POLLEN ANALYTICAL INVESTIGATIONS IN THE NORTHERN NETHERLANDS
WITH SPECIAL REFERENCE TO ARCHAEOLOGY

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CONTENTS

I. INTRODUCTION

For many years already there has been a close co-operation between archaeology and palynology. This co-operation is particularly concerned with the investigation of archaeological objects—sometimes even complete settlements—which were discovered in the peat. With the help of archaeologically well datable finds it was possible to obtain a dating of some parts of the pollen diagram and of stratigraphical phenomena as the recurrence surfaces in the Swedish raised bogs. Next, objects which were archaeologically not datable, viz. trackways and peat burials, could be dated more or less accurately by means of pollen analysis. In the last few years, moreover, attention has been paid to the pollen analytical investigation of samples from burial monuments. It was WATERBOLK who worked out this method, and who attained important results.

In this investigation much stress is laid on the correlation between archaeological and scientific phenomena. In this connection it was in the first place of much importance to have the disposal of a detailed diagram from a large raised bog whose pollen content cannot have been influenced to a great extent by local conditions. From this diagram reflecting the vegetation development in a given region alterations of the vegetation effected by climatic changes or human interference can be read. Moreover, by means of such a diagram other pollen analytical data from that given region—which have often been influenced by local conditions—can be compared better with those from other regions.

In order to be able to compare accurately the results of the palynological investigation of burial monuments with the results of the peat investigations, it was necessary to know what part of the diagram corresponds with the Neolithic, Bronze Age and Iron Age respectively. The pollen analytical investigation of some Dutch finds from raised bogs and that of other—already published—finds from north-west Germany and Denmark could procure the data for an archaeological dating of the pollen diagram.

The study of the raised bog from south-east Drente led naturally

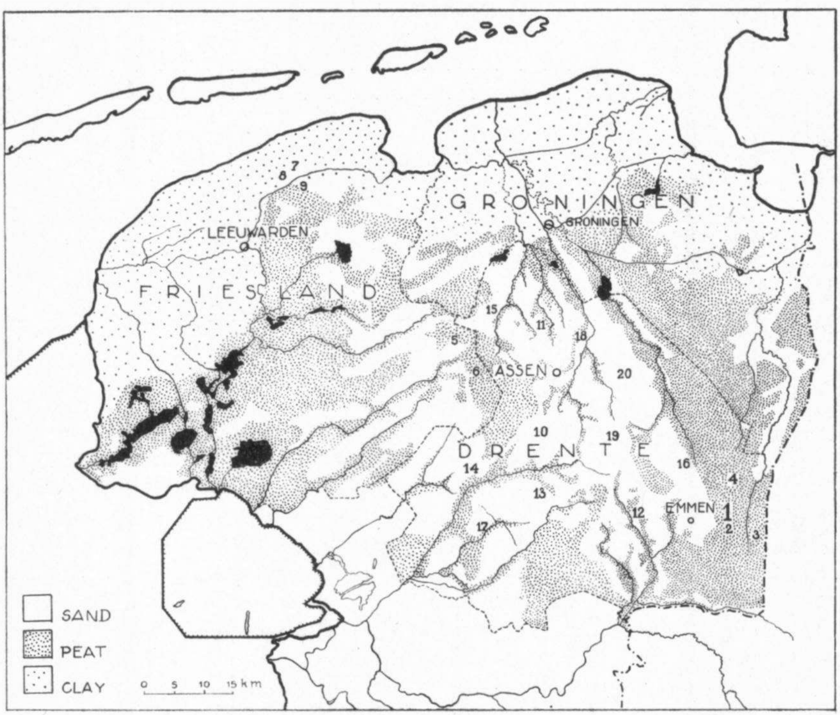

Fig. 1. Map of the northern Netherlands showing the localities referred to in this paper.

1, Raised bog near Emmererfscheidenveen. 2, Bronze dagger near Bargeroosterveld. 3, Roman coins near Bargercompascuum. 4, Bronze find of Roswinkel. 5, Late-glacial deposits near Haule. 6, Raised bog near Fochteloo. 7, Peat covered by marine clay near Lichtaard. 8, Peat covered by marine clay near Jislum. 9, Peat covered by marine clay near Klaarkamp. 10, Barrow cemetery near Hijken. 11, "Noordse Veld" near Zeijen. 12, Anglo-Saxon cemetery near Zweeloo. 13, Barrow cemetery near Wijster. 14, *Hunebeds* and tumuli in the vicinity of Diever. 15, *Hunebed* near Steenbergen. 16, *Hunebed* near Exloo. 17, Tumulus near Ruinen. 18, Tumulus near Oudemolen. 19, Tumulus near Schoonloo. 20, Tumuli near Eext.

to an examination of the pollen analytical position of the so-called *Grenzhorizont.* During the last few years opinion has greatly differed on the dating of the *Grenzhorizont* which has often been used to date archaeological objects lying not far below or above this contact surface.

In connection with the view held by some authors that there would be a correlation between the height of the sea level and the peat formation, an investigation into the flooded peat layers from the coastal region of the northern Netherlands was desirable. On account of the fact that from the coastal region of the province of Groningen no suitable profiles could be obtained, this part of our study, however, remained very incomplete.

II. GENERAL METHODS

Sampling technique

a. Peat samples. As in most cases peat walls showing good sections were available, and in some others it was possible to dig a hole in which the stratigraphy could be noticed, the use of a peat borer could nearly always be avoided. In general a complete or partial profile was sampled in sample tins. These tins have a length of 30 cm, a breadth of 3 cm and a depth of 3.5 cm. Mostly it is rather easy to push them into the peat wall, and by sticking a spade or knife behind them the tins are recovered filled with peat. In this way a profile can be "tinned" without much difficulty in a short time. By pinching a strip of parchment paper between the tin and the lid the drying up is highly reduced, so that the contents will remain moist for a long time.

b. Sand samples. This method cannot be recommended for collecting sand samples. The layer which has to be investigated, *e.g.* the old surface level or a sod of a barrow, is mostly not thicker than one or a few cm. In the field such a humous layer can easily be recognized, and the profile section with the layer in question could be sampled in the way described above. As, however, in spite of precaution the sand in the tins dries up quickly, it becomes very difficult to recognize afterwards the humous layer in the tin. It is for that reason that always in the field only the layer in question was sampled, and that no complete or partial profile was collected. If the layer was thicker than 1 cm always the uppermost cm was sampled, so that corresponding layers could be compared. For a detailed description concerning the sampling of barrows etc. we may refer to Waterbolk (1954*b*, Chapter IV).

Preparation of samples

The samples for pollen analysis were prepared according to the method described by Faegri and Iversen (1950, pp. 62–3). This method is a modification of the acetolysis method introduced by Erdtman and Erdtman (1933), and which in course of time has been improved (*cf.* Erdtman, 1943). Staining was carried out by boiling in a water bath the residue to which a weak KOH solution and some drops of safranin were added. The quantity of safranin to be added depends on the nature of the sample. If after acetolysis there is much dye adsorbing material, *e.g.* charcoal or certain remains of plants, of course, more stain has to be supplied than in the case that practically only the pollen grains are stained. An overstaining can be improved by washing out with a weak alcoholic solution.

Although after acetolysis most pollen grains can be easily recognized without staining, a good staining is not superfluous as otherwise the risk to overlook the small, thin-walled pollen grains is not imaginary. Especially in preparations of sand samples in which the fragile pollen grains are often badly damaged a good staining proved to be very useful.

All sand samples were treated with HF as only decanting appeared to be insufficient.

Preservation of preparations

The preservation of the counted slides is not well possible. In spite of sealing the cover-glass by a sealing wax air very often enters, especially if under the cover-glass some larger particles are present, which is nearly always so with preparations of sand samples. It is for that reason that not the counted slides but the unused part of the preparation liquid is preserved. Small glass tubes (contents about 0.5 cc) which can be closed by a rubber stopper are very suitable for this purpose. These tubes can be stored in perforated wooden blocks.

Diagrams

a. Composition. The published diagrams are a combination of the composite and the dissolved type of diagram. The curves for *Ulmus*, *Tilia*, *Fraxinus*, *Fagus* and *Carpinus* whose pollen occurs in relatively low percentages in the peat deposits from the northern Netherlands are reproduced on an enlarged scale in an auxiliary diagram. Otherwise the often characteristic course of these curves would not show up. Concerning the herbaceous pollen the curves for *Gramineae*, *Cyperaceae* and *Ericaceae* are also reproduced in an auxiliary diagram, while the other herbaceous types and the spores are represented by means of partial diagrams, just as the pollen of *Hedera*, *Picea*, *Acer*, *Myrica*. [1] *Populus*, *Humulus* and sometimes of *Salix*.

The results of the analysis of the samples from barrows and other archaeological objects are reproduced in tables.

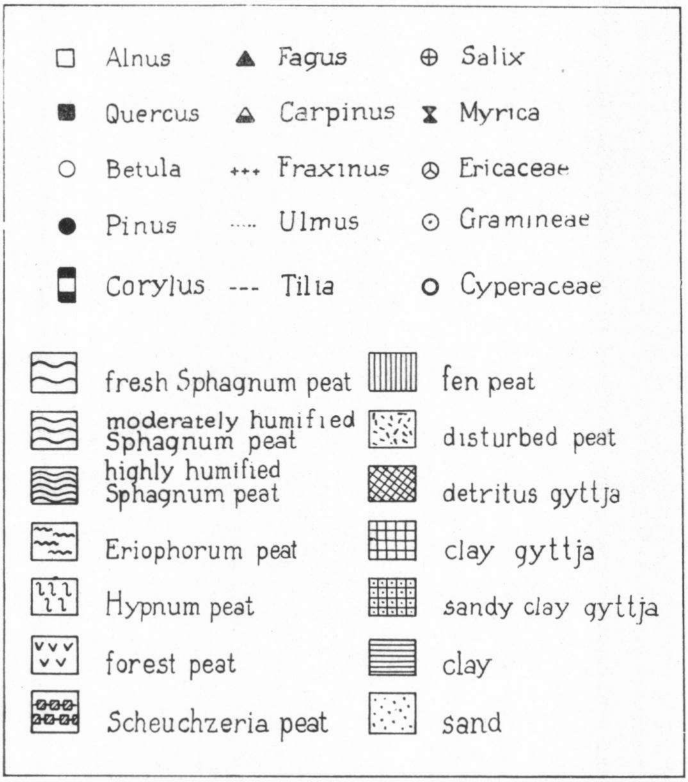

Fig. 2. Key to symbols for pollen diagrams.

[1] If *Myrica* was present in greater quantities a curve for this shrub is drawn in the auxiliary diagram with *Ericaceae*, *Cyperaceae* and *Gramineae*.

b. Quercetum mixtum. In contrast with a great number of published diagrams the pollen of *Quercus, Tilia, Ulmus* and *Fraxinus* are not combined here to the so-called *Quercetum mixtum*. Apart from phytosociological objections against this conception there are also pollen analytical objections. The *Quercetum mixtum* does not form a unit, because its constituents do not show the same behaviour. For instance *Ulmus* already reaches relatively high values in Boreal time when the values for *Tilia* and *Fraxinus* are still very low and *Quercus* also shows a relatively low value. In the first part of the Subatlantic time the *Tilia* percentages are insignificant and fall to zero after 400 A.D., whereas the other constituents still show rather high values. On that account the term *Quercetum mixtum* is avoided here, and the symbol of the *Quercetum mixtum* is used for *Quercus* alone.

c. Corylus in the tree pollen sum. Also in contrast with the usual method the pollen of *Corylus* is included in the tree pollen sum (ΣAP). Bertsch (1942, p. 38) did no longer exclude *Corylus* from the ΣAP, whilst later on Faegri and Iversen (1950, pp. 68 and 86–8) and Jonker (1952) put forward various arguments in favour of including *Corylus* in the ΣAP. For that reason these arguments will not be repeated here. Concerning the disadvantage that by including *Corylus* in the ΣAP these diagrams could not be compared with others, it may be remarked that in general the course of the curves does not show important changes by including *Corylus* in the tree pollen sum. The diagrams published in the present paper can be compared without difficulty with other diagrams whereby *Corylus* is not included in the ΣAP.

Tree pollen sum (ΣAP)

In a large number of samples about 1000 AP were counted. This large number of tree pollen was counted in order to obtain reliable curves for those types of pollen occurring in rather low percentages. This is true not only for the pollen of trees as *Ulmus, Tilia, Fraxinus* and others, but also for various herbs, *e.g. Rumex, Plantago, Artemisia* and *Chenopodiaceae*. When counting a rather small number of pollen grains the curves for the less abundant pollen types are too irregular. In spite of the high tree pollen sum, however, there always remains a chance of considerable deviations on account of the statistical error. For a discussion of the statistical error we may refer to Faegri and Iversen (1950, pp. 98–109).

If less than 1000 AP were counted in each sample this is mentioned in the diagram or in the text, as among others in the peat deposits from the northern part of the province of Friesland, which contain relatively few pollen grains.

Stratigraphy

Concerning the stratigraphy only the composition and the degree of humification of the concerning peat layers are given. A detailed investigation into seeds and remains of plants, which were not of much importance for the peat formation, was not carried out.

Although the measurements of the degree of humification according to Overbeck (Overbeck and Schneider, 1940; Overbeck, 1947) are much more exact than the so-called fist method, it was—especially on account of technical reasons—not yet possible to carry out these measurements. In most cases a good impression of the degree of humification can be obtained by dissolving a piece of peat in water.

III. THE VEGETATION DEVELOPMENT IN THE NORTHERN NETHERLANDS

As a basis for the palynological investigations discussed in the following chapters the preparation of a detailed diagram or series of diagrams was required which would give a reliable picture of the vegetation development in the northern Netherlands. Up to now a small number of diagrams from large raised bogs in the northern Netherlands has been published. These diagrams, however, are not well suited for our purpose as the intervals between the analysed samples are too great, the number of pollen grains counted in each sample is too small, and practically no attention was paid to herbaceous pollen. WATERBOLK (1954*b*) published some detailed diagrams from small raised bogs in Drente which comprise only a part of the post-glacial vegetation development. Moreover, the pollen content of small bogs can have been greatly influenced by the local vegetation in the immediate vicinity of the bog, so that a close comparison with diagrams from large raised bogs is often difficult. Concerning the late-glacial period detailed diagrams are available by the investigations of VAN DER HAMMEN (1951). Because of the character of the vegetation local factors will not have been of much influence on the pollen rain in the small lakes in which *gyttja* was deposited.

Unfortunately no profile comprising the whole late- and post-glacial period could be found. Therefore the diagrams from three profiles were used. A *gyttja* profile not far from Haule (south-east Friesland) covers the late-glacial period—which only for the sake of completeness was investigated—and the beginning of the post-glacial period. The greater part of the post-glacial period is represented in a peat profile near Emmererfscheidenveen (south-east Drente), whilst the upper part of a diagram from the raised bog near Fochteloo (south-east Friesland) completes the last diagram. These three diagrams together give a practically complete picture of the late- and post-glacial vegetation development in the northern Netherlands.

Although, as far as possible, local influences were eliminated by collecting the samples from both post-glacial profiles at the centre of the bog, the concerning diagrams cannot simply be considered as standard diagrams of this region. Comparison with numerous other diagrams, however, learns that these diagrams give a reliable picture of the vegetation development in the northern Netherlands.

The zonation of FIRBAS (1949) as well as that of OVERBECK and SCHNEIDER (1938) are indicated on the left side of the diagrams. This does not mean that the present author always agrees with the dating of these zones. The zonation of OVERBECK and SCHNEIDER which has been established for north-west Germany and which, according to the investigations of SCHMITZ (1953), has shown its validity for Schleswig-Holstein can also easily be applied to Dutch diagrams. A third zonation applicable to Dutch diagrams is the one established for Danish diagrams by JESSEN (1934, 1938) and IVERSEN (1941).

In Table I a survey is given of the zonations mentioned above with a short characteristic of the pollen floristic zones. The correlation between the zonation of FIRBAS and that of OVERBECK and SCHNEIDER is not in agreement with that proposed by OVERBECK (1952). There is also a slight difference with the correlation WATERBOLK (1954*b*) gives. For the comparing of the zones VIII, IX and X of OVERBECK and SCHNEIDER with the zones VII and VIII of FIRBAS especially the behaviour of the curves for *Ulmus* and *Corylus* and the beginning of the curve for *Plantago lanceolata* were used.

TABLE I. Pollen analytical zonation of the late- and post-glacial time.

according to FIRBAS		according to OVERBECK and SCHNEIDER		according to JESSEN and IVERSEN	
X	Large-scale clearance of the forest. Increase of the NAP, especially of pollen of cultivation. *Alnus* often decreases, while *Quercus* shows an increase. In the upper part of this zone *Pinus* rises on account of the cultivation of the fir.		XII	IX	Subatlantic time
XI	Expansion of *Fagus*. *Carpinus* reaches relatively high values. *Corylus* shows relatively low percentages. *Tilia* no longer forms a continuous curve.		XI		
VIII	Increase of *Fagus*. *Carpinus* is present in low percentages. Decrease of *Corylus* in the upper part of this zone.	Fall of *Corylus*. Increase of *Fagus*.	X		
		Less *Ulmus* and *Tilia*. *Fagus* shows a continuous curve. Border with zone X: the last *Corylus* maximum (C_4).	IX	VIII	Subboreal time
VII	*Ulmus* and *Tilia* show a slight fall. *Fraxinus* increases. *Fagus* occurs regularly. First pollen of *Cerealia*. *Corylus* is abundant, with a maximum at the end of this zone. Border with zone VIII: decrease of *Tilia* and *Ulmus*.	*Ulmus* and *Tilia* reach relatively high values. *Fraxinus* appears. *Corylus* is abundant, and shows some maxima. *Alnus* and *Quercus* equally can reach high values. Appearance of *Plantago* and *Cerealia* in the upper part of this zone. Border with zone IX: the last *Corylus* maximum but one (C_3).	VIII	VII	Atlantic time
VI	*Quercus*, *Corylus* and *Alnus* reach high percentages. *Ulmus* and *Tilia* are relatively abundant. Border with zone VII: decrease of *Pinus*.				
V	*Pinus* is usually dominant, but *Betula* equally can show high values. *Corylus* shows a sharp rise, and reaches its first maximum in the second part of this zone. *Quercus* increases, whilst *Ulmus* also reaches a relatively high percentage. At the end of this zone *Tilia* and *Alnus* expand. Border with zone VI: sharp rise of *Alnus* and decrease of *Pinus* and *Corylus*.	Fir-hazel time. Characterized by a *Corylus* maximum (C_1). *Ulmus* and *Quercus* increase. *Tilia* and *Alnus* reach a continuous curve. Border with zone VIII: intersection of the curves for *Pinus* and *Alnus*.	VII	VI	Boreal time
		Fir time. *Pinus* is dominant. *Corylus* increases. *Quercus* and *Ulmus* are present, but not yet *Tilia* and *Alnus*. Border with zone VII: sharp rise in the *Corylus* curve.	VI	V	
IV	Final amelioration of climate. *Betula* is still dominant, but *Pinus* shows an increase. The NAP shows a sharp decline. *Corylus* appears, just as *Ulmus*. Border with the following zone: the beginning of the increase of *Corylus*.		V	IV	Preboreal time
III	A sharp rise of the NAP, and a decline of the AP, especially of *Pinus*.		IV	III	Late Dryas time
II	A sharp decline of all NAP. Rather dense forests. At first especially *Betula*, in the second phase of this period also much *Pinus*.		III	II	Allerød time
I*b*	First amelioration of climate. Decrease of the extremely high NAP, particularly of *Cyperaceae*. Increase of *Artemisia*, and appearance of *Plantago*, *Helianthemum* and others. *Betula* is present.		II	I	Older Dryas time
I*a*	Very high herbaceous percentages, especially of *Cyperaceae*. *Pinus* is relatively abundant on account of long distance transport.		I		

In addition the periods of BLYTT/SERNANDER are generally applied.

An investigation into the immigration of the present flora in Norway led BLYTT (1876) to accept a number of alternating rainy and dry periods since the retreat of the ice. The stratigraphy of the Norwegian raised bogs was considered by him as evidence for his theory. This theory which at first did not meet with much approval could in the main be confirmed by SERNANDER (1908, 1910) on the ground of his investigations into the stratigraphy of the Swedish bogs. After having undergone some alterations proposed by SERNANDER this theory concerning the sequence of climatic periods became generally accepted in Europe. The periods of BLYTT/SERNANDER are still fairly generally applied, although more recent stratigraphical and pollen analytical investigations have demonstrated that the climatological interpretation cannot be quite correct.

The beginning of the Preboreal time is generally placed at the beginning of the final amelioration of climate after the Late Dryas time. In the diagrams this is shown in a steep decline of the herbaceous pollen.

The Preboreal/Boreal transition coincides with the beginning of the first increase of *Corylus* (FIRBAS, 1949; OVERBECK and SCHNEIDER, 1938).

In western Europe the Boreal/Atlantic transition is generally placed at the level where the rising *Alnus* curve intersects the falling *Pinus* curve.

There is less general agreement with regard to the Atlantic/Subboreal transition. WEBER (1910, 1926, 1930) supposed that during the Subboreal time no peat formation took place, so that Subatlantic peat would rest directly on Atlantic peat which during the Subboreal time would have undergone a strong weathering. Later on, when it appeared that—at least in the large raised bogs—peat formation had not come to a standstill, the upper part of the highly humified *Sphagnum* peat which contains many remains of heather was supposed to have been formed during the Subboreal time. Pollen analytically the Subboreal time would be characterized by the presence of *Fagus* and high *Calluna* percentages.

In north-west Europe the Neolithic period would comprise the upper part of the Atlantic time, while the Bronze Age would coincide with the Subboreal time (SERNANDER, 1908; H. A. WEBER, 1918). As the chief argument for placing the Atlantic/Subboreal transition at the border between the Late Stone Age and the Bronze Age VAN GIFFEN (1941*b*, 1943, 1947) puts forward the phenomenon that on the higher sandy soils the subsoil of the Bronze Age and Iron Age barrows always shows a podzol profile. Below Neolithic tumuli, on the other hand, such a podzol profile never has been found. This difference in soil formation must, according to VAN GIFFEN, be the effect of a change of climate which would separate the Atlantic and Subboreal time.

This border between the Atlantic and Subboreal time is based, however, on stratigraphy and is pollen analytically not well defined. In Danish diagrams IVERSEN (1941) places the Atlantic/Subboreal transition at the level where the curves for *Hedera* and *Ulmus* show a decline—a steep one for *Hedera*—and *Fraxinus* rises. According to IVERSEN the steep decline of *Hedera* must be effected by a change of climate, viz. a fall in winter temperatures which would be characteristic of the Subboreal time. Just above this transition the first pollen grains of *Plantago lanceolata* and *Cerealia* appear. The appearance of these pollen types points to the beginning of Neolithic agriculture. It must be noted that in this case—contrary to the original zonation —the Neolithic period covers the first part of the Subboreal time. This Atlantic/Subboreal transition of IVERSEN coincides with the zone border VII/VIII of JESSEN (1934, 1938) who places that border at the level where in his diagrams the curves for *Ulmus* and *Tilia* show a rather sharp decline.

In the English and Irish diagrams the transition VII*a* (Atlantic time)/VII*b* (Subboreal time) is placed at the fall of the *Ulmus* curve (GODWIN, 1943; JESSEN, 1949; MITCHELL, 1951). Here the first pollen grains of *Plantago lanceolata* and *Cerealia* appear likewise at the beginning of the Subboreal time.

In Drente WATERBOLK (1954*b*) found a decrease of *Ulmus* and *Tilia* accompanied by the beginning of the plantain curve.

FIRBAS (1949) places the beginning of the Subboreal time at the beginning of his zone VIII (beginning of the increase of *Fagus*, decrease of *Tilia* and *Ulmus*). This criterion for the Atlantic/Subboreal transition corresponds with that used by the authors mentioned above. The fact that, according to FIRBAS, in central Europe the first pollen grains of *Cerealia* already appear at the end of the Atlantic time would suggest that there agriculture was practised at an earlier time than in north-west Europe. This would be in agreement with the theories of the archaeologists. It must, however, be borne in mind that it is quite well possible that the decline of *Ulmus* is not a synchronous phenomenon in central and north-west Europe. This has to be investigated by means of radio-carbon dating.

OVERBECK (1952) leaves the exact position of the Atlantic/Subboreal transition undecided when he states that his zone IX belongs partly to the Atlantic, partly to the Subboreal time. In his preceding zone VIII, however, plantain already occurs regularly. Consequently his Atlantic/Subboreal transition cannot agree with that of the Danish investigators, not even if the whole zone IX is counted to the Subboreal time (SCHMITZ, 1953).

In the present paper the Atlantic/Subboreal transition is placed at the fall of *Tilia* and *Ulmus*.

As a transition from the Subboreal to the Subatlantic time the so-called *Grenzhorizont* of WEBER is still fairly generally used. As will be discussed in Chapter VI this *Grenzhorizont*, however, is not a synchronous phenomenon, and must on that account be abandoned as a zone border.

In the Danish diagrams JESSEN (1934, 1938), IVERSEN (1941) and MIKKELSEN (1949) place the Subboreal/Subatlantic transition at the level where *Fagus*—dependent on the type of soil—for the first time regularly occurs or shows its first increase. In the diagrams from

Danish *gyttja* deposits the curves for herbaceous pollen types rise markedly from that border onwards. This increase would be the effect of the interference of Early Iron Age people with the natural vegetation (IVERSEN, 1941; MIKKELSEN, 1949). As the increase of *Fagus* is also clearly shown in the diagrams from north-west Germany and the Netherlands the beginning of this increase can be used as a criterion for defining the Subboreal/Subatlantic transition.

Haule. On account of a prolonged drought during the autumn of 1951 a deep drainage trench exposing *gyttja* deposits in the south-eastern part of the province of Friesland did no longer contain water. It was clearly visible that the *gyttja* deposits do not extend over a long distance, but that these deposits always occur in basin-shaped depressions in the boulder clay. During the late-glacial time there must have been here a large number of fens.

The diagram of Fig. 3 is composed of the diagrams from two profiles. The distance between the two spots where the samples were collected is 2000 m. In one diagram the course of the late-glacial vegetation development with the exception of the earliest phases could be observed, whereas in the other diagram it was just these early phases which were represented. As it was quite possible to fit both diagrams together one diagram is composed. The place where the diagrams are fitted together is indicated by an interruption of the pollen lines.

The composition of this late-glacial diagram differs from that generally used for post-glacial diagrams. By this way of representing worked out by IVERSEN (1947) the course of the relation between tree and herbaceous pollen characteristic of the late-glacial time is clearly shown.

On the spots where the samples were collected the following profiles were recorded

I.	0– 63	cm	disturbed soil
	63– 68	„	sandy peat
	68–105	„	sandy clay *gyttja*
	105–115	„	detritus *gyttja*
	115–120	„	clay *gyttja*
	120–130	„	detritus *gyttja*
	130–140	„	clay *gyttja*
	140–145	„	sandy clay *gyttja*
	145–	„	sand
II.	0–160	„	drift sand
	160–175	„	sandy peat
	175–260	„	sandy clay *gyttja*
	260–340	„	alternating layers of sand and weathered boulder clay
	340–	„	boulder clay

Emmererfscheidenveen. The raised bog near Emmererfscheidenveen forms part of the formerly extensive raised bog east of the chain of hills called Hondsrug. This raised bog lies in the initial valley of the Hunze. At the lowest parts peat formation already started in late-glacial time. The natural drainage of this raised bog, which in the south-east joins the Bourtanger raised bog at both sides of the German-Dutch border, took place by a stream called Runde which is running in northern direction. For further details we may refer to VISSCHER (1931) who made a geographical study of this region.

The bogs east of the Hondsrug have vanished for the greater part in consequence of intensive peat-digging. As the peat is cut away in long strips a number of good sections can be observed, especially shortly after the peat-digging campaign. Everywhere the upper peat layer has vanished as during the last century, on behalf of the buck-wheat culture, the peat surface was set on fire every year.

At a site about 6 km east-north-east of Emmen and about 3 km south-west of Emmererfscheidenveen a complete profile was collected

0– 61	cm	fresh *Sphagnum imbricatum* peat
61– 66	„	fresh *Sphagnum papillosum* peat
66– 90	„	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
90–106	„	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
106–115	„	highly humified *Sphagnum* peat with remains of *Ericaceae*
115–145	„	highly humified *Eriophorum* peat
145–191	„	highly humified *Sphagnum* peat with remains of *Eriophorum* and *Ericaceae*
191–200	„	moderately humified *Sphagnum cuspidatum* peat
200–270	„	highly humified *Hypnum* peat
270–278	„	moderately humified *Sphagnum rubellum* peat
278–300	„	highly humified wood peat
300–329	„	highly humified fen peat
329–330	„	charcoal layer
330–334	„	*gyttja*
334–342	„	*Carex-Hypnum* peat
342–	„	sand

The spectra of the lowest part of this profile, which is a late-glacial deposit, have not been published. Moreover, in consequence of a prehistoric fire there is a gap between the deposits below and above the charcoal layer, so that the earliest phases of the Boreal time are not represented.

Fochteloo. This profile containing a more complete Subatlantic part than the profile from south-east Drente was sampled on the territory of the peat-moss-litter factory between Veenhuizen and Fochteloo. This raised bog is situated at both sides of the border between the provinces of Friesland and Drente, at about 12 km west of Assen.

It is interesting to note that in some places where the peat had been removed the stumps could be observed of the trees constituting the forest that represented the natural vegetation before peat formation started. The effect of a rise in the ground water table was clearly visible. At a later stage the original oak forest was replaced by an *Alnetum.* The superficial root system of the alder trees points to a lack of oxygen on account of the high level of the ground water.

On the spot where the samples were collected the profile was as follows

0– 10	cm	disturbed peat
10– 20	„	moderately to highly humified *Sphagnum imbricatum* and *palustre* peat with many *Monocotyledons* and some *Eriophorum*
20– 26	„	moderately humified *Sphagnum imbricatum* and *palustre* peat with many *Monocotyledons* and *Eriophorum*
26– 37	„	fresh *Sphagnum imbricatum* peat
37– 48	„	fresh *Sphagnum cuspidatum* peat
48– 56	„	moderately humified *Sphagnum imbricatum* peat with *Monocotyledons*, *Eriophorum* and some *Calluna*
56– 63	„	highly humified *Sphagnum imbricatum* peat with *Monocotyledons*, *Eriophorum* and *Calluna*
63– 70	„	moderately humified *Eriophorum* peat
70– 76	„	moderately humified *Sphagnum palustre* and *imbricatum* peat
76– 82	„	fresh *Sphagnum palustre* and *imbricatum* peat
82– 84	„	moderately humified *Sphagnum palustre* and *imbricatum* peat
84– 90	„	moderately humified *Sphagnum magellanicum* peat with *Monocotyledons*
90– 97	„	moderately humified *Sphagnum imbricatum* peat with some *Eriophorum*
97–103	„	rather fresh *Sphagnum imbricatum* peat
103–107	„	fresh *Sphagnum imbricatum* peat with rhizomes of *Scheuchzeria*
107–111	„	fresh *Sphagnum cuspidatum* peat
111–118	„	highly humified *Eriophorum* peat
118–145	„	highly humified peat with abundant remains of *Monocotyledons*
145–150	„	humous sand

Discussion of the diagrams

Late-glacial time. It appears that the lower part of the Haule profile must still have been deposited in the so-called pleni-glacial time, *i.e.* in the last cold stage of the Würm glaciation, before the beginning of the late-glacial time. The relation between tree and herbaceous pollen in the lower part of the diagram points to a tree-less arctic vegetation. Moreover, in this part of the diagram *Pinus* is the main constituent of the tree pollen, while *Betula* pollen only occurs in very small numbers. Investigations of surface samples from the tundra region in north Finland by Aario (1940) have demonstrated that in those samples the pollen of *Pinus* is more abundant than that of *Betula*, although the distance from the tundra to the pine forests is greater than that from the tundra to the birch forests which form a belt between the tundra and the pine forests. Pollen analysis of surface samples from the tundra region by Van der Hammen (1951) led to the same result. The fact that many plants which occur regularly in the late-glacial time are lacking in the lowermost samples of the diagram is in accordance with the cold climate.

Van der Hammen (1951) considers the rise of the *Artemisia* curve as the first effect of the amelioration of climate, the beginning of late-glacial time. In the lowermost samples *Artemisia* shows very low percentages, while at a depth of 245 cm the pollen of this plant reaches a value of 1.5 %. This increase of *Artemisia* is accompanied by a decrease in the extremely high herbaceous percentages of the pleni-glacial time.

During the Older Dryas time (zone II according to Overbeck and Schneider, zone I*b* according to Firbas) the herbaceous percentages remain high, while *Betula* is now the main contributor of tree pollen. The relatively high values for *Artemisia*, *Juniperus*, *Plantago*, *Helianthemum, Rumex* and *Thalictrum* and the very low *Ericaceae* percentages are characteristic of this period.

The Older Dryas time can be subdivided into an Earliest and Earlier Dryas time, separated by a small oscillation of climate, the so-called Bølling oscillation. Although at a depth of 145 cm the tree pollen shows a slight maximum, which could represent the Bølling oscillation, this subdivision of the Older Dryas time is not applied here.

Some special attention must be paid to the occurrence of a pollen grain of *Polemonium coeruleum* in the not published part of the lower diagram which belongs to the Older Dryas time. Up to now this pollen grain which can easily be recognized has not been mentioned for the late-glacial time of the Netherlands. GODWIN (1950) and SCHMITZ (1953) report the occurrence of this pollen in late-glacial deposits of England and north Germany respectively.

The Allerød time (zone III according to OVERBECK and SCHNEIDER, zone II according to FIRBAS) is characterized by a steep decline in *Gramineae, Cyperaceae* and other herbs. The forest, at first a birch forest and in the second part of this period a mixed pine-birch forest, must have been rather dense. The presence of small pieces of *Pinus* charcoal in the so-called Allerød layer in the coversand deposits is in agreement with the fairly high *Pinus* percentages in the second part of the Allerød time.

In the Late Dryas time (zone IV according to OVERBECK and SCHNEIDER, zone III according to FIRBAS) herbaceous pollen again reaches fairly high values. In contrast with the other diagrams from the northern Netherlands published up to now, viz. Hijkermeer (VAN DER HAMMEN, 1949), Mekelermeer (VAN DER HAMMEN, 1951) and a late-glacial deposit near Opeinde (DE PLANQUE, 1950), in the Haule diagram pollen of *Ericales* is not abundant. *Empetrum* hardly exceeds 2 %, whereas in the diagrams mentioned above *Empetrum* reaches values of 25 to 30 %. The low values for *Empetrum* in the Haule diagram suggest that in the Late Dryas time the *Empetrum* vegetations must have had a local character in the northern Netherlands. The increase of *Sphagnum* spores begins in the upper part of the Allerød time, and during the Late Dryas time the *Sphagnum* percentages remain high. According to VAN DER HAMMEN (1951) the expansion of *Empetrum* and *Sphagnum* indicates a more oceanic character of the climate.

