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Early Postglacial in Aamosen

Geological and Pollen-Analytical Investigations of Maglemosian Settlements in the West-Zealand Bog Aamosen

by

Svend Jørgensen

Vol. I

Dansk sammendrag:
Tidlig postglacial tid belyst ved geologisk-pollenanalytiske undersøgelser af Maglemosebopladser i den vestsjællandske Aamose

With 22 Plates

I kommission hos
C. A. REITZELS FORLAG (JØRGEN SANDAL)
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Denne afhandling er af det matematisk-naturvidenskabelige fakultet ved Københavns universitet antaget til offentlig at forsvares for den filosofiske doktorgrad.

København, den 29. december 1962

Th. Bang
h. a. dec.

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PREFACE

THE DEPARTMENT OF NATURAL SCIENCES OF THE NATIONAL MUSEUM has in many respects grown out of the bog laboratory of the GEOLOGICAL SURVEY OF DENMARK (D.G.U.). This relationship has always been recognized by D.G.U., and has been expressed, not only in readiness to advise and assist in scientific matters, but even by giving direct economic aid. Thus the drawing of the maps and diagrams in this paper has been partly paid for by D.G.U. That this paper is being published in one of D.G.U.'s series of publications is also proof of the interest shown in the DEPARTMENT OF NATURAL SCIENCES. For this I would like to express my gratitude to the Director of D.G.U., Dr. HILMAR ØDUM.

When the laboratory investigations of the material from Verup were begun in 1945 the economic basis was a grant from THE CARLSBERG FOUNDATION, and I want to express my gratitude to the Foundation.

I owe thanks to many colleagues in THE DEPARTMENT OF NATURAL SCIENCES for their help and collaboration through the many years the work has been going on. To Mrs. AGNES GULDBRANDSEN, Mrs. KIRSTEN KASSOW, Miss INGRID SØRENSEN, Miss BIRGITTE HENRIKSEN, Mrs. ELISABETH ØSTBJERG, and Miss KIRSTEN PEDERSEN I express my warmest thanks.

I am much indebted to Mr. BENT FREDSKILD, keeper at THE DEPARTMENT OF NATURAL SCIENCES, for identification of botanical macrofossils, and for much botanical information, and to Mr. HENRIK TAUBER, head of THE CARBON-14 DATING LABORATORY, for his help with the statistical part of the work.

To Mr. TYGE CHRISTENSEN, lecturer at the BOTANICAL LABORATORY OF THE UNIVERSITY OF COPENHAGEN, I owe thanks for his ever ready help in questions of Latin nomenclature.

The drawing of the maps and diagrams has been done by Mr. O. HAEUSLER, Mr. HELGE JENSEN, Mr. M. NILAUSEN, and Mr. ARNE JENSEN, cartographers at THE GEODETICAL INSTITUTE, and I thank them for the care and accuracy shown in their work.

I am most grateful to Mrs. IDA SPÄRCK JONES for having undertaken the translation of this paper into English. At her suggestion the English text was read through and corrected by Dr. ROGER NEEDHAM and Mrs. KAREN NEEDHAM, Cambridge, to whom I would like to express my thanks.

Finally I would like to thank Mr. KNUD ANDERSEN, who has carried out the archaeological part of the work on the Verup find, and Dr. TROELS-SMITH, head of THE DEPARTMENT OF NATURAL SCIENCES, at whose suggestion I started the Verup investigation, and who has helped and encouraged me in many respects during the work.

In the course of these years the three of us have had many discussions about the Verup find and its interpretation, and have spent much time together in that strange place, Aamosen. Drought and dust storms, rain and floods, frost and snow often made work difficult. Still, or perhaps just for this reason, Aamosen and the collaboration it fostered stands out in my mind in a happy light of its own, as do the days we spent together there.

The English manuscript was completed in March 1963.

The Department of Natural Sciences
The National Museum, Copenhagen, July 9, 1963

Svend Jørgensen.

CONTENTS

ABSTRACT

This paper is a discussion and interpretation of the stratigraphical and pollen-analytical material presented by the author in Vol. II of this paper: "DESCRIPTION OF SECTIONS AND POLLEN-ANALYSES. – A PRESENTATION OF THE BOG-GEOLOGICAL MATERIAL".

Eight pollen diagrams from the bog Aamosen[1]) are presented, covering Preboreal, Boreal, and early Atlantic periods.

On the basis of the curves of the diagrams an attempt is made to elucidate the development of the vegetation in the area. The water-level in the basin is determined from the succession of sediments and from the pollen diagrams, and a possible alternation with the oscillations of the Littorina sea is pointed out.

The climate development is discussed, and a climatic oscillation in the early Atlantic period is deduced from the courses of the curves for *Hedera* and *Viscum*.

Finally the habitation at the Maglemose settlement Verup 5 in Aamosen is interpreted, and individual phases of it are pollen-analytically dated.

[1]) According to present spelling „Aamosen" may now be spelt „Åmosen".

I. INTRODUCTION

JAPETUS STEENSTRUP laid the foundations of bog geology proper in this country with his investigations of forest bogs in northern Zealand (JAPETUS STEENSTRUP, 1842). On the basis of the remains of wood found in layers of peat he drew up the order of immigration of forest trees after the last Glacial period, and interpreted this order as an indication of climatic changes.

STEENSTRUPS "palaeo-floristic" method was improved by later scientists (including GUNNAR ANDERSSON), and extended to all botanical macrofossils.

Later the so-called "palaeo-physiognomic" method was introduced. This stressed the investigation of the peat-forming elements themselves (the Mother-formation), and attached less importance to the embedded fossil remains (RUTGER SERNANDER and C. A. WEBER). On the basis of these two methods, bog-geological investigations here and in our neighbouring countries have led to a more complete understanding of the changes in climate and the development of vegetation after the Ice Age.

Epoch-making investigations were published by BLYTT (1876), GUNNAR ANDERSSON (1896 and 1902), HOLMBOE (1903), SERNANDER (1908 and 1910), and WEBER (1910). In this country investigations by HARTZ and KNUD JESSEN may be considered as the culmination of these methods (HARTZ, 1901 and 1902; JESSEN, 1920).

With VON POST's introduction of pollen-analysis as a method of investigation, a new era in bog-geology began (VON POST, 1916). In a series of investigations in which the pollen-analytic method was used, the earlier interpretations were verified and corrected, and were extended to gain regional validity (VON POST, 1924, 1925 & 1933; GAMS and NORDHAGEN, 1923; GRANLUND, 1932).

Pollen analysis was introduced into this country by KNUD JESSEN, who, on the basis of his own investigations, set up the division of the Late-glacial and Post-glacial periods into pollen-analytic zones which in general remains uncontested, and which has been a model for corresponding zone-divisions in neighbouring countries (KNUD JESSEN, 1935 a, 1937 & 1938).

A new situation arose, however, when JOHS. IVERSEN (1941) showed that the clearings made by prehistoric man were an essential factor in the development of the forest. This led to a great extension of pollen-analysis, as the field for investigation had now, to a far greater extent than before, to include herbaceous plants. At about the same time as IVERSEN's demonstration of the so-called "landnam" (land occupation), the problems of the transgressions of the Littorina sea were drawn into the searchlicht of pollen-analysis, and the different phases of the Littorina transgression were dated in relation to the forest development (JOHS. IVERSEN, 1937 a; K. JESSEN, 1937; TROELS-SMITH, 1937, 1939 & 1942).

Since then the pollen-analytic investigations of Post-glacial deposits in this country have mainly been devoted to questions of detail, the solution of which have corrected or supplemented, but not changed, the main features of the basic picture of climatic changes, development of vegetation, and fluctuations in sea-level.

The present investigation belongs to this category, as, in addition to the archaeological problems, it deals with a climatic feature of the early Atlantic period, and attempts to demonstrate fluctuations in the water-level in the interior of the country, and to fit them into the picture which we already have of natural conditions in the Mesolithic period.

The field investigations on which this thesis is based were carried out in the big West-Zealand bog Aamosen, which lies between the towns of Holbæk, Sorø, and Slagelse (Fig. 1).

I shall not here give an account of the geology of Aamosen and the surrounding country, but for this refer to V. MILTHER's paper: "NORDVESTSJÆLLANDS GEOLOGI" (1943, p. 74 ff.), which gives the accepted views. As for the topography and history of the area, a full account is given in THERKEL MATHIASSEN's large publications "STENALDERBOPLADSER I AAMOSEN" (1943) and "NORDVESTSJÆLLANDS OLDTIDSBEBYGGELSE" (1959). In the former, which deals with the archaeological material from the Aamose area obtained up to 1942, there are also contributions from natural scientists: DEGERBØL gives an account of the zoological material found, and TROELS-SMITH presents the results of the geological investigations and preliminary datings.

It was undoubtably this collaboration between archaeology and the natural sciences which led to the foundation of the bog laboratory of the NATIONAL MUSEUM in 1944, later re-named DEPARTMENT OF NATURAL SCIENCES (1956), with TROELS-SMITH as head. It had already become clear, during the first Aamose investigation (1938–39), that both the geological field investigations and the laboratory work had to be intensified if reliable datings and a more thorough understanding of the natural conditions which were the basis of the living conditions of prehistoric man were to be obtained.

In collaboration with the bog laboratory of the GEOLOGICAL SURVEY OF DENMARK under JOHS. IVERSEN a thorough improvement in the standard of the pollen-analytic method has taken place. A proof of this progress is the pollen morphology drawn up by these two scientists (JOHS. IVERSEN & TROELS-SMITH, 1950), which is used all over the world. In the same way the sediment system drawn up by TROELS-SMITH (TROELS-SMITH, 1955 a) is an expression of the improvement which has taken place in geological field-work during the Aamose investigations.

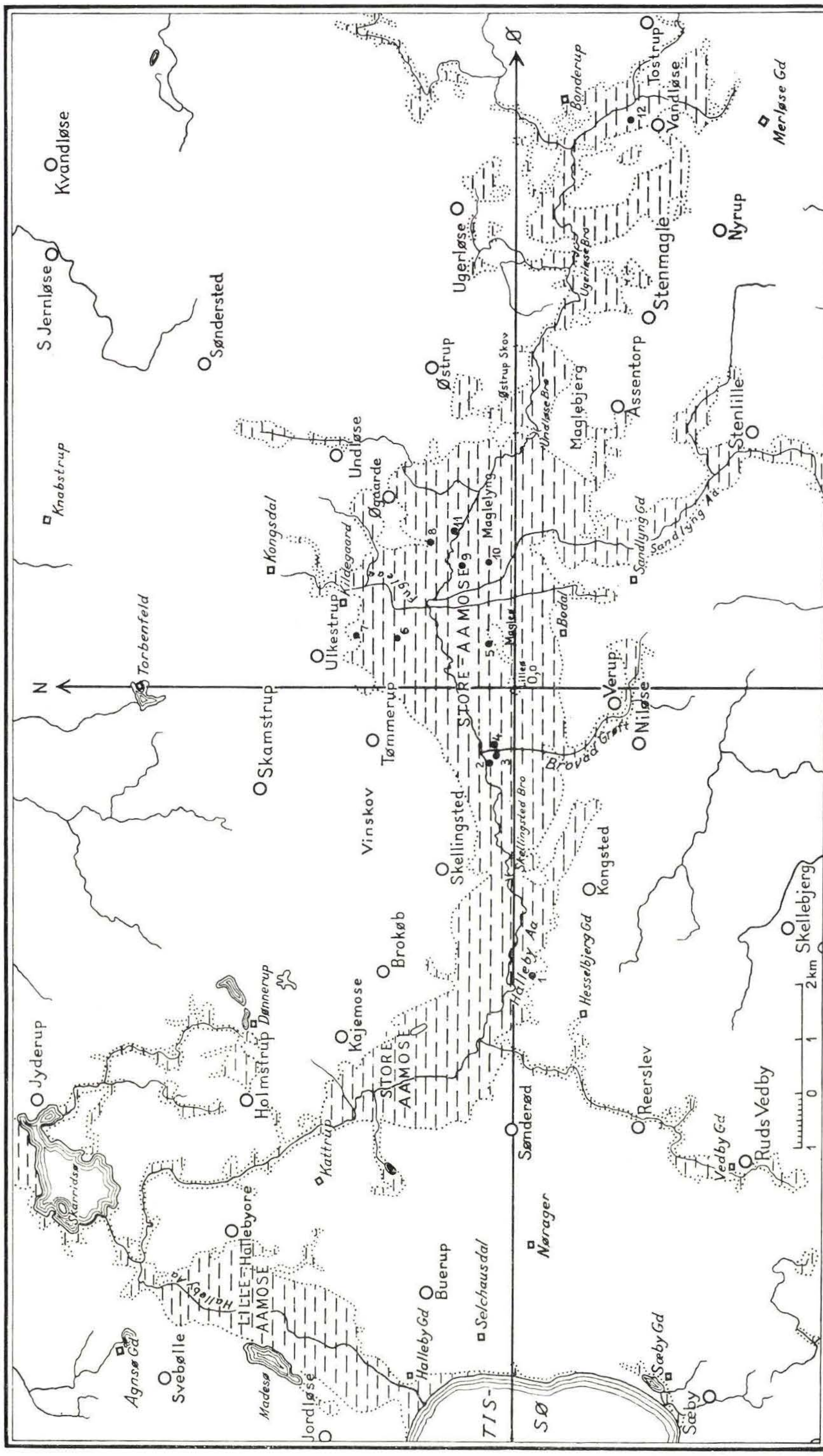

Fig. 1. Map of the Aamose district, West-Zealand. – Kort over den vestsjællandske Aamose.

1: Hesselbjerggaard; 2: Niløse; 3: Brovad Grøft (Large flint pick); 4: Verup 5; 5: Magleø; 6: Ulkestrup Lyng Øst (Ul.Ø.); 7: Kildegaard; 8: Øgaarde; 9: Muldbjerg (Mul.I.); 10: Kongemosen; 11: Aamosen N 1.000; Ø 2.840; 12: Vandløse (Notched leister prong).

In the course of the more than 20 years of investigations at Aamosen a considerable amount of archaeological material, both from Mesolithic and Neolithic cultures, has been collected, together with an even greater quantity of scientific observations and samples for pollen-analysis, seed analysis and Carbon-14 dating. The investigation of this material is not much advanced, but the collection of material was considered more important than its interpretation, as the destruction of our bogs by peat cutting, drainage and cultivation is rapidly approaching.

When the bog laboratory of the NATIONAL MUSEUM was established in 1944 it was part of Department I (the PREHISTORIC DEPARTMENT) of the Museum, and this department drew up a list of the order in which settlement finds were to be pollen-analytically examined and dated. At the top of this list was the Verup settlement (Fig. 1, No. 4).

Now, seventeen years later, but better late than never, the results of the investigation can be presented.

The field work at Verup was undertaken in 1943–44, and though it is easy today to see the shortcomings of the archaeological method of excavation, it can still, to some extent, be praised as an attempt, although it was not fully carried through, at improving the method.

The pollen-analytic investigation was started in 1945, and the upper part of Diagram P.33, which had a direct bearing on the culture layers was analyzed.

In 1951 a particularly interesting find, a large flint pick, was made in Brovad Grøft (ditch) (Fig. 1, No. 3), which runs close by the Verup settlement (cf. SOPHUS MÜLLER, 1896, pp. 341–45; THERKEL MATTHIASSEN, 1948, Bd. I, No. 45; KNUD ANDERSEN, see SVEND JØRGENSEN, 1954, p. 160). This type of artefact, which had not up to that time been dated, was by means of a pollen series from the spot where it was found, and using Diagram P.33, dated to the middle of pollen zone VI (ex SVEND JØRGENSEN), i.e. contemporaneously with the peak of the Late Maglemose culture in Aamosen and the South-Zealand bogs. In the course of this work the thought occurred, that it should be possible, using the rise in the water-level registered in P.33, to divide the later Maglemose culture into two parts, an older phase before the rise in the water-level, and a later phase after the rise. This possibility should at least exist inside the Aamose area. To verify Diagram P.33, Diagram P.28,30 was analyzed. This showed complete agreement with P.33. But to be on the safe side Diagram P.25 was analyzed as well.

With this diagram entirely new problems entered the picture – amongst others the "floating island" problem – and to pursue these problems, Diagram P.20 was analyzed. As it was quite clear that the Verup diagrams originated in the shore zone, where local conditions influenced both the sediments and the presence of pollen, the diagrams from Niløse; Baad I (Fig. 1, No. 2) and Aamosen; N.1.000; Ø.2.840 (Fig. 1, No. 11) were analyzed to elucidate contemporary conditions in the open lake. Later still another diagram from an area close to the shore was analyzed (the settlement Ulkestrup Lyng, Øst – named Ul.Ø., see Fig. 1, No. 6), and, finally, the diagram connected with the large flint pick (Fig. 1, No. 3) was revised, and re-calculated according to the principles used for the rest of the material.

In analyzing these diagrams the Post-glacial deposits were examined, from that in contact with the Late-glacial layer up to the Atlantic period (with the exception of the diagrams connected with the large flint pick and Ul.Ø., which only cover shorter periods of time), and a considerable amount of pollen-analytic material from the period in question has thus been recorded. This material is presented in Vol. II of this paper: "DESCRIPTION OF SECTIONS AND POLLEN-ANALYSES", and efforts have been made to make this presentation as complete, accurate and accessible as possible. All descriptions of the sections and lists of pollen, as well as an account of the methods of work and the form of presentation, are published there.

The archaeological interpretation of the Verup-find was undertaken by KNUD ANDERSEN (1961). A report by ULRIK MØHL on the bones found at the settlement is included in this paper.

II. FORM OF PRESENTATION

In the presentation of the material in "DESCRIPTION OF SECTIONS AND POLLEN-ANALYSES" an account is given of the methods and procedure used in connection with the field work and the investigations in the laboratory which form the basis of the present thesis.

The system of symbols for the sediments is TROELS-SMITH'S (J. TROELS-SMITH, 1955 a).

For the present investigation it was found that the purpose was best answered by making two forms of diagram for each point in the section where the samples had been taken, a MAIN DIAGRAM, and a SURVEY DIAGRAM.

The Main Diagrams

In Part A of the MAIN DIAGRAMS (the basis of calculation and contents of which can be seen from the diagram itself), only those curves or parts of curves which have a value above 1 % are, for the sake of clearness, drawn in. An appendix shows the curves for the components of the MIXED-OAK-FOREST (QUERCETUM-MIXTUM), for values exceeding 0,5 %.

The object of Part A of the MAIN DIAGRAM is to give an estimate of the chief components of the forest vegetation, and it is, basically, only an extension of the type of diagram introduced by VON POST (1916). It should, though *Corylus* is here included in the total (cf. IVERSEN & FÆGRI, 1950, pp. 68 & 88), be possible to compare the present diagrams with diagrams of the VON POST type. That the curves do not give a correct picture of the composition of the forest and the development of the vegetation on account of the very different pollen production and power of dispersal of the different species of trees must still be kept in mind.

As for Part B, the basic sum and the components appear in the diagram itself, the purpose of which is to give an estimate both of the ratio between the areas covered with forest or shrub and those not covered with forest, and of the area of the latter covered with heather. Values below 1 % are not recorded.

This type of diagram has been used before, chiefly for the Late-glacial period (cf. JOHS. IVERSEN, 1945, 1946 & 1947 a; BRORSON-CHRISTENSEN, 1949; H. KROG, 1954). The basic sum for Part B has, however, evident weaknesses, which cannot as yet be eliminated. A considerable proportion of the pollen from anemophile herbs comes from *Gramineae* and *Cyperaceae*, which grow in reed swamp, and the total of herbaceous pollen will thus contain irrelevant components, making it larger than it should be. Pollen from swamp plants (*Telmatophyta*), which can be determined, as well as pollen from water plants (*Limnophyta*) have, however, been excluded from the herb pollen total. The fact that a number of forest trees have a very large pollen production, and that pollen from trees have, in general, far better chances of dispersal than pollen from herbs, will, on the other hand mean that trees will be over-represented, and that herb vegetation will be under-represented (cf. AARIO, 1940). In the diagrams for the open lake (Diagram Aamosen; N.1000; Ø.2.840, Pls. XVII–XVIII, and the Baad I Diagram from Niløse, Pls. XV–XVI) it must, however, be assumed that the same systematic error goes through the whole diagram, so that the course of the curves should be correct, though the values may be wrong. The diagrams for the areas near the shore are, however, characterized by fluctuations in the local production of herb pollen.

Pollen of *Ericales* does not amount to 1 % in any of the diagrams presented, and as a rule constitutes less than 0,5 % of the total sum.

The Survey Diagrams

These diagrams consist of a curve-diagram (I) and a series of silhouettes (II–XVI), each of which represents a species, a genus, a family, or a biological plant group. A silhouette showing the state of preservation of the pollen grains is also given.

Section I is calculated on the basic sum of *Betula*/4, *Corylus*/4, *Fraxinus*, *Quercus*, *Tilia*, and *Ulmus* (cf. JOHS. IVERSEN, 1947 b, p. 241). This sum, Σ I, is also part of the basic sum for the diagram sections II–XIV. The composition and contents of the diagrams are apparent from the diagrams themselves. Some sections of the diagrams will, however, be discussed further.

Section VI shows the presence of spores of *Polypodiaceae*, apart from spores from identifiable species of *Polypodiaceae* which are not included. As fossil *Polypodiacé* spores almost invariably occur without an outer membrane (Perisporium) it is not possible, other than in a few exceptional cases, to determine their genus or species. It is overwhelmingly probable that in the present material the main part of the *Polypodiacé* spores come from *Thelypteris palustris*, a conclusion supported by macroscopic finds, but it is quite possible that spores of other species of *Polypodiaceae* are also included in the total.

The three sections (VIII–X) are calculated in order to obtain an idea of the changes in the local herbaceous vegetation in a hydrosere, and from this possibly to be able to draw conclusions as to the water-level. The classification is according to the principles laid down by JOHS. IVERSEN (1936). In Section VIII, aquatic plants (*Limnophyta*), the following species are included: *Nuphar* *luteum*, *Nymphaea alba*, *Potamogeton* sp., *Myriophyllum spicatum* and *M. verticillatum*, and *Lemna* sp.

Section IX comprises swamp plants (*Amphiphyta* and *Telmatophyta*), and the curve here shows the occurrence of *Alisma Plantago-aquatica*, *Hippuris vulgaris*, *Callitriche*, *Cladium*, *Rumex Hydrolapathum*, *Typha*, *Iris pseudacorus*, *Glyceria*, *Menynanthes*, *Caltha palustris*, and *Lythrum Salicaria*.

Finally, the herbaceous plants from moist soil (polyhygrobe and meso-hygrobe *Terriphyta*) are given in Section X, which contains the following species: *Thalictum flavum*, *Filipendula Ulmaria*, *Solanum Dulcamara*, *Valeriana sambucifolia* and *Sanguisorba officinalis*.

In a correlative evaluation of these three groups one must, however, remember, that they are not equally representative, and that the curves are consequently not qualitatively similar, as a considerable part of the pollen of *Gramineae* and *Cyperaceae* not identified by species undoubtably derives from plants which grew in the reed swamp or in the moist soil.

In the calculation of the curve for *Hedera*, XV, and *Viscum*, XVI, a different basic sum from that in the other sections of the diagrams has been used. In an investigation recently published on the influence of the first phases of agriculture on *Hedera* and *Viscum* (Troels-Smith, 1960), the *Hedera* curve has been based on a total sum of pollen from those trees which give so little shade – even in dense growth – that *Hedera* has a chance to flower. At the same time corrections were made for the different pollen production of the different species of trees. By using the basic sum (*Betula*/4, *Pinus*/4, *Fraxinus*, *Quercus*, *Populus*) a more accurate picture of the occurrence of *Hedera* is undoubtably obtained than by using the customary basis of calculation.

In the same way the *Viscum* curve was calculated on the basis of the total of the pollen of its host-plants – again with corrections for different pollen production (Troels-Smith, 1960). The sum suggested by Troels-Smith (*Betula*/4, *Pinus*/4, *Abies*, *Populus*, *Salix*, *Acer* × 2, *Crataegus* × 2, *Malus* × 2, *Prunus* × 2, *Sorbus* × 2, *Tilia* × 2), has also been used here.

The last curve in the Survey Diagrams gives, together with a.i.d. and a.i.p. numbers in the tables[1]), the state of preservation of the pollen grains.

The curve for the degree of destruction (Troels-Smith, 1941) is here calculated in the following way: the total of pollen with signs of corrosion, of *Tilia*, *Ulmus*, *Betula*, *Corylus*, and *Gramineae*, is for each analysis expressed in percentages of the total of pollen of these species. As can be seen, it is only pollen with psilate exines, and pollen of *Tilia* and *Ulmus*, where corrosion can be easily and certainly recognized, which have been included in the calculation.

In all the diagrams, in the Main as well as in the Survey Diagrams, pollen

[1]) a.i.d. = ad indeterminabile destructum
a.i.p. = ad indeterminabile plicatum.
Tables refer to the pollen lists published in "Description of Sections and Pollen-Analyses". (Vol. II of this paper).

zones, as established respectively by KNUD JESSEN (1935a, 1937 & 1938) and by the present author (SVEND JØRGENSEN, 1954), are given on the extreme right. Where zones and zone boundaries are mentioned in the following, the reference is to the latter, unless another author is given.

Before leaving the subject of Method, it would be natural to explain another point. It is not directly obvious why the basic sum, Σ I (Σ *Betula*/4, *Corylus*/4, *Fraxinus*, *Quercus*, *Tilia*, *Ulmus*), which constitutes, or is part of, the total for the curves in the SURVEY DIAGRAMS has this particular composition.

If the object of the diagrams had been to give as correct a picture as possible of the composition of the forest from the Pre-boreal to the Atlantic period, it would have been more rational to use a basic sum which included pollen from all the trees and shrubs present, with corrections for the individual species in proportion to their pollen production and their power of dispersal, perhaps with the exclusion of species dependent on, or highly benefited by, very moist soil. Part A of the MAIN DIAGRAM could be used for this purpose.

The main purpose has, however, been to make the diagrams from the shore zone (Verup P.33, P.28,30, P.25, P.20, the Large Flint Pick, and Ul.Ø.) directly comparable with the diagrams from the open lake (the diagrams from Aamosen; N.1.000; Ø.2.840, and Niløse; Baad I). Consequently *Alnus* and *Salix* had to be excluded, as they are over-represented in the diagrams from the shore zone and *Pinus* had to be excluded for the same reason. As far as *Pinus* is concerned the over-representation is not only due to a local *Pinus* stand on the bog at Verup, but also to the fact that the pollen destruction in the upper layers at Verup and Ulkestrup (Ul.Ø.) is considerable, and this favours *Pinus* to a high degree. For example, *Pinus* pollen constitutes 60–70% of the tree pollen total in certain analyses from Verup, while it is 10–20% in corresponding analyses from the open lake (cf. TAGE NILSSON, 1947, p. 206). Pollen from less prevalent trees and shrubs has, with the exception of *Populus* in the Pre-boreal period, no real statistical significance, and is for that reason not included.

For Verup 5 SURVEY DIAGRAMS have only been drawn up for those parts of the diagrams which are of direct importance in the understanding of the local conditions.

III. DESCRIPTION OF THE SECTIONS

1. Localities from the Shore Zone of the Aamose Lake

A. The Verup-Kompleks; Verup 5
(see Fig. 1, No. 4)

P.33 (Fig. 2 and Plates II–III)

From the layer of sand (Layer 1) no pollen samples exist in the four sample series from Verup 5. This layer of sand is known from numerous places in the Aamose basin, from open sections as well as from borings, and it must be assumed that it exists over almost all Aamosen. In the central part of the basin it has a thickness of a few mm (cf. the sections from Aamosen; N.1.000; Ø.2.840, and Niløse; Baad I). The thickness increases towards the shores of the former lake, and a thickness of 1–5 cm has often been observed. At Verup it must presumably be much thicker, as no notes exist of it having been dug through. In all the sections from Aamosen so far examined it forms a boundary layer between the Post-glacial deposits and the Late-glacial varved clay. It is therefore likely, though there is no direct proof of it, that there is also Late-glacial clay under the layer of sand at Verup.

As no pollen analyses exist either from the layer of sand or from the deeper layers, it cannot be decided with certainty whether there is a lacuna in the succession of layers at Verup, partly between the ascertained Post-glacial layers and the layer of sand, partly between this and the Late-glacial layers, as is the case in numerous places in Aamosen, for example in the profile Aamosen; N.1.000; Ø.2.840 (Pls. XVII–XVIII).

In P.33 the Pre-boreal and older Boreal layers consist of calcareous mud, and the description of the section shows that the calcareous mud in layers 2, 3, and 4 has a low sand and clay content, decreasing upwards, until in layer 5 there are no mineral particles at all. In the parts of the diagrams corresponding with the layers in question, the curves and tables show a presence of pollen typical of the youngest part of zone IV. Layer 6, on the other hand, again contains sand, and fine clay and charcoal dust were found microscopically. At the same time the curves of the diagrams show a peculiar feature, in that the rising *Pinus* curve, which here has reached the same value as the *Betula* curve, suddenly falls steeply, while the *Betula* curve rises (analyses 7–9). The point where these fluctuations in the curves occur is immediately before the violent rise in the *Corylus* curve, i.e. at the beginning of zone Va.

