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THE COMPOSITION OF THE FORESTS IN NORTHERN EUROPE IN EPIPALÆOLITHIC TIME

BY

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WITH 3 PLATES

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At the time when epipalæolithic culture[1] prevailed in Denmark, in the Mullerup or Maglemose period, a very peculiar composition of the vegetation was found here. *Pinus silvestris* was still the dominating tree in the upper vegetation layer of the forest, while at the same time *Corylus avellana* must have been very common and may be supposed to have been a highly important component of its shrub growth, or perhaps in places it may have formed pure coppices[2]. But at the same time the trees advancing from the south such as *Quercus robur*, *Ulmus glabra*, *Tilia cordata* and *Alnus glutinosa* were about to colonize the Danish forests, that is to say the northernmost outposts of the central European deciduous forest, the advance of which in the countries south of the Baltic especially K. Rudolph[3] has described, were just gaining a footing in Denmark, associated with a great number of

[1] The term epipalæolithic will in this paper practically be taken as comprising the Azilian and the Tardenoisian even if it is still uncertain whether the younger Tardenoisian cultures can be contemporaneous with the boreal forest type in Denmark.

[2]) L. v. Post, Ur de sydsvenska Skogarnas regionala historia under postarktisk tid. Geol. Fören. i Stockholm Förhandl. 1923, p. 92. English Summary p. 123.

[3] K. Rudolph, Grundzüge der nacheiszeitlichen Waldgeschichte Mitteleuropas. Beihefte z. Bot. Centralbl. Bd. XLVII (1930) Abt. II.

central European thermophilous plants which now also invaded the country[1].

The synchronism of these two phases, the cultural and the forestal, in the biological development in Denmark in boreal time is shown particularly through the study of the plant remains in the peat and mud layers which contain the great culture layers of the well known Mullerup dwelling places in bogs on Sealand, the geological and botanical conditions of which have been discussed on different occasions, partly in connection with the treatment of the archæological material[2].

A find in 1929 of a new Mullerup culture layer viz. in Lundby Bog in the vicinity of Sværdborg in southern Sealand, excavated by the Keeper of the National Museum

[1] Knud Jessen, Moseundersøgelser i det nordøstlige Sjælland. Danmark Geol. Undersøgelse. II. Række. No. 34. København 1920, p. 229 f. English Summary p. 267.

[2] G. Sarauw, En Stenalders Boplads i Maglemose ved Mullerup Aarbøger for nord. Oldkyndighed og Historie. København 1903, p. 150 ff. Cfr. the same author, Maglemose. Ein steinzeitlicher Wohnplatz im Moor bei Mullerup auf Seeland. Prähist. Zeitschr. Berlin 1911, p. 52 ff.

Lauge Koch, Nye Bidrag til Mullerupkulturens Alder. Meddel. fra Dansk Geolog. Forening. Bd. 5. Nr. 6. Kbhvn. 1916.

Knud Jessen, De geologiske Forhold ved Stenalderbopladsen i Sværdborg Mose, in K. Friis Johansen, En Boplads fra den ældste Stenalder i Sværdborg Mose. Aarb. f. nord. Oldk. & Hist. 1919, p. 121—127. Condition géologique d'une station du plus ancien âge de la pierre dans la tourbière de Sværdborg. Mém. de la soc. roy. des antiq. du nord. Copenhague 1919.

Knud Jessen 1920, p. 114, 252.

Knud Jessen, De geologiske Forhold ved de to Bopladser i Holmegaards Mose, in H. C. Broholm, Nye Fund fra den ældste Stenalder. Aarb. f. nord. Oldk. & Hist. 1925, p. 14—27. Conditions géologique des deux stations du plus ancien âge de la pierre dans la tourbière de Holmegaard. Mém. de la soc. roy. des antiq. du nord. 1926.

Knud Jessen, Senkvartære Studier fra Mors. Danm. geol. Unders. IV. Række, Bd. 2. No. 5, 1929, p. 11 f. Summary; Late Quaternary Studies from the Isle of Mors in Jutland, p. 21 f.

Knud Jessen, Bjørnen (Ursus arctus L.) i Danmark. Ibidem No. 6, 1929, p. 8. English Summary.

Th. Thomsen, made it desirable to obtain a comprehensive view of the geological and botanical conditions of all the known Danish dwelling places of that type, and on the same occasion to work out a more detailed pollen analytic survey of the sections from the bogs in question than that to which they have hitherto been subject, based upon new collections of material where it would still be possible to obtain such. The results of this survey permit the discussion of the question on the relative age of the Danish Mullerup dwelling places. On the last pages the pollen analyses of epipalæolithic finds from other northern European countries will be discussed in connection with the Danish results.

Mullerup Bog.

(Maglemose at Mullerup).

With regard to the geographical and topographical features of this bog lying in western Sealand the reader is referred to the papers of G. Sarauw. In later excavations two other dwelling places have been studied in the vicinity of the clasical one partly by C. Neergaard in 1904 for the National Museum, partly by Lauge Koch and Therkel Mathiassen in 1915. The situation of these three sites is shown on a map and in sections by Lauge Koch 1916 figs. 1 and 2. They lie on projections of an elongated rising of the diluvial ground of the lake, "Sarauw's Holm" southernmost, "Neergaard's Holm" and "Koch's Holm" near each other ca. 120 m more to the north. As Lauge Koch shows, the two northern dwelling places lay on forest clad holms in the lake when the Mullerup people lived there, while it was impossible definitively to point out what were the conditions at the same time on Sarauw's

Holm where the implements were mainly found in a layer of *Cyanophyceæ*-mud, because Sarauw dug through the whole culture layer.

In 1915 I had the opportunity to visit the locality when Lauge Koch and Th. Mathiassen undertook their excavation, and I then surveyed a section through the bog from the western part of the culture layer and towards the west (fig. 1). Below a layer of destroyed surface soil lay a stratum of

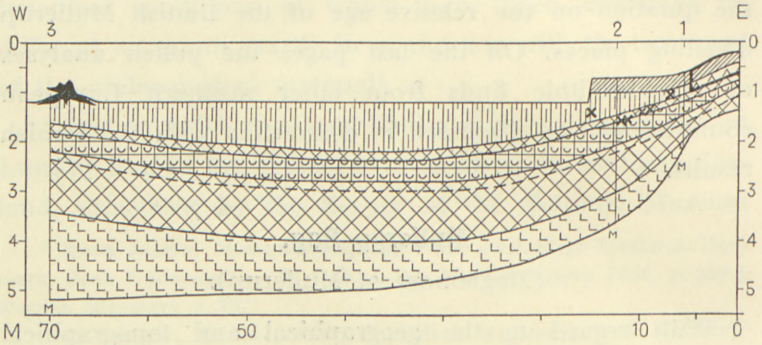

Fig. 1. Mullerup Bog 1915, section from Koch's Holm and towards the west. The western part af the culture layer proper is framed with heavy lines; at xx finds of flint implements and flint chips; at point 3 a pine stump. For explanation of the other signs see Pl. I.

forest peat with stumps of birch, as mentioned by Lauge Koch, changing over towards the west into a layer of swamp peat formed of a *Phragmites communis* and *Cladium mariscus*-vegetation. These upper peat layers rested upon mud the upper part of which was developed as a *Cyanophyceæ*-mud. At the basis of the section is seen late glacial clay. According to Lauge Koch by far the greatest part of the implements were lying in the forest peat and in the surface soil, only some few pieces were found in the *Cyanophyceæ*-mud or on the surface of the underlying snail mud, and a few flint chips were also found in the swamp peat west of the

culture layer proper, these shattered finds being things thrown out from the dwelling place proper. Some samples for pollen analyses were taken, but to get a complete series of samples the section shown in fig. 1, Pl. II was surveyed in 1933 at a point just at the site of the excavation of 1915. In this section the same sequence of layers was found as was seen in the 1915-section directly west of the forest layer, thus also a thin layer of fresh *Sphagnum*-peat resting on the surface of the *Phragmites-Cladium* peat. The pollen analyses of the samples from 1915 agree with the corresponding analyses in the pollen diagram in fig. 1, showing that the *Phragmites-Cladium* peat and the *Cyanophyceæ*-mud in that are synchronous with the culture layer.

In the upper part of the swamp peat which indicates the growing over of the deeper parts of the lake (cfr. fig. 1) there has been a rather close growth of stout pine trees (*Pinus silvestris*) some stumps of which still are left. M. J. Mathiassen[1] has mapped some of these stumps and levelled the height above the sea of their uppermost horizontal root; for the stump in fig. 1 4.04 m was found. The stumps were standing in one layer sloping slightly from the edge of the bog towards its more central parts, most of them between 4.05 and 3.75 m above sea level and no doubt constituting a single horizon.

In accordance with the sections of Lauge Koch the mud layer reached up to ca. 4.7 m above sea level on Neergaard's Holm, and since the base of the forest layer on Koch's Holm lies at ca. 4.2 m the water level in the lake must have been lowered at least half a metre before the birch forest settled on this Holm, for the compression of the thin mud

[1] M. J. Mathiassen, Lidt om Nutids- og Fortids-Plantedækket i Maglemose ved Mullerup. Botanisk Tidsskr. Bd. 33. Kbhvn. 1912.

layers cannot have been greater on Koch's Holm than on Neergaard's Holm. Even if it is uncertain if the water level in the lake sunk below the measured level for the lowermost pine stumps — for a certain compression may have taken place in the peat and mud layers, especially where they are thickest — the stump layer undoubtedly indicates a maximum of sinking of the water level. That, as KOCH mentions, this occured in the boreal time is evident, cfr. the pollen diagram in fig. 2, Pl. II, even if the pine stump in fig. 1 may be somewhat younger than the top of the culture layer on Sarauw's Holm. A comparison of the pollen diagrams figs. 1 and 2, Pl. II shows that the growing over of the lake west of Koch's Holm occured very quickly, most probably as a consequence of the sinking of the water level, and this feature in the hydrography of the boreal Mullerup Lake may be taken as one testimony among others of the drying effect of the boreal climate, compare e. g. the mould layers in well chalk deposits[1] and pine stump layers in many other bogs, especially in Jutland.

The pollen diagram from Sarauw's Holm, fig. 3, Pl. II is based upon a series of samples which were taken by Mr. M. J. MATHIASSEN in the mud layers below the swamp peat directly at the dwelling place[2]. The upper mud layer, SARAUW's "Wassertorf" (Lebertorf), the *Cyanophyceæ*-mud contained, as is known, the main part of the cultural remains from this dwelling place. It has the same features

[1] KNUD JESSEN, Skandinaviske Kalktuffer. Naturens Verden. København 1922.

[2]) This samples were collected for the swedish state geologist N. O. HOLST, compare SARAUW 1911, p. 73, and by Professor LAGERHEIM, Stockholm given to me in 1914. Some of the analyses of them have previously been published in KNUD JESSEN 1920, p. 114 and elsewhere.

and the same content of plant remains as the corresponding mud layer on Koch's Holm. As confirmed by Dr. JOHS. BOYE PETERSEN, the elastic mass of this layer consisted mainly of remains of *Cyanophyceæ*, (closely interwoven sheats of *Lyngbya*?), *Chroococcus* sp. and *Gloeocapsa* sp. besides of species of *Cosmarium*, *Pediastrum boryanum*, *P. duplex*, *P. integrum*, *P. Kawraiskyi* and *P. muticum*, *Botryococcus Braunii*, *Scenedesmus quadricauda*, *Tetraedron minimum* and other plankton algæ, and of fruits of vascular plants, especially many of *Cladium mariscus* and *Najas marina*. The whole situation shows that this layer has been sedimented in shallow water near the border of the lake.

A comparison of the pollen diagrams in fig. 1 and fig. 3, Pl. II shows that the under borders of the two culture layers are in the main contemporaneous. Especially the parts in the diagrams where the rapidly rising hazel curve intersects the curves of the pine and the birch exhibit great congruity, showing that the transition from the snail mud to the *Cyanophyceæ*-mud is synchronous in the two sections. Some features mark that the upper part of the *Cyanophyceæ*-mud on Sarauw's Holm is younger than the culture layer on Koch's Holm, *Alnus* and *Tilia* only being found in that layer (fig. 3), in the upper part of which the *Ulmus* curve reaches a significant maximum, and the index $\frac{Q}{P}$[1] in pollen diagram fig. 1 spectra 2—6 being only

[1] $\frac{Q}{P} = \frac{\text{pollem sum of oak} + \text{elm} + \text{lime}}{\text{pollen number of pine}}$. This quotient gives an expression for the constellation in the struggle between the pine and the trees of the oak mixed forest, and since as a rule it varies very regularly from 0 to 1 in boreal layers in Denmark, it is here of great value for relative age determinations of deposits (compare KNUD JESSEN, 1920, p. 113, 252).

0.04 and 0.08 in spectrum 1, while in the pollen diagram fig. 3 it rises from 0.06 in spectrum 5 to 0.26 in spectrum 2 and 0.24 in spectrum 1. Consequently in accordance with this, the pollen diagrams make it probable that in the composition of the surrounding forest a greater change has taken place at the time when the dwelling place on Sarauw's Holm was in use than while Koch's Holm was inhabited, so it may probably be assumed that this was left before Sarauw's Holm was left. One reason why it was given up may be the overgrowing of the lake and the developing of the bog vegetation, at least it was abandoned when the pine colonized the bog, for the 2—3 upper spectra in the pollen diagram from below the pine stump (Tab. II fig. 2) are younger than the upper part of the culture layer on Koch's Holm, cfr. the curves of *Ulmus*, *Alnus* and *Tilia*.

Since the implements found by SARAUW occured mainly in a water deposit, the *Cyanophyceæ*-mud, he discussed the possibility of the people living on rafts, a view which, however, does not seem to have been accepted, and of a pile dwelling he found no traces. How then did the people live on Sarauw's Holm? It seems worth while to consider that they may have lived on the mud surface directly, when this lay bare in the summer time due to the seasonal sinking of the water level in the lake, in other words that the site on Sarauw's Holm has been a summer dwelling place as is assumed for the contemporaneous dwelling places in southern Sealand, where e. g. in Holmegaard Bog hearths have been found in the mud[1].

The common view of the climate in boreal time in Denmark is that the summer was at least as warm as and the winter somewhat cooler than in present

[1] H. C. BROHOLM 1926, p. 12, 18.

times[1], that the climate had a drying effect on the bog surfaces, and that the main precipitation fell in the winter half-year[2]. If this is right, rather strong oscillations of the water level may have taken place in Mullerup Lake. The winter water level, however, did not reach higher than to ca. 4.2 m above sea level, the base of the birch peat on Koch's Holm lying at that level, but if as high as that level, the water, according to KOCH's sections, would have covered the mud surface on Sarauw's Holm which was still without peat, while Koch's Holm was inhabited (cfr. figs. 1 and 3). A sinking of some dcm of the water level in the summer time would however have laid dry the mud surface on Sarauw's Holm which owing to its elastic condition and a certain drying up would be hard to walk on. The facts that the number of implements per square unit was less on Sarauw's Holm than on Koch's Holm (KOCH p. 8) where the people could stay the whole year round, and that some of the remains of animals found on Sarauw's Holm point towards the using of this dwelling place in the summer half-year, none indicate the winter time, support this view. Against it speaks, that SARAUW did not find any actual hearth in the mud, only a great amount of charcoal[3].

According to G. SARAUW (1911, p. 93) by far the greater part of this charcoal, as of the wood and of the bark found in the culture layer, was of *Pinus silvestris*, the following trees being

[1] KNUD JESSEN & JENS LIND, Det danske Markukrudts Historie. Kgl. Danske Vidensk. Selsk. Skrifter, naturv. og mathem. Afd., 8. Række, VIII. Kbhvn. 1923, p. 58—59.

[2] L. VON POST, Gotlands-agen (*Cladium Mariscus*) R. Br.) i Sveriges postarktikum. Ymer, Stockholm 1925, p. 309.

[3] It is not possible to draw in in this discussion the position of the pine stumps since they may have sunk with the swamp peat owing to recent articifical lowering of the water level in the bog.

Macroscopic plant remains from Mullerup bog at Sarauw's holm.

