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ERNEST MAGNUSSON

POLLEN-ANALYTICAL INVESTIGATIONS AT TÅKERN, DAGSMOSSE AND THE NEOLITHIC SETTLEMENT AT ALVASTRA, SWEDEN

STOCKHOLM 1964

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WITH ONE PLATE

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CONTENTS

Abstract: This paper presents three rather detailed pollen diagrams from Lake Tåkern, the bog Dagsmosse and the spring mire at Alvastra. The diagram from Dagsmosse covers the whole Post-glacial period. Of the Late-glacial strata only the very youngest parts are investigated. On the basis of the diagrams the Post-glacial forest development is discussed.

The prime aim of this investigation has been an attempt to elucidate the vegetational environment when the pile-dwellings in the mire at Alvastra were inhabited and to trace early cultivation in the area. The first pollen grains of cereals are recorded from the very oldest part of zone VIII, i.e. several hundred years before the settlement in the mire began.

In Dagsmosse there have been taken two series of peat samples for radiocarbon dating. The results are difficult to interpret but most likely all datings are much too low. Archaeologically the dwelling-place at Alvastra has been dated to the Middle Neolithic period (c. 2300—1800 B.C.) but according to the radiocarbon datings it existed between c. 1100—1200 and c. 2000—2100 B.C. An attempt to date the dwelling-place by means of the recurrence-surfaces in Dagsmosse has also been made. According to these the settlement is to be placed within the period between 1800—1900 and 2500—2600 B. C.

STOCKHOLM 1964

KUNGL. BOKTRYCKERIET P. A. NORSTEDT & SÖNER

Introduction

The Neolithic pile-dwelling at Alvastra was, during the years 1909—1919 and 1928—1930 the subject of extensive archaeological excavations, when a considerable part of the platform of logs on which the site rested was uncovered.

Of the rich material from these investigations only the results of the fieldwork during the first year have been preliminarily described by O. Frödin (1910).

Already at the time of the discovery of the site in 1908 L. von Post had been making extensive investigations of the stratigraphy and the evolution of the bog Dagsmosse. The Neolithic site is situated in the southwestern part of the Dagsmosse mire complex and naturally he extended his investigations and concentrated much of his interest to this part. The results were published in two papers (von Post 1913 and 1916).

In 1956 a working up of all the archaeological material from the previous excavations of the Alvastra Neolithic site was planned. In connection with this the task of making a pollen-analytical investigation of some sample series from the area was assigned to the present author. The prime aim of this investigation was to illustrate the vegetational environment when the pile-dwellings were inhabited, and the Post-glacial development of the vegetation and the traces of early cultivation in the area.

Grants have been made from Statens Humanistiska Forskningsråd for field and laboratory work.

The laboratory work was carried out for the most part in 1957 at the Institution for Quaternary Geology at the University of Lund were Dr. Tage Nilsson, demonstrator and head of the Institution, kindly supplied working space and microscopes for this investigation. I am indebted to him for help and discussion.

For unremitting work at their microscopes I wish to express my gratitude to Mrs Mimi Varga who has made most of the analyses from Dagsmosse, and Mrs Marianne Teeling who has taken part in the investigation of the samples from Lake Tåkern. I am also grateful to Mrs Birgit Lindeberg for her careful drawing of the diagrams.

General geographical and geological survey

The sites investigated, Lake Tåkern and the mire south-west of the lake, called Dagsmosse, are located near Mount Omberg in the western part of the plain of Östergötland, E. Sweden. The mire of Dagsmosse is a complex one and it consists of two raised bogs, one of which is rather small. There are also laggs and fens which constitute considerable areas especially in the eastern part. The southwestern part of the mire is complex and contains natural springs and is thus different from the rest of the mire. It is, according to von Post, called the spring mire of Alvastra (*Alvastra källmosse*). The complex as a whole constitutes

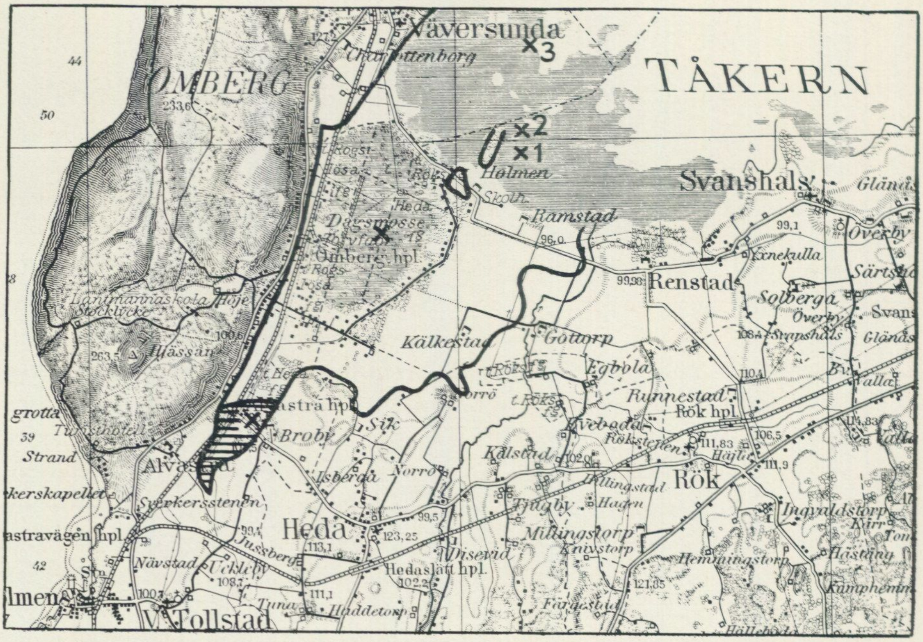


Fig. 1. Map showing the location of the investigation area and the boundaries of the mire complex (according to von Post 1916). The bog Dagsmosse with surrounding fen areas is limited by the heavy line. The Alvastra spring mire is shaded. Of the three borings in Lake Tåkern only no. 2 is described in this paper. Scale 1: 100000. — För spridning godkänd i rikets allmänna kartverk den 5 oktober 1964.

a fourth of the whole Tåkern basin and reaches westwards as far as the foot of Mount Omberg.

During the years 1832—1844 the level of Lake Tåkern was lowered about 1.7 m. after which the mean water-level has been 93.7 m. above sea level. The lake has its outflow through the stream Mjölnaån, which runs towards the north and discharges its water into Lake Vättern near the small town of Vadstena.

Several streams supply Lake Tåkern with water from the precipitation area which is estimated to be about 380 km^2 and of which the area of Lake Tåkern itself amounts to about 44 km^2. (Melin 1928, p. 27). The more important streams come from areas with Archaean bed-rock in the south. The mire Dagsmosse is now only partly drained to Lake Tåkern. The principal outflow is towards the south-west, directly into Lake Vättern.

The triangular area between Lake Vättern and Lake Roxen which forms the plain of Östergötland is underlain by a Cambro-Silurian sequence, the preservation of which is due to faults north and west of the plain. The sub-Cambrian peneplain within an area between the lakes Vättern and Roxen descends to about 90 m. below sea level (Thorslund 1960, p. 85). The Cambro-Silurian sequence dips mainly towards the north except closest to the northern fault line where it dips steeply towards the south. The southern limit between the Cambro-Silurian and the Precambrian rocks is near the southern shore of Lake Tåkern and has the direction WSW—ENE. The southern part of the lake is thus underlain by Cambrian sandstone and the northern and greater part by alum shales (Rosén 1922, Fig. 8).

The main soils of this plain are clay and boulder-clay which together cover about 45 per cent of the area while areas covered by glacial till of other types than boulder-clay constitute about 20 per cent (Lundqvist 1958, p. 62). The boulder-clay is almost always calcareous. The $CaCO_3$-content may amount to nearly 20 per cent but varies over wide ranges (Blomberg 1905, p. 25). On the contrary, the $CaCO_3$-content of the glacial varved clays is low, especially in the upper layers, and in the lower layers it amounts to only a few per cent (Blomberg 1905, p. 36).

The distribution of boulder-clay lies farther south and south-east than the Cambro-Silurian rocks, which is, of course, due to transportation during the Ice Age. Thus, the whole complex mire system of Dagsmosse lies within the boulder-clay area. The mire is, however, partly surrounded by varved clays, i.e. in the east and south-east. The $CaCO_3$-content of the boulder-clay has formed an important edaphic factor especially during the oldest stages in the development of the Tåkern basin and even more for the development of the spring mire at Alvastra.

Material and method of investigation

As a consequence of von Post's exhaustive stratigraphical investigations of both the bog Dagsmosse and the spring mire at Alvastra it has not seemed necessary to make new sections through the mires. Instead von Post's section through Dagsmosse (1913, Fig. 1) and his sections through the spring mire (1916, Pl. X) have been used as guides when siting borings in order to take samples for pollen analysis. Concerning Dagsmosse a profile with a sequence as complete as possible was sought for. The boring was also placed where the gyttja was thick and brushwood peat could be expected to be lacking. In the spring mire the boring was made as near the Neolithic site as possible but outside the previously excavated area so eliminating the risk of sampling disturbed peat.

It was clear when this investigation began, that interpretation of the pollen diagram from the settlement area would most probably be difficult without other diagrams from the neighbourhood for comparison. As the pollen diagram from the sequence of mainly peat in the bog Dagsmosse could be affected by local disturbances, the best chance of obtaining material for a standard pollen diagram representative of the area seemed to be in Lake Tåkern. For that purpose three borings were carried out in the southwestern part of the lake outside Holmsör, a small headland consisting of glacial till. One of these sample series was unsuitable because the sequence was too short. Besides the profile to be described another profile was partly investigated from a boring about 1200 m. NNE of Holmsör. Probably as a result of a slow sedimentation rate the diagram of this profile is very compressed and for this reason is not very suitable as a standard pollen diagram.

In all profiles samples were taken at intervals of 5 cm. The gyttja and peat samples have been treated according to the acetolysis method (G. & H. Erdtman 1933; G. Erdtman 1934 and 1960) in order to concentrate the pollen and spores. Oxidation with $NaClO_3$ has, however, been avoided in the sample series from Lake Tåkern and in the samples of the Dagsmosse series consisting of gyttja, as in these cases it was possible to get a rather good concentration without oxidation. The reason for avoiding oxidation when possible is the danger of damaging the pollen walls, especially in pollen types with a thin ectexine (cf. Fægri & Iversen 1950, p. 63). Most of the samples from Dagsmosse have nevertheless been oxidized in order to obtain a sufficient concentration. The acetolysis method has also been modified in some other minor respects.

The samples with a high content of silt have been treated with hydrogen fluoride in the usual manner (Assarsson and Granlund 1924).

In every separate analysis from Lake Tåkern and the bog about 1200—1400 tree pollen grains have been counted except in those cases when the pollen was not sufficiently abundant to obtain such numbers of pollen grains, e.g. in some samples consisting of fresh *Sphagnum* peat in the uppermost portion of the bog from which the material collected was not enough. The reason for counting such a rather large number of grains in the analyses was to obtain also a tolerably good statistical reliability for some of those vegetational components which have only low frequencies, and to increase the possibility of connecting the different diagrams with each other with the greatest possible accuracy. In order to fulfil these aims it was necessary to count at least the numbers mentioned. According to Fægri (1947, p. 64) one has to count at least 1000 pollen grains, if a vegetational component constituting one per cent of the pollen flora in a sample is to be indicated with certainty. In practice tree pollen dominates the pollen flora, and the number of tree pollen grains must be the determining factor for the counts. Among pollen types usually occurring at low frequencies those indicating cultivation are often of special interest. But because of the location of this area reliable values for the tree pollen are also of importance as the pollen of some trees occurring here is rare throughout the sequences, or periodic.

The pollen diagrams are drawn as simple as possible in order to make them easily readable. The left part of every diagram is a tree pollen diagram of the classical type. The tree pollen sum comprises the pollen of all trees and willows. Other bushes, such as *Corylus* and *Hippophaë,* are excluded from the base sum. The reason for calculating *Corylus* as a percentage of the tree pollen sum (though *Corylus* is not part of this sum) is principally the desire to maintain comparability with other diagrams. In almost all diagrams from pollen investigations in Sweden up to now *Corylus* has been excluded as was the case in the first analyses published by von Post. Whether one includes *Hippophaë* and other bushes or not is of minor importance in this case because they have only very low frequencies.

The herb pollen has been divided into two groups: NAP in a restricted sense, i.e. the pollen of mainly terrestrial plants, and AqP, the pollen of mainly aquatic plants. The different pollen types have been calculated individually as percentages of the tree pollen sum. Calculation of NAP on the AP sum and the number of pollen grains of the NAP respectively, is now rather usual (Andersen 1954, Fries 1958, Helmfrid 1958), but has not been done here. The method may be of a certain importance when illustrating the vegetational changes in an open landscape as it levels the pollen curves but does not increase the statistical reliability, as suggested by Helmfrid (1958, p. 249). The reliability is only due to the number of pollen grains counted in the analyses.

The zoning of the diagrams follows the Danish system (Jessen 1935, 1938) which has been used earlier in Sweden, mainly in diagrams from the southwestern part of the country (Fries 1951, 1958).

Profiles and pollen diagrams

LAKE TÅKERN

All the Post-glacial samples have been analysed from one of the three profiles bored in Lake Tåkern, but only a few of the Late-glacial samples. This boring, called BP 2, is situated about 300 m. east of the outermost part of the headland Holmsör (see Fig. 1). The vegetation around this boring point is a little area of sedge fen dominated by *Carex rostrata* and *Equiseum fluviatile:* other plants include *Scirpus lacustris* and *Ranunculus lingua.* This little sedge fen is surrounded by a dense vegetation of common reeds which is the most typical plant for Lake Tåkern today. The ground surface was 93.8 m. above sea level. Levelling started from a fixed point at the farm Holmen.

The sequence of BP 1, situated about 300 m. south of BP 2, was only 1.69 m. thick and there probably Post-glacial layers rested directly on boulder-clay. From this boring no samples have been investigated.

Another boring (BP 3) was made from two small boats near the farthest tufts of reeds, about 1200 m. NNE of Holmsör. The water depth was 25 cm. at this point. Most of the Post-glacial samples from this boring have been investigated and the diagram shows a rather good agreement with the diagram for BP 2, except that the middle part is more compressed. Instead, the uppermost portion is a little thicker most probably as a result of continued sedimentation into recent time. Zone IX is here 60 cm. thick as against 43 cm. in BP 2. At BP 2 possibly the youngest lake sediments were eroded when the lake was lowered.

The stratigraphy of BP 2 is as follows:

0— 82 cm.	clayey detritus mud (= gyttja) — clay-mud, grey, in the upper portion rich in roots of *Carex* and other plants
82—138 cm.	fine detritus mud, clayey, brownish green and often a little elastic; with a few remains of *Equisetum* roots
138—169 cm.	algal mud, greenish brown, rather elastic, with roots of *Equisetum* and in the lowermost part one seed of *Najas*
169—191 cm.	calcareous mud, brownish green; with one specimen of *Pisidium* and several undeterminable shell fragments
191—214 cm.	lake marl, greenish to yellowish grey
214—247 cm.	muddy clay, greenish grey, calcareous
247—258 cm.	clay-mud, brownish grey, calcareous
258—274 cm.	muddy clay, grey, calcareous
274—281 cm.	clay, bluish grey, calcareous and with thin layers of silt
281—288 cm.	clayey coarse silt, a little calcareous
288—400 cm.	clay, reddish grey, calcareous
	boulder-clay

The samples have been treated for pollen analysis by the methods mentioned above and for analysis of other microfossils only by boiling in NaOH. By doing so the field observations have been partly controlled and complemented.