As similar fluctuations also occur in the other Verup diagrams, a discussion

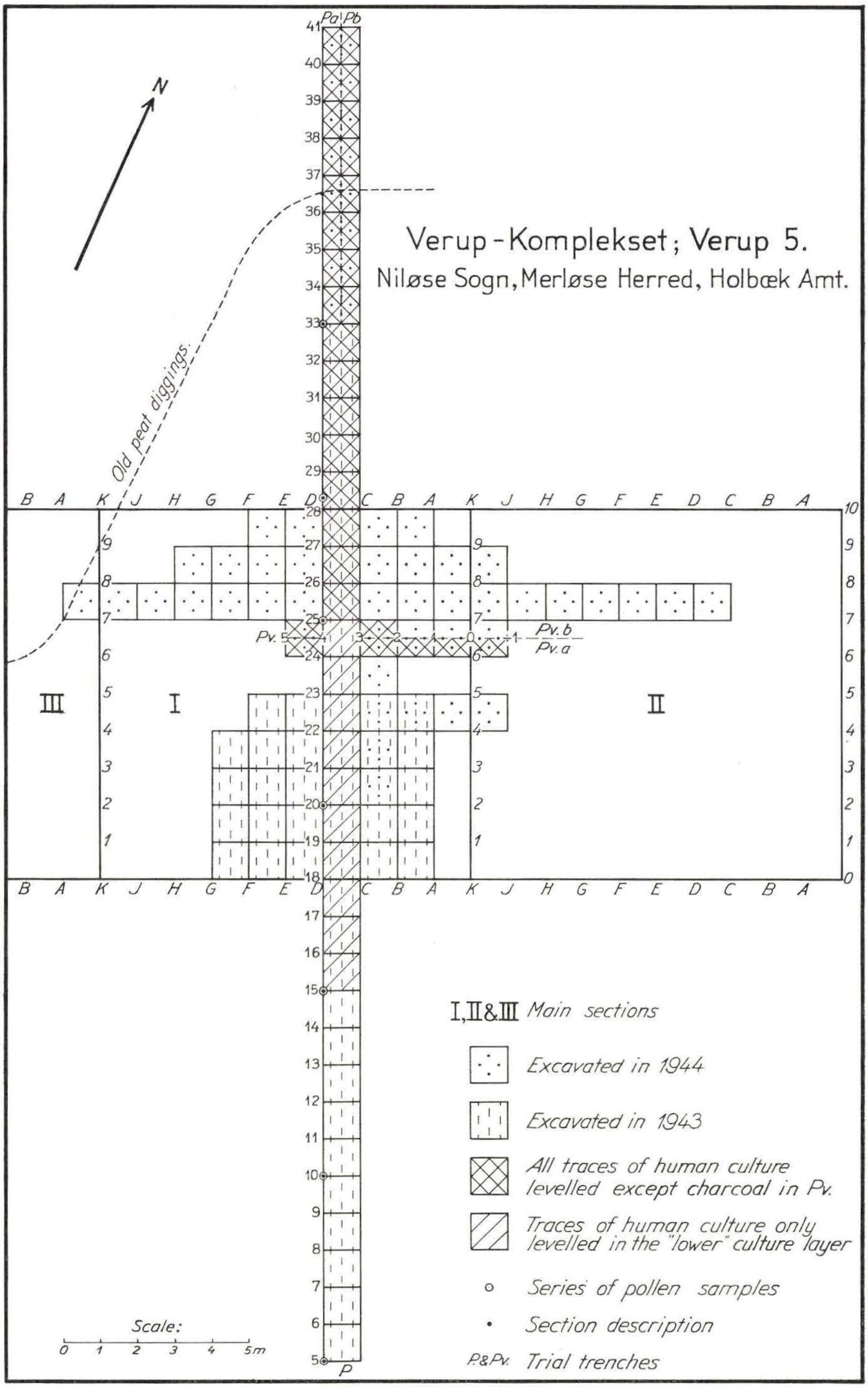

Fig. 2. Verup 5. – Plan of the excavation.
Verup 5. – Udgravningsplan.

and interpretation of the phenomenon would seem to be required when all the sections have been discussed.

Layer 7 is again purely organic, and in layer 8 we find, for the first time, considerable quantities of swamp peat. This peat must here be considered as secondary: it is probably derived from the vegetation which contributed to layer 9, as this vegetation sent roots and rhizomes down into layer 8, which originally consisted of calcareous mud.

Layers 6 and 7, together with the greater part of layer 8 make up that part of the sequence of layers which pollen-analytically is referred to pollen-zone V.

Layer 9 is, according to the investigator in the field, a culture layer, and according to its composition must be characterized as swamp peat-containing drift mud.

Layers 10 and 11 are swamp peat with a considerable content of different types of gyttja, from the finest to the coarsest, as well as some drift; they only differ in the fact that layer 10 is lighter in colour and less humified than layer 11.

The top part of layer 8, layers 9 and 10, and the lower part of layer 11 can be referred to zone VI, while the top part of layer 11 belongs to zone VII.

For layer 12, which consists of alder fen peat, no pollen analyses exist. Charcoal dust was unfortunately not systematically registered in the analyses from 1945–46, but a re-examination of the slides in 1960 showed that from the lower boundary of the culture layer (analysis 17) up to analysis 24, charcoal dust was present in enormous quantities. In analyses 25–28 there was an unmistakable and steady decrease, and in analyses 29–31 charcoal dust occured only sporadically, though in all the slides.

The nature and succession of the sediments show that in P.33 the water was shallow, and that in zone VI the reed swamp spread and reached the area. The curves of the pollen diagrams confirm this supposition.

The special problems concerning the settlement and its relation to the development of the vegetation, the fluctuations in the water-level, and the climatic conditions will be dealt with in connection with the other diagrams from this locality, and with the diagrams from Ul.Ø.

P.28.30 (Fig. 2 and plates IV–V)

The similarity between P.28,30 and P.33 is, as could be expected, clear, both in the sequence of layers and in the diagrams. There are however differences. According to the pollen diagrams P.28,30 goes further back in time than P.33, which suggests that there may be a lacuna in the sedimentation between the sand and the calcareous mud, as is known from other localities in the Aamose. The thin layer of sand (layer 3) has probably been washed up. The interesting course of the curves of *Pinus* and *Betula* immediately before the steep rise in the *Corylus* curve stands out very clearly, and is, as in P.33 connected with a change in the sediments (layer 7, analysis 13).

In the upper part of the two sections the agreement is also good. There is thus in both, a transition layer between the calcareous mud and the chalk-free formations (layer 10 in P.28,30 and layer 8 in P.33). Certain sharp changes in the curves at the zone border V–VI (the curve for Q.M., *Alnus*, and *Polypodiaceae*, etc.) seem to indicate that erosion took place, causing a small gap in the succession at this level.

Layers 11 and 12 in P.28,30 correspond in time with layer 9 in P.33, and there is good agreement between the sediment in layers 11 and 9 from the two sections, while layer 12 in P.28,30 is a gyttja- and drift-containing swamp peat. Layer 13 in P.28,30 corresponds both in time and in type of sediment with layer 10 in P.33. It is characteristic that both these layers are less humified than those below and above in the two sections. Layers 11, 12, and 13, as well as the lower part of layer 14 in P.28,30 can be referred to pollen zone VI. Layer 14 corresponds with layer 11 in P.33. Only the highest analysis (No. 36) should be referred to zone VII.

In general one gets the impression that the rate of sedimentation was greater in in P.28,30 than in P.33, and both the sediments and the relatively high percentages of herb pollen indicate that the filling-up started earlier and more intensively in P.28 than in P.33. These facts indicate that P.28,30 was closer to the shore than P.33.

P.25 (Fig. 2 and Plates VI–VIII)

As far as the calcareous deposits are concerned (layers 2–6) the similarity with P.33 and P.28,30 is so evident that a discussion of the sequence of layers and the diagrams is unnecessary. In this section the transition layer between the calcareous mud and the deposits containing peat and gyttja is missing. Presumably it has eroded, a supposition supported by the pollen diagrams, where the curves at the transition from layer 6 to layer 7 are strikingly steep.

Immediately above the calcareous mud comes the so-called "lower culture layer", which consists of drift gyttja with many traces of culture (layer 7).

The pollen curves pass evenly into layer 8, and continue the same course through this layer, which is a typical coarse detritus gyttja, without artefacts, but with much charcoal dust. Layers 7–8 belong to zone VI, and according to the pollen curves the highest sample in layer 8 (sample 19) must be referred to a rather late date in zone VI.

Layer 9 is a slightly humified swamp peat with a low gyttja content. The pollen diagrams are peculiar in that the lowest sample from layer 9 (sample 20) must be referred to the end of zone V. From here the curves again run a comparatively normal course, and this continues through the whole layer. The border to layer 10 corresponds with zone border V–VI.

Layer 10, included by the field investigator in the so-called "upper culture layer", is a rather humified swamp peat layer slightly mixed with both drift and gyttja. Traces of culture were found in considerable quantities. Pollen destruction was heavy, 14% in the lowest sample (No. 22), but light, 1.9% in the highest sample (No. 23).

Layer 11 consists of coarse detritus gyttja containing swamp peat and coarse and fine drift. The traces of culture are limited to fragments of charcoal, and there is a small fine sand content. Pollen corrosion is slight (2–4%). The pollen curves here again show a retrogression in time and date approximately to zone border V–VI. The four spectra from layer 11 (samples 24–27) are remarkably similar.

The top layer of the section (layer 12) is a fairly decomposed swamp peat with a gyttja content of the same character as in layer 11. Artefacts and other traces of culture found were plentiful, and the pollen corrosion was considerable (11%). The curves here also show an extraordinary break, as for the lowest sample in layer 12 (sample 28) we are clearly in zone VI, and analyses 29–30 continue evenly from here.

The extraordinary discontinuity in the curves in these diagrams is not limited to the curves of tree pollen, but is found, generally speaking, in all the curves for herbaceous pollen as well (see Pl. VII)

As the "leaps" in the curves are so striking, and as they also coincide with boundaries between layers, the curves in the diagrams have only been inserted piece-wise. If we now make the experiment of "cutting out" certain layers from the sequence, we shall, by eliminating layers 7–8 and 11, get the diagram Pl. VIII. This shows curves in perfect agreement with P.33.

The justification for this drastic operation in the diagram will be presented in connection with the discussion on the problems of habitation and fluctations in the water-level.

It is regretable that diagram P.25 does not extend in time as late as do P.33 and P.28,30, as we thus lack material for elucidating what happened round zone border VI–VII.

If the partial diagram is in general correct, it would show that in P.25 there was originally swamp peat directly on top of the calcareous mud, which would indicate that about the time of zone border V–VI the area had changed into a relatively dry bog.

P.20 (Fig. 2 and Plates IX–X)

All the calcareous deposits in P.20 (i.e. layers 1–8) agree, both as regards the sequence of layers, the sediments, and the curves of the pollen diagrams, with the other sections from Verup. The difference that the top 3 cm of the sand in layer 2 are mixed with gyttja may indicate that P.20 was nearer to the then shore.

The upper deposits at P.20 (layers 9–15) are on the other hand dominantly swamp peat, while the main part of contemporary deposits in the other sections is gyttja.

Layer 9, which from a pollen-analytical point of view belongs to the end of zone V, is a gyttja-containing swamp peat, in which culture remains in the shape of flint waste and charcoal were found.

Layers 10–12 all contain charcoal dust, and according to the diagram, layer 10 must be referred to zone V, and layers 11–12 to zone VI. The curve-picture is however somewhat irregular, presumably because of a considerable, but fluctuating, over-representation of *Betula* in the area. In the diagrams from P.25 and P.33 there is a small rise in the *Betula* curve during the same period. The svamp peat must have been deposited in a relatively short time and under rather dry conditions (compare with the curve for *Pediastrum*). The pollen destruction increases greatly going upwards, and culminates in layer 12, where the sediment is also most humified.

The swamp peat in layer 13 contains more gyttja, deposited under moister conditions, a fact also indicated by less pollen destruction. In this and in the following layer (layer 14) no charcoal dust was found. In layer 14 the destruction is again greater, and at the top of the layer there is sand, which shows that we are approaching the "upper culture layer" (layer 15). This layer is unfortunately not in a fit condition to be analyzed.

From the descriptions of the sections and the pollen diagrams it can be seen that the overgrowing of the area had already started in zone V, and that the surface of the bog was predominantly dry through the greater part of zone VI.

P.15 (Fig. 2 and Pl. XIX)

The sequence of layers in P.15 is apparently identical with the sequence in P.20.

In order to examine the possibility of dating the lower boundary of the "upper culture layer" more accurately by pollen-analytical means than it was possible to do in P.20, the top sample and that third from the top from the series in P.15 (layer 5) were prepared, and pollen slides were made. The state of preservation of the pollen material in both samples was, however, unfortunately so poor that counting was considered futile.

On the basis of the measurements and descriptions of the layers a section drawing from P.15 to P.33 (Pl. XIX) was made. For each of the section points examined there is a column giving the deposit symbols of the respective layers, corresponding to the sediment columns in the pollen diagrams. In the centre of this column a minor column has been inserted to show the presence of charcoal. Thick lines indicate that macroscopic charcoal was found in the samples, broken thick lines indicate mass presence of microscopic charcoal dust, thin lines frequent presence, and broken thin lines infrequent presence.

To the left of the sediment column the pollen-analytical zone borders are given, and to the right, marked by arrows, synchronous levels, which have been determined by pollen-analysis. The symbol × indicates the secondary *Betula* maximum in zone Va; A indicates the oldest level with certain traces of culture, corresponding to layer 9 in P.20 (a percentage value of 5 for Q.M. in the SURVEY DIAGRAMS). B indicates the beginning of the second level with artefacts ("lower culture layer"), and it was fixed to correspond with the lower boundary of layer 10 in P.25 (a percentage value of 20 for Q.M. in the SURVEY DIAGRAMS). B_1 marks the upper limit of this culture layer, and was determined to correspond with the upper boundary of layer 10 in P.25 (Q.M. 32% in the SURVEY DIAGRAMS). C marks the beginning of the "upper culture layer", and has been fixed to correspond with the lower boundary of layer 12 in P.25 (Q.M. 48% in the SURVEY DIAGRAMS), while C_1 in the opinion of this author marks the estimated time when the habitation, the remains of which are designated the "upper culture layer", ceased to exist. This time is fixed to correspond with the upper boundary of layer 9 in P.33 (Q.M. 55% in the SURVEY DIAGRAMS). C_x indicates the approximate upper boundary of the culture layer named by the excavator the "upper culture layer", and it is fixed to correspond with the upper boundary of layer 8 in P.25 (Q.M. 62% in the SURVEY DIAGRAMS). Finally, C_{xx} indicates the approximate upper boundary of the youngest traces of culture excavated (Q.M. 70% in the SURVEY DIAGRAMS).

From 6 specimens of archeologically important finds pollen samples are available. In the method of excavation used, only the levels of the finds were recorded, not the position inside the given square metre. In the drawing of the section this level has been marked by horizontal lines, ending in arrows, and the number of the square metre and the number of the find are given on these lines. The corresponding pollen analyses are added under the SURVEY DIAGRAMS P.33, P.28,30 and P.25.

Finally, some of the main boundaries between the sediments are marked by lines of different thicknesses. The boundary between sand and calcareous mud is a dot-and-dash line, as this boundary is only known at the examined points in the section. The boundary between calcareous mud and the peat- or gyttja-like layers is an unbroken line; the boundary between the deposits containing swamp peat and alder fen peat, as well as the surface of the bog in 1943, are shown in the same way.

B. The Niløse-Kompleks, Brovad Grøft (*Large Flint Pick*)[1]
(Fig. 1, No. 3 and Pls. XI–XII)

Zero in the measurements marks the surface of the section. This does not correspond with the surface of the bog at that time on account of the steeply sloping sides of the ditch.

The position of the large flint pick is indicated by a black rectangle on the

[1]) The find has been described by KNUD ANDERSEN (see SVEND JØRGENSEN, 1954, p. 160).

right side of the sediment columns. The columns with horizontal dot-and-dash lines on the left-hand side indicate the presence of charcoal dust.

The profile from the area covers a shorter period of time than the Verup sections. It only goes back to the youngest part of zone Va (calcareous mud, layer 1). On the boundary between layers 2 and 3, which coincides with zone border V–VI, some of the pollen curves are very steep, which might indicate that in this section there was also a lacuna in the deposits at this zone border. The overgrowing set in shortly before, or at, this time. In contrast to the profiles from P.33 and P.28,30 there are here no deposits with a gyttja character. Layers 3–5 are found by pollen statistics to belong to the older and middle part of zone VI.

C. The Kildegaard-Kompleks, Ulkestrup Mose
(Ul.Ø.; S.13.00; V.6.25)[1])
(Fig. 1, No. 6 and Pls. XIII–XIV)

The lowest layer in the section is the calcareous mud, layer 1, the thickness of which is 1.2–1.3 m. It has not been dug or bored through at this point, but at a number of other points inside the area of the settlement this has been done, and there are sample series for the whole layer.

Under the calcareous mud there is sand. Over it there is a thin layer of heavily felted swamp peat with many seeds of *Scirpus lacustris*, and a good deal of charcoal (layer 2). The part of layer 1 which has been analyzed, and layer 2, can be referred to zone Va, which shows that at this time an overgrowing of the area has set in.

Layer 3 is a *Cyanophycé*-gyttja with some swamp peat, small quantities of coarse detritus and fine drift, as well as charcoal, some shell fragments and sand, and a touch of clay mixed in. The boundary with the layer above, layer 4, is sharp. This layer is a rather coarse drift gyttja with more sand and charcoal than layer 3. The mineral components are however lacking at the top of the layer, and at the bottom of the layer, on the border to layer 3, a few flint chips were found here and there in the section. The upper boundary to layer 5 is also sharp. Layer 5 is almost identical to layer 3, with only the small sand and shell fragment content missing.

Layers 3–5 are obviously sediments from the open lake, and apart from the lowest sample (No. 7) they are, generally, of the same pollen-analytical age, and can be referred to the older part of zone VI.

Layer 6 is swamp peat identical with layer 2, and pollen-analytically it belongs, like that layer, to zone Va. It should be pointed out that in the sediment column the border between layers 5 and 6 does not coincide with the

[1]) The co-ordinates do not refer to the main co-ordination system for Aamosen (see Fig. 1), but to an arbitrary system of co-ordination for the Ulkestrup excavation.
Preliminary report on the find by KNUD ANDERSEN (1951).

retrogression in time shown by the pollen curves, as the lowest sample in layer 6 belongs to zone VI. The explanation of this discrepancy may be that the border between layers 5 and 6 did not run horizontally, but sloped upwards just behind the face of the section, with the result that the top part of the sample in the glass tube which was used for the slides came from layer 5 and not from layer 6.

Layer 7 is also swamp peat, slightly more humified than layer 6, and above layer 7 follows a humified alder fen peat (layer 8). Layer 7 and the lowest part of layer 8 belong to pollen zone Vb.

Layer 9 is also humified alder fen peat, and the lowest part of this layer must, together with the upper part of layer 8, be referred to pollen zone VI, while the rest of layer 9 belongs to zone VII. At the transition between layers 8 and 9 there are traces of culture (flint, wood, charcoal, hazelnut shells, etc.).

As in the section Verup 5, P.25 we find here a sequence of layers which does not reflect a normal filling up, and the pollen curves do not run consecutively. If, however, we imagine that the layers 3, 4, and 5 are removed from the sequence in the Ul.Ø. diagram, a section and a pollen diagram with a more logical sequence would emerge. Layers 3, 4, and 5 can therefore be considered to be secondary deposits "inserted" into a sequence of primary deposits. For this reason a question-mark has been put by these layers in the columns for zone-boundaries in the diagrams.

The two levels where artefacts were found have been marked by black rectangles on the left side of the sediment column.

2. Localities from the Central Part of the Aamose Lake

A. The Niløse-Kompleks; Baad I (Boat I)
Fig. 1, No. 2, and Pls. XV–XVI)

The diagram covers layers 3–8 of the sequence of layers, as there are no pollen samples from layers 1 and 2. A pollen sample from the lower part of layer 3 proved to be without interest, as the analysis of a single slide showed that it was heavily contaminated by secondary pollen.

It is possible that the layer with the mollucs shells, layer 5, indicates a lacuna in the sequence, but the curves of the pollen diagrams show no anomalies at this level.

The analyzed part of the sequence consists of fairly uniform gyttja. In layers 3–7 there is sand, silt, and clay, mostly in layers 3–4, where it was indeed noticed in the field. The laboratory examination also showed that these layers were faintly calcareous. The thinness of the Pre-boreal, and particularly of the Boreal, layers (zone V) point to a rather slow sedimentation, while the thicker layers higher up in the section indicate a considerably higher rate of sedimentation.

B. Aamosen; N.1.000; Ø.2.840; Bp.Ib
(Fig. 1, No. 11, and Pls. XVII–XVIII)

In this section there is apparently a hiatus in the sequence of layers. Layer 3 is a layer of sand only 2 cm thick, with fragments of *Unio* or *Anodonta* shells. Under this layer there is Late-glacial varved clay (layer 1 and layer 2), and above it follows clayey and sandy gyttja, which pollen-analytically can be referred to zone VI, as all the components of the MIXED-OAK-FOREST as well as *Hedera* are present in analysis 1 (layer 4). The question of whether the hiatus in the sequence was due to absence of sedimentation during this period on account of currents, or whether sediments deposited at the time have later eroded, must remain open. The presence of the thin layer of sand with the fragments of big mussel shells can be attributed to both possibilities. A change in the depth of the water on account of melted dead ice is also a possible cause.

In the rest of the section presented here there is nothing, either in the sequence of the sediments, or in the curves of the pollen diagram, which points to interruption in the sedimentation, and from the thickness of the deposit it can be concluded that the rate of sedimentation was extremely high compared with the areas close to the shore at Verup 5. As can be seen from the description, the sediment in the analyzed part of the section is practically homogeneous, as it consists of fine detritus gyttja with a slowly decreasing content of mineral components going upwards, balanced in the upper layers by an increasing chalk content.

IV. DISCUSSION AND INTERPRETATION

1. The Development of Vegetation

Zone IV – The Pre-boreal Period

(Verup 5, P.33, Pls. II–III, Analyses 1–7;
P.28,30, Pls. IV–V, Analyses 1–12;
P.25, Pls. VI–VII, Analyses 1–6;
P.20, Pls. IX–X, Analyses 1–7;
Niløse; Baad I, Pls. XV–XVI, Analyses 1–3)

The curves both in the MAIN and in the SURVEY DIAGRAMS from the four points in the section at Verup 5 all agree, and they show a forest characterized by pioneer trees. *Betula* dominates, followed by *Pinus*, which, however, gradually increases at the expence of *Betula. Populus*, from a pollen-analytic point of view, comes third, and then *Salix*. All other pollen present is, quantitatively, without importance. From Part B of the MAIN DIAGRAMS it can be seen that the total of herbaceous pollen only amounts to 5%, or less. From this, however, the lower part of the diagram from P.28,30 must be excluded, for, as mentioned before, it goes further back in time than the rest of the diagrams. In Analyses 1–4 from this section we have a percentage of herbaceous pollen of about 10, and pollen from *Juniperus*, the presence of which is generally very sparse, is more plentiful in this section of the diagram (Table II). Judging both from the low values of the curves of the herbaceous pollen, and from the limited occurrence of *Juniperus* pollen, even the oldest deposits of calcareous mud at Verup must be presumed to have been deposited rather late in zone IV.

Pollen of *Ulmus* and *Corylus* can be found practically down to the bottom in all the diagrams, while *Quercus* pollen is altogether absent in the oldest parts of the diagram from 28,30, and occurs only rather sporadically in the lower analyses of the other diagrams.

Whether *Ulmus* and *Corylus* have grown in the Aamose area from the beginning of the period we are considering here is rather doubtful, and we have no macroscopic finds to resolve the problem.

The first sparse occurrences of pollen from *Corylus*, *Ulmus* and *Quercus* may have been due to long distance transport, but towards the end of zone IV the greater frequency of pollen from these trees seem to indicate that they were approaching, and here and there in the birch and pine forests of the Aamose region individual trees of these species may have grown. That there was already suitable climatic conditions for them is proved by the finds of *Cladium* pollen (analysis No. 6 from P.28,30) (cf. JOHS. IVERSEN, 1960, p. 8).

A series of rare pollen finds may be derived from relics of the Late-glacial flora, for example *Sorbus rupicola*, *Hippophaë rhamnoides*, *Helianthemum* cf. *nummularium*, *Saxifraga aizoides*, *Plantago maritima*, and *Ephedra* cf. *distachya* (cf. JOHS. IVERSEN, 1954, p. 87 ff.).

When it comes to judging the value, from a plant-geographical point of view, of the find of a single pollen from some plant, the possible sources of error must be kept in mind (cf. FÆGRI & JOHS. IVERSEN, 1950, p. 90 ff.). If contamination and incorrect identification are disregarded, rebedded pollen and long distance transport are the only possible errors left.

The extremely small content of clay in the calcareous mud does not indicate wash-out of any importance, either of boulder clay or of Late-glacial clay, and as in all the Pre-boreal deposits from Verup 5 only one specimen of "HYSTRIX" (analysis 2 from P.28,30) and one pollen grain which can with certainty be said to be secondary (a *Fagus* pollen in analysis 1 from P.20) have been found, contamination by secondary pollen must be considered to be negligible.

As for long distance transport, the possibility of this is greatest for pollen from *Hippophaë*, *Plantago maritima*, and *Ephedra*, as they are wind pollinated. Pollen from *Hippophaë* is, however, in all the material we have from Aamosen almost exclusively associated with zones IV and V, as only one of the finds can be referred to zone VI, and none to the younger deposits. This seems to indicate that *Hippophaë* also grew in the Aamose region after the Late-glacial period.

As for *Ephedra* one would be inclined to consider long distance transport as the likely source of its presence in analysis 4 in P.28,30. In 1955 the first find of *Ephedra* pollen from Aamosen occurred in a sample taken immediately below the culture layer at the Kongemose settlement (the transition between zones V and VI; unpublished; cf. the Map, Fig. 1, No. 10, and SVEND JØRGENSEN, 1956).

Another Post-glacial find of *Ephedra* pollen from Aamosen was made by BENT FREDSKILD in 1959 (the settlement Muldbjerg I, Late-atlantic period; Fig. 1, No. 9; unpublished). We have, in other words, three finds, one from zone IV, one from zones V–VI, and one from zone VII.

Pollen from *Ephedra* cf. *distachya* has been found in Post-glacial deposits in south-east Norway (HAFSTEN, 1956), and S. TH. ANDERSEN has registered four finds from Alvaret on Öland, one from the Boreal period, and three from the Atlantic period (cf. JOHS. IVERSEN, 1954, p. 105). In IVERSEN's opinion both these localities are well suited to being Post-glacial refuges for *Ephedra*, but he considers that long distance transport over a heavily wooded Europe is less likely.

In the Aamose area it is difficult to imagine that the soil conditions were suitable in the Post-glacial period for a steppe plant like *Ephedra*, with its extreme requirements for dryness. This, as well as its sporadic occurrence far into Atlantic period seems to indicate long distance transport as a more likely cause of its presence.

In 1951 I found an *Ephedra* pollen in a Swiss Post-glacial deposit (Burgmoos, youngest Mesolithicum; cf. TROELS-SMITH, 1955 b), and later in 1951 another Post-glacial *Ephedra* pollen in Norway (Sostelid; cf. ANDERS HAGEN, 1953). These finds were made not far from recent occurrences of *Ephedra* in the Alps and presumed Post-glacial refuges in south-east Norway respectively.

The Diagram Niløse; Baad I agrees in all main respects with the Verup diagrams as far as zone IV is concerned, apart from the fact that it is more compressed. This difference is presumably due to slower sedimentation in the locality further from the shore.

Zone V – The Boreal Period

(Verup 5, P.33, Pls. II–III, Analyses 8–15;
P.28,30, Pls. IV–V, Analyses 13–18;
P.25, Pls. VI–VIII, Analyses 7–13 and 20–21;
P.20, Pls. IX–X, Analyses 8–15;
Niløse; Large Flint Pick, Pls. XI–XII, Analyses 1–4;
The Kildegaard-Kompleks; Ul.Ø., Pls. XIII–XIV, Analyse 1–6 and 21–24;
Niløse; Baad I, Pls. XV–XVI, Analyses 4–5)

Zone V is characterized by the usual *Corylus* maximum in the pollen diagrams, which indicates that *Corylus* must have covered great areas, growing partly in separate communities and partly as undergrowth in the pine and birch forests. These trees suffered from the increase of *Corylus*, though it had no influence on *Ulmus* and *Quercus*. These are slowly but surely consolidating their position before the great increase in them sets in. Late-glacial relic-plants like *Hippophaë* and *Helianthemum* are still found, and two light-demanding trees, *Sorbus* cf. *aucuparia*, and *Viburnum Opulus* reach their optimum in zone V. A decline in the curve for herb pollen in Part B of the MAIN DIAGRAMS shows that the herbs had less favourable conditions under the more shady *Corylus*. The rise in the herb pollen curves for the area near the shore at the end of the period is due to the local over-growing. Altogether the curves show the common picture of vegetational development in the Boreal period.

One point, however, requires further discussion.

At, or slightly above, zone border IV–V the four MAIN DIAGRAMS from Verup show the extraordinary course of the curves for *Betula* and *Pinus* mentioned above.

From the diagrams it can be seen that the irregular course of the curves chiefly concerns *Betula* and *Pinus*. It is true that there also seems to be a simultaneous fall in the *Populus* curve, and possibly also in those for *Humulus* and *Calluna*, and a fall in the curve for *Limnophyta* seems also to occur at this time, or a little later. The curves do not, however, entirely correspond. It should also be pointed out that the *Betula* increase in P.20 seems to come slightly later, compared with the rise in *Corylus*, than in the other diagrams. That climatic deterioration should have been the cause of this trend seems unlikely, as no observations of any kind which might indicate a fall in temperature at the time have been made.

