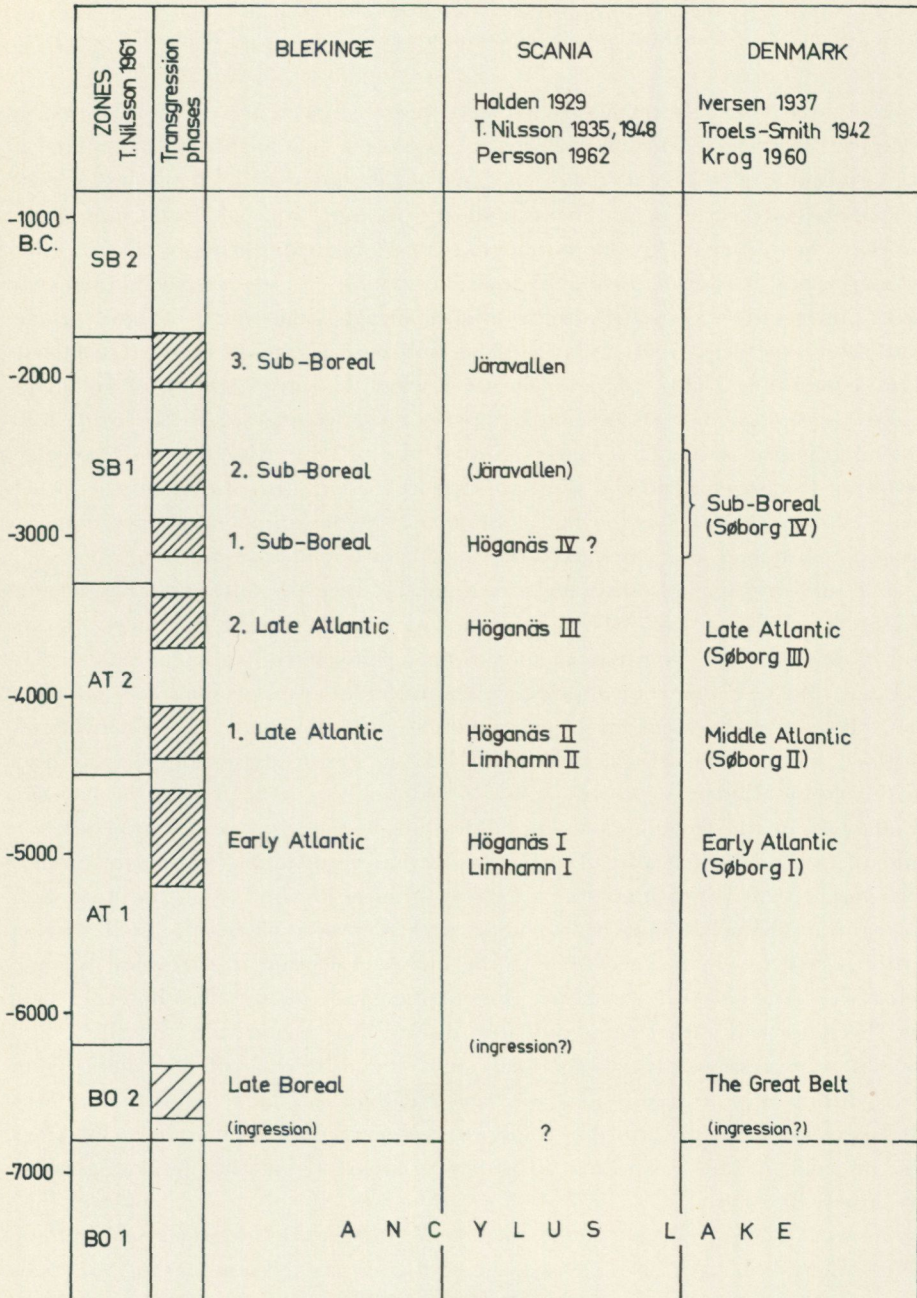


Fig. 24. Scheme showing the relation between the Littorina transgressions of Blekinge, Scania and Denmark according to the author's opinion.