The pollen grains of thermophilous trees which were rather regularly found must partly be of secondary origin—which in view of the character of the deposits is quite well possible—partly be the effect of a long distance transport. For AARIO (1940) mentions that in the surface samples from the tundra region near Petsamo pollen grains of *Picea* and *Alnus* occur. This occurrence must be ascribed to a long distance transport. On that account it is not unlikely that the pollen grains of *Alnus* and *Picea* found in the Haule deposits were dispersed by trees of a river-bound forest at a distance of some hundreds of kilometers.

Post-glacial time. The first part of the post-glacial time is still represented in the Haule diagram. The beginning of the post-glacial time is placed at the beginning of the final amelioration of climate which in the first place effected an increase of tree pollen and a corresponding decrease of herbaceous pollen. In the Haule diagram the Preboreal time begins at a depth of 90 cm. The appearance of thermophilous trees in the northern Netherlands did not take place until the end of the Preboreal time when *Ulmus* and *Corylus* immigrate. At the end of the Preboreal time the *Pinus* curve shows a steep increase.

Just above a depth of 70 cm the first part of the Boreal time begins. The herbaceous percentage is very low, *Pinus* pollen is dominant and the *Corylus* curve shows a beginning of increase. Of the other thermophilous trees only *Ulmus* is present. *Quercus*, *Alnus*, *Tilia* and *Fraxinus* will appear later on.

The further course of the vegetation development can be followed in the Emmererfscheidenveen diagram (Fig. 4) which fits rather well with the Haule diagram.

A small number of diagrams from the region of south-east Drente has already been published, viz. three diagrams in the vicinity of Zwartemeer (VAN RAALTE and WASSINK, 1932), one diagram near Valthermond (VAN DOBBEN, 1932) and one near Roswinkel (FLORSCHÜTZ and WASSINK, 1935). As the intervals between the analysed samples are too great these diagrams only give a rather rough picture of the vegetation development of the region.

As already mentioned VISSCHER (1931) made a geographical study of this region. It is to be regretted that he did not complete his detailed stratigraphical investigation with a pollen analytical investigation of some profiles. In that case some incorrect conclusions, which for the rest he mentions again in a later paper (VISSCHER, 1949), could have been avoided. It appears that the so-called middle layer of tree stumps—on top of the fen peat—was not formed in the "very dry and warm" Boreal time, but as late as the Atlantic time.

As in the diagrams already published from this region (VAN RAALTE and WASSINK, 1932; VAN DOBBEN, 1932) the Boreal *Corylus* maximum is not high. The behaviour of the *Pinus* curve caused some difficulties. From a depth of 310 cm the *Pinus* curve shows a steep decline in order to reach a value below that of *Alnus* at a depth of 300 cm. Somewhat upwards, however, *Pinus* reaches again a fairly high percentage, and between 285 and 290 cm the rising *Alnus* line intersects the—now final—falling *Pinus* line for the second time. The question arose where the Boreal/Atlantic transition has to be placed. On account of the alternating dominance of *Pinus* and *Betula* in the lower part of the diagram it is not possible to determine the correct position of the Boreal/Atlantic transition. For that reason the lower part of a second profile from the same raised bog was analysed (Emmererfscheidenveen II, Fig. 5).

This profile was already sampled in 1938 on the occasion of the discovery of a peat burial. As the peat monolith was dried up it was not possible to give a somewhat accurate stratigraphy.

Although in the Boreal part of this diagram there are also alternating high *Pinus* and *Betula* percentages it is yet clear that the Boreal/

Atlantic transition must be placed at a depth of about 260 cm, where the rising *Alnus* curve intersects the falling curves for *Pinus* and *Betula*. By comparison of the curves for *Tilia* and *Fraxinus* in both diagrams it is clear that in the diagram of Fig. 4 the Boreal/Atlantic transition lies between 285 and 289 cm. At the end of the Boreal time the *Fraxinus* curve rises quickly to a value of 2–4 % at the beginning of the Atlantic time, whilst the increase of *Tilia* comes to an end at the Boreal/Atlantic transition.

The occurrence of high *Betula* percentages in Boreal and early Atlantic time can also be seen in other diagrams from the northern Netherlands (*cf.* Hoornder Veen, ESHUIS, 1936; Princehof A, VAN ZEIST, 1950), and must be the effect of local production of birch pollen.

At the beginning of the Atlantic time, at a depth of 275 cm, there is a rather low *Corylus* maximum which corresponds with the C_2 of OVERBECK and SCHNEIDER (1938). Concerning the behaviour of the other curves in the left part of the diagram it can be noted that *Quercus* does not reach an average value of 20 % until a depth of about 260 cm, and that the *Alnus* percentages—compared with those in the later phases of the post-glacial time—are rather low. During the Atlantic time the mixed deciduous forest, the composition of which will have varied dependent on edaphic factors, was the dominant vegetation type, whereas the share of the *Alneta* was relatively small.

The occurrence of a few pollen grains of *Viscum* must be noted. As the factors for a wide distribution of the pollen of this semi-parasite are not favourable it is not surprising that *Viscum* pollen is very rare in deposits of large raised bogs.

In most sections of the raised bog from south-east Drente a conspicuous *Scheuchzeria* layer with numerous stumps of *Pinus* and *Betula* can be located. This layer, which forms the transition from the fen peat to the *Sphagnum* peat and which locally can be lacking, was not present on the spot where the samples for the Emmererfscheidenveen I diagram were collected. For this reason a separate diagram was prepared from samples collected on a spot with a well developed *Scheuchzeria* layer (Emmererfscheidenveen III, Fig. 6). The *Scheuchzeria* layer contained large amounts of *Betula* pollen, whereas the *Pinus* percentages are not higher than those in the samples below and above that layer. It is highly probable that on the spot in question birch was the dominant tree. When we compare both diagrams it becomes clear that the *Pinus* maximum between 204 and 210 cm in the diagram of Fig. 4 corresponds with the layer of tree stumps. There is a close correspondence between the spectra from 215 to 230 cm in the small diagram and the spectra from 220 to 235 cm in the Emmererfscheidenveen I diagram, while the spectrum at a depth of 190 cm, above the *Scheuchzeria* layer, corresponds with the spectrum at a depth of 179 cm in the diagram of Fig. 4.

Concerning the Emmererfscheidenveen III diagram the relatively high percentage of *Nymphaea* in the lowermost spectrum has to be mentioned.

Although in a very low percentage (0.2 %) *Fagus* was already found rather regularly in the upper part of the Atlantic time. It is not probable, however, that during that time this tree already formed part of the vegetation of the northern Netherlands. The regular occurrence of *Fagus* pollen suggests that the beech will have occurred not too far from this region. Pollen of *Picea* and *Acer* which will never have formed part of the natural vegetation of this area were found from the beginning of the Atlantic time. Scattered *Humulus* pollen was found throughout the whole profile.

Concerning the herbaceous pollen special attention must be paid to the *Rumex* curve which shows the highest percentages in the Atlantic part of the diagram. In general the regular occurrence of pollen of this plant is regarded as evidence of human activity. Although in post-glacial *gyttja* deposits relatively high *Rumex* percentages undoubtedly will be due to human influence on the vegetation this is not always true of bog deposits as *Rumex* can form part of the bog vegetation.

In the *Ulmus* curve four maxima can be distinguished, viz. at a depth of 305, 260, 205 and 170 cm. In many diagrams from Ostfriesland (north-west Germany) the *Ulmus* curve shows also four maxima (GROHNE, oral communication), so that this phenomenon probably is not only of local importance. Just above the last *Ulmus* maximum the Atlantic/Subboreal transition is placed. At the same time the *Tilia* curve shows a decline, whilst *Plantago lanceolata* suddenly appears. As has been stated on p. 9 these features are regarded as a reliable criterion for defining the Atlantic/Subboreal transition. It is not quite clear whether the few pollen grains of *Plantago lanceolata* which were found below a depth of 165 cm must be ascribed to human (Mesolithic?) activity or that *Plantago lanceolata* already occurred here before the immigration of Neolithic man. According to IVERSEN (1949) this plant did not grow in Denmark before the beginning of Neolithic agriculture. As has already been noted by WATERBOLK (1954*b*) the decline in the *Ulmus* curve is—in contrast with Danish diagrams—not accompanied by an increase of *Fraxinus* which already in Atlantic time shows relatively high values in Dutch diagrams. The sharp decline of *Hedera*, which is a characteristic feature in Danish diagrams, cannot be observed in the diagrams from the northern Netherlands as the *Hedera* values in the first part of the Subboreal time do not differ from those in the Atlantic time. A marked decrease of *Hedera* takes place in the upper part of the Subboreal time, and in Subatlantic time this liane virtually disappears altogether.

The *Corylus* maximum at a depth of 160 cm can be compared with the $C_\times$ of OVERBECK (1952) which in all diagrams from the raised bog near Gifhorn coincides with the beginning of the *Plantago* curve. The *Corylus* maximum at a depth of 125 cm corresponds with the C_3 of OVERBECK and SCHNEIDER (1938). The *Fagus* percentages show a slight increase at a depth of 100 cm. This first—although very small—increase of *Fagus* is typical of the diagrams from south-east Drente, and corresponds with a similar increase—in most cases the beginning of the continuous *Fagus* curve—in the diagrams from north-west Germany. This increase of *Fagus* pollen points to the appearance of *Fagus* in the northern Netherlands. A second more important increase of *Fagus* pollen starts at a depth of 85 cm. This last increase of *Fagus* is accompanied by the final decline of *Corylus* after the last *Corylus* maximum (C_4 of OVERBECK and SCHNEIDER, 1938) at a depth of 85 cm. In all diagrams from south-east Drente the beginning of the expansion of *Fagus* coincides with the beginning of the decline of *Corylus*. This is also true for most diagrams from north-west Germany, while in the diagrams from the Peel bogs (southern Netherlands) the same behaviour of the curves for *Fagus* and *Corylus* can be observed (ESHUIS, 1946). At a depth of 60 cm *Fagus* attains a value of about 5 %. In nearly all diagrams from south-east Drente the end of the second increase of *Fagus* is accompanied by a *Fraxinus* maximum. As most diagrams from the northern Netherlands and north-west Germany do not show a *Fraxinus* curve it is not yet possible to examine whether this is only a local phenomenon or not. In this connection it is worth mentioning that in the Fochteloo diagram (Fig. 7) there is also a *Fraxinus* maximum at the level where *Fagus* reaches a value of about 5 %.

From the level where *Fagus* begins its expansion *Carpinus* shows a continuous curve. Although in the corresponding part of the other diagrams from this region the *Carpinus* curve is not always a continuous one, yet it can be generally stated that the first important increase of *Fagus* is accompanied by a regular occurrence of *Carpinus*. An increase in the *Carpinus* curve, which is likewise characteristic of all diagrams from the northern Netherlands and north-west Germany, can be seen at a depth of 25 cm.

Alnus shows high percentages in the upper part of the diagram. In consequence of the gradual decrease of the forest cover on the higher sandy soils the *Alneta*, which not until later will be cleared, are relatively on the increase. The fairly high values for *Plantago lanceolata* and *Artemisia* and the regular occurrence of *Urtica*, *Plantago major* and *Cerealia* in the upper part of the diagram also indicate an increasing human activity.

On pp. 9–10 the Subboreal/Subatlantic transition has already been discussed. In agreement with Danish investigators this transition is placed here at the beginning of the first important increase of *Fagus*. As in nearly all diagrams from north-west Germany the beginning of this increase coincides with the last *Corylus* maximum (C_4 of OVERBECK and SCHNEIDER, 1938) this pollen analytical criterion is well suited to define the transition from Subboreal to Subatlantic time. This in order to substitute the so-called *Grenzhorizont* of WEBER which—as will be demonstrated in Chapter VI—is not a synchronous phenomenon, and which on that account cannot be used as zone border. In north-west Europe the criterion mentioned above approximately coincides with the transition from Bronze Age to Iron Age (*cf.* Chapter IV) which can be dated at about 500 B.C. Consequently the dating of this pollen analytically defined zone border is in agreement with the general view to let Subatlantic time start at about 500 B.C.

In the Emmererfscheidenveen I diagram the vegetation development is represented up to some centuries A.D. as in consequence of buckwheat cultures the upper part of the peat has vanished.

The course of the curves in the lower part of the Fochteloo diagram (Fig. 7) is not quite clear. It is not possible to decide whether the last *Corylus* maximum (C_4) must be placed below the lowermost spectrum or that the spectrum at a depth of 137 cm shows this maximum, and that in consequence of local circumstances the *Corylus* percentages are too low. At any rate it is certain that the spectrum at a depth of 132 cm corresponds with that at a depth of 59 cm in the diagram from Emmererfscheidenveen (*Fagus* reaches a value of about 5 %, *Fraxinus* maximum). More upwards the curves show a close correspondence with those of the Emmererfscheidenveen diagram. The high *Myrica* percentages deserve some special attention. These prove once more to be suspicious of unexpected and very high "*Corylus*" percentages.

From a depth of about 110 cm the curves in the left part of the Fochteloo diagram (Fig. 7) do not longer show important alterations with the exception of the *Alnus* curve which gradually falls in the upper part of the diagram. The curves for *Fagus* and *Carpinus*, however, show some characteristic features. The first increase of *Carpinus*, which in the Fochteloo diagram takes place at a depth of 95 cm, is also present in the Emmererfscheidenveen diagram. At about the same time the continuous *Tilia* curve comes to an end. For the present the *Carpinus* percentages fluctuate between 0.5 and 2 %, while *Fagus* maintains a value of about 4 %. In the upper part of the Emmererfscheidenveen diagram there is a crest of nearly 9 % in the *Fagus* curve. It is not impossible that with a shorter distance between the analysed samples in the Fochteloo diagram also one or more incidentally high *Fagus* percentages would have been found. A second increase of *Carpinus* starts at a depth of 55 cm in order to reach values of more than 5 % in the upper part of the diagram. The *Fagus* percentages which are less regular than those of *Carpinus* also show an—on an average—important increase. In the upper part of the diagram the values for *Fagus* and *Carpinus* remain relatively high.

On account of the generally too great intervals between the spectra and the small number of pollen counted in each sample this course of the curves for *Fagus* and *Carpinus* is not very clear in the other diagrams from the northern Netherlands. The behaviour of the curves for *Fagus* and *Carpinus* in the diagrams Paterswal 2 and Engbertsdijk (eastern Netherlands) corresponds rather well with that in the Fochteloo diagram (FLORSCHÜTZ and WASSINK, 1935). More to the east, in north-west Germany, where *Fagus* and *Carpinus* reach higher values, the curves for both trees show essentially the same aspect. Consequently these diagrams can be very well compared with the diagram from Fochteloo as far as the Subatlantic time is concerned. In the Wakenitz diagram near Lübeck (SCHMITZ, 1951) this course of the curves for *Fagus* and *Carpinus* can also be noticed. The behaviour of *Fagus* and *Carpinus* in Denmark agrees very well with that in the northern Netherlands, on the understanding that on the fertile soils of the Danish islands *Fagus* and *Carpinus* were more numerous than in Drente (MIKKELSEN, 1949).

The gradual decrease of *Alnus* in the upper part of the diagram must be ascribed to the cutting down of the *Alneta* along the streams and on other low lying sites. The marked increase of *Gramineae*, *Cerealia*, *Chenopodiaceae*, *Rumex* and *Plantago* in the upper part of the diagram also points to an increase of the cultivated area.

It is not possible to determine exactly till what time the vegetation development can be followed in this diagram. As the *Pinus* percentages in the upper part of the diagram remain low it is certain that the time in which man changed the character of the forests by means of the laying-out of *Pinus* plantations is not represented.

As already has been noted at the beginning of this chapter the zonation of OVERBECK and SCHNEIDER (1938) can be very well applied to diagrams from the northern Netherlands. Zone I, the tree-less tundra time, covers the three spectra at the bottom of the Haule diagram. At a depth of 247 cm zone II begins with the increase of *Artemisia*. This zone in which the herbaceous percentages are not as high as in zone I ends at a depth of 135 cm where the sharp decline in herbaceous pollen starts. In this zone *Betula* pollen shows an important increase, whilst *Pinus* reaches fairly high values in the second part of zone III. The III/IV transition can be placed at a depth of 112 cm. Zone IV is characterized by rather high herbaceous percentages and a decrease of tree pollen. At a depth of 95 cm zone V begins which shows a decrease in the herbaceous percentages. At first *Betula* is dominant, whereas *Pinus* shows high values in the upper part of this zone. At the end of zone V the first thermophilous trees, viz. *Ulmus* and *Corylus*, appear. The zone border V/VI lies at a depth of 67 cm where the *Corylus* curve begins to rise. In zone VI *Tilia* and *Quercus* appear, while in the Emmererfscheidenveen diagram also *Alnus* was met with. Zone VII begins at a depth of 325 cm where *Corylus* rises quickly to the first maximum (C_1) which characterizes this zone. In the second part of zone VII *Alnus* increases, while *Fraxinus* appears at the end of this zone. As already has been discussed on p. 15 the Boreal/Atlantic transition which coincides with the zone border VII/VIII has to be placed at a depth of about 287 cm. The *Corylus* maximum (C_2) at a depth of 275 cm is characteristic of the lower part of zone VIII. The border between the subzones *a* and *b* lies at a depth of 230 cm where the *Pinus* curve falls to rather low values (5–10 %). Zone VIII ends at the *Corylus* maximum (C_3) at a depth of 135 cm. In the upper part of zone VIII*b* pollen of *Plantago lanceolata* shows a continuous curve. Zone IX ranges from the C_3 to the C_4 at a depth of 85 cm. Zone X is characterized by a decrease of *Corylus* and an increase of *Fagus*. The X/XI transition is placed at a depth of 60 cm where the decrease of *Corylus* comes to an end and *Fagus* reaches a relatively high value. As OVERBECK and SCHNEIDER (1938) used the *Grenzhorizont* of WEBER as the border between their zones X and XI they did not give a well defined pollen analytical criterion for this border. In the upper part of the Fochteloo diagram at a depth of 30 cm, where the herbaceous percentages show a marked increase the zone border XI/XII is placed.

The zonation according to FIRBAS agrees with that according to OVERBECK and SCHNEIDER as far as the late-glacial period is concerned. There is only a slight difference in numbering. Zone V comprises the zones VI and VII of OVERBECK and SCHNEIDER. The VI/VII transition lies at a depth of 230 cm where the *Pinus* curve drops to a value of 5–10 %. The transition from zone VII to VIII has to be placed at the decrease of *Tilia* and *Ulmus* at a depth of 160 cm. As, according to FIRBAS, in north Germany the end of the decrease of *Corylus* can be used as a criterion for defining the VIII/IX transition this border is placed at a depth of 60 cm. The zone border IX/X coincides with the zone border XI/XII according to OVERBECK and SCHNEIDER and is consequently placed at a depth of 30 cm in the Fochteloo diagram.

IV. THE ARCHAEOLOGICAL DATING OF THE POLLEN DIAGRAM

This chapter will discuss the pollen analytical investigation of a number of archaeological objects found in bogs from north-west Europe. Among these finds there are two which have not yet been published, whilst one find, the bronze find of Roswinkel, was re-examined. This archaeological dating is not intended as a means to arrive at an absolute dating of the pollen diagram. Therefore the data are, as a rule, not sufficiently accurate, and there is not infrequently too much difference of opinion concerning the absolute age of the archaeological objects. Moreover, a ^{14}C-dating will give more accurate and more reliable results. The main purpose of this archaeological dating of the pollen diagram is to examine in what part of the diagram the Late Stone Age, the Bronze Age and the Iron Age have to be placed. In this way a comparison is possible of the results of the palynological investigation of peat samples and those of sand samples from barrows etc. As no sand samples older than Neolithic time were investigated this discussion will be confined to finds from the Late Stone Age, the Bronze Age and the Iron Age.

NEOLITHIC

Although in Drente various stone axes were found in the peat no single one hitherto appeared to be suitable for a pollen analytical investigation. The object had always been carefully cleaned, and, moreover, its position in the peat could not be established, because sometimes years elapsed before the find came into the hands of archaeologists. [1]

To a few Neolithic settlements which lay buried in the peat or which could be followed in the peat pollen analysis has been applied.

A Neolithic settlement near Hekelingen, west of Rotterdam (western Netherlands) was recently excavated (MODDERMAN, 1953). This settlement which lay on the bank of a river was overgrown by peat. Moreover, it was possible to follow the culture layer in the peat deposits behind the bank. Unfortunately the diagrams published by

[1] VAN GIFFEN (1925) mentions the presence of about 170 archaeological objects found in the raised bogs from Drente. With the exception of a few peat burials to which still peat is adhering, the bronze find of Roswinkel is the only one which is still suitable for a pollen analytical investigation.

FLORSCHÜTZ (1953) cannot be compared with those from the northern Netherlands.

JESSEN (1938) carried out a pollen analytical investigation of a culture layer which is ascribed to the Older Passage Grave period on the isle of Langeland. This culture layer was situated near the Gamellung bog in which it could be followed in the form of scattered bones of domestic animals, worked pieces of wood, sling stones and such like. Now it appears that in the pollen diagram this culture layer lies at a short distance above the decline of *Ulmus* and *Tilia*. This is in perfect agreement with IVERSEN (1941, 1949) who, on the ground of the sudden appearance of *Plantago lanceolata* and an increase of other weeds, arrived at the conclusion that in Denmark the beginning of the Neolithic period would correspond with the level immediately above the decrease of *Ulmus*.

A culture layer from the Younger Passage Grave period in Bundsö on the isle of Als appeared to lie at about 75 cm above the decline of *Ulmus* and *Tilia* (JESSEN, 1938). It is not possible, however, to transfer accurately the spectrum which corresponds with the culture layer to the diagrams from north-west Germany and the northern Netherlands.

Another Neolithic settlement to which pollen analysis has been applied is that near the Dümmersee. On the border of this formerly rather extensive lake a settlement from the Passage Grave culture was excavated (REINERTH, 1939). On top of the culture layer which rested on peat, *gyttja* was deposited. The diagram PFAFFENBERG prepared from a Dümmersee profile was published by FIRBAS (1949, Fig. 110*a*). At about 20 cm below the bottom of the culture layer the diagram shows a marked decrease of *Tilia* and *Ulmus*. Concerning the further interpretation of this diagram the following remarks can be made. The fact that the *Fagus* percentages remain low in the diagram (5 %) must, according to PFAFFENBERG (in FIRBAS, 1949), be ascribed to the circumstance that in this region the soil is not favourable to beech. It is not unlikely, however, that this diagram is not complete, and that the greater part of the Subatlantic time is lacking, the more so as also *Carpinus* occurs only in very low percentages in the upper part of the diagram. The *Corylus* maximum in the upper part of the culture layer corresponds very probably with the C_3 of OVERBECK and SCHNEIDER (1938), whilst the first increase of *Fagus* takes place just above the culture layer. In many diagrams from north-west Germany and the Netherlands *Fagus* shows its first—although slight—increase not far above the C_3. If this interpretation, which differs somewhat from the zoning that FIRBAS placed besides the Dümmersee diagram, is correct the pollen analytical position of this culture layer agrees with that of the other Neolithic finds.

SCHUBERT (1933) carried out the pollen analytical investigation of the flint dagger of Iselersheim. Not until 8 years after the discovery a profile was sampled in the vicinity of the find-spot. The accurate position of the dagger in the peat could, however, no longer be verified. The pollen analytical result that the flint dagger has to be placed in that part of the diagram in which *Fagus* does not yet show a countinuous curve agrees with the position of the Neolithic settlements discussed above. This investigation does not, however, permit further conclusions.

The same holds for the pollen analytical examination of the flint dagger from Wiepenkathen (BERTSCH in CASSAU, 1935). Although all conditions for a reliable palynological investigation of this unique find were present, the result is rather disappointing on account of the excessive intervals between the spectra and too small a number of pollen grains counted in each sample. It can only be stated that the find level lies rather far below the appearance of *Fagus* in this diagram.

The examination of the stone axe from the Passage Grave period found in the "Oyter Moor" near Bremen has not yet been published (*cf.* OVERBECK and SCHNEIDER, 1938).

JONASSEN (1950) investigated a stone axe from the Passage Grave period discovered *in situ* during the cleaning up of a peat wall in the Høgild bog on behalf of a stratigraphical examination. It appears that the find level has to be placed below the appearance of *Fagus*. It is not possible, however, to fit accurately the position of this stone axe into diagrams from north-west Germany.

EARLY BRONZE AGE

The bronze find of Roswinkel. In October 1924 a number of objects, viz. a ball of wool, some pieces of woollen fabric, a remnant of a hair comb, a small piece of leather, a fragment of a bronze palstave and a string of amber beads, were discovered in the "Roswinkeler Veen" near Oude Schutting. These objects, which are shown in the "Provinciaal Museum van Drente" at Assen, are said to have been found together (VAN GIFFEN, 1947, Plate 76). The fragment of the bronze palstave gives an archaeological dating to this find, namely Early Bronze Age, MONTELIUS II (VAN GIFFEN, 1930, pp. 79–80). It is a fortunate circumstance that the ball of wool has been preserved with its surrounding peat, whilst a second sod of peat shows the casts of two amber beads and a piece of woollen fabric. On that account a palynological examination of this find is still possible. Such an investigation was already carried out by FLORSCHÜTZ and WASSINK (1935). The latter were able to transfer the diagram prepared from the sod of peat with the ball of wool to the diagram from a profile which in 1930 was sampled in the vicinity of the find-spot. On the ground of this examination FLORSCHÜTZ and WASSINK arrived at the conclusion that the final fall of *Corylus* and the beginning of the *Fagus* curve have to be dated at about 1500 B.C.

As it is not well possible to transfer the results of FLORSCHÜTZ and WASSINK to the diagram from Emmererfscheidenveen a new pollen analytical investigation appeared necessary. For that purpose the two sods mentioned above were analysed without intervals ("*Lupendiagramm*"). Besides, it was necessary to prepare a diagram to which the diagrams from the sods could be transferred. Unfortunately the peat in the immediate vicinity of the find-spot had been cut away. At a distance of 500–750 m from the find-spot a strip of peat was still present. The upper part of the profile, which in connection with this find is of importance, was sampled.

At this site the profile was as follows

0– 20	cm	moderately humified *Sphagnum* peat with many roots of *Molinia* covering the bog surface
20– 39	„	fresh *Sphagnum imbricatum* peat
39– 44	„	rather fresh *Sphagnum cuspidatum* peat with some roots of *Monocotyledons* and leaves of *Andromeda*
44– 98	„	highly humified *Sphagnum rubellum* and *cf. palustre* peat with remains of *Eriophorum* and *Calluna*
98–103	„	moderately humified *Sphagnum cuspidatum* peat
103–114	„	highly humified *Sphagnum* peat with remains of *Calluna* and *Eriophorum*
114–143	„	highly humified *Sphagnum* peat with remains of *Monocotyledons*, especially *Eriophorum*, and *Calluna*

The distance between the analysed samples is, as a rule, 5 cm. In that part of the diagram to which the diagrams from both sods of peat had to be transferred, a sample distance of 2.5 cm appeared necessary. In the intermediate samples a number of 500 AP was usually counted, which number was raised to 1000 wherever this was desirable.

The diagram from Roswinkel (Fig. 8) agrees fairly well with that from Emmererfscheidenveen which lies at a distance of about 6 km. The first characteristic point is the *Corylus* maximum (C_3) at a depth of 115 cm. The following sharp decline of *Corylus* and the *Quercus* maximum are also present in the Emmererfscheidenveen diagram. The *Fagus* values between 104.5 and 109.5 cm are—compared with those in the corresponding part of other diagrams—relatively high (0.5–0.8 %), which may perhaps be due to the local occurrence of one or a few trees. In this part of the diagram the *Betula* percentages are higher than those in the diagram from Emmererfscheidenveen. It is clear that the spectrum at a depth of 97 cm corresponds with that at a depth of 105 cm in the diagram from Emmererfscheidenveen: *Alnus* minimum, *Quercus* maximum, the spectrum preceding to the first increase of *Fagus*. The last *Corylus* maximum (C_4) after which *Corylus* falls to a value of about 10 %, is present at a depth of 67 cm. Just as in the other diagrams from south-east Drente the fall of *Corylus* is accompanied by the second more important increase in the Fagus curve, while here also the end of this increase of *Fagus* is coupled with a *Fraxinus* maximum.

The layer between 67 and 92 cm is much thicker than the corresponding layer in the profile from Emmererfscheidenveen. Moreover, the behaviour of the *Corylus* curve differs from that in the Emmererfscheidenveen diagram, and is more in agreement with that in the diagram from Bargeroosterveld (Fig. 9) which will be discussed on p. 26. From the *Corylus* minimum at a depth of 92 cm, which corresponds with the minimum at a depth of 95 cm in the diagram from Emmererfscheidenveen, *Corylus* does not rise right away to the last *Corylus* maximum (C_4) as in the Emmererfscheidenveen diagram.

At a depth of 79.5 cm the *Corylus* curve shows a new peak in order to reach the last maximum via a minimum at a depth of 74.5 cm. The *Corylus* curve thus shows some marked fluctuations between the C_3 and the C_4. As in the corresponding part of other diagrams from the raised bog of south-east Drente the *Corylus* curve shows similar fluctuations the behaviour of the *Corylus* curve in the diagram from Roswinkel can be considered as the normal one.

Summarizing it can thus be stated that the Roswinkel diagram agrees well with the other diagrams from south-east Drente. There is also a fairly good agreement with the diagram published by FLORSCHÜTZ and WASSINK (1935). It appears, however, that in the last diagram the upper *Corylus* maximum does not correspond with the C_4, but with the C_3.

Proceeding now to a discussion of the analysis of both sods of peat difficulties arise. Although all objects would have been found together (VAN GIFFEN, 1947, Plate 76) the structure of the peat of both sods shows a marked difference. The peat surrounding the ball of wool has a rather loose structure with many stems of *Calluna*, whereas the other sod of peat is more compact without macroscopic remains of *Ericaceae*. In both cases we have highly to rather highly humified *Sphagnum* peat. In addition to this difference in structure the diagrams from both sods do not agree (Fig. 8 A and B). [1] The diagram with the casts of amber beads is quite uniform with high *Alnus* percentages (50 %) and also high values for *Corylus* (28–35 %). The diagram of the other sod of peat shows more variation. This last diagram can easily be transferred to the diagram from Roswinkel: The spectrum No 4 corresponds with that at a depth of 67 cm in the Roswinkel diagram, viz. the last *Corylus* maximum and the beginning of the second increase of *Fagus*. The spectrum at a depth of 64.5 cm corresponds with the average of the samples 1 and 2. It is less clear how the samples 5–8 can be transferred, but it is fairly certain that the spectrum of sample 6 corresponds with that at a depth of 74.5 cm in the Roswinkel diagram. In that case peat formation at the site of the Roswinkel profile must—at least during the time in question—have been more rapid than at the site where the ball of wool was discovered. The find level of the ball of wool then corresponds with a depth of about 75 cm in the diagram from Roswinkel. The possibility remains that the find level lies somewhat higher if the equalization of sample 6 with the spectrum at a depth of 74.5 cm would not be correct. As it is certain, however, that the samples 1–4 correspond with that part of the diagram that lies between 64 and 67 cm the upper limit of this find level cannot be higher than 70 cm.

In the diagram from Roswinkel there is only one spectrum which bears sufficient resemblance to the very uniform diagram from the sod with the casts of amber beads, namely the spectrum at a depth of 87 cm. The high *Alnus* percentage, just as the values for *Corylus*,

[1] As both sods of peat were analysed without intervals the vertical scale of both small diagrams does not agree with that of the diagram from Roswinkel.

Betula, *Pinus* and *Quercus* are of excellent agreement, whilst the percentages of the other trees do not vary considerably.

Concomitant with the fact that the peat of both sods shows a different structure, the find levels of the ball of wool and the amber beads appear not to coincide. Although the distance between the spectra corresponding with the find levels of the objects of both sods is not great (min. 12.5 cm, max. 17.5 cm) it cannot be neglected, the more so as 12.5 to 17.5 cm highly humified *Sphagnum* peat represents a not unimportant course of time.

As this examination led to a contradictory result the question arose what mistake had been made. In the report of a lecture which was read half a year after the discovery of the find, VAN GIFFEN (1925) did not mention the ball of wool at the enumeration of the objects of the bronze find of Roswinkel, nor is this ball of wool reported in a later enumeration (VAN GIFFEN, 1930, pp. 79–80). The fact that on the 1 : 50000 ordnance map in the archives of the Institute for Biological Archaeology two marks representing points at a mutual distance of 350 m have been placed at the site in question, suggests that the ball of wool was found at some distance from the find-spot of the other objects. Moreover, according to VAN GIFFEN (oral communication) it is quite certain that the amber beads and the fragment of the bronze palstave were found together. On that account it is certainly justified to place the archaeological dating MONTELIUS II at a depth of 87 cm, that is 5 cm above the *Corylus* minimum which is present in all diagrams from south-east Drente.

The bronze dagger of Bargeroosterveld. The result of the pollen analytical examination of a recent—not yet published—discovery of a bronze dagger (Earliest Bonze Age) at Bargeroosterveld agrees with that of the find of Roswinkel. In the autumn of 1953 this fine specimen, the horn hilt of which has also been preserved, was found during a reclamation of a field of the brothers HAITEL. During this work a surviving block of peat was partially cut away, and in it the mentioned find was made. It was not until some weeks after the discovery, however, that this site was visited by Dr W. GLASBERGEN and the present author. In the meantime the cutting of the peat had progressed about 30 m. For that reason it was not possible to check the position of the bronze dagger. Inquiries of a workman who had been a witness of the discovery enabled us to indicate approximately the find level in the profile at a distance of 30 m from the find-spot. The part of the profile between 30 and 90 cm below the surface was sampled. In this profile the position of the bronze dagger would correspond with a depth of about 80 cm. On this spot the profile was as follows

0–30 cm	disturbed peat
30–54 „	fresh *Sphagnum imbricatum* peat
54–81 „	highly humified *Sphagnum* peat (*Sphagnum rubellum*, *papillosum*, *cf. fuscum*, *cf. molluscum*) with remains of *Ericaceae* and *Monocotyledons*, especially *Eriophorum*
81–84 „	fresh *Sphagnum papillosum* peat
84–90 „	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*

Taking into account that peat formation was much slower here than at the site where the profile from Roswinkel was sampled, the diagram from Bargeroosterveld (Fig. 9) agrees well with that from Roswinkel. The *Corylus* curve shows the same fluctuations. In the lower part of the diagram the first increase in the *Fagus* curve can just be seen. The expansion of *Fagus* with the accompanying final fall of *Corylus* is also present in this diagram. In contrast with the other diagrams the *Fraxinus* maximum, which always coincides with the end of the second increase in the *Fagus* curve, is absent here.