The clayey mud at the top contains few determinable remains. Most common are green algæ of the genus *Pediastrum*. In most samples *P. boryanum* dominates. In some samples the *Pediastra* are dominated by *P. kawraiskyi*. Other species occurring are *P. duplex* and *P. muticum*.

The frequency of diatoms is low in the uppermost samples but increases further down.

Remains of *Cladocera* occur in practically all samples. Especially common are antennæ of *Bosmina* sp. Other remains of *Cladocera* are antennæ and abdomens of *Sida crystallina, Eurycercus lamellatus* and cf. *Alona*.

In the fine detritus mud diatoms are the most usual fossils and this is the case especially in the lower part of this mud. In one of the general diatom analyses the distribution among the different types is shown by Tab. I. The nomenclature follows that of Cleve-Euler (1951—1955).

Colonies of *Pediastrum* occur rather abundantly in the fine detritus mud. In most samples *Pediastrum kawraiskyi* dominates and *P. boryanum* and *P. duplex* occur regularly, while occurrences of *P. muticum* and *P. integrum,* and *P. clathratum* are more sporadic. Algal species of the genera *Cosmarium, Staurastrum,* and *Scenedesmus* occur in low frequencies.

Remains of higher plants are rare and consist of fragments of bark and wood of deciduous trees, hairs of *Nymphaeaceae,* hair bases of *Nymphaea* and *Nuphar* etc.

In this layer remains of *Cladocera* are not common but in some samples antennae of *Bosmina* sp. are recorded.

Tab. I. Diatom analysis from 1.25 m. depth in Lake Tåkern (255 frustules counted)

	Per cent
Campylodiscus hibernicus v. *hungaricus*	0.4
Cyclotella comta v. *genuina*	15.7
Cymatopleura solea	0.8
Cymbella aequalis	0.4
C. caespitosa	0.4
C. ehrenbergii	1.2
C. lacustris	0.8
C. microcephala	0.4
C. sp.	0.4
Epithemia hyndmanii	1.2
E. zebra	2.4
Fragilaria brevistriata	2.7
F. cf. *capucina*	0.8
F. construens	5.9
Gomphonema acuminatum (v. *coronatum*)	5.5
G. angustatum (v. *genuinum*)	3.1
Gyrosigma acuminatum	1.6
Melosira granulata	32.8
Navicula cryptocephala	3.9
N. gastrum	0.8
N. viridula	0.8
N. sp.	0.4
Nitzschia linearis v. *genuina*	1.6
Pinnularia viridis	0.8
P. sp.	0.8
Stauroneis phoenicentron	0.4
Stephanodiscus astraea	3.1
Surirella elegans v. *norvegica*	0.4
Synedra acus v. *mesoleia*	2.4
S. ulna v. *genuina*	0.4
Tabellaria fenestrata	0.8
Undetermined	7.0
	99.9

Spicules of lacustrine sponge, most of which probably come from *Spongilla lacustris,* have been observed in small numbers in some samples.

In the algal mud *Pediastra* are the dominating type of algæ and they are represented by the same species as in the fine detritus mud. The frequency of diatoms is considerably lower, but other algæ, such as *Gloeocapsa, Cosmarium, Staurastrum,* and *Scenedesmus* occur abundantly. Spicules are also more common. Remains of *Cladocera* are rare. Remains of higher plants are represented by fragments of brown mosses (e.g. *Aulacomium palustre)* and peat-mosses, hairs, hair bases and epidermis of *Nymphaea,* a few epidermis fragments of *Carex* and *Phragmites* etc.

In both the calcareous mud and the lake marl algæ are rarely found. Among them *Pediastrum boryanum* and *P. integrum,* and *Staurastrum* may be mentioned. Of higher plants there occur remains of the same types as in the algal mud. In the calcareous mud spicules are considerably more common than in the other sediments of the profile.

In the underlying clayey mud only a few microfossils have been observed,

2†—*640615. SGU. Magnusson*

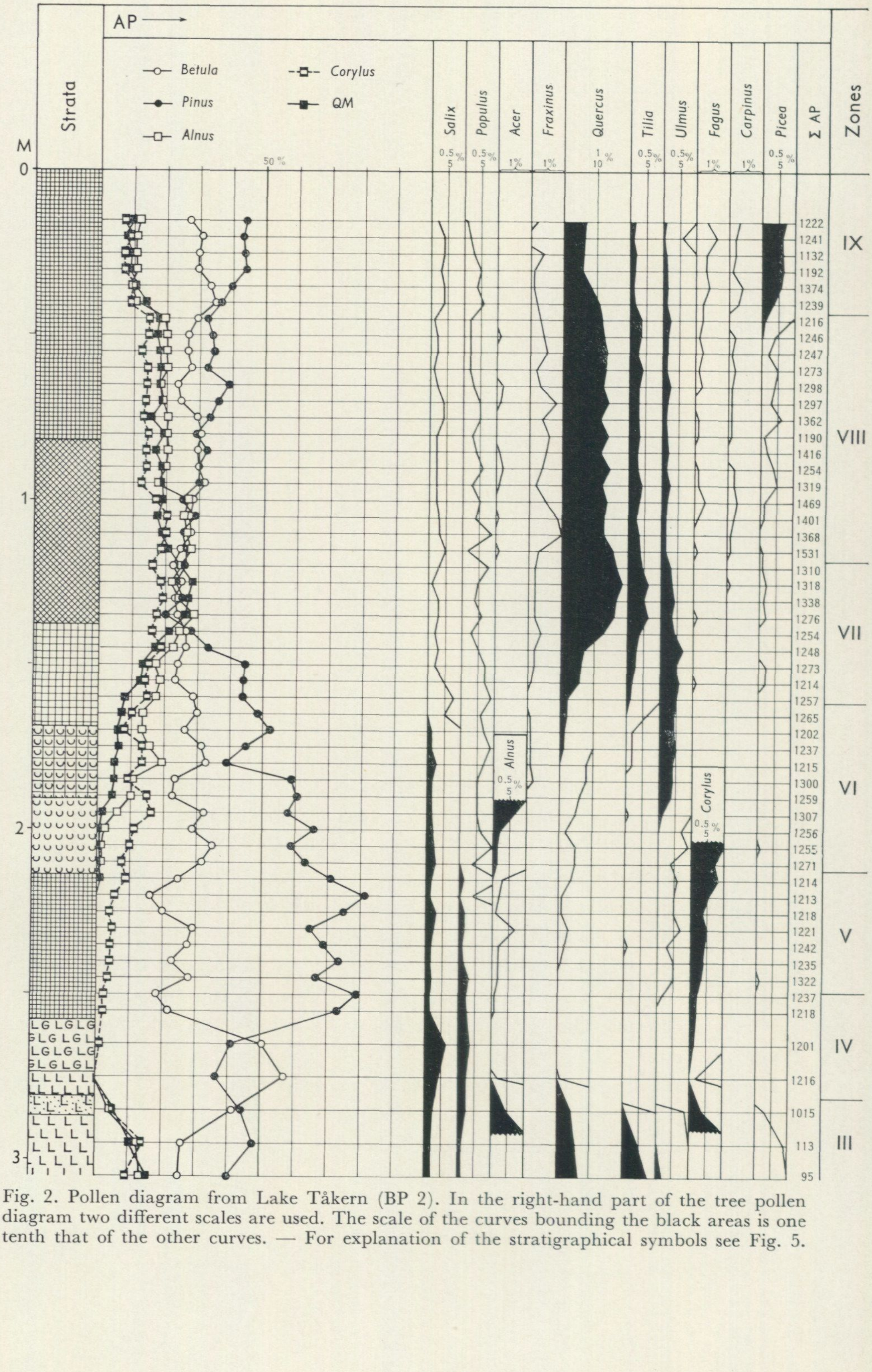
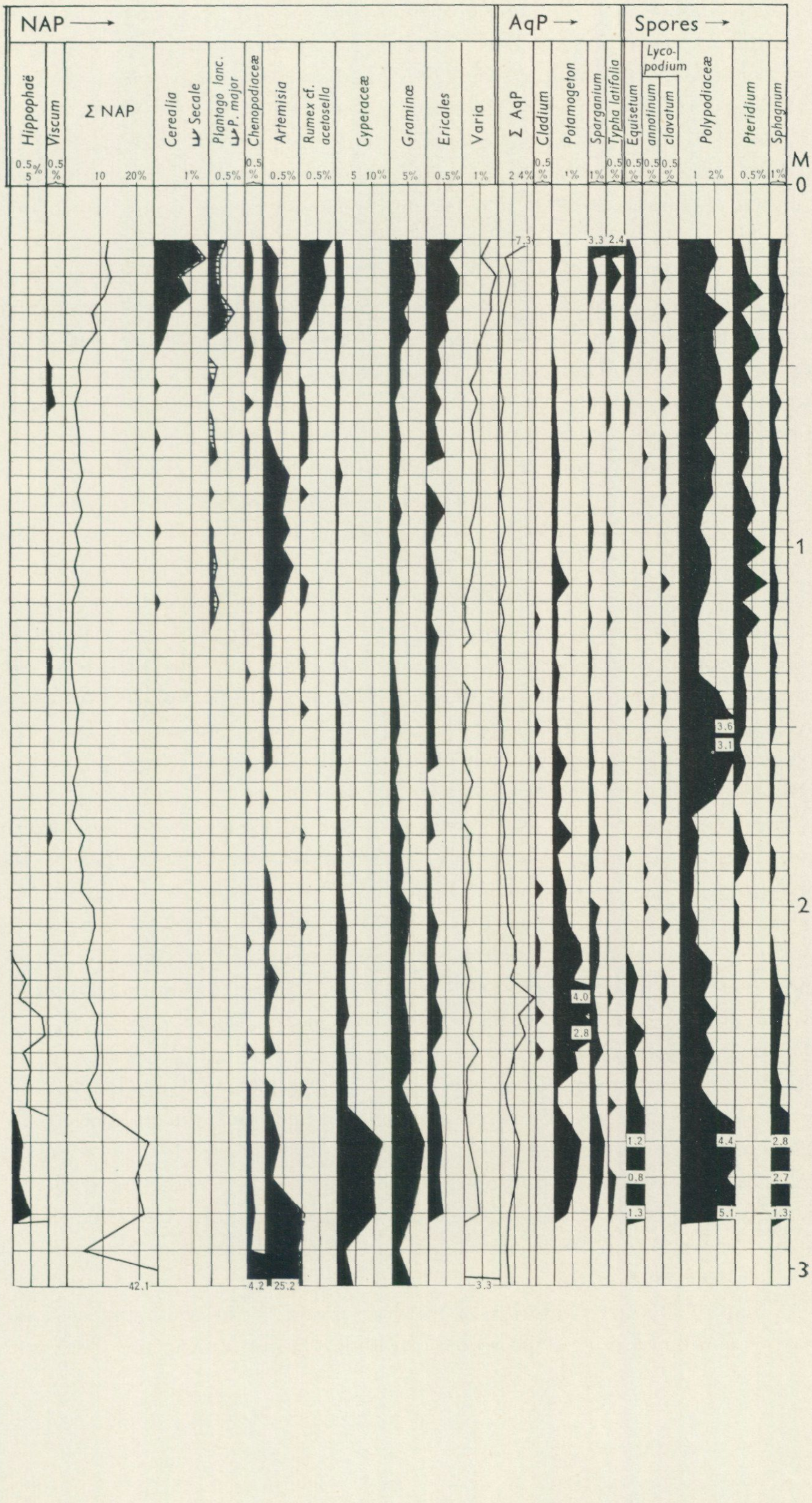


Fig. 2. Pollen diagram from Lake Tåkern (BP 2). In the right-hand part of the tree pollen diagram two different scales are used. The scale of the curves bounding the black areas is one tenth that of the other curves. — For explanation of the stratigraphical symbols see Fig. 5.


NAP
AqP
Spores
Hippophaë
Viscum
Σ NAP
Cerealia
Secale
Plantago lanc.
P. major
Chenopodiaceæ
Artemisia
Rumex cf. acetosella
Cyperaceæ
Graminæ
Ericales
Varia
Σ AqP
Cladium
Potamogeton
Sparganium
Typha latifolia
Equisetum
Lycopodium
annotinum
clavatum
Polypodiaceæ
Pteridium
Sphagnum
M
0
1
2
3
42.1
4.2
25.2
3.3
7.3
3.3
2.4
4.0
2.8
3.6
3.1
1.2
0.8
1.3
4.4
5.1
2.8
2.7
1.3

namely, algal colonies of *Pediastrum boryanum* and one of *P. kawraiskyi.* Remains of higher plants are represented by fibres of *Potamogeton* and leaf fragments of brown mosses. In the sample from 2.45 m. depth there was found one leaf spine of *Najas.* In all samples in this layer spicules have been observed. In the sample from 2.35 m. depth one specimen of the Rhizopod *Nebela collaris,* which mainly lives among *Sphagna* but is rather uncommon also in *Sphagnum* peat (Hoogenraad 1936) was found. It is the only specimen of the group Rhizopoda found in this profile from Lake Tåkern.

From the clay-mud between 2.47 m. and 2.58 m. two samples have been analysed. The microfossils in them are completely dominated by fragmentary brown moss leaves. Besides these only some fibres of *Potamogeton* and some colonies of *Pediastrum boryanum* were observed.

In the underlying muddy clay and in the purer clay sediments fragmentary brown moss leaves are also common, while other microfossils are very rare.

The pollen diagram, shown in Fig. 2, comprises zones III—IX. Late-glacial time is only represented by zone III. The area in question was not ice-free until the close of period III (younger Dryas time) which is seen by the recession line for about the year 8900 B.C. just south of Dagsmosse (Lundqvist 1961, the map). The same map also shows, that Mount Omberg was free from ice considerably earlier than the plain east of it and earlier than the basin of Lake Vättern in particular. On the highest parts of Mount Omberg the ice hade melted at the latest during early Alleröd time, as shown by Donner (1951, pp. 59—63) who has investigated two fens at about the 220 m. level on this mountain. The chronology of the Alleröd and younger Dryas periods has recently been unravelled by E. Nilsson (1960) on the basis of varve measurements.

Only the uppermost portion of the thick Late-glacial sequence of Lake Tåkern has been investigated pollen analytically. The clay deposited during period III is characterized by a very low pollen frequency. Pollen of *Pinus* dominates but there also occurs pollen of *Alnus, Quercus, Tilia,* and *Corylus.* All these types most probably occur secondarily. Herb pollen is very numerous especially in the lowermost of the analysed samples. *Artemisia* with a frequency of more than 25 per cent of the tree pollen sum characterizes this pollen flora.