SB 1 c—d	the second Sub-Boreal transgression (about 6 m above sea)
SB 1/SB 2	the third Sub-Boreal transgression (about 5 m above sea)

The three youngest transgressions have been connected with shore lines. In southern Blekinge the first Sub-Boreal transgression has formed the Post-Glacial transgression limit (PG). It has been dated pollen-analytically at the beach ridge of Sandbäcksviken. The sediments and the diatom flora of Hallarums mosse support the dating. This shore line like those formed during younger, lower transgressions is easy to distinguish morphologically, mostly as beach ridges. In accordance with the datings of the highest beach ridge the two lower ridges correspond to the second and the third Sub-Boreal transgressions respectively. This assumption is also supported in other ways. The investigation of Inlångans mosse shows that its transgression sediments must be referred to the third Sub-Boreal transgression with a water level of about 5 m. Also the archaeological results at Pyslingebacken and Björkärr support these datings. Layers of the pitted-ware culture (MN III according to Becker, 1954) seem to be younger than the second Sub-Boreal and older than the third Sub-Boreal transgression.

The survey in Fig. 24 shows the correlation between the different transgressions in the South Baltic area. There is some uncertainty especially concerning the Sub-Boreal period. The Höganäs locality in northwestern Scania investigated by Halden (1929) is still very important. The different transgressions are named in the following way: Höganäs I corresponds to an early small, and somewhat indistinct, transgression, Höganäs II and III to the two transgressions distinguished positively by Halden, while Höganäs IV eventually is indicated by the covering sand layer in the Höganäs sequence. Most likely the last transgression was the highest in the Höganäs area. The land uplift has been similar to that in southern Blekinge (p. 3). It is therefore of great interest to find that the first Sub-Boreal transgression is supposed to be the highest in both cases (cf. also T. Nilsson 1935, p. 546 f.). In southern Scania the highest Littorina transgression is somewhat younger. The complex beach ridge named Järavallen is Sub-Boreal. Its top has been formed rather late, probably during the second and the third Sub-Boreal transgressions. It is very likely that the difference of the mean water level during these transgressions was very small in this area. Sandegren (1929) distinguished several Littorina transgressions at Siretorp in western Blekinge. At this point of time it is rather difficult to compare them with the transgressions of eastern Blekinge.

Persson's (1962) datings of the first two Littorina transgressions in Limhamn south of Malmö have been revised. According to the present author the transgressions mentioned correspond to the Early Atlantic and the first Late Atlantic transgressions respectively. The pollen diagrams do not contradict this assumption and the radiocarbon analysis rather supports the dating. Sigling (unpublished) has reached similar results at the Segeå River north of Malmö.
























The Danish Littorina transgressions described by Iversen (1937) and named Søborg I—IV after the type locality in northeastern Zealand have been transferred to very detailed pollen diagrams at Dyrholmen (Troels-Smith 1942). It is rather easy to correlate them with the diagrams of Blekinge and to find out the corresponding transgressions. Probably Søborg IV is complex and analogous with the first two Sub-Boreal transgressions in Blekinge.

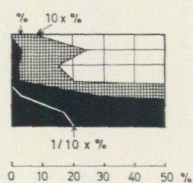
During the Early Atlantic part of the Littorina Sea *s.s.* the water was brackish; the salinity approximately 5—7 per mille (cf. Mölder 1943). Later it became marine with a salinity probably higher than nowadays, > 7 per mille (op.cit.). During the brackish stage the *Mastogloia* species (*M. braunii*, *M. elliptica*, *M. smithii*) dominated together with some diatoms requiring higher salinity. This period corresponds to the Clypeus stage in Central Sweden (S. Florin 1948). The very beginning of the Atlantic time is a transition period to the more marine stage. At AT 2 f there is a sudden change; the frequency of marine diatoms including plankton forms increases distinctly, just as the marine hystrichosphaerids and the sea shore plants of the genus *Artemisia* and the family Chenopodiaceae. This change is synchronous in the bay of Sörevik and in the inlet of Hallarums mosse. At this point of time the flora seems to have developed its present-day character.

THE LIMNAEA SEA

After the third Sub-Boreal transgression there was possibly one minor, which took place in the Late Sub-Boreal time. The water level during this stage was 2.5 to 3 m higher than the present sea level. After this event there seems to have been a more or less continuous regression. No lower shore lines have been found. Probably the salinity of the water successively decreased.