On account of the circumstances mentioned above it is not possible to indicate exactly the position of the dagger in the diagram. The approximate position at a depth of 80 cm is in harmony with that of the find of Roswinkel which also corresponds with a level not far above the first, small increase in the *Fagus* curve.

Another bronze find from that time is the bronze axe (MONTELIUS I) from the "Meerhusemer Moor" near Aurich (Ostfriesland). The pollen analytical investigation of this find has not yet been published, but, according to OVERBECK and SCHNEIDER (1938), this axe has to be placed at the beginning of the continuous *Fagus* curve. This is thus in agreement with the results of Roswinkel and Bargeroosterveld.

The bronze axe of Minstedt (MONTELIUS II) was investigated by SCHUBERT (1933) 30 years after its discovery. It was still possible to indicate fairly exactly the position of this axe in the peat profile because the height of the object above the sandy subsoil was known, and since the time of the discovery not much peat had been cut away. Concerning this find it can only be remarked that the find level lies above the beginning of the continuous *Fagus* curve and below the last *Corylus* maximum. This again is in agreement with the results discussed above.

It appears that all finds from the Early Bronze Age have to be placed above the first, very small increase in the *Fagus* curve, which in most diagrams from north-west Germany is represented by the beginning of the continuous *Fagus* curve. This in contrast with the finds from the Late Stone Age which were lying below this increase in the *Fagus* curve. The first increase of *Fagus* pollen, which in the diagram from Emmererfscheidenveen lies between 100 and 105 cm, thus coincides approximately with the transition from the Neolithic to the Bronze Age.

LATE BRONZE AGE

A find from the end of the Bronze Age which lent itself very well to pollen analysis is that of a bronze vessel containing a number of bronze objects discovered in the Brøndsum bog, at 6 km west-south-west of Hobro (Jutland). This find—highly probably a votive hoard—was investigated by JESSEN (1934). Unfortunately on account of the high *Betula* percentages the values for the other trees have been strongly depressed, so that an exact comparison of this diagram with other north-west European diagrams is not possible. It is clear, however, that this find level which belongs to the end of the Bronze Age lies in the upper part of JESSEN's zone VIII, that is immediately below the appearance of *Fagus* and *Carpinus*. The appearance of *Fagus* in the diagrams from Jutland corresponds with the expansion of *Fagus* and the accompanying fall of *Corylus* in the diagrams from north-west Germany and the northern Netherlands.

IRON AGE

Traces of human activity found in two bogs in Schleswig-Holstein have been subjected to pollen analysis by SCHÜTRUMPF. In the first place a culture layer is concerned with a great number of bones of domestic animals and some pottery discovered in a bog near Barsbek (Kreis Plön). This culture layer, which pottery has dated at about the beginning of the era (RADDATZ, 1952), could not contribute to a dating of a pollen analytical horizon as the diagram from that site is difficult to interpret (SCHÜTRUMPF, 1952): The *Pinus* percentages are relatively high, whilst the *Fagus* curve is atypical and in the upper part of the diagram even shows a decline instead of reaching the expected high values. The behaviour of the *Carpinus* curve, also, is not quite normal.

The pollen analytical examination of pottery from the same time found in the Rüder bog (Kreis Schleswig) has led to a more positive result. In sections which were to be seen in peat cuttings, pits filled up with fresh *Sphagnum* peat showed up in the highly humified *Sphagnum* peat (SCHWABEDISSEN, 1951). According to SCHWABEDISSEN these pits would be the effect of prehistoric peat-digging. On some spots pottery had been buried in the highly humified *Sphagnum* peat below the pits. This pottery could be dated at about the beginning of the era. As a result of the pollen analytical examination carried out by SCHÜTRUMPF (1951) the level at a short distance above the end of the first expansion of *Fagus* can be dated at about the beginning of the era. Concerning this dating it has been supposed that in the pits peat formation started immediately after the burying of the offerings, so that the lowermost spectrum of the fresh *Sphagnum* peat in the pits can be dated at about the beginning of the era.

The find of a hoard of Roman silver coins near Bargercompascuum. From the first centuries A.D. a number of finds from bogs has been described. A recent, not yet published one is the discovery of Roman coins in the raised bog near Bargercompascuum. Besides the exact dating evidence this find is therefore so valuable because it was possible to verify its exact position in the peat. In the autumn of 1952 during the digging away of the fresh *Sphagnum* peat a large number of Roman silver coins (*denarii*) and pieces of leather were discovered by Mr T. DUINKERKEN at Bargercompascuum. The coins and pieces of leather were collected by him, but the spot where the coins were found remained intact, since a 17 cm high peat monolith the upper side of which represented the find level was saved. The situation on the spot as seen by Dr W. GLASBERGEN and the present author in January 1953 is shown in Fig. 10. The vertical plane A represents a section of the fresh, Younger *Sphagnum* peat which is cut away before the beginning of the peat-cutting campaign. The horizontal plane B is the level to where the fresh *Sphagnum* peat is cut away. The vertical plane C is the section of the very humified *Sphagnum* peat, and finally the horizontal plane D represents the sandy subsoil. The distance between the peat monolith and the plane A is 1 m.

During our visit some pieces of leather and a small number of coins could still be collected. The total number of coins collected on this spot is 313. These coins which are still being investigated range from NERO (54–68) to COMMODUS (180–192). It appeared possible to reconstruct from the pieces of leather a purse with a part of the girdle (SCHLABOW, not yet published).

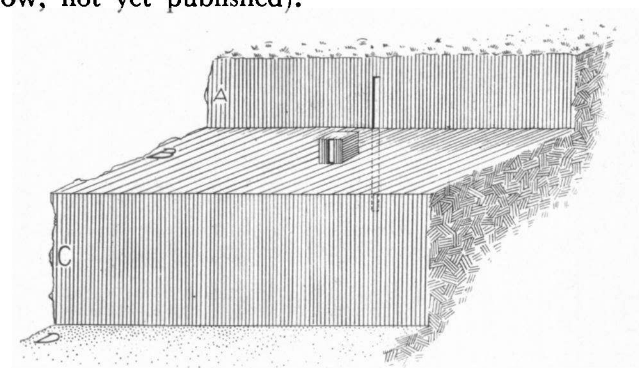

Fig. 10. Situation on the find-spot of the Roman coins near Bargercompascuum.

Through the presence of some coins of COMMODUS this find can be dated at about 190 A.D. The question may be raised whether the possibility has been taken into account that the bag with money had been buried in the peat, so that the find level would not correspond with the actual bog surface at 190 A.D. Up to now a considerable number of hoards from the first five centuries A.D. was discovered (*cf.* DE BOONE, 1954). The purse lay on a thick tussock of *Eriophorum*, so that it is likely that it intentionally had been laid down in a solitary tussock of cotton-grass in order to find it again easily. Moreover—as will be discussed later on—the result of the pollen analytical investigation of this find agrees with that of some other finds from about the same time.

In addition to the small peat monolith a 90 cm high section of the profile behind the monolith was sampled. In this way it would be possible to fit the diagram of the peat monolith into the greater diagram which again could be compared with the diagram from Emmererfscheidenveen.

The following profile was sampled

0– 30	cm	disturbed peat
30– 38	„	rather fresh *Sphagnum imbricatum* peat
38– 49	„	fresh *Sphagnum cuspidatum* peat
49– 55	„	highly humified *Sphagnum* peat with *Eriophorum*
55– 75	„	fresh *Sphagnum imbricatum* peat with *Eriophorum*

75– 90 cm fresh *Sphagnum cuspidatum* peat with some *Eriophorum* and *Monocotyledons*
90– 94 „ moderately humified *Sphagnum imbricatum* peat with some *Calluna* and *Monocotyledons*
94–120 „ highly humified *Sphagnum* peat with *Calluna* and *Eriophorum*

Peat monolith

48– 55 cm *Eriophorum* peat
55– 65 „ moderately humified *Sphagnum imbricatum* and *cuspidatum* peat with remains of *Eriophorum, Calluna, Andromeda* and *Scirpus*

No marked *Grenzhorizont* is present in this profile. The layer between 90 and 94 cm can be considered as intermediate.

In the lower part of the diagram from Bargercompascuum (Fig. 11) the last *Corylus* maximum (C_4) is present at a depth of 102 cm. The fact that below this *Corylus* maximum the *Fagus* percentages are very low (0.2–0.4 %) does not agree with the other diagrams from south-east Drente. It is not unlikely that we have here a gap in the deposits. It is not impossible that in former times the Runde, which is running at a distance of 150 m from the find-spot, locally has washed away peat layers. Above the last *Corylus* maximum the diagram is quite comparable with the other diagrams from this region. *Corylus* falls to values of about 10 %, *Fagus* reaches relatively high percentages, and *Carpinus* shows a continuous curve. The end of the increase of *Fagus* at a depth of 77 cm again coincides with a *Fraxinus* maximum. The behaviour of *Alnus* and *Quercus* also agrees with that in the diagram from Emmererfscheidenveen, whilst the first, although slight increase of *Carpinus* begins at a depth of 57 cm. This diagram is thus well comparable with the other diagrams from south-east Drente.

Above this diagram are represented the result of the investigation of the peat monolith and the spectrum of the peat adhering to a piece of leather. On account of the low pollen content in the upper part of the monolith the total number of tree pollen counted in the upper two samples does not reach 1000, but 500 and 375 respectively. As the distance from the monolith to the profile was only 1 m no difficulties were expected in fitting the diagram of the peat monolith into the greater diagram. This is indeed well possible, but not until some intermediate samples between a depth of 47 and 57 cm were analysed. In the diagram from the monolith there is a—for the rest unimportant—*Pinus* maximum. In the diagram from Bargercompascuum this maximum can be seen at a depth of 50 cm. In both diagrams a temporary increase of *Quercus* is clearly shown. A characteristic feature is the first increase in the *Carpinus* curve between the upper spectrum of the peat monolith and the spectrum of the leather purse. The corresponding increase of *Carpinus* is also seen in the lower diagram. As the find level of the purse lies between the upper sample from the monolith and the sample from the purse the dating of about 190 A.D. has to be placed half-way the first increase of *Carpinus*. For this reason this date has to be placed at a depth of about 47 cm in the Bargercompascuum diagram, whilst in the diagrams from Emmererfscheidenveen and Fochteloo this date corresponds with a depth of 25 and 95 cm respectively.

Archaeological objects from about the same time as the find of the coins, which have been subjected to pollen analysis, are the bronze fibulae from the "Oldenbrooker Moor" in Oldenburg (OVERBECK and SCHMITZ, 1931) and the peat burial ("*Moorleiche*") from the "Wolfsbrucher Moor" in Kehdingen (SCHUBERT, 1933). The peat burial from Obenaltendorf—on which WEBER based his dating of the *Grenzhorizont*—will be discussed below on pp. 49–50. WATERBOLK (1950) has already remarked that SCHUBERT fitted the spectrum of the peat burial too high into the diagram from Obenaltendorf, which —as far as the Subatlantic part is concerned—agrees very well with the Fochteloo diagram. According to SCHUBERT the spectrum of the peat burial would correspond with a depth of 210 cm, whereas the Ericaceous percentage and the values for the tree pollen suggest that the spectrum of the peat burial corresponds with a depth of 270 cm in the Obenaltendorf diagram. The age of the peat burial has been given by SCHUBERT at about 300 A.D. This date can be placed at the level where the first increase of *Carpinus* comes to an end. This is in agreement with the result of the find of the Roman coins, *i.e.* that the date of 190 A.D. has to be placed at the first increase of *Carpinus*.

The examination of a find consisting of 28 bronze fibulae ornamented with silver and discovered at 50 cm above the *Grenzhorizont* in the "Oldenbrooker Moor", could confirm the results discussed above. The pollen analytical examination of a profile sampled by SCHÜTTE some weeks after the discovery was carried out by OVERBECK (OVERBECK and SCHMITZ, 1931). The upper part of the diagram [1] agrees well with that from Fochteloo, considering that in eastern Oldenburg the values for *Fagus* and *Carpinus* are higher than in the northern Netherlands. Unfortunately peat no longer adhered to the fibulae, which would have allowed a check analysis. According to OVERBECK there is no question about the accurate position of the fibulae—which have been dated at 200–300 A.D.—in the diagram. It appears that the find level, which corresponds with a date of 200–300 A.D., lies at the end of the first increase in the *Carpinus* curve.

Consequently the results of these three finds from the 3rd and 4th century A.D. show considerable agreement, and on that account it is certainly warranted to date the first increase of *Carpinus* at about 200 A.D.

The position of a "*Bügelplattenstück*" from the 5th–6th century A.D. discovered in the "Holler Moor" (OVERBECK and SCHMITZ, 1931) is in harmony with this dating of the first increase of *Carpinus*. On account of the fact that this object, according to the report of the finder, was lying on the transition from highly humified to fresh *Sphagnum* peat OVERBECK supposed that this report must be incorrect, or that the fibula immediately after it had been lost, would have come to rest in a deeper layer. It appears, however, that the position of the

[1] This diagram, as that of SCHUBERT, has also been published in FIRBAS (1949).

fibula—following up the finder's report—corresponds with a level at some distance above the first increase of *Carpinus*, which is thus somewhat above the position of the finds discussed above.

From about the same time are the culture remains in the "Bolleveen" (VAN GIFFEN, 1950) and the fortified settlement near the "Witteveen" (VAN GIFFEN, 1949, 1950), both near Zeijen in the province of Drente. WATERBOLK (1950) carried out a pollen analytical investigation of both sites.

In the mentioned "Bolleveen" irregular pits (depth about 0.80 m, diameter 2–4 m) in which fresh *Sphagnum* peat had been deposited, showed up in the highly humified *Sphagnum* peat. Besides many pieces of timber also bones—especially of cows (VAN GIFFEN, 1952)—and sherds were discovered at the bottom of these pits which undoubtedly are the effect of human activity (prehistoric peat-digging?). Through the presence of Saxon pottery the beginning of the formation of fresh *Sphagnum* peat in these pits could be dated at about 400 A.D. The lower part of a diagram from a Younger *Sphagnum* peat profile in such a pit can be well compared with the diagram from Fochteloo. The lowest spectrum of this "Bolleveen" diagram shows a relatively high *Fagus* percentage, whilst *Carpinus* has a value of 1–2 %. The beginning of this profile thus falls after the first increase in the *Carpinus* curve. A comparison of this diagram with that from Fochteloo learns that the lowest spectrum, which can be dated at about 400 A.D., corresponds with a depth of about 87 cm in the Fochteloo diagram. This again is in agreement with the position of the other finds discussed above.

In a part of a ditch of the fortified settlement near the "Witteveen", which also can be dated at about 400 A.D., fresh *Sphagnum* peat had been formed. It is likely that after the building of the fortification the small raised bog on the north side expanded somewhat. On account of local circumstances the *Fagus* and *Carpinus* percentages are much lower than in the "Bolleveen" diagram. For that reason it is not possible to transfer the beginning of the peat formation in the ditch to the diagram from Fochteloo.

Finally the diagram from the Wakenitz bog near Lübeck can be mentioned (SCHMITZ, 1951). In the profiles from this bog a marked change in the stratigraphy can be observed. In consequence of the damming up of the water of the Wakenitz river a strong rise of the water level took place. On that account the formation of sedge peat suddenly passed into calcareous deposits. As according to the charter in question the building of the dam took place at 1298 A.D., the sudden change in the stratigraphy can be dated at 1300 A.D. It appears that this date has to be placed at the level where *Fagus* as well as *Carpinus* reach a maximum. Although on account of the great distance and the particular circumstances an accurate comparison of this diagram with that from Fochteloo is not possible, the spectrum in question will approximately correspond with a depth of 20–25 cm in the last diagram.

Summarizing it can be stated that the result of the pollen analytical investigation of a number of archaeological finds from bogs has led to the following archaeological dating of the pollen diagram from the northern Netherlands. In view of the beginning of the curve for *Plantago lanceolata* at a depth of 160 cm in the Emmererfscheidenveen diagram the beginning of the Neolithic time can be placed here at that depth. Just as in the diagrams from Denmark and north-west Germany the beginning of the *Plantago* curve is accompanied by a decrease of *Tilia* and *Ulmus*. The Neolithic settlements discovered in the peat appeared to be situated above the decrease of *Tilia* and *Ulmus*.

In the Emmererfscheidenveen diagram the transition from Neolithic time to Bronze Age approximately falls at a depth of 100 cm where the *Fagus* curve shows its first, although slight increase. Various finds from the Early Bronze Age were lying above this increase in the *Fagus* curve, whereas all finds from the Late Stone Age have to be placed below this characteristic feature.

Unfortunately practically no archaeological objects from the Late Bronze Age were examined so far. The Danish find from the end of the Bronze Age falls immediately below the expansion of *Fagus*. In the Emmererfscheidenveen diagram the Bronze Age/Iron Age transition lies approximately at a depth of 85 cm.

A reliable dating of a pollen analytical level from the first centuries A.D. gives the find of the Roman coins near Bargercompascuum. The first increase in the *Carpinus* curve (at a depth of 25 cm in the Emmererfscheidenveen diagram and at a depth of 95 cm in the Fochteloo diagram) could be dated at about 200 A.D. This dating is in agreement with the position of some other finds from north-west Germany.

Finally the well dated horizon in the Wakenitz bog has to be mentioned (1300 A.D.). In the diagram from Fochteloo the corresponding level lies approximately at a depth of 20–25 cm.

V. THE POLLEN ANALYTICAL INVESTIGATION OF BURIAL MONUMENTS

In discussing the results of the pollen analytical investigation of burial monuments some terms will be used that need an explanation.

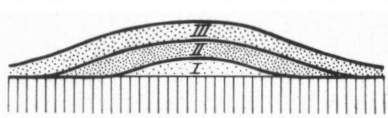

Fig. 12. Schematic section of a three-period barrow or tumulus.

Fig. 12 represents a schematic section of a three-period barrow. The surface on which a tumulus has been built is called old surface. A pollen analytical examination of that old surface can give an impression of the vegetation at the time of the construction of the

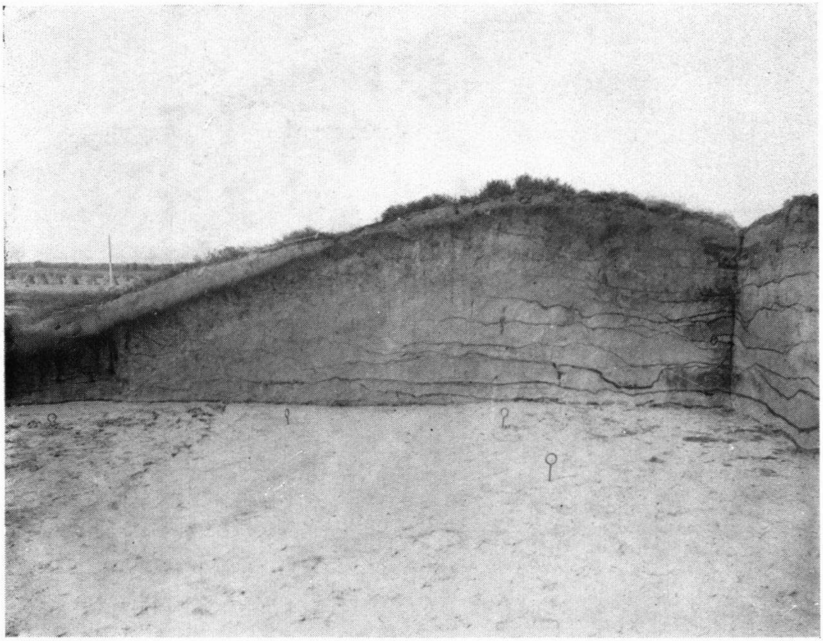

Fig. 13. Neolithic barrow near Gasteren. The barrow consisting of yellow sand has been raised on a hardly perceptible old surface. The horizontal infiltration veins are characteristic of Neolithic tumuli (VAN GIFFEN, 1941*a*).

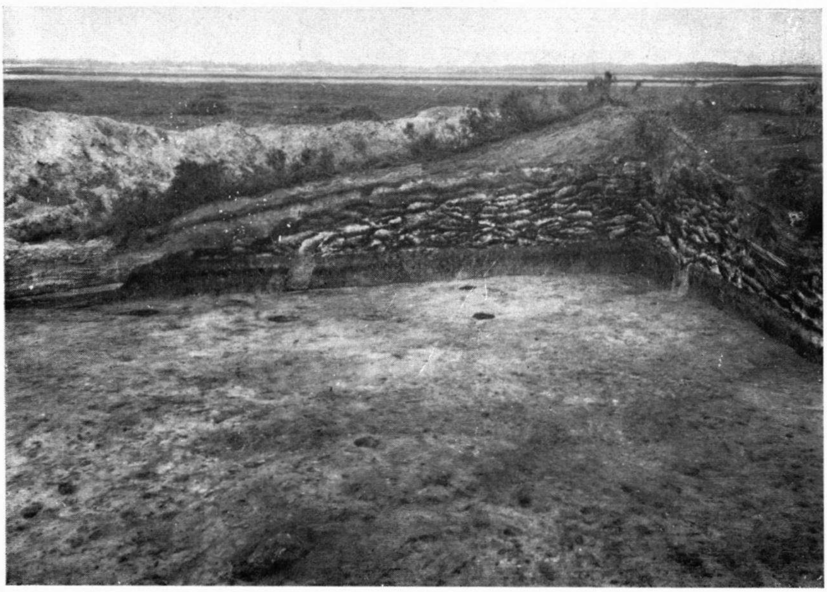

Fig. 14. Bronze Age barrow near Havelte (tumulus 2). The barrow has been built of inverted heather sods. The subsoil shows a podzol profile (VAN GIFFEN, 1951).

barrow. The burial mounds from the Late Stone Age consist of structureless, clean yellow to dirty grey sand (Fig. 13), whereas most tumuli from the Bronze and Iron Age have been built of—mostly inverted—heather sods (Fig. 14). The pollen content of a sod—just as that of the old surface—reflects the vegetation at the time of the construction of the barrow.

The subsoil of the barrows from the Bronze and Iron Age shows —apart from exceptional cases—a more or less well developed podzol profile. Below Neolithic barrows mostly no clear soil profile is present. For that reason it is often difficult to locate the exact position of the old surface. Sometimes the old surface of a Neolithic barrow can be recognized as a faintly humous layer.

In many cases more periods of construction can be recognized in one tumulus, *e.g.* a Neolithic primary mound (I) is sealed beneath a Bronze Age capping of sods (II). The number of periods in one tumulus is not confined to two. Tumuli of three periods are not rare, while tumuli of a yet greater number of periods equally occur. As mostly a considerable time elapsed between the building of two successive periods, a vegetation could develop on the surface of the underlying mound, so that often the successive periods are separated by a humous layer.

Sometimes two or more constructional phases can be distinguished within one period. It is quite probable that only a short time elapsed between the building of two successive phases.

Besides a primary grave which, as a rule, lies approximately at the centre of the barrow, mostly one or more secondary interments are found in the peripheral parts of the mound.

Many tumuli were surrounded by peripheral constructions as single or multiple rings of timber uprights (post-circles), an enclosing circular ditch or, exceptionally, an enclosing bank and ditch. These archaeologically important constructions will not be described here. For a detailed description of the barrows we may refer to the quoted excavation reports.

In contrast with the samples from bogs *Betula* is not included in the ΣAP of the samples from burial monuments. It appears that the *Betula* percentages of the various samples from one barrow cemetery show considerable fluctuations. These are not effected by climatic changes, but are due to the fact that in sandy districts the birch is the first to return after the abandoning of the fields. In this way locally the birch could play an important part. As on account of the high *Betula* percentages those of the other trees would be depressed too much, *Betula* is excluded from the ΣAP. Moreover, the results can more easily be compared now with those of Waterbolk (1954*b*).

The barrow cemetery near Hijken, municipality of Beilen (*Table II*)

In 1953 the greater part of a barrow cemetery near Hijken (municipality of Beilen) was excavated.

Tumulus 1, a two-period barrow, consisting of:

A primary barrow of greyish sand, raised on a partly faintly humous old surface. A ^{14}C-measurement of charcoal from the primary grave—which did not contain grave goods—by Professor HL. DE VRIES, Physical Laboratory of the University of Groningen, gave a dating of 1350 ± 150 B.C.

A covering mound of light-coloured sand in which a few clear sods could be distinguished.

Both periods belong to the Neolithic period.

Tumulus 8, a two-period barrow, consisting of:

A primary barrow of dirty yellow sand, on a humous old surface. The primary grave of this period contained, among other things, a debased herringbone beaker (Late Neolithic).

A sod-built covering mound.

The following barrows had all been built of—mostly inverted—sods, and can—with the exception of tumulus 2—be assigned to the Bronze Age. Of all Bronze Age tumuli of this cemetery in which a primary grave was discovered, the corpse had been buried in a trunk coffin.

Tumulus 10 consisted of a core of dark, peaty sods, smoothed over by a capping of yellowish soil with light-coloured sods and a talus of greyish sand. This mound was covered by a mantle of light-coloured sods. The podzolized subsoil showed a rather weakly developed hard pan.

Tumulus 9, a two-period barrow, consisting of:

A primary mound showing a core of tightly packed, dark, peaty sods, and a capping of less dark-coloured sods which had not been so tightly packed. Where the base of the mound had been stripped off only the leached layer and the hard pan were present. In the primary grave, among others, two gold spirals and a bronze pin were discovered.

A covering mound of reddish-brown sand with some sods.

Tumuli 3 and 4 were long barrows, a not very common type in the Netherlands. Tumulus 3 showed three phases. The first phase was a round barrow consisting of a core of greyish sods covered by a capping of tightly packed humous sods. This core was smoothed over by yellow sand. The last phase showed an elongated ground plan. The original round barrow had been extended to the south for about 10 m.

Tumulus 4 had been built of—sometimes rather faint—grey to dark sods. The old surface had been stripped off, and the subsoil showed a not very well developed podzol profile.

Tumuli 5 and 6 had been built of a core of arable soil with a covering of grey to dark long sods. Both tumuli were overlying old arable with very distinct plough markings. In tumulus 6 a second period—a capping of reddish-brown sand—was present.

Tumulus 7 consisted of a core of short, brown-yellow and greyish sods, and a capping of rather long, grey to dark sods. The subsoil did not show a heather podzol profile, but a grey layer about 15 cm thick, suggesting old arable.

Tumulus 2 was an isolated barrow, lying at a distance of about 1000 m from the Hijken barrow cemetery. Three constructional phases could be distinguished, viz. a core of short, dark sods, a capping of less dark-coloured sods, and a third phase of reddish-brown sand with a few sods. The old surface had been stripped off for the greater part before the erection of the barrow. According to a few pieces of iron and a spread of cremated bone this tumulus undoubtedly belongs to the Iron Age.

Concerning the relative chronology of the barrows of the Hijken cemetery the following may be remarked. Tumulus 1 and the primary mound of tumulus 8 are the earliest (Late Stone Age), whilst tumulus 2 is the latest one (Iron Age). As the tree pollen spectra show no characteristic differences they do not give support to the determining of the relative chronology of the Bronze Age barrows. It is remarkable that there can be considerable differences between the various spectra of a single barrow, *e.g.* the difference in *Corylus* and *Quercus* percentage between the spectra of the old surface and dark-coloured sod of tumulus 7, the relatively high *Tilia* percentages in the old arable samples from the tumuli 5 and 6. It appears that not unfrequently the differences between the spectra from a single barrow are greater than those between the barrows mutually. It is for that reason that only the *Calluna* percentages, which in a given area increase with time (WATERBOLK, 1949, 1954*a*), could give an indication of the relative chronology of the barrows. Unfortunately also the *Calluna* percentages in the various spectra of one tumulus appear to fluctuate rather greatly. The low *Calluna* percentages of the tumuli 9 and 10 suggest that these two barrows are the earliest of the Bronze Age tumuli of this cemetery. For this reason they have been placed after the Neolithic tumuli. In consideration of the, on an average, rather high *Calluna* values the tumuli 5, 6 and 7 are the latest of the Bronze Age barrows, while the long barrows 3 and 4 have to be placed between the tumuli 9 and 10 on the one side and the tumuli 5, 6 and 7 on the other.

With regard to the separate spectra the following may be remarked. The pollen of the old surface sample from tumulus 1 was badly preserved, which perhaps is the cause of the fact that *e.g.* no *Fraxinus* pollen was met with. The *Tilia* value is rather high (4.5 %), whilst that of *Calluna* is extremely low (6.4 %). The high values for *Gramineae*, *Plantago*, *Compositae* and *Caryophyllaceae* point to a semi-wild pasture land originating after the clearing of the forest in consequence of grazing. The high *Succisa* percentage likewise indicates a type of meadow. The sample from the sod of the second period of this tumulus shows a somewhat higher *Calluna* value (21.1 %), while the values for the various herbs have markedly decreased, just as the *Tilia* percentage. There is a considerable difference in *Quercus* percentage between both periods of this tumulus (4.5 and 42.1 % respectively).

Judging from the *Calluna* percentage the primary mound of tumulus 8 must be later than the second period of tumulus 1. The *Corylus* value is fairly high, whilst that for *Quercus* is extremely low. The values for the various herbs do not differ considerably from those in the Bronze Age barrows. *Fagus* is completely absent in the Neolithic spectra in this table.

The spectra of both samples from the covering mound of tumulus 8 are in fairly good agreement, and differ mainly by the much higher *Quercus* percentage from the spectrum of the primary barrow. The *Calluna* percentage in both sods is only a little higher than that in the old surface of the Neolithic period. The herbaceous percentages of both periods do not show much difference either.

The spectra of the old surface of the tumuli 9 and 10 show much resemblance. Only the *Betula* percentage in the old surface of tumulus 10 is much higher than that of tumulus 9. At the time of the construction of the tumuli 9 and 10 *Betula* must have played an important part on that spot. As the *Quercus* percentage in the sods of both barrows is markedly higher than that in the old surface, it seems likely that the sods will not have been cut in the immediate vicinity of the tumuli.

Tumulus 3 showed three constructional phases. As on the surface of the first two phases no traces of a vegetation cover could be observed, it is likely that little time elapsed between the construction of the successive phases. The result of the pollen analytical examination can confirm this supposition. The spectra of sods of the first and third constructional phase do not give any indication of a considerable difference in time. The subsoil of the round barrow did not show a podzol profile, but a yellow-grey layer passing downwards into the yellow-coloured virgin soil suggests old arable which had been abandoned some time before the construction of the barrow. The pollen analytical result also points to that. Compared with the sod samples the old surface shows a fairly low *Calluna* percentage, whilst the values for *Gramineae* and *Plantago* are more than twice as high as those in the sod samples. This suggests that the vegetation of the old surface of the round barrow was no typical heath, but that *Gramineae* and *Plantago* still played an important part.

The spectra of both sod samples from tumulus 4 show nothing in particular.

The spectra of the old arable below the tumuli 5 and 6 are interesting. Very likely this old arable had been cultivated till the construction of the barrows. The clear plough markings as well as the pollen spectra point to that. In contrast with the sod samples from the same barrows the pollen in the old arable samples was badly preserved. This is easy understandable as—in contrast with the compact grass and heather sod—arable soil has a loose structure, so that before the construction of the barrow the air could easily enter, badly damaging the pollen grains. The spectra of both old arable samples are in fairly good agreement. On account of the low pollen content and the bad state of preservation a small quantity of tree pollen was counted in these samples. Compared with the average value of 0.6 % in the other samples the *Tilia* percentages in both old arable samples are high (3.4 and 3.0 %). Pollen of *Plantago* occurs in overwhelming quantities (363 and 267 %). The pollen of *Caryophyllaceae* shows a relatively high percentage, whilst *Rumex* is fairly abundant. Mention must be made of the occurrence of *Spergula* (4.9 %) in the old arable below tumulus 5. The spectra of the various sod samples again show mutual differences, suggesting that the sods will have been cut on different spots.

The old surface sample from tumulus 7 contained rather much pollen of plantain (40 %), while moreover the *Calluna* value is high (287 %). Through the absence of a podzol profile the subsoil of tumulus 7 could clearly be recognized as an original old arable which

—in view of the fairly distinct humous surface—must have been abandoned some time before the construction of the barrow. The high *Calluna* percentage also indicates that the heather must have covered this old arable. The pollen grains were well preserved, this contrary to the old arable samples from the tumuli 5 and 6. As in general the *Calluna* percentages in the various samples from tumulus 7 are the highest of all Bronze Age samples in Table II, this tumulus is probably the youngest of the Hijken barrow cemetery.

Compared with the Bronze Age samples the spectra of the isolated Iron Age barrow (tumulus 2) show some characteristic differences. The average *Fagus* value in the Bronze Age spectra is 0.6 %, and that in the spectra of tumulus 2 is 3.1 %. *Carpinus* is present in all samples from tumulus 2, while *Tilia* shows a decrease, namely from an average of 0.6 % (some extremely high percentages were not worked up in calculating this average) to an average of 0.3 %. *Corylus* has also decreased (from 18.0 to 13.3 %), while *Calluna* shows an important rise. For the same reason as for tumulus 3 it is not likely that much time elapsed between the construction of the successive phases of tumulus 2. This supposition is confirmed by the results of the pollen analytical investigation.

The "Noordse Veld" near Zeijen, municipality of Vries (Table III)

In some barrows—already excavated many years ago—of the cultural reserve the "Noordse Veld"—archaeologically well-known by the excavations of VAN GIFFEN (1919, 1920, 1930, 1949)—a trench was dug in order to take samples for pollen analysis.

The tumuli 113 and 114 which were sampled for pollen analysis belong to a group of four barrows from the Early Bronze Age (VAN GIFFEN, 1920). The barrows had been built of long, inverted, dark-coloured sods, while the subsoil shows a well developed podzol profile. These barrows which show a great similarity are dated by a bronze riveted dagger (MONTELIUS II) from tumulus 114.

The samples from the tumuli 113 and 114 appeared to contain abundant pollen in a good state of preservation. Concerning the spectra of the old surface and a sod of both barrows it may be noted that *Fagus* already occurs in a low percentage (0.3–0.7 %). Compared with that in the Iron Age samples the *Calluna* value is low (97–134 %). There is a striking difference in *Tilia* percentage between both burial mounds. The pollen of cultivation shows nothing in particular. The high values for *Pteridium* (15.8–46.2 %) point to an expansion of *Pteridium* on the forest clearings.

The equally sampled tumuli 8, 14 and 31 belong to the great group of barrows, raised on a burnt-out pyre, which date from some centuries B.C. till after the time of the Roman occupation. Tumulus 31 had been built on the junction of four banks in a system of *Celtic Fields*. Tumulus 8, also, had been raised on old arable. As the old arable appeared to be poor in pollen, no samole was counted from that. The subsoil of tumulus 14 consisted partly of old arable, partly of an undisturbed podzol profile.

Compared with the Early Bronze Age tumuli the regular occurrence of *Carpinus* and the fairly high *Fagus* values (3.8–4.4 %) are striking.

