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II. Række. Nr. 80.
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Studies in Vegetational History

in honour of

Knud Jessen

29th November 1954

With 21 Plates

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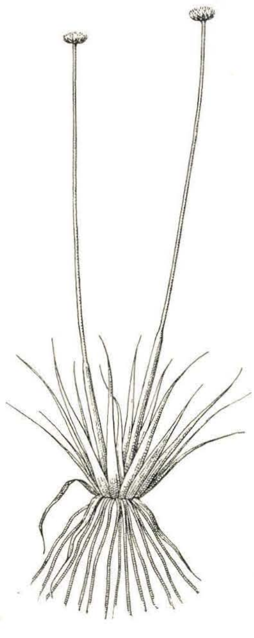

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Editor: Johs. Iversen.

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Knud Jessens navn er uløseligt knyttet til den nordeuropæiske floras historie, i mere end en menneskealder er han gået i spidsen på dette forskningsområde. Hvor han begyndte i Danmark og i Irland fulgte andre efter, inspireret af hans indsats og støttet af hans kraftfulde initiativ og venlige hjælpsomhed. I hans fodspor blomstrede forskningen op, præget af frugtbart samarbejde til alle sider. Dette lykkelige forhold kan føres tilbage til Knud Jessens vindende og frodige personlighed.

Streng saglighed præger Knud Jessens hele videnskabelige værk, og dog bæres hans arbejde som forsker af en spontan og smittende glæde. Vi håber da også, at den saglige hyldest, som er indholdet af denne bog, skrevet af kolleger, elever, venner, må glæde ham.

Knud Jessens virkefelt er ikke indskrænket til Danmark. Han har undersøgt tyske moser, bearbejdet engelske og norske fund, og fra hans hånd stammer de grundlæggende arbejder over Irlands vegetationshistorie. Det var derfor naturligt at give nogle af hans venner fra disse lande lejlighed til at deltage i denne hyldest.

Bogen er udgivet af Danmarks Geologiske Undersøgelse; den er en hilsen fra hans gamle institut, som han har skænket mange frugtbare arbejdsår som leder af Moselaboratoriet.

Johs. Iversen.

KNUD JESSEN's name is inherently associated with the history of the flora of northern Europe; for more than a lifetime he has been at the forefront in this field of research. Where he began, in Denmark and in Ireland, others followed, inspired by his achievement, sustained by his vital initiative, and his kind assistance. In his footsteps research flourished, characterized by fruitful allround co-operation. This felicitous esprit de corps can be traced to Knud Jessens charming and downwright personality.

Strict objectivity distinguishes Knud Jessen's entire scientific work, yet his daily work of research is borne by a spontaneous and infectious joy. Accordingly, we hope that the specific tribute expressed in this book, written by colleages, pupils, friends, will please him.

Knud Jessen's sphere of activity is not limited to Denmark. He has investigated German bogs, worked with English and Norwegian finds, and from his hand derives the fundamental work on the vegetational history of Ireland. It was, therefore, natural to afford some of his friends from the countries mentioned an opportunity to partake in the tribute.

The book has been published by the Geological Survey of Denmark as a greeting from his old institute to which he has given many fruitful years of work as the leader of the bog laboratory.

Johs. Iversen.

CONTENTS

New Mounting Media for Pollen Grains.

By

B. Brorson Christensen

Nationalmuseet, Copenhagen.

Glycerin and glycerin-jelly have so far been the only embedding media commonly employed in the microscopy of pollen exines. As they are by no means ideal for the purpose the author has carried out experiments in order to find better media. Below some results of these experiments are described: Some drawbacks are mentioned of the more conventional embedding media as regards their usefulness in pollen microscopy. Several new media are proposed: Poppy-seed oil, Aesculus-gum, both of low refraction, and two artificial resins of very high refractive index, "Pleurax" and "Lurifax" of which the latter is described here for the first time.

When, more than half a century ago, the minute markings and intricate patterns on the silicious skeleton of diatoms began to be studied with great intensity and even enthusiasm, "diatomists" soon discovered that most of the mounting media commonly used in botanical microscopy were somewhat inadequate for this special purpose.