Signatures of diagrams and sections :

	Rock or boulder		Fine detritus gyttja
	Moraine		Coarse detritus gyttja
	Small boulders		Marine gyttja
	Sand		Gyttja generally
	Fine sand		Drift gyttja
	Aeolic sand		Fen peat
	Humus-rich sand		Carex-Sphagnum peat H 6-10
	Clay		Sphagnum peat H 6-7
	Muddy clay		Sphagnum peat H 8-10
	Clay gyttja		Carr peat
	Algae gyttja		Terrestrial grass peat
	Shell gyttja		



The value of the complex curves

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 GFF = Geologiska Föreningens i Stockholm Förhandlingar
 SGU = Sveriges geologiska undersökning
 SMHI = Sveriges meteorologisk-hydrografiska institut
 Stockholm I = Östlund 1957
 Stockholm II = Östlund 1959
 Stockholm III = Östlund & Engstrand 1960
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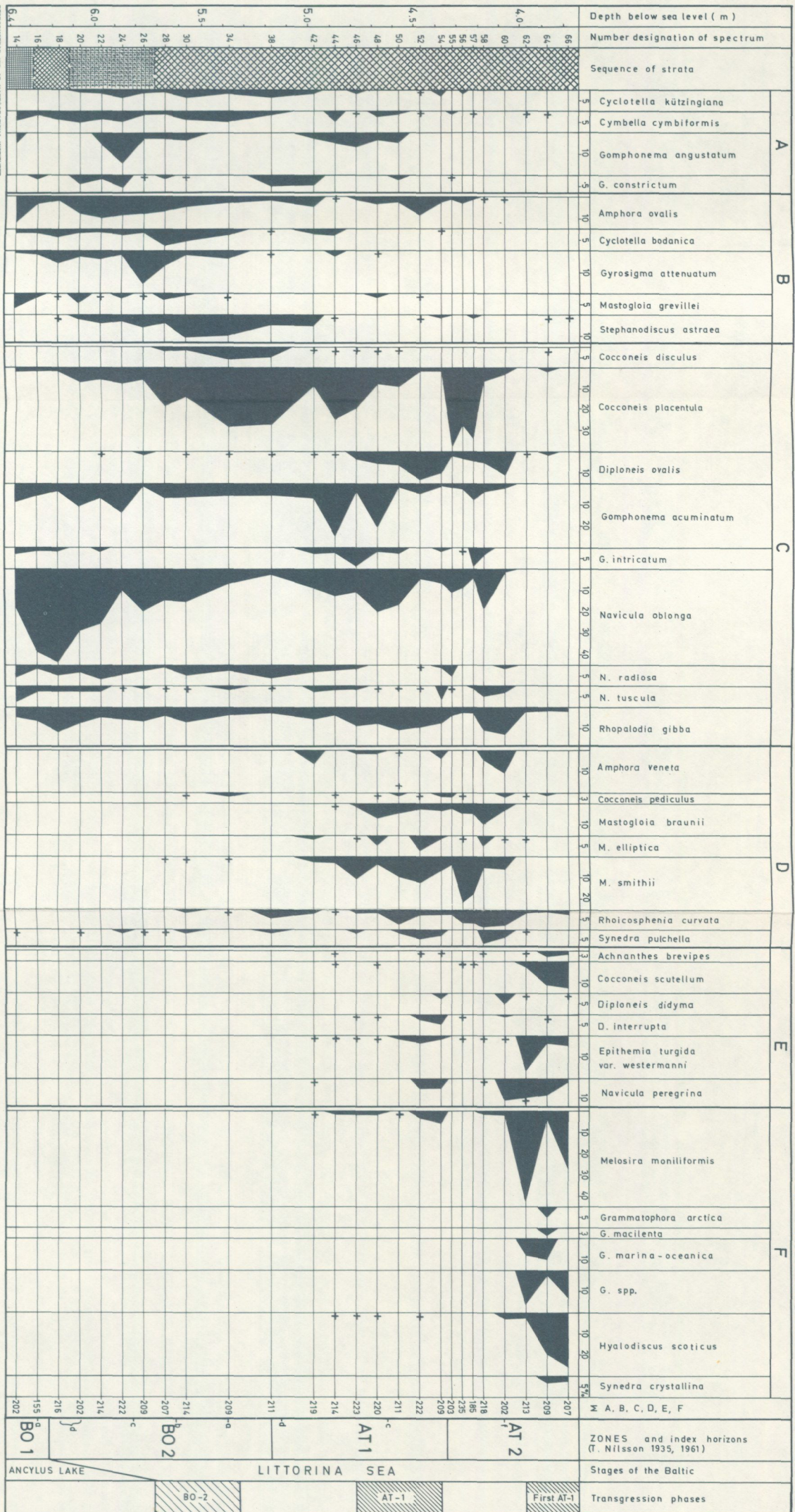
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Table 1. Radiocarbon-