TABLE III
Noordse Veld

	tumulus 114 old surface	tumulus 114 sod	tumulus 113 old surface	tumulus 113 sod	tumulus 14 old surface	tumulus 14 sod	tumulus 8 sod	tumulus 31 sod
Alnus	47.4	51.9	52.1	59.2	58.9	62.0	63.3	61.5
Corylus	27.4	23.2	20.9	19.3	28.0	22.6	16.8	17.8
Quercus	19.6	18.3	19.4	19.0	9.4	10.8	8.4	11.4
Tilia	1.9	2.1	0.5	0.6	0.4	0.5	0.3	0.2
Ulmus	0.6	0.3	1.2	0.9	0.6	0.2	0.4	0.2
Fraxinus	1.0	0.4	0.8	0.1	0.2	0.2	0.6	0.6
Fagus	0.3	0.3	0.7	0.5	3.8	3.1	4.4	3.5
Carpinus	—	—	—	—	0.4	0.2	0.8	0.7
Pinus	1.8	3.3	4.3	1.6	0.4	0.2	2.6	4.0
Picea	—	0.1	—	—	—	—	0.1	0.2
Salix	—	0.1	—	—	—	—	0.1	0.2
Ilex	—	—	—	—	—	—	0.1	—
ΣAP—Betula	685	754	746	789	477	424	724	853
Betula	46.0	30.0	34.0	26.7	12.8	12.0	16.6	17.2
Myrica	—	—	—	—	0.6	1.9	114	0.7
Calluna	97.3	113	134	127	323	300	500	223
Gramineae	25.5	21.2	28.3	17.1	175	93.4	280	47.5
Cerealia	1.5	0.5	0.7	0.5	4.2	10.1	7.9	2.6
Rumex	7.6	3.8	6.6	10.6	15.3	8.2	55.2	4.1
Plantago lanceolata	3.2	2.0	3.3	1.8	7.8	6.1	5.8	3.4
Tubulifl. Compositae	0.9	0.5	0.7	1.0	2.7	0.9	1.9	0.6
Ligulifl. Compositae	1.6	0.8	2.7	2.3	9.9	6.4	11.5	0.9
Chenopodiaceae	0.6	0.4	0.7	0.3	2.5	1.9	2.3	0.5
Artemisia	0.9	0.8	1.5	0.8	2.1	0.2	1.0	1.4
Spergula	—	—	—	—	2.7	4.0	1.1	0.2
Campanulaceae	—	0.5	0.8	0.1	1.3	1.4	1.5	—
Ranunculaceae	—	0.4	0.1	0.4	—	—	0.4	0.4
Rosaceae	—	—	—	0.1	0.2	—	—	—
Potentilla-type	0.7	—	0.8	0.6	0.4	0.9	—	1.9
Mentha-type	0.1	—	0.1	0.1	—	—	0.1	—
Succisa	0.4	0.4	0.4	0.4	5.0	6.4	2.2	0.7
Cyperaceae	0.1	—	0.3	—	—	—	0.3	0.4
Caryophyllaceae	0.4	0.4	0.4	—	2.9	1.4	1.2	0.5
Umbelliferae	0.1	—	—	—	0.2	—	—	0.4
Polygonum Persicaria	—	—	—	—	0.2	0.2	0.1	—
Sparganium	—	—	0.1	—	—	—	—	—
Papilionaceae	—	0.1	—	—	—	—	—	—
Valeriana	—	—	—	0.1	—	—	—	—
Lycopodium cf. clavatum	—	0.1	—	—	—	—	—	—
Lycopodium cf. inundatum	—	—	—	—	—	0.2	0.4	—
Dryopteris	1.9	1.9	3.5	1.8	13.6	9.7	4.6	3.2
Pteridium	26.9	25.5	46.2	15.8	3.6	5.9	3.4	3.3
Polypodium	—	—	—	—	1.0	0.5	—	—
Sphagnum	1.0	0.7	1.1	1.1	9.4	11.6	8.4	3.8

The high *Myrica* percentage in a sod sample from tumulus 8 is remarkable (114 %). In most cases it was easy to separate the pollen of *Corylus* and *Myrica*. The *Calluna* values in these barrows are very high (223–500 %). In general the pollen of cultivation also shows high values (*Rumex* 55.2 % in tumulus 8), whilst pollen of *Spergula* occurs regularly in these samples (up to 4 %). *Succisa* shows a conspicuous high value in the sample from tumulus 14.

With regard to a more accurate dating of the tumuli 8, 14 and 31 it is of importance to note that the spectra of these tumuli agree well with those of the Iron Age tumuli near Oudemolen (WATERBOLK, 1954*b*). As on the ground of a datable find the last tumuli could be dated at about 200 B.C. it is very likely that the tumuli 8, 14 and 31 were raised at about the same time.

Anglo-Saxon cemetery near Zweeloo (Table IV)

During the digging of sand on a high-lying open field (dutch: *es*) east of the village of Zweeloo an Anglo-Saxon cemetery was discovered.

Although the cemetery had already been partly destroyed, the greater part of it could be excavated. The coffins containing the dead bodies had been placed in oblong graves. As a rule the graves had been filled up with clearly outlined sods. Two types of graves could be distinguished, namely graves directed east-west and north-south. Presumably the graves directed east-west date from after the christianization, the ones directed north-south from before that time. Moreover, a number of horse graves recognizable by the shape of the grave, the remains of horse bones and the presence of pieces of harnass could be recognized.

In general only sparse grave goods had been given. In two graves, however, rich furniture was discovered. One grave contained a fine, intact, pointed beaker of olive-brown glass, whilst in another grave a great, equal-armed, bronze fibula, ornamented with animal motifs, a great number of amber, glass, faience, bronze and other beads, a bronze bracelet, two bronze keys and a specimen of Anglo-Saxon pottery were found. On the ground of the finds this cemetery has to be placed in the 5th to 7th century A.D.

From various graves sod samples for pollen analysis were taken. The results of the analysis of five samples, viz. two from east-west graves, two from north-south graves and one from a horse grave, are represented in Table IV. The pollen grains of the analysed samples showed a fairly good state of preservation.

With regard to the tree pollen spectra the absence of *Tilia* and the relatively high *Fagus* and *Carpinus* percentages are conspicuous. Especially in both samples from east-west graves *Carpinus* is relatively abundant. In accordance with the expectation *Corylus* does not reach high values. *Ilex* is present in both samples from north-south graves and in that from the horse grave. In this connection it may be remarked that in another sample from a north-south grave, in which only about 200 AP were counted, *Ilex* shows a value of 10 %.

In view of the relatively low age of these samples the *Calluna* percentages are not conspicuously high. The pollen of *Cerealia*—nearly all of *Secale cereale*—shows high percentages, whilst the values for *Plantago lanceolata*, *Rumex* and *Compositae* are also fairly high in most samples. *Spergula* occurs regularly in a low percentage. Two types of

TABLE IV
Anglo-Saxon cemetery near Zweeloo

	north-south grave I	north-south grave III	horse grave	east-west grave IV	east-west grave V
Alnus	54.0	72.2	71.9	56.2	55.5
Corylus	14.3	14.7	10.6	13.4	10.4
Quercus	22.7	6.9	12.1	22.2	22.4
Tilia	—	—	—	—	—
Ulmus	0.4	0.1	0.5	0.8	0.7
Fraxinus	0.8	0.6	0.3	0.2	0.5
Fagus	3.8	3.9	2.3	3.8	5.9
Carpinus	0.5	0.4	0.5	2.1	1.1
Pinus	2.6	0.7	1.3	1.1	2.1
Picea	—	—	0.1	0.2	0.1
Salix	0.4	—	0.1	0.1	1.0
Acer	0.1	0.1	—	—	0.2
Hedera	0.1	—	—	—	—
Ilex	0.2	0.3	0.2	—	—
Abies	—	—	—	—	0.1
ΣAP—Betula	917	668	858	924	885
Betula	9.7	10.5	10.5	8.2	13.0
Myrica	—	0.1	0.1	—	—
Calluna	153	192	147	129	125
Gramineae	74.3	30.7	35.0	11.1	20.4
Cerealia	17.7	8.9	11.5	6.3	7.8
Plantago lanceolata	11.7	13.9	5.1	1.5	7.5
Rumex	9.4	2.4	2.0	1.8	3.9
Tubulifl. Compositae	1.9	1.5	1.2	1.0	1.2
Ligulifl. Compositae	9.0	3.4	11.5	2.1	6.7
Artemisia	1.9	—	—	0.1	—
Chenopodiaceae	0.2	0.4	0.2	0.1	0.1
Polygonum Persicaria	—	0.3	—	—	0.1
Spergula	0.8	0.4	0.5	0.5	0.7
Caryophyllaceae	2.1	0.6	0.2	—	0.8
Cruciferae	0.5	—	0.2	—	—
Cyperaceae	0.9	0.4	—	2.9	0.2
Umbelliferae	0.1	0.3	—	—	—
Mentha-type	2.1	0.4	0.2	—	0.7
Potentilla-type	0.8	—	0.1	—	0.5
Ranunculaceae	1.6	0.7	0.8	0.8	1.1
Batrachium-type	0.3	0.4	0.5	0.2	0.2
Campanulaceae	0.8	0.3	0.4	0.1	0.6
Succisa	0.1	0.1	—	0.1	0.2
Scrophulariaceae	0.2	—	—	—	—
Sparganium	0.2	—	—	—	—
Frangula	—	—	—	0.1	—
cf. Lysimachia	—	—	0.2	—	—
Pteridium	1.7	0.6	1.7	0.2	0.7
Dryopteris	0.5	1.6	3.3	0.4	1.0
Polypodium	0.2	0.1	1.5	—	0.6
Lycopodium cf. clavatum	0.1	—	0.1	—	—
Sphagnum	2.9	4.0	5.9	3.5	2.4

Ranunculaceous pollen could generally be distinguished, viz. a *Batrachium*-type and a much smaller, likewise tricolpate, scabrate type with a rather irregular sculpture.

The barrow cemetery on the "Emelange" near Wijster (Table V)

This group was composed of five tumuli which were excavated in 1952 (VAN GIFFEN, 1954*a*). All barrows had been built of inverted, short, dark-coloured sods. The old surface consisted partly of a distinct heather podzol, partly of old arable. A remarkable phenomenon is the double podzol profile which could be observed below all tumuli. The lower podzol was covered by a drift sand deposit in which a number of narrow humous layers, suggesting short periods of standstill in which a vegetation could develop, could be seen. On the ground of some archaeological objects these tumuli have to be placed in the pre-Roman Iron Age. A ^{14}C-measurement of charcoal from tumulus 1 and 4 by Professor HL. DE VRIES at Groningen gave a dating of 35 ± 150 B.C. and 75 ± 175 B.C. respectively.

The results of the pollen analytical investigation of these barrows —which have already been published (VAN ZEIST, 1954)—are represented in Table V. This table distinguishes in chronological sequence:

a. The sample from a Neolithic tumulus near Drijber which for comparison was added to this table.

b. Both samples from the humous horizon of the lower podzol.

c. The samples from the barrows.

a. The sample from the Neolithic tumulus near Drijber agrees with the other analyses of Late Stone Age barrows. *Corylus* shows a fairly high percentage, while *Fagus* is absent. The *Tilia* value is not particularly high. Concerning the herbaceous pollen the following can be said. The *Calluna* percentage is relatively low. Although the values for *Plantago* and *Dryopteris* are not particularly high this spectrum does show a typical "*landnam*" character.

b. Both samples from the lower podzol do not vary much from the spectrum of the Neolithic tumulus. *Tilia* is slightly lower, whilst *Fagus* has reached a low value (0.3 %). The *Calluna* percentage is fairly low (about 70 %), whilst *Plantago* and *Dryopteris* show lower values than in the sample from the Neolithic barrow.

The time of the development of the lower podzol was succeeded by a period of sand drifts which came to an end some time before the construction of the barrows. For the subsoil of the barrows showed a clear podzol profile. Judging from the faintly humous zones in the drift sand deposit there must have been periods of rest during the sand drifts. The analysis of a sample from such a narrow humous layer gives a relatively low *Calluna* percentage (44.5 %) and a fairly high value for *Gramineae* (45.6 %) and *Cyperaceae* (10.6 %). This suggests that during the periods in which the drifting locally ceased no typical heath could develop, but that *Gramineae* and *Cyperaceae* must have played an important part. It is in this respect that *Carex arenaria*, *Festuca ovina* and *Corynephorus canescens* can be thought of, all species that are frequently met with in recent sand drifts. The occurrence of *Artemisia*, *Plantago* and others point to human activity in these surroundings during the period of sand drifts.

c. A comparison of the spectra of the lower podzol with those of the samples from the barrows shows some characteristic differences. Primarily the *Corylus* percentage in the barrow samples appears to have fallen to about one third. In the second place the *Fagus* percentages show a marked increase. In the barrow samples *Fagus* fluctuates between 0.8 and 2.7 % (on an average 1.6 %). A sharp decline in the *Corylus* percentage accompanied by an increase of *Fagus* can also be seen in the diagram from a small raised bog near Wijster (FLORSCHÜTZ and WASSINK, 1941). As has already been discussed this course of the curves for *Fagus* and *Corylus* can be observed in all diagrams from the northern Netherlands and north-west Germany.

The barrow samples are further characterized by an increase of *Calluna* and herbaceous pollen (*Compositae*, *Rumex*, *Plantago*). This increase of herbaceous pollen effected by a heightened human activity in this area corresponds with the archaeological evidence of human habitation, viz. barrows and old arable.

The spectra of various samples from one barrow again can show considerable mutual differences. Compare *e.g.* the difference in *Quercus* percentage between sod and old arable of tumulus 4 and between sod and old surface of tumulus 6. On discussing the Hijken barrow cemetery attention has already been drawn to this phenomenon. That pollen analysis of samples from the same time and from the same spot gives a practically equal result can be seen in both spectra of the old surface of tumulus 1 and of tumulus 6. In both cases the spectra show considerable agreement.

Below all barrows old arable was present. In many cases the old arable consisted of so-called ridge-shaped fields ("*Hochäcker*") surrounded by oblong, rectangular ditches. Three samples from old arable were analysed. It is remarkable that the analyses of the old arable below the tumuli 1 and 6 do not show spectra characteristic of old arable. In both cases the *Calluna* value is high, whilst that for the pollen of cultivation is not higher than in the sod samples. Only the sample below tumulus 4 yields a fairly typical old arable spectrum with comparatively little *Calluna* and rather much *Gramineae*, *Cerealia*, *Rumex*, *Plantago* and *Cyperaceae*. For this reason it seems likely that the old arable below the tumuli 1 and 6 must have been abandoned a long time before the concerning barrows were raised, so that the heather could prevail over this arable land. The high *Salix* percentage in the old arable of tumulus 1 suggests that a *Salix* species—probably *Salix repens*—had settled on the abandoned arable plot. Only the arable below tumulus 4 must have been in use till a short time before the construction of the barrow.

Hunebeds and barrows near Diever (*Table VI*)

The results of the pollen analytical examination of some burial monuments in the vicinity of Diever are represented in Table VI.

For the *hunebed* (Passage Grave) D LII [1] near Diever a "sod"—a somewhat humous, dark spot in the otherwise rather clean sand of the *hunebed* mound—was analysed. The old surface was hardly perceptible, so that no reliable sample could be taken from it. The sod sample appeared to contain few pollen grains, so that it was not possible to count a sufficient amount of pollen in a reasonable time. As, moreover, the state of preservation was very bad, differential preservation will have changed the pollen content. The count of one sample yielded the following numbers of pollen: *Alnus* 4, *Betula* 1, *Corylus* 1, *Quercus* 2, *Tilia* 12, *Pinus* 1, *Calluna* 5, *Gramineae* 14, *Succisa* 1, *Dryopteris* 58, *Pteridium* 8, *Polypodium* 3.

In the mound of the destroyed *hunebed* near Wapse a trench was dug. Both the old surface and a dark-coloured sod—which was clearly outlined in the yellow sand of the mound—were sampled. The old surface sample appeared to contain no pollen, but the sod was fairly rich in well preserved pollen. The spectrum of this sample differs considerably from the other *hunebed* spectra. *Fagus* shows a value of 0.7 %, while also *Carpinus* occurs, and the *Calluna* percentage is high (144 %). At present it is not possible to give a plausible "explanation" of this remarkable result.

Stone cist barrow. In 1929 a barrow, the primary grave of which consisted of a so-called stone cist (dutch: *steenkist*) was excavated (VAN GIFFEN, 1930). On account of the grave goods and the stone cist this barrow must be assigned to the latest phase of the *hunebed* culture. These indications of a Late Neolithic barrow agree with the fact that in the barrow, which consisted of dirty yellow sand, a number of clear sods could be distinguished, and that the subsoil showed a beginning podzolization.
In order to collect samples from this important barrow a trench was dug. In this trench some dark-coloured sods and the beginning podzolization were clearly visible.

A sample from the old surface and from a sod contained both abundant pollen grains in a good state of preservation. Both spectra show considerable agreement. The relatively high *Calluna* percentage (about 100 %) and the presence of *Fagus* are conspicuous. In the sod sample even a pollen grain of *Carpinus* was found. The values for *Gramineae*, *Rumex*, *Plantago* and *Compositae* are low.

This result is in striking contrast with that of WATERBOLK (1954*b*) who found a typical "*landnam*" spectrum. It is not impossible that the sample analysed by WATERBOLK—which was already collected in 1929—is not comparable with that from the old surface of this tumulus, but that this sample belongs to a secondary interment from the Beaker culture which had partly destroyed the primary grave. The sample in question was taken from a slightly humous spot in the primary grave.

Near this stone cist tumulus there is another barrow excavated by VAN GIFFEN in 1931. The barrow had been built of light-coloured sods. The subsoil showed a beginning podzolization, *i.e.* a leached layer, about 10 cm thick, but not yet a hard pan.

A spectrum of a sod of this tumulus agrees in every respect with the spectra of the stone cist barrow. The resemblance is so great that not much time can have elapsed between the construction of both tumuli. On account of the sod structure and the type of the primary grave—a trunk coffin—this barrow has to be assigned to the Early

[1] For the numbering and description of the *hunebeds* we may refer to VAN GIFFEN (1925–7).

Bronze Age. As the pollen spectrum of the stone cist barrow shows much similarity with that of the sod-built barrow, the stone cist

TABLE VI
Burial monuments in the vicinity of Diever

	hunebed Wapse	stone cist barrow old surface	stone cist barrow sod	sod-built barrow sod	Paasberg sod, prim. mound	Paasberg sod, capping
Alnus	52.0	45.5	47.8	51.7	68.5	64.2
Corylus	30.1	30.9	27.1	29.9	12.5	14.9
Quercus	9.3	19.3	16.4	15.4	13.2	15.2
Tilia	2.1	1.1	1.2	1.1	1.1	0.6
Ulmus	0.8	0.1	0.4	0.5	0.7	0.6
Fraxinus	0.4	0.4	0.5	0.1	0.4	0.6
Fagus	0.7	0.3	0.1	0.1	1.3	1.4
Carpinus	0.1	—	0.1	—	—	—
Pinus	4.1	2.4	3.9	1.0	2.0	2.0
Picea	—	—	—	0.1	—	—
Salix	0.2	—	—	—	—	—
Ilex	0.1	—	—	—	—	—
ΣAP—Betula	857	747	836	816	455	657
Betula	16.7	33.9	22.8	22.5	13.6	11.3
Myrica	0.1	—	—	—	—	0.3
Calluna	144	94.1	107	109	136	194
Gramineae	21.6	9.9	11.2	15.2	170	81.4
Cerealia	1.9	0.4	0.4	0.8	13.2	8.7
Plantago lanceolata	1.1	0.7	1.6	0.9	22.0	8.3
Rumex	1.1	2.8	1.4	0.9	14.1	14.2
Tubulifl. Compositae	0.9	0.7	0.1	—	2.9	3.2
Ligulifl. Compositae	2.4	0.3	1.7	1.0	7.7	3.2
Artemisia	0.5	0.1	0.6	0.4	0.9	0.8
Chenopodiaceae	0.2	—	—	—	1.5	1.5
Polygonum Persicaria	—	—	—	—	0.4	0.9
Spergula	—	—	—	—	—	4.0
cf. Spergularia	—	—	—	—	5.7	0.2
Caryophyllaceae	0.8	—	0.1	0.1	1.3	0.8
Rosaceae	—	—	—	—	0.2	0.3
Potentilla-type	—	—	—	0.1	—	0.5
Ranunculaceae	0.2	0.1	0.1	0.7	1.5	0.2
Umbelliferae	0.1	—	—	—	—	—
Campanulaceae	0.4	0.1	0.4	0.1	0.2	0.3
Galium-type	—	—	—	—	0.7	—
Mentha-type	—	—	—	—	0.4	0.5
Papilionaceae	—	—	—	—	0.2	—
Succisa	0.9	0.3	0.6	0.4	1.1	0.8
Cyperaceae	—	—	0.1	—	—	0.5
Sparganium	—	—	0.1	—	—	0.3
Dryopteris	11.7	2.6	4.2	5.1	7.7	5.0
Pteridium	4.1	1.5	1.2	3.9	2.6	3.3
Polypodium	9.4	0.1	0.1	—	0.2	—
Sphagnum	10.6	0.3	0.6	1.7	2.8	3.2

barrow must probably be placed about the transition from Neolithic time to Bronze Age.

Paasberg. The "Paasberg" near Diever, also excavated by VAN GIFFEN in 1931, had been built of fairly clear sods. A core of fairly dark-coloured sods and a capping of greyish sods could be distinguished.

The spectra of both constructional phases agree very well as far as the tree pollen is concerned. The low *Corylus* values and the fairly high *Fagus* percentages suggest that the "Paasberg" must have been constructed in the Early Iron Age (*cf.* the spectra of the barrows near Wijster, Table V).

The herbaceous percentages of both sods show rather great differences. The spectrum of the sample from the core has higher *Gramineae* and *Plantago* percentages and a lower *Calluna* percentage than that of the sod of the covering mound. In the first sample a pollen grain which in all probability has to be ascribed to *Spergularia* frequently occurred, while in the other sample *Spergula* was rather abundant.

Table VII represents the pollen spectra of some isolated burial monuments.

Hunebed Steenbergen, D I. The *hunebed* mound consisted of yellow sand, while the old surface could be recognized as a clear, dark-grey layer of about 10 cm thick. The sample from the old surface appeared to contain a small quantity of badly preserved pollen grains, so that differential preservation may have changed the pollen content.

Hunebed Exloo, D XXXI. The *hunebed* mound had been raised from yellow sand on a humous old surface, about 10 cm thick. The pollen was rather badly preserved.

The *Tilia* percentage in both *hunebed* samples is relatively high (8.5 and 6.6 %). *Fagus* and *Carpinus* do not occur. Attention is drawn to the occurrence of a pollen grain of *Viscum* in the sample from Exloo. In the sample from Steenbergen the *Calluna* value is rather low, and that for *Gramineae* fairly high. *Calluna* is more abundant in the sample from Exloo. In the sample from Steenbergen *Plantago* is scarce, and is even lacking in the sample from Exloo. This last sample shows relatively high values for *Liguliflorae*, *Artemisia* and *Caryophyllaceae*.

Galgenberg near Ruinen. A three-period barrow, consisting of:
A primary mound of brownish-grey sand on a hardly perceptible old surface of washed-out gravel. Beaker Culture, Late Neolithic (*cf.* GLASBERGEN, 1954).
A second and third period equally of sand without sods.

The old surface of the primary mound contained—contrary to expectation—a fairly large amount of pollen grains in a rather good state of preservation. This sample shows a typical "*landnam*" spectrum, viz. fairly much *Plantago*, *Rumex*, *Compositae*, *Gramineae* and *Dryopteris*. *Fagus* does not occur. In the sample from the second period *Fagus* is present, whilst the values for *Rumex*, *Plantago* and *Gramineae* have greatly decreased. It is striking that the *Calluna* percentage of the capping is not noticeably higher than that of the primary mound.

TABLE VII
Various isolated burial monuments

	hunebed D I Steenbergen	hunebed D XXXI Exloo	Galgenberg near Ruinen period 1	Galgenberg near Ruinen period 2	Galgenberg near Ruinen period 3	Oudemolen tumulus 13 old surface	Oudemolen tumulus 13 sod, period 2	Oudemolen tumulus 13 sod, period 3	tumulus near Schoonloo	Eext tumulus 2
Alnus	61.5	43.3	57.3	59.1	24.7	55.6	51.9	53.5	55.9	57.7
Corylus	25.2	34.1	29.1	33.0	35.1	30.1	28.0	26.0	36.1	22.9
Quercus	3.4	11.5	11.0	4.1	34.9	11.1	16.1	12.7	4.3	12.9
Tilia	8.5	6.6	1.9	1.0	0.3	0.8	0.8	0.3	0.8	1.2
Ulmus	0.3	0.2	0.1	0.4	0.2	0.6	0.7	0.9	0.4	0.2
Fraxinus	0.3	0.8	0.4	0.3	—	0.5	0.2	0.1	0.2	0.1
Fagus	—	—	—	0.4	2.7	0.2	0.4	1.7	0.1	3.5
Carpinus	—	—	—	—	0.8	—	—	0.1	—	0.1
Pinus	0.3	2.7	0.2	1.8	1.2	1.1	1.7	4.5	2.1	1.2
Picea	—	—	—	—	—	—	0.1	—	—	—
Salix	0.7	0.4	—	—	0.2	—	—	—	—	—
Hedera	—	0.2	—	—	—	—	—	—	—	—
Viscum	—	0.2	—	—	—	—	—	—	—	—
ΣAP—Betula	294	487	829	782	639	876	845	866	923	946
Betula	7.5	25.3	20.6	7.5	16.2	14.1	18.3	15.2	8.3	5.8
Humulus	—	—	—	—	—	—	—	0.1	—	—
Myrica	—	—	—	—	—	—	—	—	—	0.1
Calluna	20.7	55.2	33.7	36.3	162	123	93.7	230	95.2	132
Gramineae	37.4	16.0	64.9	26.8	31.1	23.5	10.7	7.0	10.7	16.5
Cerealia	—	—	1.7	3.6	7.5	1.9	0.7	0.5	0.1	0.7
Plantago lanceolata	1.0	—	9.3	4.0	0.8	1.0	1.3	0.5	0.2	4.0
Rumex	2.0	2.7	6.1	0.4	1.9	3.5	0.4	0.3	0.9	0.5
Tubulifl. Compositae	1.4	1.2	3.9	0.9	0.6	0.8	—	0.1	0.2	0.4
Ligulifl. Compositae	4.4	14.6	6.3	4.4	2.3	3.5	0.2	0.2	—	3.5
Artemisia	—	2.7	0.1	0.3	—	0.1	—	—	0.2	—
Cyperaceae	0.4	2.0	0.1	—	0.9	—	—	—	0.5	—
Caryophyllaceae	0.3	4.5	1.1	1.9	—	0.5	—	0.1	0.1	0.5
Spergula	—	0.2	—	—	0.3	—	—	—	—	—
Succisa	1.4	0.2	1.7	0.4	0.2	0.9	—	1.2	—	2.9
Chenopodiaceae	—	—	0.2	0.3	—	0.2	—	0.4	—	0.3
Polygonum Persicaria	—	—	—	—	—	—	—	—	—	0.1
Ranunculaceae	—	0.6	0.4	0.3	0.3	0.1	0.1	0.1	—	0.6
Potentilla-type	—	0.4	—	—	0.2	—	0.1	—	—	—
Galium-type	0.3	—	—	0.1	0.2	—	—	—	—	—
Umbelliferae	—	0.2	—	—	0.6	—	—	—	—	—
Campanulaceae	—	1.8	—	0.1	—	—	—	—	—	—
Valeriana	—	—	—	—	0.2	0.1	—	—	—	—
Frangula	—	—	—	—	0.3	—	—	—	—	—
Mentha-type	—	—	0.1	—	—	—	—	—	—	—
Dryopteris	106	3.1	23.9	10.9	5.0	5.4	2.4	1.3	1.7	6.0
Polypodium	3.4	—	0.1	0.6	—	0.1	—	0.1	0.1	0.2
Pteridium	7.5	0.2	6.5	300	5.2	3.7	2.6	1.4	0.9	1.5
Dryopteris Linnaeana	0.3	—	—	—	—	—	—	—	—	—
Lycopodium cf. clavatum	0.7	—	—	0.1	—	—	—	—	—	—
Sphagnum	41.5	1.0	4.0	5.0	11.7	1.3	0.5	0.9	0.5	6.6

In view of the *Fagus* percentage (2.7 %) and the *Carpinus* value of 0.8 % the last capping (period 3) has to be placed in the Early Iron Age; although the *Corylus* value (35.1 %) is very high for a spectrum from that time. The *Calluna* percentage—compared with that of the preceding periods—shows a sharp rise, indicating an expansion of the heather.

Tumulus 13 near Oudemolen. This tumulus which joins the barrow cemetery near Oudemolen (pollen analytical investigation by WATERBOLK, 1954*b*) consisted of three periods. The primary mound of dirty yellow sand had been raised on a humous old surface. The second period was a capping of rather clear, long sods, whilst in the third period only a few sods could be observed.

The spectrum of the old surface of the primary barrow shows much resemblance to that of the first period of tumulus 12 (WATERBOLK, 1954*b*). The primary mound of that tumulus had been built of yellow sand with some long sods on a subsoil with some accumulation of humus. Although in the primary mound of tumulus 13 no sods could be distinguished, the structural resemblance to tumulus 12 is great, whilst moreover in both cases the primary grave contained a trunk coffin. A ^{14}C-measurement of a charcoal sample from the primary grave by Professor HL. DE VRIES at Groningen gave a dating of 1550 ± 125 B.C.

With regard to the spectrum of the old surface it may be noted that *Fagus* is present already. In contrast with most spectra of Neolithic barrows the values for *Gramineae, Plantago* and *Compositae* are relatively low, while that for *Calluna* is high. The spectrum of a sod of the second period shows much resemblance to that of the first period. It is remarkable that the *Calluna* percentage of this period is lower than that of the primary mound. The spectrum of a sod of the third period shows some marked differences with the spectra of the preceding periods. *Fagus* has increased (from 0.3 to 1.7 %), just as *Calluna*. The *Corylus* percentage is not markedly lower than that of the other periods. For that reason it seems likely that the third period still must be assigned to the Late Bronze Age (*cf.* tumulus 12, periods 3 and 4).

Barrow with stone revetment near Schoonloo. This was a partly destroyed, sod-built barrow with a clearly podzolized subsoil. As the central part of this barrow had been heavily damaged, the primary grave could no longer be recognized. The presence of a stone revetment around the barrow has to be mentioned.

The spectrum of the old surface is not characteristic. The value for *Corylus* is high, whilst that for *Quercus* is low. *Fagus* occurs in a very low percentage, whilst also the pollen of cultivation shows low values.

Tumuli near Eext. In 1952 two tumuli near Eext were excavated. Both barrows showed a considerable similarity. Only the old surface of tumulus 2 was more dark-coloured than that of tumulus 1. The barrows had been built of light-coloured sods on a faintly podzolized subsoil.

Only the old surface of tumulus 2 appeared to contain a sufficient amount of well preserved pollen grains. Concerning this spectrum it must be mentioned that the *Fagus* value is fairly high (3.5 %), whilst *Carpinus* is also present. The *Fagus* and *Carpinus* percentages suggest that this tumulus must have been built in the Early Iron Age.

Trackways near Emmererfscheidenveen. During the very intensive exploitation of the raised bog near Emmererfscheidenveen two trackways—both lying in the Younger *Sphagnum* peat—were brought to light. One trackway showed a very simple construction, namely longitudinally laid rods, of birch among others. This track was not excavated, so that only its cross-section in the peat profile could be observed. The other trackway had been built of oak planks. In 1952 a part of this trackway was excavated. It appeared, however, that the excavated part had been destroyed at an earlier date in order to interrupt the communication. As far as that could be examined this trackway had been constructed of successive pairs of planks which had been laid longitudinally side by side. These planks, about 30 cm in width, were supported by transverse planks. Both ends of every transverse beam were perforated by a square-cut mortise hole, through which a sharpened vertical stake had been driven into the peat, so that in this way the track was held in place.

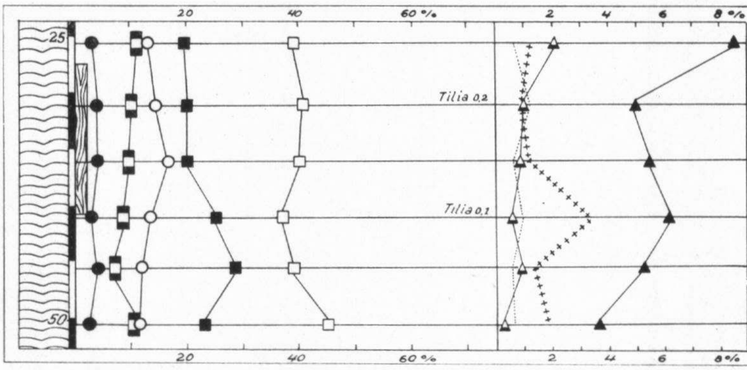

Fig. 15. Pollen analytical position of the trackway of longitudinally laid rods near Emmererfscheidenveen.

In Fig. 15 the position of the first trackway is indicated. The *Corylus* value is low, whilst *Tilia* occurs irregularly. In the middle part of the diagram *Carpinus* shows a value of about 1 %, while that for *Fagus* is about 5 %. The fact that in the upper spectrum, which lies just above the trackway, *Carpinus* increases could suggest that this is the beginning of the second increase of *Carpinus*. In the lower part of the diagram the first increase of *Carpinus* is just visible. Therefore the trackway must have been constructed after 200 A.D. It is likely that this track dates from the 4th to 6th century A.D.

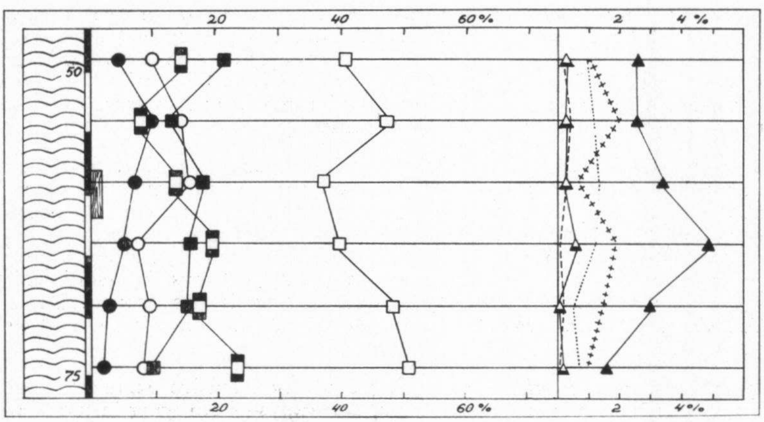

Fig. 16. Pollen analytical position of the trackway built of planks near Emmererfscheidenveen.