Even though the filling-up of the basin was only slight *Betula* may have profited by possible changes in the water-level. Other possibilities are human interference and forest fire.

At present we have no evidence of real habitation in the Aamose area in the Pre-boreal and the beginning of the Boreal periods, but a number of stray finds of notched leister prongs are known (THERKEL MATHIASSEN, 1948, Vol. I, Nos. 175 and 176). One of these, from the easternmost part of the basin, Vandløse Mose (Fig. 1, No. 12), has been dated by TROELS-SMITH, by pollen statistics, to the beginning of zone V. (cf. TH. MATHIASSEN, 1943, p. 132). A confirmation of this dating can be obtained from the excavation now being carried out at Mørke Enge, about 10 km north of Aamosen (not yet published). Here a considerable number of notched leister prongs have been found, and a preliminary dating by pollen statistics of specimens found in situ refers them to zone border IV–V. It must be assumed that the Aamose region was inhabited or visited only by few and small tribes, or rather families, in the Pre-boreal period, and that the timber used by a small population of hunters and fishermen for fire, boats, huts and tools cannot have caused the striking decline in the *Pinus* curve, particularly as other trees than *Pinus* must be presumed to have been used as well.

As for the third possibility, forest fire, man also comes into the picture here, as he could have started a fire either inadvertently or on purpose.

Whether fire was used in hunting, as is known from primitive peoples now living and from old accounts can rarely be decided with certainty. But as such a method calls for the collaboration of a considerable number of people, it was probably not used in this case. The suggestion that this method was used in an Interglacial period in England has been put forward (C. M. B. MCBURNEY & R. G. WEST, 1955). From the composition of the forest, and from what the climatic conditions seem to have been, a forest fire would have been quite possible in the Pre-boreal period, whether started by man or by lightning. The sudden increase in the *Betula* curve would then have been a result of the fact that *Betula* regenerates more quickly than *Pinus* after a forest fire.

A characteristic feature of pollen diagrams where a forest fire or a clearing by fire has been registered, is the sudden and marked rise in the herb pollen curves as a result of better light conditions immediately after the fire (cf. JOHS.

IVERSEN, 1941; TROELS-SMITH, 1942; VAN DER HAMMEN, 1951). This does not occur in the Verup diagrams, which may perhaps be due to the sampling, or to the fact that the area ravaged by fire was not directly on the shore. The fall in the *Calluna* curve is however, not easily reconciled with this theory either, as heather quickly regenerates after a fire and even, in fact, flowers particularly abundantly then.

The presence of charcoal dust at this level supports the fire theory. The sparseness of the dust perhaps indicates that the possible fire did not occur in the immediate neighbourhood of the lake. With the charcoal dust there are also small quantities of clay and sand, while both the layers below and above are free from mineral particles. Whether this difference in the sediments is due to an increase in mineral material caused by greater wash-out from the area denuded of vegetation by the fire, or whether it is due to fluctuations in the water-level is still a matter of guesswork.

The profile for the great flint pick does not go as deep as the zone border IV–V, and thus cannot clear up the problem, but the trends of the curves in the MAIN DIAGRAM from Ul.Ø. indicate that the secondary *Betula* maximum in zone Va occurs in the Ulkestrup region as well.

In the diagram from Niløse; Baad I these variations in the curves do not occur. Whether this is due to the scanty sedimentation further out in the open lake, or that the phenomenon is tied only to the shore zone can not be determined from the material to hand.

A picture of the curves corresponding to that in the Verup diagrams is to be found in a diagram published by V. MIKKELSEN from Even lake, Bp.21 (MIKKELSEN, 1949). In relation to the *Corylus* increase the phenomenon takes place only slightly later than at Verup. No rise at all in the herb pollen curves is registered in that diagram. No charcoal or charcoal dust was found, and no change in the sediments was noticed. MIKKELSEN suggests that a forest fire caused these fluctuations in the curves.

Though the presence of charcoal dust in the Verup diagrams may indicate a fire, and the changes in the sediments can fit in with this view, there can not be said to be a compelling argument for this interpretation of the curves, and we must still direct our attention to possible fluctuations in the water-level. The solution of this problem will be one of the tasks connected with the dating of the big and important Mesolithic finds from the Aamose area.

Zone VI – The Early Atlantic Period

(Verup 5, P.33, Pls. II–III, Analyses 16–28;
P.28,30, Pls. IV–V, Analyses 19–35;
P.25, Pls. VI–VIII, Analyses 22–23 and 28–30;
P.20, Pls. IX–X, Analyses 16–23;
Niløse; Large Flint Pick, Pls. XI–XII, Analyses 5–17;
The Kildegaard-Kompleks; Ul.Ø., Pls. XIII–XIV, Analyses 25–28;
Niløse; Baad I, Pls. XV–XVI, Analyses 6–21;
Aamosen; N.1.000; Ø.2.840; Bp Ib, Pls. XVII–XVIII, Analyses 1–36)

The parts of the two diagrams from the central part of the lake (Niløse; Baad I and Aamosen; N.1.000; Ø.2.840; Bp Ib) referred to this period, show an extraordinary agreement both in general and in detail. The curves give a beautiful illustration of how the climax trees (*Ulmus*, *Quercus* and *Tilia*) oust the pioneer trees (*Betula* and *Pinus*) and *Corylus*, until a climax vegetation conditioned by the climatic and edafic factors obtaining has been reached (cf. JOHS. IVERSEN, 1960, pp. 8–9). *Alnus* is not involved in this competition as it can grow in a soil too moist for climax trees. Where moisture conditions are favourable it consequently increases considerably, and in competition with *Alnus*, *Salix* has to give way.

The increasing shade in the forest is reflected not only in the sparseness of herb-pollen, for the decreasing frequency of light-demanding trees like *Viburnum Opulus*, *Prunus Padus* and *Sorbus aucuparia* is also proof of the shade produced by the climax trees. The curve for *Humulus Lupulus* shows a similar decline, though one would have thought that *Humulus* with its climbing growth was better equipped for finding a place in the sun. Light-demanding plants from the Late-glacial flora have only been registered as single finds, for example *Sorbus* cf. *rupicola*, *Hippophaë* and *Helianthemum* cf. *nummularium*.

In estimating the courses of the curves in the corresponding sections of the diagrams for the localities near the shore, some special circumstances must be kept in mind. Thus the local vegetation will affect the curves, as the pollen production of the reed swamp will give very high herb pollen percentages, and the tree pollen curves will be influenced by the local pollen production of *Alnus*, *Pinus*, *Betula*, and *Salix*. As the shore zone is a border region, possible fluctuations in the water-level will also cause changes in the local vegetation, and thus further complicate the picture.

Points P.33 and P.28,30 in the section are furthest away from the then shore, and the deposits which can be referred to zone VI consist exclusively of sediments from the open lake, and seem to be relatively untouched by the uplift and re-depositions which have disturbed the succession of the layers in P.25. The curves for forest tree pollen, apart from a steeper slope due to a smaller rate of sedimentation, also agree very well with the curves in the diagrams from the open lake.

In the steady progress of vegetational development towards the Atlantic climax vegetation, there is, however, a section which calls for attention. From the MAIN, as well as from the SURVEY DIAGRAMS, of the comparable profile points mentioned above, it appears that just below the zone border VI–VII there is a slight decline or retardation in the curve for Q.M. before it rises to its maximum value at the zone border (P.33, analysis 26; P.28,30, analysis 33; Niløse; Baad I, analysis 19; Aamosen, Analyses 30–31). The decisive decrease in the *Corylus* curve sets in simultaneously. At the same time time there is a rise in the curve for *Alnus*, and immediately after this a rise in the *Betula* curve. A more or less obvious rise can also be seen in the *Salix* curve. From a vegetational point of view it is natural to interpret these changes as indications of progress for the trees demanding or tolerating a moist soil. The MIXED-OAK-FOREST has probably not in reality decreased, but *Corylus* most likely has. The curves in the SURVEY DIAGRAMS for *Polypodiaceae* sp. and *Pediastrum*, and in particular the curve giving the degree of destruction in Diagrams P.33 and P.28,30 support the assumption that increased moisture of the soil causes the changes in the curves in the tree pollen diagram. In the other diagrams for the areas near the shore, the course of the curves here described does not stand out as clearly, partly because a re-sedimentation or filling-up has taken place, which obscures the picture, and partly because some of the diagrams do not cover this period.

Zone VII – The Full Atlantic Period

(Verup 5, P.33, Pls. II–III, Analyses 29–31;
P.28,30, Pls. IV–V, Analysis 36;
The Kildegaard-Kompleks; Ul.Ø., Pls. XIII–XIV, Analyses 29–31;
Niløse; Baad I, Pls. XV–XVI, Analyses 22–28;
Aamosen; N.1.000; Ø.2.840; Bp Ib, Pls. XVII–XVIII, Analyses 37–45)

At the zone border VI–VII there is a fall in the *Populus*, *Salix*, *Betula*, and *Pinus* curves, after which they remain constant on the new lower level. The decrease in *Salix* and *Betula* is presumably caused by an increase in *Alnus*. Amongst the climax trees there seems to be a slight increase in *Tilia* at the expense of *Ulmus*. The parallel courses of the curves seem, all things considered, to indicate that in the first part of zone VII, which is the one under discussion, there was a temporary equilibrium between the components of the forest. As far as the diagrams for the areas near the shore are concerned, the sharply increasing percentages of herb-pollen indicate that the filling-up of these areas was progressing fast. Greatly increasing pollen destruction in the higher layers unfortunately makes counting of samples from these futile, with the result that the further development of the vegetation in these areas can not be followed.

2. Changes in the Water-Level

The level of the water in a lake depends on the relation between the supply and the loss of water.

The supply of water may be due both to subsoil and to surface water; in both cases it ultimately depends on the amount of precipitation. The decisive factors affecting the loss are the overflow of water and evaporation, both direct evaporation from the lake surface, and indirect by way of vegetation.

In a case like this, where there is a question of "fossil" changes in the water-level, it is particularly difficult to decide what conditioning factors have been active.

We have no geological evidence that the area drained by the lake changed in the Post-glacial period, so that possible fluctuations in the supply of water can therefore only be ascribed to changes in the amount of precipitation.

The outlet of the Aamose basin has always been at Bromølle, and from here the stream follows the valley between Kattrup and Holmstrup (see Fig. 1). Before the effective artificial drainage took place in 1928–30 the height of the threshold at the outlet was about 25 m. The fall in the first 1200 m of the valley is gradual, and amounts to about 4 m. It has not been possible so far to find signs of erosion in this part of the valley. V. MILTHERS (1943, p. 84) points out that the gravel terrace at Kajemose might be evidence of a higher water-level in the Aamose lake. The terrace slopes gently towards the bog from Kote 28 to Kote 27 m, and the deposits are described as extra-marginal sand. MILTHERS thinks that a demonstration of the existence of cliffs caused by erosion might indicate a former higher water-level. The possible higher water-level would presumably have occurred when the ice was melting away, as the increase in the water supply would probably have been heavy, and derived from a greater area than the present drainage area (MILTHERS, 1943, l.c.). A long series of steep slopes in other places along the edge of the basin look like erosion cliffs caused by a higher water-level; but in a number of cases we know that these are due to the removal of earth for spreading on the bog. During the period from the first artificial drainage of Aamosen in 1777 to the end of the last century, enormous quantities of sand, gravel and clay were dumped onto the bog as filling or to improve the soil[1]), and the present shape of the pronounced slopes at Maglebjerg in Assentorp, at Kildegaard and Nygaard in Ulkestrup, as well as along the northern border of Tømmerup bog are certainly known to have been caused by human intervention[2]). Many low, 1–1.5 m high steep

[1]) 400–500 cart-loads of filling per Tønde Land (about $\frac{1}{2}$ hectare) was considered necessary to improve the boggy ground (LACOPPIDAN, 1860, p. 306).

[2]) Told me by my grandfather, NIELS JØRGENSEN, Undløse, born in 1844. In his childhood he had also often heard of the first big work of cultivation undertaken in Aamosen in this neighbourhood. It was started by H. F. J. ESTRUP, owner of the manor-house Kongsdal. In the course of the years 1837–38 the 57 Tønder Land (about 25 hectares) big Kongsdal Kvægmose was ditched, levelled, and the ground cultivated, an impressive effort at that time. A written account of this can be found in H. F. J. ESTRUP's Collected Works, 1851, Vol. II, p. 243ff.

slopes along the present edge of the bog are simply due to cultivation, and we must therefore keep in mind the fact that this has left a considerable impression on the landscape round the bog as it is today.

We have thus no certain evidence that the Aamose lake underwent any drastic changes in drainage, or had an appreciably higher water-level than at the present time, and according to all available observations, the erosion of the bar at Bromølle took place gradually and very slowly.

After the land had become wooded, the possibility of landslides occuring in the drainage valley which would impede the outlet is not very great. An overgrowth of the outlet, or the possibility that beaver dams might at intervals have obstructed the passage of water seems more likely. The artificial damming for the working of the Bromølle mill from 1199 to 1770, which can be historically verified (cf. H. F. J. ESTRUP, 1851, Vol. II, p. 250 ff.) may date even further back, but still not as far back as the time period we are dealing with here.

Altogether it seems reasonable to assume that the outlet possibilities in the pre-historical part of the Post-glacial period were practically constant; and if changes have taken place, it is most likely that they have tended toward a very slow lowering of the water-level in the Aamose lake. A possibility which cannot be disregarded is that the depth of the Aamose lake was greater at some time in the Post-glacial period as a consequence of the bottom of the lake having sunk due to the melting of buried dead ice. There is, however, no definite proof of this in the sediments from the profiles we have examined (cf. A. ANDERSEN, 1954, p. 191 ff.). Such a process would presumably take place so slowly that it would hardly influence the absolute height of the surface of the water to any extent.

We are then left with climatic fluctuations as the cause of possible changes in the water-level.

In accordance with the BLYTT-SERNANDER climatic theory we find a great deal of evidence in Aamosen pointing to a lower water-level in the Boreal period. Thus a stratification consisting of calcareous mud, slightly humified swamp peat, highly humified swamp peat with stumps and trunks of pine, and above this, coarse detritus gyttja, is common along the edges of the bog. This series of layers is interpreted as the Boreal drying- and filling-up, followed by the Atlantic rise in the water-level. But before we have pollen-analyses of the layers we can not be certain that this interpretation is right.

The sedimentation and filling-up in a big lake is often a very complicated matter (cf. G. LUNDQUIST, 1925), and the greatest caution must therefore be exercised in interpreting and drawing parallels on the basis of profiles and diagrams. We can, however, take it as a general rule, that a rise in the water-level should be fairly easily recognizable, both from the sediments and the pollen curves (gyttja on top of peat, "floating islands"), while it may be very difficult to distinguish between the effects of a fall in the water-level and the picture presented by the natural processes of filling-up.

Metaphorically speaking, one might compare the filling-up and overgrowth with an "isostatic" raising, while the real fluctuations in the water-level are "eustatic", and it is the result of the interaction of these factors which is the basis of our working material.

We turn to the Verup profile with the four diagrams covering a distance of only 13 m (the geological profile and diagrams, Pls. II–X and XIX).

The four section columns are fundamentally similar in zone IV and zone V, so that we cannot obtain any information about changes in the water-level in this period from the character and composition of the sediments. Nor do the curves of the tree pollen give us any information. But in the herb-pollen curves there are some characteristic features, which occur simultaneously in the four diagrams. In zone Va there is a marked fall in the curves for *Limnophyta* (Part VIII in the SURVEY DIAGRAMS), which is followed by a corresponding, or even greater rise at the zone border V–VI. A similar trend in the curves for *Pediastrum* can be seen (Part VII). The pollen tables inform us that *Limnophyta* before this decrease consisted almost exclusively of *Potamogeton* sp., while the succeeding great increase is not due to the return of *Potamogeton*, but chiefly to *Nymphaea alba*.

The curves for pollen corrosion (se the SURVEY DIAGRAMS from P.28,30 and P.25) show the opposite picture of the curves for *Limnophyta* and *Pediastrum*. It is most extraordinary to find such immense destruction in deposits of this type in Aamosen. This destruction must be primary, i.e. have taken place before the overlying layers were deposited, as these show little or no destruction. In P.33 and P.20 we find no signs of destruction, which can easily be explained as far as P.33 is concerned, because of lower situation, but is apparently inconsistent as far as P.20 is concerned.

In 1943 the zone border Va–Vb, as fixed in the four section points, sloped gently, with a fall of about 0.35 m from P.20 to P.33 (cf. Pl. XIX). This gradient did not necessarily originate in the Boreal period, but may have been due to compression of the layers. As the layers of calcareous mud in P.20, from the sand bottom to the zone border Va–Vb, are thinner than in the other section points, it is quite possible that the zone border was at a greater depth in P.20 than in P.25 and P.28,30 when the sediments were deposited. It is possible that the explanation of the different degree of destruction is to be found in this phenomenon.

Observations on compression of gyttja layers of similar dimensions have been made in Wauwilermoos, Switzerland (cf. TROELS-SMITH, 1955 b, p. 22).

Whether the low water-level suggested by these curves is the result of the gradual filling-up of the basin at Verup, or whether the surface of the water fell, the following rise in the water-level must have been real enough in the sense that the depth of the water increased. Whether this was caused by an absolute raising of the surface of the water, or because the bottom of the lake sank through melting of ice buried in the underlying moraine, can not as yet be decided.

But, in the great mass of samples from Aamosen (the trial ditches at Øgaarde, Ul.Ø., Kongemosen etc., see Fig. 1) it should be possible not only to determine this with certainty, but also to elucidate the actual course of events.

From what has been said here we can assume that a rise in the water-level took place in the Aamose basin at zone border V–VI. In P.20 and P.25 the filling-up has already set in in zone V, while in the lower-lying part of the area it did not make any progress till the zone border V–VI. Judging from the sediments and the presence of pollen, the section point P.33 was just outside the reed swamp for the whole of zone VI, and the filling-up indicated by the very big increases in the curves for plants belonging to the reed swamp and the moist soil, does not occur until zone VII.

The filling-up of the area did not, however, take place evenly. This is seen most clearly in diagram P.33, where the curve for *Polypodiacea* (practically identical with *Thelypteris palustris*) shows a vigorous, but gradual increase up to analysis 20, i.e. almost up to the middle of zone VI. There a distinct decrease sets in, which lasts almost till zone border VI–VII, where a heavy increase again sets in, matching the rise at the beginning of zone VI. In the *Pediastrum* curve (Part VII) a sharp rise sets in simultaneously with the fall in the *Polypodiacea* curve, and the further course of the *Pediastrum* curve is the inverse of the *Polypodiacea* curve. The interpretation of the course of these curves must be that the advance of the reed swamp at a certain time halted, and was later resumed. The reason for this may have been a rise in the water-level. This drove the *Thelypteris palustris* away from some of the places where it had been growing, and the new growing places may possibly have been further away from the open lake.

In the rest of the curves there is nothing to contradict this explanation. Thus the curve for *Alnus* reaches its maximum in the diagram simultaneously with the minimum in the *Polypodiacea* curve. A rise in the water-level will not harm *Alnus* where it has established itself, and will actually favour it in soil which was formerly too dry. As mentioned before, there is also an increase in the curves for *Salix* and *Betula* at this time. The curve fluctuations here described are also found, simultaneously, in the SURVEY DIAGRAM from P.28,30.

If the correctness of this interpretation should be questioned, we are fortunate in having in P.25 clear evidence of what really took place.

The abrupt course of the curves in Diagram P.25 can be satisfactorily explained by the "floating island" theory (TROELS-SMITH, 1951), and the factor on which this depends is a rise in the water-level. If, as suggested before, we imagine the layers 7–8 and 11 taken out of the sequence of layers, there will be a natural succession in the sediments and the curves of the diagram, though there will be small gaps due to erosion where the layers were taken out.

Above the calcareous mud, the upper part of which, as well as the usual transition layer, is lacking, probably on account of erosion connected with the formation of the floating island, there follows swamp peat, layer 9, as is the case in P.20. The destruction curve also supports this hypothesis, in that layer 9 in P.25, just as the calcareous mud immediately below, shows only very slight pollen destruction, while in layer 10 there is a very steep increase in the destruction, and this must certainly be original, as in the layer above (layer 11) the pollen destruction is far less. This layer, which pollen-analytically is clearly older than the layer below, layer 10, must be rebedded, and must be taken to be washed-up material, presumably formed at the time of the elevation of the "island", or immediately after.

The lower part of layer 7 (analysis 14) has almost the same pollen-analytical age as layer 11, and was presumably deposited at the same time. The pollen-analytical age of these deposits indicates that they are very much mixed with older material which was exposed and torn loose during the process of elevation of the "island". The generally uniform pollen spectra from layer 11 and sample 14 from layer 7 indicate that the deposition took place within a short period of time. The rest of layer 7 and layer 8 were then deposited in the gap between the calcareous mud and layer 9 by being washed up and by oozing in. Simultaneously with this filling-up, layer 12, and possibly parts of layers still higher up, were deposited in the normal way.

The very rainy summer of 1954 offered many possibilities for observing the formation of a "floating island" in all its stages. In the big peat cuttings in Aamosen dating from the first war years (1939–1943), which had been entirely emptied of peat and gyttja, so that the calcareous mud lay bare, a luxuriant swamp vegetation grew up in the course of the following years, as the cuttings were full of water during the winter and spring, while they were normally dry during the summer and early autumn. In 1954 water stood in the cuttings even in early summer, but not till August, when the level of the water had risen more than 1 m, which is far above the usual winter high water mark, did the newly formed swamp peat layer break loose from the mud, and extensive "floating islands" were formed. Washed-up material was common during all stages of the rise in the water-level.

In 1955 conditions were again normal, and when digging in the parts where there had been "floating islands" in 1954 took place, the thin, black layers of gyttja deposited under the "floating island" were easily recognized between the white calcareous mud and the root- and rhizome-filled swamp peat layer.

In spite of the agreement between deposits in P.25 at Verup and fossil and recent "floating islands", we should consider other possible interpretations of the strange succession of layers and courses of the curves in P.25.

Let us then first presume that layers 7 and 8 are primary deposits in natural succession to layer 6, and see what the consequence of this would be.

The layers above (9, 10, 11, and 12) would then have been deposited at a time very close to zone border VI–VII, and according to their age would be a secondary deposit.

If these layers were washed up gradually, the substance would derive from different places and presuppose very deep erosions. The swamp peat layers 9 and 10 can, however, not have been formed by a gradual wash-up, but must, if they are secondary deposits, have come, in bulk, to the place of deposit.

A land-slide of the whole sequence of layers from a higher level is unlikely according to the knowledge we have of the inclination of the layers and of the ground.

That the wind and current should have carried the layers in question afloat – in a body – from another place is conceivable, and is possible from a physical point of view. This presupposes, however, a considerable rise in the water-level.

Only the latter possibility looks at all plausible. We have, however, no direct observations to support it, and the artefacts found in the different layers definitely contradict it (cf. the archaeological profile, Pl. XX).

We must, therefore, conclude that layers 7 and 8 were deposited in P.25 after layers 9 and 10, and that they are thus not primary deposits in the real sense.

If there should be objections to the suggestion that layer 11 is a washed-up deposit, the kind and age of the sediments only leave one other possibility, namely that it is a washed-in secondary layer on the lines of layers 7 and 8. This theory would presuppose that layer 12 is a "floating island" layer like layers 9 and 10. Layer 12 is, however, a layer of relatively high specific gravity, as it contains many drift constituents, and has a heavy content of mineral material (flint and sand). It is therefore not likely that it formed a floating island.

Even if we presume this to have been the case, there is the question of timing to be taken into consideration. The lifting-up of layer 12, if it took place, must have occurred after the lifting-up of layers 9 and 10, as deposits of the same age as layer 12 have been found under these layers. A possible elevation of layer 12 while layers 9 and 10 were still afloat is unlikely, when we take into consideration the fact that layer 12 has a greater specific gravity than layers 9 and 10, and has consequently less buoyancy. The elevation of layer 12 can thus, for chronological reasons, hardly have taken place in connection with the rise in the water-level we are discussing. Elevation by a possible later rise in the water-level would make the greater age of layer 11 even less explicable.

A characteristic feature of all the "floating islands" so far investigated is that the material washed in is younger than the layers beneath and above. This fact seems definitely to disprove the supposition that layer 11 could be a washed-in layer under a "floating island".

Taking these points into account, the most likely interpretation seems to be that layer 11 is washed-up material deposited simultaneously or immediately after the elevation of layers 9 and 10.

The formation of the "floating island" and the consequent rise in the water-level at Verup must thus be taken to be a fact, but the problem is to decide with reasonable accuracy when the elevation took place, and how long it lasted.

According to the profile (Pl. XIX) and the Survey Diagrams from P.25 (Pl. VII) the elevation must, in view of the above discussion, have taken place at a time between the highest analysis in layer 10 (No. 23) and the lowest analysis in layer 12 (No. 28), i.e. inside the period when the curve for the Mixed-oak-forest in the Survey Diagrams increases from about 35% to about 45%. There seems to be no possibility of narrowing this interval down further. The sedimentation under the "floating island" no doubt began immediately after the elevation, but the bottom sample in layer 7 (No. 14), the time of deposition of which it would be essential to know, is obviously very much mixed up with older material, and thus can not help us. It is, however, likely that the sample above (No. 15) is uncontaminated, even though possible contamination cannot be excluded, and it is therefore fairly probable that the time of the elevation is earlier than the pollen-analytical age of this sample, i.e. at a value for the curve for Q.M. in the Survey Diagrams of between about 35% and 40%.

In P.33 this value for the curve is at analysis 20, and if we follow this level through the Survey Diagram, it seems that we find ourselves immediately before the fall in the curve for *Polypodiaceae* sp. and at the beginning of the rise in *Pediastrum*. The curves for *Limnophyta* and *Terriphyta* indicate that the rise in the water-level began a little earlier, but not until between analyses 19 and 20 reached such a height that the formation of the "floating island" could take place.

In P.28,30 the corresponding level is on the border between layers 11 and 12. In this diagram we are at this time far from the decline in the curve for *Polypodiaceae*, while the curves for *Pediastrum*, *Limnophyta* and *Terriphyta* agree very well with the corresponding curves in P.33.

In Diagram P.20 there are no analyses for this time, but less pollen destruction in samples 21 and 22 might indicate more moisture in the period just before the elevation.

In the diagram for the large flint pick (Pl. XII) the level in question is at the border between layers 4 and 5, and it can be seen that the curve for *Polypodiaceae* is here near its peak, while the *Pediastrum* curve is rising steeply.

To establish the end of the "floating island" stage, we must again turn to P.25. The highest analysis (No. 19) in the washed-in layer 8 in P.25 gives the time when the island was still afloat. As possible mixing with older material cannot be altogether excluded, the floating island could have existed, as such, for some time yet, but we get at least an approximate terminal date for the "floating island", and the maximum rise in the water-level cannot have occurred much later than the time indicated by analysis 19 in P.25.

This analysis gives us the approximate time for the closing of the "gap" under the "floating island", but the rise in the water-level may well have reached its peak earlier, as, here again, we must take into account both "isostatic" and "eustatic" agents. The closing could thus have been caused solely by the deposition of layers 7 and 8, but could also have been the result, partly of this sedimentation, and partly of a sinking of the "floating island" due to the lowering of the water level.

The approximate terminal date for the "floating island" stage can thus be established with reasonable certainty, and if we base it on analysis 19 in P.25, it must have occurred at the point when the curve for Q.M. in the SURVEY DIAGRAM has a value of about 65%.

If we now return to the other points of the section, there is only P.33 and P.28,30 with which comparison can be made. In P.33 analysis 27 corresponds in age with this period, and if we follow this analysis along the different sections of the SURVEY DIAGRAM, we reach the series of changes in the courses of the curves mentioned above. The marked fall in the *Corylus* curve has just begun, and we have the simultaneous rise in *Betula* and *Alnus*. The *Polypodiaceae* curve we here find at a marked minimum, while the curve for *Pediastrum* has just reached its peak. We get the impression from trends in the curves, that a rise in the water-level culminates at this time, or a little earlier. This hypothesis is supported by the fact that layer 10 is less humified than the surrounding layers, and thus was presumably deposited under moister conditions than they were.

As mentioned before, it is difficult to see whether the rise in the water-level was succeeded by a fall in the water-level, as the continous filling-up from the shore manifests itself in the same way as a fall in the water-level. The sudden and violent rise in the curve for plants from the moist soil at the top of P.33 (analyses 30–31), however, seems to indicate that a fall in the water-level took place.

The impression we get from the MAIN DIAGRAM for P.28,30 (Pl. IV) is that we find ourselves in an area near the shore, where a vigorous filling-up is under way, and that sedimentation is taking place relatively rapidly. Section I of the SURVEY DIAGRAM shows a rather more detailed picture. With the interpretation of P.25 in mind, it might be natural to interpret the part of the stratification covered by analyses 24–27 in P.28,30 as a "floating island", and analyses 19–23 as a washed-in layer.

This interpretation, however, runs into difficulties both as far as the sediments are concerned, and when the problem of time is considered. There are thus no boundaries between layers – these are, by the way, very indistinct in this profile – which correspond to the jumps in the curves. The formation of a "floating island" moreover always occurs – as so far observed – when a pronounced and slightly humified swamp peat with great buoyancy is lifted up from a bed free of, or very poor in, swamp peat. Similarly, the washed-in layer is always very deficient in swamp peat constituents. In P.28,30 there is a gradual increase in the swamp peat content of the deposits from the calcareous mud and upwards, and in all layers there are considerable quantities of gyttja or a greater or smaller drift content.