Sample
Hallarums mosse 15 (St-1324): Marine to brackish, slightly clayey fine detritus gyttja. Abundant plant remains of aquatic vegetation. Immediately below the carr peat. SB 1 c.
Hallarums mosse 21 (St-1325): Marine, non-clayey fine detritus gyttja. Above SB 1 d.
Hallarums mosse 25 (St-1326): Marine, clayey fine detritus gyttja. SB 1 h.
Hallarums mosse 30 (St-1327): Marine, non-clayey fine detritus gyttja. AT 2 b.
Hallarums mosse 34 (St-1328): Marine, non-clayey fine detritus gyttja. Below AT 2 ee.
Hallarums mosse 37 (St-1330): Brackish, non-clayey fine detritus gyttja. Fragments of aquatic plants rather common. Immediately below AT 1/2.
Hallarums mosse 41 (St-1331): Brackish, non-clayey fine detritus gyttja. Fragments of aquatic plants rather common. Between AT 1 b and c.
Hallarums mosse 44 (St-1332): Lacustrine, coarse detritus gyttja. AT 1 c.
Hallarums mosse 56 (St-1333): Lacustrine, slightly clayey fine detritus gyttja. BO 2 a.
Hallarums mosse 70 (St-1334): Lacustrine, clayey fine detritus gyttja. BO 1/2.
Hallarums mosse 83 (St-1335): Lacustrine, slightly clayey fine detritus gyttja. Above PB/BO 1.
Hallarums mosse 95 (St-1336): Lacustrine, slightly clayey fine detritus gyttja. Above the transition zone PB/DR 3.
Hallarums mosse 97—98 (St-1337): Lacustrine, clayey algae gyttja and muddy clay. DR/PB.
Inlångans mosse 54 (St-1404): Lacustrine drift gyttja with wood of <i>Alnus</i> and <i>Betula</i> and fragments of <i>Phragmites</i> . SB 2.
Inlångans mosse 56 (St-1405): Lacustrine, coarse detritus gyttja with roots of <i>Phragmites</i> . Beginning of SB 2.
Inlångans mosse 59 (St-1406): Marine, slightly clayey fine detritus gyttja. SB 1/2.
Inlångans mosse 62 (St-1407): Marine, slightly clayey fine detritus gyttja. Later part of SB 1.
Långöra (St-806): Stumps of <i>Pinus</i> collected during dredging (cf. Stockholm V).
Sörevik (St-333): Drift gyttja with wood of <i>Pinus</i> . Beginning of BO 1. NBS corr. (Cf. Stockholm III.)