In Donner's diagrams from Mount Omberg (1951, Figs. 27 and 28) the sedimentation limit at the transition between Late-glacial and Post-glacial times is very sharp. During period III clay was deposited and during period IV calcareous mud. In the plain at the foot of Mount Omberg the conditions of sedimentation were obviously different, which must be due to the proximity of the ice margin and to the fact that the area was covered by the Baltic Ice Lake. The highest shore-line in the southern part of Mount Omberg is situated 149 m. above sea level and in the northern part 154 m. above sea level (Lundqvist 1961, the map). The large addition of mineral matter in the sediments of Lake Tåkern thus continued during the whole of period IV and during the older part of it there was even deposited almost pure clay with a very low content of organic matter. The change from this clay to the clay-mud above is possibly connected with the isolation of the Tåkern basin from the Yoldia Sea, of which the highest shore-line at Alvastra is situated 109 m. above sea level (E. Nilsson 1953, Fig. 23). The highest shore-line of the Ancylus-Lake at the nearest localities, i.e. in the vicinity of Linköping, is situated about 73 m. above sea level (Munthe 1940, p. 104).

The pollen zone boundary III/IV is in the first instance placed with the guidance of the ratio between the pollen of *Betula* and *Pinus* and the considerable decrease of re-worked pollen. The curve for *Artemisia* also shows a marked decline.

The zone boundary IV/V is more difficult to place unmistakably because of the slow rise of the *Corylus* curve. The cause of this slow increase of the frequency of the *Corylus* pollen may be, at least partly, that re-worked *Corylus* pollen to a certain degree is still making its impression in the pollen spectra. The zone boarder, however, has been placed where the hazel pollen curve makes a little knick at the same point as the beginning of the continuous curve for *Ulmus*. The frequencies of the pollen of *Graminae* and *Cyperaceae* are also obviously decreasing.

The hazel pollen during period V never reaches a frequency of more than 10 per cent. The pollen flora is strongly dominated by *Pinus* pollen with values of more than 80 per cent. Pollen grains of *Hippophaë* continue to occur throughout the whole zone but in lower frequencies than in the preceding zone.

The zone boundary V/VI is characterized by the marked rise of the alder pollen curve. At first it rises very slowly but a little below the middle of the zone the frequency of alder pollen increases abruptly to 10 per cent and just above to nearly 20 per cent. The marked rise of the elm pollen curve occurs in the lower part of the zone and that of the oak pollen curve in the upper part.

The zone boundary VI/VII, which corresponds to the marked rise of the lime pollen curve, is easily recognizable.

Zone VII is here especially distinguished by the strong preponderance of the oak pollen over the pollen of all other components of the mixed oak forest. The QM curve reaches its Post-glacial maximum of about 28 per cent in the upper part of the zone. Other characteristic features of zone VII are the decline of the pine curve from the very high values in the preceding zones and that ash pollen occurs in a continuous curve almost from the boundary with the preceding zone.

The zone boundary VII/VIII at the marked *Ulmus* decline between Atlantic and Subboreal times is distinct. Also the oak and lime curves fall from the high levels immediately below the zone boundary. At or only a little above this boundary pollen grains of *Picea, Fagus,* and *Carpinus* begin to occur rather regularly though with low frequencies.

During period VIII the *Pinus* curve rises and from about the middle of the

Tab. II. Pollen and spore types from Lake Tåkern not accounted for by curves in the diagram Fig. 2.

Zones	III	IV	V	VI	VII	VIII	IX
Angiospermae							
Alisma sp.						+	+
Astragalus cf. *glycyphyllus*							+
cf. *Callitriche*			+				
Caltha palustris				+	+	+	
Cardamine sp.							+
Centaurea cyanus							+ [1]
Centaurea jacea							+ [1]
cf. *Dryas*		+					
cf. *Elatine*						+	+
Filipendula ulmaria					+	+	+
Galium sp.		+		+	+	+	+
Humulus							+ [1]
Juniperus communis	+	+				+	+
cf. *Lobelia*				+			
cf. *Melampyrum*						+	
Menyanthes trifoliata		+	+				
cf. *Mercurialis*				+			
Myrica gale							+
Myriophyllum alterniflorum	+					+	+
M. spicatum	+	+				+	+
M. verticillatum					+		
Nuphar luteum				+		+	
Nymphaea alba		+		+	+	+	
N. candida				+			
cf. *Oenothera*							+
Potentilla cf. *palustris*					+		
Potentilla sp.						+	+
Ranunculus cf. *ficaria*						+	
R. cf. *flammula*							+
R. cf. *lingua*							+
R. cf. *peltatus*						+	+
Ranunculus sp.		+			+	+	+
Rhamnus cathartica						+	
Ribes sp.							+ [1]
Rumex cf. *aquaticus*						+	+
cf. *Sium*		+ [1]					
Sorbus sp.					+	+	+
cf. *Stellaria*							+ [1]
cf. *Succisa*							+
Thalictrum sp.		+		+ [1]		+	
Trapa natans			+	+			
Urtica sp.			+		+	+	+
Valeriana sp.						+	
Viburnum sp.				+			
Viola sp.					+ [1]		
Pteridophyta							
Lycopodium annotinum				+			
L. clavatum		+	+	+	+	+	
L. selago					+		
Ophioglossum sp.			+ [1]				
Polypodium vulgare			+	+			
Selaginella selaginoides		+					

[1]Only one pollen grain or one spore

zone it again predominates over all other curves. The QM curve lies approximately at a constant level (between 15 and 20 per cent) throughout the zone. The frequency of *Quercus* exceeds the frequency total for all other QM components. *Corylus* reaches its Post-glacial maximum of 20.5 per cent in this diagram not until the lower part of zone VIII. Similar high parts of the *Corylus* curve also occur in other areas in the interior of South Sweden at about the same time. Pollen diagrams from Östergötland, showing such a development, are found, for example, on the geological map sheet Åtvidaberg (Sandegren, Sundius & Lundqvist 1924, Fig. 18) and from Västergötland, e.g. on the map sheet Skövde (Lundqvist 1928, Fig. 77). Simultaneously with this *Corylus* maximum *Fraxinus* reaches its highest value of 1 per cent in this diagram. From the lower part of the zone the *Picea* curve is closed but does not rise above one half of one per cent. Pollen grains of *Fagus* and *Carpinus* occur regularly, and of *Acer* sporadically.

The zone boundary VIII/IX has been placed at the quite well-marked rise of the *Picea* curve. At the same point the curves for *Alnus, Corylus,* and the mixed oak forest decline considerably. The corresponding level has been designated index horizon *c* by Fries (1951, p. 58).

DAGSMOSSE

With the help of von Post's section (1913, Fig. 1) through the mire Dagsmosse from the shore of Lake Tåkern towards Alvastra, a boring was sited in the central and apparently unremoved part of the large raised bog. The vegetation around the boring point consists of separate pines and birches and is dominated by scrubs, particularly *Calluna vulgaris* and *Empetrum nigrum*. Also *Rubus chamaemorus, Ledum palustre,* and *Andromeda polifolia* occur. The bottom layer of lichens (mainly *Cladonia rangiferina*) is not entirely continuous. The vegetation seems to be affected by drainage due to peat-cuttings not very far from the boring point. The sequence of strata in the diagram is a little simplified compared with the following table. The surface of the bog at the boring point was obtained with respect to the fix at the farm Holmen and is 98.7 m. above sea level.

Stratification:

0— 5 cm.	*Sphagnum* peat, brown, degree of humification (H) 4
5— 38 cm.	*Sphagnum* peat, light brown, H 3
38— 50 cm.	*Sphagnum* peat, brown, H 4, abundant fibres of *Eriophorum vaginatum*
50— 65 cm.	*Sphagnum* peat, yellowish brown, H 3
65— 95 cm.	*Sphagnum* peat, light brown, H 4, with some wood of *Calluna* and fibres of *Eriophorum*
95—140 cm.	*Sphagnum* peat, light brown, H 3, with some twigs of *Calluna*
140—169 cm.	*Sphagnum* peat, dark brown, H (5—)6, with some wood of *Calluna* and fibres of *Eriophorum*
169—184 cm.	*Sphagnum* peat, brown, H 5, with some fibres
184—199 cm.	*Sphagnum* peat, brown, H 6, with some small twigs of *Calluna*

199—215 cm. *Sphagnum* peat, H 8—9, dark brown, with abundant fibres of *Eriophorum* and remains of *Ericales*
215—257 cm. *Sphagnum*-pine forest peat, black-brown, with abundant remains of *Ericales* and *Eriophorum,* and wood of pine; at about 225 cm. a piece of pine bark
257—268 cm. *Sphagnum* peat, brown, H 7, with fibres of *Eriophorum*
268—284 cm. *Sphagnum* peat, brown, H 6, with some remains of *Calluna* and *Eriophorum*
284—306 cm. *Sphagnum* peat, black-brown, H 7—8
306—339 cm. *Sphagnum* peat, dark brown, H 6—7
339—375 cm. *Carex* peat, dark brown, H 8—9, with remains of roots, leaves and stems, and fruits of *Carex,* rhizomes of *Equisteum,* one fruit and one stem base of *Cladium,* two fruits of *Potentilla palustris,* at about 350 cm. a birch twig
375—411 cm. *Carex* peat, dark brown, H 7, with remains of roots, leaves and stems and several fruits of *Carex,* two fruits of *Potentilla palustris,* in the lowermost part remains of leaves of *Phragmites communis*
411—460 cm. *Carex* peat interspersed with *Cladium* and *Phragmites,* greyish brown, H 7—8, with leaves, stems, roots, and several fruits of *Carex,* stem bases and fruits of *Cladium,* leaf remains of *Phragmites*
460—488 cm. *Cladium-Phragmites* peat, dark brown, H 7, with several stem bases and fruits of *Cladium,* abundant leaf remains of *Phragmites,* and one fruit of *Carex* and one of *Menyanthes trifoliata*
488—588 cm. *Phragmites* peat interspersed with *Carex* and *Cladium* to a varying degree, greyish dark brown, H 7—8, with several fruits of *Carex,* some fruits of *Cladium,* one fruit of *Potentilla palustris* and one of *Scirpus*
588—725 cm. coarse detritus mud, brown, especially in the uppermost portion greenish brown, with remains of *Carex* and *Phragmites* and especially between 624 and 680 cm. several small birch and pine twigs
725—760 cm. fine detritus mud, greenish brown, with several fruits of *Menyanthes trifoliata* and two of *Potamogeton*
760—762 cm. clay-mud, greyish green
762—800 cm. clay, bluish grey
800—989 cm. clay, grey
probably boulder-clay

The samples from the greater part of this profile have been analysed for various microfossils. Among the remains microscopically determinable leaves or fragments of leaves of *Sphagna* predominate. The most usual types in the younger, less humified layers are *Sphagnum* cf. *recurvum* (especially *S. apiculatum*) and *S.* cf. *fuscum.* In some cases fragments of *S. cuspidatum* also occur. Bark and wood of *Calluna* and other *Ericales* are rather common in most layers. Of other fossils may be mentioned the Rhizopods *Amphitrema flavum, Arcella* cf. *artocrea,* and *Assulina seminulum.*

In the lower, highly humified *Sphagnum* peat and the *Sphagnum*-pine forest peat remains of *Sphagnum* cf. *recurvum* and *S.* cf. *fuscum* are usual and occur in varying quantities as does *S. cuspidatum.* In the two lowermost layers of *Sphagnum* peat remains of brown mosses often predominate over those of *Sphagna.* Fragments of roots, bark, and sometimes of wood of *Ericales* are very usual in the *Sphagnum*-pine forest peat and are rather usual in most of the other layers. In the pine forest peat some wood and stomata of *Pinus* type are observed. Of Rhizopods only *Assulina seminulum* is found, but in some samples this species occurs in very high frequencies.

The three uppermost samples from the *Carex* peat contain a mixed flora of *Sphagna,* brown mosses, and *Carex* species, i.e. a flora characteristic for the transitional type of peat called *Carex-Sphagnum* peat. Plants characteristic for *Carex* peat are, however, dominant. In most of the samples roots of *Carex lasiocarpa* are preponderant, while the occurrence of roots of *Carex rostrata* type is more variable. Root fragments of *Phragmites, Cladium,* and *Lastrea thelypteris* occur in minor amounts. A few remains of *Cladocera* (cf. *Alona*) and some Rhizopods (*Euglypha* sp. and *Assulina seminulum*) have been observed.

In the *Cladium-Phragmites* peat particularly, roots of *Cladium* and *Phragmites* constitute most of the remains. In some samples there are also many roots of *Carex lasiocarpa.* Fragments of brown mosses occur with varying frequencies but are usually common. A few specimens of algæ of the genus *Cosmarium* have been observed in the lower part of this peat.

The contents of fossil remains in the *Phragmites* peat are of a very different character in the different samples. Fossil types most constantly occurring with high frequencies are root fragments of *Phragmites communis* and of *Carex lasiocarpa.* In some samples, however, roots of *Cladium* predominate, in others roots of *Carex* cf. *rostrata* and of *C.* cf. *fusca* are abundant. Fragments of the epidermis of *Cladium, Phragmites* as well as *Carex* occur. Leaves or leaf fragments of brown mosses are especially abundant in the uppermost portion of the layer. Among the more rare fossil types may be mentioned remains of *Lastrea thelypteris,* posterior claws of the Cladocer *Eurycercus lamellatus,* a few spicules and one specimen of *Arcella vulgaris.*

The upper portion of the coarse detritus mud contains abundant roots most probably grown down from the former *Phragmites* fen. These of *Phragmites, Carex lasiocarpa, C.* cf. *rostrata,* and of *Cladium* are usually well represented. About 25—30 cm. down in the detritus mud the roots cease to dominate and the fossil contents are then more variable. Roots of *Phragmites* and *Carex* cf. *rostrata,* however, have been observed in practically all samples from this mud. Leaf fragments of brown mosses are very usual in most of the samples and occur in some samples abundantly. This is especially the case in the three lowermost samples in which the easily determinable species *Aulacomium palustre* constitutes more than half the fragments of brown mosses, the other half being usually different *Drepanocladus* species. Leaf fragments of *Sphagna* of different types occur in many samples as do pieces of wood and the bark of birch and sometimes of pine. Algæ are rather rare and only some specimens of the genus *Cosmarium* have been recorded. Rhizopods are more usual and the most frequent species is *Arcella vulgaris.*

3†—*640615. SGU. Magnusson*

The fine detritus mud is, especially in the upper portion, rich in fragments of brown mosses, mainly of *Drepanocladus* type. Also *Aulacomium palustre* is represented. Root fragments of *Phragmites, Lastrea thelypteris, Equisetum, Carex* cf. *rostrata,* and *C.* cf. *fusca* occur regularly. Hairs of *Nymphaeaceae* and hair bases of *Nymphaea* were met with in several samples. Among other fossils may be mentioned epidermis and stomata of *Pinus* type. Algæ occur but with rather low frequencies and are dominated by different species of *Cosmarium.* In the lowermost samples diatoms are usual as is *Pediastrum boryanum.*

The clay has not been investigated for other fossils than pollen and spores.