The images obtained with the conventional media were flat and devoid of contrast and detail; in glycerin, for instance, diatoms proved to be hardly visible, gum damar and Canada balsam were only slightly better. This calamity was the result of insufficient difference between the refractive indices of object (diatom silica in this case) and mounting medium. The normal remedy when this problem arises in microscopy is of course staining, but diatom silica is impervious to staining.

The other alternative is to apply other mounting media of refractive indices, either considerably lower, or considerably higher than that of the diatom skeletons ($n = 1.43$). With the advent of modern oil-immersion objectives, especially the apochromatics, media of very low refraction are losing interest, as they will of course affect the performance of such optical equipment. Accordingly, a search has been made for suitable media of very high refractive index, and to-day the diatomist has at his disposal a whole series of mounting media that give ample contrast and, when the microscope is correctly handled, show details that would be completely invisible with the "oldfashioned" media:

Styrax	n = 1.58–1.62
"Hyrax" (a synthetic resin)	1.71
"Sirax" (- - -)	1.80
Realgar (disulphide of arsenic)	2.55

In view of these results, it may seem remarkable that in pollen analysis, and pollen morphology, where problems are fairly similar to those confronting the diatomists, glycerin and glycerin-jelly still seem to be preferred mounting media. True, these mounting media are justly popular because they are very convenient in daily use, and they often give good results optically. Yet, they both have a great many drawbacks: The good optical results are very often due to a considerable amount of water being present in the slides, so that the refractive index of the medium is appreciably lowered. When slides are made absolutely free from water, results are not nearly as good. The refractive index of pure glycerin is 1.47, that of glycerin-jelly usually a little lower. Normally, pollen-exines have a refractive index of about 1.55–1.60, but when mounted in glycerin or glycerin-jelly they tend to become "soaked" and "swollen", with the result that their refraction is considerably lowered, and the contrast in the slides is less than might be expected. When the water that may have been present has evaporated from the mounting medium, the pollen grains are frequently very nearly invisible. This swelling is particularly pronounced when the material has been acetolysed.

To all this may be added that pollen slides mounted in these media have rather poor keeping qualities, they are apt to become dried out and ruined even when carefully sealed.

Now, of course, pollen exines are easily stained, but several leading scientists in this field seem to agree that the results of staining are not ideal. And though nowadays such equipment exists as the phase-contrast microscope, and the truly formidable electron-microscope, neither of these seems to be on the point of making the conventional kind of microscopy superfluous, or obsolete. The present author has, accordingly, for some time been carrying out experiments in order to find mounting media of better qualities, optical and otherwise, for the use in pollen investigation. It is naturally too early to form an opinion, whether the author has succeeded in finding media that will give "permanent" slides; but it is certain that details invisible or very nearly so in glycerin and glycerin-jelly, are easy to observe and photograph in such media as "F" and "G" (see below).

Because of the somewhat higher refractive index of pollen-exines as compared to that of diatoms it is possible to choose media of low refractive index, and to get good contrast this way, without deterioration in the performance of the finest objectives; on the other hand, the range of possibilities is limited, to some extent, by the fact that pollen grains are by no means as resistent to chemicals and heat as are the diatoms. For this reason, several otherwise very promising possibilities have had to be given up; hyrax and realgar, for instance, both seem to be impracticable.

Out of several hundred substances which have been tried as mounting media for pollen grains, only a few that have given promising results will be described below.

All the photographs in plate I represent pollen grains of *Corylus avellana* L. and *Salix* sp. in the acetolysed state. The amplification is 750 diameters, numerical aperture 1.37.

A. *Poppy seed oil* (n=1.46), see Plate I, Fig. A. With this substance the results obtained are somewhat better, optically, than with glycerin. Pollen material is mounted from benzene, and as poppy seed oil is one of the "drying oils" there is no reason for sealing the slides. After a few days, solidifying of the oil will fasten the cover-glass effectively along the edges, while the interior of the slide remains liquid over a considerable period. Thus it is possible by means of gentle pressure on the cover to move the pollen grains a little, if so required.

This medium does not seem to have any influence upon the size of pollen grains, and as it is not volatile there will be no tendency towards "drying out" of the slides.

B. *Glycerin* (n=1.47). The photograph, Plate I, Fig. B, is of a mount that contains no water at all. Although the slide was quite new at the time, swelling of the exines has begun, and already the contrast is less than might be expected. (It ought to be mentioned that the adjustments of the microscope and its lamp were not touched while the ten photographs in plate I were taken). Advantages and drawbacks of glycerin have, however, been discussed above.