If we furthermore assume that analyses 19–23 in P.28,30 represent a washed-in layer, and compare it with a corresponding layer in P.25, it can be seen that the "gap" under the "floating island" closed at an earlier time than in P.25, which is extraordinary, as, judging from all the observations, it is probable that P.28,30 was closer to the open water than P.25.

It therefore seems more likely that the deposits we are considering are formations which were continuously deposited near the shore, characterized, at certain levels, by re-deposited older material, and that this was caused by the gradual rise in the water-level.

Apart from analyses 24, 28 and 29, the courses of the curves in P.28,30 are in good agreement with those in P.33. The curves for *Polypodiaceae* and *Pediastrum* correspond in time in the two diagrams, and both the slighter humification of layer 13 and the destruction curve indicate that the water-level was higher just before the zone border VI–VII.

As a result of these observations and reflections it can be seen that after the Boreal drying up in zone V in the Verup area, an increase in moisture set in, which gradually reached a point at which a "floating island" was formed (presumably before the middle of zone VI). It can furthermore be established that the maximum height of the water-level occured near the end of zone VI.

As it is of very great importance to verify these results, a profile of another locality near the shore at Aamosen was investigated. This is the profile from the Maglemose settlement at Ulkestrup: Ul.Ø.; S.13,00; V.6,25 (Pls. XIII–XIV).

The natural explanation of the stratification in the profile and the curves of the diagrams is, as mentioned before, a "floating island" formation.

The difficulty here, as at Verup, is to determine the times when the "floating island" stage began and ended. The only clue we seem to have is the age of the washed-in layers 3, 4, and 5. If we disregard the lowest analysis (No. 7) in layer 3, which, according to all the indications, consists of mixed-up material, all the pollen spectra in the washed-in material are strikingly similar, which might indicate very rapid sedimentation. Provided that the washed-in material is not mixed with older material, we can conclude from the curves of the SURVEY DIAGRAMS that the raising of the "floating island" at Ul.Ø. cannot have taken place before the curve for Q.M. had reached a value of 20–25%, i.e. apparently before the rise at Verup.

The case is not, however, as simple as this.

From the profile description it appears that layer 4 is a drift gyttja, which in its lower part contains traces of culture in the shape of flint and charcoal. Layer 4 is sharply differentiated from the layers below and above, which consist of *Cyanophycé* gyttja. Two interpretations of this stratification and the corresponding courses of the curves are possible:

1) Layers 3, 4, and 5 were being deposited continuously, the sediment in layer 4 being of a different character because it was deposited when people were settling on top of the "floating island", or

2) Layers 3 and 5 form a continuous deposit which filled the "gap" under the "floating island" completely. Later a new lifting took place, when layer 5 was also raised, and in the new space between layers 3 and 5, layer 4 was deposited.

The latter theory is supported by the fact that layer 4 shows considerable destruction and very high percentages in the *Polypodiaceae* curve. These both indicate a later period when compared with the curves in the upper part of the diagram. Otherwise the upper part of the diagram gives no further information, either about the beginning of the raising or about the time of the maximum water-level.

Whether the lifting took place in one or in two stages the filling of the gap under the "floating island" was caused by rapid sedimentation, and it must be remembered that in these conditions considerable mixing with older material is probable.

We must therefore conclude that the formation of the "floating island" at Ul.Ø. took place in the first half of zone VI, either slightly before or at the same time as the lifting at Verup. But no new information about the time of the maximum water-level is obtainable from the Ul.Ø. diagram.

The variations in the water-level shown in profiles and diagrams from the areas near the shore, as might be expected, are not found in the sediments from the open lake, where the depth was too great for the fluctuations to influence the sedimentation. It is, however, not unlikely that the curves of the pollen diagrams may show fluctuations due to the changes in the water-level.

We can only expect to find the Boreal drying-up in zone V which we found in the areas near the shore in the diagram for Niløse; Baad I. The pollen destruction which was an important indication of this in the Verup area naturally does not occur in the Niløse Diagram, where no pollen destruction at all has been found. There seems, however, to be a decline in the curves for *Pediastrum* and *Limnophyta* at this time. This agrees with the Verup diagrams.

The formation of "floating islands" at Verup and Ul.Ø. seems, as we saw, to have taken place in the first half of zone VI. If we look, in the diagrams for Niløse; Baad I, and Aamosen; N.1,000; Ø.2,840; Bp Ib, for evidence of a higher water-level at this time, we do not find many noticeable fluctuations in the curves.

In the Niløse diagram there is a steady rise in the curves for *Pediastrum* and *Limnophyta* from the zone border V–VI upwards. Towards the middle of zone VI there seems to be a slight rise in the curves for *Populus* and *Salix*. It is possible that a rise in the water-level contributed to the sharp rise in the *Alnus* curve. Similar courses in the curves can be found, more or less clearly, in the diagram from Aamosen; N.1,000; Ø.2,840; Bp Ib.

If we turn to the sections of the diagrams corresponding in time to the maximum water-level at Verup, we find, as far as the trees are concerned, the same trend in the curves in the diagrams for the areas near the shore and for those away from the shore. There is a marked decrease in the *Corylus* curve, and a rise in *Alnus*, *Betula*, and *Salix*. At this level there also seems to be a last slight rise in *Populus* before it declines again.

At the top of the Niløse Diagram there is a fall in the *Pediastrum* curve, and a rise in the curve for *Terriphyta*. This may indicate that an overgrowing is approaching, and this could indeed have been favoured by a fall in the water-level.

Most of the fluctuations in the curves indicated here were presumably associated with changes in the water-level, but as far as the *Populus* curve is concerned a connection is not directly obvious.

We should also refer to former investigations in the Aamose basin dealing with the problem of fluctuations in the water-level.

In 1943 TROELS-SMITH pointed out that changes in the water-level in the Aamose basin corresponded with the BLYTT-SERNANDER climatic scheme, and supported this with examples from the different phases (TROELS-SMITH, 1943, p. 163).

According to his investigations a drying-up in the Boreal period, i.e. in zone V and VI (ex KNUD JESSEN), was succeeded by a rise in the water-level which set in at the beginning of the Atlantic period (zone VII a ex KNUD JESSEN). In the Sub-boreal period a second drying-up took place, which was succeeded by the humidity associated with the Sub-atlantic climatic deterioration.

Only the first rise in the water-level is of interest in this connection, and it is very clearly seen in a diagram from Hesselbjerggaard (TROELS-SMITH, 1943, pp. 160–61, see the attached map, Fig. 1, No. 1). According to TROELS-SMITH, the succession of layers at Hesselbjerggaard, starting at the surface, is as follows:

0.00 –0.565 m	Layer 5,	Humified peat
0.565–0.58 m	Layer 4,	Sand
0.58 –0.69 m	Layer 3,	Coarse detritus gyttja with remains of culture (flint, charcoal).
0.69 –0.82 m	Layer 2 =	Layer 3, but without remains of culture.
0.82 – ? m	Layer 1,	Sand.

Three analysed samples are available:
From layer 2, sample 1 (level 0,80 m below the surface) and sample 2 (level 0,70 m below the surface), and from layer 5, sample 3 (level 0,55 m below the surface; this is immediately above the thin layer of sand, layer 4).

A percentage calculation of the most important components of the diagram, worked out from the original analyses on the same basis as the present SURVEY DIAGRAMS gives the following values:

HESSELBJERGGAARD

Layer No.	2	2	5
Analysis No.	1	2	3
	%	%	%
Σ Q.M.	35	43	65
Betula/4	16	11	8,6
Corylus/4	49	47	26
Quercus	14	17	29
Fraxinus	0,80	1,3	2,1
Tilia	7,6	5,2	9,8
Ulmus	12	19	24
Σ I. (basic sum)	250,25	153	285,25
	%	%	%
Pinus/4	17	31	12
Alnus/4	11	6,6	19
Polypodiaceae sp.	51	84	75
Pediastrum	38	12	79

TROELS-SMITH's interpretation of profile and diagram is that an incipient overgrowing was interrupted by a rise in the water-level, when the narrow layer of sand (layer 4) was formed. Pollen-analytically he refers analyses 1 and 2 to zone VI (ex KNUD JESSEN), while analysis 3 lies on the border VI–VII a (ex KNUD JESSEN).

If the values in the table above are compared with diagram P.33, it appears from analyses 1–2 from Hesselbjerggaard, which represent layer 2, that this layer was formed at the same time as, or immediately after, the raising of the "floating island" at Verup, while analysis 3, from immediately above the thin layer of sand, shows that this layer was formed during the maximum rise in the water-level.

At Øgaarde (TROELS-SMITH, 1943, p. 148 ff.) there are also indications of a rise in the water-level at the end of zone VI, and this is also true of the diagram from Kildegaard II (TROELS-SMITH, 1943, p. 158).

For Magleø we have two diagrams (TROELS-SMITH, 1943, pp. 156–57), which TROELS-SMITH also interprets as indicating a rise in the water-level in zone VII a (ex KNUD JESSEN). After a re-calculation of these diagrams to make them comparable with the present diagrams, it turns out that the rise in water-level in question is in zone VII b (ex KNUD JESSEN), and is thus not identical with the rise in the water-level with which we are concerned. It will presumably correspond to the climatic oscillation later in the Atlantic period, mentioned by TROELS-SMITH in his publication on *Hedera*, *Viscum*, and *Ulmus*. However, further down in the two Magleø diagrams, there are indications of a rise in the water-level at the end of zone VI, though this can not be stated with certainty because of the insufficient number of pollen counted in each analysis, and the great distance between the samples taken.

We have thus from earlier investigations evidence of a rise in the water-level in the Aamose basin at the end of zone VI, i.e. one occurring at the same time as the maximum water-level at Verup established in the present investigation. On the other hand the rise in the water-level which caused the formation of the "floating island" at Verup 5 and in Ul.Ø. was not noted in the earlier investigations.

The picture we get of the conditions associated with the water-level in the Aamose in the Boreal and the beginning of the Atlantic periods, then, is the following: after a low water-level in zone V a gradual rise in the water-level set in at the zone border V–VI. In the middle of zone VI a stagnation occurred; but before this, "floating island"s were formed where the local overgrowth was suitable. Towards the end of zone VI the water-level rose to its maximum height, followed by a stagnation, or possibly a fall at the transition to zone VII.

Whether there were two separate rises in the water-level in the Aamose lake in zone VI, or whether it is a question of two phases inside the same general rise cannot yet be decided.

3. Climatic Oscillations

The climatic causes of changes in the water-level in a lake basin may partly be changes in precipitation, partly changes in the temperature. It is clear that an increase in precipitation associated with a fall in temperature will produce the maximum rise in the water-level, and a decrease in precipitation associated with a rise in temperature will cause the greatest fall in the water-level. Roughly speaking this means that an oceanic climate will lead to a higher water-level in a lake basin, and a continental climate to a reduction in the water-level.

If we look at the tables and diagrams for indications of more abundant precipitation, we have really only *Calluna* to refer to, as this plant seems to be more dependent on humidity in the air than on moisture in the soil (cf. GRAM & JESSEN, 1951, Vol. 3, p. 1043). In the diagrams for Niløse (Pls. XV–XVI) and Aamosen; N.1.000; Ø.2.840 (Pls. XVII–XVIII) a slight increase in *Calluna* can be observed for the period of time in question, but we cannot properly draw any strong conclusions from these slight fluctuations in the curve. We therefore have to turn to the other factor, temperature.

Post-glacial improvement in the climate is the main reason for the vegetational development described above in connection with the pollen diagrams presented.

As far as forest trees are concerned, immigration depends not only on climate, but also on their power of dispersal; their age of maturity also plays a considerable part in the speed of their immigration. The mass presence of

Corylus in the Boreal period is an example which is frequently given (cf. FIRBAS, 1949, Vol. I, p. 147 ff.; JOHS. IVERSEN, 1960, p. 9). Herbaceous plants with good dispersal possibilities should therefore be more reliable indicators of a climatic improvement than the more slowly reacting trees. *Cladium Mariscus* fulfils these conditions, as its place of growth gives it very favourable dispersal possibilities, both by water and by water birds. The biology and ecology of this species has been carefully investigated, and also its recent and fossil presence in Scandinavia (GUNNAR ANDERSSON, 1896; HOLMBOE, 1923; v. POST, 1925; HAFSTEN, 1956). It is probable that *Cladium Mariscus* occurred in Aamosen shortly after suitable climatic conditions were reached, as such an extensive basin with calcareous water undoubtably offered it an appropriate environment. In the Niløse Diagram (Baad I) its rational limit is at the zone border IV–V, but in one of the Verup diagrams (P.28,30) we find individual occurrences of *Cladium* even in zone IV. We thus have evidence that the Post-glacial climate had already considerably improved in the Pre-boreal period, and that it probably followed a parabolic curve (GAMS & NORDHAGEN, 1923, p. 293 ff.).

The even and concurrent courses of the curves in the diagrams from the open lake suggest that a slight climatic improvement took place in zone VI, though it was much less pronounced than the great and more sudden climatic improvement which introduced the Post-glacial period. In the most complete of the diagrams from the area near the shore (P.33 and P.28,30) the courses of the curves are more unstable: there is sometimes, for example, an alternation between stronger and slighter increases, with occasional stagnation. This need not indicate fluctuations in the climate, but may, among other things, be due to a changing rate of sedimentation. If, however, a temporary decrease in a curve occurs, which, but for this, is gradually increasing, or an increase in a curve otherwise on the decrease, this can not be due to varying rates of sedimentation, but must have other causes. The temporary increases in the *Populus* curve in the diagram for Aamosen; N.1.000; Ø.2.840, analyses 16–19 and 31–33, mentioned above, are examples of such a trend.

In the part of the diagram for the level immediately below the zone border VI–VII the characteristic courses of the tree pollen curves mentioned above can be seen, both in the diagrams for the open lake and in those for points near the shore (P.33 and P.28,30). In the diagrams for the open lake the curves for *Hedera* and *Viscum* show a pronounced minimum just here. In the Diagram Aamosen; N.1.000; Ø.2.840, *Viscum* pollen has indeed not been found at all in four consecutive analyses immediately below the zone border VI–VII (Pl. XVIII, analyses 33–36).

As *Hedera* and *Viscum* are very sensitive temperature indicators in this country because here they are at their climatic limit for flowering and germination, these curves are very remarkable (JOHS. IVERSEN, 1944 and 1960; TROELS-SMITH, 1960). If the fall in the two curves mentioned above is real, and not

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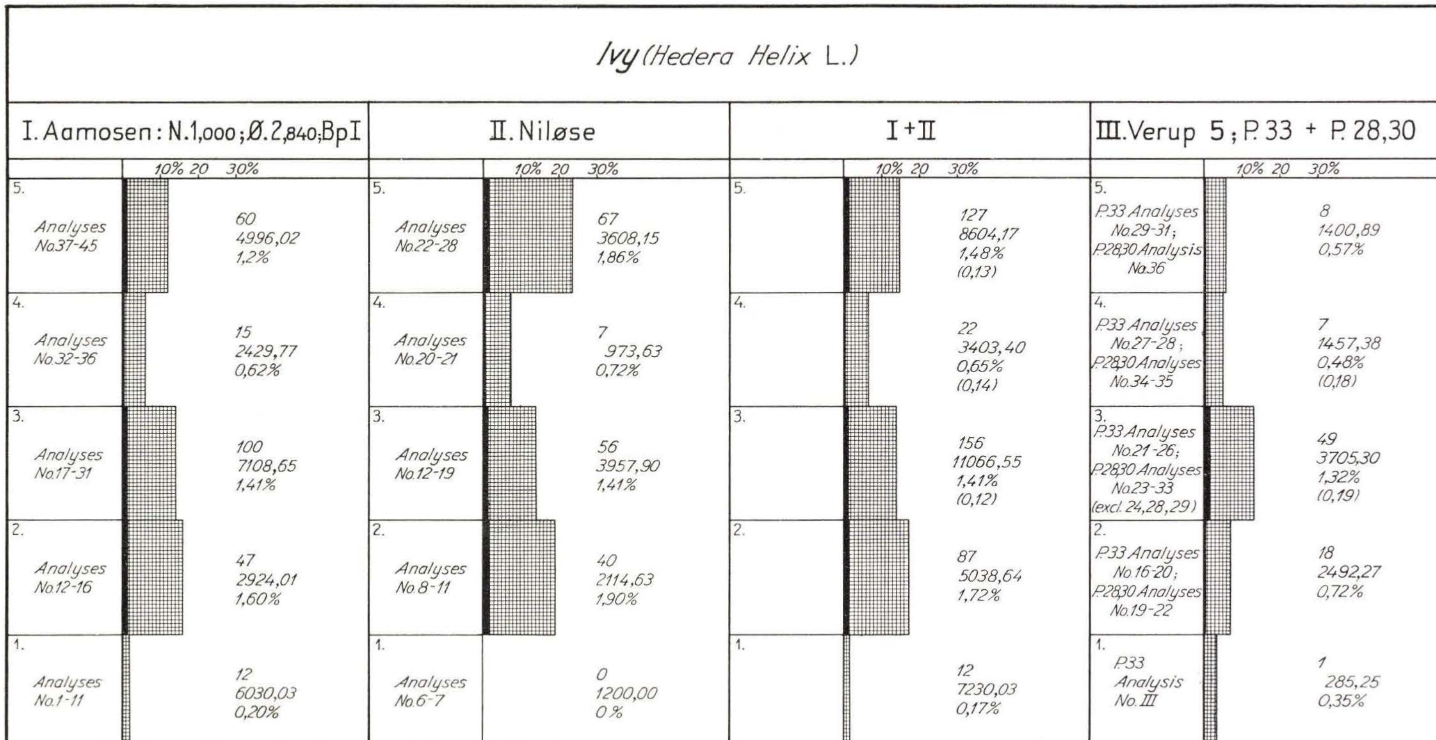

Fig. 3. Histograms showing the frequency of *Hedera*-pollen in Early Atlantic time in the Aamose district (see p. 50 and Pl. I).
Blokdiagrammer over forekomsten af *Hedera*pollen (vedbend) i tidlig atlantisk tid i Aamoseegnen.

due to statistical error, we here have proof of a fall, both in the winter and in the summer temperature at this time. This presumed fall in the temperature is likely to have set in somewhat earlier than is indicated by these curves, but did not until then reach values which had a decisive influence on these plants. It can also be presumed that the succeeding rise in the temperature set in before the increase in the curves for *Hedera* and *Viscum* is renewed. As the two profiles from the open lake agree both in sediments and in the courses and values of the pollen curves, the simultaneous fall in the curves of *Hedera* and *Viscum* in the two diagrams will be statistically tested.

Fig. 3 shows as histograms percentages of *Hedera* for different time intervals, which are well defined in the two diagrams.

Interval 1 covers the period from zone border V–VI (ex Sv. Jørgensen) to zone border V–VI (ex Knud Jessen), as the rational limit for *Alnus* must be considered to be synchronous inside the same basin (Aamosen; N.1.000; Ø.2.840, analyses 1–11; Niløse; Baad I, analyses 6–7).

Interval 2 covers the period from zone border V–VI (ex Knud Jessen) to the point in the Survey Diagrams where the curves for *Corylus* and Q.M. intersect. The uniformity of the diagrams allows us, in this case, to consider the level mentioned as contemporaneous in the two diagrams (Aamosen; N.1.000; Ø.2.840, analyses 12–16; Niløse; Baad I, analyses 8–11).

Interval 3 covers the period from this demarkation to the point in the diagrams where the marked fall in the *Corylus* curve begins (Aamosen; N.1.000; Ø.2.840, analyses 17–31; Niløse; Baad I, analyses 12–19).

Interval 4 covers the period from the above to the zone border VI–VII (Aamosen; N.1.000; Ø.2.840, analyses 32–36; Niløse; Baad I, analyses 20–21).

Interval 5 covers the rest of the diagrams (Aamosen; N.1.000; Ø.2.840, analyses 37–45, Niløse; Baad I, analyses 22–28).

At the side of each block in the histograms three figures are given, the top one gives the number of *Hedera* pollen, the next the basic sum used, and the bottom one the calculated percentage. The two histograms, I & II, as can be seen, agree closely. In the third histogram, which has been calculated on the basis of the total number of pollen grains in the material from both localities, the figure in parenthesis below the three values gives the standard deviation of the calculated percentages. The calculation has been carried out according to the formula:

$$\text{Standard deviation} = m = \sqrt{\frac{(100 + p) \times p}{n}}$$

where p is the percentage in the pollen diagram, and n is the total number of pollen grains in the basic sum.

The probability that the calculated percentages are significantly different depends on the ratio:

$$\frac{p_a \div p_b}{\sqrt{m_a^2 + m_b^2}}$$

where p_a and p_b are pollen percentages and m_a and m_b are the standard deviations.

If the figures from intervals 5 and 4 are substituted in the formula, the ratio becomes:

$$\frac{1{,}48 \div 0{,}65}{\sqrt{0{,}13^2 + 0{,}14^2}} = \frac{0{,}83}{0{,}19}$$

Since $0{,}83 > 4 \times 0{,}19$, the statistical probability that the true percentages are different is more than 99,96%.

For intervals 3 and 4 we get:

$$\frac{1{,}41 \div 0{,}65}{\sqrt{0{,}12^2 + 0{,}14^2}} = \frac{0{,}76}{0{,}19}$$

and since $0{,}76 = 4 \times 0{,}19$, the statistical probability that the true percentages are different is more than 99,96%.

The histograms in Fig. 4 show the presence of *Viscum* for the same periods. A probability calculation for *Viscum* gives:

For intervals 5 and 4:

$$\frac{0{,}44 \div 0{,}11}{\sqrt{0{,}08^2 + 0{,}06^2}} = \frac{0{,}33}{0{,}10}$$

Since $0{,}33 > 3 \times 0{,}10$, the probability in this case is more than 99,7%.

For intervals 3 and 4:

$$\frac{0{,}32 \div 0{,}11}{\sqrt{0{,}06^2 + 0{,}06^2}} = \frac{0{,}21}{0{,}09}$$

$0{,}21 > 2 \times 0{,}09$, i.e. a probability of more than 95,5%.

These calculations show that a possibility that the minimum shown in the two curves is due to statistical variations can be excluded. According to IVERSEN's investigations on *Hedera*, *Viscum*, and *Ilex* (JOHS. IVERSEN, 1944) the simultaneous decrease in the pollen curves of both *Hedera* and *Viscum* should indicate a general fall in temperature. In a paper on *Hedera*, *Viscum*, and *Ulmus*, TROELS-SMITH (1960) points out a decline in the occurrence of *Hedera* and *Viscum* when the first signs of farming appear, and thinks this is due to the fact that these plants were used as fodder.

The conclusion drawn by TROELS-SMITH from his investigations is that the occurrence of *Hedera* and *Viscum* is not determined by climate alone when the first farmers have appeared.

It is difficult to imagine what use the Mesolithic hunter-fisher folk could

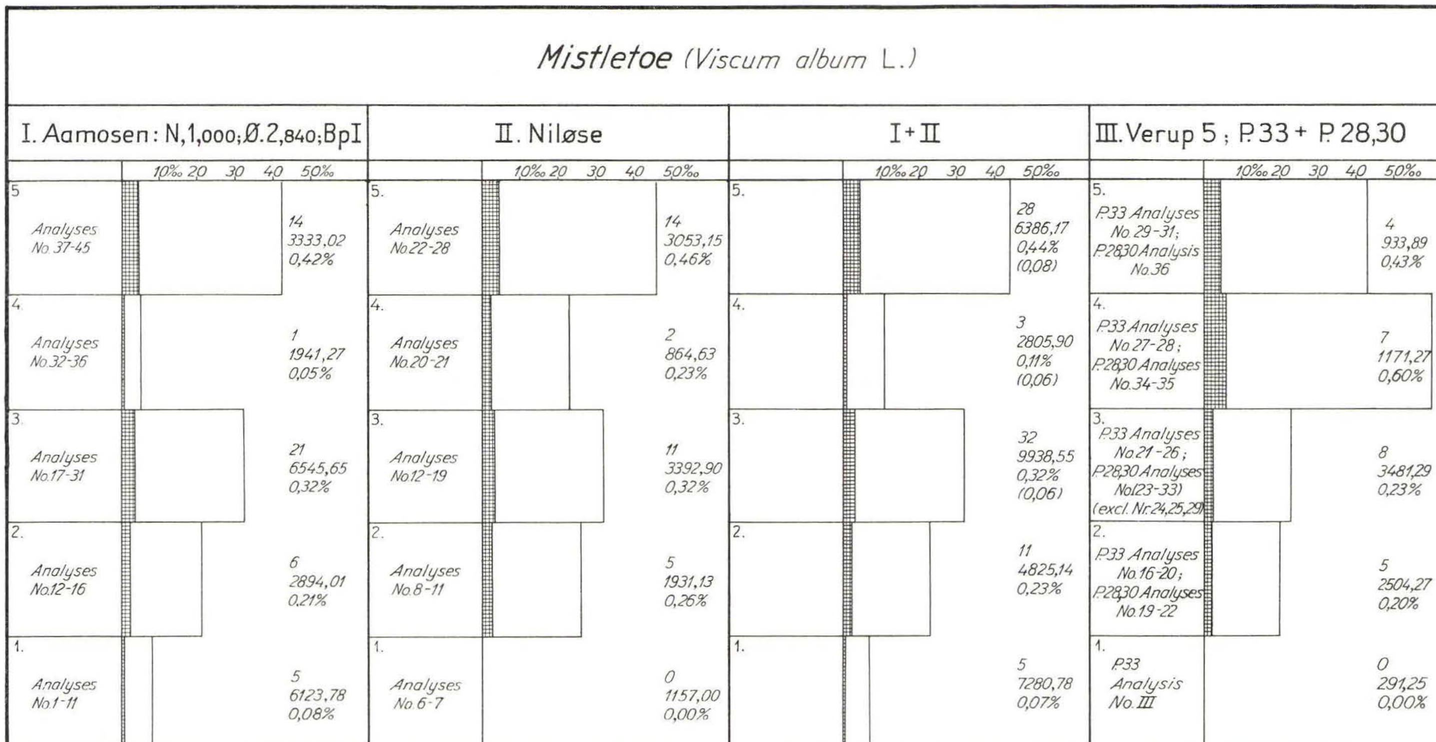

Fig. 4. Histograms showing the frequency of *Viscum*-pollen in Early Atlantic time in the Aamose district (see p. 50 and Pl. I).
Blokdiagrammer over forekomsten af *Viscum*pollen (mistelten) i tidlig atlantisk tid i Aamosegnen.

have made of these plants. They can hardly have been used as food, but it is possible that even then it was known that bird lime could be made from mistletoe berries. The consumption can, however, hardly have been great, considering the small population, and finds of bones from small birds are not known from Mesolithic settlements[1]). Whether these plants were used in cult activities must remain hypothetical. All things considered it must be unlikely that the presence of *Hedera* and *Viscum* was affected by human interference, and we can thus consider them reliable indicators of the climate.

We can appropriately investigate whether the curves of *Hedera* and *Viscum* show the same characteristic courses in the areas near the shore as in the diagrams for the open lake. The results are shown in the fourth histogram (Figs. 3–4). In the material which represents Verup 5, only analyses from P.33 and P.28,30 are included; analyses 24, 28, and 29 from P.28,30 are, however, excluded as suspect because they are possibly mixed with older material. Nor is analysis 18 from the same diagram included, as it comes from below the zone border V–VI. P.33,I is, on the other hand, included, even though it does not derive directly from Diagram P.33.

When assessing the histogram P.33 + P.28,30 the following must be taken into consideration: as the rational limit for *Alnus* here corresponds to the zone border V–VI, interval 1 is only represented by analysis P.33,I.

Because of the sparseness of the material the statistical accuracy is only adequate in a single case (*Hedera*, interval 3–4) for drawing conclusions about real differences. The fact that the deposits come from a zone near the shore, where supply of macroscopic material and insufficient mixing make the material heterogeneous causes additional uncertainty. The fact that in P.33, interval 4, for *Viscum*, 21 slides altogether coming from only two samples were counted, can be mentioned as an example. *Viscum* was found in only two of these slides, and they were from the same sample. In one of them 4 *Viscum* pollen grains were found, in the other 2. This is an altogether exceptional distribution, and must, no doubt, be due to macroscopic admission. If the 6 *Viscum* pollen grains in this sample had been counted as one find, there would have been very close agreement between this and the other histograms for *Viscum*, as the *Viscum* percentage then would have been 0,17 instead of 0,6.

With respect to the *Hedera* curve the following calculation of the statistical probability for intervals 3 and 4 can be made:

$$\frac{1{,}32 \div 0{,}48}{\sqrt{0{,}19^2 + 0{,}18^2}} = \frac{0{,}84}{0{,}26}$$

$0{,}84 > 3 \times 0{,}26$, from which it follows that there is a probability of more than 99,7 % of there being a difference in these two percentage values.

[1]) The smallest birds known from Mesolithic inland settlements are the jay (*Garrulus glandarius* L.) and the black woodpecker (*Dryocopus martius* L.) (H. Winge, 1903, p. 103).

We have thus, according to the histogram for Verup, a similar indication of a decrease in *Hedera* at the end of zone VI as in the histogram for the open lake. The increase at the zone border VI–VII is not found near the shore, but we must not overlook the fact that in interval 5, in particular, there is heavy pollen destruction in P.33 and P.28,30.