The pollen diagram (Pl. 1), like the diagram from Lake Tåkern, begins in the upper part of zone III. The remaining part of the Late-glacial sequence of strata has not been analysed at all. The zone boundary III/IV has been placed analogously to this boundary in the Tåkern diagram. In this way the very lowermost portion of zone IV will also here consist of clay. The pollen flora is dominated by *Betula* in almost the whole zone except in the upper part, where *Pinus* exceeds *Betula.* Pollen grains of *Populus* have been identified in some samples from this zone and *Populus* shows a slight maximum at the zone boundary III/IV. The samples from 7.25 m. depth and downwards have not been oxidized which facilitated identification of *Populus* pollen. The NAP frequency is very high throughout almost the whole zone. As in the Tåkern diagram this is mainly composed of pollen of *Cyperaceae,* which, however, here reaches considerably higher values. Pollen of *Artemisia* occurs throughout the zone but in lesser quantities in the upper part. The *Hippophaë* curve shows a maximum immediately below the boundary with the preceding zone and then falls rapidly ceasing entirely before the middle part of the zone.

The zone boundary IV/V is probably placed with greater certainty in this diagram than in the Tåkern diagram at the marked rise of the *Corylus* curve at 7 m. depth. The cause of this more marked rise may be the deposition of fine detritus mud in Dagsmosse but in the muddy clay in Lake Tåkern there is most probably some reworked pollen included. The zone boundary falls in both diagrams a little above the marked decline of the NAP curves.

Zone V is very thick in Dagsmosse being represented by 1.35 m. of deposits, i.e. 1 m. thicker than in Lake Tåkern. This fact makes a comparison difficult as characteristic features in the pollen curves of both diagrams do not directly correspond to each other. A maximum in the Tåkern diagram may be equivalent to two or perhaps three separate maxima in the Dagsmosse diagram. Thus, the maximum of the *Pinus* curve at the zone boundary IV/V will have its equivalent in three maxima in the Dagsmosse diagram, one uppermost in zone IV and two in the lower part of zone V.

Pinus predominates over the other pollen types throughout zone V. The very high values in the upper part of the zone (maximum 98.3 per cent at 5.95 m. depth) are most probably not only dependent on the abundance of pine trees in

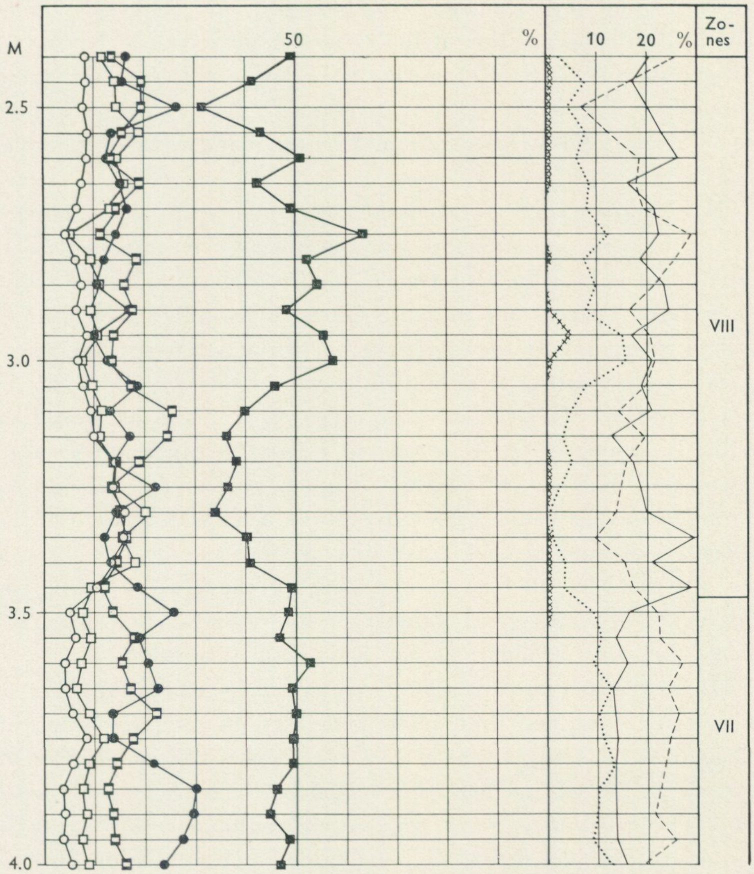


Fig. 3. Special pollen diagram from a portion of Dagsmosse with reduced spectra (*Betula*, *Pinus*, *Alnus*, and *Corylus* divided by four) and *Corylus* included in the tree pollen sum. — For further explanations see also Fig. 2.

the area but also on secondary concentration of pine pollen in the vegetation belt in shallow water near the former shore.

The zone boundary V/VI at the marked rise of the *Alnus* curve is readily seen. In this diagram the first marked rise of the *Ulmus* curve also seems to fall at the same level as the zone boundary, while the most marked rise in the Tåkern diagram falls some way up in zone VI. In the latter diagram there is also, however, an obvious increase of the frequency of *Ulmus* pollen at the zone boundary. The difference may probably be explained by the greater distance of the boring point in Lake Tåkern from the land areas of that time compared with the boring point in Dagsmosse, and consequently more distant for the spread of the relatively heavy elm pollen grains.

In spite of certain disturbances of the pollen curves in zone VI due to overrepresentation of pine pollen in the *Phragmites* peat and in the *Cladium-Phragmites* peat through concentration at the former shore zone (T. Nilsson 1947, p. 206; cf. Magnusson 1962, p. 25), pollen zone VI in this diagram agrees with the corresponding zone in the Tåkern diagram.

The zone boundary VI/VII is determined by the marked rise of the lime pollen curve.

Zone VII is characterized by a considerable increase of *Tilia* which in the upper half of the zone predominates over the other QM components. The QM curve in the upper part of the zone reaches higher values than in the corresponding levels in Lake Tåkern, but they are exceeded by still higher values in the middle part of zone VIII. In the upper portion of the zone especially hazel pollen plays a greater role than in preceding zones.

The zone boundary VII/VIII shows up very well in this diagram and has been placed at the beginning of the very marked *Ulmus*-fall. In this way apparently also the two small maxima of *Tilia* in the upper part of the zone are equated with two similar maxima of the *Tilia* curve in the Tåkern diagram. On the other hand the courses of the *Quercus* curves in both diagrams do not correspond to each other. In the Tåkern diagram the slope of the *Quercus* curve shows a downwards tendency at the zone boundary, while it shows two maxima immediately above the same boundary in the Dagsmosse diagram.

Zone VIII is, in this diagram, also characterized by increasing *Tilia* towards the middle of the zone and even more pollen grains of *Tilia* occur in some samples than those of *Quercus*. As is the case in the Tåkern diagram *Corylus* does not reach its Post-glacial maximum (56.6 per cent) before the lower part of this zone. The *Fraxinus* curve is not entirely continuous, but the occurrence of pollen grains of *Fraxinus* shows two maxima of which at least the first seems to be equivalent to the one of 1 per cent in the Tåkern diagram. The *Picea* curves in this zone are rather similar in both diagrams. In the Dagsmosse diagram it is, however, more uneven and shows slightly higher maxima of which one immediately below the middle of the zone amounts to 1 per cent, but instead it is there discontinuous. Nor is the marked rise of the *Picea* curve as even in the Dagsmosse diagram as in that of the Tåkern diagram, but occurs in two steps. The zone boundary VIII/IX has been located at the level of the very marked rise of the *Picea* curve at 2 m. depth. It nearly coincides with the boundary between highly and slightly humified *Sphagnum* peat at 1.99 m. depth which most probably represents a recurrence surface, and is the same as Granlund's RY III. Further up in zone IX (at 1.4 m. depth) the *Picea* curve has another marked rise of about the same order of size. This rise occurs also at the same time as a probable recurrence surface which possibly may be parallelled with Granlund's RY II.

Already in the upper part of zone VIII the frequencies of *Alnus*, QM, and *Corylus* markedly decrease and at the zone boundary they fall still more. Of the

Tab. III. Pollen and spore types from Dagsmosse not accounted for by curves in the diagram Fig. 3.

Zones	III	IV	V	VI	VII	VIII	IX
Angiospermae							
Abies sp.							+ [1]
Caltha palustris							+
Campanula sp.			+ [1]				
Centaurea cf. *jacea*							+
Drosera intermedia						+	+
D. rotundifolia						+	+
cf. *Dryas*	+ [1]						
Epilobium spp.		+	+				
Filipendula ulmaria		+		+			
Galium sp.		+	+	+	+	+	+
Juniperus communis		+				+	+
Lycopus europaeus				+			
Menyanthes trifoliata		+	+				
cf. *Mercurialis*							+
Myriophyllum alterniflorum				+			
Nymphaea candida			+				
Polygonum cf. *aviculare*							+
P. cf. *convolvulus*							+
Populus tremula		+					
Potentilla cf. *palustris*				+	+	+	
Potentilla sp.				+	+		
Ranunculus cf. *repens*							+
Ranunculus spp.		+	+				
Rubus chamaemorus						+	
Rumex cf. *hyrolapathum*					+ [1]		
cf. *Scabiosa*							+
cf. *Scrophularia*							+
Sorbus sp.				+	+		
Thalictrum sp.		+					
Typha latifolia		+	+				
Valeriana cf. *dioeca*						+	
V. cf. *officinalis*							+ [1]
V. cf. *sambucifolia*					+ [1]		
Pteridophyta							
Botrychium cf. *lunaria*	+ [1]						
Polypodium vulgare				+	+	+	
Selaginella selaginoides	+						

[1] Only one pollen grain or one spore

components of the mixed oak forest *Tilia, Ulmus,* and *Fraxinus* occur with continuous but low curves in the lower part of zone IX, but from the middle part of the zone pollen grains of *Tilia* and *Fraxinus* are almost absent. The *Quercus* curve on the other hand continues at a level of about 5 per cent. At the zone boundary both *Fagus* and *Carpinus* increase to values of more than 1 per cent. The corresponding pollen zone boundary in Scania (II^S/III^S) is characterized by a marked rise of the beech pollen curve (Nilsson 1935, p. 394). While the frequency of *Carpinus* pollen already in the middle of the zone falls to insignificant values, the frequency of *Fagus* pollen increases a little, but the maximum value does not amount to more than 2.4 per cent (at 55 cm. depth).

ALVASTRA

A boring was carried out about 3 m. from the northern border of the excavated area in the spring mire, at Alvastra, nowadays largely a meadow. The excavated part of the dwelling-place is now overgrown by a forest of deciduous trees. The ground surface at the boring point is situated about 98.5 m. above sea level. Stratification:

0— 23 cm.	highly humified fen peat, black-brown mould
23— 55 cm.	*Carex* peat, brownish black, highly humified
55— 74 cm.	*Cladium-Phragmites* peat, at 73 cm. depth a piece of weathered limestone and several pieces of bone charcoal and charcoal
74— 83 cm.	culture layer, greyish black, abundant in charcoal and bark fragments
83— 88 cm.	sand with detritus mud, greyish brown
88—101 cm.	culture layer, black, with several pieces of charcoal and some pieces of wood; in the upper part a rather high content of sand, diminishing downwards; at 91 cm. a piece of flint waste
101—113 cm.	lake marl, greyish yellow
113—117 cm.	lake marl with several remains of *Cladium* and a very decayed piece of wood
117—127 cm.	*Cladium* peat, reddish brown, with one shell of *Pupa* sp. and one of *Helix* sp.
127—184 cm.	mainly brownish green calcareous mud with remains of *Cladium* (among them also stem bases) alternating with layers of more pure *Cladium* peat; shell remains, often fragmentary, are usual, e.g. of *Planorbis carinatus, Valvata piscinalis, Limnaea* cf. *palustris* and *Bithynia* sp.
184—186 cm.	muddy peat with several wood remains and a piece of wood
186—196 cm.	lake marl, yellowish grey, with shell fragments and remains of *Cladium*
196—200 cm.	fen peat, dark grey
200—207 cm.	muddy *Cladium* peat, greyish brown
207—231 cm.	lake marl, yellowish grey, with some *Cladium* remains
231—247 cm.	detritus mud, dark grey, with shell fragments
247—309 cm.	weathered calcareous tufa, greyish yellow
309—318 cm.	*Cladium* peat, greyish brown
318—340 cm.	muddy calcareous tufa, grey
340—346 cm.	"dy" dark grey
346—440 cm.	calcareous tufa, slightly clayey
440—450 cm.	clayey calcearous tufa, with a little sand
	boring probably determined in hard calcareous tufa

In the uppermost layer of this sequence there are no determinable plant or other remains except pollen.

The *Carex* peat is dominated by fragments of epidermis and roots which are quite undeterminable because of the high degree of humification. Two specimens of Rhizopods were observed: *Centropyxis aculeata* and *Difflugia pyriformis*.

In the *Cladium-Phragmites* peat root fragments of *Phragmites communis* and *Carex* cf. *rostrata* predominate. The content of *Cladium* roots varies rather greatly.

The culture layer representing the dwelling-place, is divided into two portions by the thin layer of muddy sand. In the upper of these there is a low content of determinable plant remains. They consist mainly of root fragments of *Phragmites* and *Carex* and bark fragments of *Pinus*. The content of charcoal is very high. Most pieces are of deciduous trees, while a lesser part are of pine. The intercalated sand layer is very poor in fossils including pollen. Some root fragments of *Carex* cf. *rostrata* and wood of deciduous trees have been identified. The lower portion of the culture layer contains even more charcoal than the upper one hence the black colour. Here no fragments of roots were observed but instead several fragments of brown mosses, mainly of the genus *Drepanocladus*. Unburnt wood of *Betula* and other deciduous trees also occurs.

The culture layer is underlain by lake marl which contains some fragments of brown mosses of *Drepanocladus* type and a few algæ of the genus *Cosmarium*. In the lower portion of this layer there are roots of *Cladium* and *Phragmites*.

The *Cladium* peat between 117 cm. and 127 cm. contains mainly roots of *Cladium*. Roots of *Phragmites* and *Carex* cf. *rostrata* are also present. Fragments of brown mosses and pine bark occur occasionally. Algæ of the genus *Cosmarium* are rather common. One specimen of *Nebela* cf. *collaris* was observed.

The calcareous mud (127—184 cm.) contains not only layers of *Cladium* peat but also thin layers more like lake marl than calcareous mud. In most of the samples from this mud, however, there are roots of *Cladium*, while the occurrence of roots of *Phragmites* and *Carex* is more irregular. Fragments of brown mosses are found with low frequencies in several samples. Only a few specimens of *Cosmarium* were met with and only one of *Arcella vulgaris*.

In the thin peat layer between 184 cm. and 186 cm. were recorded only a few plant remains including pine bark, wood of deciduous trees and epidermis of sedges.

In the lake marl between 186 cm. and 196 cm. root fragments of *Phragmites* and *Carex* cf. *rostrata* are rare but leaf fragments of brown mosses more frequent.

The fen peat following in the sequence is dominated by roots of sedges, mainly of *Carex* cf. *rostrata*, and brown moss leaves. Some root fragments of *Cladium* and *Phragmites* were also found.

In the muddy *Cladium* peat (200—207 cm.) leaf fragments of brown mosses are very numerous, while roots and epidermis fragments are also common.

The layer of lake marl between 207 cm. and 231 cm. contains few determinable plant remains, e.g. fragments of roots and epidermis of *Cladium* and *Phragmites*.

In the dark grey detritus mud the content of charcoal is again high. Root fragments occur rarely.