(ch = charcoal and wood or bark, fr = fruits, rh = rhizomes, s = seeds; cc = very common, c = common, + not rare, r = rare; an asterisc denotes that the horizon is only approximate).

Depth, cm	Section	*Betula cfr. pubescens*, fr, ch	*Carex pseudocyperus*, fr	*Carex* sp., fr	*Cladium mariscus*, fr	*Corylus avellana*, ch, fr	*Frangula alnus*, ch, s	*Menyanthes trifoliata*, s	*Najas marina*, fr	*Nymphæa alba*, s	*Peucedanum palustre*, fr	*Phragmites communis*, rh	*Pinus silvestris*, ch, s	*Populus tremula*, ch	*Potamogeton natans*, fr	*Potamogeton* sp., fr	*Rubus saxatilis*, fr	*Rumex hydrolapathum*, fr	*Sambucus nigra*, 1 fr-stone	*Scirpus Tabernæmontani*, fr	*Ulmus glabra*, ch
10	Moulded peat	..	..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..
20		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..
30		..	..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c	..
40	*Phragmites-*	..	..	..	c	..	..	..	..	..	..	..	..	..	..	..	..	..	r*	+*	..
50	*Cladium*	..	..	..	c	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
60	peat	..	..	..	cc	..	..	r	..	..	..	cc	..	..	..	..	..	..	..	..	..
70		..	..	..	c	..	r	..	r	+	..	..	..	..	..	..	..	..	..	..	..
80		..	..	..	+	r	..	..	r	+	..	c	..	..	..	..	..	..	..	..	..
90	Culture layer	..	..	..	c	c	r	..	c	+	..	..	..	r	..	r	r	r	..	..	..
100	(*Cyanoph.*-mud)	r	r	..	r	c	..	r	c	+	r	..	cc	..	..	..	..	r	..	..	+
110	Snail mud	r	..	..	r	..	..	..	c	..	..	..	..	..	r	r	..	..	..	..	..
120		r	..	..	r	..	..	..	c	..	..	..	..	..	r	..	..	..	..	..	..

represented among the rest mentioned according to decreasing frequency: *Corylus avellana* (of this also a lot of nuts were found, the short form *f. silvestris* Hort. as well as the more oblong ones *f. ovata* Willd. and *f. oblonga* G. Ands., the short form being here as in Sweden and in Norway by far the commonest[1]),

[1] G. Andersson, Hasseln i Sverige fordom och nu. Sveriges geolog. Undersökning, Ser. Ca. No. 3. Stockholm 1902, p. 155 f., 167. Deutsches Résumé. — Jens Holmboe, Planterester i Norske torvmyrer. Videnskabsselskabets Skrifter. I. Mathem.-naturv. Klasse, No. 2, Kristiania 1903, p. 160 f.

Ulmus glabra, *Populus tremula*, *Betula* cfr. *pubescens* and *Frangula alnus*.

In the before standing list are specified together with these plant species some others found by Dr. N. HARTZ in different mud and peat layers from samples collected by G. SARAUW on the dwelling place, cfr. the report of N. HARTZ to the National Museum here used with the permission of the Museum.

Holmegaard Bog.

The archæological treatment of the two Mullerup culture dwelling places which the National Museum excavated in the years 1922—23 in Holmegaard Bog, lying north of Næstved in southern Sealand, is given by H. C. BROHOLM in the papers quoted, and on the same occasion the geological and botanical features of these sites were treated by KNUD JESSEN. Referring the reader to these papers, I shall give some pollen diagrams from these two culture layers even if they are rather imcomplete.

The two dwelling places lay at a reciprocal distance of 2.2 km both of them about 400 m from the southern border of the bog, and as the pollen diagrams show, the culture layers are contemporaneous with the zones V and VI characterized by dominance of pine and hazel and a relatively low frequency for the oak forest species.

From the western dwelling place the two pollen diagrams (fig. 1 and 2, Pl. III) indicate how the culture layer extended from the mud up into the *Phragmites-Cladium* peat, which covered the top of a little holm in the lake where the Mullerup people lived. The culture layer also here is contemporaneous with the *Corylus*-maximum.

In the diagram fig. 2 this lie above the *Pinus*-maximum as in most of the danish pollen diagrams, this last mentioned maximum not being hit in the pollen diagram fig. 1 where the samples have too great intervals. The $\frac{Q}{P}$ index in the spectra fig. 2 is reckoned from below upward 0.08 — 0.34 — 0.44, *Alnus* reaching a considerable frequency. That the *Tilia* pollen here is relatively common may perhaps be due to this pollen species being more durable than the pollen of the other deciduous trees which were here rather decayed.

On the eastern dwelling place nearly the whole culture layer had been dug away before the survey of the site could take place, but the implements found show coincidence with the western great find. The culture layer here covered a rise of the $\frac{Q}{P}$ index from about 0.2 to 0.5 (fig. 4, Pl. II), and the two dwelling places in Holmegaard Bog may very likely in part have been inhabited contemporaneously. An attempt at a relative age determination of them based principally on the hazel curve, on the assumption that the hazel maximum is synchronous on the both sites, would show the eastern one to be essentially younger than the other[1]. But as it seems that the hazel maximum on the eastern site occurs extraordinarily early, before the beginning of the alder curve as far as can be judged from the incomplete diagram, a feature which is known but from some few other Danish pollen diagrams (cfr. Mullerup Bog), it may be safer to base the age comparison of the two sites

[1] L. von Post in Otto Rydbeck & L. v. Post, Ornerad skafthålsyxa av hjorthorn funnen i Höganäs. Fornvännen. Stockholm 1929, p. 151. Deutsche Zusammenfassung.

on the $\frac{Q}{P}$ index, which expresses the state of competition between several trees, and on the alder curve; compare fig. 6 and p. 32.

Macroscopic plant remains found below, in and close above the culture layers in Holmegaard Bog.

(ch = charcoal, fr = fruits, rh = rhizomes, s = seeds, w = wood; cc = very common, c = common, + not rare, r = rare, rr = very rare).

Species[1]	Western site		Eastern site	
	Culture layer		Snail mud	Culture layer Swamp peat
	Snail mud	Swamp peat		
Actæa spicata, s (fig. 4 *a*)	..	rr	..	..
Alnus glutinosa, ch, fr	..	+	..	r
Batrachium sp., fr	..	rr	..	..
— *sceleratum*, fr.	..	c	..	..
Betula alba (coll), ch, fr	r	r	..	..
— *pendula*, fr	rr	..	..	..
— *pubescens*, fr	rr	..	..	..
Carex lasiocarpa, fr	..	..	..	r
— *pseudocyperus*, fr	..	c	..	..
— *sp.*, fr	..	+	..	..
Caryophyllaceæ, s (fig. 4 *i,k*)	..	r	..	..
Cladium mariscus, fr, rh	+	c	..	+
Corylus avellana, fr	..	cc	..	+
Eupatorium cannabinum, fr (fig. 4 *e*)	..	c	..	..
Frangula alnus ?, s	..	rr	..	..
Hippuris vulgaris, fr	..	rr	..	..
Iris pseudacorus, s (fig. 4 *d*)	..	rr	..	..
Mentha sp.? fr	..	r	..	..
Menyanthes trifoliata, s	..	r	..	r
Najas marina, fr	r	+	r	r
Nuphar luteum, s	..	cc	..	r

[1] Besides the pollen of the forest trees also some few pollen of *Typha latifolia* and many spores of *Dryopteris thelypteris* were found in the culture layers.

Macroscopic Plant remains found below, in and close above the culture layers in Holmegaard Bog.
(continued)

Species	Western site		Eastern site	
	Culture layer		Snail mud	Culture layer Swamp peat
	Snail mud	Swamp peat		
Nymphœa alba, s	+	c	..	+
Phragmites communis, rh..	+	c	..	+
Pinus silvestris, ch, w	cc	cc	cc	cc
Potamogeton cfr. natans, fr	..	r	..	rr
Quercus cfr. robur, ch.....	..	rr	..	..
Ranunculus repens, fr.....	..	rr	..	..
Rubus idœus, fr.....	..	c	..	..
Rumex cfr. hydrolapathum, fr	..	rr	..	rr
Salix sp., ch	..	r	..	r
Scirpus lacuster, fr.	..	c	..	rr
Solamum dulcamara, s....	..	+	..	..
Sparganium minimum, fr..	..	rr	..	..
Ulmus glabra, ch.....	..	+	..	rr
Umbelliferæ, fr.....	rr	..	..	..
Urtica dioeca, fr	..	c	..	..

Sværdborg Bog.

The dwelling place in Sværdborg Bog (se fig. 2) lying 9 km north of Vordingborg in South Sealand was excavated for the National Museum in the years 1917—18 by K. Friis Johansen[1] who published the results, Knud Jessen on the same occasion describing the geological and botanical conditions of the site. Some supplementary remarks concerning the natural history of the bog shall here be given.

The sections figs. I, II, IV on Pl. I, constructed as mentioned p. 24, show the stratification of the eastern part of the bog,

[1] Cfr. p. 3.

the whole cross section of this from southeast to northwest being about 1.8 km long. In the central part of the bog the limnic layers reach a thickness of up to 2.4 m, late glacial clay and sand constituting the lower part of them; in the marginal zone no such are found. The sedimentation started here in preboreal time on a somewhat higher level than that to which the late glacial strata reach, as will be seen in the subjoined list of pollen spectra from mud samples taken at three points near the bottom of the bog.

Table 1. Sværdborg. Pollen spectra from the bottom of the mud in the border zone.

No.	Section II, points	*Salix*	*Betula*	*Pinus*	*Corylus*
1	4	1	69	30	4
2	12	2	71	26	..
3	17	1	56	43	5

The main part of the mud is developed as a "snail mud" of white or grayish colour and very rich in chalk. According to Dr. V. Nordmann it contains a mollusc fauna typical of the *Bithynia tentaculata-Planorbis stroemi* Zone[1], i. e. besides these two species especially *Limnæa pereger*, *Physa fontinalis*, *Pisidium milium*, *Planorbis fontanus*, *P. nautileus*, *P. umbillicatus*, *Spærium corneum*, *Valvata cristata*, *V. piscinalis*. Of great interest was the find of shells of *Planorbis corneus* in the upper part of the mud below the culture layer, this snail being a southern type characteristic of the oak mixed forest zone in Danish bogs, and here,

[1] A. C. Johansen, Om den fossile kvartære Molluskfauna i Danmark og dens Relationer til Klimaet. Kbhvn. 1904.

together with other thermophilous species, indicating that the summer was rather warm in the Mullerup time in Denmark.

The growing over of the very shallow marginal zone of the lake started in early boreal time with a growth of a swamp vegetation dominated by *Phragmites communis* alone or in company i. a. with *Cladium mariscus* and species of *Carex*. In section II there occurs a layer of a rather fresh *Phragmites* peat, the most common form of the swamp peat having a strongly humified "dy"-like consistence. Peat of that type with remains of the swamp plants mentioned covered the top of a low cropping out of the diluvial lake-bottom (boulder clay) around point 12, (this point being the same in the three sections), and here enclosed the culture layer. Particularly in section IV over the greater part of its length it is seen how the mud surface is covered with such a layer of "dy"-peat. In the other sections this peat layer has a greater extension than shown, but being very thin, the peat layer directly covering the mud in most of the drillings contained some remains of wood and has been drawn as forest peat like the layer above. At any rate a growth of *Alnus glutinosa* has quickly taken possession of the swamp, in places settling directly on the mud surface. That the growing over of the lake begun earliest nearest the border is indicated by the fact that the $\frac{Q}{P}$ index in the very top of the mud in section II is 0.04 at point 4 but 0.15 at point 12.

The average position of the no doubt rather diffuse shore line of this shallow lake in Mullerup time is shown in fig. 2, the drawing of it being directed by the sections and by the determination of the $\frac{Q}{P}$ index from the upper surface of the mud

layer, this index being lower than 0.39 inside this line and higher than 0.39 outside it corresponding to the fact that a raising from 0.15 to 0.39 of this index covers the time in which the site was inhabited. The pollen spectra in the following table give the details.

According to this the dwelling place must have been situated on a low swampy peninsula in the lake, clad with

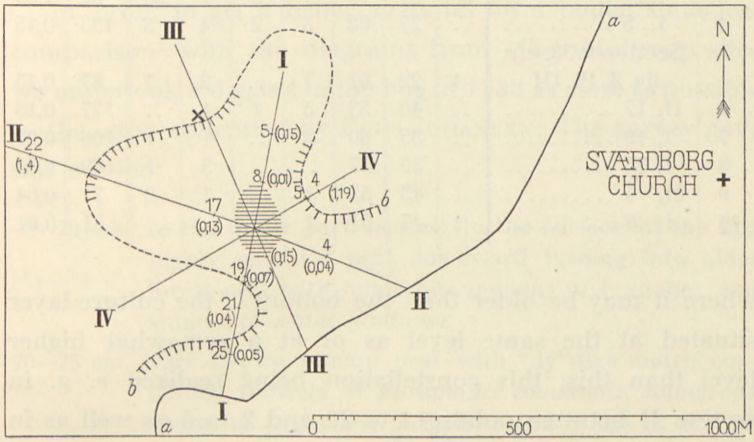

Fig. 2. Sværdborg Bog at the dwelling place. The line a—a is the eastern border of the bog. I—I, II—II etc. show the position of the sections, parts of which are represented on Pl. I. The sections cut each other at point 12. The hatched area shows the average extension of the culture layer according to K. Friis Johansen. The line b—b gives the average position of the shore line of the lake when the site was inhabited. The numbers in parenthesis give the $\frac{Q}{P}$ index from the mud surface at different points. NW of x at section III the mud surface fell rather quickly.

a swamp vegetation mostly of a "dy"-forming nature and in places perhaps somewhat meadow-like harbouring here i. a. *Cirsium palustre* and *Lychnis flos cuculi*, and besides with a scattered growth of *Alnus* coppices.

As will appear from the comparison of the sections with the pollen spectra given in table 2, the mud surface was in places

Table 2. Sværdborg bog. Pollen spectra from the upper surface of the mud layer at different points.

No.	Section Points	*Salix*	*Betula*	*Pinus*	*Ulmus*	*Quercus*	*Tilia*	*Alnus*	*Corylus*	$\frac{Q}{P}$
1	II, 22	..	16	17	9	9	5	44	91	1,4
2	IV, 4	..	16	16	8	6	4	50	67	1,19
3	I, 21	+	31	19	7	6	7	30	62	1,04
4	I, 5	..	27	62	3	2	4	3	133	0,15
5	Section 1933, cfr. fig. 3, Pl. III ..	1	22	61	7	..	2	7	87	0,15
6	II, 17	..	40	53	5	1	1	..	177	0,13
7	I, 19	..	35	60	3	..	1	1	106	0,07
8	I, 25	..	39	57	..	..	3	1	89	0,05
9	II, 4	..	43	53	1	..	1	2	71	0,04
10	I, 8	1	47	51	1	..	..	..	31	0,01

where it may be older than the bottom of the culture layer situated at the same level as or at a somewhat higher level than this, this constellation being realized e. g. in section II between points 14 to 20 and 2 to 5 as well as in section I between points 3 to 8[1].

According to these features it may be safe to say that a slight lowering of the water level in the lake has taken place just before the Mullerup people settled in the swamp. The formation of the strongly humified peat of the culture layer would otherwise be unintelligible as well as the fact that the people had their fires burning on the site. At least in the summer time the site must have been dry enough to permit the people to live there, on the other hand, however, the whole situation makes it very likely

[1] The determination of the pollen spectrum No. 4 in tab. 2 (point I, 5) is rather uncertain due to the pollen being much destroyed here, but the spectrum seems to indicate an age of the mud surface here very near the time for the starting of the settlement in the bog.

that this low lying swampy flat was inundated at high water in the winter time, as is also assumed for the dwelling places in Holmegaard bog owing to the nature of the plant community, a *Phragmites-Cladium* swamp, which enclosed the culture layer there too[1]; cfr. the remarks on the supposed nature of the boreal climate p. 10.