It must, however, not be forgotten that, but for this, the agreement between the Verup diagrams and the two diagrams for the lake is so good, that we can justifiably consider that there is a correlation between them; and even though the climatic change at the end of zone VI, which is so clearly seen in the curves for *Hedera* and *Viscum* in the Aamosen; N.1.000; Ø.2.840 and Niløse; Baad I diagrams, does not show up so clearly in the corresponding curves in the Verup diagrams, there is more than a suggestion of it.

We can therefore justifiably interpret the courses of the curves at the end of zone VI, in the Verup diagrams as well, as the result of a temporary climatic deterioration. We know that there was a general fall in the temperature, though we have no certain clues as far as precipitation is concerned.

Beside the statistically certain fall in the curves for *Hedera* and *Viscum* in interval 4 of the histograms for Aamosen; N.1.000; Ø.2.840, and Niløse; Baad I there are other features which seem extraordinary, though they may be accidental. Interval 1 of the histograms shows that *Hedera* and *Viscum* are only sparse during this period. From the pollen tables it can be seen that the two plants immigrate at about the same time into the Aamose area. Interval 2 shows an increase, both in *Hedera* and *Viscum*, and this continues for *Viscum* in interval 3, while *Hedera* here decreases.

If these steps in the curves express real differences in the occurrence of *Hedera* and *Viscum*, the reasons may be biological or climatic. It may be that the rise in the *Viscum* curve is slower than in the *Hedera* curve for biological reasons, but this does not explain the decline in *Hedera* in interval 3, as there can hardly have been any question of competition of any consequence between the two plants, neither as regards host plants nor as regards light. If, on the other hand, the climate were more continental in interval 3 than in interval 2, this would explain the changes in the curves.

The curve for *Cladium Mariscus* seems in some cases to support this hypothesis. For the shore zone we only have Diagram P.28,30, and here we have a *Cladium* curve (SURVEY DIAGRAM P.28,30, XIV), which is identical with that of *Hedera*, but for the fact that *Cladium* immigrated before *Hedera*. In the diagram for Niløse; Baad I there is a similar parallelism, while the diagram from Aamosen; N.1.000; Ø.2.840 is less clear. As far as *Cladium* is concerned we must however be careful when interpreting the curves, as its presence may have been conditioned by purely local factors. Its pollen dispersal was also apparently fairly poor.

As *Cladium* does not thrive in hard winters, the courses of the *Cladium* curves just mentioned can, with certain reservations, be used as an argument to support the suggestion that a more continental climate obtained in interval 3 of the histograms. In interval 3 the rise in the *Populus* curve in the SURVEY DIAGRAMS from Aamosen; N.1.000; Ø.2.840 and Niløse; Baad I also sets in. This rise is maintained in interval 4.

We can, then, imagine the climate in the period covered by pollen zone VI to have been as follows:

The rise in temperature in the Post-glacial improvement in the climate continued slowly and gradually until the middle of zone VI. It is possible that from there the climate became more continental, with warmer summers and colder winters. Towards the end of zone VI a temporary general fall in the temperature took place.

At the beginning of zone VII the temperature again gradually rose and to its optimum in the Post-glacial climatic improvement. At this time the forest reaches its climax, the curves for *Hedera* and *Viscum* again rise sharply, and it should be mentioned that at the beginning of zone VII a find of *Ilex Aquifolium* has been registered in both the diagrams for the open lake.

In zone VI a sinking of the country set in. The North Sea was formed, sounds and belts came into being, and it thus seems likely that there was an increase in the precipitation through zone VI. This would cause a rise in the water-level inland, which, however, would be retarded, or possibly halted during the presumed continental period at and after the middle of zone VI, as greater evaporation made for an increase in precipitation. Towards the end of zone VI the general fall in temperature would cause less evaporation, and in connection with the increase in precipitation gave the maximum rise in the water-level inland. The general rise in the temperature at the beginning of zone VII would arrest this rise in the water-level, and possibly even lower it.

As climatic changes presumably are the main causes of the fluctuations in the water-level in the Aamose basin in zone VI, similar variations should be found in diagrams from other localities.

In a diagram from Even Sø; Bp.21 (MIKKELSEN, 1949) these same phenomena can be found in the sediments and in the pollen diagram. Layer K in this profile consists, according to the description (p. 59), of a highly humified *Cladium* peat underneath, onto which a less humified *Phragmites* peat has been superimposed. Pollen-analytically the investigator refers the *Cladium* peat to zone VI and zone VII a (ex VALDEMAR MIKKELSEN), while the *Phragmites* peat was deposited later in zone VII a (ex VALDEMAR MIKKELSEN). In the pollen diagram a marked retardation in the curve of the MIXED-OAK-FOREST can be seen just at the transition between these two deposits, and simultaneously a sharp fall in the *Corylus* curve sets in. Neither *Hedera* nor *Viscum* pollen was apparently present at this level. This fact must however be treated with reservation considering the small pollen total. MIKKELSEN suggests that the change in the sediment and the humification found here are due to increased moisture ("rising water-level") at the beginning of the Atlantic period. There is unfortunately a lacuna in the diagram immediately above the *Phragmites* peat, so that the natural course of the curves can not be followed into the Atlantic period.

In IVERSEN's diagram from Søborg Sø (1937 a) one can, in spite of the uneven courses of the curves, find the same retardation in the curve of the MIXED-OAK-FOREST in zone VII a (ex KNUD JESSEN). In time it corresponds to the lake stage between fjord periods I and II in Søborg lake, which is the same as the regression between the Early Atlantic and the Full Atlantic transgression of the Littorina sea.

TROELS-SMITH (1956) has advanced the theory that corresponding to the transgressions in the Littorina sea the bogs were drying out, and with the regression phases at the coast there were rising water-levels inland. The temporal correlation between the rise in the water-level in the Aamose basin, and the lake stage between the two first fjord periods in Søborg Sø just mentioned supports this theory. If climatic fluctuations are assumed to be the chief cause of the transgressions of the Littorina sea, as a rise in the temperature would bring about a more vigorous melting of the glaciers and would thus cause a higher water-level, while a fall in the temperature would mean that more precipitation was tied up in the great glaciers which would result in a lowering of the surface of the ocean, the changes in climate and water-level with which we are concerned fit into the picture. If looked for carefully, the two later regression phases can undoubtably be recognized inland as rises in the water-level. But probably only the first two of the three rises in the level inland can be demonstrated as climatic fluctuations in the pollen diagrams, as agriculture will now affect the curves in the diagrams, and preventing the Atlantic-Subboreal climatic oscillation from showing.

4. Archaeological Evidence and its Dating

As the Verup diagrams come directly from a prehistoric settlement, it would be natural first to find out whether the life and activities of these hunting and fishing people left traces in the surrounding vegetation which can be recognized in the curves of the pollen diagrams or in the occurrence of particular species of pollen.

An examination of Tables I–VI and the corresponding diagrams is not, however, very profitable in this respect. Pollen from *Chenopodiacea* was previously considered to be an indicator of Mesolithic settlements inland (cf. JOHS. IVERSEN, 1941, p. 39; TROELS-SMITH, 1941, 1942, p. 191, and 1943; NILSSON, 1948, p. 10; V. MIKKELSEN, 1949, p. 19); but the presence of *Chenopodiaceae* pollen in the present material does not seem to have any connection with the habitation, and thus does not confirm this hypothesis. Nor is the suggestion that *Artemisia* was favoured by Mesolithic habitation (V. Mikkelsen, 1949, p. 19) supported by the present investigation. But *Lemna* may possibly have been favoured by the more nutritious water near a settlement (Samuelsson, 1934, p. 106; Johs. Iversen & Sigurd Olsen, 1943; Troels-Smith, 1955 b, p. 39). Tables I–VI, however, show that the occurrence of *Lemna* is so insignificant that it would be inadmissable to attribute any value to it as an indicator.

Urtica dioeca has, on account of its nitrophilous character, been put on the same footing as *Chenopodiaceae* as an indicator of Mesolithic inland habitation by Iversen (1949, p. 9), but it must also be remembered that it naturally belongs to a hydrosere.

In the two highest analyses for Verup 5, P.33 (analyses 30 and 31) we find mass occurrence of *Urtica* pollen. Unfortunately, however, none of the other series from Verup are in a fit state for analysis to a sufficiently recent date for us to be able to decide whether there was a luxuriant growth of nettles on the nitrogenous soil, or whether the unusual occurrence of *Urtica* pollen in P.33 is to be interpreted as a phenomenon connected with overgrowing. In the profile from Ul.Ø. there also seems to be an increase in the occurrence of *Urtica* pollen directly above the culture layer (analyses 29–30).

In three of the pollen series from Verup, as well as in the series for the large flint pick, pollen has been found which has been classed with *Carex* cf. *hirta*. Some botanists (Gram & Jessen, 1949, Vol. I, p. 237) consider that *Carex hirta* is a plant which is favourably affected when human activity causes changes in the natural vegetation. Six of the seven pollen finds of *Carex* cf. *hirta* in the Verup area (P.28,30, analysis 26; P.25, analysis 23; P.20, analyses 20 and 22, as well as analyses 3 and 15 from the great flint pick) can, from the temporal point of view, be referred to phases of habitation. The seventh is from P.28,30, analysis 14, i.e. from a level immediately above the secondary *Betula* maximum in zone V. From Ul.Ø. we furthermore have two finds of *Carex* cf. *hirta* (Ul.Ø., analyses 16 and 30), which may both belong to the period of habitation.

It is thus possible that Mesolithic habitation influenced the occurrence of *Carex* cf. *hirta* favourably.

As would be expected the curves of forest tree pollen do not react to the habitation.

Finds of seeds and fruits which might have been gathered by man have not been noted by the excavators, and in the sample material there are, apart from the oospores of *Characeae*, practically no finds of botanical macrofossils.

Considering the distance from the Mesolithic settlement under consideration, it is clear that the traces left on the vegetation by a rather small hunter and fisher population would not be found in the diagrams for areas some distance from the shore. The diagram Niløse; Baad I is taken from a point about 150 metres from the Verup settlement, and the curves for the plants considered to be indicators of Mesolithic inland habitation (cf. p. 56) do not seem to be influenced by the settlement at Verup 5. The presence of a pollen grain of *Plantago lanceolata* (analysis 25) is no doubt attributable to long-distance transport. From the knowledge we have of the settlements it can be estimated that the diagram Aamosen; N.1.000; Ø.2.840 is for a spot about 0.5 km from the nearest contemporary settlement. Table IX shows that *Urtica* pollen is more abundant in the lower part of the diagram than in the upper part. We cannot, however, in all cases, draw conclusions about habitation from the presence of *Urtica* pollen. In analysis No. 27 a single pollen of *Plantago lanceolata* was registered (long-distance transport).

Apart from the presence of a little charcoal dust, which in most cases presumably derives from human activity, no traces of culture were found in the parts of the two diagrams under discussion. It should be noted that the occurrence is sparsest in zone VII. This distribution agrees with the fact that we do not know of any settlement in the Aamose area which can be dated to this period. The dug-out and the earthen vessel which led to the Niløse investigation were found on such a high level that they are not included in the part of the diagram with which we are concerned. In short, the two diagrams for the open lake do not seem to give indications of reliable value about the habitation in the period covered by the diagrams.

We have, however, a considerable collection of artefacts from the Verup area. The archaeological work on these was undertaken by KNUD ANDERSEN (1961), and I shall here give only an account of the connection between the phases of the habitation and contemporary natural conditions, as these have been analyzed above. The disturbances in sedimentation, and therefore in the artefacts deposited, caused by the fluctuations in the water-level, will also be elucidated, making a relative dating of the different phases of the settlement possible.

The plan of the excavation (Fig. 2) shows when and how the excavation was done. The whole pollen-analytic-geological exposition rests on measurements, observations, and sample series from the western profile wall in the trial ditch P, which means that we are in the unfortunate situation of having only one geological cut, and that only a very fragmentary one, through the area of habitation (Pl. XIX). For this reason we cannot determine the course of the shore of the lake, which would have been a help in understanding the habitation.

Because of the method of excavation used we have no really systematically excavated artefacts from Verup, "systematically excavated" meaning that the position of each culture remain is registered to 1 cm in a three-dimensional co-ordinate system. Attempts at such a standard of excavation affect only part of the material found in the trial ditches P and Pv. Here we know, not only the square metre where they were found, but also the level. We do not, however, know the position of the finds inside the square. We cannot therefore draw a real profile for the artefacts, or place the individual finds in a geological profile.

In order to use the information on the distribution of the artefacts contained in the report on the excavation (VEBÆK, 1946) I have drawn an artefact profile (Pl. XX) based on these records. This has been drawn to the same scale as the geological profile (Pl. XIX). The profile construction was based on a zero axis drawn along the middle of each square metre. The number of finds from the different categories of culture remains is shown by different symbols in horizontal bars from this line at the level indicated in the list of finds. 0.5 mm is the size of a find unit. An explanation of the symbols is to be found with the profile. The level at which artefacts which have been pollen-analytically dated were found is also marked in the profile. Using the material found in Pv. four artefact profiles have similarly been drawn, two parallel with P., and two at right-angles to P. (Pl. XXI). In Pv. nivellations of charcoal have, however, not been taken.

The excavator in his report on the excavation says, that notes were made on the degree of patination of flint. This was not, however, done consistently, but the plan, Fig. 5, is based on the available information. This shows the degree of patination in each square metre, and also gives the square metres where finds of bones and/or antlers were made.

The report on the excavation also shows that a distinction was made between an "upper" and a "lower" culture layer, separated by a layer almost without finds. Some artefacts, though, were found here and there in this intermediate level, which could be referred neither to the "upper" nor to the "lower" culture layer, and for these cases an "intermediate layer" was introduced.

The artefact profile (Pl. XX) shows that the excavator could trace the "upper culture layer" from P.15 to P.25 and that it was uncovered along practically all of this length when the excavation took place. The pollen-analytic investigation has, however, shown that the "upper culture layer", in any case at P.25, is not a homogeneous, continuously deposited culture layer, but consists of three different deposits containing culture remains (layers 10, 11, and 12).

The "lower culture layer" can also be traced between these points, but is not distinctly demarcated upwards. Towards P.25 there is a trace of the so-called "intermediate layer", which can also be found at P.26. Further north the culture layers merge, so that no distinction can be made, though the uneven concentration of finds suggests that there are probably several layers.

In connection with the dating of the large flint pick, which was found near the settlement, KNUD ANDERSEN examined the artefacts discovered during the excavation of Verup 5 (cf. SV. JØRGENSEN, 1954, p. 166). In doing this he met with so many typological difficulties, that he came to the conclusion that rebedding of the material must have taken place, and suggested the possibility of a "floating island" formation. As at that time we had only the diagram for P.33, which did not give the slightest indication of this phenomenon, and as TROELS-SMITH had noticed nothing which might be interpreted in this way during the field investigations, the problem was not pursued. It can, however,

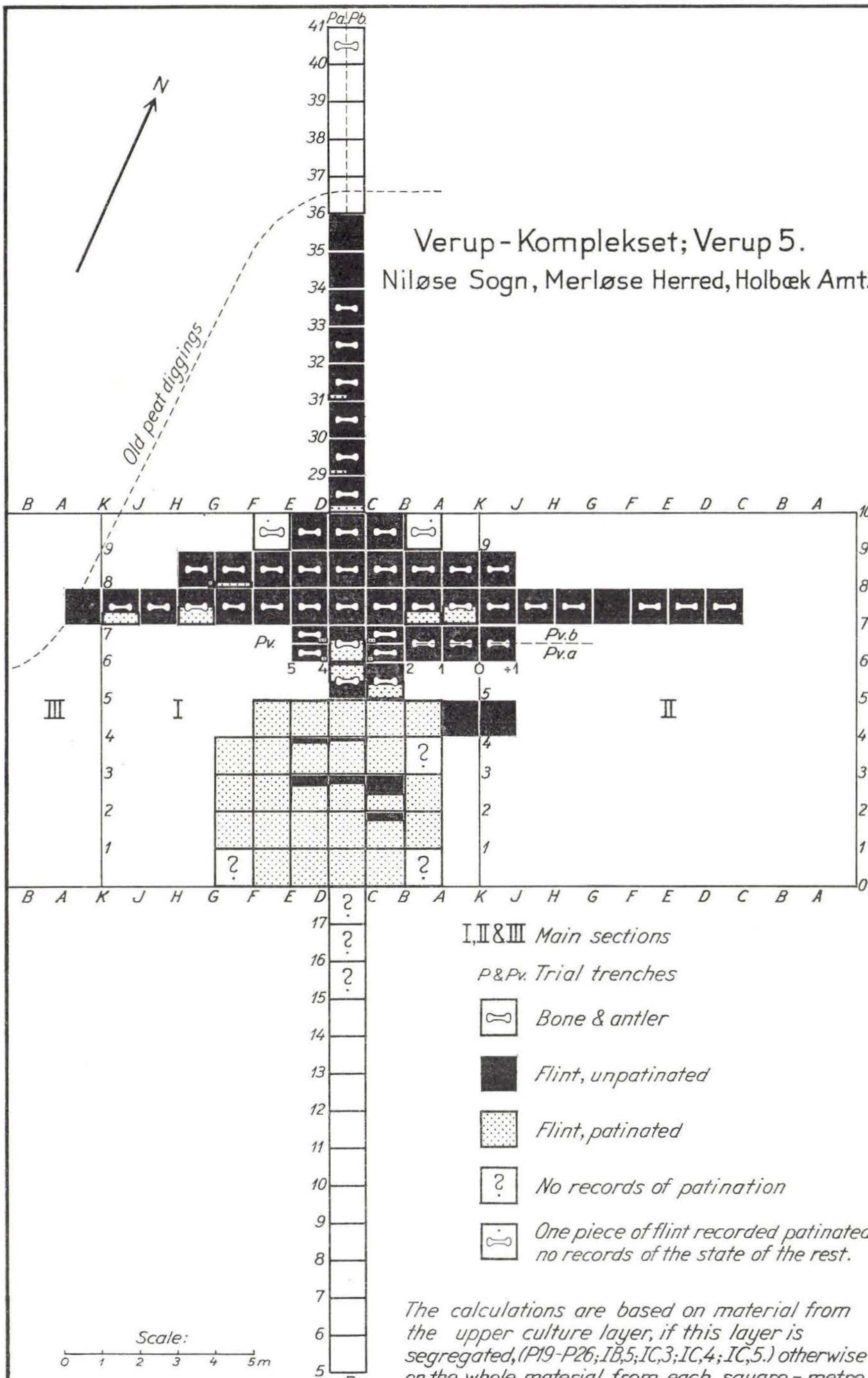

Fig. 5. Verup 5. Plan showing the distribution of unpatinated and patinated flint and where bone and antler survived.

Verup 5. Plan over fordelingen af upatineret og patineret flint samt de felter, hvor ben og tak er bevaret.

be observed, that at the time of the field investigation in Verup, the "floating island" problem was still unknown in bog geology in this country, and only the foresight shown by the investigator in the field in taking the great number of pollen series has given us the opportunity to establish and explain the problem as far as this settlement is concerned.

In Pl. XXII a series of profiles in general outline has been constructed, where the settlements have been placed in relation to geological development as interpreted in the foregoing. For the sake of clearness the sediment signatures have been greatly simplified. The profiles have been drawn up on the basis of the sediment descriptions and the pollen diagrams, as well as on the geological and archaeological profiles (Pls. XIX–XX). The culture remains noted are based on the presence of traces of culture in the section points examined, as well as on the single finds, to which individual pollen analyses are attached (cf. the SURVEY DIAGRAMS from P.33, P.28,30, and P.25).

The surface in profile I (Pl. XXII) is defined as the top of the calcareous mud in P.20 and the levels synchronous with this in the other section points, according to the SURVEY DIAGRAMS. The unbroken horizontal line marks the assumed water-level at the time. At P.20 and outwards to P.25 an overgrowing has set in, while in the rest of the profile calcareous mud is still being deposited. On this surface we find the first certain traces of culture. At P.20 charcoal and sand was found, and further north at P.28,30 an axe made of an elk antler has been found (P.29, I), and at P.33 a number of bones (P.33, I, II, III). These finds were made in the calcarous mud, and below the culture layers proper. We are in the fortunate position of having pollen samples for these individual finds, and the results of the analyses will be found below the SURVEY DIAGRAMS for P.33 and P.28,30 respectively. These finds all clearly belong to zone Vb, as does layer 9 in P.20, and we can thus relate the traces of the first habitation to the end of zone V. The artefacts found must be presumed to be refuse from a settlement at a higher level, still unknown. The artefact horizon is marked by an A.

The surface in Profile 2 (Pl. XXII) is synchronous with the zone border V–VI. It can be seen that the overgrowing was considerable in the southernmost part of the profile, while calcareous mud is still being deposited in the areas covered by water. At this time real habitation on the spot begins, and we get deposits partly from the settlement itself on the bog surface, partly refuse at the bottom of the lake on top of the calcareous mud. On land we find the artefacts, here designated by a B, incorporated in more or less humified swamp peat, while in the shore zone, and further out in the lake, they are found in swamp peat-containing drift gyttja.

The beginning of the settlement period has been fixed at the lower boundary of layer 10 in P.25. Here we happen to have a definite lower boundary. Whether the upper boundary can be considered as certain is more doubtful, as erosion and mixing in the deposition of layer 11 above could have occured, but by keeping the boundary here indicated we can be certain that only artefacts really belonging to this layer have been counted. The tooth bead found at P.30 (see Table V and Pl. XX) thus belongs to this culture layer.

Profile 3 (Pl. XXII) is intended to illustrate the end of the settlement period, which is marked B_1. Pollen-analytically this habitation can be dated to the older part of zone VI, and it occured during an increasing overgrowing of the lake basin here at Verup, and presumably during a slight rise in the water-level.

Up to now the stratification has been consistent, but in the fourth picture in the series of drawings (Pl. XXII, 4) irregularities set in.

Due to a higher water-level layers 9 and 10 in P.25 were lifted up and torn loose from layer 6, and a floating peninsula was formed, as shown in Profile 4 (Pl. XXII). As a result of this, older sediments were exposed and laid open to erosion. A mixed sediment of older and younger material thus resulted, with an intermediate pollen-analytic age. This sediment was deposited directly after the elevation, as the lowest part of layer 7, and as layer 11, in P.25. In the lowest part of layer 7 we would thus expect to find artefacts both from the culture horizon A, and from $B–B_1$. Layer 11 contains much charcoal and some sand, but only a few artefacts, which support the wash-up theory. Profile 5 (Pl. XXII) illustrates conditions after these events.

The rise in the water-level which led to the formation of the "floating island", also influenced the settlement, as the area at P.25 became too wet for habitation. The question then is: was Verup 5 abandoned altogether for some time, or did people continue to live here, though forced to move further south by the rising water. In the SURVEY DIAGRAM for P.20 it can be seen that the deposition of the upper culture layer, which is here at its thickest has started, after the deposition of layer 10 at P.25 ended – though how long after it is difficult to find out. Layers 13 and 14 at P.20 were, judging from the sediments and the pollen destruction, deposited under moister conditions than layer 12 below, and according to the pollen-analysis (P.20, No. 23) layer 14 at P.20 was deposited later than layer 10 at P.25. In layers 13 and 14 at P.20 no traces at all of culture were found. This is, however, not decisive proof of an interruption in the habitation.

If we look at P.25 there seems to be evidence of two settlements, as artefacts were found both in layer 10 and in layer 12, which are clearly separated in time. Layer 11, which was discussed above, was deposited in the earlier part of the time gap between layers 10 and 12.

Layer 12 was deposited in water or under wet conditions in a reed swamp, and can consequently not be a proper settlement layer. We must either imagine that the artefacts in the layer are primary refuse from a contemporary settlement on a higher level, or have been washed out from a deserted older settlement. A combination of these two possibilities is a third explanation. The first alternative is not supported by the degree of patination of the flint in the square metres P.24 and P.25 (cf. Fig. 5, and the artefact profile, Pl. XX). One would have expected an extremely sparse occurrence of patinated flint; but in the square metres in question about half the flint is patinated. The degree of patination would however fit both latter alternatives. That the sediment in P.25, layer 8, is finer than in layer 7, and that the culture remains in layer 8 consist almost exclusively of charcoal, may indicate that layer 8 was deposited after the end of the habitation. This supports the hypothesis that layer 12 was deposited partly at the same time as the habitation (the lower part of the layer), partly after the end of the habitation (the upper part of layer 12).

If the lower part of layer 12 in P.25 contains refuse from a contemporary habitation on a higher level, analysis 28 from P.25 will give the approximate date when this settlement began. In the square metre P.25 a leister prong was found during the excavation, and we have a pollen sample for this find (P.25, I). According to its level the object was found near the bottom of layer 11 (cf. Plate XX), but pollen-analysis (cf. the SURVEY DIAGRAM P.25, at the bottom) proves it to be of the same age, or slightly older, than analysis 28 for P.25. One can therefore infer that layer 11 at P.25 is very variable in thickness, and sometimes may not occur at all. The presence of artefacts in sections P.28,30 and P.33 gives no information about breaks in the habitation. In the lake, surf and current will cause litter to collect, and as charcoal can keep afloat for a long time, there may, though habitation has ceased, still be found some artefacts mixed up in the sediments (B_x).

In the two artefact profiles I, B 6 – I, B 7 and I, E 6 – I, E 7 (Pl. XXI) the presence of patinated flint at two horizons corresponding to the periods of habitation B–B_1 and C–C_1 may suggest that there was a period without habitation. An indication that there was an interruption in the settlement at Verup 5 in the first half of zone VI is found in the section for the large flint pick. The sediment column in the diagrams (Pls. XI–XII), as well as Table VI, show that mass occurrence of charcoal dust was registered in analyses 6, 7, and 8, which are, on the whole, contemporaneous with the settlement B–B_1 at Verup 5. In the following analyses (Nos. 9, 10, and 11) no charcoal dust at all was found, while in the rest of the diagram there was again a mass occurrence of it. As the place where the large flint pick was found is only 20–25 m from Verup 5, the charcoal dust referred to above must support the theory that there were two separate settlements at Verup 5 in zone VI.

Picture No. 6 in Pl. XXII gives the conditions at the time when the last settlement, C, began, and Picture 7 shows the end of this habitation. The latter is marked by C_1, and has been determined from the upper boundary of layer 9 in P.33.

The rising water-level is presumably the reason why the settlement was abandoned, and it gradually led to the erosion and rebedding of the material from the settlement. These rebedded artefacts are marked by C_x.

Profile 8 (Pl. XXII) illustrates the period when the "gap" under the floating island was completely filled. The top of the sediment is here fixed in time from the upper limit of layer 8 in P.25.

Finally, Picture 9 (Pl. XXII) gives the conditions at the beginning of the fall in the water-level shortly before zone border VI–VII. The artefacts which were rebedded while the water-level was falling are marked by C_{XX}. The reed swamp, however, favoured by the falling water-level soon spread over the area, followed by the alder peat swamp, as indicated by the highest deposits at section point P.33.

With respect to the shore line during the settlement $C–C_1$ we have not, apart from the information obtained from Section P, many facts on which to build. In Fig. 5, for each square metre of the excavated area, any finds of bones or antlers are indicated, and the relation between the number of patinated and unpatinated pieces of flint, expressed in percentages, is also given. It is quite clear from Fig. 5 that in the areas where flint is heavily or completely patinated, bones and antlers have not been preserved, and we are thus, in the actual settlement area, on a relatively dry bog surface. In the artefact profile (Pl. XX) it can be seen that the areas inside the settlement where unpatinated flint has been found are areas with a heavy culture layer. This was also noticed by the excavator (VEBÆK's report 1946). In the lake sediments bones and antlers have been preserved, and the patinated flint actually only occurs at an edge along the shore. The interpretation given, is, that it originates from secondary material washed out from the actual settlement layers. The patinated flint in the square metres P.29 and P.30 must, according to the level at which it was found, originate from the settlement $B–B_1$. The plan, Fig. 5, also shows that the areas which would have been decisive in clarifying the course of the shore line have unfortunately not been excavated.

From the artefact profiles P., Pv. (a & b), and Pva. (Pls. XX–XXI) it can be seen that a "floating island" did exist inside an area limited by the points P.23; I, E 6; I, E 7; P.26; I, B 7 and I, B 6 (cf. Fig. 2), but we do not know what its full extent was.

Another observation should be mentioned. According to the report on the find a big granite stone was found at P.25 (35 × 25 × 18 cm) (cf. Pl. XX). We do not know what its position in the square metre P.25 was, but the levels at the top and bottom of the stone show that it rested on the calcarous mud, and extended up through layers 7, 8, and 9, i.e. up into the old swamp peat. Though it is conceivable that it was carried to the spot by drifting ice, it is, however, more probable that it was carried to the settlement by man. But then to what settlement layer does it belong? It is inconceivable that such a big and heavy stone was washed in under the "floating island", and the stone must then either rest in its primary position in the old culture layer on the calcareous mud, or have sunk from the younger culture layers above. Its sinking through the felty swamp peat of the so-called "lower culture layer", layer 10, as well as through layer 9 below, presupposes a crack in the "floating island", which would allow the stone to sink through. We have several instances of such a phenomenon from other "floating islands" in Aamosen, but there we always find it associated with a deposit cone of sand, shells, artefacts etc. underneath the crack, and a trail of this material can be followed up through the crack. No such crack is noted in the report on the excavation, but a millimetre thin layer of sand with charcoal and fine flint chips was registered and its level noted in this square metre.