C. *Aesculus-gum* (or -balsam), n.=1.49, Plate I, Fig. C. This is the brown, glistening and sticky matter seen on the buds of the common horse chestnut. The substance is easily isolated by soaking of the buds in benzene followed by straining and evaporating. In thin layers it is of a very pale green hue, the consistency is somewhat like molasses. Pollen grains may be mounted in this substance from absolute alcohol or benzene, (of which the latter is to be preferred). The optical results seem slightly better than with glycerin. There is no need for any sealing, since slides that have been stored for one year show neither any drying out nor a tendency towards hardening. Pollen grains may be moved as described above.

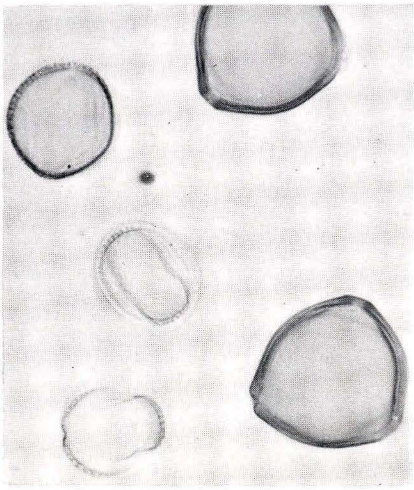
D. and E. *Damar and Styrax* (n = 1.52 and 1.58 respectively). Plate I, Figs. D. and E. These mounting media have of course excellent keeping qualities, but this is about all that may be said in their favour. The common photographic plate is rather insensitive to the yellow colour of acetolysed pollen grains, so the pictures show some contrast between the pollen grains and their background, but scarcely any details are visible.

The refractive indices of the two mounting media below mentioned are much higher than those of the media A-E, and above that of the pollen grains as well. Accordingly, the results obtained may seem strange to microscopists accustomed to studying pollen in media of low refraction. Nevertheless there can be no doubt that the media F and G show minute and delicate detail far better than any of the "conventional" media. This, however, is only quite apparent with an absolutely first class microscope, carefully adjusted.

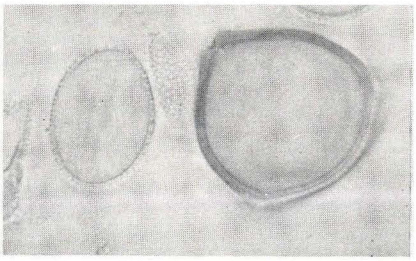
F. "*Pleurax*", *phenol-sulphur resin*, (n > 1.90). See Plate I, Figs. F, 1, 2, & 3. This substance—a light green, very transparent resin—is just beginning to be known as a mountant for diatoms. In the litterature of "plastics" it is however mentioned as far back as 1907, and so it is a veteran among synthetic resins. With some care pollen grains may be mounted in "pleurax" from pure alcohol, and the results are very satisfactory indeed, at least with regard to the optical requirements. (Acetolysed pollen material is apt to swell a little in alcohol). The keeping qualities are, of course, not sufficiently known as yet, but slides six months old have not shown any signs of deteriorating. A sealing ought to be carried out as "pleurax" is slightly sensitive to atmospheric moisture. The sample of phenol-sulphur resin used in these experiments was prepared by the author in the National Museum.

G. "*Lurifax*", (n > 2.00). See Plate I, Figs G. 1 & 2, and Plate II, E. This synthetic resin is still in its early infancy since it was invented by the present author during the experiments, here described. It is a compound of cinnamic acid and sulphur, and it is easily soluble in benzene and xylene as well as in chloroform. The preparation of the resin may be carried out by the microscopist himself at the working table—that is, if he is not too particular about smells and fumes:

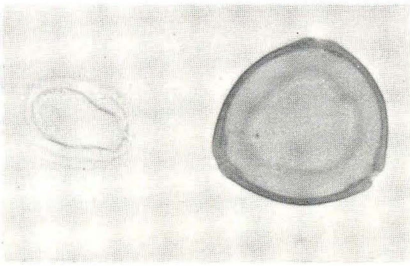
A mixture of 60 grs of β phenyl-acrylic acid (cinnamic acid) and 40 grs of sublimated sulphur is kept for 2–3 hours (in a retort) at a temperature of about 120° C. The result-after cooling- is a dark brown substance, rather soft but of a crystalline nature. This is dissolved in a little chloroform; isolated drops of the solution are placed on a glass plate and by means of a spirit lamp heated evenly but rather strongly. In this way polymerisation is completed and superfluous cinnamic acid is got rid of. This part of the process is not easy, partly because the dense yellow smoke that escapes is apt to catch fire, which it must not, partly because the heating ought not to be continued any longer than is



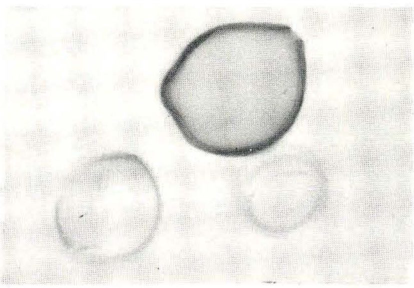
A



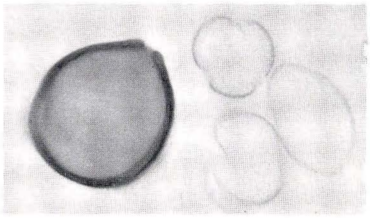
B



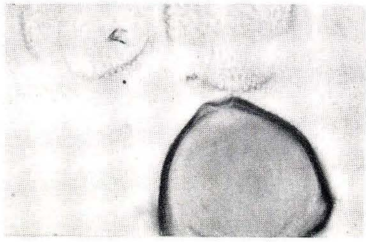
C



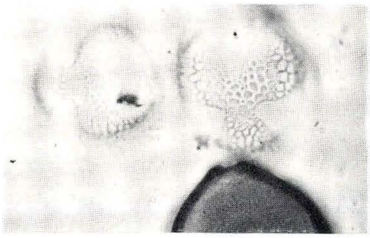
D



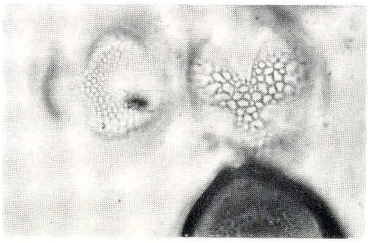
E



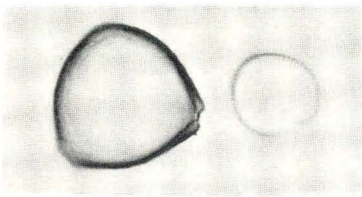
F_1



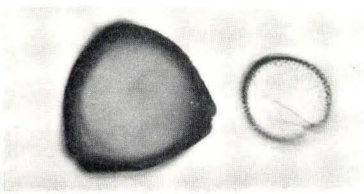
F_2



F_3

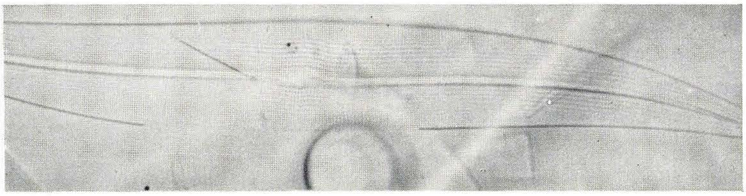


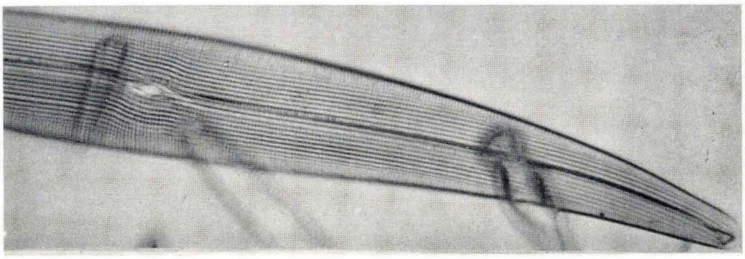
G_1

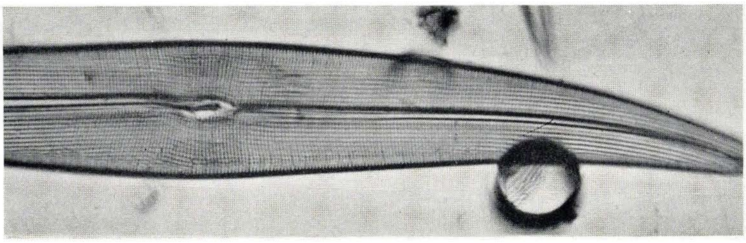


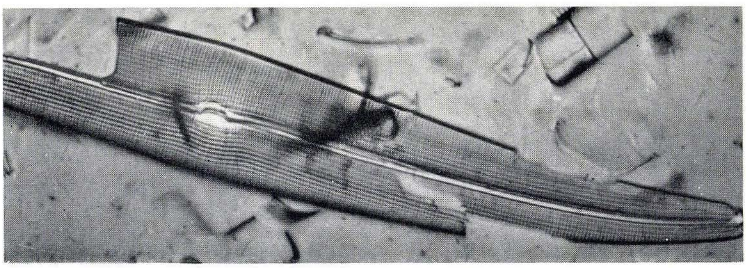
G_2


A


B


C


D


E

absolutely necessary. When cool, the drops should consist of a dark brown "resin", very smooth and shining, absolutely amorphous and, though brittle, so hard that it cannot be marked with a finger-nail. For use a sort of thick balsam is made by dissolving the resin in a small amount of benzene or chloroform.

Diatom slides are prepared in the same way as with styrax. Pollen-grains are mounted from benzene, a rather difficult procedure. The solvent should be very nearly got rid of before the cover-glass is placed on the slide and only very gentle heat may be employed.

This medium, it is true, is *very* dark yellow, but if slides are thin sufficient light is transmitted to permit a blue-green glass filter to be used, and results are very striking with diatoms as well as pollen grains. The keeping qualities are naturally quite unknown.