In the upper part of the calcareous tufa there are fragments of roots and

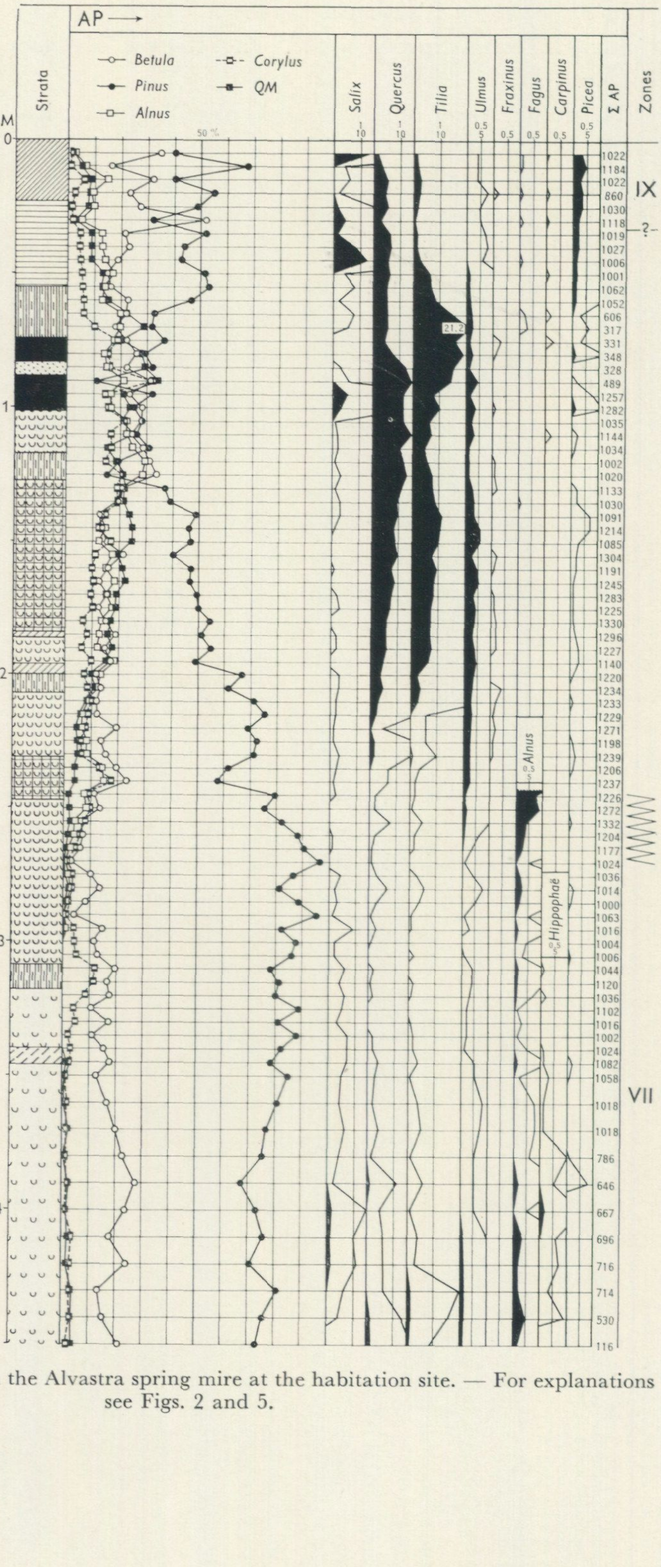
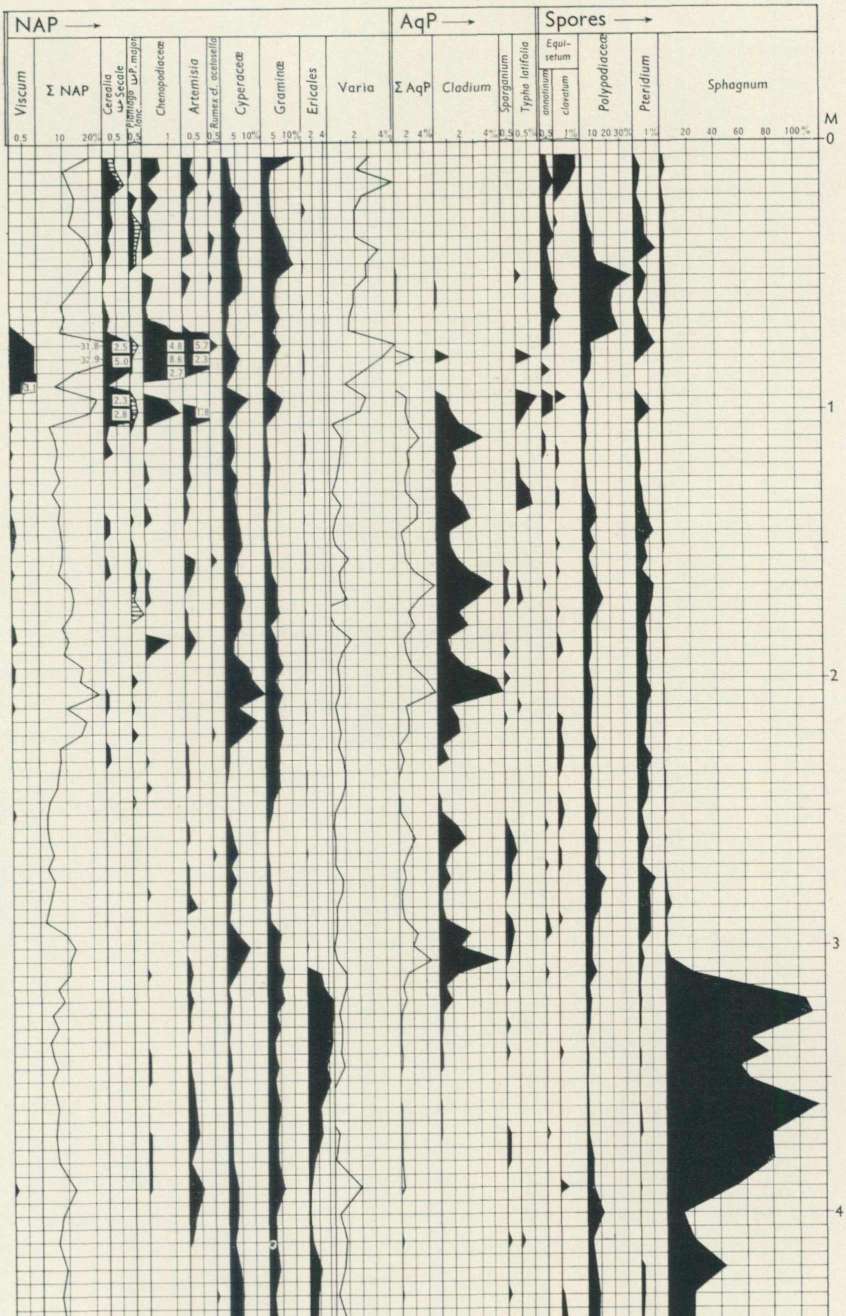


Fig. 4. Pollen diagram from the Alvastra spring mire at the habitation site. — For explanations see Figs. 2 and 5.


NAP →
AqP →
Spores →
Viscum
Σ NAP
Cerealia
Secale
Plantago lanc.
P. major
Chenopodiaceæ
Artemisia
Rumex cf. acetosella
Cyperaceæ
Gramineæ
Ericales
Varia
Σ AqP
Cladium
Sparganium
Typha latifolia
Equisetum
annotinum
clavatum
Polypodiaceæ
Pteridium
Sphagnum
M
0
1
2
3
4

epidermis of *Phragmites,* and of brown mosses. The remaining part of the tufa is very poor in determinable plant remains.

The *Cladium* peat between 309 cm. and 318 cm. is, in the uppermost part, very rich in *Cladium* remains. In the lower part remains of *Phragmites* are somewhat more common.

In the calcareous tufa which follows only a few leaf fragments of brown mosses were observed.

The thin layer of "dy" is dominated by fragmentary *Sphagna* not more exactly determinable. Remains of *Phragmites, Ericales,* and brown mosses occur subordinately.

The upper part of the calcareous tufa from 346 cm. depth contains abundant fragments of *Sphagna,* which are generally not determinable. A great number of fragments, however, seem to be of *S. fimbriatum* type. There also occur root fragments, especially of *Phragmites* but also of *Ericales.* The rest of this tufa and the following one are poor in plant remains.

The pollen diagram (Fig. 4) does not reach the underlying mineral soil owing to the difficulty of taking samples in the hard calcareous tufa and to the poorness of pollen in this tufa. In the calcareous tufa as in other sediments with a high content of lime in this sequence much destroyed pollen grains are very common and most often the pollen of deciduous trees and herbs is entirely destroyed or at least very difficult to identify. Air sacs of conifer pollen are, however, rather easy to identify even though in a very bad state of preservation and from this it appears that there is an apparent preponderance of *Pinus* in such samples. It is a very general feature of basic soils to be unfavourable for the preservation of pollen grains.

According to von Post (1916, p. 238) the deposition of calcareous tufa started at about the time of the maximum of the Ancylus Lake, i.e. during period V. The oldest part of this diagram seems, however, to belong to zone VII. This is indicated by the rather high frequencies of lime pollen which at 4.3 m. depth reach 2.0 per cent. This zoning is in contrast to von Post's interpretation. He suggested that the formation of the calcareous tufa ceased at about the beginning of the Atlantic period, approximately corresponding to the zone boundary VI/VII when the increased precipitation probably stopped it. During the Atlantic period lake marl was mainly deposited in the greater part of the spring mire (von Post 1916, p. 240). The weathering of the upper calcareous tufa implies that the calcareous tufa already formed, then weathered and thus there was stagnation for a time in the development of the mire.

The occurrence of *Hippophaë* pollen ceases in Dagsmosse already in the lower part of zone IV. In Lake Tåkern it persists until the zone boundary V/VI, i.e. until the middle of the Boreal period. In the diagram from the dwelling-place *Hippophaë* pollen occurs even into late Atlantic time (zone VII). This occurrence, during the Atlantic period is not entirely unique for sites in the interior of

Sweden as may be seen from an account by Sandegren (1943, Fig. 5 and the list on pp. 14—19) and from some pollen finds in zone VII in Västergötland (Fries 1958, p. 23). The conditions during deposition of the calcareous tufa at Alvastra were probably favourable for the survival of *Hippophaë* till most of the tufa was invaded by *Cladium* and other plants. In other areas also calcareous tufa sometimes has floras which include *Hippophaë*. These floras, however, are Late-glacial survivals. In Jämtland *Hippophaë* appears in several places as a survival together with *Dryas octopetala* and other plants in Boreal and possibly in Atlantic layers (Halle 1915) though rarely. Upon calcareous tufas in Gudbrandsdalen in Norway there were, during Boreal time, similar plant communities. *Hippophaë,* however, died out during the course of the Boreal period, according to Nordhagen (1921) owing to increased shading by the more dense forest in the neighbourhood.

The level for the zone boundary VII/VIII in this diagram is uncertain. The elm curve is so low and irregular that the usually very marked *Ulmus*-fall is hardly seen. Minima on the *Ulmus* curve, which may indicate the zone boundary, occur at 2.45 m. and 2.70 m. depth respectively. It seems, however, impossible to fix this boundary more exactly with the aid of the other curves.

Except from the lowermost part of zone VIII the pollen curves of this zone are more normal and may be readily compared with those in the Dagsmosse diagram. In this case sometimes *Tilia,* sometimes *Quercus* may dominate the components of the QM. The frequency of *Ulmus* is constantly low except in the middle part of the zone where a low maximum is developed.

Zone VIII approximately corresponds to the Sub-boreal period in the scheme of Blytt and Sernander. The climate during this period has been much discussed, especially the precipitation. According to earlier opinions a pronounced dry and warm climate prevailed throughout the whole period. In contrast, the opinion now usually held is that it was warm with relatively dry conditions during the early part of the Sub-boreal period becoming progressively wetter towards the end (see Godwin 1954; Mitchell 1956). The development of the raised bogs also seems to indicate conditions as dry at the end of the Atlantic period as at the beginning of the Sub-boreal period (cf. Magnusson 1962, p. 31—32). Whether this dryness was due to low precipitation or to high evaporation, cannot yet be decided. According to Mitchell (1951, p. 198) it is difficult to believe that the Sub-boreal was drier than the Atlantic period because of the often marked rise of the alder pollen curve at the transition between these periods. But as this rise of the *Alnus* curve is often short-lived and associated with the decline of the *Ulmus* curve, it may be affected by the decrease in amounts of other pollen types (Smith 1961, p. 39). Such a rise of the *Alnus* curve is also seen in the Dagsmosse diagram and the frequency of alder pollen is here rather high and generally higher in zone VIII than in zone VII. On the other hand, Iversen (1944, p. 480) has shown, that the highest summer temperatures in Post-glacial time were at the transition between the Atlantic and Sub-boreal periods. Also the distribution during that period of the European pond tortoise seems to indicate high summer temperatures during the whole Sub-boreal period (Degerbøl and Krog 1951, p. 86). In this case, however, there seems to be an essential difference between the conditions in Denmark and Southern Sweden as the Swedish finds of *Emys* from this period are very few (Isberg 1929, Fig. 2; Degerbøl and Krog 1951, p. 83).

According to von Post (1916, p. 240) lake marl was deposited at Alvastra, mainly during the Atlantic period. In the actual profile and thus most probably within a great part of the most important nucleus area of the spring mire, lake marl, however, was also deposited intermittently during the Sub-boreal period. This resulted in three layers of lake marl with intercalated calcareous mud and thin peat layers. Furthermore, if the summer temperatures at the time of the deposition of these layers of lake marl were not quite as high as previously, the evaporation would not have been much lower, but the cause of it seems rather to be periodically increased precipitation. A contributory cause may possibly have been worse conditions of drainage as a result of the spread of *Cladium* vegetation in great parts of the central part of the spring mire, and of brush wood in the marginal parts. *Cladium* and brush wood peat were already formed towards the end of the Boreal period (von Post 1916, p. 240). This vegetation may have blocked the free outflow of spring water and possibly also caused a periodic damming-up of water.

It is, however, remarkable that von Post did not consider lake-marl to have been deposited during Sub-boreal time except to a very restricted extent in spite of his statement that the horisontal tree-trunks of the dwelling-place rested on lake-marl. It is also surprising with regard to his dating of the settlement to the marked rise of the spruce pollen curve (von Post 1926, Fig. 12). He seems to have placed these events in the Atlantic period.

Like the preceding zone boundary the boundary VIII/IX is rather difficult to determine in contrast to both the other diagrams, where a marked rise of *Picea* coincides with decrease of *Alnus,* QM, and *Corylus.* In this diagram the spruce pollen curve rises very slowly. The most probable placing is where the *Picea* curve rises a little and the curves for *Alnus,* QM, and *Corylus* decline rather markedly. A possible level is also about 20 cm. further down where the same characteristics occur. If the marked birch maximum at 30 cm. depth in this profile may be connected with the similar maximum at 160 cm. depth in the Dagsmosse profile, the lower placing of the zone boundary is correct. It is, however, very uncertain if these birch maxima may be connected with each other.

Some help in identifying the zone boundary is the beginning of the *Secale* curve which in both the Tåkern and Dagsmosse diagrams lies at some distance from the zone boundary. Owing to the very different soils formed at this time at the three sites, not even this event gives more accurate guidance.