In order to get a better material for a pollen statistical comparison[2] with the diagrams from other Mullerup sites we undertook a digging in the bog in 1933 as close as possible to the area excavated by Friis Johansen. The survey gave this section:

0—70 cm. In the upper part, nearest to the surface of the bog highly moulded peat downward turning into alder forest peat with numerous remains of branches and stumps of *Alnus glutinosa.*

70—78 cm. Dark brown swamp peat with "dy"-like matrix containing radicels of *Phragmites communis,* numerous spores of *Dryopteris thelypteris* and lumps of *Botryococcus Braunii.* Between 71 cm and 78 cm below the surface were found numerous flint chips, fragments of flakes, some microlithes and a core with very narrow cleavage flats.

78—85 cm. Light greyish brown chalk mud with shells.

85—87 cm. Brown elastic mud.

87—90 cm. + Gravel with many stones.

In the upper part of the upper layer the pollen was totally destroyed, being countable alone in the lower part of the section; the pollen diagram is seen in fig. 3, Pl. III. The culture layer covers the upper part of Zone V and the

[1] Knud Jessen 1926, p. 18.

[2] Pollen spectra from Sværdborg Bog have been published in Knud Jessen 1920, p. 114 and elsewhere.

lower part of Zone VI, its lower part being contemporaneous with the here coinciding maxima of *Pinus* and *Corylus*, the *Alnus* curve starting close below it. The $\frac{Q}{P}$ index is for the three spectra 4—3—2 from the culture layer respectively 0.15—0.3—0.39.

Macroscopic Plant remains found below and in the Culture layer in Sværdborg Bog.

(ch = charcoal, fr = fruits, rh = rhizomes, w = wood; c = common, + not rare, r = rare, rr very rare).

Species	Mud below the culture layer	Culture layer *Phragmites cladium* peat
Alnus glutinosa, ch	..	r
Arctium sp.[1]	..	r
Betula pubescens, fr	r	..
Carex pseudocyperus, fr	..	r
— *sp.*, fr	..	+
Ceratophyllum demersum, fr	..	rr
Cirsium palustre, fr (fig. 4 *g*)	..	rr
Cladium mariscus, fr	r	+
Corylus avellana, ch	..	r
Lychnis flos cuculi, s	..	rr
Najas marina, fr	+	..
Nymphæa alba, s	+	..
Oenanthe aquatica, fr	..	r
Pinus silvestris, w, ch	+	c
Phragmites communis, rh	r	+
Potamogeton cf. *natans*, fr	r	..
— *perfoliatus* fr (fig. 4 *c*)	+[2]	..
Rumex sp., fr	..	rr
Scirpus lacuster, fr	rr	..
Solanum dulcamara, s	..	rr
Ulmus glabra, ch	..	r

[1] Charred stems determined by Mr. Fr. J. Mathiesen.

[2] 20 fruits from the layer of clay mud at point 4 in section IV.

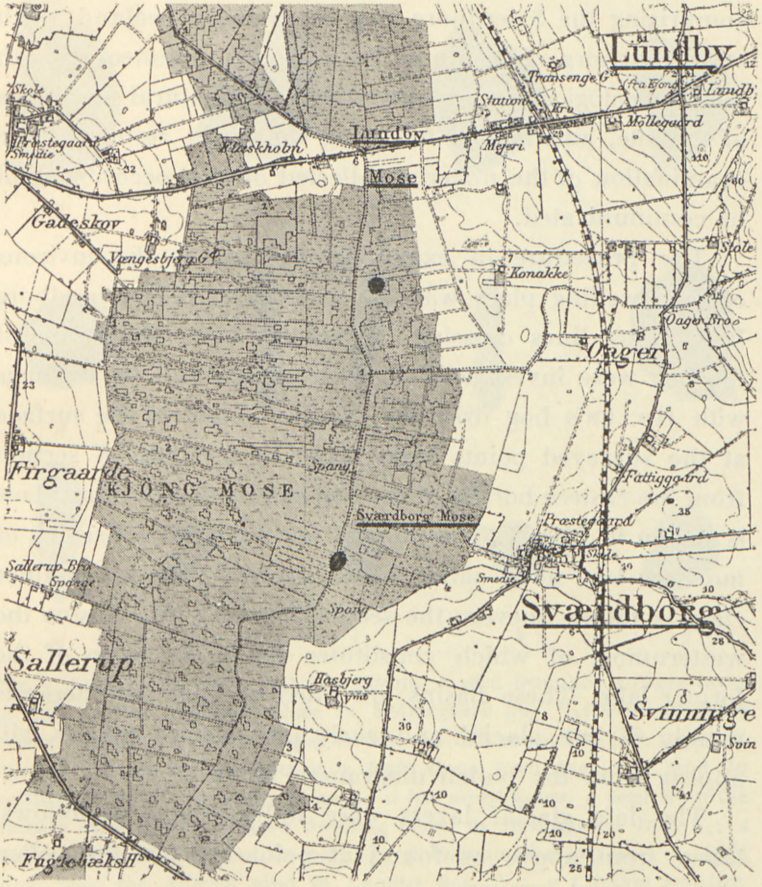

Fig. 3. Section of the Ordnance maps Knudshoved and Vordingborg (1/40000) showing part of the bog complex at Sværdborg and Lundby. The situation of the two dwelling places is marked with dots. Contour lines for each 10 feet.

Lundby Bog.

As previously mentioned, the National Museum in 1929 undertook an excavation by the Keeper Th. Thomsen of a culture layer with a typical Mullerup industry in Lundby Bog which constitutes part of the great bog complex also

comprising the Sværdborg Bog in southern Sealand north of Vordingborg, cfr. the map fig. 3. Contemporaneously with the archæological survey I investigated the natural conditions of the site, and in the following the main results of the examination of the material collected on that occasion shall be communicated.

The procedure in examining the bog in the environs of the dwelling place was the same as used in Sværdborg Bog; along lines crossing the culture layer the strata of the bog were investigated in excavations, and by drillings with Hiller's bog drill, the relative height of the surface at the surveyed points being fixed by levelling. A section from the eastern border of the bog cutting the dwelling place is shown in Plate I. The diluvial underground consisting of more or less stony sand, which probably covers boulder clay, is rather uneven, the section showing two basins the westernmost of which constitutes the main basin of the former lake. These basins are filled up with lake deposits mainly of late glacial and early post glacial age, as will appear from the pollen diagrams Plate III.

The late glacial layers were differentiated as follows, taken from above as found at point 26, cfr. the pollen diagram fig. 4, Pl. III.

(0—160 cm. Post glacial layers.)

160—217 cm. Greyish clay without stones, somewhat muddy; a leaf of *Betula nana* was found in the central part of the layer. (Upper Dryas clay).[1]

In the upper 18 cm of the clay layer at point 13 were found *Potamogeton prælongus* (1 fruit), *P. filiformis* (2 fruits, fig. 4 *l*), and

[1] Concerning the Danish late glacial fresh water deposits cfr. Summary of the Geology of Denmark, Danmarks geolog. Undersøgelse. V. Række, No. 4, 1928, p. 132 f.

Fig. 4. Fruits and seeds. *a Actæa spicata*, a seed from the culture layer at the western dwelling place in Holmegaard bog, $^6/_1$; *b Ranunculus repens*, two nuts from the upper Dryas clay in Lundby bog (cfr. the text), $^6/_1$; *c Potamogeton perfoliatus*, a fruit stone from the clay mud in section IV, 4 in Sværdborg Bog, $^6/_1$; *d Iris pseudacorus*, a seed from the culture layer at the western dwelling place in Holmegaard Bog, $^2/_1$; *e Eupatorium cannabinum*, ibidem, $^6/_1$; *f Potamogeton alpinus*, a fruit stone from the Allerød mud in Lundby Bog, $^6/_1$; *g Cirsium palustre*, a nut from the culture layer in Sværdborg Bog, $^6/_1$; *h Potamogeton prælongus*, a fruit stone from the Allerød mud in Lundby Bog, $^2/_1$; *i* and *k*, seeds of two *Caryophyllaceæ* from the culture layer at the western dwelling place in Holmegaard Bog, $^6/_1$; *l Potamogeton filiformis*, a fruit stone from the upper Dryas clay in Lundby Bog, $^6/_1$. Dr. K. Gram, fot.

Ranunculus repens (2 fruits, fig. 4 *b*); since Allerød mud was not met with here the age of these fruits seems somewhat uncertain, *Ranunculus repens* has previously been recorded from Denmark not earlier than from the pine-hazel zone[1], and has no distribution in purely artic regions.

[1] Knud Jessen 1929 (a), p. 17.

217—260 cm. Mud estimated as Allerød mud and differentiated as follows taken from above:
13 cm greyish brown clay mud,
25 cm yellow brown chalk mud,
5 cm sandy clay mud.

In the Allerød mud at points 12 and 25 were found:
Batrachium sp., 5 fruits,
Betula nana, 1 fruit (point 12),
Betula pubescens, 1 catkin scale (point 25),
Potamogeton alpinus, 1 fruit (fig. 4*f*),
— *prælongus*, 3 fruits (fig. 4*h*),
Characeæ, many oospores.

260—346 cm. Grey sticky clay. (Lower Dryas clay).
Sand.

In the pollen diagram from point 26 the upper peat layers were destitute of countable pollen due to very great destruction of it. To the part of the diagram which covers zones IV—VI reference will be made later on. In the lower part of it the *Salix* curve shows maxima in zones I and III in which the remains of arctic willow species met with elsewhere in Danish fresh water deposits are common, *Betula* dominates, and there is much *Pinus*. Still there is no reason for estimating the pine curve as representing more than pollen transported by the wind from far away, no macroscopical remains of pine having hitherto been found in Danish late glacial deposits, even if such could be expected from the Allerød period, the summer temperature of which may have been high enough to permit the growth of pine. That the pine curve shows the greatest relative frequency of pine pollen in the two Dryas zones may be due to the fact that the local production of pollen in these periods with their dominating tundra vegetation must have been rather small. At the top of zone III the curves approximate to the vegetation condition known from zone IV

through macroscopical finds: Dominating *Betula pubescens* and upwards increasing *Pinus silvestris*. In the Allerød period too *Betula pubescens* was common and here in zone II the pollen diagram shows a birch maximum. It would be of special interest to know how great a part *Betula nana* takes in the birch curve, macroscopical remains of it being found in zones II and III. The pollen content, however, was very scanty, and it was necessary to treat the samples with fluor acid after the method of ASSARSSON & GRANLUND so as to work out the pollen diagram from these zones, but as the pollen may change size by this treatment we do not trust the results obtained by our measurings of the size of the birch pollen *B. nana*, however, very likely it shows maxima in zones I and III and a minimum in zone II.

The post glacial layers were developed very homogeneously through the marginal zone of the bog. As an example shall be quoted the survey of a section through the culture layer a few metres from point 21 in the section, cfr. the pollen diagram Pl. III, fig. 5.

0—10 cm. Surface soil.

10—40 cm. Dark brown strongly humified *Carex* peat without wood remains.

40—59 cm. Dark brown alder forest peat with trunks, branches and stumps of *Alnus glutinosa* and rhizomes of *Phragmites communis* which increased downwards in frequency.

59—71 cm. Brown rather fresh *Phragmites* peat with roots of alder from the layer above. The culture layer was situated from 62 cm below the surface to the lower border of the layer; much charcoal of pine.

71—76 cm. Whitish snail mud containing the same fauna as mentioned p. 17 from Sværdborg, yet no *Planorbis corneus*.

The upper one or two cm of this layer could at other points be developed as a *Cyanophyceæ* mud; west of point 22 it grew thicker and contained fruits of *Najas marina*.

76—105 cm. Greyish white chalk mud with scattered fragments of shells.

105—112 cm. Light grey chalky clay mud. Bracts of *Myriophyllum verticillatum* were found in this layer at another point of the section.
Sand.

The culture layer covers zone V and the lower part of zone VI. The maxima for the pine and the hazel coinciding here too lie above its central part just as the starting horizon for the alder curve. A rise of the $\frac{Q}{P}$ index from 0.01 to ca. 0.3 covers the time when the site was inhabited. A comparison between zones V and VI in the two pollen diagrams from Lundby Bog permits the pointing out of synchronous horizons in the two sections with great certainty, and the same is the case on comparison of these diagrams with the pollen diagram from Sværdborg Bog. The changes in the composition of the forest vegetation must have been quite analogous in nearly all details here and at Lundby in the Mullerup time judging from the course of the curves, and have then very likely been contemporaneous on the two sites. On this supposition I have worked out the average diagram fig. 6, Pl. III, showing 4 pollen spectra from the time in which the Mullerup people lived in the two dwelling places and rendering it credible that the culture layer in Lundby Bog is somewhat older than the upper part of the culture layer in Sværdborg Bog; cfr. also the values of the $\frac{Q}{P}$ index from the two layers, p. 22 and p. 28.

As the section shows, the late glacial layers are not

found in the high lying parts of the bottom of the former lake, being perhaps replaced here by a deposition of sand; but in the preboreal time a sedimentation of mud started in this shallow zone of the lake, the pollen spectra from the bottom of the mud layer being here at various points very nearly the same as No 1 in Table 1. This feature, as will

Table 3. Lundby bog. Pollen spectra from the upper border of the mud.

No.	Points	*Salix*	*Betula*	*Pinus*	*Ulmus*	*Quercus*	*Tilia*	*Alnus*	*Corylus*	Q/P
1	26	..	20	23	16	5	5	31	112	1,15
2	27	..	25	23	9	7	8	28	135	1,04
3	31	..	34	25	14	3	7	17	150	0,96
4	12	1	27	25	12	4	4	27	112	0,76
5	34[1]	..	37	39	15	1	7	1	216	0,56
6	18	..	30	56	7	1	3	3	164	0,19
7	near 21	2	68	29	1	..	..	..	23	0,01
8	6	1	69	30	..	..	..	..	2	0,0

be remembered, is just what was found in Sværdborg Bog and is common met with in other Danish bogs[2]. It is, however, here not possible to clear up if it is due to a rising of the water level in the lake with the beginning of the post-glacial time, or to the changing sedimentation conditions in the lake conditional to the changes of the climate and in the vegetation cover of the surrounding land at this time.

The growing over of the lake was realized through a

[1] The sample taken 8 cm. below the mud surface.

[2] Cfr. also F. Tidelski, Untersuchungen über spät- und postglaziale Ablagerungen in der kuppigen Grundmoränenlandschaft Schleswig-Holsteins. Arch. f. Hydrobiologie, XX, p. 394. The greater part of the basins were without water in late glacial time, not containing lakes or bogs before in early post-glacial time.

swamp vegetation, the dominant of which was *Phragmites communis*. In Table 3 are given some pollen spectra from the upper part or from the very top of the mud layer at various points seen on the map fig. 5.

The table makes it evident that the growing over of the border zone of the lake took place at rather different times at different points, the time being expressed through

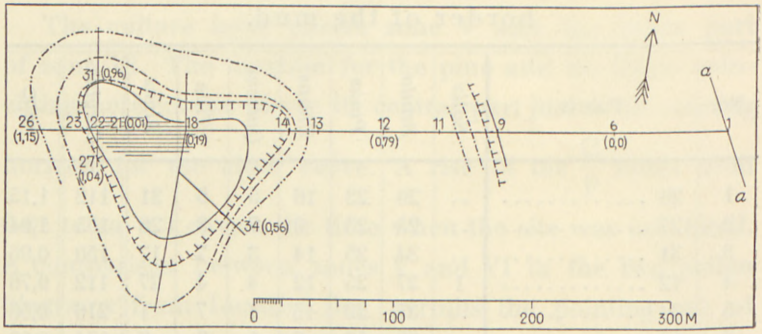

Fig. 5. Lundby Bog at the dwelling place. The line *a*—*a* is the eastern border. The straight lines show the position of the sections, the line 1—26 representing the section on Pl. I. TTTTT average position of the border of the *Phragmites* swamp on the Holm and along the eastern border of the lake when the site was inhabited. Contour lines of the bottom of the lake basin, ———— 1m, —·—·—· 2m, —··—·· 3m below the zero line in the section Pl. I. The hatched area shows the position of the culture layer according to the excavations of TH. THOMSEN.

the $\frac{Q}{P}$ index which shows that the swamp vegetation covered the lake earliest where it was most shallow, the deeper parts of it having still open water with mud sedimentation. At the time at which the dwelling place in Lundby Bog was in use, the $\frac{Q}{P}$ index, as mentioned above, increased from 0.01 to ca. 0.3, and a glance at Table 3, the map fig. 5, and the section will make it evident that the dwelling place

has been situated on a swamp island lying close outside the eastern shore of the lake which was also covered by a growth of Common Reed, while the free water surface still existed at points 26, 27, 31, 34 and 12 when the site was abandoned.