In plate II five specimens of *Gyrosigma* are shown photographed in five different media, at 640 diameters and at a numerical aperture of 0.85. The reason for this is that diatoms, being quite colourless and transparent, are well suited to the purpose of showing how contrast increases with a greater difference between refractive index of object on the one hand and mounting medium on the other hand. In A the medium is damar, B is mounted with styrax; C with "hyrax"; D with "pleurax" and E with "lurifax". In every case, except E, all conditions and adjustments are quite identical. E requires some more light than the others.

References.

MORRELL, R. S., 1943: Synthetic Resins and Allied Plastics, London.

SÉGUY, E., 1951: Le Microscope, emploi et application, I–II, Paris.

SPITTA, E. J., 1920: Microscopy, London.

STRASBURGER, E. 1902: Botanisches Praktikum, Jena.

WREDDEN, R. H., 1946: The Microscope, its Theory and Application, London.

Dansk résumé.

Indenfor pollenanalyse og morphologiske pollenundersøgelser har man hidtil som indeslutningsmidler for pollenkorn i mikroskopiske præparater anvendt glycerin og glyceringelatine. Disse stoffer lader imidlertid meget tilbage at ønske både med hensyn til præparaternes holdbarhed og i optisk henseende. Derfor foreslås her (som resultat af en række forsøg) nogle stoffer, der kunde tænkes egnede til at erstatte de glycerinholdige indeslutningsmidler:

Valmueolie og Aesculus-balsam med lavere lysbrydning end pollenexinerne, begge i optisk henseende så gode som eller bedre end glycerin og, hvad holdbarheden angår, antagelig at foretrække for denne. Endvidere to kunstharpikser, "Pleurax" og "Lurifax", begge med overordentlig høj brydningsindex og meget egnede til synliggørelse af fine og sarte exinestrukturer. Det sidstnævnte af disse stoffer er helt nyt og beskrives her for første gang.

Die Synchronisierung der mitteleuropäischen Pollendiagramme.

Von

F. FIRBAS

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Zusammenfassung.

Es wird versucht, eine kurze Übersicht über die Grundlagen zu geben, auf denen die Synchronisierung der mitteleuropäischen Pollendiagramme beruht.