Zone IX seems to be incompletely represented, only the oldest part being present. Most probably the uppermost part of the original peat has been destroyed

Tab. IV. Pollen and spore types from the dwelling-place at Alvastra not accounted for in the diagram Fig. 3.

Zones	VII	VIII	IX
Angiospermae			
Caltha palustris		+	+
cf. *Cardamine*		+	
Centaurea cyanus			+[1]
Elytrigia repens			+
Epilobium sp.	+	+	+
Filipendula ulmaria	+	+	
Galium sp.	+	+	+
Menyanthes trifoliata		+	
cf. *Mercurialis*		+	
Myrica gale		+	
Myriophyllum spicatum		+	
cf. *Oenanthe*		+	
Polygonum cf. *aviculare*		+	+
P. cf. *bistorta*		+[1]	
P. cf. *convolvulus*		+[1]	
Potentilla cf. *palustris*		+	
Ranunculus cf. *ficaria*		+[1]	
R. cf. *repens*			+
R. cf. *peltatus*	+		
Ranunculus sp.	+	+	+
Rhamnus frangula		+	
cf. *Sium*		+	
Sorbus sp.	+	+	+
cf. *Succisa*		+	+
Thalictrum sp.		+	
Valeriana cf. *officinalis*		+	
V. cf. *sambucifolia*		+	
Valeriana sp.		+	+
cf. *Vicia*		+	
Viola sp.		+	
Pteridophyta			
Lycopodium inundatum	+		+
L. selago		+	+
Polypodium vulgare		+	+
Selaginella selaginoides		+[1]	

[1]Only one pollen grain or one spore

by oxidation in connection with cultivation of this part of the mire. The pollen curves seem to be more dependent on local factors than both the other diagrams. This is reflected in higher frequencies of *Tilia* and *Ulmus* but lower frequencies of *Fagus* and *Carpinus*.

The main features of the Post-glacial forest development

Pre-boreal period (zone IV). During the Pre-boreal period birch forests expanded to the north. But as land areas at that time were rather distant from the investigation area most pollen would be far transported. This seems to be indicated by the high frequencies of pine pollen and NAP. The NAP frequency declines during the later part of the period indicating that the forests came closer to the area. The high NAP values in the early part of the period are primarily due to *Cyperaceae* pollen which at this time, before any peat formation had begun, may indicate rather open forest. Pollen of aspen (*Populus tremula*), which in the Tåkern profile has been identified in all samples from this period, is a little more abundant during the Pre-boreal than during later periods. As *Populus* is a very bad pollen producer, this tree most likely played a considerable role in the birch forests of this area. Pollen of *Juniperus communis* is rather common during this period and more common than in other periods except the later part of zone IX. The frequency is, however, low (max. only 2 per cent).

As a consequence of the land up-lift there arose favourable sites for *Hippophaë rhamnoides,* which evidently occurred during the whole period near the prevailing shores. Upon the calcareous tufa at Alvastra *Hippophaë* survived longer (see p. 26).

In the lowermost sample of this period, from Lake Tåkern, two pollen grains, probably of *Dryas octopetala,* have been observed. These, together with the high *Artemisia* values, indicate open habitats and perhaps the vegetation was tundra during the early part of the period.

Of the more thermophilous water plants which migrated in during this period, *Typha latifolia* may be mentioned. One pollen grain has been recorded from the uppermost zone III in Lake Tåkern.

Hazel pollen is found in small amounts in all samples of zone IV in Lake Tåkern, but these occurrences seem to be mainly secondary. In zone IV of Dagsmosse there are very few finds from the greater part of this zone, but in the upper part the hazel pollen curve rises. Thus, it is possible that *Corylus* grew not very distant from the area before the end of the Pre-boreal period.

Boreal period (zones V and VI). The very marked rise of the *Corylus* curve generally seen in diagrams from southernmost Sweden at the opening of this period, is lacking in these diagrams. The *Corylus* rise is here rather slow and the maximum value of hazel pollen in zone V is only 9.2 per cent. At this time the hazel probably grew on the slopes of Mt. Omberg but hardly on the lowlands, newly uplifted from the Ancylus-Lake (concerning the Ancylus limit, see p. 13).

In zone V there is a considerable predominance of pine pollen over all other pollen types. In the Tåkern diagram the *Pinus* curve reaches a maximum of 81.5 per cent in the upper part of zone V but then declines. In the Dagsmosse diagram still higher values are reached at the transition between the coarse detritus mud and the *Phragmites* peat with a maximum value of 98.3 per cent. This very high frequency of pine pollen is certainly to some extent due to over-representation caused by concentration of pine pollen on the shores of the time (cf. T. Nilsson 1947, p. 206). As the NAP curve is rather low there is reason to conclude that the forests in the early part of the Boreal period were closed. The sample points were, however, in this rather large basin considerably distant from the surrounding forested areas of that time and therefore the pine pollen is represented by a proportionally much larger share of the pollen rain than would have been the case in a lesser basin because of the high pollen production of pines and the good possibilities of dispersal of their pollen. As shown by Davis (1963) by an example from the Pine Pollen Zone in a pollen diagram from Vermont, U.S.A., pine pollen percentages of over 50 per cent of the total tree pollen are equal to only a few per cent of the pines in the forests. Despite this it is obvious that pines constituted an important component of the vegetation in early Boreal time and most likely the pine was the predominant forest tree, possibly more common than the birch. The hazel evidently played an unimportant role at this time and alder, oak, and elm probably did not occur in this area at all.

About the middle of the period (zone boundary V/VI) the pollen frequencies of hazel, alder, and elm increase a little, but not until the time corresponding to the level 5.5 m. in Dagsmosse and 2 m. in Tåkern do hazel and alder form elements of importance in the vegetation. The expansion of alder obviously took place in two stages expressed by two marked rises of the *Alnus* curve, a fact earlier observed in diagrams from Scania (T. Nilsson 1935, p. 501; Magnusson 1962, p. 47) and from Halland (Olausson 1957, p. 42). About the same time as the second *Alnus* rise or a little later elm and oak were certainly present in the area also. Considering the high production and dispersal of alder pollen it cannot be entirely excluded that elm and perhaps also oak, migrated into the area before alder as is the case in Scania (T. Nilsson 1935, p. 501). During the later part of the Boreal period pine and birch wold still have been the predominant forest trees.

The first pollen grains of *Viscum album* are recorded from the lower part of zone VI. *Hedera* pollen is rare in these diagrams; in Dagsmosse the oldest *Hedera* pollen grain is observed in a sample at the boundary with the following zone. In Denmark, as shown by Iversen (1944), there is a marked increase of *Hedera* and *Viscum* pollen at the zone boundary V/VI but both plants migrated into the area in the early part of the Boreal period and *Hedera* perhaps a little earlier than *Viscum*. Judging from the few records from Dagsmosse and Tåkern *Viscum* seems to have migrated in earlier than *Hedera* but here these plants are considerably later than in Denmark and evidently later than in Scania (T. Nilsson 1961, p. 14; Magnusson 1962, p. 47).

A t l a n t i c p e r i o d (z o n e V I I). The favourable climatological conditions during the Atlantic period are first and foremost indicated by the marked rise of the *Tilia* pollen curve. *Tilia* is without doubt the most thermophilous of

Swedish forest trees and demands especially high temperatures during a long period in summer (cf. Enquist 1924; Hafsten 1956, p. 90). In Denmark, the frequency of *Hedera* which is very sensitive to extremely cold winters, also points to relatively high mean temperatures in winter (Iversen 1944). The presence of *Hedera* in the neighbourhood of Dagsmosse, as illustrated by the few pollen finds in the analyses from the bog, only indicates that the winter climate was as favourable as it is to-day. Ivy is still growing in several places in Östergötland (Hultén 1950, map no. 1304) and as this site is also now within the distribution area for ivy, it is not possible to draw further conclusions. Most likely the climatic conditions were similar to those in Denmark, even if they were not as pronouncedly oceanic.

During the Atlantic period mixed oak forest flourished in this area as in other parts of South Sweden. In the latter half of the period the *Tilia* values are high, especially in Dagsmosse. The lime consequently occurred abundantly in the area and at this time it seems to have predominated in the mixed oak forest. The frequency of *Ulmus* pollen is as high or a little higher than in the preceding zone, which may mean an increase of the elm frequency in the forests. Concerning the frequency of *Quercus* pollen there is a very distinct difference between the diagrams from Tåkern and Dagsmosse. In the former, the *Quercus* curve culminates with high values during the later part of this period. In the Dagsmosse diagram there is no such maximum at this time but several maxima with higher values for oak than for lime occur in the following zone. In Scania the oak is usually the dominant component of the mixed oak forest as early as during the latter half of the Atlantic period (cf. Magnusson 1962, p. 16), i.e. in zone V^{S} or zone AT-2 in the new Scanian zone system (T. Nilsson 1961). In the northwestern part of South Sweden the oak is not, in most cases, predominant in the mixed oak forest until the Sub-boreal period (Fries 1951, p. 144). Another difference between the two diagrams is the constantly higher oak values in Tåkern than in Dagsmosse. What these differencies mean is hard to explain. They probably reflect local distinctions in the forest composition but may possibly indicate some overrepresentation of the light *Quercus* pollen in the sediments of Tåkern.

The *Betula* and *Pinus* curves are also different in the two diagrams. The frequency of *Betula* is higher throughout the whole period in Tåkern and the frequency of *Pinus* decreases earlier. The *Alnus* values, too, are usually higher in Tåkern than in Dagsmosse. This conditon may depend on the fact that the composition of the pollen rain over Lake Tåkern was more affected by the presence of brush wood in parts of the fens and along the shores because of the location in relation to the prevailing wind directions.

In order to illustrate the forest development during the latter half of the Atlantic period and the greater part of the Sub-boreal period more adequately a special diagram, Fig. 3 (p. 19), has been constructed. In this the pollen spectra are reduced, i.e. the pollen numbers for *Alnus, Betula, Corylus,* and *Pinus* are divided by four. Furthermore *Corylus* is included in the base sum. Among other things, this diagram shows the very important role of *Tilia* in late Atlantic time. The analyses from Dagsmosse have been chosen as this site is situated closer to the dwelling-place than Lake Tåkern and because it is better suited to show the actual forest composition in the vicinity. From the diagram for the dwelling-place it is not possible to draw any conclusions in this respect. In this portion it only shows that *Hippophaë* was growing there until the later part of the period (see also p. 26).

Sub-boreal period (zone VIII). The outstanding feature of the transition between the Atlantic and Sub-boreal periods is the abrupt decline of the *Ulmus* curve. In both the Tåkern and Dagsmosse diagrams there are very distinct declines characterizing the zone boundary VII/VIII. Simultaneously with the *Ulmus* fall there is a regression of *Tilia.* This is especially marked in Dagsmosse. In Tåkern, where the *Fraxinus* curve is continuous for a long time, there is a clear increase of *Fraxinus* a little above the zone boundary. In Dagsmosse the *Fraxinus* curve is irregular and low until the short-lived but remarkably high maximum at 2.95 m. depth with which there is no equivalent in Tåkern. The striking contrast between the two diagrams is, however, the rise of the *Quercus* curve in the Dagsmosse diagram and its decline in the Tåkern diagram contemporaneously with the *Ulmus* decline.

In the special diagram (Fig. 3) it is evident that the mixed oak forest had at least the same importance as it had during the Atlantic period. But in the Tåkern diagram this is mainly due to high *Quercus* values. In the Dagsmosse diagram the *Quercus* and *Tilia* curves dominate alternately. This difference between the diagrams in the later Atlantic and the whole of Sub-boreal time has already been mentioned (p. 32). One possible cause is thought to be local differences in the forest composition depending on different soil or ground water conditions or other edaphic factors. In the low-lying areas around Lake Tåkern *Quercus* may have been more usual than *Tilia* (cf. Iversen 1960, p. 11 and 19) but on Mt. Omberg and its eastern slopes the conditions were more favourable to *Tilia.* In the Sub-boreal period it is also possible that *Quercus* to a certain degree was selectively favoured by the inhabitants.

The *Ulmus* curve is considerably lower in both diagrams in this period than in the preceding one. In the Tåkern diagram the frequency of *Fraxinus* is higher than in the Dagsmosse diagram throughout this period but nevertheless rather low. The maximum value is only 1.0 per cent, reached a little above the zone boundary. The course of the *Fraxinus* curve is, however, in general inverse to that of *Ulmus,* which may mean that *Fraxinus* partly replaced *Ulmus* on damp, fertile boulder-clay. Records of *Acer* are rather rare in these analyses, but they show that *Acer* must have been present in the forests of this area.

During the greater part of the Sub-boreal period *Betula* and *Pinus* were not much more important than in Atlantic time, but towards the end of the Sub-boreal period the frequency of pine pollen increased considerably when the deciduous forest trees retreated.

Pollen finds of *Carpinus* and *Fagus* are scarce during this period but in its later part they had obviously established themselves in the area. This is argued from the fact that these trees have poor pollen dispersal and the presence of pollen values at all must indicate their existence.

The frequency of *Picea* pollen increases slowly with some shortlived, low maxima of only a few per cent. The courses of the *Picea* curves in all three diagrams from the area are very similar and it seems therefore possible to use the maxima for correlation purposes for a pollen-analytical dating of the settlement period in the pile-dwellings at Alvastra (see the last chapter of this paper). *Picea* was until the transition to the Sub-atlantic period, rather rare in this area. In the culture layer at Alvastra, a piece of a twig of spruce has, however, been found (Berggren 1956, p. 105) indicating that this tree really grew in the neighbourhood already when the pile-dwellings were inhabited.

The *Ulmus* fall opening the Sub-boreal period has been much discussed and several different interpretations offered. The present investigation does not solve the problem but as it is of some interest in connection with this investigation it will be briefly discussed. The different opinions are thoroughly elucidated by Iversen (1960) and Troels-Smith (1960).

Iversen (1941) fixed the zone boundary VII/VIII where the *Ulmus* and *Hedera* curves begin to decline. *Fraxinus* often increases at the same time. Iversen suggested this event to be due to a change to a more continental type of climate. He based his opinion on the high frequencies of *Hedera* and *Viscum* in the Atlantic period in Denmark and still rather high frequency of *Viscum* in the Sub-boreal period (Iversen 1944). Iversen traced another distinct and later decline of *Ulmus* together with declines of *Quercus, Tilia* and *Fraxinus* and contemporary rises of the *Betula, Alnus* and *Corylus* curves. This change in the forest composition he considered to be the result of the well-known land occupation (*Landnam*) phase marked by extensive forest clearings for pasture and cultivation.

This interpretation of the latter event is almost generally accepted but the difficulties in applying this theory and tracing the course of events in an area so near Denmark as Scania have been discussed earlier (T. Nilsson 1948, p. 40—49; Magnusson 1962, p. 51—53).

The interpretation of the first distinct *Ulmus* fall is the object of considerably more opposing opinions. Iversen's interpretation of it as being climatologically conditioned is supported by several workers. The other important opinion is that the *Ulmus* fall was caused solely by human activity. It was first hinted at by Fægri (1940, p. 122) who considered that in Jæren, in southwestern Norway, the *Ulmus* fall could hardly be attributed to climatological causes, as the climatic optimum there is thought to have occurred in the Sub-boreal period. Thus, he explained the *Ulmus* fall as a result of harvesting of the leaves of the elms by human beings. Later on, Troels-Smith (1953 and other papers) has further developed this theory by applying it to Danish and Swiss pollen diagrams. Very important in this respect are indications of cultivation revealed by records of cereal pollen before the land occupation phase in Iversen's sense. This earliest form of agriculture is ascribed to people belonging to the Ertebølle culture, while clearings connected with the land occupation were made by an immigrant people, the shepherds.