Concluding Remarks.

The survey here carried through has confirmed the view that the Mullerup culture throughout Sealand was contemporaneous with one and the same phase in the boreal forestal development, viz. the pine-hazel period, in which the central European deciduous forest advanced its northern-most outposts to Denmark. The steadily increasing value of the $\frac{Q}{P}$ index from below upwards in zones V and VI gives a numerical expression for the beginning victorious struggle on Danish ground of this forest against the pine, and in the period in which the known Mullerup dwelling places in Sealand were inhabited the index rises from 0.01 to 0.5 in sharp contrast to its value in Ertebølle time when it was 2 or more. Simultaneously with this advancing of the oak mixed forest (oak, elm, lime) the alder also came in and increased in frequency, while the hazel attained a very significant maximum.

The various Mullerup culture layers are, however, hardly absolutely contemporaneous, some, as it seems, important pollen analytical differences between them being pointed out, especially relative to the value of the $\frac{Q}{P}$ index, the position of the hazel maximum, and the starting of the alder curve. As I am inclined to ascribe to the variations of this index and to the alder curve a greater chronological value

within zones V and VI than to the hazel curve since they give expressions for the evenly advancing change in the competition between the forest trees without the degree of "capriciousness" which the hazel curve may show (cfr. p. 33), we have in fig. 4 tried to range the various culture layers in agreement with the varying of the $\frac{Q}{P}$ index as an expression of their reciprocal differences in age[1], and besides the Sealandic sites is also drawn in in the figure the horizon in Sejerslev Bog on the island Mors in Jutland, in which has been found a core of the Mullerup type[2].

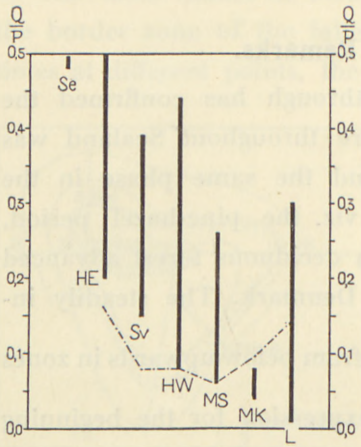

Fig. 6. Age determination of the Danish Mullerup culture layers in proportion to the values of the $\frac{Q}{P}$ index which they cover. HE Holmegaard East, HW Holmegaard West, L Lundby, MK Koch's Holm and MS Sarauw's Holm in Mullerup Bog, Se Sejerslev, Sv Sværdborg. — The broken line connects the $\frac{Q}{P}$ value of the horizons where the alder curve starts.

The sequence of the localities in the figures from right to left is according to increasing values of the $\frac{Q}{P}$ index of the lower side of the culture layers. This view of the proportional age of the starting of the settlements is in good agreement with the age determination of the lower side of the culture layers relative to the *Alnus* curve, supposing that the rational border of it is synchronous in the pollen diagrams in

[1] Cfr. by L. VON POST, in O. RYDBECK & L. VON POST l. c.

[2] KNUD JESSEN 1929 (a) p. 9 and 12. — The harpoon from Taaderup (H. ØDUM. Et Elsdyrfund fra Taaderup paa Falster. Danmarks Geol. Undersøg. IV R. Bd. 1 Nr. 11. 1920) is not discussed here as it is somewhat younger than the Mullerup culture layers.

question. According to this, Mullerup-Koch and the lower part of Lundby should be older than Mullerup-Sarauw and Holmegaard West as to the beginning of the settlement, this being latest at Sværdborg and Holmegaard East (the determination of the $\frac{Q}{P}$ index for the *Alnus* border here is uncertain, cfr. the pollen diagram), the occupation at Mullerup-Koch should have been of comparatively short duration, and Holmegaard West and Holmegaard East should have been abandoned last.

Even if the hazel maximum is excellent as a leading horizon for the boreal period I find it, as mentioned p. 14, less valuable for relative age determinations of the Danish Mullerup culture layers, and in this view I find confirmation by a comparison of the pollen diagrams from the culture layers at Mullerup-Koch and at Holmegaard West, it being very improbable that the first mentioned should be on an average contemporaneous with the culture layer at Holmegaard West; cfr. fig. 1, Pl. II and fig. 2, Pl. III.

Not only the oak mixed forest trees invaded Denmark in the Mullerup period and the time just before. According to the geographical conditions there were at that time the best possible circumstances for the invasion of southern species (cfr. fig. 8) and the first discovery of a series of relative thermophilous plants and animals in zones IV, V and VI, especially in the two last of them tells us that the climatic conditions improved very much, and particularly the invasion in this period of such species as are checked in their distribution by lack of suitable summer warmth makes it evident that the summer isotherms were shifting towards the north. Besides the forest trees mentioned, such mainly southern Scandinavian species as the following are known

to have settled in preboreal and especially in boreal time in Denmark:[1] *Carex pseudocyperus, Ceratophyllum demersum, Cladium mariscus, Dryopteris thelypteris, Eupatorium cannabinum, Fraxinus excelsior, Iris pseudacorus, Najas marina, Peucedanum palustre. Rumex hydrolapathum, Solanum dulcamara.* Since these species at present have their main distribution in Scandinavia in the southern and central part, they give evidence of a summer temperature in boreal time in Denmark not very different from the present, and considering the fact that *Emys orbicularis* and *Planorbis corneus* are found in the Mullerup culture layers, it is very likely that the summer temperature has been at least as high as now, as this snail has its present northern boundary running through Jutland, and the tortoise is unknown in the true wild state north of the Baltic[2]; the great frequency of *Najas marina* in boreal mud layers together with remains of the same water flora as is known from the present time in Denmark also induce the supposition of a rather high summer temperature, this species now having its main distribution farther to the south.

Discussion of pollen-analysed epipalæolithic Culture Layers outside Denmark.

On the basis of the results of the pollen-statistical survey of the Danish Mullerup culture layers here advanced, we shall in the following consider some epipalæolithic bog finds in adjacent countries which have been analysed for pollen, such localities being known from southern Sweden, Esthonia

[1] Cfr. Knud Jessen 1920, p. 229 f., 240.

[2] C. Kurch, Den forntida ütbredningen af Kärrsköldpaddan Emys orbicularis (Lin.) i Sverige, Danmark och angränsande Länder. With a German Summary. Lunds Universitets Årsskrift. N. F. Avd. 2, Bd. 13, Nr. 9, Lund 1917.

and other regions around the Gulf of Finland, as well as from Germany and England.

Of bog finds of epipalæolithic type from Scania which have been submitted to pollen analytical investigations are known some "fowl-arrows" and a horn axe from Stora Dode Bog. The culture layer in Bare Bog may also be mentioned, even if this find typologically is uncertain[1]. L. v. Post[2], to whom the pollen analyses of these finds are due, thinks it very likely that the fowl arrows are contemporaneous with that period in which the water level of the Baltic certainly was determined by the thresholds in the German-Danish sounds, but when the Ancylus transgression had been superseded by regression in its eastern parts, while, on the other hand, the oldest parts of the Danish Mullerup culture layers, as also the Bare Bog culture layer, may probably be nearly contemporaneous with the formation of the highest shore line of the Ancylus Lake[3]. In table 4 are given some of the pollen spectra of L. v. Post from these finds. They make it evident that the epipalæolithic culture in Scania too goes back to the period when the oak mixed

[1] R. Sernander, Om Ancylustidens människa och tallperioden i södra Skandinavien. Geol. Foren. Förhandl., Bd. 30, Stockholm 1908, p. 388 f.

Of other typological, uncertain finds from about this time determined by pollen analyses also may be mentioned two horn axes from Scania (O. Isberg, Tvenne egenartade hornyxor och deres ålderbestämning. Ymer. Stockholm 1931, p. 169 ff.) and a reindeer antler worked by men and found in Hylteberga Bog, Scania, by O. Isberg referred to the transition period of boreal and atlantic time (Till frågan om människans och renens första upträdande på den skandinaviska halvön under postarktisk tid, Ymer 1930, p. 381 f. Cfr. also O. Rydbeck, Aktuelle Steinzeitprobleme. Meddelanden från Lunds Universitets Historiska Museum. Lund 1934, p. 71 f.).

[2] O. Rydbeck & L. v. Post 1929, p. 145 ff. — L. v. Post, Svea Älvs geologiska tidsställning. Sveriges Geol. Undersökning. Ser. C. No. 347. Stockholm 1928, p. 67. English Summary.

[3] Cfr. H. Munthe, J. E. Hede & L. v. Post, Gotlands Geologi. Sveriges Geol. Undersökning. Ser. C. No. 331. Stockholm 1925, Pl. 7.

Table 4. Epipalæolithic pollen spectra from Scania. Nos. 1—8 from samples fixed to the implements. After L. v. POST.

	No.	*Salix*	*Betula*	*Pinus*	Oak mixed forest				*Alnus*	*Corylus*	Q/P	*Corylus*-index (L. v. Post)
					Ulmus	*Quercus*	*Tilia*	Sum				
Fowl-arrows												
Åmossen (no. 3191 b)	1	..	18	19	8	2	11	21	42	20	1,1	0,3
Hylteberga Bog (no. 14053)	2	..	21	26	10	6	10	26	27	15	1,0	0,5
Stora Dode Bog (no. 1728)	3	..	19	30	13	3	11	27	24	36	0,9	0,7
Åmossen (no. 3191 a)	4	..	31	33	5	5	7	17	19	53	0,5	1,5
Stora Dode Bog (no. 2173)	5	..	25	35	5	2	6	13	27	32	0,37	0,8
Bussjö Bog (no. 13075)	6	..	31	40	3	3	3	8	21	48	0,2	1,6
Åmossen (no. 2918)	7	..	41	43	5	1	..	6	10	47	0,14	2,8
Horn axe												
Stora Dode Bog, sample close the axe	8	+	24	53	+	..	+	1	21	28	0,02	1,3
Stora Dode Bog, sample near below the axe	9	2	23	72	2	..	..	2	1	143	0,03	48
Bare Bog												
Close above the culture layer	10	..	43	51	4	1	..	5	1	260	0,1	43
Culture layer, top	11	..	56	44	..	..	..	..	..	33	0,0	..
— — middle	12	2	39	58	1	..	..	1	..	47	0,02	47
— — bottom	13	+	50	49	1	..	..	1	..	30	0,02	30

forest started its colonizing in the pine woods, and the hazel was very common.

Assuming that the development of the boreal forest in southern Scania and Sealand, territories lying so near each other and having on an average the same edaphic conditions, has had a nearly synchronous progress, which seems to be in good accordance with the testimony of most of the pollen diagrams published from these areas, it is tempting to try a closer comparison of the epipalæolithic

layers in these territories, laying stress especially on the changing of the $\frac{Q}{P}$ index and on the occurrence of the alder rather than on the pollen frequency of the hazel (cfr. p. 33).

A comparison of the pollen diagrams from Bare Bog (L. v. Post 1929) and Lundby Bog will make it evident that the culture layer in the first-named locality is somewhat older than even the lowermost part of the Lundby culture layer, which may be the oldest known in Denmark, a conception which also is supported by the hazel curve, the culture layer only in Bare Bog being older than the hazel maximum. The pollen spectrum from the axe from Stora Dode Bog is peculiar because of its high frequency of alder in connection with but traces of elm and lime and the absence of oak, a constellation which is unknown in Danish Mullerup spectra; yet it may very likely date from the Mullerup Time.

The arrangement of the pollen spectra from the fowl-arrows according to the changing of the $\frac{Q}{P}$ index makes it very propable that there is a not unessential difference in age between the uppermost and the lowermost of them in the table, the pine and the birch decreasing and the oak mixed forest species and the alder increasing upwards in the table. The pollen spectra nos. 4—7 are of nearly the same type as the Danish Mullerup spectra even if the frequency of hazel is rather low, its mean frequency in the four spectra being 45. The three upper spectra, however, are surely younger and may date from a somewhat later time than the Danish Mullerup culture layers, the sum of pollen of the oak mixed forest species being on an average as high as the sum of the pine pollen, the frequency of hazel is diminished, and

the *Corylus* index is below 1. On this view it should thus be the three first mentioned fowl-arrows alone (Nos. 1—3) which date from the regression period of the Ancylus lake.

The fact that implements of epipalæolithical type, but younger than the Danish Mullerup culture layers, are found in Sweden is probably also met with on Öland. Here G. Lundquist[1] has given a pollen analytical survey of 4 such bone implements found in Öj Bog, and he points out that they fit in very well in a zone in the pollen diagrams from Öland which belongs to a period shortly before the entrance of the Litorina sea into the Baltic. According to the same author, two fowl-arrows or bone harpoons from Fuglasjö on Lister in county Blekinge should be of the same age, the site where they were found being pollen analytically investigated by U. Sundelin[2], and H. Thomasson[3] agrees in the main with Lundquist about the age of these bone implements from Öland and Lister; but even if they are somewhat younger than the Danish Mullerup culture layers, yet their pollen spectra give evidence of a composition of the forest not unlike that which is known from Denmark in Mullerup time.

In the just cited paper of the stone age dwelling places on Sandarna at Gothenburg H. Thomasson gives a thorough age determination of the culture layers imbedded in a strand

[1] G. Lundquist, Studier i Ölands Myrmarker. Sveriges Geolog. Undersökning. Ser. C. No. 353. Stockholm 1928, p. 75 ff. Mit deutscher Zusammenfassung.

[2] U. Sundelin, Om Sydskandinaviens senkvartära nivåförändringar. Geolog. Fören. Förhand. Bd. 46, Stockholm 1924, p. 499 f.

[3] J. Alin, N. Niklasson & H. Thomasson, Stenåldersboplatsen på Sandarna vid Göteborg. Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälles Handlingar. Femte Följden. Ser. A, Bd. 3, No. 6, Göteborg 1934, p. 211 ff. With German Summary.

wall formation. According to its main character the flint industry from Sandarna is by N. NIKLASSON estimated as typologically essentially older than the Mullerup culture, but THOMASSON dates the central culture layer to be nearly contemporaneous with the Bare Bog layer, while other culture layers at Sandarna are contemporaneous with or younger than the Mullerup period. The forest at Gothenburg in the period of the central culture layer had a strongly northern character, being composed mainly of pine and birch, while the spectra commonly show but a very low frequency of hazel and scattered traces of alder, elm and oak, the continual alder curve only starting at a higher level. On the other hand, the pollen diagrams in the horizon which according to THOMASSON may be estimated as contemporaneous with at least the younger Danish Mullerup layers have an appearance much like the Danish Mullerup spectra with pine still dominating, low frequencies of alder and in many diagrams a pronounced hazel maximum and oak and often elm in continual curves. Discussing the age of the Danish Mullerup culture (p. 210), he refers the beginning of it to a zone between his pollen levels AIV (the beginning of the continual alder curve) and MI (transitional between his Ancylus and his Mastogloia or Tapes period[1]). As will appear from the analyses of the culture layers in Lundby Bog and at Koch's Holm in Mullerup Bog, the beginning of the settlement in these localities falls a good time before the start of the continual alder curve; it should then in age approach the top of the Bare Bog culture layer or correspond with a horizon between THOMASSON'S pollen levels AII and

[1] It seems unfortunate to use the term Tapes period for a transitional period between the Ancylus and the Litorina periods, as this term already is preoccupied in another sense in the literature.

AIV, in his chronological diagram p. 215 fitting in between 6500 and 7000 BC.