The position of the other trackway is indicated in Fig. 16. *Tilia* still occurs throughout the diagram. *Corylus* shows a decrease which corresponds with the final fall in the *Corylus* curve. In this diagram the decline of *Corylus* is likewise accompanied by a rise of *Fagus*. The rather low *Fagus* percentages in the upper spectra of the diagram are somewhat remarkable. The first increase of *Carpinus* is not yet present in this diagram. On the ground of the position in the pollen diagram this trackway must probably have been constructed in the first or second century B.C.

VI. THE POLLEN ANALYTICAL POSITION OF THE SO-CALLED *GRENZHORIZONT*

The most conspicuous phenomenon in the stratigraphy of the raised bogs from western Europe is the so-called *Grenzhorizont* the first time described by WEBER (1900). This contact surface constitutes the border between the dark-coloured, highly humified Older *Sphagnum* peat and the overlying, light-coloured, fresh Younger *Sphagnum* peat.[1] WEBER (1910, 1926, 1930) assumed that originally the Older *Sphagnum* peat had the same appearance as the Younger *Sphagnum* peat, but that during a dry time, the Subboreal period, this peat got its present high degree of humification. According to WEBER peat formation came to a standstill during that dry time, and the surface of the raised bog was covered with a vegetation of *Calluna* and *Eriophorum*. Later on, when the climate became more humid, in the Subatlantic time, the formation of Younger *Sphagnum* peat would have started, beginning at the borders of the raised bogs. Much time would have elapsed between the ceasing of the growth of the Older *Sphagnum* peat and the beginning of the growth of the Younger *Sphagnum* peat. WEBER assumed a period of at least 1000 years. He accepted the post-glacial climatic scheme of BLYTT/SERNANDER which distinguishes a dry Boreal, a wet Atlantic, a dry Subboreal and a wet Subatlantic time, since SERNANDER (1908) already had equalized the Younger *Sphagnum* peat with the Subatlantic time and the *Grenzhorizont* with the Subboreal time.

WEBER (1926, 1930) dated the beginning of the growth of the Younger *Sphagnum* peat between 1000 and 750 B.C. This dating was based on the discovery of a peat burial ("*Moorleiche*"). In 1895 in the "Wolfsbrucher Moor" near Obenaltendorf (Kreis Kehdingen) a peat burial was discovered in the Younger *Sphagnum* peat at 150 cm below the surface. Through the presence of grave goods this peat burial could be dated in the 4th century A.D. From that time till the middle of the 19th century—when on account of drainage peat formation came to an end—150 cm fresh *Sphagnum* peat had been formed, that is 1 m per 1000 years. The greatest thickness of the Younger

[1] The Older *Sphagnum* peat not being always older than the Younger *Sphagnum* peat—as will be demonstrated—these terms only indicate humified and fresh *Sphagnum* peat respectively.

Sphagnum peat in the "Wolfsbrucher Moor" was nearly 3 m. From this WEBER concluded that the formation of Younger *Sphagnum* peat must have started between 1000 and 750 B.C.

It must once more be pointed out that, according to WEBER, the formation of Younger *Sphagnum* peat in a single raised bog did not start everywhere at the same time, but that after the Subboreal period of standstill the formation of this type of peat started at the borders, whereas at the centre of the raised bog the formation of fresh *Sphagnum* peat did not take place until later. On the other hand, it has been supposed by most west European peat investigators after WEBER that the formation of fresh *Sphagnum* peat started everywhere at the same time, so that the beginning of the formation of Younger *Sphagnum* peat would be a synchronous phenomenon.

WEBER's idea that during a long period peat formation did not take place, and that the high degree of humification of the Older *Sphagnum* peat would be a secondary phenomenon, was soon abandoned by nearly all investigators. As the chief argument against a long period of standstill SCHROEDER (1930) puts forward that in the pollen diagrams from the raised bogs near Worpswede the pollen lines do not show interruptions at the transition from Older to Younger *Sphagnum* peat. This uninterrupted course of the curves is clearly shown in the so-called "*Lupendiagramm*" from Bergedorf, equally near Worpswede. According to GROSS (1930) and OVERBECK and SCHMITZ (1931) the difference in humification must be ascribed to a difference in climate effecting a different rate of decay during the peat formation.

The dating of the beginning of the growth of the Younger *Sphagnum* peat according to WEBER was confirmed by SCHUBERT (1933). This author sampled a profile near the spot where the peat burial was discovered. At the removal of the dead body, present in the museum at Stade, also a sod of peat showing the cast of a piece of fabric pertaining to the peat burial was collected. SCHUBERT analysed the peat profile and fitted the spectrum of the sod into the diagram. He arrived at the conclusion that the *Grenzhorizont* has to be dated between 1000 and 750 B.C.

One gets the impression that WEBER's dating was accepted as too firm a fact to raise objections against. In examining other finds from bogs it was too easily accepted that this dating of the *Grenzhorizont* was correct. On that account various objects—especially trackways and peat burials—which lay just above or below the *Grenzhorizont* were dated too early, *e.g.* the peat burial from the bog near Veerssen (KOCH, 1934*b*), the trackway from the "Wittmoor" (HALLIK, 1949) and some trackways from the raised bog near Diepholz (PFAFFENBERG, 1936).

After synchronizing the *Grenzhorizont* with the RY III of GRANLUND (1932) a dating of 500–600 B.C. is fairly generally accepted for this contact surface.

In Swedish raised bogs not one, but a number of contact surfaces between more and less humified *Sphagnum* peat can be recognized (GRANLUND, 1932; LUNDQUIST, 1932). These so-called recurrence surfaces have been dated with the help of archaeological finds. The following contact surfaces are distinguished:

RY I	about 1200 A.D.	RY V	about 2300 B.C.
RY II	„ 400 A.D.	RY VI	„ 2800 B.C.
RY III	„ 600 B.C.	RY VII	„ 3700 B.C.
RY IV	„ 1200 B.C.		

In north-west European raised bogs generally one distinct contact surface, the *Grenzhorizont*, can be distinguished. OVERBECK and SCHNEIDER (1938) pointed out already that even in a single raised bog the *Grenzhorizont* must not be considered too much as a fixed point of time, and that the dating of the *Grenz* in the various regions is yet far from certain. In later years this opinion was underlined by OVERBECK (1952) once again. OVERBECK and collaborators, however, maintain—in spite of the labile character—the *Grenzhorizont* as the border between the Subboreal and Subatlantic time.

As a result of an archaeological and pollen analytical investigation of the "Bolleveen" near Zeijen WATERBOLK (1950) and VAN GIFFEN (1947, 1950) arrived at another dating of the *Grenzhorizont*. This investigation has already been discussed on p. 31. As in this small raised bog the formation of fresh *Sphagnum* peat started at about 400 A.D. the *Grenzhorizont* would here be synchronous with the RY II of GRANLUND. On the ground of a comparison of the "Bolleveen" diagram with the diagrams from large raised bogs WATERBOLK concluded that in general the *Grenzhorizont* would not be synchronous with the RY III, but with the RY II, and that consequently the beginning of the growth of the Younger *Sphagnum* peat has to be dated at about 400 A.D.

NILSSON (1948) arrived at a completely different conclusion. This investigator compared diagrams from north-west Germany and the Netherlands with those from Sweden, and concluded that the *Grenzhorizont* not always coincides with the RY III. There would be, however, raised bogs in which the *Grenzhorizont* corresponds with one of the other recurrence surfaces. In the Netherlands and in north-west Germany the formation of the Younger *Sphagnum* peat could have started at the following times: about 400 A.D., about the beginning of the era, about 500 B.C., about 1200 B.C. and about 2300 B.C. SCHMITZ (1952) is of the same opinion. Although, according to this author, in north-west Germany the transition from highly humified to fresh *Sphagnum* peat in general would correspond with the RY III, there would also occur raised bogs in which this transition is synchronous with one of the other Swedish recurrence surfaces.

According to BENNEMA (1954) it seems likely that the beginning of the growth of the fresh *Sphagnum* peat was not a synchronous phenomenon, as it was local conditions that effected the transition from highly humified to fresh *Sphagnum* peat.

In order to get an impression of the behaviour of the *Grenzhorizont*[1]

[1] The name *Grenzhorizont* is used here for the contact surface between highly humified and fresh *Sphagnum* peat, independent of the dating. This in contrast

in a single raised bog an investigation was carried out into the pollen analytical position of the *Grenz* in the raised bog near Emmererfscheidenveen. It is for this reason that from this raised bog, besides a complete profile (*cf.* Chapter III), at various sites the peat section below and above the *Grenzhorizont* was sampled and analysed. For the sake of surveyability only the stratigraphy and the curves for the more important trees are represented in these diagrams, because the curves for species as *Salix*, *Acer* and others, just as those for the herbaceous types, are not of importance for this purpose.

Not unfrequently a so-called "*Vorlaufstorf*", a *Sphagnum cuspidatum* peat layer, is present. This type of peat overlies directly the highly humified *Sphagnum* peat, without a transitional layer. The structure of this easily fissile *Sphagnum cuspidatum* peat differs greatly from the fresh, sponge *Sphagnum imbricatum* and *papillosum* peat. On account of the low degree of humification this type of peat is assigned to the Younger *Sphagnum* peat (WEBER in JONAS, 1933). The contact surface of this "*Vorlaufstorf*" with the highly humified *Sphagnum* peat thus constitutes the *Grenzhorizont*.

It is true that in the profile of diagram A (Fig. 17) a 24 cm thick layer of humified *Sphagnum* peat is present on top of the *Sphagnum cuspidatum* layer. A comparison with *e.g.* profile B, where only a 5 cm thick layer of humified peat overlies the "*Vorlaufstorf*", suggests that it is justifiable to place the *Grenzhorizont* in the profile A at a depth of 106 cm. In the diagrams from the raised bog near Gifhorn (OVERBECK, 1952) there is a similar layer of humified *Sphagnum* peat on top of the *Sphagnum cuspidatum* peat.

STRATIGRAPHY

Diagram A

45– 61	cm	fresh *Sphagnum imbricatum* peat
61– 66	,,	fresh *Sphagnum papillosum* peat
66– 90	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
90–106	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
106–115	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram B

60– 75	cm	fresh *Sphagnum papillosum* peat
75– 80	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
80– 99	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
99–110	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

with OVERBECK (1952) and SCHMITZ (1952) who proposed to confine that name to the contact surface which can be dated at about 500 B.C.

Diagram C

80– 92	cm	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum*
92–105	„	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

N.B. Above a depth of 80 cm the peat had already been cut away.

Diagram D

70– 80	cm	fresh *Sphagnum papillosum* peat
80– 89	„	fresh *Sphagnum cuspidatum* peat
89–100	„	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram E

75– 80	cm	fresh *Sphagnum papillosum* peat
80– 85	„	fresh *Sphagnum cuspidatum* peat with some *Sphagnum papillosum*
85– 99	„	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
99–105	„	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

Diagram F

20– 30	cm	fresh *Sphagnum papillosum* peat
30– 50	„	*Eriophorum* peat with remains of fresh *Sphagnum papillosum*
50– 56	„	highly humified *Sphagnum* peat with remains of *Eriophorum*
56– 80	„	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram G

15– 27	cm	fresh *Sphagnum imbricatum* and *papillosum* peat
27– 28	„	fresh *Sphagnum cuspidatum* peat
28– 45	„	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

A comparison of the diagrams A to G (Figs. 17–23) shows that they are not quite identical. Especially the *Quercus* percentages vary greatly in the various diagrams. This phenomenon suggests that the pollen rain at the various sites of the raised bog was not the same. As the forest vegetation in the vicinity of the raised bog will have varied dependent on local factors the position of a given part of the bog in respect to the higher sandy soils was of much importance for the pollen rain on the spot. On this account more attention must be paid to the general course of the curves and the presence of characteristic points than to the absolute percentages. It then appears that the diagrams are quite well comparable.

Diagram A (Fig. 17) forms part of the diagram from Emmererfscheidenveen discussed in Chapter III. For a more detailed comparison with the other diagrams from this region a sample distance of 5 cm appeared in general yet too large, so that a number of intermediate samples was analysed. In the lower part of diagram A the *Fagus* percentages are very low (0.2–0.4 %). At a depth of 100 cm *Fagus* shows a somewhat higher value (about 1 %). The same increase of *Fagus* can also be observed in the diagrams B and C (Figs. 18 and 19). The other diagrams start at a point where *Fagus* has reached already these somewhat higher values. In diagram A *Fagus* rises regularly from a depth of 85 cm in order to reach a value of 5 % at a depth of 59 cm. In the other diagrams this rise in the *Fagus* curve sometimes shows small irregularities. It has already been noted that the last *Corylus* maximum (C_4) coincides with the point whence *Fagus* starts to increase. In the other diagrams from this raised bog this coincidence

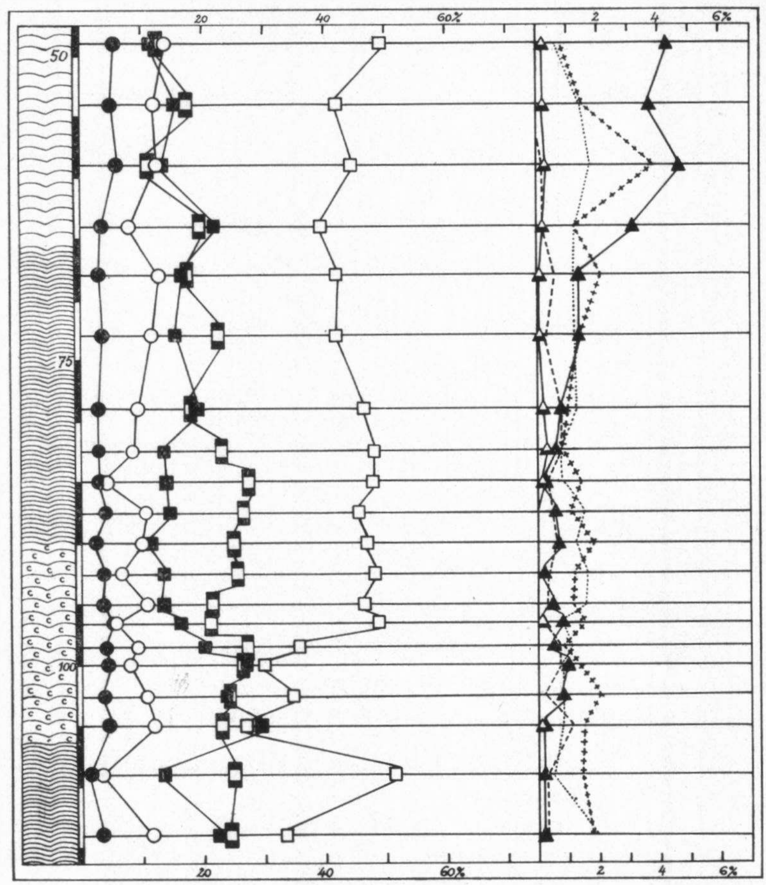

Fig. 17. Emmererfscheidenveen A.

is always clearly shown. The end of the expansion of *Fagus* is always coupled with a *Fraxinus* maximum.

Concerning the course of the *Corylus* curve in the diagrams from Emmererfscheidenveen it is useful to compare these diagrams with that from Bargeroosterveld (Fig. 9). In that diagram—just as in that from Roswinkel—the *Corylus* curve shows some fluctuations not present in diagram A. These fluctuations are of importance for a correct interpretation of the position of the *Grenzhorizont* in the diagrams D and E (Figs. 20 and 21). In the diagram from Bargeroosterveld a *Corylus* minimum is seen at a depth of 82 cm, which minimum in the diagrams A, B and C is present at a depth of 96, 96 and 91 cm respectively. This minimum is followed by a sudden rise, likewise present in the diagrams A, B and C. Before reaching the last maximum the *Corylus* curve shows another minimum at a depth of 74.5 cm in the Bargeroosterveld diagram. This minimum is not shown in the diagrams A and B. In the upper part of diagram C this minimum can just be seen. The course of the *Corylus* curve in diagram D is well comparable with that in the Bargeroosterveld diagram. The spectrum at a depth of 95 cm corresponds with that at a depth of 79.5 cm in the diagram from Bargeroosterveld. In the diagrams D and E the *Corylus* minimum immediately below the C_4 is present at a depth of 88 and 104 cm respectively. The different rate of peat formation at

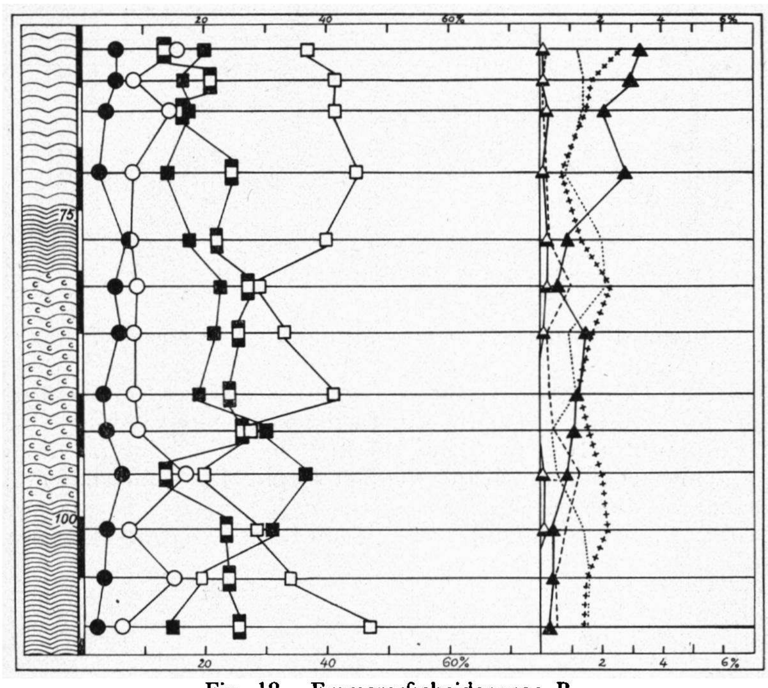

Fig. 18. Emmererfscheidenveen B.

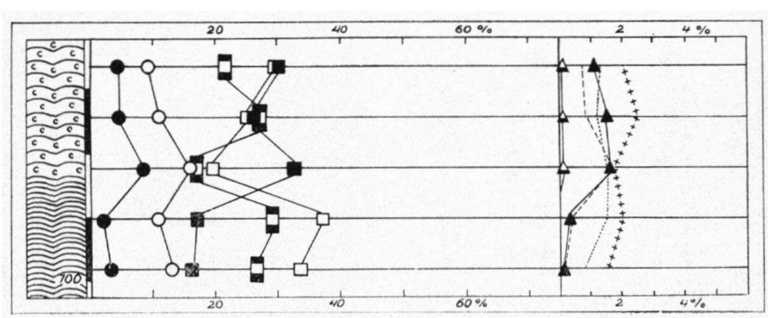

Fig. 19. Emmererfscheidenveen C.

the various sites of a raised bog is again clearly presented in these profiles. For a correct comparison of the diagrams D and E with diagram A the Bargeroosterveld diagram is thus very useful, as otherwise the *Corylus* minimum in the diagrams D and E could have been

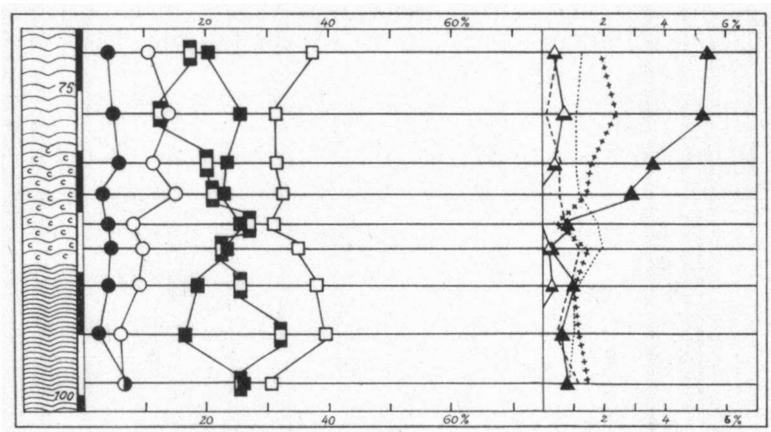

Fig. 20. Emmererfscheidenveen D.

easily equalized with the *Corylus* minimum at a depth of 96 cm in diagram A.

When we examine the position of the *Grenzhorizont* in the various profiles the result is the following: In diagram A this contact surface lies at a depth of 106 cm, below the first, small increase in the *Fagus* curve, while in diagram B this contact surface lies somewhat higher, immediately above the increase in the *Fagus* curve. The position of the *Grenzhorizont* in diagram C coincides with that in diagram B.

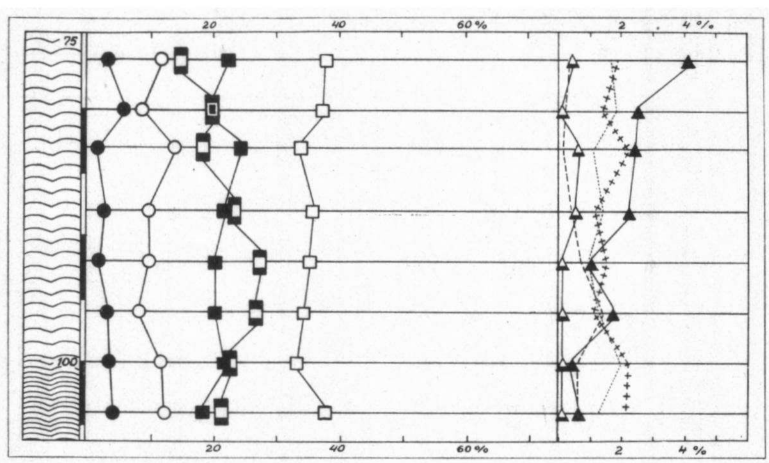

Fig. 21. Emmererfscheidenveen E.

In diagram D the *Grenz* corresponds with the *Corylus* minimum preceding the last *Corylus* maximum. In diagram E this contact surface lies somewhat higher, just below the last *Corylus* maximum. In diagram F no distinct contact surface was present. From 50 cm downwards the peat consisted of highly humified *Sphagnum* peat, whereas the

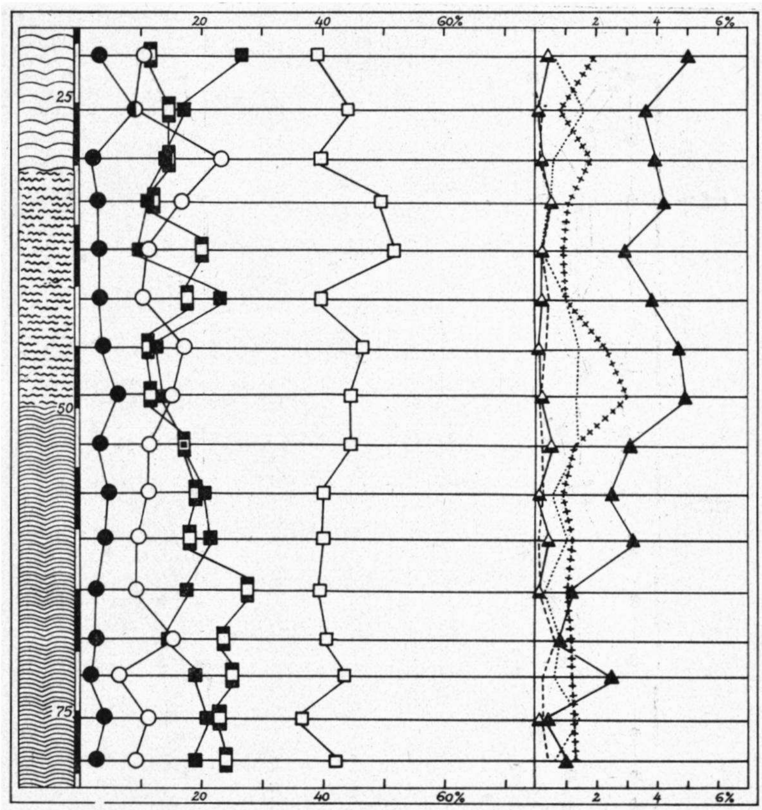

Fig. 22. Emmererfscheidenveen F.

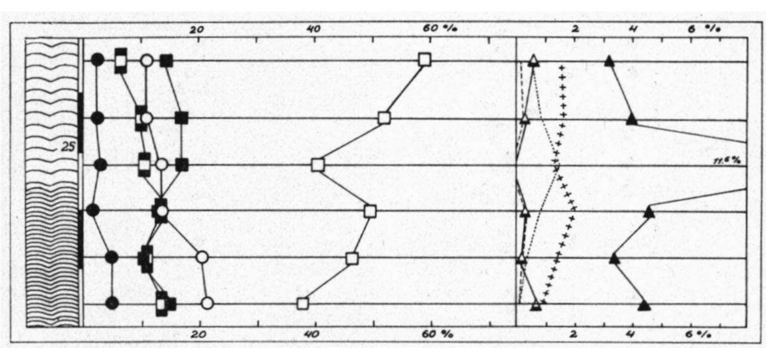

Fig. 23. Emmererfscheidenveen G.

layer between 30 and 50 cm was composed of *Eriophorum* peat with remains of fresh *Sphagnum* papillosum. For this reason the beginning of the formation of fresh *Sphagnum* peat is placed at a depth of 50 cm, that is just below the end of the expansion of *Fagus*. In diagram G the transition in question falls even much later.

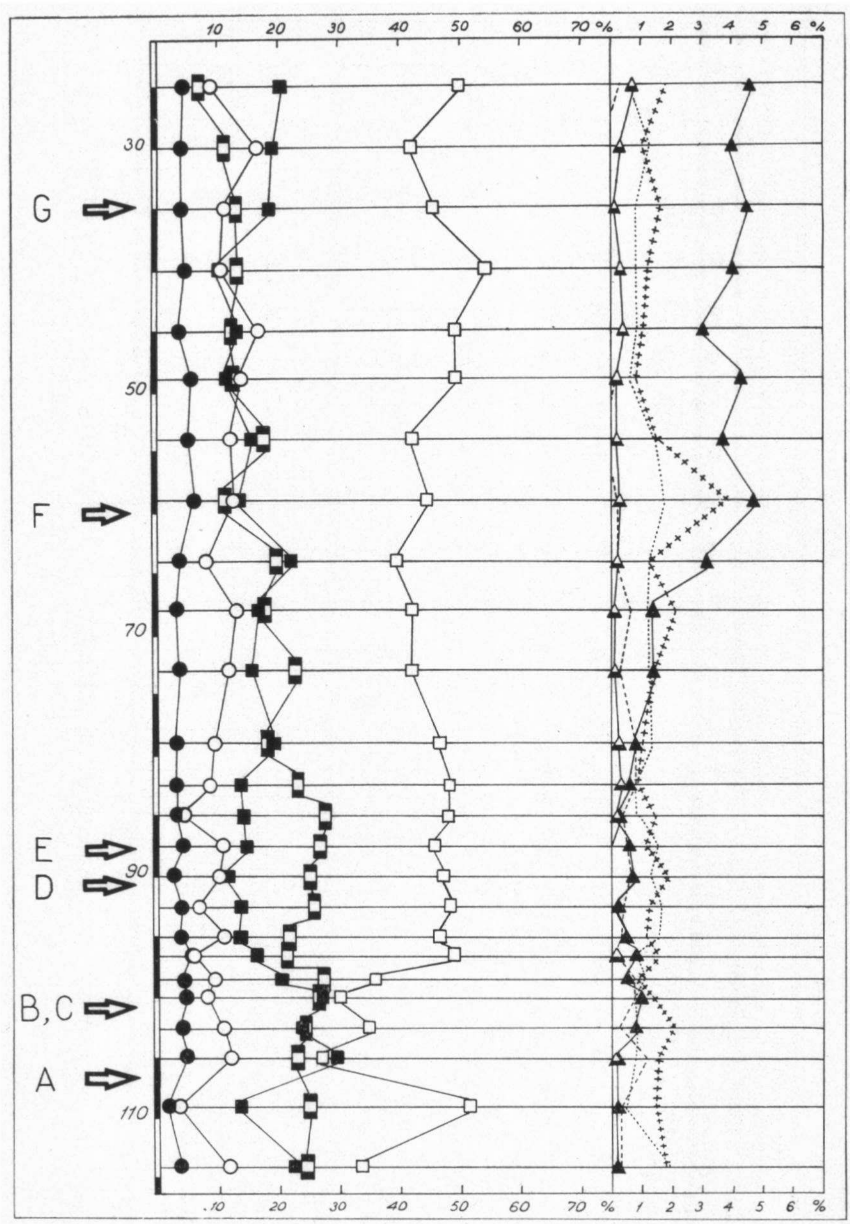

Fig. 24. In this diagram the position of the *Grenzhorizont* in the profiles of the diagrams Emmererfscheidenveen A–G is indicated by means of arrows.

In Fig. 24 the position of the *Grenzhorizont* in the various profiles from Emmererfscheidenveen is indicated in one diagram. As has already been noted the *Corylus* minimum just below the last *Corylus* maximum is not present in diagram A, to which the position of the *Grenzhorizont* in the other profiles is transferred. This *Corylus* minimum has been equalized with the spectrum at a depth of 90 cm. In this way it is clear once again that the contact surface in the various profiles is not synchronous. The diagrams F and G show the latest contact surface. The spots where these two profiles were sampled lie comparatively near the border of the raised bog.

If one prefers to leave the *Grenzhorizont* in profile A out of consideration on account of the 24 cm thick layer of humified *Sphagnum* peat on top of the *Sphagnum cuspidatum* peat, this will not alter the fact that even in a single raised bog the transition from highly humified to fresh *Sphagnum* peat is not a synchronous phenomenon. It appears thus that while on one spot formation of fresh *Sphagnum* peat took place, on another spot in the same raised bog still typical Older *Sphagnum* peat was formed.

The phenomenon discussed above is not confined to the raised bog from south-east Drente, but in various papers in which some diagrams from a single raised bog have been published the same behaviour of the *Grenzhorizont* can be seen. It is in this connection that in the first place the investigation of JONAS (1933) in the "Wilde Moor" near Papenburg has to be mentioned. In the diagrams JONAS gives from the *Sphagnum cuspidatum* layer in various profiles from that raised bog it is clear that the contact surface between Older and Younger *Sphagnum* peat in those profiles cannot be synchronous, a phenomenon to which JONAS already has drawn attention.

This unstable position of the *Grenzhorizont* is also very clear in the diagrams from the raised bog near Vriezenveen (FLORSCHÜTZ and WASSINK, 1935). Especially in the diagram from the border zone of that raised bog the transition from highly humified to fresh *Sphagnum* peat falls—in view of the relatively high *Fagus* and *Carpinus* percentages —distinctly later than in the other diagrams.

The various profiles from the "Fresenburgsmoor" (SCHUBERT, 1933) show a different pollen analytical position of the *Grenz.*

In one diagram from the raised bogs near Worpswede (SCHROEDER, 1930), namely the diagram "Worpswede", the *Grenzhorizont* must fall much later than in the other diagrams from that region. SCHROEDER ascribed the high *Fagus* percentage at the level of the contact surface to an early occurrence of *Fagus* on the sand isle "Weyer Berg" on the lee-side of the profile in question. In addition to the course of the *Fagus* curve that of the other curves also points to a late contact surface in this profile, compared with the other profiles from the raised bogs near Worpswede.

In both diagrams from the raised bog near Oldenbrook (OVERBECK and SCHMITZ, 1931) the contact surface does not correspond with the same pollen analytical horizon. In one diagram the contact surface lies below the first increase of *Carpinus*, whereas in a second diagram this transition corresponds with a level at some distance above the first increase of *Carpinus*.

Finally OVERBECK and SCHNEIDER (1938) already pointed out the irregularity in the position of the contact surface in the various profiles from the raised bog near Melbeck.

In the raised bogs mentioned above the same phenomenon as in the raised bog from south-east Drente can be observed, viz. that the contact surface between highly humified and fresh *Sphagnum* peat is not synchronous in the various parts of the same raised bog.

As in a single raised bog the *Grenzhorizont* can be formed at various times, it is not to be wondered at that a comparison of the pollen

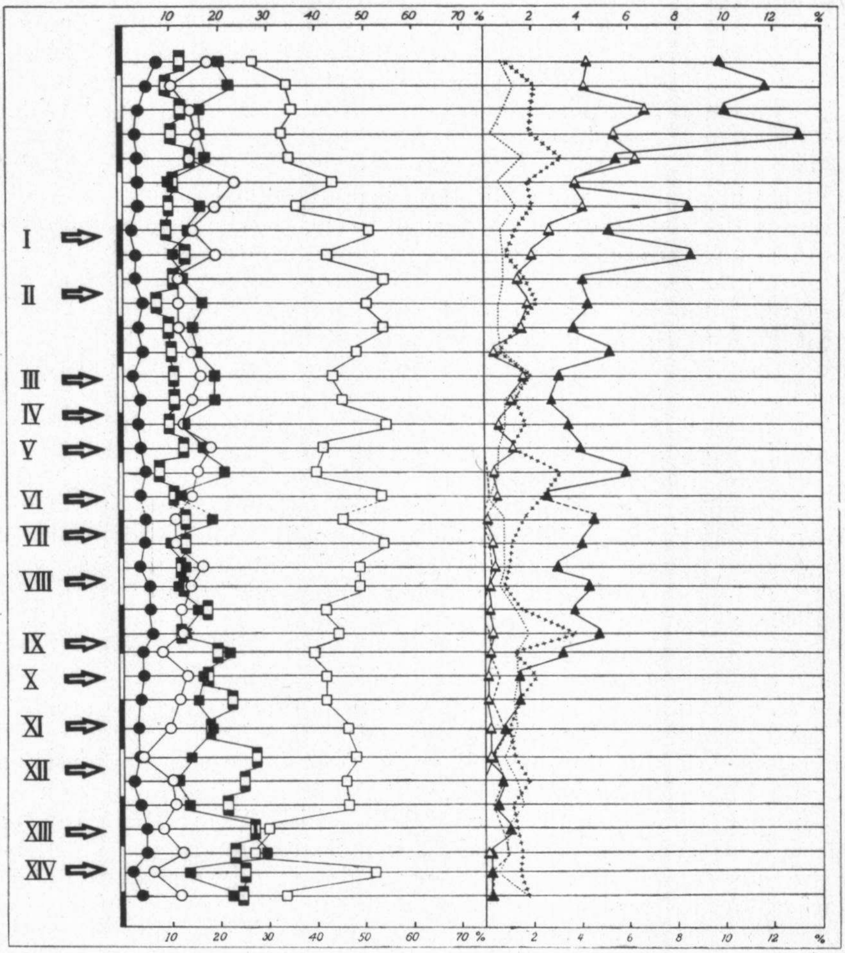

Fig. 25. In this diagram the position is indicated of the *Grenzhorizont* in the profiles summed up on the opposite page. The Roman figures left of the diagram correspond with those of the profiles.

analytical position of the *Grenzhorizont* in the various raised bogs shows great mutual differences. In order to illustrate this the pollen analytical position of the transition from highly humified to fresh *Sphagnum* peat in a number of profiles from north-west Germany and the Netherlands is indicated in Fig. 25. The diagram, to which the position of the *Grenzhorizont* in the various profiles is transferred, is composed of the upper part of the Emmererfscheidenveen I diagram and the upper part of the Fochteloo diagram. As in the earlier diagrams in general the sample distance is rather great (15–25 cm), it is not always possible to determine the pollen analytical position of the *Grenzhorizont* in the concerning profiles as exactly as desired. A second source of error lies in the fact that the diagram of Fig. 25 cannot be compared in all details with the diagrams summed up below, whilst in the third place the number of pollen grains counted in each sample is rather low in most of the earlier diagrams. Various irregularities in the curves, particularly for the less abundant pollen types, of those diagrams will undoubtedly be due to this small number of pollen grains counted.