These primitive farmers not only cultivated cereals, they also had oxen and sheep (Troels-Smith 1960, p. 23). An important element supporting the opinion of human influence on the forest is that the oxen were kept in stalls during the greater part of the year and the cattle mainly fed on leaves. In the first place the people pollarded the elms but also ash, lime, hazel etc. (Troels-Smith 1960, p. 23). The cause of the more pronounced decrease in the frequency of Ulmus pollen rather than of other trees is that the pollarded elms are prevented from flowering for a longer time than other trees.

As earlier stated (Magnusson 1962, p. 53—56) this related interpretation of the Ulmus fall seems improbable in some respects. The *Ulmus* fall seems to occur throughout all northwestern Europe and is apparently synchronous. Even if leaves were collected over areas several km^2 in extent as is said to have been done in Switzerland (Troels-Smith 1955, p. 40), this does not seem to be enough to cause this general decline of the elm frequency in areas with a low population density at the time (cf. Watts 1961, p. 35).

Nor is the necessity of stall-feeding all the year apparent. Indeed there was undoubtedly too little grass vegetation in the primeval forests for pasturing cattle, but it must have been possible for the cattle to graze and browse on other types of natural vegetation, e.g. in marshes around fens and lakes. In northernmost Sweden, where cattle still graze freely along the roads, they are often seen to make excursions into grass-grown mires besides the roads. But even when allowing for grazing, the addition of leaves to the fodder was perhaps necessary.

Troels-Smith's earlier opinion (1954, 1955) that the leaves of elms are decidedly superior to those of other tree types as cattle fodder, seems to be a rather weak link in his argument. Recently he has modified this opinion a little by saying that elm and ash are always the most valuable trees (Troels-Smith 1960, p. 26).

In Sweden there is much information in the literature concerning the pollarding leaves for fodder (cf. Magnusson 1962, p. 54—55). The list, in order of value, is approximately as follows: firstly ash, aspen, sallow, and birch (the three latter mainly for sheep and horses); secondly elm and hazel. Also the leaves of horn-beam (*Sorbus intermedia*) were highly appreciated, when present. The hazel was not much used for cropping as the hazelnuts were valuable to the people. An example of this is found in the settlement layer at Alvastra, which is often very rich in nut-shells.

If, as Troels-Smith suggests, the elms were more pollarded for their leaves than other trees, this could naturally cause a decline of the elm frequency. It seems improbable, however, that the ash was less used for this purpose by the Neolithic people, as it has always been considered more valuable, at least until recent years. Selander (1957, p. 320) emphasizes that the ash was specially favoured and was in many places planted in meadow glades (= *löväng* in Swedish). These consist of lightly wooded areas with deciduous trees and were mainly utilized for hay and pollarding. They were common in Sweden until recent time. Thus, the fact that pollarded twigs of ash are prevented from flowering for only 2—3 years but of elm for as much as 7—8 years, cannot satisfactorily explain why the frequency of *Fraxinus* pollen is higher in the Sub-boreal period than in Atlantic time, while the *Ulmus* frequency is lower. It seems to be more probable that the climate could cause such a development.

Troels-Smith (1960) suggested that the *Hedera* decline contemporaneous with the *Ulmus* fall as well as the lower frequency of *Viscum* in the Sub-boreal period were due to human activity. Very high percentages of *Hedera* pollen in culture layers in the Swiss sites investigated have been interpreted as indicating the use of flowering ivy as fodder for cattle.

In all three diagrams from the Alvastra region the numbers of *Viscum* pollen are very small (and of *Hedera* still smaller). But in one analysis from the culture layer at Alvastra there was found as much as 3.1 per cent *Viscum* pollen. The high *Tilia* curve at the same time in the Alvastra diagram shows that there was no lack of host trees in the neighbourhood of the dwelling-place and considering the fact that *Viscum* sometimes grows on sallow, the plants may have grown rather near the dwelling-place. The distance to the nearest morainic hill is only about a hundred meters and between this and the mire proper there was at that time a zone with alder fen (cf. von Post 1916, p. 241) where sallows most likely occurred. The *Salix* pollen curve is generally high in this part of the diagram but not in the samples with the highest frequency of *Viscum* pollen, strangely enough. Anyhow, this high percentage of *Viscum* may have a natural explanation. The first thought, however, when analysing this sample series was that the inhabitants of the pile-dwelling had collected and brought home flowering *Viscum* plants for some purpose, e.g. ritual. It cannot be excluded, however, that twigs or whole plants of mistletoe were collected for cattle fodder. As mistletoe flowers in spring, high pollen values of it in connection with fodder collecting are just probable. In spring, before the trees burst into leaf, the mistletoe may have been especially valuable for that purpose.

Sub-atlantic period (zone IX). The development during the Sub-atlantic period is best seen in the Dagsmosse diagram because the rather thick peat layer deposited during the period gives drawn-out and complete pollen curves up to recent time.

The transition between the Sub-boreal and Sub-atlantic periods coincides in Dagsmosse with a clear humification limit of the *Sphagnum* peat, and most likely corresponds to Granlund's RY III. Characteristic for this level are the rise of the *Picea* curve and decline of the *Alnus, Corylus,* and QM curves. Increasing *Picea* values are in this case considerably more evident in the Dagsmosse diagram (from about 5 per cent to about 20 per cent) than in the Tåkern diagram (from a few per cent to about 5 per cent). This difference would be connected with the location of the boring point in the southwestern part of Lake Tåkern. Spruce pollen grains are most likely more numerous in the sediments in the northeastern part of the lake because of the prevailing winds. At Alvastra the rise of the *Picea* pollen curve is insignificant owing to more local pollen dispersal of other trees.

The rather high frequency of *Picea* pollen at the beginning of the Sub-atlantic period indicates that spruce had then already spread to the vicinity of the investigation area and probably spruces grew on Mt. Omberg.

The mixed oak forest consisted almost solely of *Quercus* already in early Sub-atlantic time and *Quercus* was even more predominant in later time, even if the frequency of this tree also declined more and more. In the early part of the period there was, evidently a richer occurrence of *Quercus,* as is shown by the maximum between 1.40 m. and 1.55 m. in Dagsmosse. Such an early Sub-atlantic rise of the *Quercus* curve has also been noted in southwestern Sweden (cf. Fries 1951, p. 149), where it is supposed to have been due to expansion of *Quercus petraea* (von Post 1924, p. 96). It is just possible this is the case here although the species does not now occur in western Östergötland but rarely in the southern part of the province (cf. Hultén 1950, map no. 601).

At 1.40 m. depth in Dagsmosse there is another humification change of the *Sphagnum* peat which possibly — but not with certainty — may be a recurrence surface. At this level there is a new and considerable increase of the pollen values for *Picea,* which can most likely be correlated with the index horizon b in western South Sweden (Fries 1951, p. 58) and as a consequence of this may also be correlated with Granlund's RY II (c. 300 A.D.). At the same time the QM curve declines even further. The frequency of *Quercus* shows a slight increase a little above this level but the curve for *Fraxinus, Tilia* and *Ulmus* ceases to be continuous from about this time. Both the Tåkern and Alvastra diagrams finish at or a little before this event.

Fagus and *Carpinus* increase at the zone boundary VIII/IX and continue with almost continuous curves throughout the period. *Carpinus* reaches its highest pollen values already in early Sub-atlantic time while the frequency of *Fagus* is highest in the very last part. The maximum values are never more than two per cent of either of them even in Dagsmosse but they were probably more common in the area, especially on Mt. Omberg, than they are to-day.

The *Pinus* curve rises considerably at the Sub-boreal — Sub-atlantic transition and this coincides with the second marked rise of the *Picea* curve at 1.4 m. depth in Dagsmosse. The frequency of *Betula* is rather high throughout the period but shows several fluctuations. The courses of the *Alnus* and *Corylus* curves are very similar and they decline gradually up to recent time, the pollen values of these trees now being unimportant.

It is obvious that the change in the forest composition at the supposed RY II was even more important than the changes at the zone boundary VIII/IX. From that time the forests were of about the same type and composition as they are now. This is also shown by the fact that *Juniperus* pollen is more common than earlier, except in early Pre-boreal time, but the frequency does not reach more than a few per cent. Because of the possibility that the number of juniper pollen observed may be affected by the different methods of treating the samples for concentration of the pollen, no curves for it have been drawn.

Evidence of prehistoric agriculture

The interpretation of the *Ulmus* fall at the Atlantic—Sub-boreal transition as a possible result of human interference has been discussed in the preceding chapter. The first certain traces of human activity in this area are, however, the first occurrence of pollen grains of plants indicating cultivation or pastures, e.g. of cereals or *Plantago major* and *lanceolata,* and also increased frequencies of plants which are favoured by such activities, e.g. *Artemisia, Rumex* cf. *acetosella* and *Pteridium aquilinum.*

The first pollen grains of cereals are recorded from the very oldest part of zone VIII in Tåkern and Alvastra (except for the uncertain zoning of the Alvastra diagram). In Tåkern a pollen grain of *Triticum* type was found and at Alvastra one of *Hordeum* type. In Dagsmosse, cereal pollen does not occur until the later part of zone VIII and then with a very low frequency. From this zone, corresponding to the Neolithic period of the Stone Age and the Bronze Age, the only types of cereal pollen recorded are of *Hordeum* and *Triticum,* grains of the former being more numerous. Some pollen grains are not exactly determined but in general belong to one of these genera except a few pollen grains from the later part of the period which probably are of *Avena* type. The size limit between cereal pollen and pollen of other *Graminae* has been drawn at 44 μ which practically no pollen grains of wild grasses reach (cf. Beug 1961, p. 30—31). The reverse is, however, possible: pollen grains of *Panicum miliaceum, Triticum monococcum* and of some cultivated *Avena* species can be determined as wild grass pollen. Beug (1961, p. 31) considers the lower size limit of 37 μ to be suitable if all cultivated species of *Triticum* and *Avena* are to be included in the cereal pollen sum.

It is clear from investigations of the cereal impressions in prehistoric earthenware (Hjelmqvist 1955) that naked barley was considerably more cultivated than other cereals in the Early Neolithic Period. In the Middle Neolithic Period the most important cereal in cultivation was small spelt (*Triticum monococcum*), then emmer (*Triticum dicoccum*) and naked barley. There are also several impressions of chess (*Bromus secalinus*), which is also considered to have been cultivated. From the Late Neolithic Period the impressions in earthenware are rather few but are dominated by emmer.

From the Alvastra dwelling-place, archaeologically dated to the Middle Neolithic Period, Hjelmqvist (1955, p. 31—33) apparently investigated only a little material, partly carbonized cereal grains, partly impressions showing the occurrence of both naked and hulled barley and of small spelt. The impressions are, however, only of naked barley. Berggren (1956) investigated a large number of fruits and seeds from Alvastra, and pointed out that most of the barley grains found there were not naked. Of 315 barley grains examined 285 were evidently of the hulled, six-rowed type and so were at least most of the rest (Berggren 1956, p. 100). Other cereals at Alvastra include wheat and possibly rye (two carbonized grains) and oats (only fragmentary glumes).

In the bored profile at Alvastra the total number of cereal pollen grains recorded from the culture layer is 43. Of these 21 belong to the *Hordeum* type, 13 to the *Triticum* type and 9 are undetermined but agree with the *Hordeum* type with the possible exception of one of the *Avena* type and one of the *Elytrigia repens* type. In an additional analysis of a sample from the lower part of the culture layer taken in the wall of a little dug pit there were found as many as 2511 cereal pollen grains (with only 351 tree pollen grains) of which 2087 were of *Hordeum* type, 312 of *Triticum* type, 101 of *Hordeum* or *Triticum* type, 10 of *Elytrigia repens* type and possibly one of *Avena* type.

In the *Hordeum* type are, however, included not only the different species of *Hordeum* but also several species of the genera *Glyceria, Bromus* and *Agropyron* and partly also the pollen of *Secale cereale* and *Triticum monococcum* (Beug 1961, p. 40). Thus the pollen grains of the last mentioned species may be assigned to the *Triticum, Hordeum* or wild grass types. As small spelt is shown to occur in the Alvastra culture layer (Hjelmqvist 1955, p. 32) it is possible that some pollen grains of especially the *Hordeum* type come from that cereal.

In the remaining samples from the Neolithic Period and from the Bronze Age few cereal pollen grains are recorded. They are mainly of the same types and have the same distribution as in the culture layer but in the sample from 2.15 m. depth in Dagsmosse one certain pollen grain of *Avena* type was observed.

The zone boundary VIII/IX corresponds approximately to the transition between the Bronze Age and the Iron Age (cf. Fries 1958, p. 25, 38). In the portion between the zone boundary and the beginning of the *Secale* pollen curve the *Hordeum* type evidently predominates over the *Triticum* type, which agrees with the finds of impressions in earthenware from the Early Iron Age in Östergötland (Hjelmqvist 1955, Tab. 12).

When the cultivation of rye began in Sweden is not entirely clear, but it has generally been supposed that the rye was introduced into Sweden at about the same time as into Denmark, i.e. in the first century A.D. (Helbæk 1938, p. 220). Hjelmqvist (1955, p. 106, 142) assigns some impressions of rye found in Västergötland to the Early Iron Age, one of which is certainly dated to the Pre-roman Period. He concludes that rye probably came to Sweden not from the south through Scania but perhaps from the east. The earliest impressions dated with certainty in earthenware from Östergötland are, however, not older than from the Viking Period (c. 800—c. 1000 A.D.) and there are only two possibly older impressions, one of which may be from the Early Iron Age, i.e. from Pre-roman or Roman Periods (Hjelmqvist 1955, Tab. 12).

Helmfrid (1958) has investigated the Sub-atlantic development in an area located only about 5.5 km. NE of Lake Tåkern. Here the beginning of the *Secale* pollen curve was radiocarbon dated. As the sample consisted of a lake sediment, the result, 120 $\pm$ 110 years B.C., is considered to be a little too high and Helmfrid (1958, p. 251) considers the lower limit to correspond to the beginning of that curve, i.e. about the time of the birth of Christ.

In Dagsmosse the *Secale* curve begins a little above the humification change supposed to be the same as Granlund's RY II, dated at about 300—400 A.D. (Granlund 1932). The formation of the peat layer about 70 cm. thick between RY III and the beginning of the *Secale* curve may be roughly estimated to have taken 800—1000 years, which gives about the same result. Thus, rye was probably not cultivated in the vicinity of Dagsmosse until the later part of the Roman Period (0—c. 400 A.D.). The radiocarbon dating of the recurrence surface here supposed to be RY III, which gave an age of c. 700 A.D. (see p. 41), would, however, date the *Secale* curve as to having begun in the Middle Ages.