This layer of sand is, however, on the border between layers 7 and 8, and in this position it marks the end of the settlement C–C_1. It is therefore most likely that the stone belongs to the culture horizon in zone V, and that it remained in its original position when the elevation of the "island" took place.

In the pollen-analytical material we find no clues which could help us to decide whether the area was inhabited in both summer and winter. Finds of hazel-nut shells may indicate that people lived there in the early autumn. ULRIK MØHL, who has examined and identified the bone material found, could find no evidence that the place was inhabited in the winter half of the year. But teeth and bones from animals so young that a summer habitation could be deduced from them have not been found either. MØHL suggests that the presence of mallard (*Anas platyrhynchos*), shoveler (*Spatula clypeata*), coot (*Fulica atra*), and young heron (*Ardea cinerea*, juv.) indicate a summer and autumn habitation, as these birds leave lakes and streams when ice begins to form (cf. KNUD ANDERSEN, 1961, p. 132).

The situation of the settlement on boggy ground near the then shore of the lake places it in the series of late Maglemosian settlements in Aamosen, called swamp settlements by THERKEL MATHIASSEN, (1943).

The foregoing discussion gives us reason to assume that the area was used as a hunting and fishing ground for three separate periods inside a span of time stretching from the last part of zone V into the latter half of zone VI, i.e. the period in which the development of the forest changes from the relatively light and open Boreal PINE-HAZEL-BIRCH-FOREST to the dense and dark Atlantic MIXED-OAK-FOREST. The area was deserted twice in the course of this period for a longer time, perhaps because the conditions for habitation were unsatisfactory on account of increasing moisture, or because opportunities for hunting and fishing were better in other places. We must, however, not imagine that the place was visited every summer during the periods when it was in use. It is only that we cannot now recognize the intervals which there no doubt were in its use during the main periods.

It we compare the dating of the phases of the Verup settlements given here with the earlier dating (SV. JØRGENSEN, 1954, p. 183), we find considerable divergences. These differences are not based on the pollen-analytic examination, but are due to a changed interpretation of the occurrence of the culture remains. The presence of charcoal at the top of Section P.33, which in 1954 was considered to be contemporary or identical with the "upper culture layer", has in the present examination been interpreted as secondary material deposited only after the settlement had finally been abandoned and deserted. The "lower culture layer" in the 1954 investigation in fact includes both the two upper culture horizons, from which it follows that the theory that the late Maglemosian culture in Aamosen could be followed into zone VII is not confirmed. The Maglemosian settlement in Verup is clearly at an end before zone border VI–VII.

This does not, however, undermine the dating given in 1954 to the large flint pick found near the Verup settlement. From the many finds of this type of artefact in the Kongemose settlement, we now know that these large flint picks belong to the so-called "old coastal culture", and that this culture flourished in Aamosen during the period in zone VI to which the Verup settlements belong. According to the pollen-analysis the large flint pick from Brovad Grøft is contemporary with the beginning of the settlement period $C–C_1$.

The discussion given here of the habitation at the Verup settlements is chiefly based on examination of the nature and occurrence of the sediments, and on their pollen-analytic age. Only archaeological material which is directly concerned with these investigations, the patination of the flint, and the presence of bones and antlers inside the area, have been taken into consideration.

As mentioned before, the artefacts from the Verup settlements were not really systematically excavated. But the attempts at improving the method of excavating in layers, 10 cm thick by square metres, then prevailing, are admirable. For some of the artefact material from the trial ditches P. and Pv. we thus know the level of the finds for each square metre, and in certain parts of the ditches even for each half square metre.

The value of this reduction in the size of the excavation unit is better seen in a comparison of the two artefact profiles I, E 6 – I, E 7, and I, B 6 – I, B 7, with the artefact profiles I, B 7 – I, E 7 (Pl. XXI) than if said with words.

V. SUMMARY

The pollen-analytical observations presented in Tables I–IX (Vol. II) have, together with the foregoing descriptions of the geological sections, been used to elucidate the conditions associated with the habitation in the Verup settlement, and to give a relative dating of the different culture horizons.

The course of the investigation has touched on fields involving problems whose solution is of more than archaeological importance.

These are the establishment of climatic changes and of the associated fluctuations of the water-level inland.

The Early Atlantic Climatic Oscillation

8 pollen diagrams from the same basin have been presented. The courses of the curves in these, when not affected by particular local conditions, are so uniform that they amply confirm the reliability of the pollen statistics method. In the curves and the tables the changing composition of the vegetation, chiefly of the forest, from the Pre-boreal to the Atlantic period, is clearly illustrated, in which Post-glacial climatic improvement is the main factor. In all the diagrams covering the period in question we find, towards the end of pollen zone VI, an apparent retardation in the advance of the climax trees towards absolute hegemony in the forest. The curves furthermore show a heavy fall in *Corylus*, partly counterbalanced by a rise in the curves for *Alnus* and *Betula*. Simultaneously a temporary, but marked, and statistically reliable, fall in the occurrence of *Hedera* and *Viscum* is noted. It seems natural to connect these phenomena with each other, and to find the common cause in a temporary decline in the temperature. Judging from the curves for *Hedera*, *Viscum*, and *Cladium* it is furthermore possible that preceding the general fall in the temperature, there was a change in the climate in the continental direction (from the middle of zone VI).

This hypothesis will be either verified or invalidated when the investigations of the enormous sample of material we have from Aamosen are, some day in the future, concluded.

For the present the demonstration of climatic change shortly before zone border VI–VII must be considered to be one of the results of this investigation.

Oscillations in the Water-Level Inland in Boreal and Atlantic Time

From the herb pollen curves in the SURVEY DIAGRAMS and the curves representing pollen destruction it can be seen that in zone V, a drying of the calcareous mud at Verup took place. The drying-up was probably succeeded by a rise in the water-level at the transition to zone VI.

This rise continued in the first half of zone VI. This can be confirmed both from the courses of the pollen curves and from the fact that "floating islands" were formed.

At the middle of zone VI a halt in the rise in the water-level seems to have occurred; the rise was resumed, however, and culminated shortly before zone border VI–VII.

From the temporal point of view the maximum in the water-level in the Aamose lake corresponds with the regression between the Early Atlantic and the Full Atlantic transgressions of the Littorina sea.

The presumed halt in the rise in the water-level in Aamosen is contemporary with the Early Atlantic transgression.

Archaeological Evidence and its Dating

During the investigation we have succeeded in distinguishing three artefact horizons at the Verup settlement.

The oldest layer, at the end of zone V, which, because not the settlement itself, but only a small part of the so-called refuse has been found, is only poorly represented in the artefact material. This habitation is contemporaneous with the older Maglemosian culture (Mullerup, Lundby, cf. KNUD JESSEN, 1935 b).

There were, moreover, two habitations on the spot, separated in time: the elder occurred in the first half of zone VI, corresponding in time with Holmegaard Vest (KNUD JESSEN, 1935 b), the younger in the latter half of the same zone, corresponding in time with the youngest Sværdborg (KNUD JESSEN, 1935 b), and Øgaarde II, Magleø I, and Hesselbjerggaard, as these are dated by TROELS-SMITH (1943).

At the beginning of the latter of these two settlements at Verup 5, there is, from the same area, a single find, which belongs to the old coastal culture (the large flint pick, SV. JØRGENSEN, 1954).

As a fourth possible culture horizon the layer with charcoal dust at the start of zone V may finally be mentioned. This would correspond in time with Klosterlund (JOHS. IVERSEN, 1937 b). However, an equally possible interpretation of this occurrence of charcoal is to connect it with a forest fire. This interpretation is supported by the course of the curves in the pollen diagrams.

For the settlement at Ul.Ø. (Hut I) we can not, from the present diagram, give a more accurate dating than zone VI.

A further result of the investigations is the experience we have gained about the complicated process of sedimentation near a shore. This experience shows that the greatest possible attention and accuracy should be exercised in geological field work, and that the greatest circumspection is required in the interpretation of pollen diagrams from areas near a shore, and in their correlation with other kinds of diagrams.

For archaeology the experience gained is a warning against drawing binding conclusions from the stratigraphy alone, whether vertical or horizontal, and serves as a reminder that an investigation which has not been carried out as carefully and conscientiously as possible is an irresponsible handling of our archaeological heritage.

VI. DANSK SAMMENDRAG

Tidlig postglacial tid belyst ved geologisk-pollenanalytiske undersøgelser af Maglemosebopladser i den vestsjællandske Aamose

Indledning

Hovedtrækkene i mosegeologiens udvikling fra Japetus Steenstrups tid til vore dage omtales, og der gives en kort redegørelse for den pollenanalytiske metodes betydning for udredningen af vegetationsudviklingen, klimaforløbet og vandstandssvingningerne i havet i den postglaciale periode.

Samarbejdet mellem naturvidenskaberne og arkæologien, som her i landet kan føres tilbage til arkæologiens barndom, understreges; et samarbejde, der i tidens løb stadig er blevet mere intensivt, og som i 1944 førte til oprettelsen af Nationalmuseets Moselaboratorium (senere Nationalmuseets Naturvidenskabelige Afdeling, 1956).

Som følge af krigstidens omfattende tørveskær og den efterfølgende afvanding og dyrkning har Nationalmuseet nu i mere end 20 år foretaget arkæologiske og mosegeologiske undersøgelser i den vestsjællandske Aamose for at redde værdifuldt videnskabeligt materiale fra ødelæggelse. Dette materiale består af arkæologiske fund, tørve- og gytjeprøver, samt mosegeologiske iagttagelser og opmålinger.

Disse mange års undersøgelser har bevirket en forbedring og forfinelse af arbejdsmetoderne såvel i marken som i laboratoriet, men ikke levnet ret megen tid til bearbejdelsen af det indsamlede materiale.

Nærværende afhandling behandler en detaille fra dette overordentlig vigtige indsamlings- og forskningsområde, idet der gøres et forsøg på at udrede naturforholdene omkring en maglemoseboplads i Aamosen (Verup 5, se fig. 1) og gives en relativ datering af bebyggelsens forskellige faser.

Udover de specielle forhold vedrørende selve bopladsen behandles områdets vegetationsudvikling, bassinets hydrografi samt klimaforløbet inden for tidsrummet præboreal – boreal – tidlig atlantisk tid, og der gøres et forsøg på at indpasse de påviste vandstandssvingninger i indlandet i det skema, der foreligger over Littorinahavets transgressioner.

Til støtte for disse udredninger er der udover bearbejdelsen af det foreliggende materiale fra selve bopladsområdet udført mosegeologiske undersøgelser og udarbejdet pollendiagrammer, dels fra en anden brednær lokalitet (Ulkestrup

Lyng Øst; Ul.Ø.), dels fra den centrale del af den daværende Aamosesø (Niløse; Båd I og Aamosen; N.1,000; Ø.2,600; Bp Ib; se fig. 1).

Den arkæologiske undersøgelse ved Verup 5 er foretaget af C. L. VEBÆK i årene 1943 og 1944, medens de samtidige mosegeologiske undersøgelser er udført af J. TROELS-SMITH.

Det arkæologiske fundstof fra Verup 5 er bearbejdet og publiceret af KNUD ANDERSEN (1961). I denne publikation indgår en bestemmelse og vurdering af det fundne knoglemateriale ved ULRIK MØHL. Den laboratoriemæssige undersøgelse af det mosegeologiske materiale, der ligger til grund for denne afhandling, er foretaget af forfatteren i årene 1945–60, og de detaillerede profilbeskrivelser samt de fuldstændige lister over de gjorte pollenfund er publiceret i materialefremlæggelsen: PROFILBESKRIVELSER OG POLLENANALYSER. (Vol. II af denne afhandling).

Fremlæggelsesform

For hvert af de undersøgte profilpunkter er der udarbejdet 2 diagrammer, et OVERSIGTSDIAGRAM og et SPECIALDIAGRAM. OVERSIGTSDIAGRAMMERNES part A er et sammensat kurvediagram for de almindelige skovtræer, medens part B giver et skøn over forholdet mellem de skov- og kratdækkede arealer og det skovfri land. Beregningssum og komponenter kan ses af diagrammet.

SPECIALDIAGRAMMERNE består af et kurvediagram og en serie silhuetter, der viser pollenforekomsten af en række planter eller plantegrupper, som har betydning for undersøgelsen. Komponenter og beregningssum fremgår af selve diagrammet. Kurvediagrammet er beregnet for at gøre diagrammerne sammenlignelige, uanset om de stammer fra brednære eller bredfjerne lokaliteter. Signaturen i profilsøjlerne er efter TROELS-SMITHS system (TROELS-SMITH, 1955a).

Gennemgang af profilerne

På grundlag af diagrammernes profilsøjler gennemgås sedimenterne i de enkelte profilpunkter, og slutninger om sedimentationens hastighed og lakuner i lagserien samt sedimenternes alder drages udfra pollendiagrammernes kurver. Ligeledes fastslås tilgroningens tid og rytme i de brednære områder, og hængesækdannelser påvises. Der gøres rede for forekomsten af oldtidslevn i de forskellige bopladsområder, og udfra profilbeskrivelser og pollendiagrammer er der konstrueret et linieprofil gennem Verup 5 (Pl. XIX).

I dette profil er forekomsten af trækulstøv markeret i de enkelte profilsøjler og tillige de anvendte pollenanalytiske zonegrænser. En række andre synkrone niveauer, der er pollenanalytisk bestemt, og som angiver de forskellige bebyggelsesfaser, er ligeledes indtegnet. Endelig er der angivet nogle arkæologiske enkeltfund, som er pollenanalytisk dateret.

Diskussion og tolkning

Vegetationsudviklingen

Vegetationens, navnlig skovens skiftende sammensætning fra præboreal til ind i atlantisk tid skildres udfra pollendiagrammernes kurver.

Den gradvise ændring af skovbilledet fra en lysåben birke-fyrreskov i præboreal tid, over den boreale hassel- fyrre- birkeskov til den mørke atlantiske egeblandingsskov afspejler de forskellige træers indvandringskapacitet og konkurrenceevne efter en afgørende klimaforbedring.

I denne "normale" skovudvikling henledes opmærksomheden på specielle planteforekomster og på tilsyneladende uregelmæssigheder i pollendiagrammernes kurveforløb. For den præboreale periodes vedkommende diskuteres således forekomsten af senglaciale relikter, bl. a. *Ephedra*.

I begyndelsen af boreal tid forekommer der i diagrammerne fra de brednære områder et ejendommeligt kurvebillede, idet den faldende birkekurve og den stigende fyrrekurve pludselig viser et kortvarigt kurveforløb i modsat retning. Dette fænomen kan eventuelt forklares ved en skovbrand, hvilken antagelse støttes af en forekomst af trækulstøv i sedimenterne; men muligheden for, at årsagen skal søges i en vandstandsændring, holdes åben.

I pollenzone VI, der er det tidsrum, hvor klimaxtræerne trænger frem og udkonkurrerer pionertræerne, sker der i den sidste halvdel af perioden en tilsyneladende retardering i kurven for egeblandingsskovens træer, og der sætter et kraftigt fald ind i hasselkurven. Samtidig sker der en kortvarig stigning i kurverne for el, birk, og pil, d.v.s. de træer, der foretrækker eller kan tåle en fugtig jordbund. De nævnte kurveforløb tolkes som følger af en forbigående fugtighedsforøgelse.

Efter denne tøven i sin fremmarch går egeblandingsskoven atter frem for sluttelig at nå det ubestridte herredømme i skoven. I pollenzone VII er kurveforløbene i diagrammerne parallelle, hvilket betyder, at der nu er nået en stabil ligevægt i den atlantiske skovs sammensætning.

Vandstandsændringer

De betingende faktorer for vandstandsændringer i et indsøbassin gennemgås, og der gøres rede for den tidligere Aamosesøs afløbsforhold. Vidnesbyrd om en højere vandstand i søens diskuteres, og det påpeges, at kulturindgreb har frembragt en række tilsyneladende erosionsskrænter langs moseranden. Det må formodes, at klimasvingninger har været den væsentligste årsag til vandstandsændringer i den fordums sø.

Der gøres opmærksom på, at sedimentation og tilgroning har samme indvirkning på en søs dybde og udstrækning som en reel vandstandssænkning. Derfor er en vandstandsstigning mere sikkert erkendelig i søens aflejringer end en vandstandssænkning.

Bortsmeltning af dødis, begravet under søbunden, påpeges som mulig årsag til ændringer i bassinets vanddybde. Den boreale udtørring konstateres i Verupområdet på grundlag af en nedgang i kurverne for pollen af vandplanter og en tilsyneladende umotiveret stigning i pollendestruktionen.

Ud fra specialdiagrammernes urtepollenkurver påvises en tiltagende vanddybde i Verupområdet fra begyndelsen af pollenzone VI, og tilstedeværelsen af en hængesæk godtgør, at der har fundet en vandstandsstigning sted.

Der gøres rede for iagttagelser i forbindelse med andre hængesække i Aamosen, såvel fossile som recente, og hændelsesforløbet i forbindelse med hængesækdannelsen ved Verup udredes og dateres pollenanalytisk til hen mod midten af zone VI. En samtidig hængesækdannelse ved bopladsen Ul.Ø. beskrives og diskuteres.

Vandstandsstigningens maksimum fastlægges ved hjælp af Verupdiagrammerne og dateres til slutningen af pollenzone VI.

Den efterfølgende tilgroning i Verupområdet er så voldsom, at en vandstandssænkning i begyndelsen af zone VII må formodes.

Ved tidligere undersøgelser i Aamosen (Troels-Smith, 1943) er den boreale udtørring konstateret, og ligeledes en vandstandsstigning, der tidsmæssigt svarer til vandstandsmaksimet i slutningen af zone VI.

På en lokalitet (Magleø) er en vandstandsstigning påvist i zone VII.

Om der i Aamosen har været to adskilte vandstandsstigninger i zone VI, eller om hængesækdannelsen og vandstandsmaksimet er udtryk for to særlig udtalte faser inden for samme vandstandsstigning, kan endnu ikke afgøres.

I forhold til Littorinahavets transgressioner ligger hængesækdannelsen ved Verup før den tidlig atlantiske transgression, og den højeste vandstand i Zone VI har været i tidsrummet mellem den tidlig atlantiske og den højatlantiske transgression (Iversen, 1937 a).

Klimaoscillationer

Det forelagte materiale synes ikke at give andre sikre oplysninger om ændringer i nedbørsmængden inden for tidsrummet præboreal – tidlig atlantisk tid, end at nedbøren formentlig er større i atlantisk tid (fra zone VI) end i boreal tid.

Derimod er der i pollendiagrammernes kurveforløb vidnesbyrd om temperatursvingninger. Af specialdiagrammerne fra den åbne sø (Aamosen; N.1,000; Ø.2,600; Bp I og Niløse; Båd I) fremgår det, at der samtidig med de tidligere beskrevne ændringer i træpollenkurverne i slutningen af zone VI forekommer et fald i kurverne for vedbend og mistelten.

Kurverne for disse to plantearter fra ovennævnte diagrammer opdeles i 5 tidsafsnit, og det vises, at det omtalte fald i pollenforekomsterne for vedbend og mistelten ikke skyldes statistisk usikkerhed (fig. 3 & 4).

Da denne samtidige nedgang i de to planters pollenforekomst formentlig ikke kan skyldes menneskelig aktivitet, tolkes den som et udtryk for et fald i såvel vinter- som sommertemperaturen i slutningen af zone VI. Dette generelle temperaturfald opfattes som årsag til det maksimum i Aamosebassinets vandstand, der er konstateret i Verupområdet.

På grundlag af variation i forekomsten af vedbend, mistelten og hvas avneknippe fremsættes formodning om, at der omkring midten af zone VI har hersket et mere kontinentalt præget klima end i begyndelsen og slutningen af zonen.

Da klimaændringer må kunne spores over større områder, skulle der være mulighed for at finde synkrone vandstandssvingninger i søbassiner på andre lokaliteter.

Som eksempel nævnes Even Sø ved Præstø (V. Mikkelsen, 1949).

Der foretages en konnektion mellem de her påviste vandstandssvingninger i indlandet og svingninger i Littorinahavets vandspejl, og det fremgår, at der til sænkninger i havets vandstand svarer vandstandsstigninger i søerne og omvendt. Denne sammenhæng støtter den anskuelse, at Littorinahavets vekslende vandstand hovedsagelig er klimatisk betinget.

Arkæologiske vidnesbyrd og deres datering

Mulige spor i vegetationen som følge af menneskers færden og liv i ældre stenalder efterforskes og diskuteres.

Da den anvendte udgravningsmetode ikke muliggør tegningen af virkelige oldsagsprofiler gennem bopladsområdet, er der på grundlag af de optegnelser, udgravningsberetningen indeholder, konstrueret et profil (Pl. XX), der giver de foreliggende oplysninger om oldsagernes forekomst i prøvegrøften P (se fig. 2).

Oldsagsprofilet er tegnet i samme målestok som det geologiske profil (Pl. XIX), og konstruktion og indhold fremgår af selve tegningen. De synkrone niveauer fra det geologiske profil er overført til det arkæologiske, ligesom de pollenanalytisk daterede enkeltfund er markeret. På grundlag af fundforekomsterne i prøvegrøften Pv (se fig. 2) er der på samme måde tegnet 4 oldsagsprofiler, to der er parallelle med P og to vinkelret på P (Pl. XXI).

Efter udgravningsprotokollens notater er der tillige tegnet en plan over forekomsten af patineret og upatineret flint samt knogler og takker. (Fig. 5) Denne plan gør det muligt at skønne, hvor grænsen mellem den beboede moseflade og søen har gået, men desværre er netop selve grænseområdet ikke udgravet.

Under udgravningen er der skelnet mellem et "øvre" og et "nedre" kulturlag, skilt ved et i regelen fundtomt område. Hvor der i dette er fundet oldsager, er disse skilt ud som et "mellemlag".

Den pollenanalytiske undersøgelse har imidlertid vist, at forholdene langtfra er så enkle. I P 25 består det "øvre" kulturlag således ikke af et kontinuerligt aflejret kulturlag, men af 3 tidsmæssigt forskellige, kulturførende aflejringer (lagene 10, 11 og 12).

Den pollenanalytiske undersøgelse har tillige påvist vandstandsstigninger i Aamosen og en dermed forbunden hængesækdannelse i bopladsområdet, hvilket i høj grad har indvirket på aflejringsforholdene og dermed på oldsagsforekomsterne.

I en tegneserie (Pl. XXII) er der på grundlag af de foreliggende notater, profiler og pollenanalyser gjort et forsøg på at skildre såvel den geologiske udvikling som bebyggelseshistorien på Verup 5.

Slutresultatet af disse udredninger bliver da følgende: Den første bebyggelses spor er enkeltfundne oldsager fra en endnu ukendt bebyggelse i slutningen af zone V (markeret ved A i tegneseriens profiler). Denne kulturhorisont er af samme alder som den ældre Maglemosekultur (Mullerup, Lundby; cf. KNUD JESSEN, 1935 b).

Derefter følger 2 i tid adskilte bebyggelser på selve stedet. Den ældste, der er markeret ved bogstaverne B–B_1, ligger i første halvdel af zone VI, d.v.s. samtidig med Holmegaard Vest (KNUD JESSEN, 1935 b). Den yngste (C–C_1) ligger i sidste halvdel af zone VI og svarer tidsmæssigt til det yngste Sværdborg (KNUD JESSEN, 1935 b) og Øgaarde II, Magleø I og Hesselbjerggaard i Aamosen (TROELS-SMITH, 1943).

Ved begyndelsen af bebyggelsen C–C_1 foreligger der fra samme område et enkeltfund, som hører til gammel Kystkultur (det store spidsvåben, SV. JØRGENSEN, 1954).

Endelig kan laget med trækulstøv i begyndelsen af zone V (mærket med ×) muligvis være en kulturhorisont. I tid svarer den til Klosterlund (JOHS. IVERSEN, 1937b).

Bebyggelsen ved Ul.Ø. (hytte I) kan udfra det foreliggende diagram ikke dateres nøjere end til pollenzone VI.

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Denne bog er sat med Monotype Times og trykt i 2025 eksemplarer
i Andelsbogtrykkeriet i Odense.
Papir: Ekstraglittet 605, 125 g, fra a/s De forenede Papirfabrikker.

Plate I

Signatures for sediment components

The proportion of the components is indicated by the spacing of the signatures.
The degree of humification (Tl, Th & Ld) is indicated by the thinkness of line of the signatures. (Cf. Troels-Smith 1955a).

Signaturer for sedimenternes bestanddele

Bestanddelenes mængdeforhold angives ved signaturernes tæthed. Humificeringsgraden (Tl, Th og Ld) angives ved de enkelte signaturtegns stregtykkelse. (Cf. Troels-Smith 1955a).

Signatures for sediment components.

Sh *Substantia humosa (humous substance)*

Tl *Turfa lignosa (tree roots, stumps etc. strongly decomposed)*

Th *Turfa herbacea (herbaceous roots etc. more or less decomposed)*

Dl *Detritus lignosus (ligneous plant fragments)*

Dh *Detritus herbosus (herbaceous plant fragments)*

Dg *Detritus granosus (coarse-detritus)*

Ld *Limus humosus (fine-detritus + some humous substance)*

Lc *Limus calcareus (marl, not hardned)*

As *Argilla steatodes (mineral particles, < 0,002 $^m/_m$; clay)*

Ag *Argilla granosa (mineral particles, 0,06-0,002 $^m/_m$; silt)*

Ga *Grana arenosa (mineral particles, 0,6-0,06 $^m/_m$; fine sand)*

Gs *Grana saburralia (mineral particles, 2,0-0,6 $^m/_m$; coarse sand)*

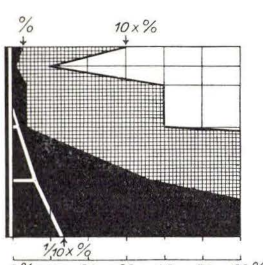
Gg *(maj & min)* *Grana glareosa (mineral particles, 20-2 $^m/_m$; gravel)*

Test. *(moll.)* *Testae (molluscorum) (mollusc shells)*

Part. test. *(moll.)* *Particulae testarum (molluscorum)*
(fragments of mollusc shells)

(I)′ *Radices lignosae (roots of ligneous plants)*

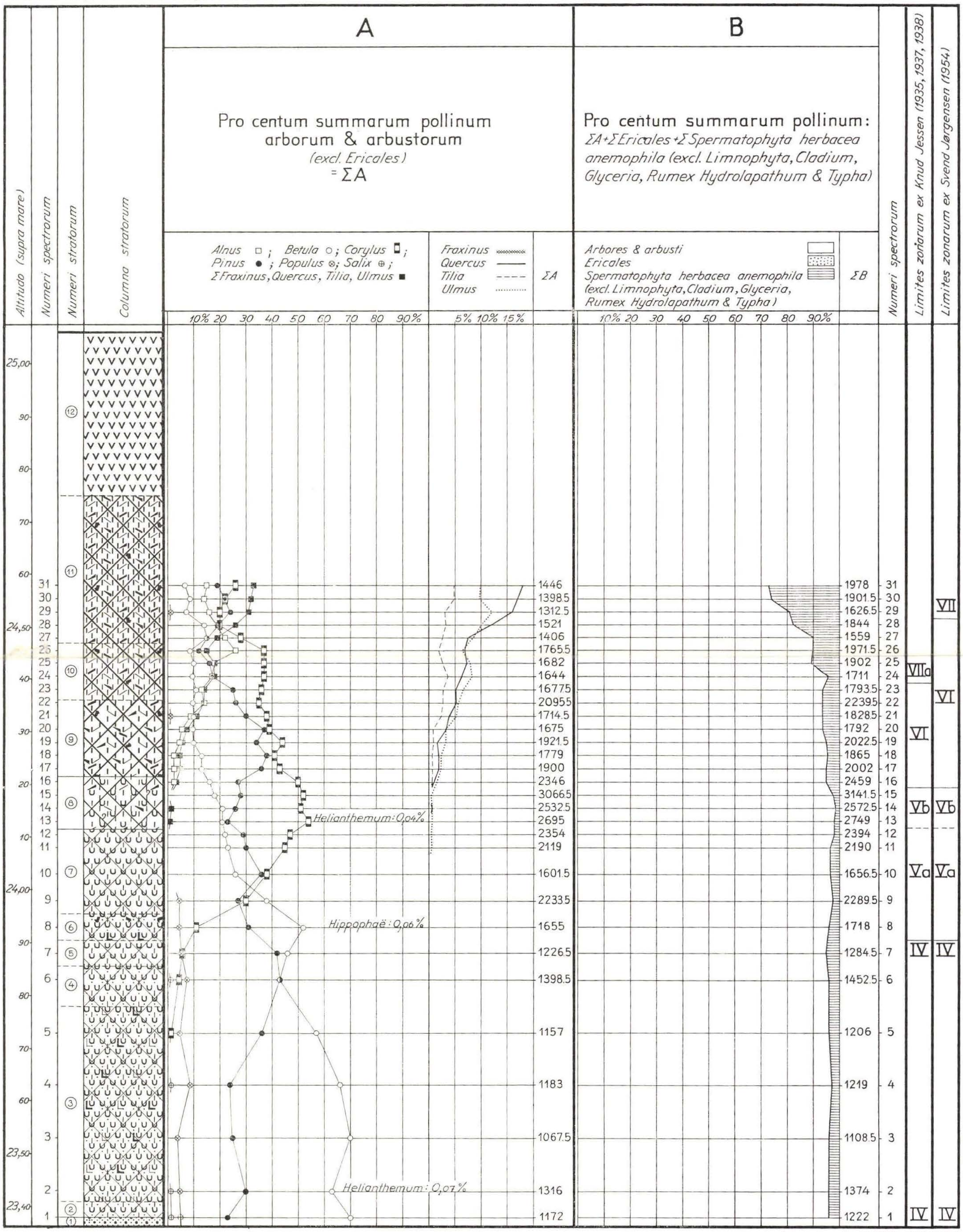
Anthrax *(charcoal)*



The Value of the curves

Verup-Komplekset; Verup 5; Profil 33.