Thomasson synchronizes the pollen level of the upper surface of the youngest Danish Mullerup layers (Holmegaard) with the Tapes maximum which in his scheme p. 215 he places about 5500 BC, or about 1000 years earlier than the Litorina maximum. Probably this synchronizing is especially due to the lime curve which starts at that level at Gothenburg (Poppelmansgatan fig. 62), giving this horizon a certain similarity to the Danish layers mentioned. But if so, it may be worth while mentioning that the lime seems to have been much delayed on its way from Dano-Scania to the environs of Gothenburg, as the rational border of its curve in the west Baltic regions is most commonly placed at the same level where the continual curves of the alder and the oak start. That the connection mentioned must be uncertain will also be evident on looking at the composition of the pollen spectra from the time of the Tapes maximum in the north-eastern part of Denmark[1]; they all differ quite essentially even from the youngest Mullerup spectra, the $\frac{Q}{P}$ index from them being more than 2. And there is no doubt that there is a long span of time between the youngest Mullerup culture layers and the Tapes maximum, which in Denmark is contemporaneous with the Ertebölle culture. Undoubtedly Thomasson is wrong when on the basis of comparisons of pollen diagrams respectively from the east coast and from the west coast of Sweden he would place the Tapes maximum in Skager Rack about a thousand

[1] K. Jessen 1920, p. 154 f., 1929, p. 18 f. The same Author, Et Kulturlag fra den ældre Stenalder ved Horsø. Medd. fra Dansk geol. Foren. Bd. 7. 1926, p. 135. — Magnus Degerböl, Danmarks Pattedyr i Fortiden. I. København 1933, p. 381, English Summary p. 621.

years before the Litorina maximum in the Baltic, and I must here agree with R. SANDEGREEN[1] in his criticism of this point and when he maintains that the Tapes maximum is identical in time with the Litorina maximum, falling about 4500 BC.

Of course it is only very approximately that the beginning of the Mullerup culture in Denmark can be fixed as attempted above, and at the present time it does not seem practicable to fix the age of the youngest Danish Mullerup layers by direct pollen diagrammatic comparisons; but presuming that these too are older than the entrance of the sea into the Baltic basin (cfr. p. 60), which is estimated to have taken place about 5500 BC, the Mullerup culture in Denmark as it is represented through the known layers should have developed within a period of about a thousand years[2].

The much discussed Kunda find in Esthonia is by P.W. THOMSON[3] referred to boreal time due to stratigraphical facts. The great number of artefacts, among which harpoons of elk bone and scrapers prevail, and which are still insufficiently studied, were found mainly in the upper part of a boreal chalk mud lying above preboreal mud and late glacial Dryas clay formed in a former lake, which was dammed up by a strand wall of the Baltic ice lake. The upper part of the chalk mud contained a pollen flora giving evidence of a forest vegetation with dominating pine, much birch, and with just invading hazel, elm and alder. Peat and mud

[1] R. SANDEGREEN, Om den postglaciala havstransgressionen vid Sydsveriges kuster. Geol. Fören. i Stockholm Förhandl. 1934, p. 628.

[2] Cfr. MUNTHE, HEDE & v. POST 1925, Pl. 7.

[3] P. W. THOMSON, Die regionale Entwicklungsgeschichte der Wälder Estlands. Acta et Commentationes Universitatis Tartuensis (Dorpatensis) A XVII, 2. Dorpat 1929. The same Author, Geologische Datierungen archäologischer Funde in Estland. Fornvännen. Stockholm 1930, p. 238 ff. — Cfr. ALIN, NIKLASSON & THOMASSON p. 211.

layers in the bottom of bogs which are situated below the highest Ancylus strand walls in most cases contain a pollen flora of a late boreal type, still with much pine, but already much pollen of hazel, elm and alder, a marked boreal hazel maximum not being developed in Esthonia. THOMSON synchronizes this late boreal spectrum type with the pollen spectra just above the implementiferous horizon at Kunda from which follows that this very likely may be somewhat younger than the highest Ancylus walls. Notably in respect of the alder curve, the culture horizon at Kunda may be synchronized with the transition between zones VII and VIII on Gotland and Öland, that is, with a period probably nearly contemporaneous with the maximum of the Ancylus transgression[1]. Perhaps coming investigations will make it possible to arrive at a more definite age determination of the Kunda layer relative e. g. to the Swedish pollen diagrams, but on the basis of our present knowledge the reference of it to a later part of the Ancylus period seems plausible[2], and it seems very likely that the Kunda layer may largely be estimated as contemporaneous with the younger Danish Mullerup layers.

Also from Embachtal at Dorpat THOMSON mentions finds of bone implements of epipalæolithic type which seem

[1] Cfr. besides MUNTHE, HEDE & v. POST 1925 and G. LUNDQUIST 1928 also H. THOMASSON, Baltiska tidsbestämningar och baltisk tidindelning vid Kalmarsund. (With a summary in German). Geol. Föreningens i Stockholm Förhandl. 1927, p. 68.

[2] It may be mentioned here that H. THOMASSON 1934, p. 211 on the basis of the pollen diagrams of K. MARKOW from the lower part of the river Narva in Russia thinks it likely that the Kunda horizon is contemporaneous with the transition between zones VI and VII, which correspond with the transition from the Anculus lake to his Mastogloia sea in the Baltic. MARKOW's paper has not been available to me. — After this was set up THOMSON has published a new paper on this theme in Geol. Fören. i Stockh. Förhandl. 1935.

to be contemporaneous with a pollen flora of just the same character as the Kunda find.

In southern Finland the oldest stone age find known from that country, viz. a fishing net with stone implements at Korpilathi in Antrea, has long ago been referred to the Ancylus period due to qualitative phytopalæontological facts. Now E. Hyyppä[1] has published a pollen diagram from the site where the fishing net was found, and asserts on the basis of this that the net dates from the earliest part of the Ancylus period. The first traces of the oak mixed forest in that region seem to be on an average of the same age as the net, but long before the alder was present, attaining in the pollen diagram a pollen frequency of up to 15 % in the layer below the net. A closer comparison of the pollen diagram in question particularly with the Swedish ones would be desirable for a further discussion on a pollen statistical basis of the age of this find, which from an archæological point of view has been estimated to be younger than the Ancylus period.

Of the Duvensee find, typologically closely allied to the Mullerup culture, G Schwantes[2] has given the archæological description. In the same paper M. Beyle communicates the botanical survey of the site which is situated in a bog south of Lübeck. In the culture layers macroscopical remains of pine, birch and hazel were very common, and in the lower part of the mud layer below the nether culture horizon 62 % alder pollen was recorded together with 38 % pine

[1] Esa Hyyppä, Geologische Altersbestimmung des steinzeitlichen Netzfundes von Korpilathi in Antrea (Vuoksenranta). Finnish with German summary. Suomen Museo. XL. 1933.

[2] G. Schwantes, Nordisches Paläolithicum und Mesolithicum. Mitteillungen a. d. Museum f. Völkerkunde in Hamburg. XIII. Hamburg 1928.

pollen, this pollen species reaching its maximum 70 % in the nether culture layer but still showing 56 % in the upper one. Shells of hazel nuts were found in such great quantities that Schwantes supposes that "die Hasel sheint fast die Stelle des Getreides vertreten zu haben" (p. 205). Even if no traces of oak have been recorded, the dating of Beyle "dass der Beginn der Verlandung des Sees in das Ende der Birken-Espen Zeit zu setzen ist" (p. 204) is not convincing taking into consideration the rich occurrence of alder pollen just in the lower part of the mud layer, and the conclusion of Schwantes, so far as it is based on the floristical survey of the site, that the Duvensee culture must be older than the Sealandic Mullerup culture will be largely invalidated by a comparison of the finds of Beyle with pollen diagrams known from the neighbouring regions. The pollen diagram of Tidelski[1] from Ellerbek bei Kiel (l. c. Taf. XIX) in agreement with the survey of C. A. Weber of the same site shows a very great similarity as to the boreal zone with the Danish pollen diagrams, published as well as unpublished, as also with the pollen diagram before me from a bog south of Flensburg, i. a. by the curves of *Ulmus*, *Quercus*, *Tilia* and *Alnus* starting very nearly contemporaneously with the *Corylus* maximum. Just the same feature occurs e. g. in all the pollen diagrams published by E. Schubert[2] from the region between Hamburg and Bremerhafen in which the boreal zone is represented. This contemporaneity must also be normal for Holstein as well as for the region south of Lübeck, and the following pollen spectrum from boreal chalk mud in Duvensee Bog (Tidelski l. c., p. 380) tells

[1] Fritz Tidelski, l. c.

[2] Erick Schubert, Zur Geschichte der Moore, Marchen und Wälder Nordwestdeutschlands II. Mitteilungen d. Provinzialstelle für Naturdenkmalpflege Hannover. H. 4. Hannover 1933.

that the three main trees in the oak mixed forest very likely appeared at Duvensee even previous to the alder:

Pine	Birch	Elm Oak Lime	Willow	Hazel	$\frac{Q}{P}$
70	25.5	2.5	2	40	0.04

The finding on the site in Duvensee bog of alder pollen in great quantities below the culture layer which was very rich in hazel nuts then justifies the conclusion that this epipalæolithic culture layer also dates from that part of the boreal period in which the oak mixed forest began to assert itself, or in other words that the Duvensee culture just like the Sealandic Mullerup culture has developed in the border zone between the invading deciduous forest and the pine forest. I do not maintain an absolute coincidence in age between the two culture forms, but what has been mentioned makes it evident that the results of the botanical survey of the site cannot be used as a proof of the Duvensee culture being essentially older than the Mullerup culture on Sealand.

The large site at Friesack in Rhinluch, Brandenburg which has been excavated and treated in a monograph by Max Schneider[1] is referred by this author to an early part of mesolithicum, consequently broadly contemporaneous with the epipalæolithic culture group; it differs much however from the other western European epipalæolithic cultures especially through its content of pottery i. a. the so called "Binzenkeramik". Pollen analytic investigations of the culture layer at III Rhinbrüche, deposited in connection with an outcropping of sand in the peat-covered "Berliner Urstromtal", were carried out first in 1923 by

[1] Max Schneider, Die Urkeramiker, Entstehung eines mesolithischen Volkes und seiner Kultur. Leipzig 1932.

Knud Jessen on some samples of peat and sandy matrix collected by Max Schneider (cfr. this author p. 100). Later J. Stoller[1] has procured a more extensive material by surveys in the field. His pollen diagram from one of the sections is reproduced in fig. 7. The lower part of the diagram is of preboreal type (Rudolph), here with great dominance of pine, a little of birch and small frequencies of alder; in another section Stoller mentions 9 % —9 % and 5 % of this species in three samples up to 1.1 m below the culture layer. In the upper part of this the pine curve falls quickly, corresponding with increasing frequency of the oak which reaches 22 % near its upper border; the counted number of pollen in the two upper samples, however, is rather small, 56 and 46 respectively. Stoller has found no hazel pollen. But that this species as well as the elm and perhaps also the lime has been present in the neigh-

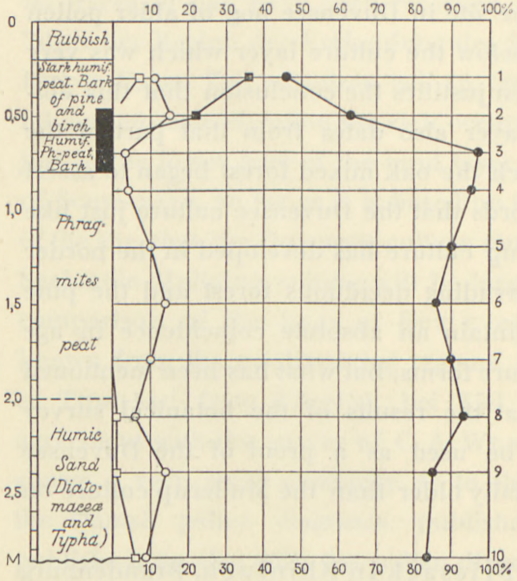

Fig. 7. Pollen diagram from Friesack after J. Stoller. The black field shows the position of the culture layer in the section. For pollen signaturs see Pl. II.

[1] J. Stoller, Moorgeologische Untersuchung im Havelländischen Luche nordwestlich von Friesack zur Feststellung des Alters einer mesolithischen Kulturschicht an der III Rhinbrüche. Jahrb. d. Preuch. Geolog. Landesanstalt. Bd. XLVIII. Berlin 1927.

bourhood during the last time of occupation is very likely taking into consideration the great representation of the oak, for in the pollen diagrams from Brandenburg of HUECK[1] and HESMER[2] these species are represented in the horizon, where the continual oak curve starts, or the lime a little later, though it may be noted that the intervals between the samples are rather great. In the pollen spectra of JESSEN[3], published by STOLLER, some of which may be nearly contemporaneous with the culture layer, small frequencies of hazel and lime besides of spruce were also found.

On the basis of his pollen analyses STOLLER refers the culture layer to an early part or at latest to the middle part of the Ancylus period. In this connection a comparison with pollen diagrams from other regions of central and northern Germany[4] will be of interest. In these regions the oak curve normally starts or bends strongly outwards after the pine maximum and just within the boreal hazel maximum

[1] K. HUECK, Die Vegetation und die Entwicklungsgeschichte des Hochmoores am Plötzendiebel (Uckermark). Beiträge zur Naturdenkmalpflege Bd. XIII, Heft 1, Berlin 1929, p. 209 ff.

[2] H. HESMER, Die natürliche Bestockung und die Waldentwicklung auf verschiedenartigen märkischen Standorten, Zeitsch. f. Forst- und Jagdwesen. Berlin 1933.

[3] When K. BERTSCH 1928, p. 34 in his paper, here cited p. 49, remarks that the number of counted pollen in the analyses of JESSEN is too low for the using of them he is speaking of analyses of STOLLER from »Profil Schneider-Ostrand«.

[4] H. FRENZEL, Entwicklungsgeschichte der sächsischen Moore und Wälder seit der letzten Eiszeit. Abhand. d. Sächsischen Geolog. Landesanstalt. Heft 9. Leipzig 1930. — P. STARK & F. OVERBECK, Zur Waldgeschichte Schlesiens. Planta. Bd. 8. Berlin 1929. — K. HUECK 1929. — K. v. BÜLOW, Drei Pollendiagramme aus Vor- und Ostpommern. Jahrb. d. Preusch. Geolog. Landesanstalt. Bd. XLIX. Berlin 1928. — K. PFAFFENBERG, Stratigraphische und pollenanalytische Untersuchungen in einigen Mooren nördlich des Wiehengebirges. Ibidem. Bd. 54. 1933. — F. TIDELSKI l. c. — E. SCHUBERT 1933.

— often a little below the very top of the curve. We may then provisionally take it for granted that this will also prove to be the case in the environs of Friesack, and we may regard the upper part of the culture layer there as contemporaneous with the boreal hazel maximum as are the epipalæolithic culture layers in most cases elsewhere. In view of this consideration the reference of the upper part of the culture layer to the middle part of the Ancylus period may be found very likely, but the question can only be solved when a more definite knowledge of the forest development in Brandenburg relative to the history of the Baltic is procured (cfr. Stoller p. 763).

The mesolithic station at Calbe a. d. Milde, Altmark in Brandenburg as to the age of which there has been much discussion[1] — typologically it seems to be much like Duvensee — is now by Frenzel and Grahmann[2] owing especially to pollen investigations, referred to the first part of the Atlantic time. The following spectrum, taken from the authors mentioned may serve as a type of the pollen flora contemporaneous with the culture:

Birch	Pine	Elm	Oak	Lime	E.+O.+L.	Alder	Spruce	Hazel
8.21	37.31	0.75	3.73	9.70	14.18	39.55	0.75	3.73

To Frenzel and Grahmann it is particularly the values of the alder as well as the pine and the oak mixed forest which point to the Atlantic time, and the lack of silver-fir, beech and common hornbeam which refer to the first part of this period. Especially perhaps the relatively high lime frequency may point in this direction, but it is difficult to form an opinion

[1] J. Andree, Beitr. zur Kenntnis des norddeutschen Paläolithicums und Mesolithicums. Mannus-Bibliothek. No. 52. Leipzig 1932. No. 9, Der mesolithische Fundplatz von Calbe a. d. Milde (Altmark), p. 62 ff.