For the transferring of the position of the *Grenzhorizont* to the diagram of Fig. 25 in addition to the *Corylus* curve the curves for

I Melbeck III, ?I (Overbeck and Schneider, 1938)
Wittmoor (Hallik, 1949)
II Holler Moor (Overbeck and Schmitz, 1931)
Worpswede (Schroeder, 1930)
III Oldenbrooker Moor II (Overbeck and Schmitz, 1931)
Dannenberg (Overbeck and Schmitz, 1931)
Tinner Dose (Koch, 1934*b*)
Vriezenveen, Bruine Haar (Florschütz and Wassink, 1935)
IV Am Lengener Meer (Overbeck and Schmitz, 1931)
Neudorf (Brinkmann, 1934)
Mantinge (Brouwer, 1947)
Bolleveen a (Waterbolk, 1950)
V Weinkaufsmoor (Overbeck and Schmitz ,1931)
Walchumer Moor (Koch, 1934*a*)
Bunnerveen III (Brouwer, 1947)
Iselersheim (Schubert, 1933)
Huvenhoopmoor (Schubert, 1933)
VI Witteveen-Havelte (Waterbolk, 1954*b*)
Fresenburgsmoor, "Bei der Höhne" (Schubert, 1933)
Spolsener Moor (Overbeck and Schmitz, 1931)
Hoornder Veen (Eshuis, 1936)
Vriezenveen, Boerendijk (Florschütz and Wassink, 1935)
Wolfsbrucher Moor (Schubert, 1933)
Minstedt (Schubert, 1933)
Dannenberg (Overbeck and Schneider, 1938)
Bergedorf 1 (Schroeder, 1930)
VII Oldenbrooker Moor I (Overbeck and Schmitz, 1931)
An den drei Pütten (Overbeck and Schmitz, 1931)
Kollrunger Moor (Wildvang, 1934*b*)
Wittmarscher Moor (Koch, 1934*a*)
VIII Fochteloo (Fig. 7)
Langenmoor Mitte (Schubert, 1933)
IX Roswinkel (Fig. 8)
Wildes Moor (Wildvang, 1934*b*; Koch, 1934*a*)
Veerssener Moor (Koch, 1934*b*)
X Vriezenveen, Paterswal I (Florschütz and Wassink, 1935)
Seehausen (Schroeder, 1930)
XI Bargercompascuum (Fig. 11)
XII Mulsemer Hohenmoor (Schubert, 1933)
Emmererfscheidenveen D (Fig. 20)
XIII Fresenburgsmoor, "Östliches Profil" (Schubert, 1933)
XIV Emmererfscheidenveen I (Fig. 4)

Fagus and *Carpinus* are used. It has already been pointed out that in the diagrams from the northern Netherlands and north-west Germany the curves for both trees bear a good resemblance. Although it has been taken into account that because of the reasons mentioned above it is not always possible to transfer the position of the *Grenzhorizont* very accurately, the distance between the successive positions of this contact surface is rather small. One may ask whether there is sense in distinguishing positions which lie so near to each other. Although it is occasionally indeed difficult to choose between two successive positions of the *Grenzhorizont*, in general this is quite well possible. It is clear that *e.g.* the position of the *Grenz* in the "Bunnerveen" III diagram corresponds with the first increase of *Carpinus*, whereas the *Grenzhorizont* in the diagram from Mantinge lies above this increase.

So the result of this comparison of the position of the *Grenz* in the various diagrams is that in the raised bogs from north-west Germany and the Netherlands the transition from humified to fresh *Sphagnum* peat could take place during a long period. Consequently this transition not only occurred at about 500 B.C. or at a limited number of times. It is true that a certain concentration in the occurrence of the *Grenzhorizont* can be seen at position VI. It is also striking that an early *Grenzhorizont* is most often found in the northern Netherlands. This does not mean, however, that we should simply speak of a shifting of the position of the *Grenzhorizont* from west to east. It is in this connection that attention must be drawn to the early position of this contact surface in one of the profiles from the "Fresenburgsmoor", whilst also in the "Mulsemer Hohenmoor" the *Grenzhorizont* was formed at an early time. It is not unlikely that in the profile from the "Berumfehner Moor", where a marked "*Vorlaufstorf*" is present (WILDVANG, 1934*a*), the contact surface also falls early. It is not possible, however, to compare this diagram adequately with that of Fig. 25 in order to transfer the position of the *Grenz*. In contrast with the early *Grenzhorizont* in various profiles from large raised bogs the transition from humified to fresh *Sphagnum* peat is late in the small raised bogs from the northern Netherlands.

The *Grenzhorizont* in various Danish peat profiles cannot be entirely synchronous either, although the fluctuations seem to be less great than in the northern Netherlands and north-west Germany. When we compare *e.g.* the position of the *Grenzhorizont* (RY III) in the diagram from Skallesøgaard I with that from Fly (JONASSEN, 1950), it is clear that in the first case the contact surface lies at 25 cm below the beginning of the continuous *Fagus* curve, whilst in the other diagram this contact surface lies above the beginning of the continuous *Fagus* curve.

VII. PEAT INVESTIGATIONS IN THE NORTHERN PART OF THE PROVINCE OF FRIESLAND

Up to now relatively few peat profiles from the Frisian coastal region have been subjected to pollen analysis. DIJKSTRA (not published), VAN ANDEL (1949) and VAN DONSELAAR and JONKER (1952) examined the so-called lower peat deposits from north-western Friesland. The results of these investigations agree with those from the western Netherlands (FLORSCHÜTZ, 1944), viz. that the post-glacial transgression reached the present coastal region in the first part of the Atlantic time. Not until much later were the peat profiles near Oud-Hof, Doniaga and Parrega analysed by FLORSCHÜTZ (1941*b*) flooded. The upper part of the peat profile near Oud-Hof consisted of fresh *Sphagnum* peat of the *Cymbifolia* section, from which FLORSCHÜTZ concluded that here also in the Subatlantic time peat formation took place. FLORSCHÜTZ supposed that during the transgression, which deposited the clay layer on the peat, the *Cymbifolia* peat near Doniaga and Parrega was uplifted and carried away. VROMAN (1952) was of opinion that the upper part of the Makkumerwaard profile also had been washed away. He thought it not unlikely that in this area the Younger *Sphagnum* peat would have been eroded in the 13th or 14th century A.D., during the formation of the Zuiderzee.

The peat profiles from Lichtaard, Jislum and Klaarkamp which will be discussed in this chapter, are situated in the area west of Dokkum. In this area a mostly undisturbed peat layer is present below a clay deposit 0.50–1 m thick. The peat layer rests on a diluvial sandy subsoil, which shows an emergence near Bornwird. More to the east, in the area north-north-west of Dokkum, no undisturbed peat layer is found below the marine clay. In that area the sea attacked the peat deposits, and large lumps of peat are met with in the clay deposit. According to VAN GIFFEN (1921) the dwelling mound of Aalsum, north of Dokkum, rests on marine clay which contains large lumps of washed-away peat.

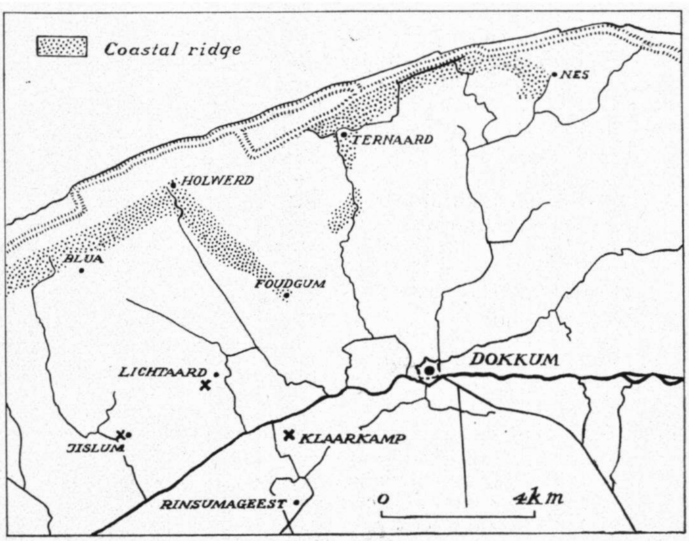

Fig. 26. Map of the coastal region of north-eastern Friesland. The coastal ridge is drawn according to WARTENA (1946).

An explanation of this difference in erosion of the peat landscape can be found in WARTENA's publication (1946). It appears that the coastal ridge running from Blija to Holwerd is broken off near Holwerd, and that this ridge again can be followed from Ternaard up to Nes (Fig. 26). This originally uninterrupted coastal ridge was washed away between Holwerd and Ternaard. The sandy material was re-deposited between Holwerd and Foudgum where at present a sand ridge is found. The ridge between Holwerd and Foudgum protected more or less the peat landscape west and south-west of this ridge against the eroding action of the sea. While in this way practically all peat in the area north-north-west of Dokkum had been taken by the sea, in general the peat deposits west of Dokkum were only covered by a clay deposit. On this clay deposit various dwelling mounds were built whose basal layer generally can be dated at about 100 A.D. (BOELES, 1951, Fig. 32 and Appendix IV).

The peat profiles in the area west of Dokkum are very suitable for a pollen analytical dating of this transgression, as it may expected that here in many cases the complete peat deposit is still present. On some spots, where by means of a boring the presence of peat below the clay could be established, a hole was dug. In this way it was possible to examine whether also the upper part of the peat profile was undisturbed. On account of the high ground water level in this area in most cases it was not possible to reach the diluvial subsoil, so that the lower part of the peat profile had to be sampled with an auger. Finally three peat profiles, namely those from Lichtaard, Jislum and Klaarkamp, which for various reasons were most suitable, were analysed (Figs. 27, 28, 29).

At the sites mentioned above the profile was as follows

Lichtaard	0– 95 cm	undisturbed clay
	95–137 „	highly humified *Sphagnum* peat with many remains of *Calluna*
	137–146 „	alternating thin clay and peat layers
	146–153 „	forest peat
	153– „	sand
Jislum	0–100 cm	undisturbed clay
	100–108 „	disturbed peat
	108–145 „	highly humified *Sphagnum* peat with many remains of *Calluna*
	145–152 „	clay layer
	152–157 „	peat
	157–160 „	clay layer
	160–170 „	highly humified fen peat
	170– „	sand
Klaarkamp	0– 50 cm	disturbed clay with pieces of cloister bricks
	50– 55 „	disturbed peat
	55– 83 „	highly humified *Sphagnum* peat with remains of *Calluna*
	83–130 „	alternating clay and peat layers
	130–180 „	forest peat
	180– „	sand

Attention has to be drawn to the narrow clay bands occurring in the peat deposits. Similar thin clay layers were often considered as the effect of minor transgressions, on account of which the bog surface would have been flooded only for a short time. After the lowering of the sea level peat formation would have continued. However, a whole series of alternating thin peat and clay layers is often found, while, moreover, the boundaries between clay and peat are very sharp. If after the deposition of a narrow clay layer peat formation again took place, it may be expected that the bog plants were rooting in that clay layer, on account of which there cannot be a sharp contact surface between the clay and the overlying peat. Consequently the narrow clay layers cannot represent interruptions in the peat formation in consequence of transgressions of short duration. The clay bands, however, must have been formed much later, during the transgression which deposited the clay on top of the peat. During storm tides parts of the peat will have been split horizontally and uplifted by the sea water which will have entered the peat landscape through a system of gullies. This uplifting of peat during extremely high tides can still be observed in the "Sehestedter Aussendeichsmoor" near the Jadebusen (*cf.* KÜNNEMANN, 1941, Fig. 1). After the flood the uplifted part of the peat sinks more or less into its original position, but in the meantime a narrow clay layer had been deposited between both peat layers. SCHÜTTE (1927) was of opinion that the peat would always be split at the transition from fen or forest peat to *Sphagnum* peat. BRINKMANN (1934), on the other hand, stated that he never found a clay band at that transition. Although it is true that in the Lichtaard profile some clay bands are present at the transition from forest peat to *Sphagnum* peat, in other—partly unpublished—profiles from this region also in the *Sphagnum* peat narrow clay bands were observed.

It is very likely that the narrow clay bands which occur in the peat profiles from the Princehof (central Friesland), and which would correspond with both Atlantic transgressions established by MULLER and VAN RAADSHOVEN (1947) in the Noordoostpolder (VAN ZEIST, 1950), have no relation with these transgressions, but that they have been much later deposited between the peat. This is very clear for the profile from the Makkumerwaard (VROMAN, 1952). In this profile there is a sandy clay layer between *Eriophorum* peat. It is not probable that after a transgression, which deposited a brackish sandy clay layer, peat formation would have started again with oligotrophic *Eriophorum* peat. TUINSTRA (1951) records that in the north-western part of the province of Noord-Brabant in the vicinity of the original gullies in the Younger *Sphagnum* peat sometimes a narrow clay band occurs which shows the same composition as the clay on top of the peat. TUINSTRA concludes that the clay band must be the effect of a slight transgression phase which would have deposited a narrow clay layer only in the vicinity of the gullies, while at some distance from the gullies peat formation would have continued without interruption. It is more likely, however, that in the vicinity of the gullies the peat was horizontally split and uplifted during the high tides which deposited the clay on top of the peat.

The beginning of the peat formation in the Lichtaard profile cannot be determined exactly, as the lower part consisted of forest peat, so that the pollen content has been greatly influenced by the local production of pollen. Although the lower spectra of the Jislum profile are more reliable in this respect, it is difficult to give an exact determination of the beginning of the peat formation. In consideration of the *Fagus* percentage peat formation will have started here at the end of the Atlantic time or at the beginning of the Subboreal time.

For a dating of the transgression which deposited the marine clay on top of the peat, the upper part of the diagrams is of importance. It is seen immediately that these diagrams differ somewhat from those discussed in the chapters III and IV. In the Lichtaard diagram the *Corylus* percentage between a depth of 118.5 and 128.5 cm is higher than that of *Alnus*, whilst the *Fagus* percentage—with the exception of the spectrum at a depth of 126 cm—is fairly low below a depth of 118.5 cm (about 1 %). Above 118.5 cm *Corylus* decreases and above 111 cm the *Corylus* values remain below those of *Alnus*. At the same time *Fagus* increases, and reaches an average value of 2.5 %. At the bottom of the Klaarkamp diagram the beginning of the fall of *Corylus* and the rise of *Fagus* can just be seen. The part between 73.5 and 78.5 cm corresponds with the part between 112 and 117 cm in the diagram from Lichtaard. The Jislum diagram is not so easily comparable with the diagram from Lichtaard. The behaviour of *Corylus* is somewhat irregular, whilst in general *Fagus* reaches less high values. The level from where *Corylus* decreases and the *Fagus* curve shows an increase corresponds with a depth of 136.5 cm, whilst the part above 124 cm can be compared with that part of the Lichtaard diagram which lies above 111 cm. A close comparison of the Jislum diagram with both other diagrams remains difficult, however. This is somewhat remarkable as there is no great distance between the various profiles (about 3.5 km).

The high *Myrica* percentages in the Jislum diagram are conspicuous, whilst the upper spectrum of the Lichtaard diagram equally shows a high *Myrica* percentage. It appears that not unfrequently *Myrica* must have been rather abundant on the bogs of the coastal region. Wildvang (1934*b*) reports the occurrence of many leaves and pollen grains of *Myrica* in the upper part of the peat profile from Emden-Wolthusen which is covered by a clay deposit. The peat profiles from Hekelingen in the coastal region of the western Netherlands appear to contain large amounts of *Myrica* pollen (Florschütz, 1953). Zwillenberg and Hendriks (1954) report the occurrence of *Myrica* pollen in the clay-covered peat deposits from Waterland (province of Noord-Holland) not far from the coast either.

The regular occurrence of pollen of *Plantago* and *Cerealia* points to human habitation on the higher sandy soils in this area in Neolithic time and later. The values for *Chenopodiaceae* and *Artemisia*—especially in the diagrams from Lichtaard and Jislum—are higher than those in the diagrams from regions at a greater distance from the coast, and will undoubtedly be due to the halophytic vegetation of the coastal region. In this respect the regular occurrence of pollen grains of *Plantago maritima* in the upper part of the Lichtaard diagram must be mentioned. Pollen of *Cruciferae*—fairly abundant in "*kwelder*" deposits—was not found in the analysed peat profiles. This will be due to the fact that *Cruciferae* are no wind pollinators, and produce a relatively small amount of pollen grains.

In comparing these diagrams with those from Drente for instance, it has to be taken into consideration that the conditions for the supply of tree pollen were not favourable. It appears that the trees which were growing on the higher sandy soils south of Dokkum must have been the chief contributors of the pollen grains coming down in the bogs west of Dokkum. These higher sandy soils are lying south-east of the investigated peat area, while west of this area nowhere suitable habitats for forest vegetation can have been present. Consequently, a pollen rain of any importance could especially take place with south-eastern winds. In this connection it is easily understandable that *Corylus* shows such high percentages, as in the early spring, when *Corylus* flowers, south-eastern winds blow regularly. How far the irregular *Fagus* curve has to be ascribed to the unfavourable position of this peat area in respect of the forest vegetation is difficult to determine. It is, however, remarkable that the *Fagus* curve—just as those for the other trees—is most regular in the Klaarkamp diagram which of the analysed profiles lies nearest to the higher sandy soils.

The most conspicuous phenomenon in the three diagrams is the fall of *Corylus* which is accompanied by an increase of *Fagus*. In contrast with the diagrams from Drente *Fagus* does not reach here a value of 4–5 %, but only an average of 2–3 %. The level from where *Corylus* decreases and the rise of *Fagus* starts, is found in the diagrams from Lichtaard, Jislum and Klaarkamp at a depth of 118.5, 136.5 and 78.5 cm respectively. This level corresponds with the last *Corylus* maximum (C_4) in the diagrams from Drente.

It is not possible to give an accurate pollen analytical dating of the transgression that deposited the clay on top of the peat. It was, however, a fairly long time after the first expansion of *Fagus*—whose beginning can be dated at about 500 B.C.—that peat formation came to an end owing to the deposition of clay. A *terminus ante quem* gives the basal layer of the dwelling mounds from this area which can be dated at about 100 A.D. (see p. 64). On the ground of both data the deposition of clay must have started shortly before the beginning of the era.

By EDELMAN and collaborators (EDELMAN, 1953) three phases are distinguished in the so-called Subatlantic transgression, viz. a pre-Roman, a late-Roman to early-Mediaeval and a third phase starting at about 1000 A.D. The first phase of the Subatlantic transgression attacked various parts of the Dutch coastal region. BENNEMA and VAN DER MEER (1950) record that shortly before or about the beginning of the era the northern part of Walcheren was flooded by the sea. The pre-Roman ebb and flood channels in the peat landscape of Westland have been investigated by VLAM (1945) and VAN LIERE (1948). DE ROO (1949) could establish pre-Roman inroads on the coast of Kennemerland, whilst DU BURCK (1949) found a pre-Roman attack of the landscape in Geesterambacht. With regard to Friesland it can be mentioned that BAKKER (1954) dated the formation of the tidal flat sand ridge between Dongjum and Berlikum at about 200–100 B.C., which formation would point to a temporary stronger rise of the sea level.

The influence of the late-Roman to early-Mediaeval phase of the Subatlantic transgression could be established in several places along the coast of the provinces of Noord- and Zuid-Holland and Zeeland. This transgression would also have left traces in the province of Friesland. According to VEENENBOS (1949) the old landscape south of Franeker consisted of marine deposits. Through this landscape various channels were running on the bank of which prehistoric man had settled. Later on, these settlements developed into dwelling mounds. This old landscape was covered by a tough clay, poor in lime, the so-called sticky clay. VEENENBOS (1949) places the deposition of this sticky clay in the period from 300 to 800 A.D. According to BAKKER (1954) the tidal flat sand ridge in Barradeel near the old sea dike, parallel to the present coast, was formed at about 300–400 A.D.

The transgression that deposited the clay on the peat landscape west of Dokkum can be assigned to the pre-Roman phase of the Subatlantic transgression.

A comparison of the Oud-Hof diagram (FLORSCHÜTZ, 1941*b*) with the diagrams from Lichtaard, Jislum and Klaarkamp shows that it is not unlikely that also in the south-western part of the province of Friesland the peat landscape must have been flooded during the first phase of the Subatlantic transgression.

The clay area of the province of Groningen has less thoroughly been investigated than many other parts of the Dutch coastal region. As appears from the profiles published by KOOPER (1939) and WIGGERS (1950) often two peat layers are met with in the subsoil of the clay area of the province of Groningen. The lower peat layer rests on diluvial sand. In connection with the results of the investigation in the western Netherlands it is obvious to suppose that this peat layer can be compared with the so-called lower peat deposits which were flooded at the beginning of the Atlantic time. Up to now no samples from this peat layer from Groningen were analysed. VERMEER-LOUMAN (1934) only analysed a partly humous clay from a depth of about — 16.80–17.50 m N.A.P. (Amsterdam Ordnance Datum) near Uithuizen. The high *Pinus* percentage in the humous clay is no evidence of a Boreal age, as in general the *Pinus* percentages in clay deposits are high.

On top of the Atlantic clay a peat deposit has been formed which again was covered by a clay layer. In the upper clay deposit two phases separated by a distinct humous horizon can be located. The dwelling mounds rest on that old surface. This would suggest that the flooding of the peat landscape in Groningen must have taken place before the beginning of the era (WIGGERS, 1950).

Dr U. TUINSTRA at Warffum placed a number of peat profiles covered by marine clay at our disposal which would make possible a pollen analytical dating of one or more transgressions. Unfortunately the pollen analytical examination did not lead to a positive result.

For the adjacent Ostfriesland (north-western Germany) HAARNAGEL (1950) mentions that there the time between about 700 and 300 B.C. was a transgression period.

VIII. DISCUSSION

THE PODZOL PROFILE

In consequence of the interference of Neolithic man with the natural vegetation the heather must locally have played an important part already in Neolithic time. The rather high *Calluna* percentages in a number of Neolithic spectra, *e.g.* Oudemolen tumulus 12, Vries tumulus III, Emmen *hunebed* D XLI, Noordse Veld tumulus 37 (WATERBOLK, 1954*b*) and Oudemolen tumulus 13 (Table VII) point to a local expansion of the heather. In spite of these fairly high *Calluna* percentages a podzol profile never occurs below a Neolithic burial monument (VAN GIFFEN, 1941*b*). Below Bronze Age tumuli, on the other hand,—at least on the higher sandy soils—a podzol profile is always present, even if sometimes the *Calluna* percentages are rather low, *e.g.* "Eupen Barchien" (WATERBOLK, 1954*b*), Hijken tumuli 9 and 10 (Table II). The stone cist tumulus near Diever and the barrow of light-coloured sods lying near this tumulus showed a beginning of podzolization. In the subsoil of these tumuli a leached layer was already present, but no hard pan yet.

WATERBOLK (1954*b*) has already pointed out that the development of a podzol profile below a heather vegetation must have been effected by an increase of precipitation. This increase of precipitation likewise offered conditions favourable to a further expansion of the heather. On account of the exhaustive cultivation—as was practised in the Netherlands at least until the end of the Bronze Age—a considerable impoverishment of the upper soil layer took place. At the beginning of the Bronze Age this impoverishment became stronger, since the leaching began to play an important part because of the increased precipitation. In consequence of this strong impoverishment of the upper soil layer the conditions for a regeneration of the forest—which in Neolithic time undoubtedly must have occurred—became very unfavourable, so that the heather, which makes low demands upon the mineral content of the soil, could easily expand after the cultivated area had been abandoned. Moreover, the acid humous layer of the *Calluna* vegetation intensifies the leaching of the soil, as on account of the low pH the iron and aluminium compounds dissolve, whilst a cemented hard pan prevents the regeneration of the forest as the roots cannot penetrate through that layer.

The development of a podzol profile in the Bronze Age thus points to an increased precipitation which effected a strong leaching of the soil. Another indication of this increased rainfall can be observed in the various profiles from the raised bog near Emmererfscheidenveen. In this raised bog fresh *Sphagnum cuspidatum* peat layers occur from the transition between Neolithic time and Bronze Age (*cf.* Emmererfscheidenveen A and B—Figs. 17 and 18—in which this *Sphagnum cuspidatum* layer starts just below and above the first, small increase in the *Fagus* curve respectively). The formation of this type of peat must be the effect of an increase in rainfall, on account of which small pools were formed on the surface of the bog. In these pools the hydrophilous *Sphagnum cuspidatum* could develop. The fact that this *Sphagnum cuspidatum* layer is highly fissile suggests that these pools dried up in the summer.

Although human activity should establish the possibility for a development of the heather vegetation by clearing the forest, it was a climatological phenomenon, namely an increase in precipitation, which was the determining factor for the expansion of the heather.

Although the difference in soil profile below Neolithic and Bronze Age barrows has led to the conclusion that the formation of a podzol profile did not take place until the beginning of the Bronze Age, some attention has to be paid to those pollen analytical examinations which would point to an earlier development of the podzol profile. The conception at which Beijerinck (1933, 1934) and Benrath and Jonas (1937) arrived on the ground of pollen analytical investigations of the concerning layers, viz. that the hard pan would be an arctic formation, and that the leached layer would have been formed during a more generous climate, cannot be correct, since well developed podzol profiles on the surface of barrows are known. Moreover, Beijerinck (1941, 1943) has modified his original view, and nowadays he considers the hard pan and leached layer as formations of winter and summer climate respectively. The result of the pollen analytical investigation of leached layers by Florschütz (1941*a*) can also be left out of consideration, as it appears clearly from the investigations of Selle (1940) that the pollen spectra of the leached layer of a podzol profile are not reliable, and that consequently those spectra cannot yield data about the time of development of the podzol profile.

It cannot be denied, however, that in a number of cases peat formation above a podzol profile started before the beginning of the Bronze Age. From this it follows that the podzol profile in question must have developed at an earlier time. Schroeder (1934) described a "Boreal" podzol profile from the Wieringermeer. The peat formation on top of this profile started at the beginning of the Atlantic time. The Ericaceous percentages in the lower sandy part are very high. The profile L from the Wieringermeer (Vermeer-Louman, 1934) also points to the presence of a podzol profile below Atlantic peat. Near Terhorne (south-west Friesland) Bodlaender (1950) found a well developed podzol profile which was overgrown by peat at about the Boreal/Atlantic transition. In north-west Brabant the presence of a podzol below peat was also established (TUINSTRA, 1951).

It is striking that similar "old" podzol profiles always occur below peat, whereas they have never been met with on the higher sandy soils. In the so-called double podzol profiles of Havelte (WATERBOLK, 1954*b*) and Wijster (VAN ZEIST, 1954) there are no indications of a pre-Bronze Age development of the lower podzol. It is in this connection that mention should be made of the stratigraphical examination of the raised bog from south-east Drente by VISSCHER (1931). This author reports that in general a leached layer and a hard pan occur below the peat. The thickness of the leached layer would range from 5–30 cm, that of the hard pan from 10–50 cm. On the higher parts of the undulating subsoil the hard pan would be weakly developed, rather soft and light-coloured. On the lower parts this layer would be more cemented and dark-coloured.

On account of these investigations it must indeed be concluded that at low lying sites, where peat formation has taken place already before the beginning of the Bronze Age, a podzol profile could develop. This would be in conflict with the results of the barrow investigations. The question arises whether the podzol profile below a bog can be compared with that on the higher sandy soils. For a typical heather podzol develops at sites where the ground water table is not too high. It may be expected, however, that just at sites where peat formation could take place, the ground water will have been high. It is a well-known fact that in water-logged soils gleization takes place (ground water profiles). In that case a leached layer may occur below the humous to peaty topsoil. In sandy soils besides the leached layer a B-(iron accumulation) layer is often met with (VEENENBOS, 1953). JOFFE (1949, p. 432) records the occurrence of podzol profiles with a clear, bleached A_2- and a, not unfrequently cemented, coffee-brown B-horizon below peat and at other sites with a high ground water table. JOFFE considers these profiles as a hydromorphic sub-type of the podzol profile. For this reason it is very likely that the podzol profile which also in the Netherlands is found below peat, represents such a ground water profile.

THE PROBLEM OF THE *Grenzhorizont*

In Chapter VI the results have been discussed of the investigation into the pollen analytical position of the *Grenzhorizont* which constitutes the transition from highly humified to fresh *Sphagnum* peat. As already has been stated on p. 51 by VAN GIFFEN (1947, 1950) and WATERBOLK (1950) the beginning of the growth of the Younger *Sphagnum* peat is dated at about 400 A.D. on the ground of an examination of the "Bolleveen" near Zeijen. They arrived at the conclusion that in general the *Grenzhorizont* would not correspond with the RY III, but with the RY II. VAN GIFFEN (1950, 1954*b*) connects the marine transgression after the third century A.D. with the beginning of the formation of fresh *Sphagnum* peat in the small raised bogs from Drente. According to VAN GIFFEN the formation of the Younger *Sphagnum* peat would be effected by a rise in the ground water table which would be closely bound up with the mentioned transgression. WATERBOLK (1954*b*) also associates this transgression with the beginning of the formation of fresh *Sphagnum* peat, whilst according to BENNEMA (1954) there would in general be a correlation between the occurrence of recurrence surfaces and transgressions. Previously WASSINK (1939) pointed already to a possible connection between the height of the sea level and the peat formation.

It is not likely, however, that a rise in the sea level of perhaps 1–1.50 m will have effected a considerable rise in the ground water in regions at a fairly great distance from the coast. Moreover, the investigations of EDELMAN and collaborators have demonstrated that there must also have been, among others, a pre-Roman transgression (*cf.* pp. 67–68). This transgression should, according to the hypothesis of VAN GIFFEN and WATERBOLK, also have to find expression in the stratigraphy of the raised bogs. However, VAN GIFFEN and WATERBOLK assume a standstill in the peat formation in the small raised bogs during the pre-Roman and Roman Iron Age, whilst during that time the peat formation in the large raised bogs would have been of slight importance. So there would be no correlation between the pre-Roman transgression and the peat formation. Besides, in the large raised bogs the formation of fresh *Sphagnum* peat appears to have started at times which cannot be linked up with a transgression.

It is more likely that the transition from highly humified to fresh *Sphagnum* peat has to be considered as the effect of climatological factors. In the raised bog from Emmererfscheidenveen the formation of fresh *Sphagnum* peat often started with a *Sphagnum cuspidatum* layer. As has already been remarked this layer must have been effected by a rather heavy precipitation which caused the formation of small pools on the bog surface. The fact that in some cases on top of the *Sphagnum cuspidatum* layer there is again a layer of humified *Sphagnum* peat suggests that in general that time (Bronze Age) was not yet very favourable to the formation of fresh *Sphagnum* peat, probably on account of still too high a temperature and too low a humidity.

In view of the fact that in the large raised bog from south-east Drente the formation of fresh *Sphagnum imbricatum* and *papillosum* peat started at about the beginning of the Iron Age, it seems likely that at that time the conditions for the formation of fresh *Sphagnum* peat became more favourable in this region. Particularly the expansion of *Sphagnum imbricatum* suggests that the moisture of the peat must have been very high. From SCHWICKERATH's (1944) examination of the vegetation of the "Hohe Venn" it is clear that *Sphagnum imbricatum* only grows in the wettest places of the raised bog. At the beginning of the Iron Age the general humidity must have increased in such a way (lower temperature, increased precipitation?) that in the large raised bogs—with the exception of the border zones—the surface of the bog became sufficiently moist in order to establish conditions favourable to the growth of *Sphagnum imbricatum*. At the same time the first expansion of *Fagus* took place. In Denmark MIKKELSEN (1949, 1952) ascribes the expansion of *Fagus* by jumps to three moist phases in the Subatlantic time. Consequently, there would be a correlation between the expansion of *Fagus* and the humidity.

This increase in humidity at the beginning of the Iron Age effected the formation of fresh *Sphagnum* peat only in large raised bogs. For the present the formation of fresh *Sphagnum* peat did not yet take place in the small raised bogs from Drente, whilst in the same way in a great number of profiles from north-west Germany the transition from humified to fresh *Sphagnum* peat occurred rather late.

It is certain that besides climatological factors the local conditions had great influence on the transition from Older to Younger *Sphagnum* peat. For the investigation into the pollen analytical position of the *Grenzhorizont* in the raised bog from south-east Drente has clearly demonstrated that even in a single raised bog this transition cannot have been a synchronous phenomenon, but that local factors must have played an important part. The same phenomenon appears to be present in various other raised bogs. In this connection it is interesting that just in the border zone of the raised bogs this transition did not take place until later times. This agrees with the fact that in the small raised bogs from Drente the *Grenzhorizont* is likewise late. Just as in the border zone of the large raised bogs the small raised bogs are relatively well drained, so that it lasted much longer before the conditions for the formation of fresh *Sphagnum* peat became favourable here. On account of the increased humidity which effected a lower evaporation, the ground water table must have risen. Consequently, this rise in the ground water considerably impeded the drainage of the small raised bogs, so that here also the conditions for the formation of fresh *Sphagnum* peat became favourable.

In the various small raised bogs from Drente the *Grenzhorizont* also appears not to be a synchronous phenomenon. In Fig. 25 the position of the *Grenz* in three small raised bogs is indicated, viz. the "Witteveen" near Havelte, the "Bolleveen" near Zeijen and the "Bunnerveen". Although there is not much difference in time between the formation of the *Grenzhorizont* in these bogs, it easily runs to some hundreds of years. This again points to the fact that besides climatological factors, the local conditions must have been of much importance to the formation of fresh *Sphagnum* peat.

It seems likely that at first edaphic factors were prevailing, which prevented the formation of fresh *Sphagnum* peat, and that only in favourable places in the raised bogs from western Europe the formation of fresh *Sphagnum* peat started as soon as the climatological factors allowed this. Not until much later, during the first four or five centuries A.D., the influence of unfavourable edaphic factors greatly declined. The diagram of Fig. 25 illustrates a concentration of *Grenzhorizonts* in that part of the diagram which corresponds with the first five centuries A.D. When we compare the peat formation over large areas it should also be borne in mind that in one region the influence of a given climatic factor will be much greater than in another region (*cf.* OVERBECK, 1952).