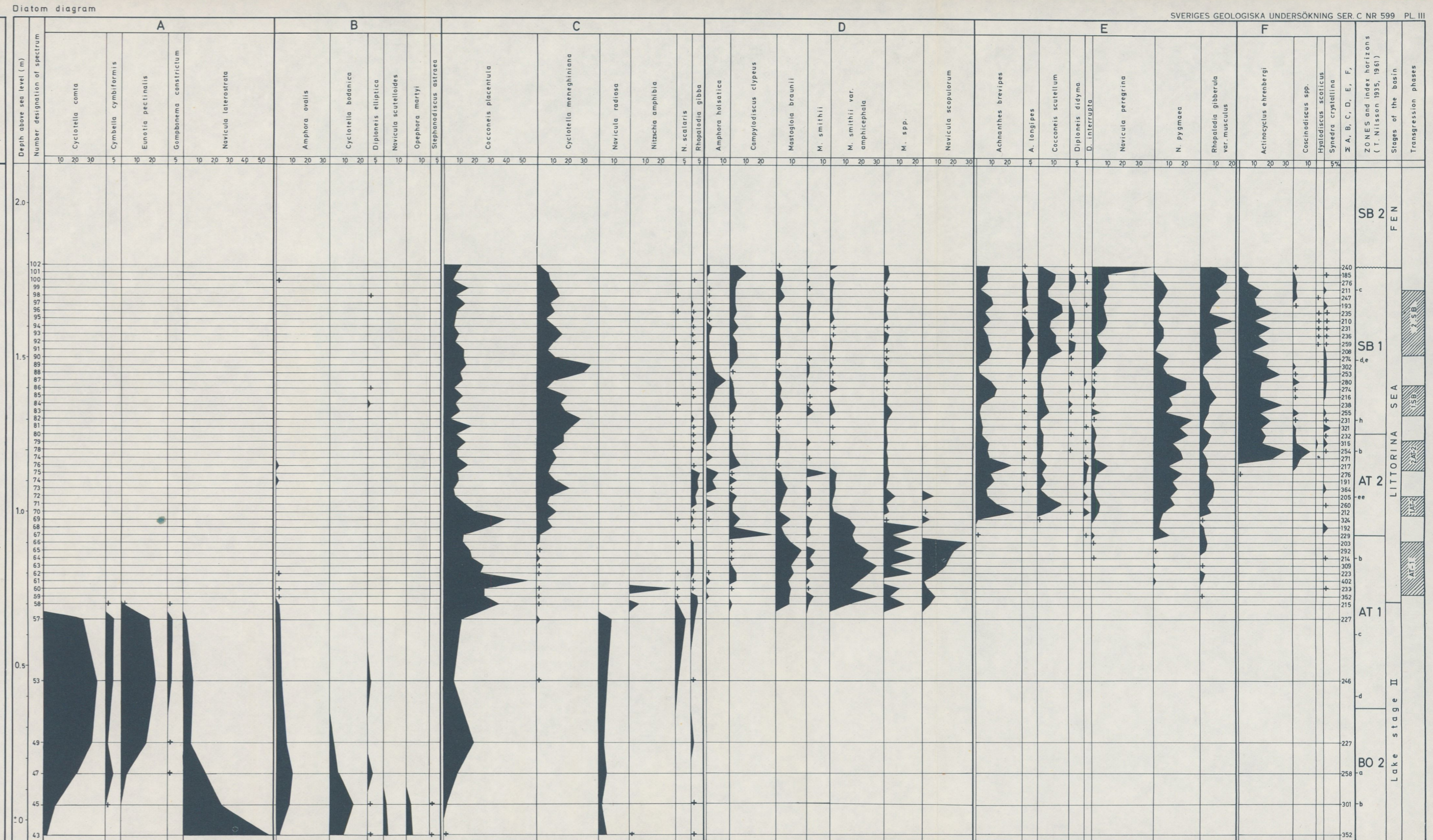
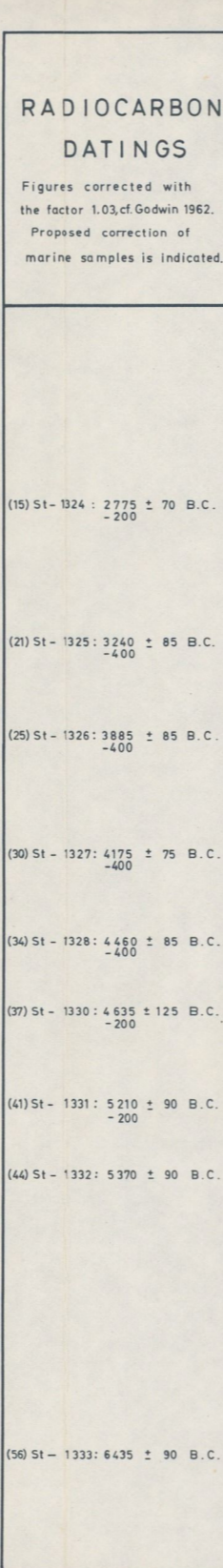
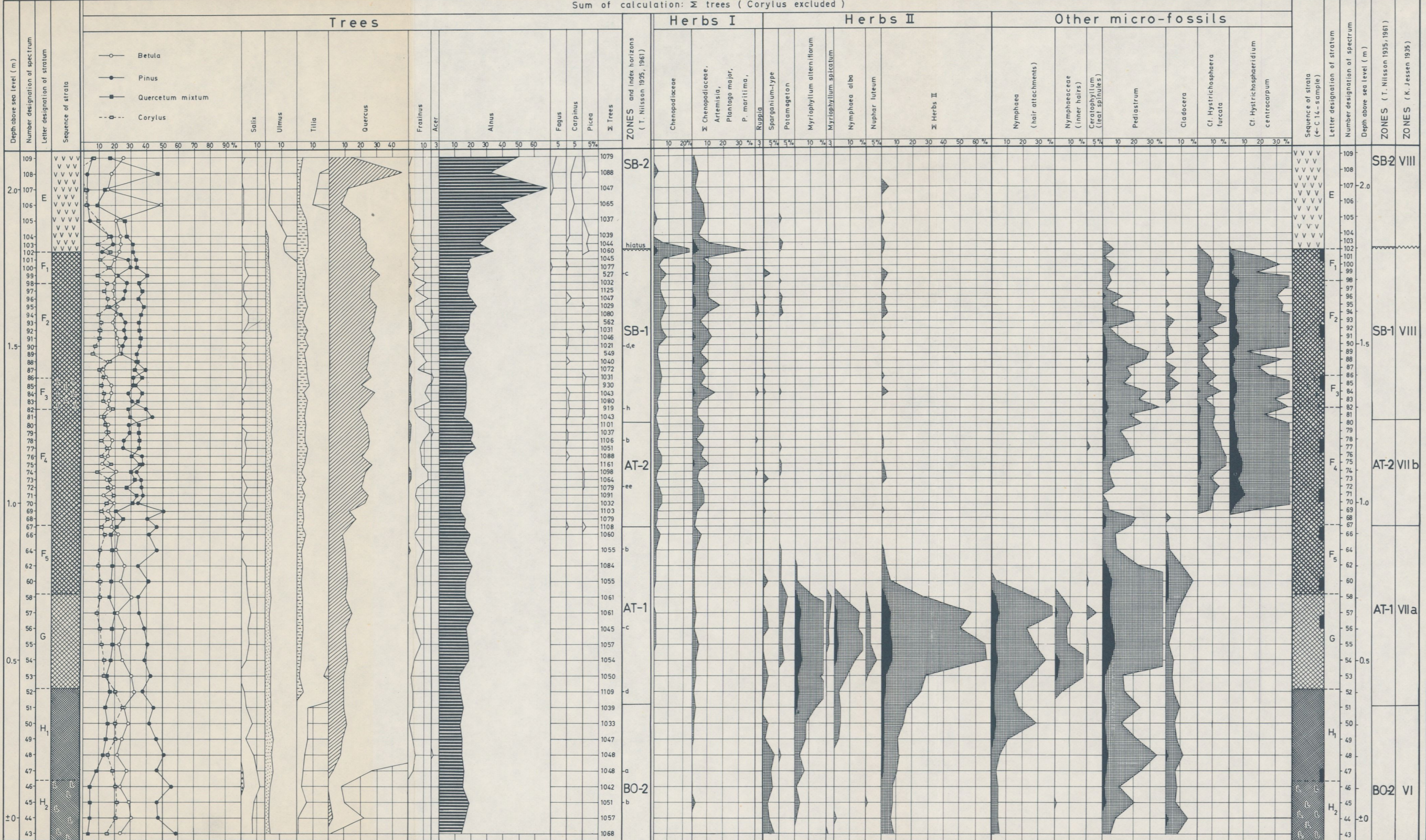
dated samples