[2] H. Frenzel & R. Grahmann, Pollenanalytische Untersuchungen des mesolitischen Fundplatzes von Calbe a. d. Milde. Ibidem p. 64 ff.

on the conclusion of FRENZEL and GRAHMANN without knowing any complete pollen diagram from the locality, which could give the answer to the question e. g. of the age of these spectra in relation to the hazel maximum. The alder frequency is certainly very high, but in what degree may it be due to over-representation? It must here be remembered that the first alder maximum e. g. in Uckermark and elsewhere is boreal (HUECK fig. 105, 108), and that the hazel frequency of the spectrum at all events is extraordinarily low. A certain similarity may be seen between the Calbe spectra and the uppermost horizon of the Friesack diagram, (cfr. the pine, the birch, the hazel and the sum of the oak mixed forest pollen), but still a final decision as to the reciprocal age of these two horizons may be premature even if the Calbe spectra have the appearance of being somewhat younger than the other.

If the age determination of FRENZEL and GRAHMANN is accepted as safe, the Calbe culture may be placed with the younger mesolithic cultures, but like the younger part of the Friesack culture it has been contemporaneous with a forest vegetation in the pollen production of which the proportion of the pollen of the oak mixed forest and of the pine have on an average had the same value as in the Baltic regions and in eastern England in epipalæolithic time.

From southern Germany too we know the composition of the forest in epipalæolithical time, thanks to the extensive investigations of K. BERTSCH[1] in the renowned

[1] KARL BERTSCH, Klima, Pflanzendecke und Besiedlung Mitteleuropas in vor- und frühgeschichtlicher Zeit nach den Ergebnissen der pollenanalytischen Forschung. Sonderabdruck aus dem XVIII. Bericht der Römisch-Germanischen Kommission. Frankfurt a. M. 1928, p. 7, figs. 2 and 13. The same Author, Paläobotanische Monographie des Federseerieds. Bibliotheca Botanica. Heft 103. Stuttgart 1931, p. 15 ff., 111 ff., figs. 8, 9, 84.

Federseeried, a great bog in southern Würtemberg. The epipalæolithic culture layers here, which were stratified in the peat near the bottom of the bog, contained numerous bones and some flint knives, according to H. Reinerth[1] contemporaneous with the western European Azil-Tardenoisian. Pollen floristically the culture zone is characterized by a well marked hazel maximum following upon the old post-glacial pine maximum, a falling pine curve and increasing of the curve for the pollen of the oak mixed forest trees which starts somewhat below the culture layer, and which in the Atlantic layers in most of the pollen diagrams from the bog far exceeds the pine curve. The continual alder curve starts in the horizon of the hazel maximum (cfr. the pollen tables in Bertsch 1931).

On the supposition that the hazel maximum is caused by the post-glacial temperature optimum Bertsch (1931, p. 112) assigns it to about 7000 BC by help of an oscillation of Milankowitsch's sun radiation curve at about 8000 BC. This determination perhaps may not be far wrong even if the premiss mentioned above seems uncertain, as the biological reactions of the post-glacial climate optimum in northern Europe, where they are fixed through the Swedish geochronology, were only realized some thousand years later, in Atlantic time.

East England and the North Sea.

During recent years we have greatly increased our knowledge of the so called period A of the forest culture in England, correlated with the boreal climate period, thanks especially to Leslie Armstrong, V. G. Childe and J. G. D. Clark,

[1] Hans Reinerth, Oberschwäbisches Mesolithicum. Nachrichten d. Deutsch. Anthrop. Ges. 1928. Here cited from K. Bertsch.

and since the method of pollen analysis also has made its way to England due to G. ERDTMAN, possibilities for comparing the forest conditions contemporaneous with the various archæological sites in England and on the continent have been procured, particularly through the work of H. and M. E. GODWIN.

In a paper, British Maglemose Harpoon Sites, these authors[1] have made a comparison of the epipalæolithic sites of Skipsea in Yorkshire, of the Leman and the Ower banks off the Norfolk coast of England, of Denmark and of Esthonia. At Skipsea, according to L. ARMSTRONG, a Mullerup flint industry associated with remains of reindeer is found in silt below peat, and at the Leman and the Ower banks a Mullerup harpoon has been taken in a lump of moorlog in about 19—20 fathoms (ca. 36 m) of water. The authors find that the pollen spectra from all these sites are practically identical with one another, and they point out that in so far as the spread of forest trees into Europe during this phase of post-glacial time was synchronous for Esthonia, Denmark and England, so far the cultures of these sites must be contemporaneous, in any case boreal in age.

Even if the pollen diagram from Skipsea in the horizon of the culture layer shows a curiously low frequency of pine and an uncommonly high amount of oak and elm — the bottom spectrum of it is seen in table 5, no. 1 — other features, as the hazel maximum and the course of the curves in general, indicate very well what may be called a

[1] H. & M. E. GODWIN, British Maglemose Harpoon Sites. Antiquity. 1933. — Cfr. G. ERDTMAN, Some Indications of the Character of Climate and Vegetation in North-western Europe during the Mesolithic Age. Proceedings of the First International Congress of Prehistoric and Protohistoric Sciences; London 1932. Printed 1934.

late boreal age of the culture layer, especially when it is compared with a surely more typical pollen spectrum e. g. that from Judy Hard in Norfolk[1].

Also some pollen spectra of the submerged peat from the Mullerup site at the Leman and the Ower banks taken from the papers of H. & M. E. GODWIN and G. ERDTMAN mentioned above are cited in table 5. Cfr. p. 56.

Besides these two, other south eastern English sites are to mention. Thus at Broxbourne in Lea Valley an epipalæolithic site sealed under boreal peat has been described[2], and this site and the continental ones — on Sealand and at Duvensee — are in respect of their industry "substantially alike with chipped flint axes, microlithes, scrapers, burins (rare), and microburins" (l. c., p. 123). No bone and horn industry is known from Broxbourne. According to the section (l. c. p. 105) the basal part of the peat layer may very likely be a little younger than the industry imbedded in the sand below it. The lowermost spectrum of the pollen diagram taken 5 cm above the sand surface in a bore some hundred feet from the culture layer is here reproduced in table 5 no. 2. It is of boreal type. Upwards in the pollen diagram the pine curve is mainly decreasing, the sum of oak and elm mainly increasing, the hazel in the lower part steady, showing rather high frequency, the alder limit lying 25 cm above the sand surface.

Also at Plantation Farm in the south eastern Fens an epipalæolithic site in peat has been pollen analytically in-

[1] H. & M. E. GODWIN, Pollen Analysis of Peats at Scolt Head Island Norfolk. The Norfolk and Norwich Naturalists' Society's Scolt Head Island. Norwich 1934.

[2] S. HAZZLEDINE WARREN, J. G. D. CLARK, H. & M. E. GODWIN and W. A. MACFADYEN, An early mesolithic site at Broxbourne sealed under boreal peat. Journal of the Royal Anthropological Institute. LXIV. London 1934.

vestigated[1]. Some pieces of Tardenoisian flint were found here, most of them lying superficially, but one flint flake was taken by the drill in peat 5.26 m below the surface (l. c. p. 271, 283, Pl. XIVII). The pollen spectrum from the level of this flake is seen in table 5 no. 3. It does not seem possible with certainty to fit in this spectrum and the pollen diagram which H. & M. E. Godwin give from the same peat layer in the other pollen diagrams known from SE. England, the alder very likely being much over represented especially in the upper part of the layer, but especially the great frequency of pine and the low value for the oak mixed forest point towards the boreal period[2].

Taking into consideration, however, the main features of these epipalæolithic pollen spectra, it will be easy to point out the horizons for most of them e. g. in the boreal zone of the Judy Hard diagram which again is very similar to the boreal zone of pollen diagrams from the western part of the continent, Holland[3], NW. Germany[4] etc., and it is seen that in East England also the epipalæolithic culture

[1] Grahame Clark, in collaboration with H. & M. E. Godwin and W. A. E. Macfadyen, Report on an early Bronze age site in the south-eastern Fens. The Antiquaries Journal. XIII, Nr. 2, London 1933.

[2] From Marsden moors in the southern Pennines T. W. Woodhead further describes two Tardenois flint workshops lying in sand below Atlantic peat. In the sand was found charcoal of birch and oak, pollen of the same species and of alder, on the surface of the sand pollen of pine. (History of the vegetation of the southern Pennines. The Journal of Ecology, Vol. XVII, 1929, p. 15 f. See also G. Erdtman, Studies in the post-arctic history of the forest of northwestern Europe. Geolog. Föreningens i Stockholm Förh. 1928, p. 131).

[3] F. Florschutz, Resultate von Untersuchungen an einigen Niederländischen Mooren. Mededeelingen van het botanisch Museum en Herbarium van de Rijks Universiteit te Utrecht. Amsterdam 1932. Especially the pollen diagram of Soesterveen.

[4] F. Overbeck & H. Schmitz, Zur Geschichte der Moore, Marchen und Wälder Nordwestdeutschlands. I. Mitteil. d. Provinzialstelle f. Naturdenkmalpflege Hannover. 1931.

Table 5. Boreal pollen spectra from East England and from moorlog samples from the North Sea. H. & M. E. GODWIN and G. ERDTMAN.

No.	Site	*Salix*	*Betula*	*Pinus*	Oak mixed forest				*Alnus*	*Corylus*
					Ulmus	*Quercus*	*Tilia*	Sum		
1	Skipsea	+	ca. 43	10	ca. 32	ca. 15	..	ca. 47	..	200
2	Broxbourne	..	ca. 1	ca. 68	ca. 21	ca. 9	..	ca. 30	..	ca. 103
3	Plantation Farm	..	5	73	3	2	3	8	14	29
4	The Leman % the Ower Banks, — 36 m.....	..	16	64	..	17	..	17	..	80
5	—	..	12	74	2	12	..	14	..	47
6	—	(+)	13	85	..	1,4	..	1,4	..	81
7	—	..	43	57	..	..	..	..	..	39
8	The Dogger Bank — 40 m.	..	52	46	1	1	..	..	..	20
9	— — 50 -	..	21	71	..	..	..	..	..	4
10	— — 41 -	..	16	84	..	..	..	..	..	8
11	— — 32 -	..	15	85	..	..	..	..	..	..

has been contemporaneous with the hazel maximum and the transition stage between the pine forest and the oak-mixed forest.

Remarks on the Map fig. 8.

Our knowledge of the distribution of land and water in the Baltic, Cattegat and Skager Rack in boreal time, as shown on the map fig. 8, is principally due to Swedish investigations[1], while the probable southern coast line of the North Sea is drawn with due regard to the submerged peat-covered areas in the southern part of this sea as

[1] H. MUNTHE, Studier över Ancylussjöens avlopp. Sveriges geolog. Undersökning. Ser. C. No. 346. Stockholm 1927. Tavl. 4. English Summary. L. v. POST, Svea, Göta och Dana Älvar. Ymer. Stockholm 1929. Fig. 13.

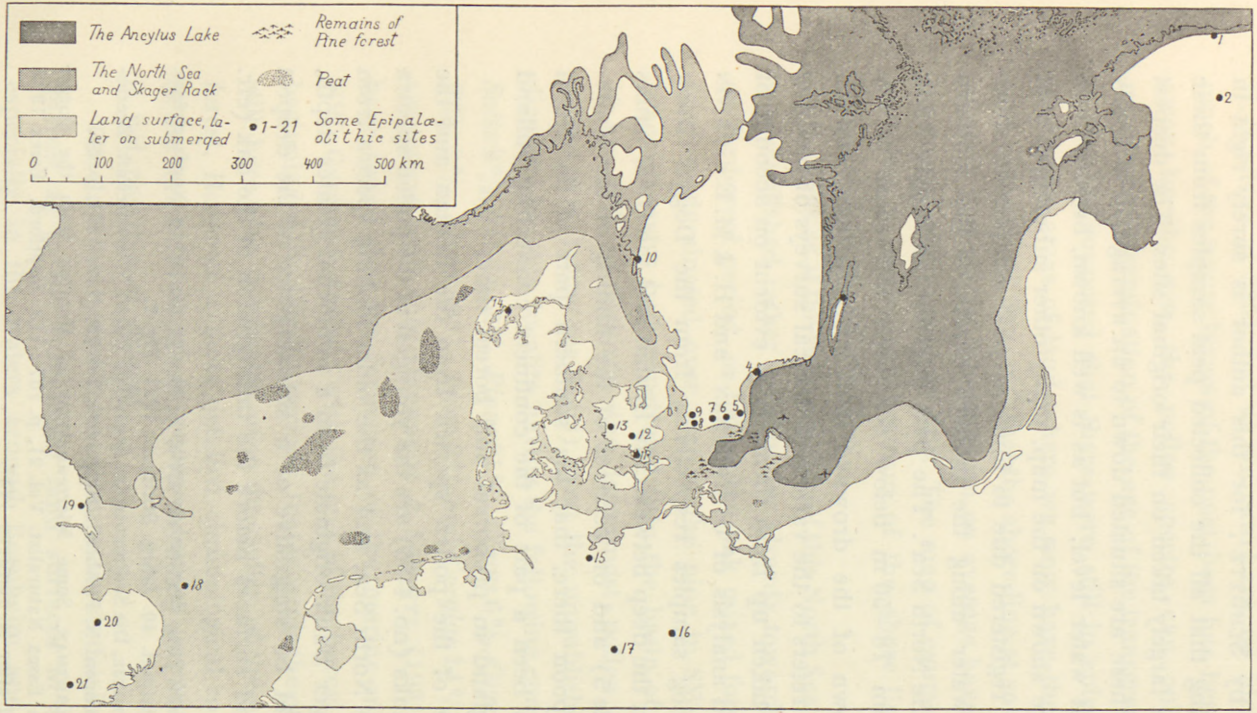

Fig. 8. Land and water in Northern Europe in boreal time. The coast line of the Ancylus Lake, in its oldest stage, and the Cattegat and the Skager Rack after MUNTHE 1927 and L. v. POST 1929. In the North Sea the coast line follows on an average the recent — 50 m contour line. The most important occurrences of submerged peat bogs and pine forest-remains are drawn in, for the North Sea after H. SCHÜTTE 1927, in the Baltic partly after O. ISBERG 1927, K. A. GRÖNWALL 1928 and O. PRATJE 1934. Cfr. the text, p. 58.

The most important localities mentioned in the text, except Federseeried: 1 Kunda, 2 Embachtal, 3 Öj Bog, 4 Lister, 5 Dode, 6 Bussjö, 7 Hylteberga, 8 Åmossen, 9 Bare, 10 Sandarna, 11 Lundby and Sværdborg Bogs, 12 Holmegaard, 13 Mullerup, 14 Sejerslev, 15 Duvensee, 16 Friesack, 17 Calbe, 18 The Leman and the Ower banks, 19 Skipsea, 20 Plantation Farm, 21 Broxbourne.

mapped by SCHÜTTE[1], for this author is surely right in maintaining that all the collected peat samples from these areas are largely taken on their original sites. The deepest lying of these are situated down to an average 50 m below the recent water level, but as is well known, besides those which are shown on the map, many other submerged peat bogs are registered due to finds of peat samples in more shallow water along the modern coasts of the southern part of the North Sea[2]. The peat bogs on the Dogger Bank lying from 18—50 m below sea level are some of the best known of the drowned land surfaces here, and H. SCHÜTTE refers to the various botanical surveys of moorlog samples taken up from them. It is evident on account of the pollen analysis of G. ERDTMAN[3] and H. & M. E. GODWIN of moorlog samples respectively from the Dogger Bank and from the deep between the Leman and the Ower banks (cfr. table 5) and on account of the finding of the Mullerup harpoon there, that the southern part of the North Sea, has been a part of the continent connecting Jutland and England in preboreal and boreal time.

Some of the pollen spectra from the Leman and the Ower banks (no. 4—6) are the youngest of the pollen spectra from the North Sea, and as the older looking spectra from the Dogger Bank originate from a somewhat greater depth, this could be suggestive of a submergence of the deepest lying land surfaces before the immigration of the oak (cfr.