WEBER's conception that the Older *Sphagnum* peat would have attained its present state of humification during a period of standstill in the peat formation could easily explain the sudden transition from highly humified to fresh *Sphagnum* peat. The present view that—at least in the large raised bogs—there has not been a standstill in the peat formation, renders an explanation of the sudden transition more difficult, since the climatic changes which are responsible for this transition always elapse rather gradually. Recently NIETSCH (1953) commented upon this question. Although OVERBECK (1947) and OVERBECK and SCHNEIDER (1940) could demonstrate that a certain decrease in the degree of humification often takes place already at some depth below the marked contact surface, yet the humification curve shows a sharp decline at the transition from Older to Younger *Sphagnum* peat.

THE CORRELATION BETWEEN THE RESULTS OF POLLEN ANALYSIS OF SAMPLES FROM BOGS AND FROM BURIAL MONUMENTS

Concerning the correlation between the results of the pollen analytical investigation of sand samples and those of peat samples the following can be remarked.

Although *Fagus* occurs regularly already in the Neolithic part of the pollen diagrams from the large raised bogs as well as from the small ones, pollen of this tree is in general not met with in the spectra of the Neolithic burial monuments in the northern Netherlands. The rather high *Fagus* percentage in the sample from the *hunebed* near Wapse is an exception. It is very likely that—apart from some exceptional cases—*Fagus* did not yet grow here during the Late Stone Age.

The examination of the pollen analytical position of archaeological objects discovered in the peat has demonstrated that the first, slight increase in the *Fagus* curve approximately coincides with the transition from Neolithic time to Bronze Age. The fact that—in contrast with the Neolithic spectra—in all spectra from Bronze Age *Fagus* is present is in accordance with the increase in the *Fagus* curve in the pollen diagrams.

The expansion of *Fagus* at the beginning of the Iron Age is likewise reflected in the barrow spectra from that time which show considerably higher *Fagus* values than the Bronze Age spectra. On account of the local circumstances the *Fagus* values can remain low, but then also —compared with the corresponding Bronze Age spectra—a marked increase can be seen (*cf.* Table V). In general the spectra of sand samples from the Iron Age show a lower *Fagus* percentage than the corresponding spectra in the diagrams from raised bogs.

In agreement with the diagrams from the raised bogs *Carpinus* occurs regularly in the sand samples from the Iron Age. The *Carpinus* values in sand samples are—just as those for *Fagus*—lower than in the corresponding peat samples.

The Neolithic and Bronze Age part of the diagrams cannot be distinguished by a difference in *Corylus* values. In both periods the curve for this tree shows some fluctuations. The marked decline of *Corylus* from the beginning of the Iron Age is also reflected in the spectra of the sand samples from that time. Especially the spectra of the Iron Age barrows near Wijster (Table V) all show low *Corylus* percentages. The *Corylus* values in the samples from the Anglo-Saxon cemetery near Zweeloo (Table IV) are also low.

The relatively high *Tilia* values are characteristic of many Neolithic spectra. Confining ourselves to the northern Netherlands the highest values found up to now are: *hunebed* Steenbergen 8.5 %, *hunebed* Exloo 6.6 %, *hunebed* Emmen D XLI 6.2 %, tumulus III near Vries 4.7 %, tumulus I Noordse Veld 12 %. The *Tilia* values in Bronze Age samples do not reach such high percentages. In contrast with the pollen diagrams from bogs in which the *Tilia* values from the Bronze Age are only slightly lower than those from the Neolithic time, the *Tilia* values in sand samples from both periods can differ considerably. While in general the *Tilia* values in peat and sand samples from the Bronze Age show considerable agreement, Neolithic sand samples not unfrequently show *Tilia* values which are much higher than in the corresponding peat samples. Although high *Tilia* percentages occur in a number of Neolithic sand samples, the *Tilia* values in other Neolithic sand samples are not much higher than those in the Bronze Age sand samples, *e.g.* Hijken tumuli 1 (period 2) and 8 (period 1), "Galgenberg" near Ruinen (period 1) and Oudemolen tumulus 13 (period 1) which yielded the following *Tilia* values: 1.1, 0.9, 1.9 and 0.8 %. WATERBOLK (1954*b*) drew attention to the fact that the *Tilia* percentages in barrows from a given area and from about the same time may differ considerably. These difference could be effected by a local occurrence of *Tilia*, but it seems more likely that there is a correlation between the *Tilia* value and the state of preservation of the pollen grains. For it appears that the Neolithic samples which contain badly preserved pollen, show a high *Tilia* percentage, *e.g.* Hijken tumulus 1 (period 1) and the samples from the *hunebeds* near Steenbergen, Exloo, and Diever, whereas this percentage is low in some Neolithic samples with a fairly good state of preservation, *e.g.* Hijken tumuli 1 (period 2) and 8 (period 1), Oudemolen tumulus 13 (period 1). In addition it is remarkable that in Bronze Age samples with badly preserved pollen *Tilia* shows fairly high values, *e.g.* Hijken light-coloured sod (2.4 %) and old arable (3.4 %) of tumulus 5 and old arable (3.0 %) of tumulus 6, whilst the *Tilia* value in the samples with a good state of preservation from both tumuli is 0.8 %.

In this connection the result of SELLE's investigation (1940) is of importance. This author found extremely high *Tilia* values in samples from the leached layer of the podzol profile, whereas in the pollen diagrams from small raised bogs in the vicinity the values for this tree were constantly low. According to SELLE these high *Tilia* values in sand samples have to be ascribed to a differential preservation favouring *Tilia*.

In consideration of these experiences and the fact that in Neolithic sand samples with a good state of preservation the *Tilia* values agree well with those in the corresponding peat samples, it is highly probable that the high *Tilia* values in a number of Neolithic spectra have not been effected by a local occurrence of *Tilia*, but by a differential preservation.

In accordance with the expectation the Iron Age sand samples show very low *Tilia* values (about 0.3 %), whilst in the samples from the Anglo-Saxon cemetery near Zweeloo *Tilia* is completely absent.

For the same reason as for *Tilia* it is very probable that a bad state of preservation has favoured the pollen of *Plantago lanceolata*. Through the presence of the characteristic pores even badly preserved pollen grains of this species can be easily recognized. The high values for *Sphagnum* and *Dryopteris* in Neolithic samples with badly preserved pollen grains will—at least partly—be due to the high resistance of the spore wall.

In general it can thus be stated that the results of the pollen analytical examination of the raised bogs are in good agreement with those of samples from burial monuments.

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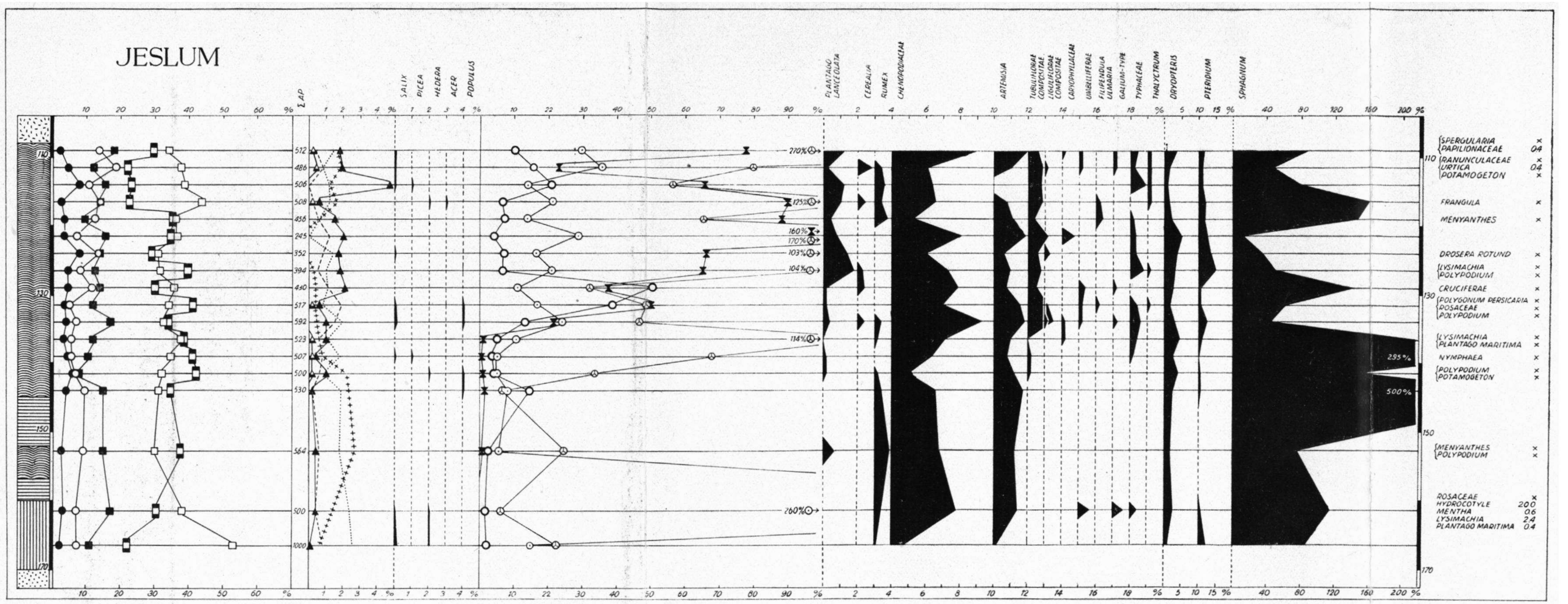

JESLUM
ΣAP
SALIX
PICEA
HEDERA
ACER
POPULUS
PLANTAGO LANCEOLATA
CEREALIA
RUMEX
CHENOPODIACEAE
ARTEMISIA
TUBULIFLORAE COMPOSITAE
LIGULIFLORAE COMPOSITAE
CARYOPHYLLACEAE
UMBELLIFERAE
FILIPENDULA ULMARIA
GALIUM-TYPE
TYPHACEAE
THALYCTRUM
DRYOPTERIS
PTERIDIUM
SPHAGNUM
SPERGULARIA
PAPILIONACEAE 0.4
RANUNCULACEAE
URTICA 0.4
POTAMOGETON
FRANGULA
MENYANTHES
DROSERA ROTUND
LYSIMACHIA
POLYPODIUM
CRUCIFERAE
POLYGONUM PERSICARIA
ROSACEAE
POLYPODIUM
LYSIMACHIA
PLANTAGO MARITIMA
NYMPHAEA
POLYPODIUM
POTAMOGETON
MENYANTHES
POLYPODIUM
ROSACEAE
HYDROCOTYLE 20.0
MENTHA 0.6
LYSIMACHIA 2.4
PLANTAGO MARITIMA 0.4
270%
125%
160%
170%
103%
104%
114%
260%
295%
500%

Fig. 28.

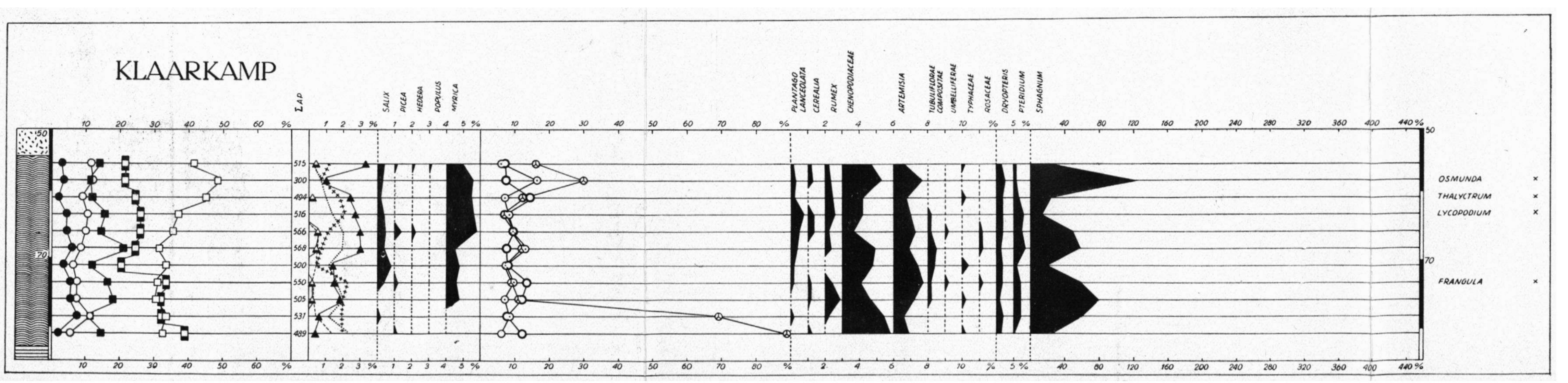

KLAARKAMP
ΣAP
SALIX
PICEA
HEDERA
POPULUS
MYRICA
PLANTAGO LANCEOLATA
CEREALIA
RUMEX
CHENOPODIACEAE
ARTEMISIA
TUBULIFLORAE COMPOSITAE
UMBELLIFERAE
TYPHACEAE
ROSACEAE
DRYOPTERIS
PTERIDIUM
SPHAGNUM
OSMUNDA
THALYCTRUM
LYCOPODIUM
FRANGULA

Fig. 29.

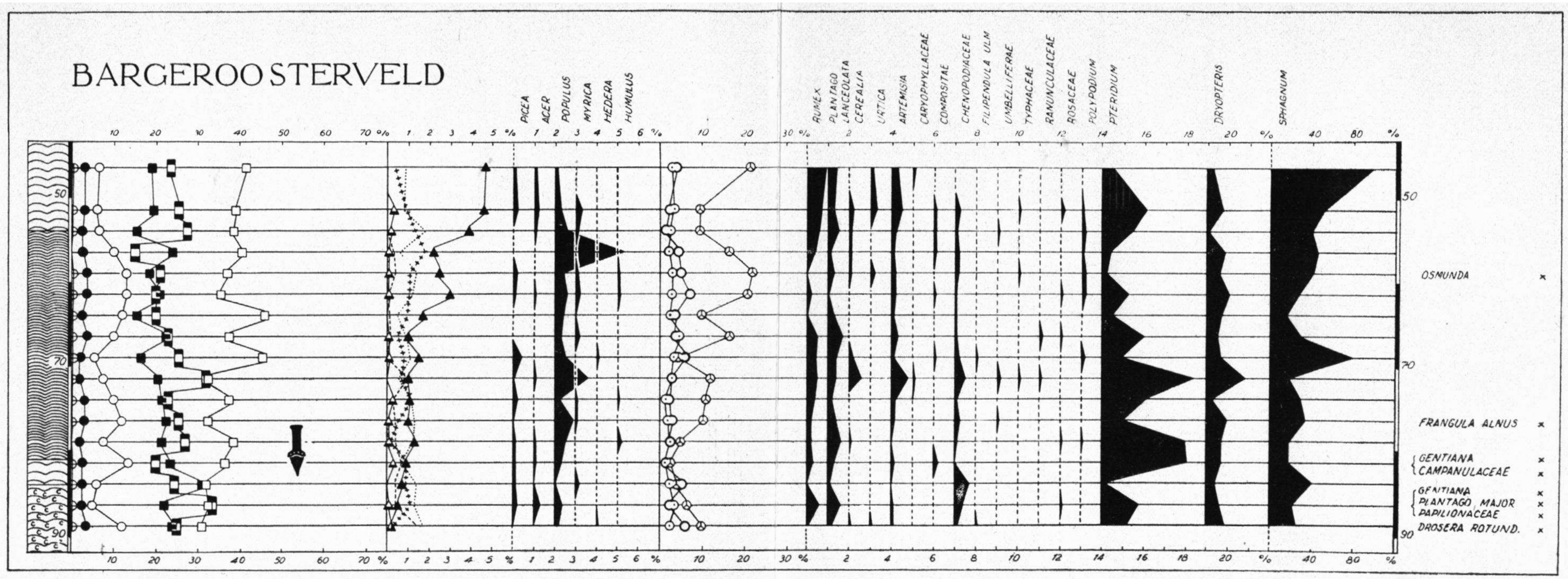


Fig. 9.

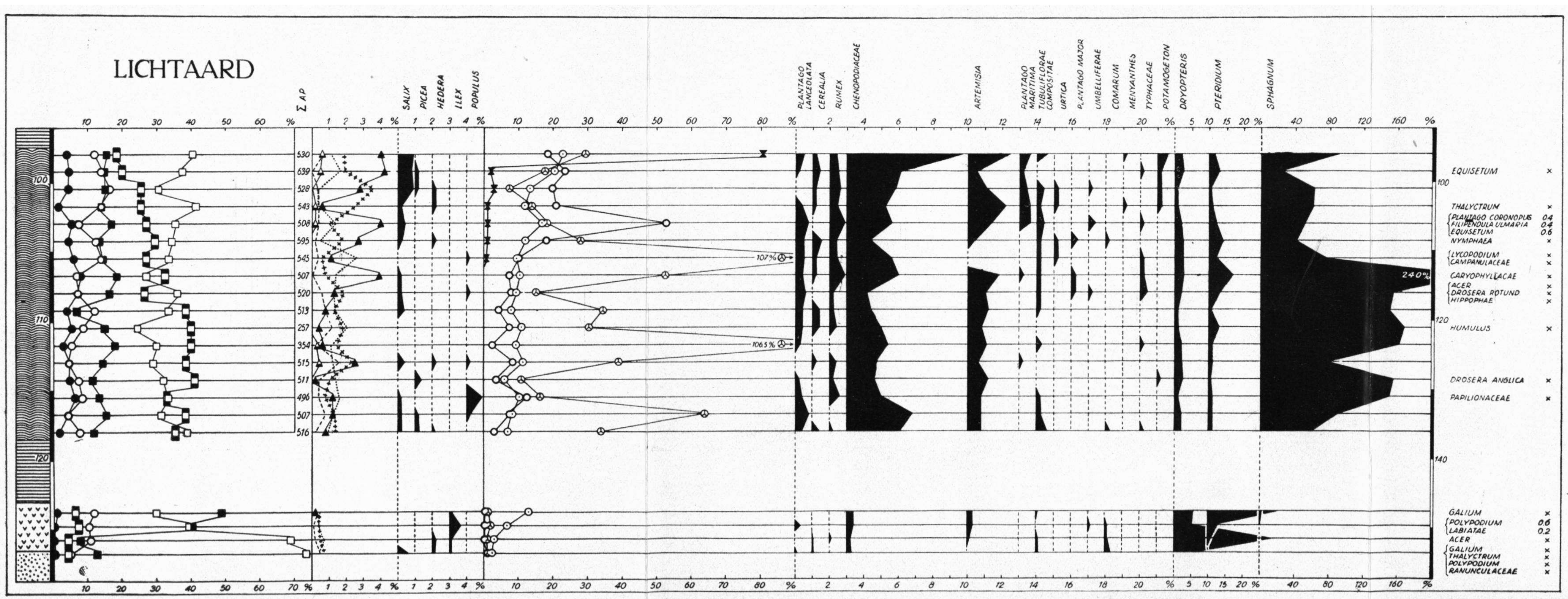


Fig. 27. The depths indicated on the left side of this diagram are incorrect. For *110* read *120*, and for *120* read *140*.

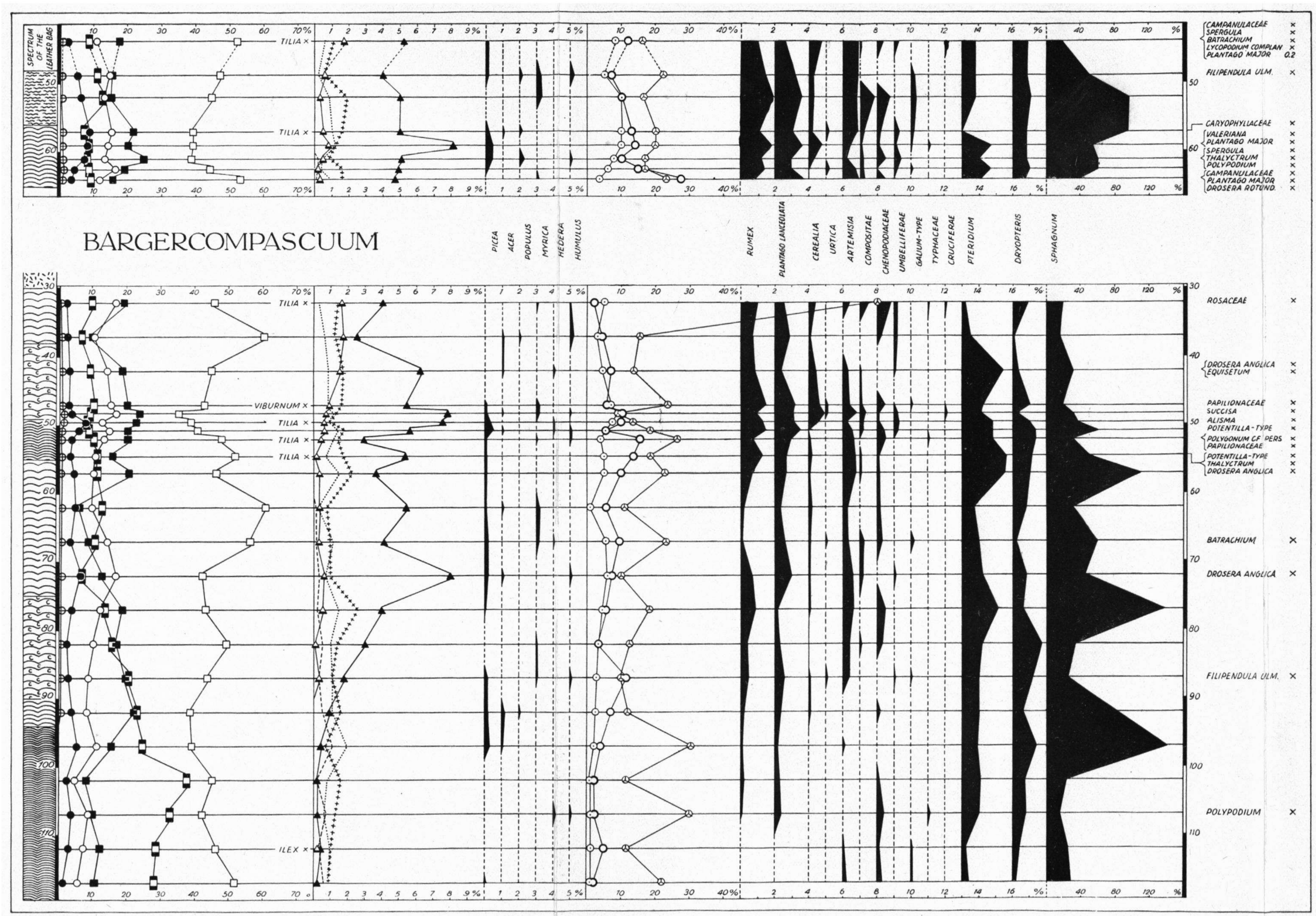

BARGERCOMPASCUUM
SPECTRUM OF THE LEATHER BAG
TILIA ×
VIBURNUM ×
ILEX ×
PICEA
ACER
POPULUS
MYRICA
HEDERA
HUMULUS
RUMEX
PLANTAGO LANCEOLATA
CEREALIA
URTICA
ARTEMISIA
COMPOSITAE
CHENOPODIACEAE
UMBELLIFERAE
GALIUM-TYPE
TYPHACEAE
CRUCIFERAE
PTERIDIUM
DRYOPTERIS
SPHAGNUM
CAMPANULACEAE ×
SPERGULA ×
BATRACHIUM ×
LYCOPODIUM COMPLAN ×
PLANTAGO MAJOR 0.2
FILIPENDULA ULM. ×
CARYOPHYLLACEAE ×
VALERIANA ×
PLANTAGO MAJOR ×
SPERGULA ×
THALYCTRUM ×
POLYPODIUM ×
CAMPANULACEAE ×
PLANTAGO MAJOR ×
DROSERA ROTUND. ×
ROSACEAE ×
DROSERA ANGLICA ×
EQUISETUM ×
PAPILIONACEAE ×
SUCCISA ×
ALISMA ×
POTENTILLA-TYPE ×
POLYGONUM CF. PERS ×
PAPILIONACEAE ×
POTENTILLA-TYPE ×
THALYCTRUM ×
DROSERA ANGLICA ×
BATRACHIUM ×
DROSERA ANGLICA ×
FILIPENDULA ULM. ×
POLYPODIUM ×

Fig. 11.

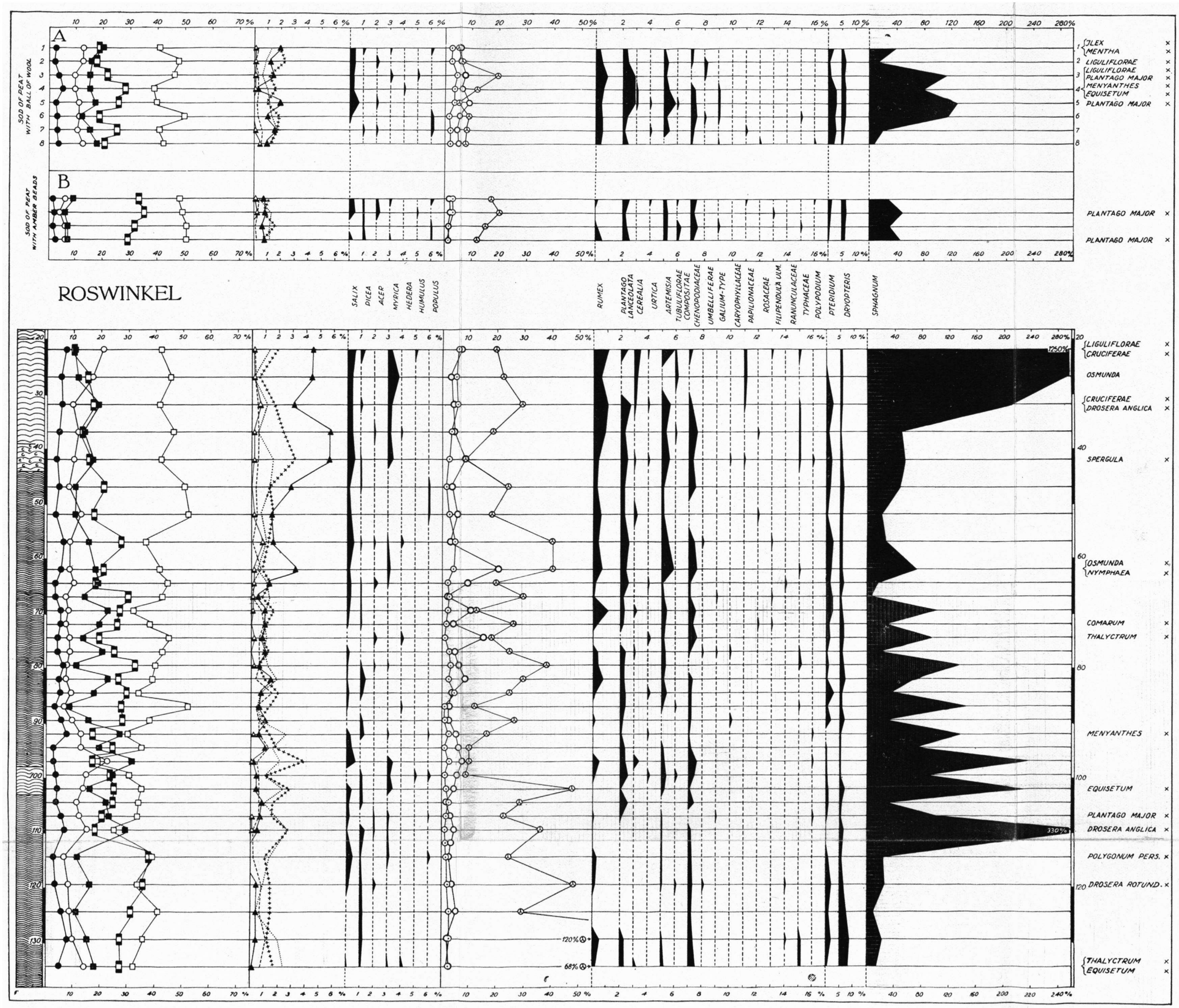
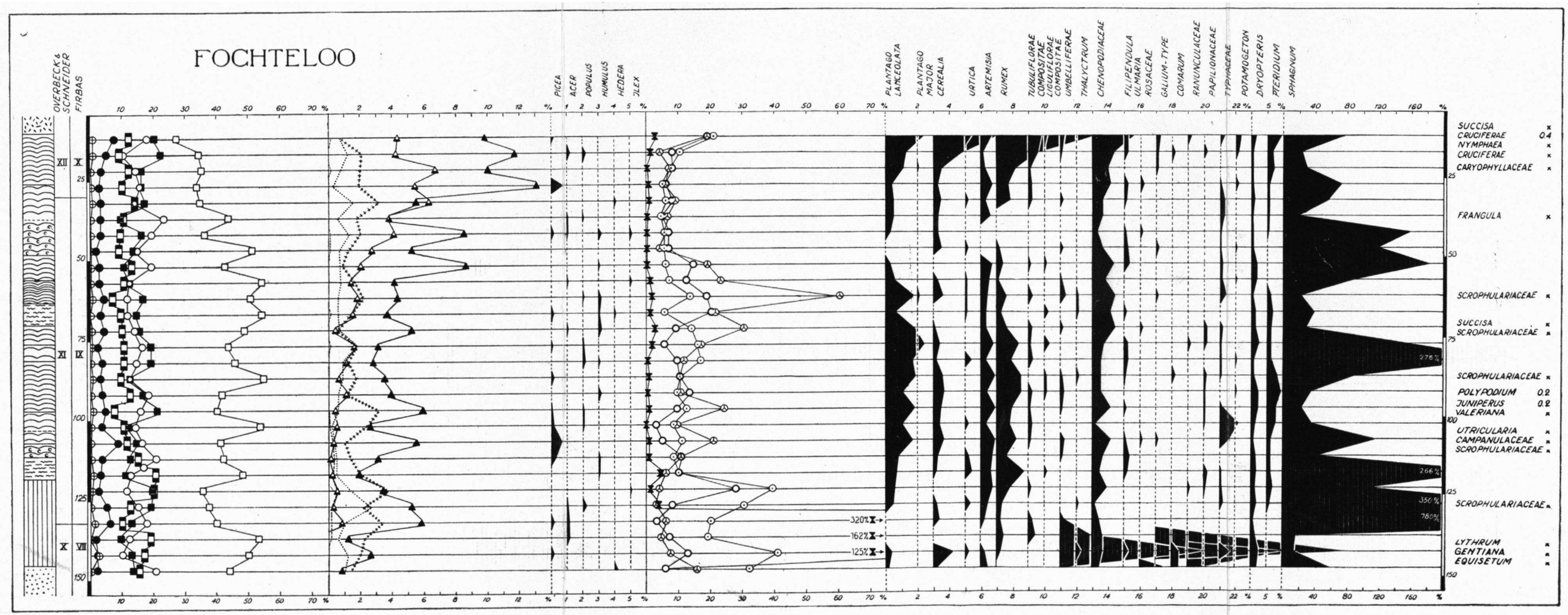
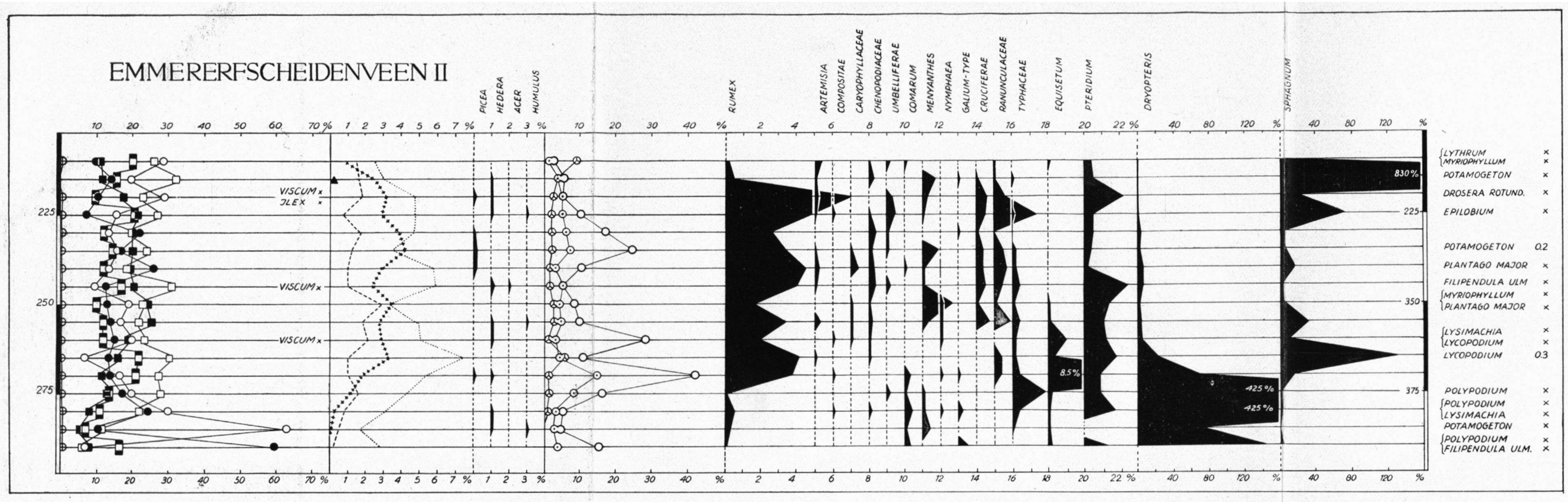

A
SOD OF PEAT WITH BALL OF WOOL
B
SOD OF PEAT WITH AMBER BEADS
ROSWINKEL
SALIX
PICEA
ACER
MYRICA
HEDERA
HUMULUS
POPULUS
RUMEX
PLANTAGO LANCEOLATA
CEREALIA
URTICA
ARTEMISIA
TUBULIFLORAE
COMPOSITAE
CHENOPODIACEAE
UMBELLIFERAE
GALIUM-TYPE
CARYOPHYLLACEAE
PAPILIONACEAE
ROSACEAE
FILIPENDULA ULM.
RANUNCULACEAE
TYPHACEAE
POLYPODIUM
PTERIDIUM
DRYOPTERIS
SPHAGNUM
JLEX
MENTHA
LIGULIFLORAE
LIGULIFLORAE
PLANTAGO MAJOR
MENYANTHES
EQUISETUM
PLANTAGO MAJOR
PLANTAGO MAJOR
PLANTAGO MAJOR
LIGULIFLORAE
CRUCIFERAE
OSMUNDA
CRUCIFERAE
DROSERA ANGLICA
SPERGULA
OSMUNDA
NYMPHAEA
COMARUM
THALYCTRUM
MENYANTHES
EQUISETUM
PLANTAGO MAJOR
DROSERA ANGLICA
POLYGONUM PERS.
DROSERA ROTUND.
THALYCTRUM
EQUISETUM
1250%
330%
120%
68%

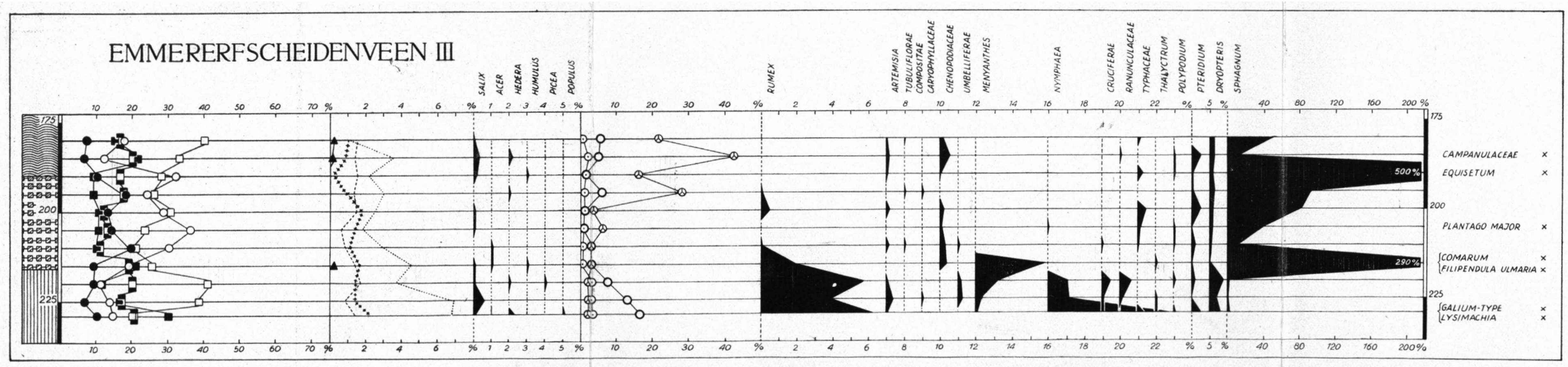
Fig. 8.