Height above the sea level, cm (Depth in parenthesis)	»Official» age figure, B.P.	Corrected age figure		Probable »sea corr.»	δ C 13 (PDB scale)
		B.P.	B.C.		
176—180 (221—224)	4585 ± 70	4725	2775	—200	—21.5
152—156 (244—248)	5040 ± 85	5190	3240	—400	—19.1
136—140 (260—264)	5665 ± 85	5835	3885	—400	—16.6
116—120 (280—284)	5945 ± 75	6125	4175	—400	—15.7
100—104 (296—300)	6220 ± 85	6410	4460	—400	—17.5
88—92 (308—312)	6395 ± 125	6585	4635	—200	—16.0
72—76 (324—328)	6950 ± 90	7160	5210	—200	—18.4
60—64 (336—340)	7105 ± 90	7320	5370	—	—28.2
12—16 (384—388)	8140 ± 90	8385	6435	—	—29.8
—40—44 (440—444)	8835 ± 170	9100	7150	—	—29.2
—92—96 (492—496)	9380 ± 110	9660	7710	—	—30.7
—139—143 (539—543)	10000 ± 170	10300	8350	—	—27.9
—148—156 (548—556)	10170 ± 230	10475	8525	—	—25.2
405—410 (70—75)	2705 ± 75	2785	835	—	—31.7
395—400 (80—85)	3145 ± 65	3240	1290	—	—19.1
380—385 (95—100)	3545 ± 65	3650	1700	—	—30.5
365—370 (110—114)	4170 ± 75	4295	2345	—	—29.5
c.—300 —390—400	9300 ± 130	9580	7630	—	—
(400—410)	8945 ± 140	9215	7265	—	—



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