[1] H. SCHÜTTE, Krustenbewegungen an der deutschen Nordseeküste. Aus der Heimat. 40. Jahrg. Stuttgart 1927. Fig. 2.

[2] O. PRATJE, Die Sedimente der deutschen Bucht. Wissenschaft. Meeresuntersuchungen. N. F. Abteil. Helgoland. Bd. 18, H. 2, 1931, p. 86.

[3] G. ERDTMAN, Some Micro-analyses of Moorlog from the Dogger Bank. The Essex Naturalist. Vol. 21, p. 107—112. Stratford, Essex 1925. Here cited after H. SCHÜTTE 1927.

H. SCHÜTTE p. 335), but as we can have no idea of how much of the upper layers of the peat bogs has been washed away by the sea, the pollen spectra can only give a maximum determination of the age of the transgression. But it may be supposed that there were still in epipalæolithic time great areas of land where we now have the southern part of the North Sea, and that the shore line at some period of early post-glacial time may on an average have followed the recent —50 m contour line. The map of course does not postulate a precise synchronism of the shore lines in the Baltic and in the North Sea.

It seems as if the submergence of this North Sea continent was etablished rather quickly, for already towards the end of the boreal period, or before the oak mixed forest pollen produce dominated over that of the pine in SW. Jutland, brackish water had penetrated into the basin of Fil Lake 30 km NW of Esbjerg, the lowermost pollen spectrum (about 6 m below sea level) from the unpublished pollen diagram for this locality having the following composition: *Salix* 2 %, *Betula* 12 %, *Pinus* 31 %, *Ulmus* 6 %, *Quercus* 14 %, *Tilia* 2 %, *Alnus* 30 %, *Picea* 2 % and *Corylus* 14 %. In good agreement with this OVERBECK & SCHMITZ (1931 p. 166) have found that the formation of the marine marshes in NW. Germany started "with the end of the boreal or in the beginning of the Atlantic period", that is, while the pine pollen still here also dominated over the pollen of the oak mixed forest. However a more detailed chronological comparison of the forest development in NW. Germany and SW. Jutland is not possible at present.

The last few years have given several details of great interest as to the submerged land surfaces in the Baltic especially in the waters around Bornholm and between

Scania and Rügen, cfr. O. Isberg, K. A. Grönwall and O. Pratje[1]. In addition I can submit some details relative to some new localities for submerged land surfaces here, which H. C. Terslin, teacher in Gilleleje, Sealand, has been kind enough to give me through The Geological Survey of Denmark. The observations are due to fishermen who have worked for many years in the Baltic.

1) North of Rügen rooted pine stumps and loose lying wood remains are found within a rather irregular area between 54°43′—54°52′ N and 12°55′—13°29′ E in about 22—40 m of water; the western part of the area, where the stumps are standing very close together and have up to 2.3 m long stems, is called by the fishermen "the forest" (Skoven). The bottom here consists mainly of fine sand.

2) Between Scania and the northern end of Bornholm 55°15′—55°20′ N and 14°19′—14°32′ E rooted stumps are met with in about 37—48 m of water.

3) Besides these submerged land surfaces not previously mentioned the Gilleleje-fishermen also know the long since recorded occurrence of remains of pine on the range from south of Bornholm towards Adler Grund, but our informers, as distinct from earlier statements, speak only of loose lying remains of trees from this part.

Besides the pollen spectra published by O. Isberg from submarine peat samples off Kåseberga in Scania

[1] O. Isberg, Beitrag zur Kenntnis der postarktischen Landbrücke. Geografiska Annaler. Stockholm 1927, p. 100 ff. — K. A. Grönwall, Till frågan om senglaciala och postglaciala nivåförändringar i södra Östersjöområdet. Meddelanden från Lunds Geologisk-Mineralogiska Institution. No. 34. Lund 1927, p. 27 f. Cfr. the same author in Sydsvenska Dagbladet Snällposten No. 6, 8. Jan. 1928. — O. Pratje, Der glaciale Untergrund der heutigen Sedimente im Bornholmer Becken. Zeitschrift d. Deutschen Geolog. Gesellsch. Bd. 85, 1933. Berlin 1934, p. 730 ff.

from about 37 m of water, which are discussed by L. v. Post (1928, p. 70f.) O. Pratje communicates some pollen analyses of P. W. Thomson from submarine peat samples from the southern part of the Baltic (cfr. the map) partly on Oder bank within the — 20 m contour line (*Carex* peat with *Hypnum*) partly SE of Bornholm (*Sphagnum* peat with *Eriophorum vaginatum* and wood of *Pinus*) in 59 m of water; cfr. the table.

Table 6. Pollen spectra from submerged peat in the Baltic. No. 1 from Kongedyb at Copenhagen. No. 2 the average spectrum after O. Isberg. No. 3 and 4 after P. W. Thomson.

No.	Station	*Hippophaës*	*Salix*	*Betula*	*Pinus*	*Ulmus*	*Quercus*	*Tilia*	*Alnus*	*Picea*	*Corylus*
1	Kongedyb,—13 to—15 m.	..	1	13	78	4	2	1	1	..	58
2	Kåseberga, — 37 m.....	..	2	10	68	4.5	1.5	1	11	2	16
3	SE of Bornholm, — 59 m.	..	..	4.5	95.5	..	..	..	..	..	..
4	Oder Bank, < — 20 m...	+	..	7	93	..	..	..	..	..	..

There can be no doubt that the spectra nos. 3 and 4 are the oldest of these, and supposing that the two peat samples in question really represent submerged peat bogs, the find of the eastern locality is especially of great interest. The Kåseberga pollen spectrum according to L. v. Post (1928, p. 123) most likely dates from a time shortly after the transgression maximum of the Ancylus Lake in eastern Sweden, and the two first-mentioned must be older than this, as pollen of oak, elm, alder and hazel are found in peat below the highest Ancylus wall on Gotland (L. v. Post[1]). The

[1] H. Munthe, J. E. Hede & L. v. Post 1925, p. 124.

lack of these pollen species, the dominance of pine pollen and the presense of pollen of *Hippophaës* (in spectrum 4) give these spectra a considerable similarity, apart from the lack of *Salix*, with spectra from zones IX and X in bogs from Öland (G. Lundquist 1928), as also with the preboreal part of pollen diagrams from Bornholm, and the eastern deep lying peat bog was very likely drowned by the Ancylus Lake previous to its reaching its transgression maximum in eastern Sweden. On account of the great depth at which the forest bottom between Scania and Bornholm is situated it is most likely that this too is older than the Ancylus maximum even if we have no particulars as to its age.

The submerged peat bog in Kongedyb at Copenhagen has been mentioned by K. Jessen (1920, p. 147). In 1928 The geological Survey of Denmark through the Sewerage of Copenhagen again had the opportunity of obtaining a peat sample from this bog. The peat layer, consisting partly of *Phragmites* peat, was found to be about 2 m thick, lying from 13 m to 15.25 m below sea level. The level in the bog section of the analysed peat sample is not known; of macroscopical plant remains it yielded i. a. *Alnus glutinosa* (branches), *Betula pubescens* (fruits, catkin scales), *Cornus sanguinea* (3 fruit stones), *Corylus avellana* (nuts) and *Tillia cordata* (one fruit). The pollen spectrum of the sample is given in table 6; it is of older Mullerup type, has a conspicuous resemblance to the Kåseberga spectrum, and gives further evidence that in Mullerup time there was no connection between the Baltic and the Cattegat through the Sound, as the threshold in the Sound between Amager south of Copenhagen and Malmö in Scania is about 7 m below the water level.

Discussion and Conclusions.

Without stating anything as to an absolute synchronism, the English and the Baltic epipalæolithic industries have been estimated to be of the same main type, and plant geographically all these cultures have developed in the boreal transition zone of the retreating pine forest and the expanding deciduous forest element, the hazel at the same time being very common. When further it is taken into consideration that the Dano-scanian Mullerup culture is contemporaneous with the Baltic continental facies, and that the continental period in the North Sea also was contemporaneous with the epipalæolithic culture, it is intelligible how the plantgeographical and the cultural development in the boreal period can show so striking a conformity over such widespread areas. But since this conformity on a large scale is also known so far to the south as in Würtemberg, it may further be asked whether it suggests a deeper connection and to what degree a synchronism of all these epipalæolithic cultures can be supposed, or, what will be the same thing, in what degree the boreal hazel maximum is synchronous within the area in question.

Relative to the first question certain conditions as they are known from Denmark may be of some interest and perhaps of wider bearing. In the Mullerup culture layers, just as from some of the other sites, are found numerous bones of the game which has been chased, and thanks to the zoologists Herluf Winge and Magnus Degerböl (see the cited archæological papers) it may be maintained that in Denmark a richer animal life unfolded itself on the land and in the lakes in the boreal period than is known

from earlier and later times. Several of the chasable animals most rich in meat, besides many other species, were common in that period, but are unknown previous to it, e. g. the urus, the stag, the roe-deer and the wild boar, and already in the Ertebölle period the elk and the urus were becoming rare. The special boreal climatical conditions with the rising temperature (cfr. p. 10) which to a high degree must have been determining for the composition of the vegetation now enriched with many new southern species, would also favour the immigration of many new animal species and thus create life conditions very favourable for hunters. This ensemble of the vegetation, the stock of animals and the epipalæolithic hunters, in the last resort depending on the climate, has formed as it were a kind of biocoenosis, which in northern Europe in its most clearly recognisable form has been confined to regions where the oak mixed forest has established itself, and which changed its composition and took other forms contemporaneously with the development of the Atlantic climate and with the change in vegetation which this involved.

The question of the synchronism in north western Europe of the *Corylus* maximum has been discussed by K. Rudolph (1930 p. 123ff.) who is inclined to answer it in the affirmative within the limits that the development of the culture type in question demands. As in large parts of central Europe, the hazel was undoubtedly also present in Denmark, Sweden and England (Judy Hard) in preboreal time, even though only in small quantities. The fact that the hazel curve over the whole of north western Europe, where the plant was thus an old inhabitant, suddenly shows this very strong and often actually explosion-like

oscillation, corresponding to a mass distribution of the plant (cfr. the great amounts of macroscopical remains of hazel in the same horizon), may be regarded as the reaction of the plant to supervening highly favourable conditions, and as far as these have been of a climatic nature, as to which many authors now agree, they may have acted on a large scale contemporaneously over wide areas.

Here attention may be called to ERDTMAN's interesting attempt to explain the hazel maximum as principally a reaction of the climate not to the growth of the hazel itself but to the ability of the bog surfaces and the lakes to conserve the hazel pollen in the early spring when this shrub flowers[1]. But even if this view should prove to be safe, the boreal hazel maximum, as it is registered in the pollen diagrams, is still to be understood as dependent upon climatic factors, and so in this case too it must be estimated as having regional value. In both cases, however, we lack details to enable us to ascertain how large were the territories over which the hazel maximum may be reckoned as contemporaneous. But so much is probable that within large areas there may be ascribed to the epipalæolithic cultures a contemporaneity in the same degree as the Danish Mullerup cultures are contemporaneous, i. e. materialized within a period of about a thousand years.

The greater part of the material from Denmark published in this paper was collected by me as a member of the staff

[1] G. ERDTMAN, The boreal hazel forests and the theory of pollen statistics. The Journal of Ecology. Vol. XIX, Nr. 1. Cambridge 1931, p. 158. — Compare H. GODWIN, Pollen analysis. An outline of the problems and potentialities of the method. The New Phytologist, Vol. XXXIII No. 4. 1934, p. 302.

of the Geological Survey of Denmark, and I am much obliged to the Director of this institution Dr. VICTOR MADSEN for permission to publish it here.

The greater part of the pollen analyses are carried out by Mr. H. JONASSEN owing to a subvention to me from the Carlsberg Foundation for which I here tender my best thanks.

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Færdig fra Trykkeriet den 29. Juni 1935.

Plate I.

Sections of Sværdborg Bog and Lundby Bog in the environs of the culture layers. Only parts of these are shown, cfr. text figures 2 and 5.

The situation of the sections from Sværdborg Bog is shown in text figure 2, of that from Lundby bog in text figure 5.

Explanation of the stratigraphic signs.

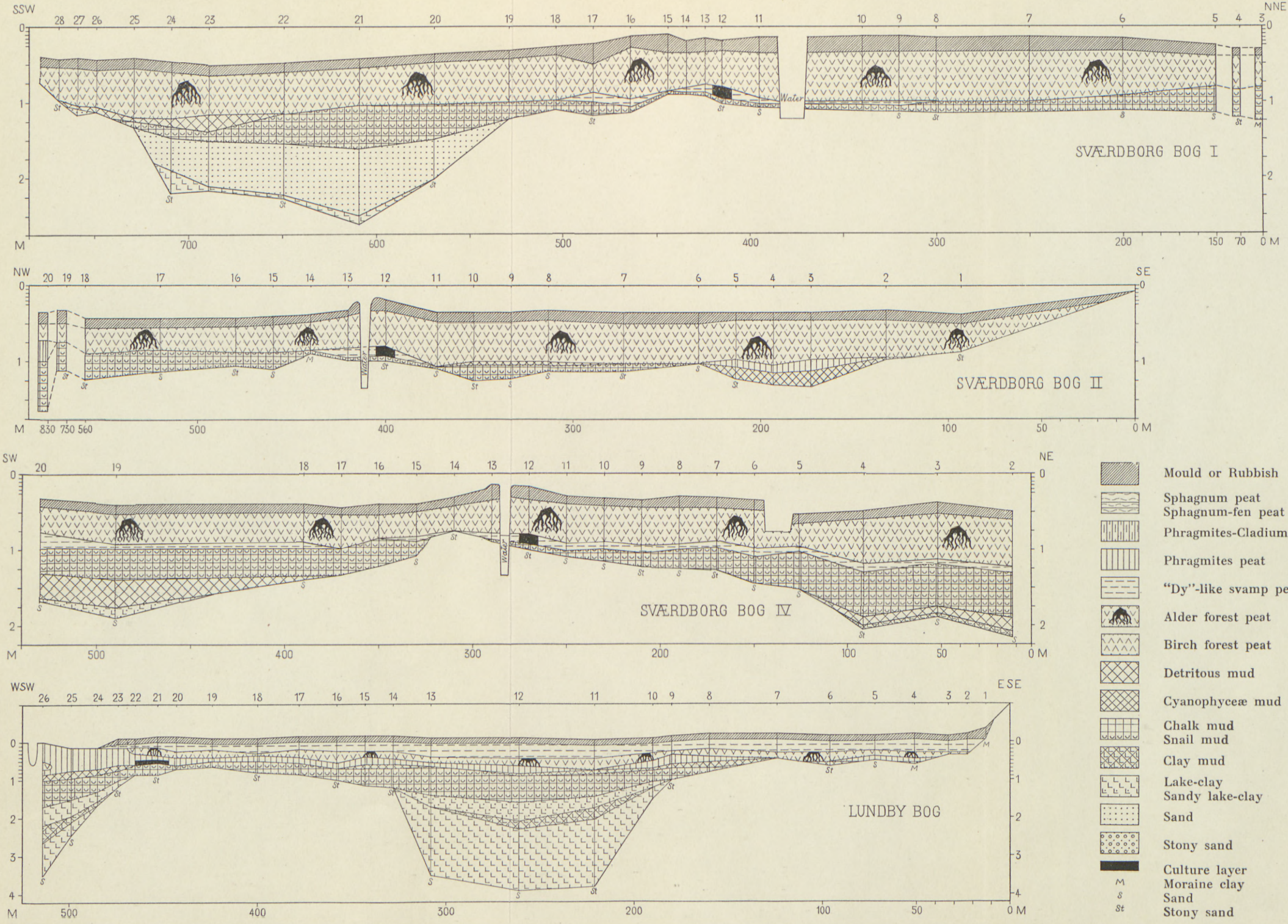

SSW
NNE
SVÆRDBORG BOG I
Water
NW
SE
SVÆRDBORG BOG II
SW
NE
SVÆRDBORG BOG IV
WSW
ESE
LUNDBY BOG
Mould or Rubbish
Sphagnum peat
Sphagnum-fen peat
Phragmites-Cladium peat
Phragmites peat
"Dy"-like svamp peat
Alder forest peat
Birch forest peat
Detritous mud
Cyanophyceæ mud
Chalk mud
Snail mud
Clay mud
Lake-clay
Sandy lake-clay
Sand
Stony sand
Culture layer
M Moraine clay
S Sand
St Stony sand

Plate II.