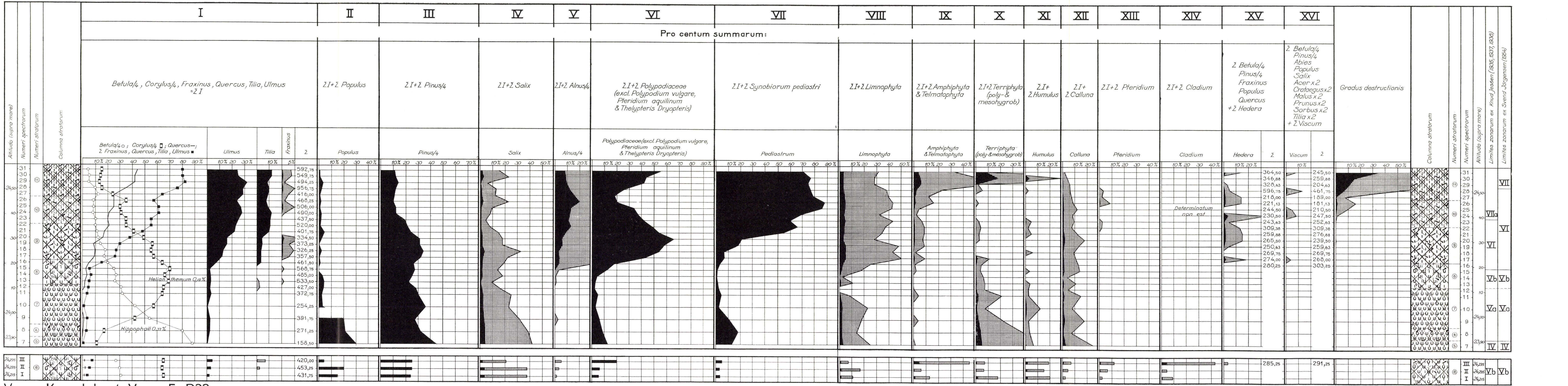
Niløse S., Merløse H., Holbæk A.



determinavit: SVEND JØRGENSEN

Verup-Komplekset; Verup 5; Profil 33.

Niløse S., Merløse H., Holbæk A.

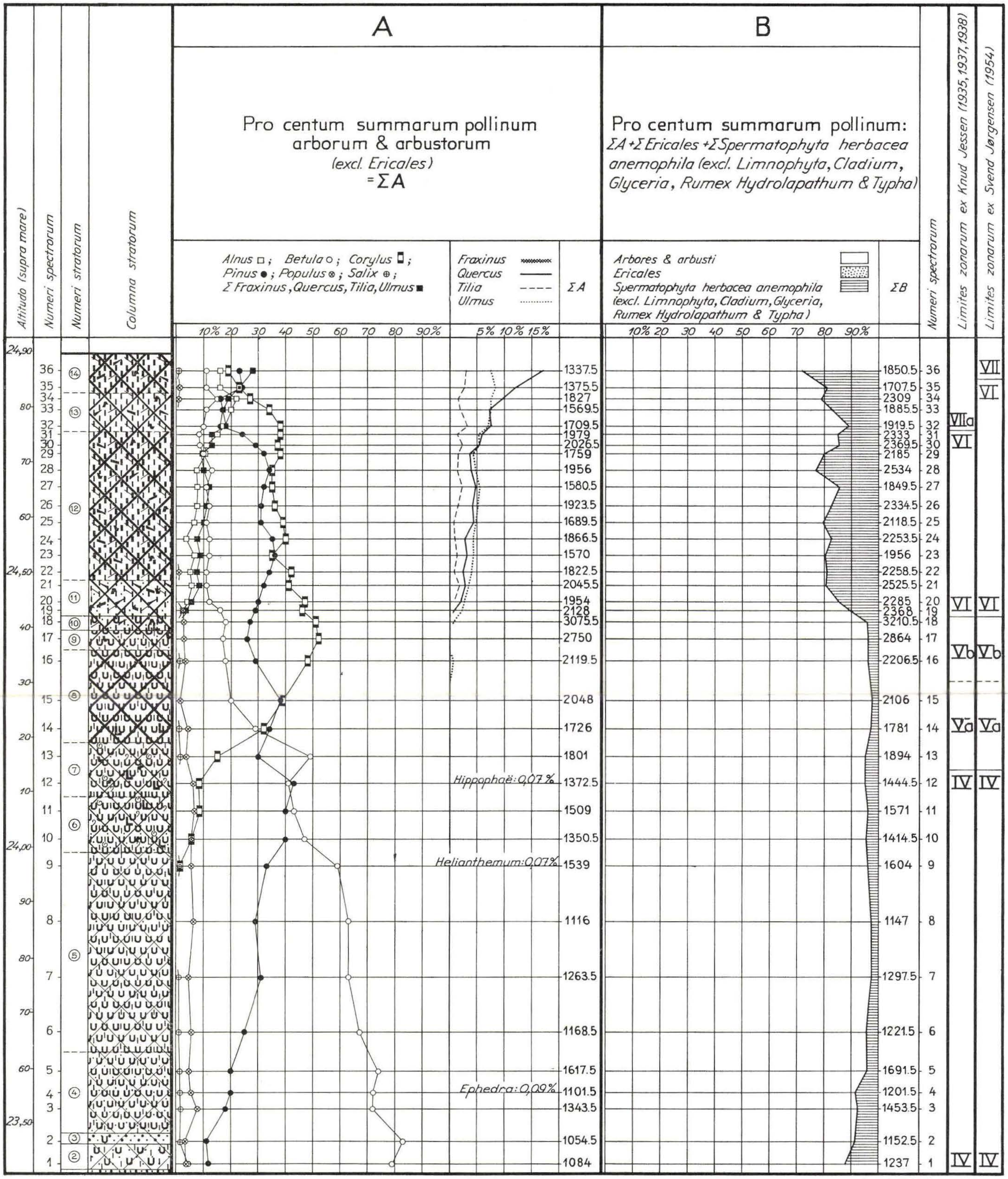


Verup-Komplekset; Verup 5; P33; P33,I: *Scapula (Sus scrofa ferus L.)*; P33,II: *Fragmentum ossis (Avis sp.)*; P33,III: *Scapula (Sus scrofa ferus L.)*.

determinavit: SVEND JØRGENSEN

Verup-Komplekset; Verup 5; Profil 28,30

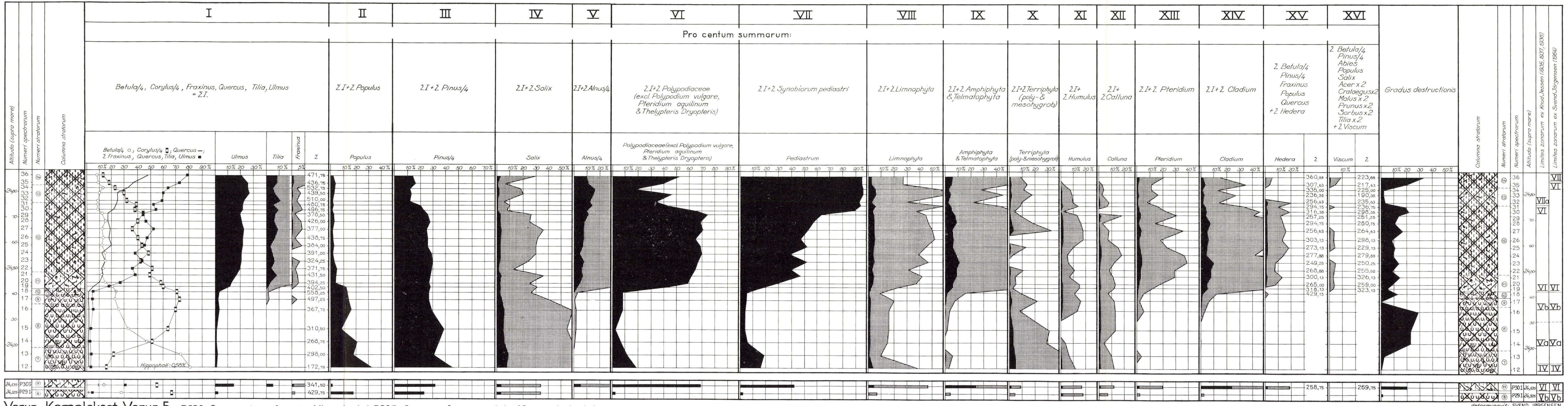
Niløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

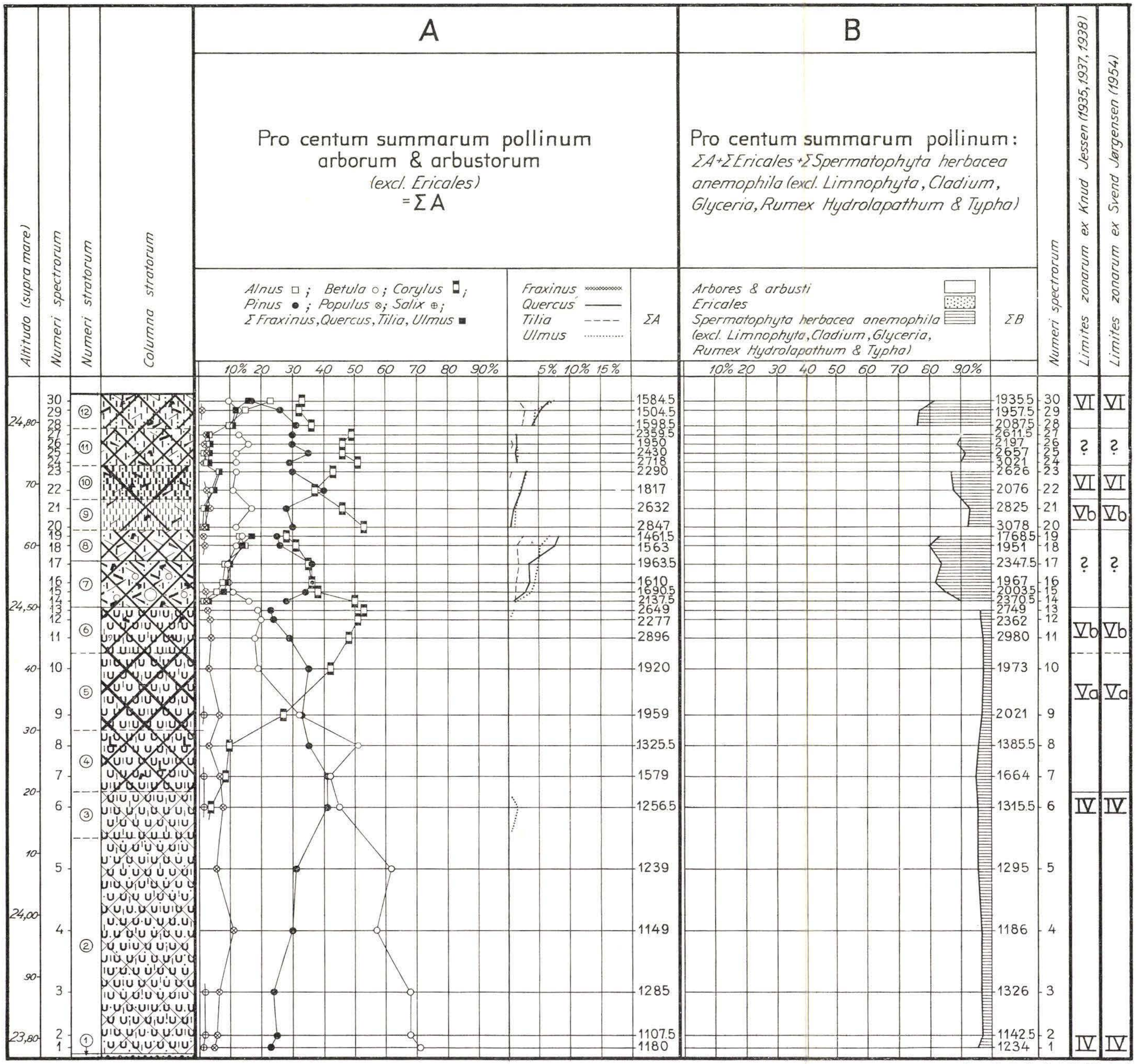
Verup-Komplekset; Verup 5; Profil 28,30

Niløse S. Merløse H. Holbæk A.



Verup-Komplekset; Verup 5; P.29 I: *Cornu cervi arte formatus (Alces alces L.)*; P.30 I: *Dens arte formatus, c¹ sin. (Cervus elaphus L.)*

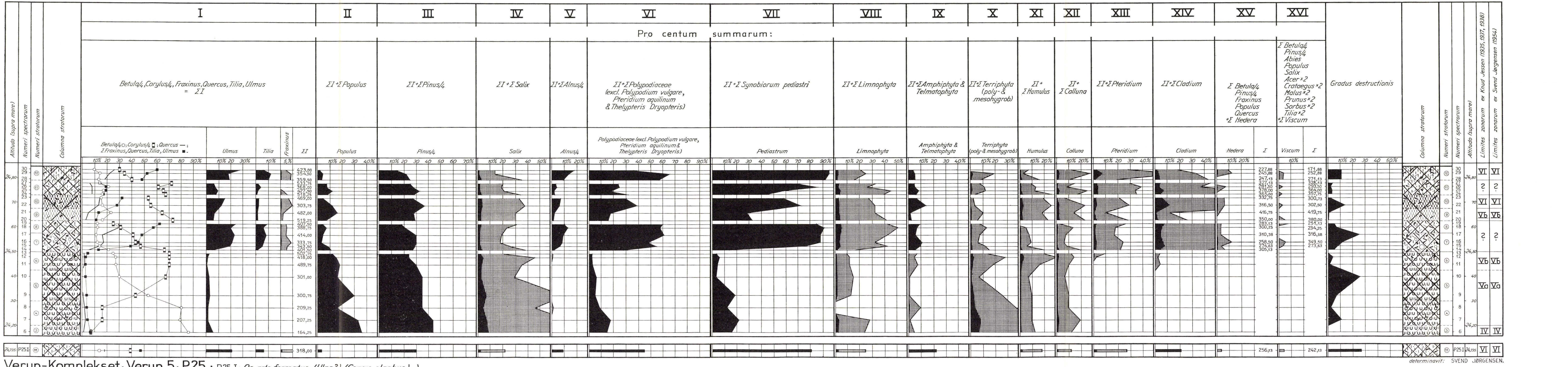
Verup-Komplekset; Verup 5; Profil 25,0
Niløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

Verup-Komplekset; Verup 5; Profil 25,0

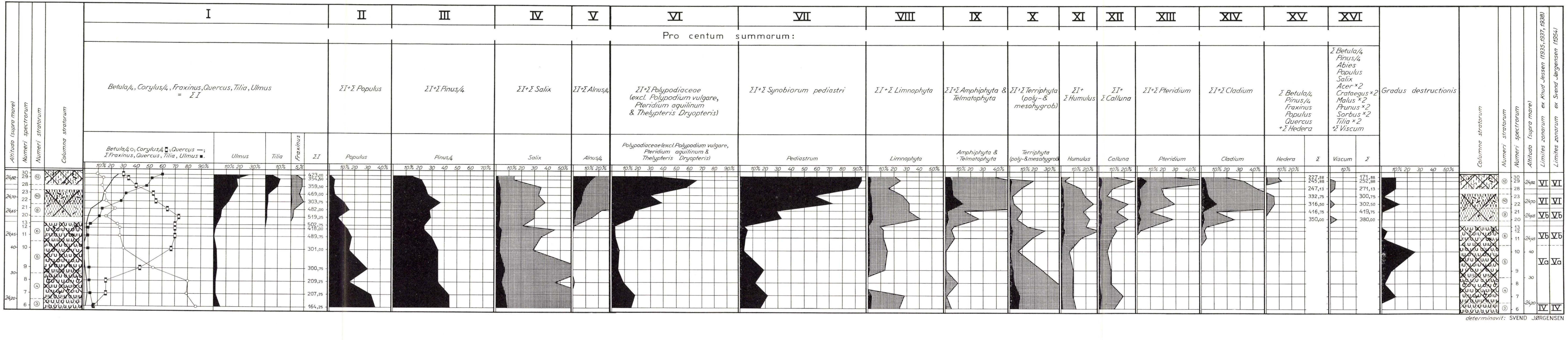
Niløse S. Merløse H. Holbæk A.



Verup-Komplekset; Verup 5; P.25 ; P25,I: *Os arte formatus, (Ulna?) (Cervus elaphus L.)*

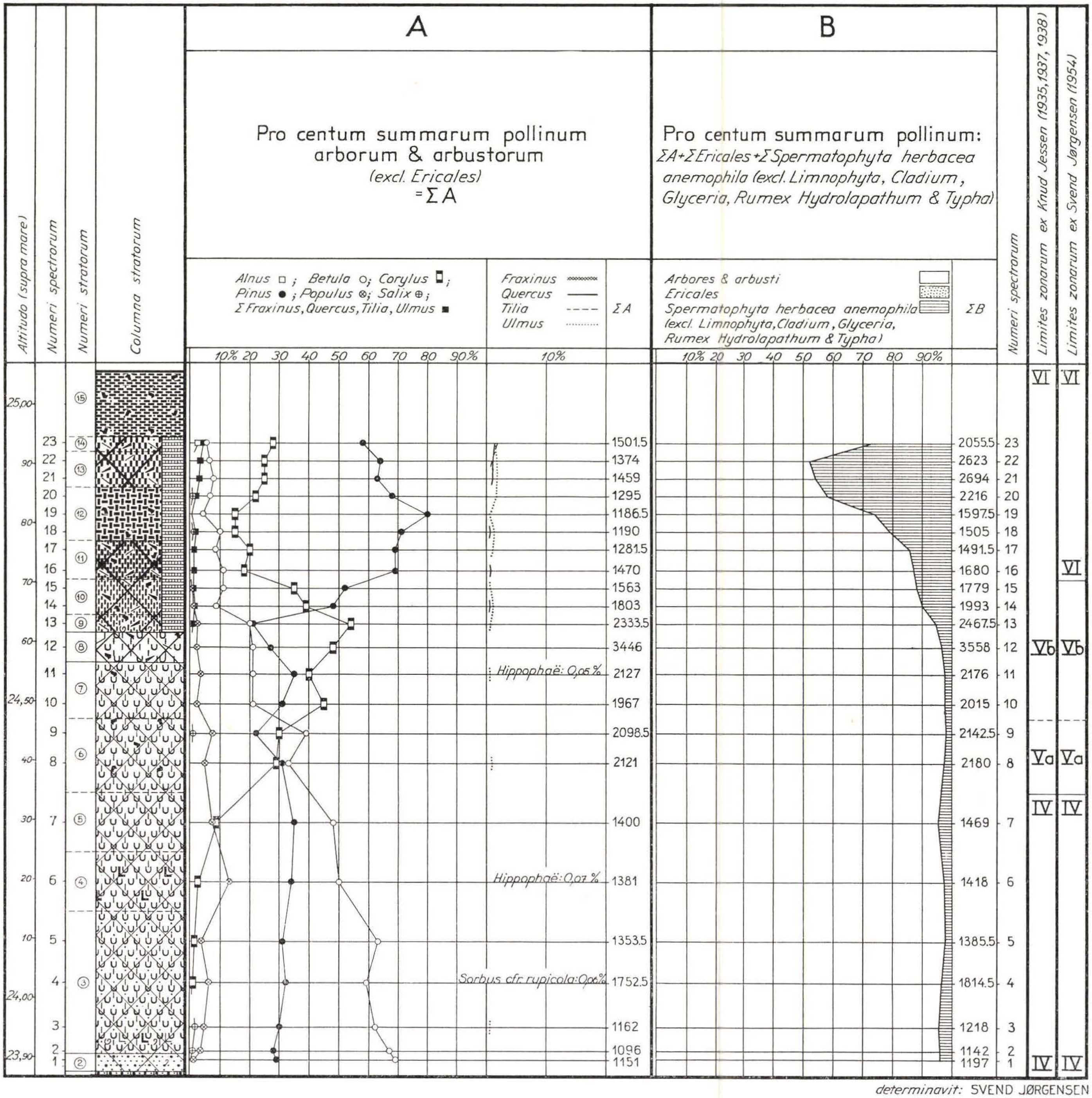
Verup-Komplekset; Verup 5; Profil 25,0 (excl. nr. str. 7-8 & 11).

Niløse S. Merløse H. Holbæk A.



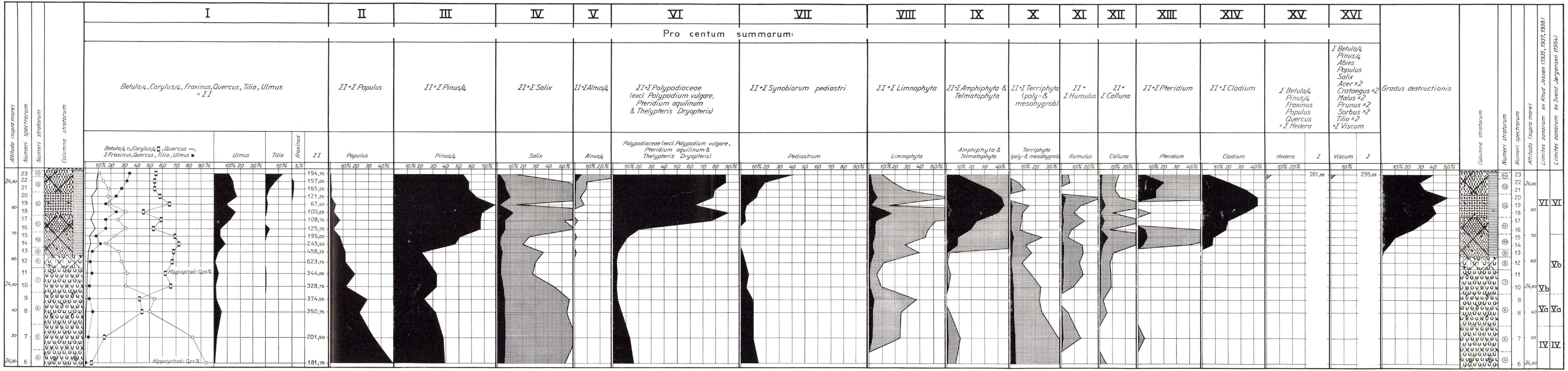
Verup-Komplekset; Verup 5; Profil 20,o

Niløse S. Merløse H. Holbæk A.



Verup-Komplekset; Verup 5; Profil 20,0

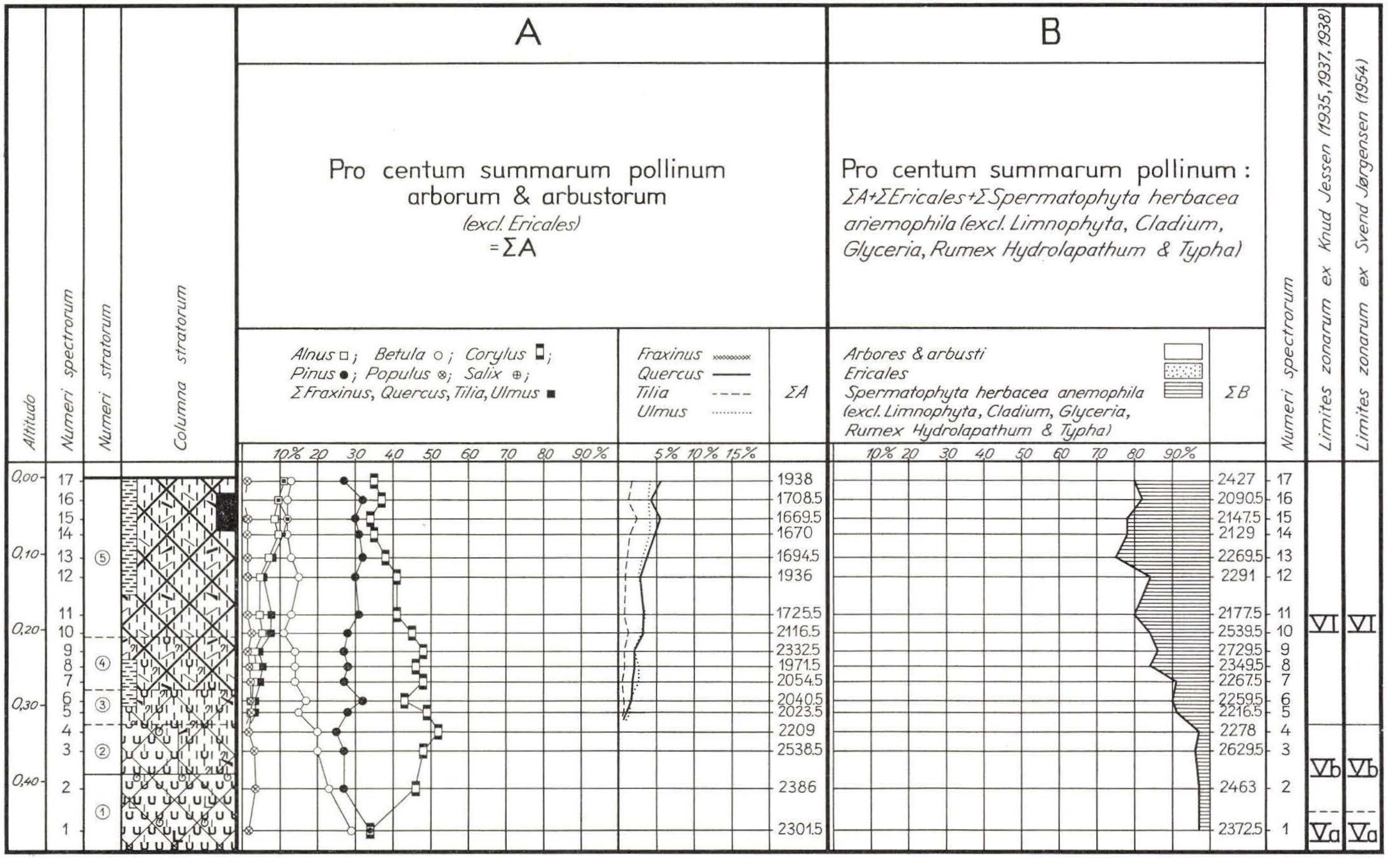
Niløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

Niløse-Komplekset, Spidsvaaben. (Large flint pick)

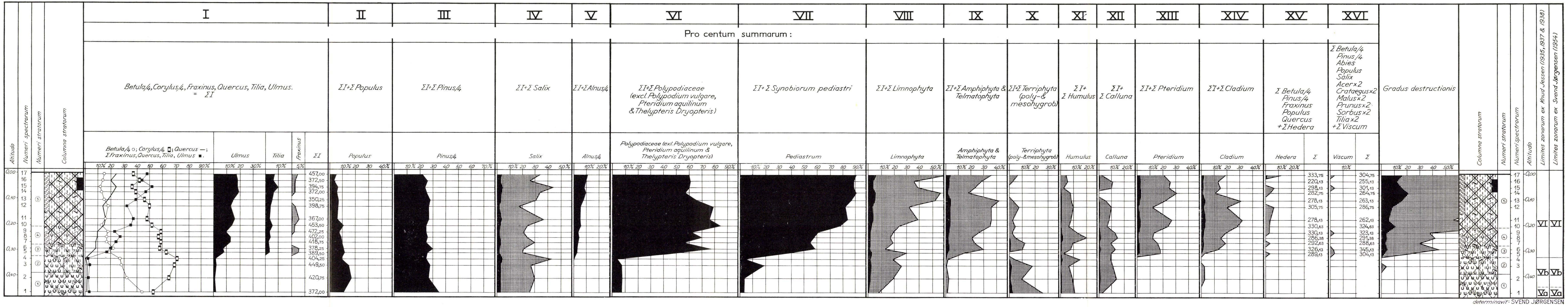
Niløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

Niløse-Komplekset, Spidsvaaben. (Large flint pick)