Von den vegetationsgeschichtlichen Ergebnissen, die man KNUD JESSEN verdankt, haben vor allem zwei auch auf die Erforschung und Darstellung der quartären Vegetationsgeschichte Deutschlands sehr anregend gewirkt: die Zonengliederung der dänischen Diagramme aus der Spät- und Nacheiszeit mit ihrer Charakterisierung der vegetationsgeschichtlichen Perioden (1935–39, Ansätze dazu 1920) und die Gliederung des letzten Interglazials (JESSEN & MILTHERS 1928). So mag es, einer freundlichen Anregung der Herausgeber folgend, gerechtfertigt erscheinen, an dieser Stelle in etwas veränderter Form einen Vortrag wiederzugeben, mit dem auf der 3. Internationalen Tagung für quartäre Vegetationsgeschichte im August 1953 in Kopenhagen eine Diskussion über die Synchronisierung von Pollendiagrammen eingeleitet worden ist. Es schien hierbei zweckmässig, sich auf die Spät- und Nacheiszeit zu beschränken und von den Erfahrungen in Mitteleuropa auszugehen. Einige Bemerkungen über Material und Methodik werden hier weggelassen.

Auf welchen Grundlagen beruht die Synchronisierung der mitteleuropäischen Pollendiagramme?

In Mitteleuropa und in grossen Teilen von West- und Nordeuropa geben die Pollendiagramme bekanntlich eine eigenartige Sukzession der vorherrschenden Waldbäume wieder, nämlich die Reihenfolge: *Betula, Pinus* — *Corylus, Ulmus, Quercus, Tilia, Alnus* — *Fagus, Abies, Carpinus.* (*Picea* schaltet sich in diese Abfolge an verschiedenen Stellen ein.) Man kann diese Sukzession im Anschluss an RUDOLPH die »mitteleuropäische Grundsukzession« nennen. Sie ist eigenartig, weil sie mit der heutigen zonalen Gliederung der Wälder gegen den Nordpol oder mit ihrer Stufenfolge in den Gebirgen nur wenig übereinstimmt. Sie muss im wesentlichen postglazial sein und findet sich im übrigen innerhalb wie ausserhalb der Grenzen der letzten Vereisung. Sie gestattet es, die Pollendiagramme in eine Reihe von Zonen einzuteilen, wie dies seit v. POST und JESSEN vielfach geschehen ist. Diese Zonen können innerhalb eines Gebiets mit mehr oder weniger gleichem Klima und Boden als praktisch synchron angesehen werden. So bewährt sich z. B. in Nordwestdeutschland seit einer Reihe von Jahren eine von OVERBECK & SCHNEIDER (1938) entworfene Gliederung. Sobald wir es aber mit grösseren Entfernungen oder mit grösseren Unterschieden des Klimas oder der Böden zu tun haben, wird die Synchronisierung zu einer immer schwierigeren Aufgabe. Es können dann die gleichen Merkmale in den Diagrammen, d. h. die gleichen vegetationsgeschichtlichen Vorgänge wie z. B. die Massenausbreitung einer Holzart, metachron werden, sie brauchen nicht synchron zu sein. Dabei ist es zunächst gleichgültig, ob solche zeitlichen Verschiebungen auf Wanderungen der Arten in bestimmten Richtungen oder aber auf die fortschreitende Ausbreitung eines gewissen Klimazustandes zurückzuführen sind, der für die Förderung einer Holzart notwendig war. Gab es nun in dieser Entwicklung Ereignisse, die sich als synchrone Leithorizonte über ein weites Gebiet verfolgen lassen?

Als wichtigsten Leithorizont muss man mit FAEGRI (1939/40) wohl die jüngere Dryas- oder Tundrenzeit (Periode III) ansehen, genauer die Zeit der grössten stadialen Temperaturerniedrigung während dieses Abschnitts. In grossen Teilen von Westeuropa, in Mitteleuropa und im südlichen Nordeuropa kam es längere Zeit nach der ersten Ausbreitung von Birken- und Kiefernwäldern und kurz vor der endgültigen Massenausbreitung der Hasel und der Bäume des »Eichenmischwalds« zu einer nochmaligen, weitgehenden Verdrängung der Wälder und zu einer Absenkung der Waldgrenze in den Gebirgen um einige hundert Meter. Diese Vorgänge müssen auf eine neuerliche Erniedrigung der Temperatur während der Vegetationszeit zurückgehen und nicht etwa auf eine Zunahme der Trockenheit. Eine solche Temperaturdepression muss überall, wo sie in gleicher Lage beobachtet wird, praktisch gleichaltrig sein. Es knüpfen sich an sie noch einige offene Fragen:

Innerhalb welchen Gebiets lässt sich die jüngere Tundrenzeit sicher nachweisen? Von den Ländern um die südliche Nordsee bis nach Holland und ins nördliche Mitteldeutschland ohne Bedenken. In Süddeutschland und in den Alpen liegen völlig eindeutige Nachweise neben noch unklaren Befunden. Eindeutig sind z. B. die Nachweise am Sewensee in den Vogesen (GRÜNIG 1946), im Südschwarzwald (G. LANG 1952, 1954) und im Lanser See bei Innsbruck (ZAGWIJN 1952), sehr wahrscheinlich der bei Lunz in Niederösterreich (GAMS 1927), wohl noch nicht restlos gesichert jene aus dem nördlichen Alpenvorland und aus der Schweiz.

Noch nicht endgültig geklärt ist auch die Zuordnung der jüngeren Dryaszeit zum Eisrückzug. Die Richtigkeit der wohl zuerst von KNUD JESSEN (1920) vorgenommenen Parallelisierung mit dem Eishalt an den mittelschwedisch-finnischen Moränen dürfte freilich durch DONNER (1951) erwiesen sein. (Nach DONNER lässt sich eine waldlose Phase »III« nur vor und zwischen den Salpausselkä-Moränen I bis III nachweisen, innerhalb von Salpausselkä III nicht mehr.) In den Alpen aber ist es noch immer fraglich, ob und wie weit wir berechtigt sind, die jüngsten Stadien (Schlern, Gschnitz, Daun) zu einer Einheit — der »Schlussvereisung« AMPFERER's — zusammenzufassen und der jüngeren Dryaszeit gleichzusetzen. Doch ist es auch nach den jüngsten Untersuchungen von WELTEN (1952) sehr wahrscheinlich, dass zumindest das Gschnitz-Stadium in III fällt, wie seit langem angenommen worden ist.

Können wir die untere und obere Grenze von III über weite Gebiete als synchrone Horizonte verfolgen? Es ist zur Zeit noch recht schwierig. Die obere Grenze (III/IV, die Grenze zum Präboreal) z. B. wird ausser durch den Abfall der Nichtbaumpollen und durch den Anstieg von *Betula* seit JESSEN auch oft durch den mehr oder weniger raschen Wechsel von mehr minerogener zu mehr organogener Sedimentation bestimmt, und dieser Wechsel als Ausdruck einer raschen Klimabesserung angesehen (JESSEN 1920, NILSSON 1935 u. a.; »geochronologischer Leithorizont I« nach GROSS 1937). Das dürfte im allgemeinen richtig sein. Beim Versuch einer genaueren Konnektierung aber muss man bedenken, dass nicht nur die Massenausbreitung einer Holzart, sondern auch stratigraphische Grenzen bzw. der ihnen zugrundeliegende Sedimentwechsel an klimatische Schwellenwerte gebunden sein müssen, die in verschiedenen Landschaften zu verschiedener Zeit erreicht werden konnten.

Wenden wir uns nun zum Spätglazial vor III, so deckt sich der Nachweis der Allerödschwankung gebietsmässig etwa mit dem der jüngeren Dryaszeit. In einem Teil von Deutschland (nach bisherigen Beobachtungen zumindest von der Eifel bis in die Gegend von Braunschweig, Halle und bis zum Südschwarzwald) lässt sich die Allerödzeit durch den vulkanischen Laacher Tuff synchronisieren. Torfmudde unmittelbar über dieser vulkanischen Schicht ergab bei Wallensen im Hils mit der Radiocarbon-Methode ein Alter von 11044±500 Jahren (nach LIBBY) bzw. von 10910±330 Jahren (nach LEVI & TAUBER). Diese Zahlen stimmen sehr gut mit den in Dänemark (von ANDERSON, LEVI & TAUBER bzw. IVERSEN) an dänischen Proben gefundenen überein: 10970±220 bis 11880±340 Jahre für das Alter der jüngeren Hälfte der Allerödzeit bzw. 10300±350 und 10830±200 für den Übergang zur jüngeren Tundrenzeit.

Von besonderem Interesse ist zur Zeit die Frage nach dem Geltungsbereich einer älteren Klimaschwankung, die u. a. IVERSEN (1942) aus Dänemark beschrieben und als »Böllingschwankung« bezeichnet hat.