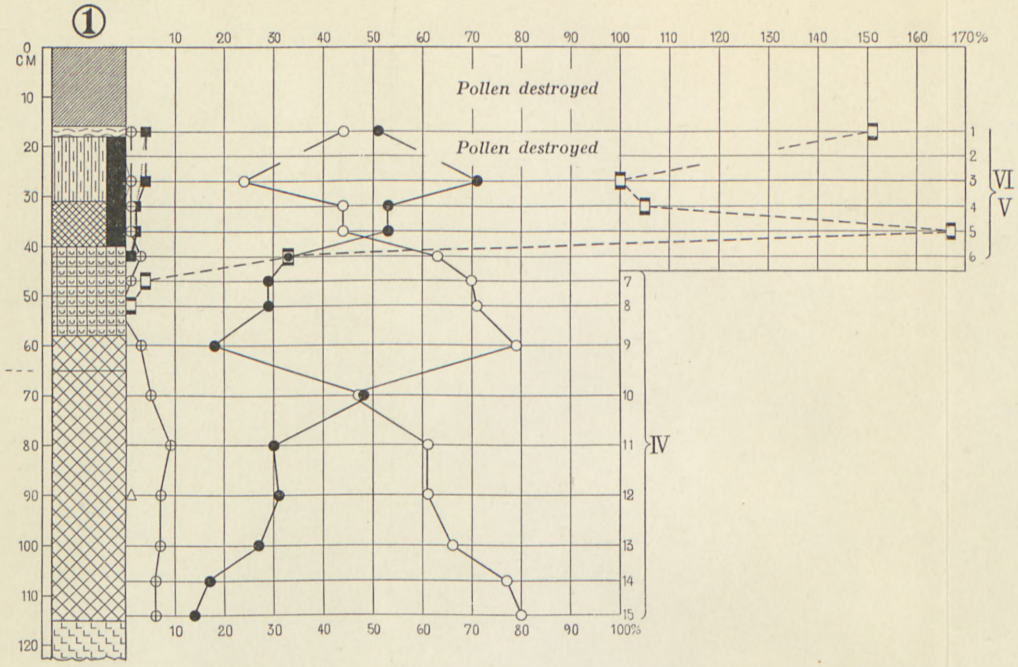
Pollen diagrams from Mullerup Bog and Holmegaard Bog.

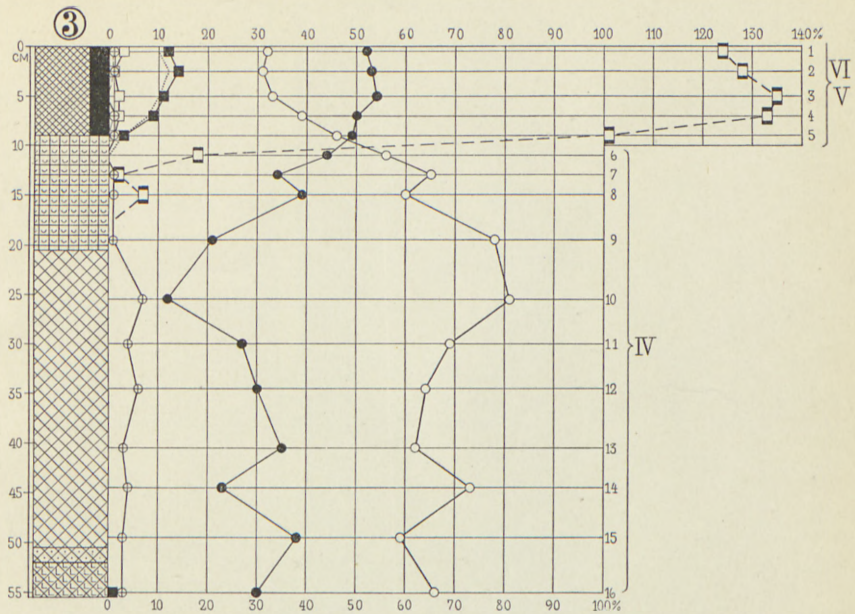
1. Mullerup Bog at Koch's Holm.
2. Mullerup Bog west of Koch's Holm at point 3 in the section, text figure 1.
3. Mullerup Bog at Sarauw's Holm.
4. Holmegaard Bog at the eastern site.

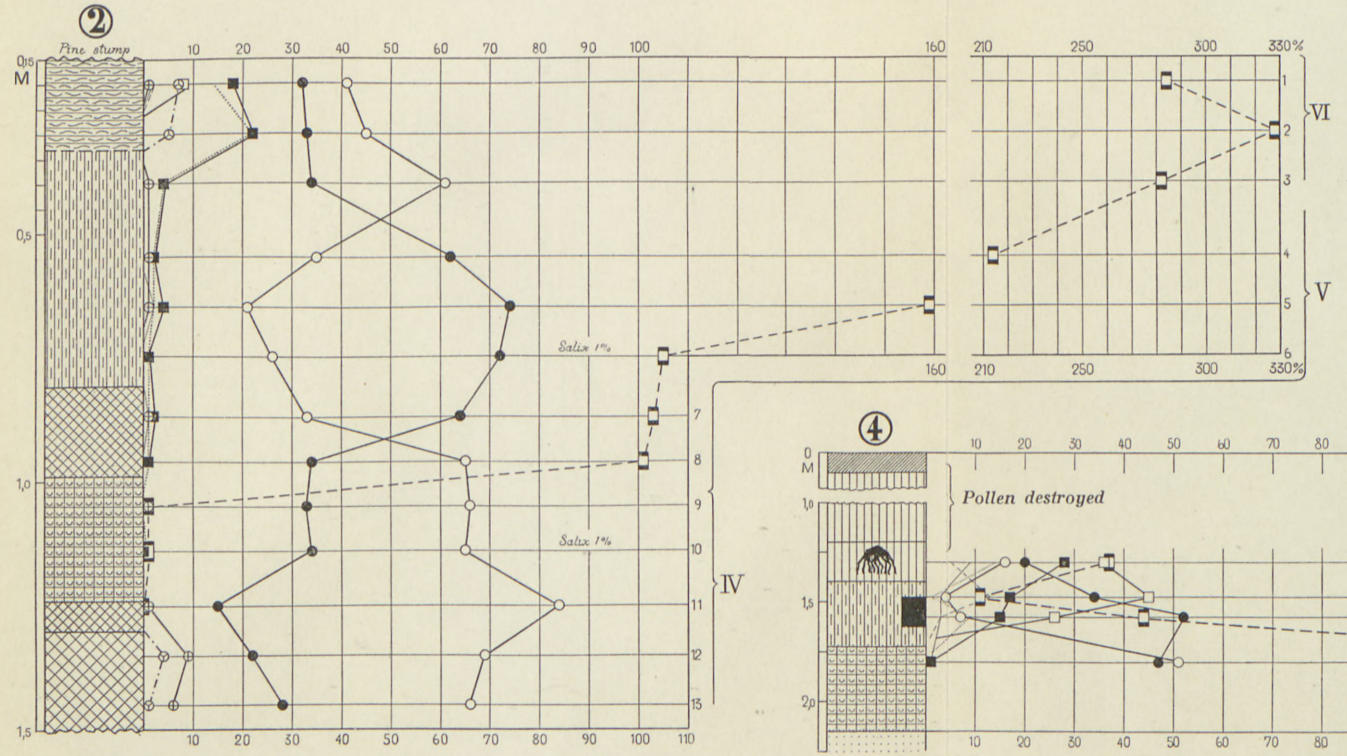
Explanation of the pollen signs.

Explanation of the stratigraphic signs on Pl. I. The black field shows the position of the culture layer in the sections.

The roman figures on the pollen diagrams on Plates II and III mark the zones, I—III representing the late glacial time (I the older Dryas period, II the Alleröd period, III the younger Dryas period), IV the præboreal period or the birch-pine period, V and VI the boreal period or the pine-hazel period (V the pine maximum, VI the hazel maximum), VII the Atlantic period (dominating oak mixed forest pollen and minimum of pine pollen). The younger zones are not represented in the pollen diagrams here published. Compare KNUD JESSEN, Archæological Dating in the History of North Jutland's Vegetation. Acta Archaeologica. København 1935.







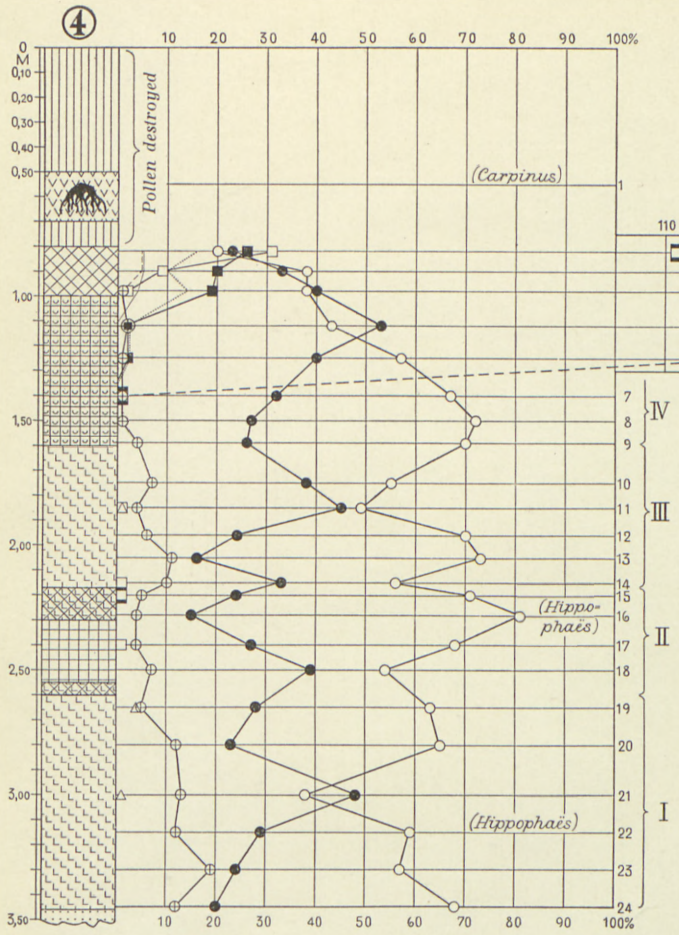
Salix
Betula
Pinus
Ulmus
Quercus
Tilia
Ulmus + Quercus + Tilia
Alnus
Carpinus
Picea
Corylus
Ericales
Empetrum

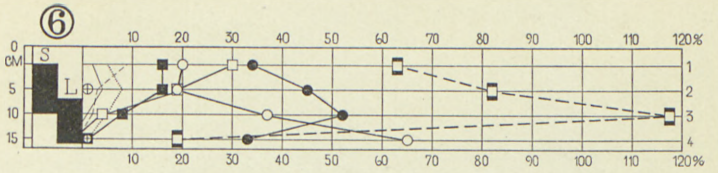
Plate III.

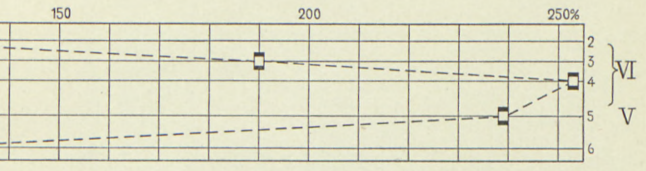
Pollen diagrams from Holmegaard Bog, Sværdborg Bog and Lundby Bog.

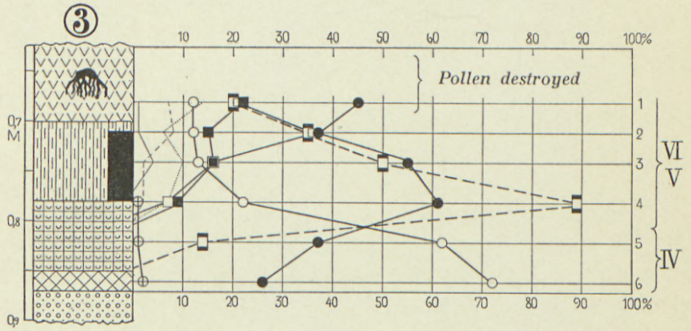
1. Holmegaard Bog at the western site, point 6 in the section of the bog (KNUD JESSEN 1926, p. 15).
2. Holmegaard Bog at the western site, point 7, 25 m SW of point 6.
3. Sværdborg Bog, section 1933.
4. Lundby Bog at point 26.
5. Lundby Bog near point 21.
6. Average pollen diagram from the culture layers in Sværdborg Bog (S) and in Lundby Bog (L).

Explanation of the stratigraphic signs on Pl. I.
The black field shows the position of the culture layer in the sections.
Explanation of the pollen signs on Pl. II.
For the Roman figures see Pl. II.


④
Pollen destroyed
(Carpinus)
(Hippo-
phaës)
(Hippophaës)
IV
III
II
I


⑥
S
L


VI
V


③
Pollen destroyed
VI
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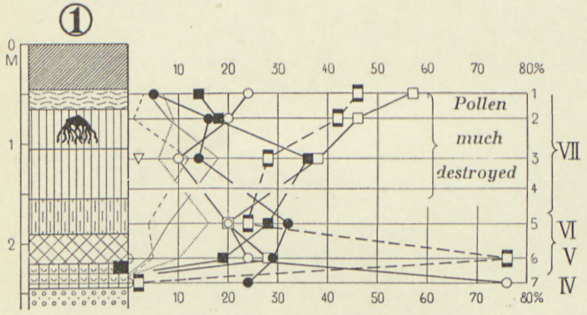
IV


①
Pollen
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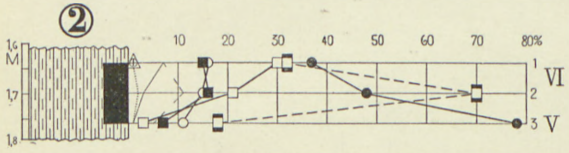
②
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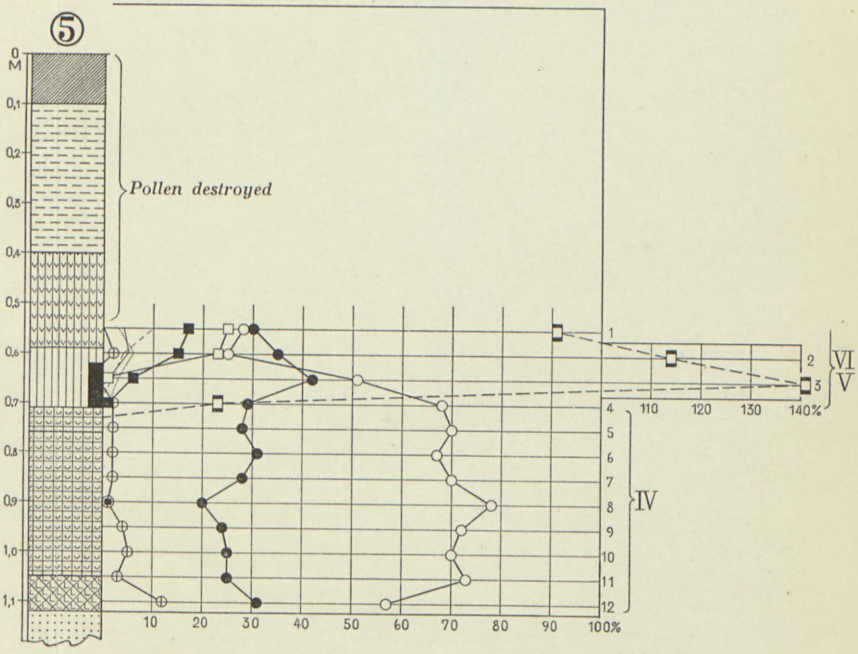
⑤
Pollen destroyed
VI
V
IV