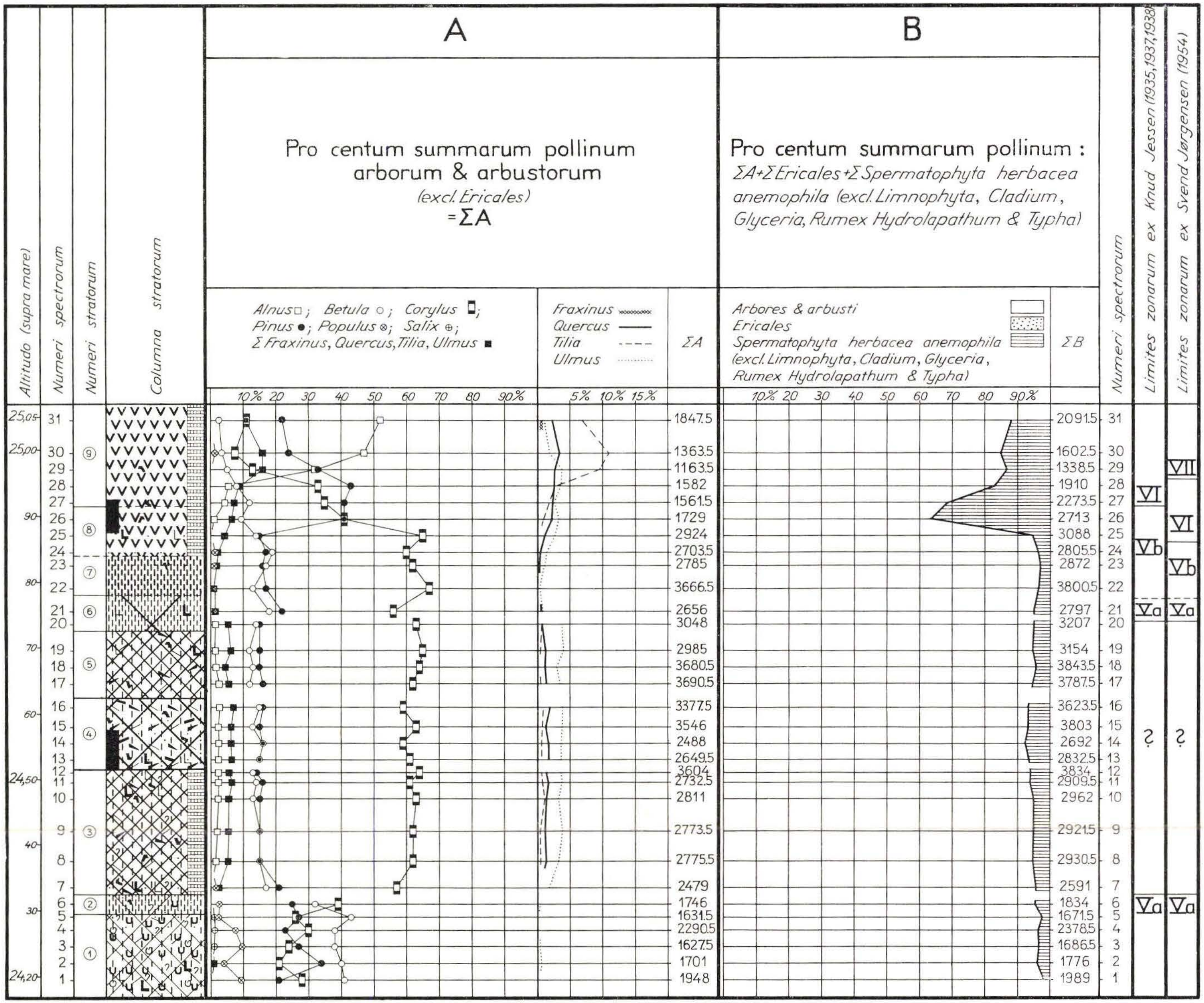
Niløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

Kildegaard-Komplekset, Ul. Ø. S:13,00; V:6,25

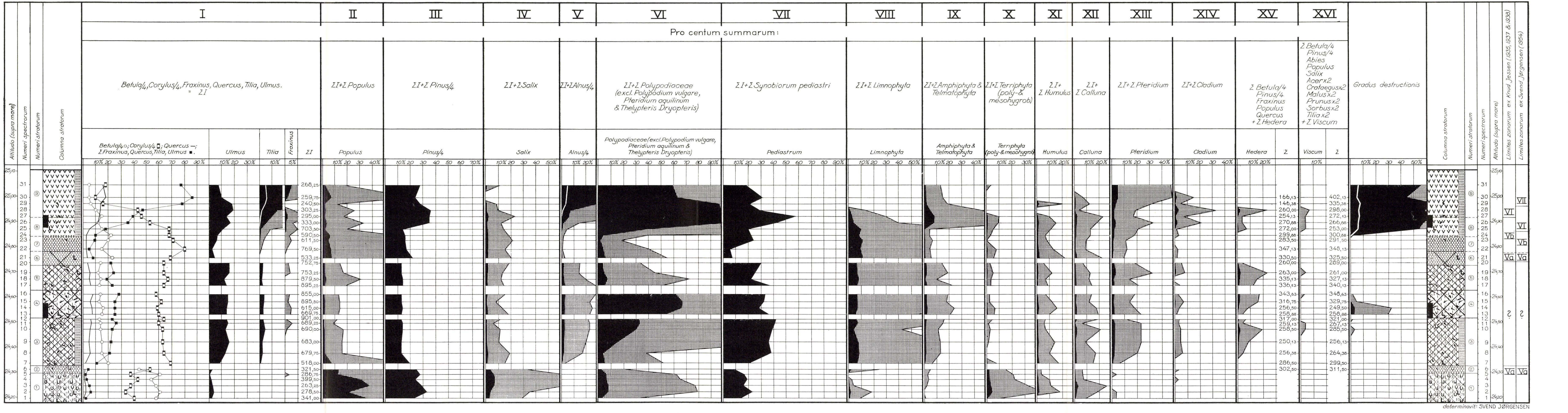
Undløse S. Merløse H. Holbæk A.



determinavit: SVEND JØRGENSEN

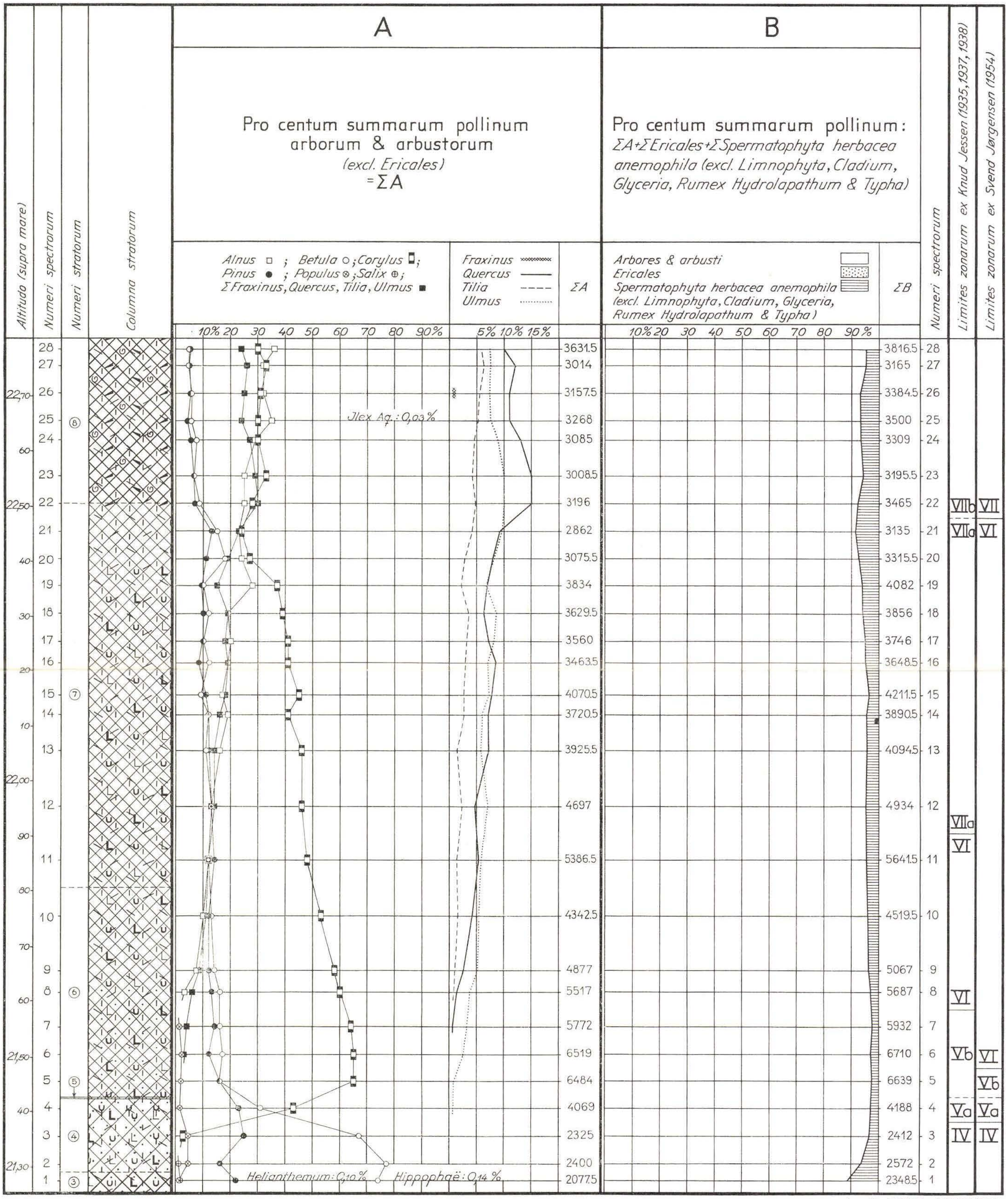
Kildegaard-Komplekset, Ul. Ø. S:13,00; V:6,25

Undløse S. Merløse H. Holbæk A.



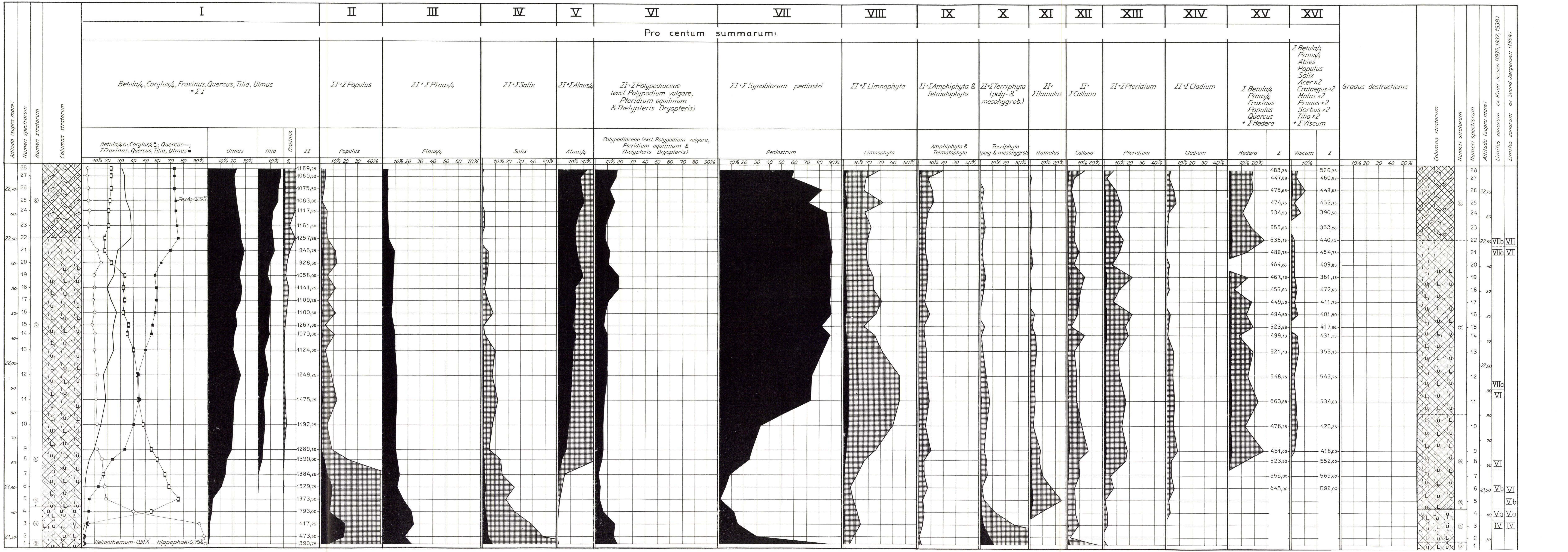
Niløse-Komplekset; Baad I, Boring I.

Niløse S., Merløse H., Holbæk A.



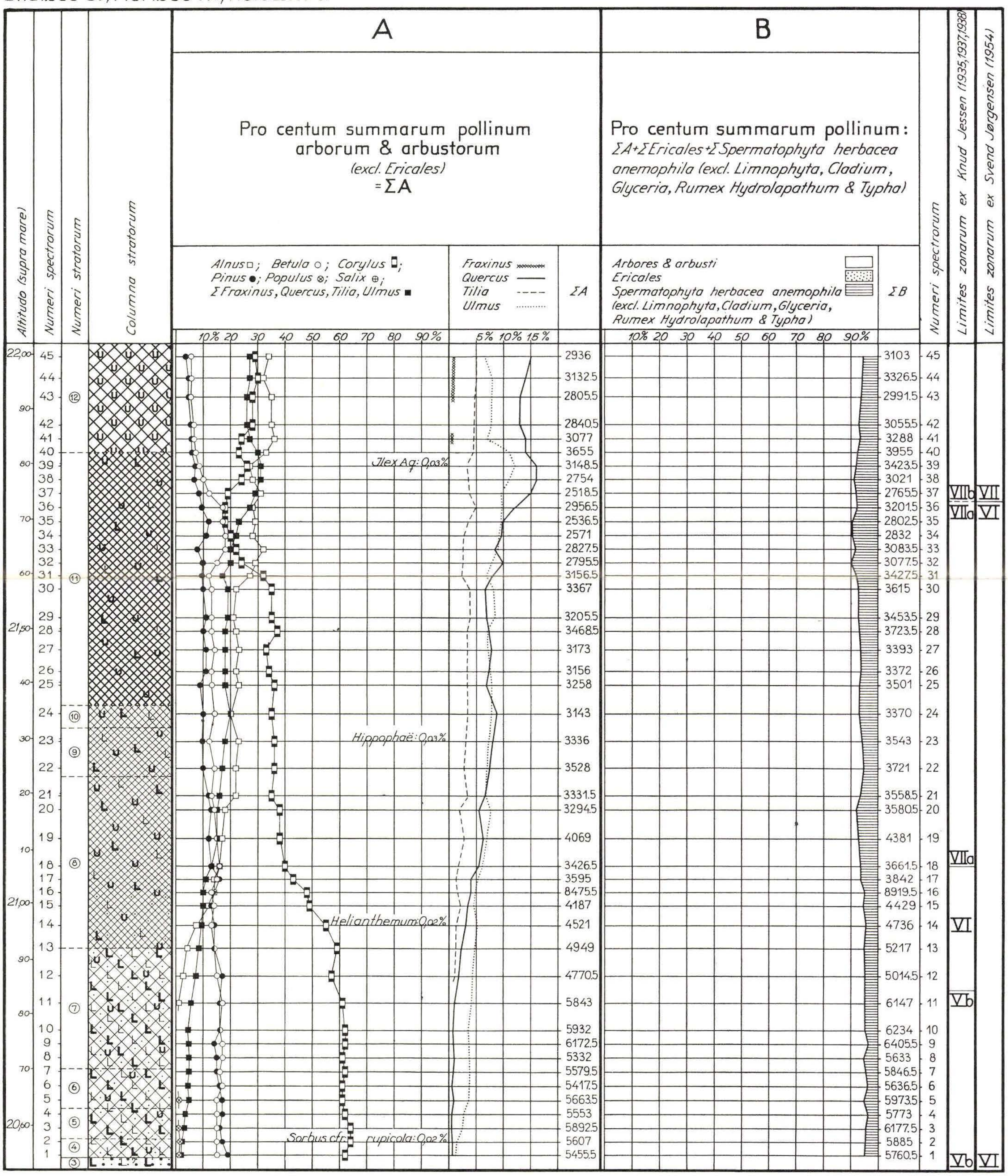
Niløse - Komplekset; Baad I, Boring I.

Niløse S., Merløse H., Holbæk A.



Aamosen: N. 1,000; Ø. 2,840; Bp Ib.

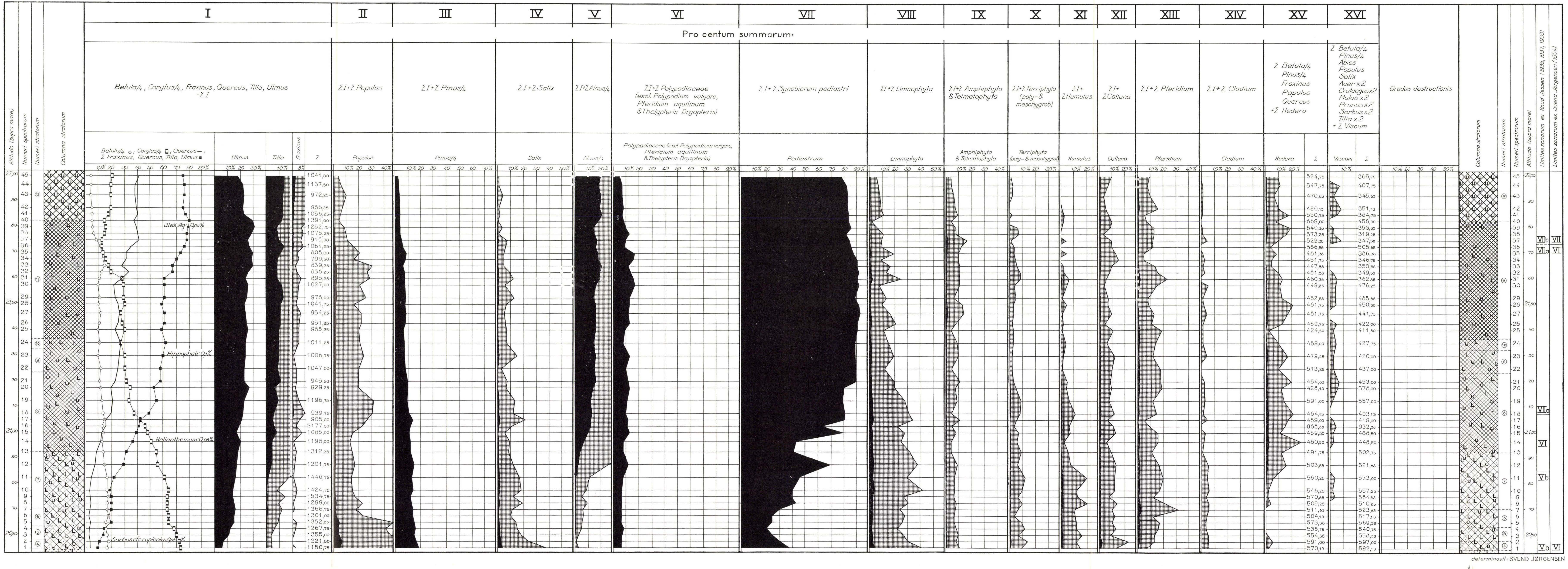
Undløse S., Merløse H., Holbæk A.



determinavit: SVEND JØRGENSEN

Aamosen; N.1,000; Ø.2,840; Bp Ib.

Undløse S., Merløse H., Holbæk A.



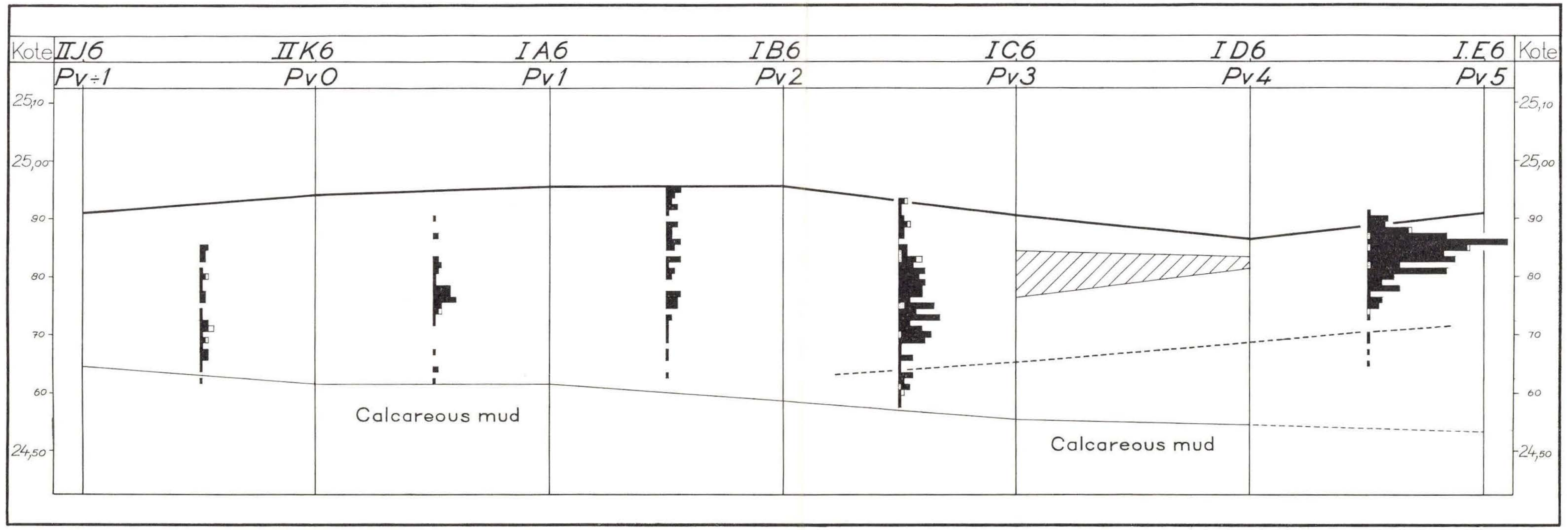
Verup-Komplekset; Verup 5. Stratigrafical and Pollenanalytical Evidences.
Niløse S. Merløse H. Holbæk A.

Verup-Komplekset; Verup 5. Profil P. Archaeological Evidences.
Niløse S. Merløse H. Holbæk A.

PLATE XXI

Verup-Komplekset; Verup 5. Pv.a. Archaeological Evidences

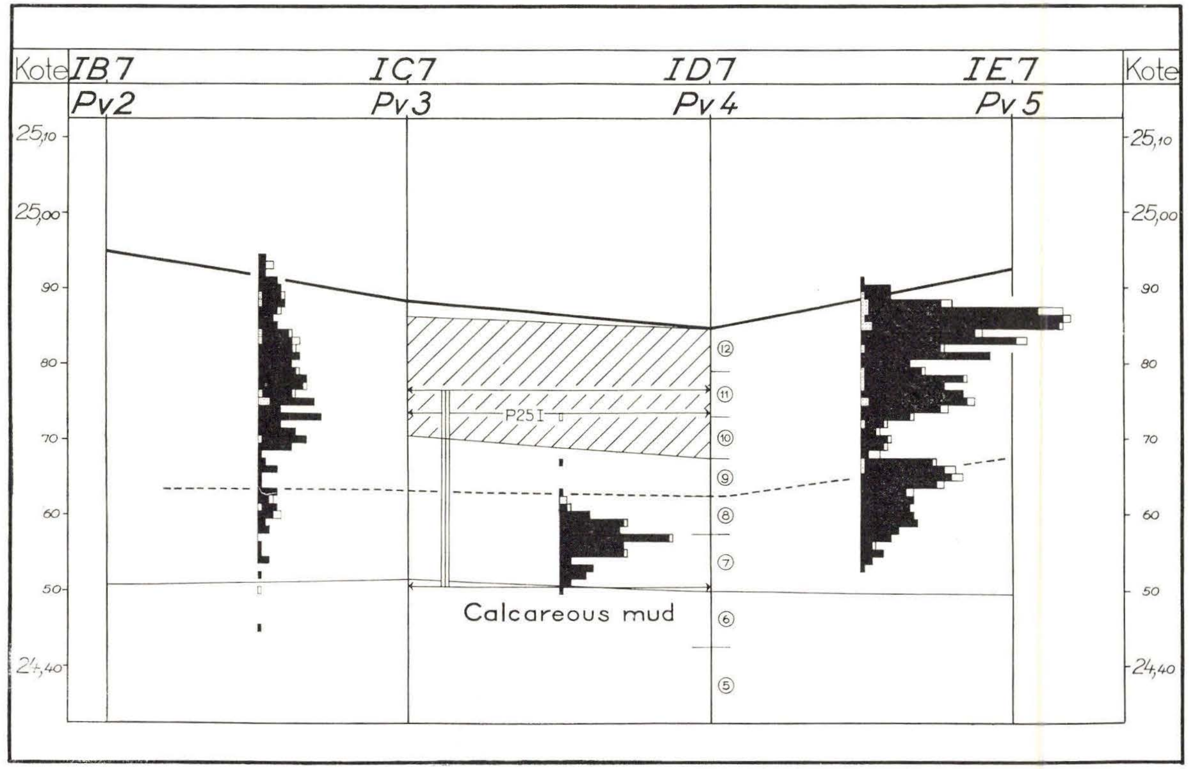
Niløse S. Merløse H. Holbæk A.



Upper culture layer.
Flint, unpatinated.
Flint, patinated.
Bone & antler.
Level of find of big granite stone.
←Po,o→ Level of find of artifacts dated by pollen statistics.
① ②···· Numbers of the layers.
---- Approximate lower border of the uplifted area.

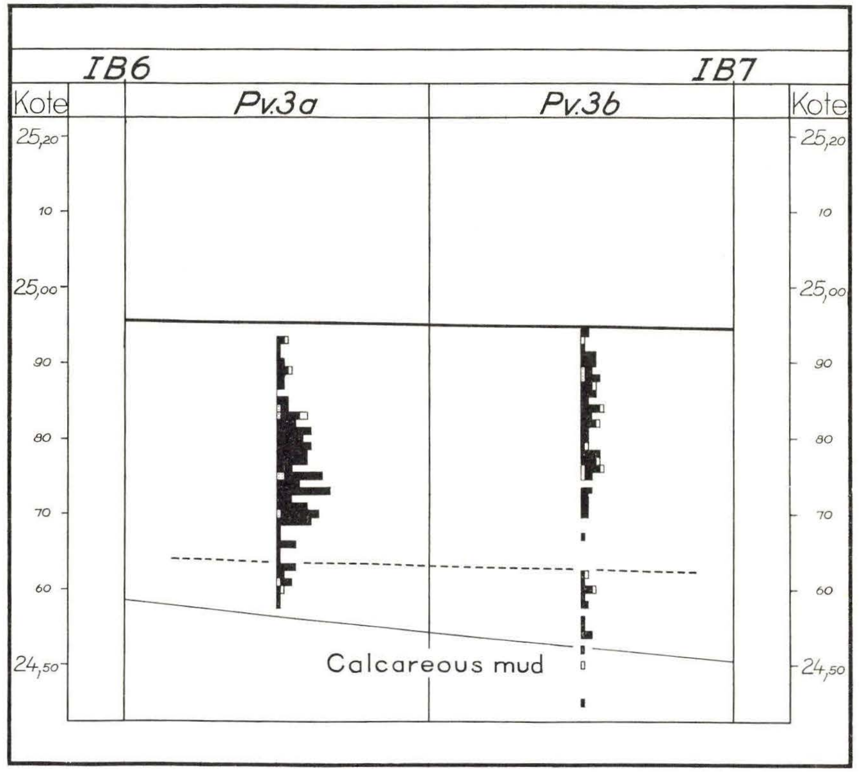
Verup-Komplekset; Verup 5. Profil Pv. (a+b) Archaeological Evidences.

Niløse S. Merløse H. Holbæk A.



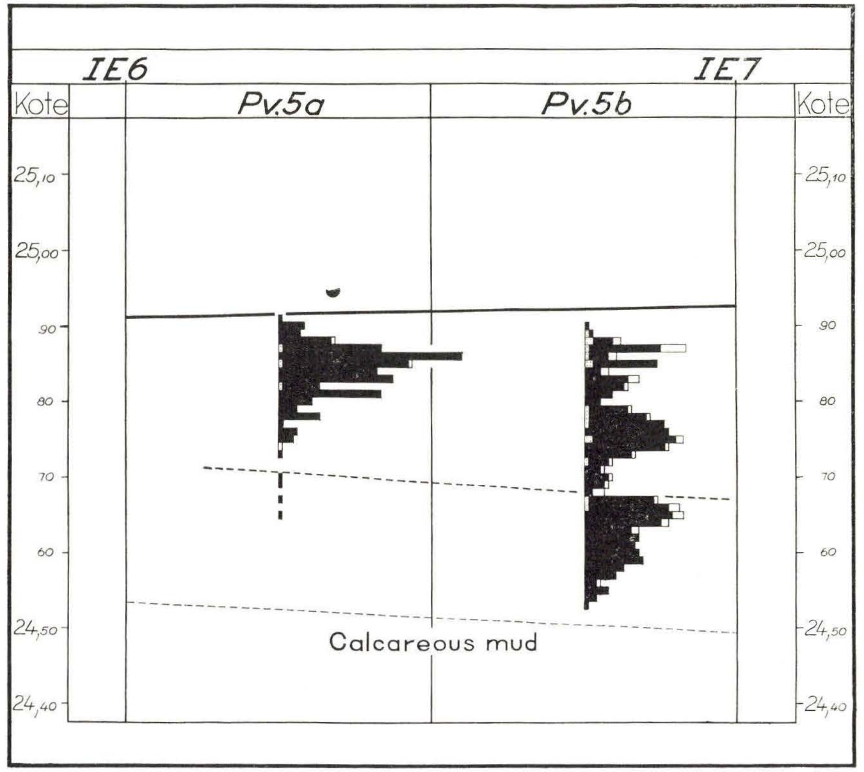
Verup-Komplekset, Verup 5. Archaeological Evidences.

Niløse S. Merløse H. Holbæk A.



Verup-Komplekset, Verup 5. Archaeological Evidences.

Niløse S. Merløse H. Holbæk A.



Pl. XXII. – Cartoon showing the probable development of natural conditions and the periods of habitation at Verup 5 in Boreal & Early Atlantic time.

Tegneserie, der viser det sandsynlige forløb af tilgroningen og vandstandssvingningerne samt bebyggelsesperioderne på Verup 5 i boreal og tidlig atlantisk tid.

Verup-Komplekset; Verup 5; Profil P.

Niløse S. Merløse H. Holbæk A.