FOCHTELOO
OVERBECK & SCHNEIDER
FIRBAS
PICEA
ACER
POPULUS
HUMULUS
HEDERA
ILEX
PLANTAGO LANCEOLATA
PLANTAGO MAJOR
CEREALIA
URTICA
ARTEMISIA
RUMEX
TUBULIFLORAE COMPOSITAE
LIGULIFLORAE COMPOSITAE
UMBELLIFERAE
THALYCTRUM
CHENOPODIACEAE
FILIPENDULA ULMARIA
ROSACEAE
GALIUM-TYPE
COMARUM
RANUNCULACEAE
PAPILIONACEAE
TYPHACEAE
POTAMOGETON
DRYOPTERIS
PTERIDIUM
SPHAGNUM
SUCCISA
CRUCIFERAE 0.4
NYMPHAEA
CRUCIFERAE
CARYOPHYLLACEAE
FRANGULA
SCROPHULARIACEAE
SUCCISA
SCROPHULARIACEAE
SCROPHULARIACEAE
POLYPODIUM 0.2
JUNIPERUS 0.2
VALERIANA
UTRICULARIA
CAMPANULACEAE
SCROPHULARIACEAE
SCROPHULARIACEAE
LYTHRUM
GENTIANA
EQUISETUM
320%
162%
125%
276%
266%
350%
780%

Fig. 7.


EMMERERFSCHEIDENVEEN II
PICEA
HEDERA
ACER
HUMULUS
RUMEX
ARTEMISIA
COMPOSITAE
CARYOPHYLLACEAE
CHENOPODIACEAE
UMBELLIFERAE
COMARUM
MENYANTHES
NYMPHAEA
GALIUM-TYPE
CRUCIFERAE
RANUNCULACEAE
TYPHACEAE
EQUISETUM
PTERIDIUM
DRYOPTERIS
SPHAGNUM
VISCUM x
ILEX x
VISCUM x
VISCUM x
8.5%
425%
425%
830%
LYTHRUM x
MYRIOPHYLLUM x
POTAMOGETON x
DROSERA ROTUND. x
EPILOBIUM x
POTAMOGETON 0.2
PLANTAGO MAJOR x
FILIPENDULA ULM x
MYRIOPHYLLUM x
PLANTAGO MAJOR x
LYSIMACHIA x
LYCOPODIUM x
LYCOPODIUM 0.3
POLYPODIUM x
POLYPODIUM x
LYSIMACHIA x
POTAMOGETON x
POLYPODIUM x
FILIPENDULA ULM. x


EMMERERFSCHEIDENVEEN III
SALIX
ACER
HEDERA
HUMULUS
PICEA
POPULUS
RUMEX
ARTEMISIA
TUBULIFLORAE
COMPOSITAE
CARYOPHYLLACEAE
CHENOPODIACEAE
UMBELLIFERAE
MENYANTHES
NYMPHAEA
CRUCIFERAE
RANUNCULACEAE
TYPHACEAE
THALYCTRUM
POLYPODIUM
PTERIDIUM
DRYOPTERIS
SPHAGNUM
500%
290%
CAMPANULACEAE x
EQUISETUM x
PLANTAGO MAJOR x
COMARUM x
FILIPENDULA ULMARIA x
GALIUM-TYPE x
LYSIMACHIA x

Figs. 5 and 6.

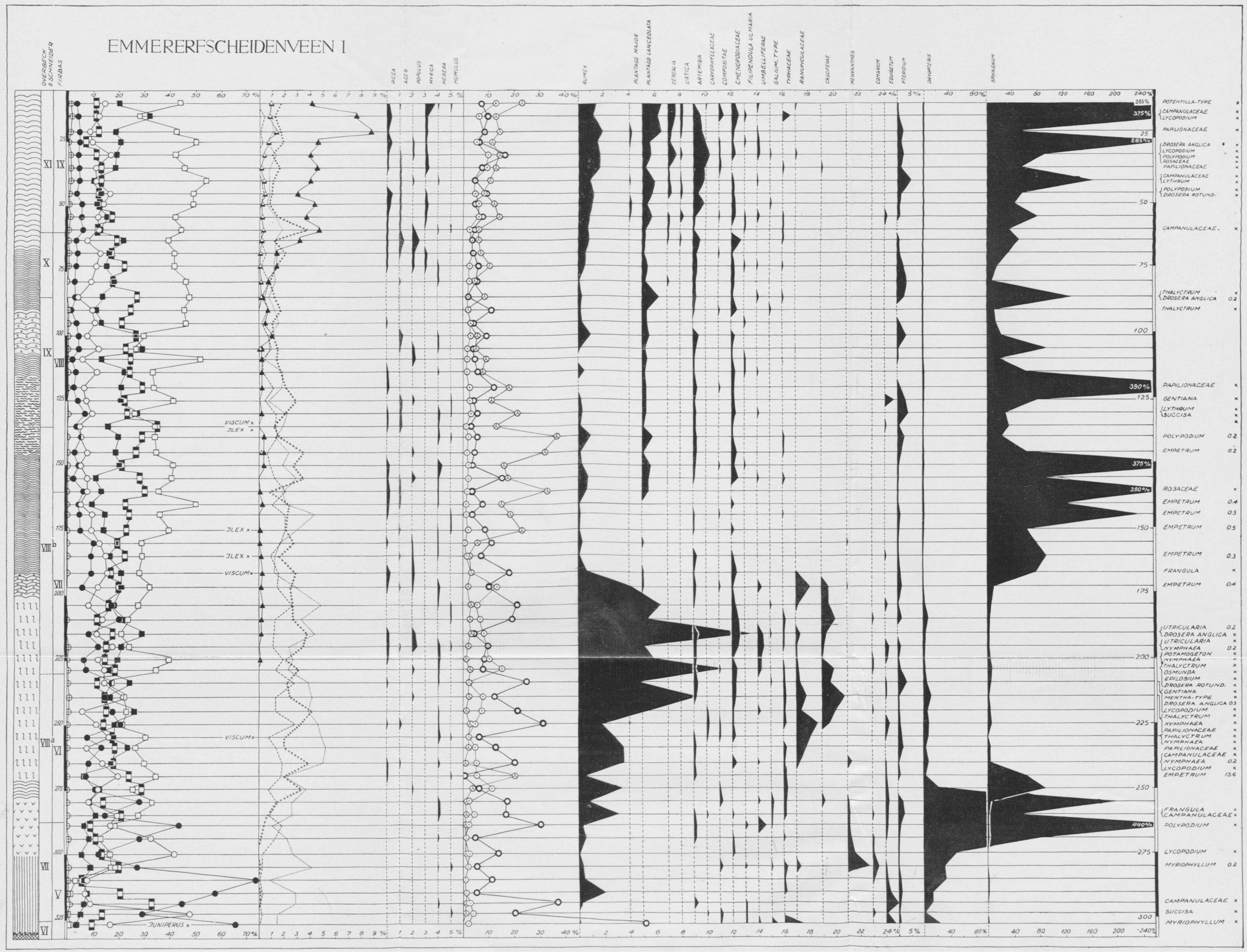


Fig. 4.

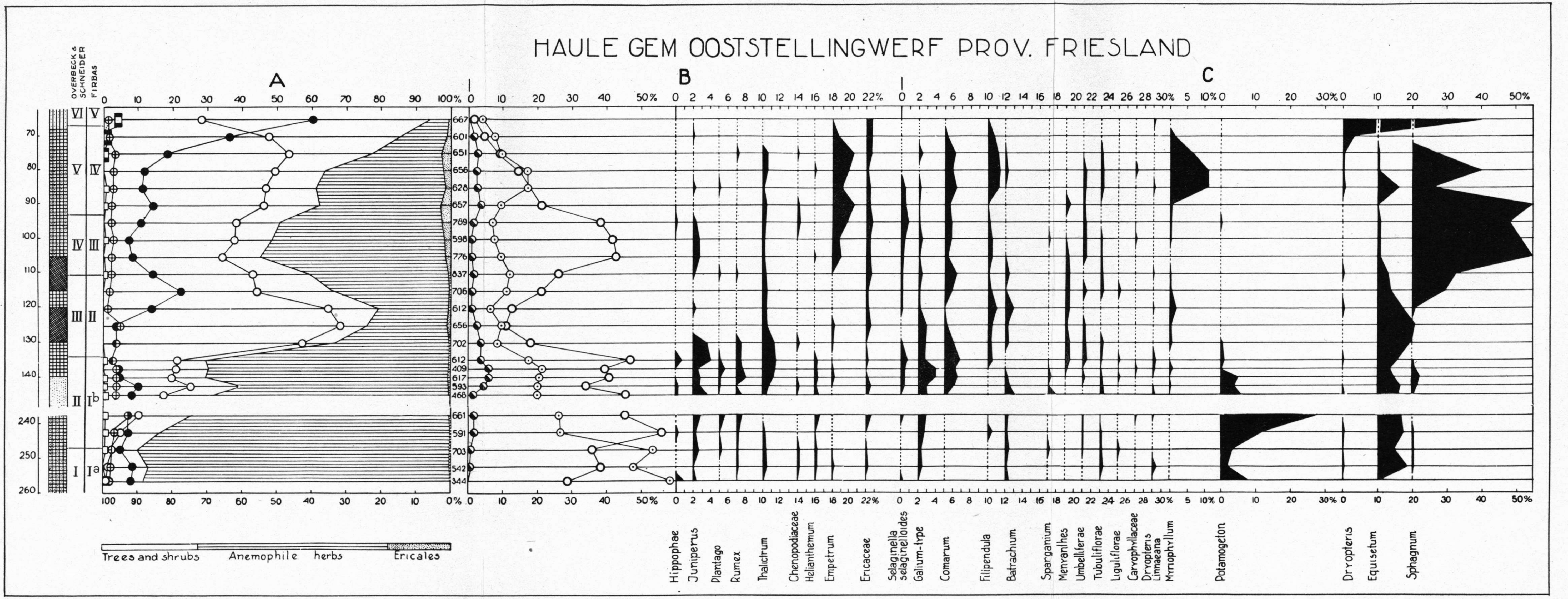


Fig. 3. Diagram Haule. In this diagram are not recorded:

66 cm Picea ×, Typha latifolia ×
71 cm Typha latifolia ×, Sagittaria ×
76 cm Quercus ×, Corylus ×, Sagittaria 0.3 %, Typha latifolia ×
81 cm Quercus ×, Sagittaria 0.3 %
86 cm Hippuris ×, Typha latifolia 0.5 %
91 cm Lycopodium ×, Mentha ×, Picea ×, Tilia ×
96 cm Valeriana ×, Urtica ×
101 cm Caltha-type 0.3 %, Quercus ×
106 cm Caltha-type ×, Picea ×, Quercus ×
111 cm Caltha-type 0.5 %, Picea ×, Quercus ×, Corylus ×
116 cm Valeriana ×, Sanguisorba officinalis ×, Corylus ×
121 cm Epilobium ×
126 cm Mentha-type 0.3 %
131 cm Valeriana ×, Urtica ×
136 cm Quercus 0.3 %
138.5 cm Polygonum Persicaria-type ×, Lycopodium ×, cf. Hottonia 0.5 %
141 cm cf. Hottonia ×, cf. Selaginella helvetica ×, Ulmus ×, Ilex ×, Tilia ×
143.5 cm Polygonum Persicaria-type ×, Lycopodium ×, cf. Hottonia 0.5 %, Picea ×, Tilia ×
146 cm cf. Selaginella helvetica ×, Picea 0.4 %, Ulmus ×
238 cm Picea ×, Carpinus ×
243 cm Alisma ×, cf. Hottonia ×, Quercus ×, Carpinus ×
248 cm cf. Parnassia ×, Corylus ×, Populus ×
253 cm Lycopodium ×, cf. Parnassia 0.4 %, Picea 0.4 %, Quercus ×, Corylus ×, Ulmus ×

TABLE V

Barrow cemetery near Wijster

	Neolithic tumulus near Drijber	lower podzol below tumulus 1	lower podzol below tumulus 6	humous layer in drift sand	tumulus 1						tumulus 2			tumulus 3		tumulus 4		tumulus 6				
					old arable	dark-coloured old surface	light-coloured old surface	sod phase 1	sod phase 2	sod phase 2	old surface	sod	sod	old surface	sod	old arable	sod	old surface	old arable	sod	old surface	
Alnus	51.3	50.5	53.3	59.3	50.4	59.6	53.8	55.0	66.8	56.8	66.1	53.4	59.9	45.7	57.4	43.8	62.4	50.3	48.2	34.5	51.9	Alnus
Corylus	37.5	34.5	31.4	18.2	12.0	12.8	12.9	13.0	10.1	11.5	8.3	15.8	17.0	9.3	10.8	11.8	14.8	12.0	11.3	8.5	11.4	Corylus
Quercus	8.5	6.9	12.2	9.3	17.6	21.7	25.7	24.3	17.2	23.7	17.4	24.7	16.1	39.6	25.9	38.6	19.5	32.0	33.5	52.1	31.8	Quercus
Tilia	1.9	0.6	0.6	0.5	0.5	0.1	0.4	0.3	—	0.1	0.3	0.3	0.3	0.1	0.3	0.7	0.1	0.1	0.8	0.2	0.1	Tilia
Ulmus	—	1.6	0.4	0.5	0.1	0.4	0.9	0.2	0.4	0.4	0.6	0.4	0.9	0.4	0.4	0.4	0.4	0.5	0.3	0.2	0.6	Ulmus
Fraxinus	0.3	1.1	0.5	0.9	0.8	0.8	1.9	1.7	1.1	1.1	2.1	0.7	1.3	1.1	1.6	1.1	0.7	0.9	1.6	1.3	0.5	Fraxinus
Fagus	—	0.3	0.3	0.2	1.1	1.1	1.2	1.4	1.5	2.3	1.7	2.7	2.7	1.8	1.6	0.8	1.5	1.7	1.5	1.7	1.4	Fagus
Carpinus	—	0.1	—	—	0.1	0.1	0.1	0.2	0.3	0.1	0.3	—	0.4	—	0.3	0.1	—	—	0.1	0.1	0.1	Carpinus
Pinus	0.3	4.2	1.4	3.6	1.6	2.3	1.5	1.7	1.5	2.6	2.8	1.7	1.2	1.1	1.2	1.5	0.4	1.7	1.5	1.0	1.4	Pinus
Salix	—	—	0.1	1.3	15.7	0.6	1.4	1.7	0.8	0.1	0.1	0.1	—	0.4	0.3	0.9	0.1	0.1	0.8	—	0.3	Salix
Picea	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	0.1	—	—	—	—	—	—	Picea
Acer	0.1	0.1	0.1	—	—	0.1	0.1	0.2	0.4	—	0.1	0.3	—	0.1	0.1	—	—	—	0.1	0.1	0.3	Acer
Hedera	—	—	—	—	—	0.1	—	0.2	—	—	—	—	—	—	—	—	—	0.1	0.1	—	—	Hedera
Viburnum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	0.1	—	—	—	Viburnum
ΣAP—Betula	680	709	798	548	794	701	738	575	745	690	712	714	671	709	751	740	737	759	734	815	770	ΣAP—Betula
Betula	20.1	9.0	6.6	10.9	10.5	14.4	12.5	49.6	15.0	16.7	12.5	15.8	14.9	15.5	9.5	7.8	10.2	9.9	10.1	7.1	9.2	Betula
Myrica	—	—	—	—	0.1	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	0.1	—	Myrica
Calluna	50.0	62.8	79.6	44.5	184	139	113	145	163	170	180	178	225	84	178	38.1	147	167	133	78.7	108	Calluna
Gramineae	31.9	28.3	17.0	45.6	13.4	22.4	27.4	27.1	36.1	17.7	36.4	37.1	26.2	41.2	24.4	70.7	28.8	30.4	38.9	35.2	16.6	Gramineae
Cerealia	0.7	1.0	0.9	0.4	0.6	0.9	1.6	1.0	1.5	0.1	1.1	1.5	0.7	1.4	1.2	3.0	0.4	0.9	1.4	1.5	0.5	Cerealia
Rumex	1.6	2.7	1.6	2.7	4.4	6.4	7.1	7.0	5.4	2.7	4.4	3.5	2.7	5.2	3.2	11.8	2.7	8.0	0.8	4.5	2.9	Rumex
Plantago lanceolata	6.2	3.4	1.0	2.7	0.5	1.7	3.0	1.7	3.1	1.1	2.1	1.3	1.9	2.1	2.0	6.9	1.6	1.8	2.2	0.7	1.7	Plantago lanceolata
Tubulifl. Compositae	1.5	0.1	0.1	0.2	0.9	0.3	0.8	0.3	0.1	—	1.1	1.4	0.6	1.1	0.3	3.9	1.9	0.1	1.1	0.7	0.8	Tubulifl. Compositae
Ligulifl. Compositae	0.3	0.6	0.1	0.4	0.4	0.3	0.1	0.2	0.5	0.4	0.6	0.3	0.3	1.4	—	0.8	0.8	0.5	1.2	0.4	0.3	Ligulifl. Compositae
Chenopodiaceae	0.1	0.1	—	0.4	0.5	0.6	0.1	0.9	0.2	0.1	0.4	0.8	1.2	0.6	0.5	1.1	0.3	0.1	0.1	1.1	0.3	Chenopodiaceae
Artemisia	—	0.1	0.9	1.1	0.1	0.6	0.7	0.5	1.1	0.6	0.4	0.8	1.2	0.7	0.7	0.8	0.8	0.3	0.4	0.4	0.3	Artemisia
Spergula	—	—	—	—	—	—	0.1	0.2	—	0.1	—	0.1	0.1	—	0.1	—	0.1	0.1	—	—	—	Spergula
Campanulaceae	0.1	0.3	—	0.4	0.1	0.4	0.2	0.2	0.1	0.1	0.1	—	—	0.6	0.4	0.9	0.4	0.3	1.0	0.1	0.3	Campanulaceae
Ranunculaceae	0.6	—	—	0.4	—	0.1	0.1	—	0.2	—	—	0.1	—	—	—	0.9	0.3	0.1	—	—	0.3	Ranunculaceae
Potentilla-type	—	—	0.5	0.2	0.6	0.1	0.7	0.3	1.5	0.6	—	0.8	0.4	0.1	0.1	0.1	0.3	0.4	1.2	0.9	2.9	Potentilla-type
Mentha-type	—	—	—	0.2	—	—	0.3	0.2	0.3	—	—	—	—	0.1	—	—	—	—	2.7	—	—	Mentha-type
Succisa	0.2	—	—	—	0.1	—	0.1	0.2	0.1	—	—	0.6	0.1	0.1	0.1	0.4	0.1	0.1	—	0.1	0.1	Succisa
Cyperaceae	0.9	8.5	0.9	10.6	0.5	0.7	0.7	0.3	0.8	1.6	0.3	0.8	2.1	1.0	0.1	4.7	0.4	1.2	1.1	0.9	0.1	Cyperaceae
Caryophyllaceae	0.4	—	0.3	0.2	0.1	0.1	0.2	0.2	0.3	0.1	0.1	—	0.1	0.4	—	0.3	—	0.3	—	0.1	—	Caryophyllaceae
Umbelliferae	—	0.1	—	—	—	—	—	—	—	0.1	—	—	—	—	0.1	0.1	—	—	—	—	—	Umbelliferae
Polygonum Persicaria	—	—	—	—	—	—	—	—	0.1	—	0.1	—	—	0.1	—	—	—	—	—	—	—	Polygonum Persicaria
Papilionaceae	—	—	—	—	—	0.3	0.1	—	0.1	0.1	—	—	—	—	0.1	—	—	—	—	—	0.3	Papilionaceae
Galium-type	—	0.1	—	0.2	0.1	0.1	0.4	0.3	0.5	—	—	—	—	0.3	—	0.7	—	0.1	0.3	0.1	0.1	Galium-type
Sparganium	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	0.4	—	—	—	0.1	—	—	Sparganium
Dryopteris	16.8	3.1	0.9	1.1	0.4	2.5	0.9	1.0	1.1	1.0	1.0	0.6	1.0	0.7	0.1	1.8	0.7	0.8	1.2	0.9	0.5	Dryopteris
Pteridium	1.2	1.7	1.8	2.2	0.4	0.9	1.4	—	0.7	1.0	1.0	0.4	0.6	1.3	0.4	0.3	0.7	0.5	1.5	0.6	0.4	Pteridium
Polypodium	0.1	0.3	—	—	—	—	—	—	—	—	0.1	—	—	—	—	0.3	—	—	—	—	—	Polypodium
Sphagnum	8.8	2.0	2.6	2.9	1.6	1.1	1.1	1.6	—	0.9	1.1	0.2	1.0	3.0	1.2	2.6	1.4	1.4	1.0	1.2	1.3	Sphagnum

TABLE II

Barrow cemetery near Hijken

	tumulus 1		tumulus 8			tumulus 10			tumulus 9			tumulus 3					tumulus 4		tumulus 5			tumulus 6				tumulus 7				tumulus 2			
	old surface primary mound	sod covering mound	old surface primary mound	sod covering mound	sod covering mound	old surface	sod phase 1	sod phase 2	old surface	dark-coloured sod	greyish sod	old surface	sod phase 1	sod phase 1	sod phase 3	sod phase 3	sod	sod	old arable	dark-coloured sod	light-coloured sod	old arable	dark-coloured sod	greyish sod	light-coloured sod	old arable	dark-coloured sod	brown-coloured sod	greyish sod	old surface	sod phase 1	sod phase 3	
Alnus	76.1	42.3	64.8	45.2	54.5	61.5	52.4	53.6	58.9	55.4	54.6	68.6	60.8	65.4	58.3	62.2	60.1	60.8	64.4	61.9	65.8	65.2	61.1	70.5	66.5	58.0	58.6	60.0	64.4	64.9	62.6	65.1	Alnus
Corylus	14.6	10.0	24.5	15.9	15.1	15.8	15.7	16.0	20.6	11.7	11.0	17.6	18.8	16.5	17.8	18.0	17.2	13.1	22.4	16.1	23.6	20.0	20.1	18.5	22.1	30.2	14.3	22.4	18.0	14.2	13.0	12.6	Corylus
Quercus	4.5	42.1	7.8	33.9	24.8	17.8	28.5	24.4	17.7	29.6	29.2	9.9	16.0	15.0	19.8	15.4	18.1	21.2	6.8	19.0	6.6	10.4	15.2	7.9	7.5	8.4	22.8	9.4	8.6	13.6	13.3	14.2	Quercus
Tilia	4.5	1.1	0.9	0.9	0.4	0.7	0.5	0.8	0.7	0.1	0.6	0.3	0.6	0.1	0.3	0.4	0.2	0.5	3.4	0.8	2.4	3.0	0.8	0.6	1.3	0.7	0.7	0.3	0.9	0.3	0.5	0.2	Tilia
Ulmus	—	0.7	—	0.7	0.8	0.5	0.4	1.1	0.2	0.1	0.6	0.5	0.4	0.1	0.5	0.4	0.7	1.1	—	0.3	—	—	0.1	0.2	0.2	0.1	0.8	0.4	0.9	0.5	0.6	0.1	Ulmus
Fraxinus	—	0.1	0.6	0.6	0.9	—	0.4	0.8	0.3	0.8	1.6	1.4	0.3	0.6	0.6	0.6	0.7	0.4	2.4	0.4	0.3	—	—	1.2	0.9	0.5	0.3	2.1	0.9	0.6	0.7	0.5	Fraxinus
Fagus	—	—	—	0.4	0.4	0.2	0.4	0.6	0.7	0.7	1.1	0.7	0.5	0.9	0.6	0.7	0.7	0.4	—	0.4	0.3	0.7	0.7	0.4	0.3	0.7	0.4	1.3	1.6	2.4	3.1	3.8	Fagus
Carpinus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	0.1	—	—	—	—	0.1	—	—	0.1	0.3	0.1	0.3	Carpinus
Pinus	0.4	3.7	0.6	3.2	2.5	2.5	1.2	1.7	1.3	1.4	1.4	0.9	2.4	1.2	2.0	2.0	2.0	2.5	—	1.2	0.5	—	1.2	0.8	1.1	1.1	2.0	3.4	4.3	3.2	6.1	2.8	Pinus
Picea	—	—	—	—	—	0.2	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.3	—	—	—	—	—	0.1	—	—	0.1	Picea
Salix	—	—	—	0.3	0.3	—	—	0.2	0.2	0.1	0.2	—	0.3	—	—	0.3	0.2	—	0.5	—	0.2	—	0.1	—	—	0.1	—	—	—	—	—	—	Salix
Acer	—	—	—	0.1	0.1	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.7	—	—	0.2	—	—	—	0.1	—	—	—	Acer
Hedera	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	0.1	Hedera
Ilex	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	Ilex
ΣAP—Betula	247	874	934	691	681	404	565	532	603	709	489	558	1101	671	635	715	441	558	205	759	881	135	725	518	638	847	713	713	789	887	864	870	ΣAP—Betula
Betula	25.5	14.4	7.1	44.6	47.0	313	313	131	120	78.1	105	79.2	40.1	49.0	57.5	39.9	127	79.2	14.1	31.9	13.5	25.1	38.2	82.6	56.6	18.3	40.5	40.5	26.9	12.8	15.8	14.9	Betula
Myrica	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	0.1	—	0.1	0.1	—	0.1	—	Myrica
Calluna	6.4	21.1	51.0	66.7	70.2	46.3	37.9	28.4	58.5	35.3	25.4	50.4	98.8	57.4	63.0	78.2	45.6	89.6	39.5	54.0	107	50.4	98.5	50.4	65.8	287	74.6	137	119	196	289	174	Calluna
Gramineae	47.0	43.5	25.2	41.2	50.4	27.7	32.0	74.8	20.9	22.7	88.5	83.0	40.7	30.7	38.1	34.3	30.4	29.1	51.7	21.7	26.4	66.0	27.3	41.7	48.3	26.8	29.2	62.8	45.9	33.8	17.8	19.9	Gramineae
Cerealia	1.6	2.1	0.3	2.6	2.3	2.5	4.1	12.4	0.3	0.4	6.1	2.5	0.4	1.2	2.0	1.9	2.7	1.4	1.0	0.4	1.7	1.5	0.6	2.3	3.9	2.5	1.3	7.7	3.2	1.4	1.6	1.0	Cerealia
Plantago lanceolata	17.8	4.2	5.8	5.9	4.1	2.7	1.4	10.7	3.0	0.7	17.2	7.0	2.5	3.0	3.2	2.5	3.0	0.9	363	1.8	85.1	267	4.7	1.1	27.6	40.1	2.4	14.7	7.1	3.7	2.0	1.1	Plantago lanceolata
Rumex	—	2.4	3.4	5.8	7.8	1.5	1.4	4.1	1.8	3.0	9.8	2.9	8.8	3.4	4.1	2.9	4.3	2.7	10.7	2.1	4.7	11.9	2.2	1.7	2.5	1.5	1.4	2.1	1.6	3.4	3.7	3.8	Rumex
Tubulifl. Compositae	2.4	1.6	0.4	0.9	1.3	0.5	0.5	1.0	1.2	1.0	0.8	1.4	1.3	0.2	0.8	0.8	0.7	0.5	1.0	0.7	0.6	—	1.2	0.8	0.3	0.5	1.1	0.6	0.1	0.3	0.1	0.4	Tubulifl. Compositae
Ligulifl. Compositae	17.4	4.5	1.6	0.9	0.9	—	1.8	0.8	0.7	0.6	1.4	1.1	2.0	0.5	1.4	1.4	0.9	1.8	1.0	2.2	1.1	2.2	1.2	1.0	3.4	0.5	0.8	1.1	0.3	0.8	1.0	1.3	Ligulifl. Compositae
Artemisia	—	0.1	0.1	0.7	0.1	0.2	0.2	0.2	0.7	0.3	0.8	0.5	0.5	0.7	1.0	0.3	0.9	0.2	0.5	—	0.3	—	0.4	—	—	0.2	0.4	1.0	0.5	0.7	1.0	1.3	Artemisia
Chenopodiaceae	0.4	0.1	—	0.1	0.3	0.8	0.5	0.6	0.5	0.1	0.6	—	0.5	0.4	0.5	0.3	0.2	0.7	2.0	0.1	0.3	2.2	0.4	0.8	0.6	0.9	0.1	0.6	0.3	0.3	0.7	0.3	Chenopodiaceae
Polygonum Persicaria	—	—	—	0.3	—	—	0.2	0.4	—	—	0.2	0.2	—	—	—	—	—	—	0.5	—	—	—	—	0.2	0.3	0.2	—	—	—	—	—	—	Polygonum Persicaria
Spergula	—	—	—	—	—	—	0.2	0.2	—	—	—	—	—	—	—	—	—	—	4.9	—	0.5	—	—	—	0.2	—	0.3	—	—	—	—	0.1	Spergula
Caryophyllaceae	10.9	0.6	0.4	0.3	0.1	0.2	0.4	0.2	0.2	—	0.6	0.2	0.2	0.2	—	0.1	—	0.2	9.3	0.1	1.4	13.3	0.6	0.2	0.9	0.4	0.1	—	0.1	—	0.1	—	Caryophyllaceae
Ranunculaceae	0.8	0.3	0.2	0.6	0.1	0.2	—	5.3	0.2	0.6	0.6	0.2	—	0.5	—	0.3	—	0.2	1.5	0.3	1.4	—	0.4	—	0.3	0.2	0.1	—	—	—	—	0.5	Ranunculaceae
Cyperaceae	—	—	0.1	—	0.1	—	—	—	0.2	—	—	0.4	0.1	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	0.5	0.2	—	Cyperaceae
Umbelliferae	—	0.1	0.2	—	—	—	—	—	—	—	—	—	—	0.2	—	—	0.2	—	—	—	0.3	—	—	—	—	—	0.1	—	—	—	—	—	Umbelliferae
Galium-type	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.1	Galium-type
Mentha-type	—	0.1	0.2	0.1	—	—	—	—	—	—	0.2	—	0.1	—	0.8	—	—	—	—	0.1	3.3	0.7	—	—	0.3	0.4	—	0.4	—	—	—	—	Mentha-type
Potentilla-type	—	—	0.2	0.9	2.6	—	0.2	0.4	—	0.8	0.4	0.7	0.2	0.3	0.8	0.7	0.5	0.7	—	0.1	0.1	—	0.1	—	—	0.1	0.3	0.7	0.4	—	1.7	0.3	Potentilla-type
Filipendula Ulmaria	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Filipendula Ulmaria
Campanulaceae	—	—	0.1	0.1	0.1	0.2	—	0.6	—	—	0.4	0.2	—	—	—	—	0.2	—	1.0	0.1	2.4	—	0.3	—	0.3	0.2	—	1.4	0.1	—	—	0.1	Campanulaceae
Succisa	91.9	2.3	0.4	1.1	0.1	1.2	1.0	1.5	0.5	0.3	1.2	1.8	1.3	0.4	1.0	0.7	0.7	0.2	6.3	0.7	2.8	4.4	1.0	1.1	0.3	0.4	0.1	0.4	0.1	1.0	0.2	0.8	Succisa
Papilionaceae	—	—	0.2	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	0.1	—	—	0.6	—	—	—	—	0.1	—	—	—	—	Papilionaceae
Sparganium	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	—	—	0.2	—	—	—	—	0.1	—	—	Sparganium
Frangula	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	—	—	—	—	—	—	—	—	—	—	Frangula
Gentiana	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Gentiana
Polygala	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	Polygala
Pteridium	14.6	73.2	5.6	32.8	14.7	33.9	34.2	28.3	14.1	27.2	34.7	13.4	15.5	9.2	17.0	10.1	8.4	10.6	30.2	8.7	14.1	6.7	18.9	16.8	10.0	6.7	27.5	14.4	20.3	17.3	9.4	10.9	Pteridium
Dryopteris	105	9.6	12.4	7.8	1.6	3.5	5.8	5.7	1.8	1.3	7.2	3.8	2.1	1.5	0.2	0.4	2.0	2.0	72.2	5.1	20.4	14.1	2.3	5.0	20.3	5.0	1.0	5.0	3.0	4.9	2.8	1.6	Dryopteris
Polypodium	2.4	0.1	0.4	—	—	—	—	0.4	—	—	—	0.2	—	0.2	0.3	—	—	—	2.9	0.1	0.9	—	0.1	0.2	1.1	—	—	0.1	0.3	0.5	0.2	0.1	Polypodium
Lycopodium cf. clavatum	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	0.2	—	—	—	—	—	0.1	—	Lycopodium cf. clavatum
Sphagnum	11.3	6.3	1.5	0.3	1.3	0.5	1.2	1.3	0.3	0.4	1.6	2.2	0.5	0.2	0.8	0.3	0.7	0.4	13.6	0.5	7.9	1.5	1.4	0.6	8.2	2.4	0.1	1.5	0.8	4.5	2.9	3.7	Sphagnum