In the earliest part of the Sub-atlantic period there is a clear preponderance of *Hordeum* pollen over *Triticum* pollen but at the rise of the cereal pollen curve at 1.55 m. depth in Dagsmosse the relation of these pollen types is changed. From about the time of the beginning of the *Secale* curve *Triticum* is evidently predominant over *Hordeum*. This condition does not agree very well with the results of the investigation of cereal impressions in earthenware, which show a strong predominance of *Hordeum* during the whole Iron Age (Hjelmqvist 1955, Tab. 18). In this portion there are also some pollen grains of *Avena* type and *Elytrigia repens* type. In the samples from Dagsmosse six pollen grains of *Centaurea cyanus* were found of which the oldest one occurs at the beginning of the *Secale* curve.

Radiocarbon datings of samples from Dagsmosse

In 1963 two sample series were taken in Dagsmosse at the earlier boring-point. The samples were submitted to the Stockholm Radioactive Dating Laboratory. Most of them do not concern the main purpose of this investigation but are of more general interest. The results of the second series in which the samples were pre-treated in order to remove the humus, are given in the following list:

1. Recurrence-surface at 1.99 m., sample taken at 1.95—1.99 m.	St-1373	670 ± 125 A.D.
2. The rise of the *Picea* curve (2.2—2.25 m.)	St-1374	190 ± 70 B.C.
3. Transition *Sphagnum* peat — pine forest peat (2.58—2.60 m.)	St-1375	1175 ± 105 B.C.
4. Recurrence-surface (?) at 2.84 m. (2.8—2.84 cm.)	St-1376	1210 ± 105 B.C.
5. Zone boundary VII/VIII (sample taken just above the boundary)	St-1377	2580 ± 80 B.C.
6. The rise of the *Tilia* curve (4.52—4.57 m.)	St-1347	4290 ± 80 B.C.
7. The rise of the *Alnus* curve (sample taken about 5—10 cm. above the first marked rise)	St-1378	5635 ± 130 B.C.

All these dates are somewhat or in some cases considerably lower than expected. The recurrence-surface dated by sample no. 1 was supposed to correspond to Granlund's RY III but with this dating and taking into consideration modern conceptions about the formation of recurrence-surfaces (Conway 1948; cf. Magnusson 1962, p. 32) and the fact that recurrence surfaces are shown to be not synchronous in one and a same bog (Lundqvist 1962, p. 8—10) it cannot be excluded that this actual recurrence-surface corresponds to a younger one than RY III. In the bog Snöromsmossen, situated south of Stockholm, which is the classical raised bog in Granlund's studies of recurrence-surfaces, the most marked of these is RY II (Granlund 1932, Fig. 51). Recently a sample from this RY in Snöromsmossen has been radiocarbon dated at about 700 A.D. (Möller 1964, Fig. 50 b). Granlund's RY III in that bog is hardly seen but the rather well-marked RY IV, radiocarbon dated at about 700 B.C., is considered to correspond to the classical *Grenzhorizont* (Möller 1964, p. 122 and Fig. 50 b). Thus, it is possible that the most marked recurrence-surface in Dagsmosse at 1.99 m. depth may correspond to RY II instead of RY III.

The change in huminosity at 2.15 m. and a little above the first marked rise of the *Picea* curve, dated by sample no. 2, may consequently correspond to Granlund's RY III. The datings of this sample means, however, that the expansion of the spruce was rather late in this region and does not agree with the conception that the first expansion of spruce in NW Götaland took place about 1000 B.C. (cf. Fries 1951, p. 150).

The ages of samples no. 3 and no. 4 show too little difference with regard to their position in the succession of strata. It seems probable that especially the dating of no. 4 is far too low.

The zone boundary VII/VIII has been dated in samples from three other places in Sweden: Mogetorp near Katrineholm in Södermanland, Kroppsjön and Spånsjön near Varnhem in Västergötland. From Mogetorp three samples were dated (U-16, U-17 and U-27) giving ages of about 3250—3400 ± 100 B.C. (Florin 1958, p. 60; Olsson 1959). The sample dated from Kroppsjön (U-12) gave the result 3330 ± 110 B.C. and from Spånsjön (U-14) 3630 ± 110 B.C. (Fries 1958, p. 40; Olsson 1959).

Of interest may also be datings of the corresponding zone boundary in Great Britain (VII a/VII b, Godwin) and in Ireland (VII/VIII a, Watts). From England may be mentioned a dating from Scaleby Moss (Q-171), which gave an age of 2970 ± 134 B.C. (Godwin and Willis 1959) and from Scotland one from Flander's Moss (Q-578), which gave 3140 B.C. (Godwin and Willis 1962).

Compared with these results the dating of the zone boundary VII/VIII in Dagsmosse is most likely too young. As the sample is taken just above the boundary, the difference may be estimated to be at least 200—300 years.

The marked rise of the *Tilia* curve characterizing the zone boundary VI/VII has not apparently been previously radiocarbon dated in Sweden, but by other methods it is dated at about 5000 B.C. (cf. Florin 1944, Pl. IX). From Scaleby Moss in England a sample (Q-165) from the corresponding zone boundary is radiocarbon dated at 5470 ± 350 B.C. (Godwin and Willis 1962).

The marked rise of the *Alnus* curve is geochronologically dated in Ångermanland, North Sweden, at about 6300 B.C. (Fromm 1938). It is, however, possible that the rise there is caused by a different *Alnus* species (*A. incana*) to that in southern Sweden (*A. glutinosa*). From South Sweden may be mentioned three radiocarbon datings of the *Alnus* rise: from Långared in Västergötland (St-173 6545 ± 110 B.C., Degerfors in Närke (St-217), 6925 ± 120 B.C. (Östlund 1957), and from Kroppsjön in Västergötland (U-11), 7920 ± 110 B.C. The latter is, however, considered to be 1000—2000 years too old. Probably the two mentioned datings of the zone boundary VII/VIII from Kroppsjön and Spånsjön are too high, possibly because of the calcareous ground-water in this region (Fries 1958, p. 40).

It is hardly possible to trust these datings from Dagsmosse entirely. As seen above, when they are compared with other results, they indicate that the values are about 500 and in some cases perhaps as much as 1000 years too low. The cause of this is unknown but it seems probable that some common factor is responsible.

The age of the pile-dwelling

The dwelling-place at Alvastra is archaeologically dated to the Middle Neolithic period (c. 2300—c. 1800 B.C.). This age is confirmed by two radiocarbon datings, one of a wooden pile from the pilework, 4210 ± 150 B.P. (St-9),

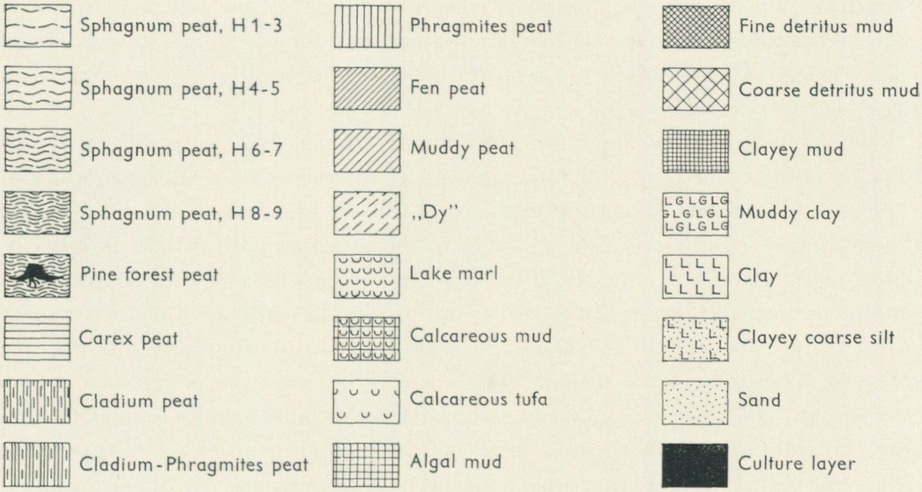


Fig. 5. Stratigraphical symbols used in the diagrams.

and one of peat from the corresponding culture layer, 4090 ± 230 B.P. (St-15) which gave an average age of c. 2225 ± 130 B.C. (Östlund 1957).

The two diagrams from Dagsmosse and Alvastra are rather difficult to connect using pollen analytical methods. Allowing for errors in the correlation the level 2.40 m. in Dagsmosse seems, however, to correlate 0.70 m. in Alvastra because of the *Tilia* maximum at the beginning of the *Picea* curve. The first part of the *Picea* curve in the Alvastra diagram is probably apparently closed, because there must be a gap in the growth of the mire, as seen from other curves, between the culture layer and the overlaying *Cladium* peat (cf. von Post 1916, p. 241). Thus, the apparent beginning of the *Picea* curve at 0.80 m. seems to correlate with level 2.75 m. in Dagsmosse and the beginning of the settlement at the dwelling-place at a level of 3.0 m.

Samples nos. 3 and 4 were specially taken for dating the culture layer at Alvastra. They are, however, of only little value for this purpose. It is also possible that the age of no. 3 is too low, as several of the other samples seem to point in that direction.

Sample no. 3 is taken at a depth in Dagsmosse corresponding to a level at Alvastra a little above the culture layer. According to the radiocarbon dating this means that the settlement at the pile-dwelling finished at about 1100—1200 B.C.

The beginning of the settlement can now only be estimated with the help of the age for the *Ulmus* decline, which is dated to c. 2600 B. C. Between the *Ulmus* decline and the level corresponding to the beginning of the settlement 40 cm. of medium humified *Sphagnum* peat and about 5 cm. *Carex* peat were formed.

The formation of these peat layers may be estimated to have taken at least 500 years. This means that the settlement period would have been between about 2000—2100 B.C. and about 1100—1200 B.C., a dating which does not at all agree with the archaeological one.

The discussion of the age of the dwelling-place may also be based on Granlund's recurrence-surfaces and their ages. If the marked change in huminosity at 1.99 m. is considered to correspond to RY III, which seems to be most likely, the changes at 2.15 m. and 2.84 m. ought to be correlated with RY IV and RY V dated at c. 1200 B.C. and c. 2300 B.C. respectively (Granlund 1932). The settlement probably began 200—300 years before the time of the development of RY V, i.e. about 2500—2600 B.C. It finished at about the same time as pine forest peat began to be formed in Dagsmosse. The formation of the peat layers between RY IV and V would evidently have taken about 1100 years of which the formation of the pine forest peat may be estimated to have taken about 600—700 years and then there are about 400—500 years left for the peat layers between 2.57 m. and 3 m., a value which seems rather probable. The result of this very rough dating is that the habitation period is to be placed somewhere between c. 2500—2600 B.C. and c. 1800—1900 B.C. This age agrees better with the archaeological dating but means perhaps that the settlement period in the mire was too long. It rests, however, on a very uncertain basis.

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BGIU = Bulletin of the Geological Institution of Upsala
DGU = Danmarks geologiske undersøgelse, Copenhagen
GFF = Geologiska Föreningens i Stockholm Förhandlingar, Stockholm
KVA = Kungl. Vetenskapsakademien, Stockholm
MDGF = Meddelelser fra Dansk Geologisk Forening, Copenhagen
SBT = Svensk Botanisk Tidskrift, Uppsala
SGU = Sveriges geologiska undersökning, Stockholm

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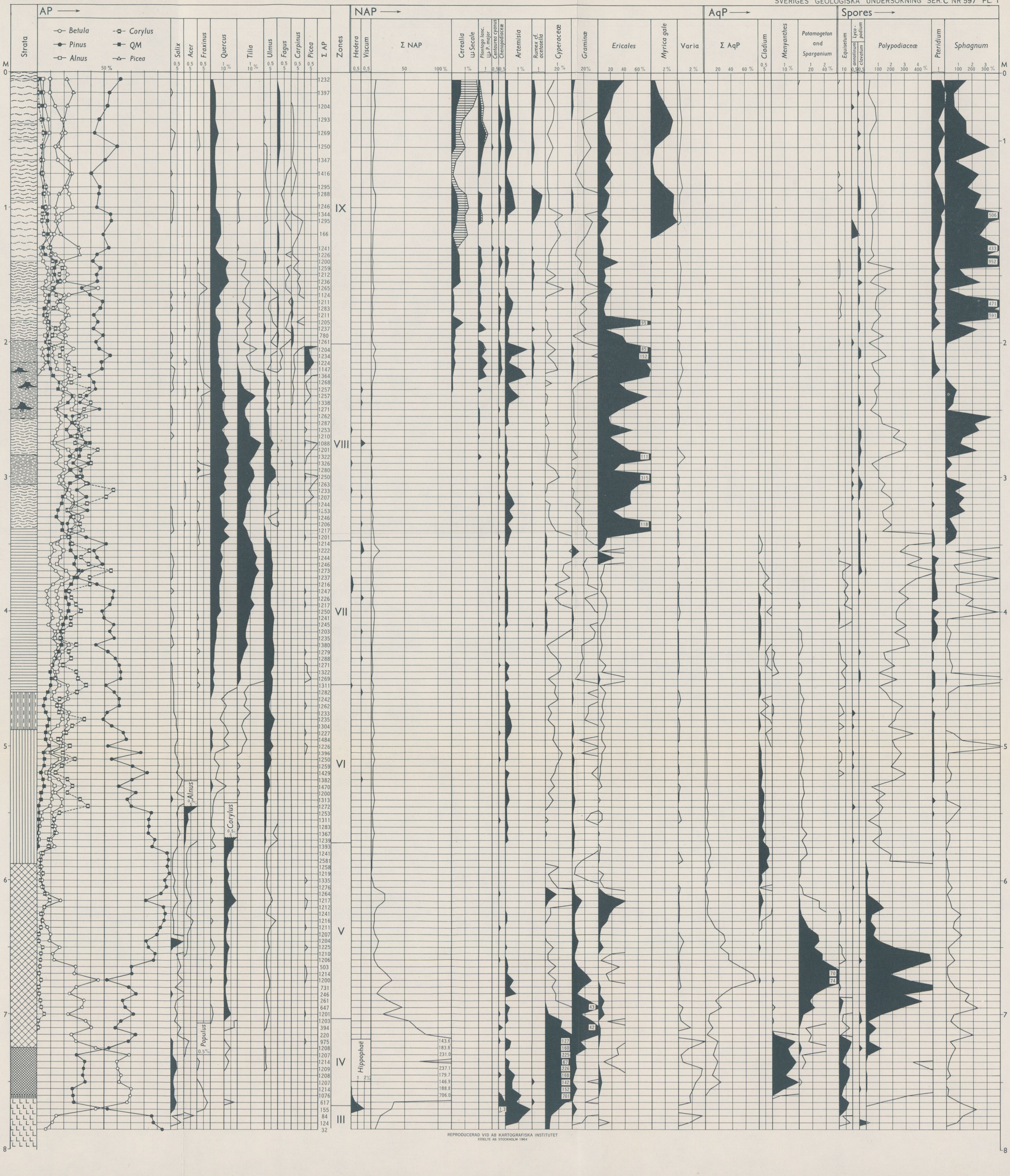
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Carpinus
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III
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NAP
Hedera
Viscum
Σ NAP
Cerealia
Secale
Plantago lanc.
P. major
Centaurea cyanus
Chenopodiaceæ
Artemisia
Rumex cf. acetosella
Cyperaceæ
Gramineæ
Ericales
Myrica gale
Varia
AqP
Σ AqP
Cladium
Menyanthes
Potamogeton and Sparganium
Spores
Equisetum
annotinum
clavatum
Lycopodium
Polypodiaceæ
Pteridium
Sphagnum
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