Dürfen wir allgemein ein unter den allerödzeitlichen Schichten liegendes nächstälteres Interstadial der Böllingschwankung zuordnen? In Ostpreussen (Gross 1937, 1942), Nordwestdeutschland (Schütrumpf 1943, Overbeck 1949) und Holland (van der Hammen 1949, 1951), also in verschiedenen Landschaften des Flachlands scheint sich diese Schwankung gut herauszuheben. Im mitteldeutschen Trockengebiet ist H. Müller (1953) bei Aschersleben in 101 m Seehöhe ein sowohl stratigraphisch wie pollenanalytisch besonders gut begründeter Nachweis einer spätglazialen Klimaschwankung gelungen, die älter als das hier durch den Laacher Tuff eindeutig bestimmte Alleröd sein muss und sehr wahrscheinlich der Böllingschwankung entspricht. An dieser Stelle werden sich auch Radiocarbon-Bestimmungen ausführen lassen. Ob die sogenannte »ältere Kiefernzeit« des Bodenseegebiets und Oberschwabens der Böllingzeit entspricht — wie G. Lang annimmt — bleibt zu entscheiden. (Über die Lage in den Alpen vgl. Welten 1952, S. 68.)

Schliesslich hat vor wenigen Jahren van der Hammen (1951) unter neuen Gesichtspunkten die Frage behandelt, welchen Horizont man in den Diagrammen als Beginn des Spätglazials ansehen soll. Er schlägt die erste stärkere Ausbreitung der im Gebiet schon vorher vorhandenen und daher nicht etwa wegen unvollständiger Einwanderung fehlenden Gattung *Artemisia* vor der Böllingzeit hierfür vor. War aber nicht auch diese Erscheinung an einen bestimmten klimatischen Schwellenwert gebunden und somit in verschiedenen Landschaften ungleichaltrig?

Betrachten wir nun die postglazialen Diagramme, so stehen uns hier bekanntlich verschiedene Wege zur Synchronisierung zur Verfügung, teils solche, die für das ganze Postglazial, teils solche, die nur für einzelne Perioden brauchbar sind.

Allgemein brauchbar ist zunächst die »Diagrammlage« im Sinne von Rudolph (1930). Wenn der Zeitabschnitt von der jüngeren Dryaszeit bis zur Gegenwart in vielen Diagrammen abgegrenzt worden ist, dann wird die gleiche Erscheinung, z. B. der Steilanstieg der *Picea*-Kurve, dort, wo er regelmässig im unteren postglazialen Teil beobachtet wird, älter sein als dort, wo man ihm meist erst in der Mitte der Diagramme oder noch höher begegnet. Man setzt also voraus, dass das Wachstum der Sedimente im Durchschnitt vieler Diagramme der Zeit ungefähr proportional gewesen ist. Das kann natürlich nur zu einer ersten Übersicht führen.

Eine allgemeine oder doch eine sehr weitreichende Geltung wird man auch von allen klimageschichtlichen Gliederungen erwarten dürfen. Die älteste ist das Blytt-Sernander'sche System. In Mitteleuropa heben sich seine Perioden in den meisten Landschaften weder in der Stratigraphie noch in der Waldentwicklung so klar heraus, dass man danach genau genug synchronisieren könnte. (Verhältnismässig am schärfsten lässt sich auch in den mitteleuropäischen Mooren natürlich das Subatlantikum, die Zeit des Jüngeren Sphagnumtorfs, erkennen.) Es scheint in jeder der Blytt-Sernander'schen Perioden feuchtere und trockenere Phasen gegeben zu haben, die extremer waren als die durchschnittlichen Unterschiede zwischen den Hauptperioden selbst. Aber auch nach diesen kürzeren Phasen, d. h. also nach den Rekurrenzflächen bzw. nach der abwechselnd mehr hygroklinen oder mehr xeroklinen Tendenz des Hochmoorwachstums (OVERBECK), sollte man sich wenigstens so lange nicht richten, so lange Zahl und Alter der Rekurrenzflächen und der Bereich ihres Vorkommens nicht endgültig festgestellt worden sind. So warnt OVERBECK (1954) mit Recht vor einer einfachen Übertragung des schwedischen Rekurrenzflächen-Systems auf die deutschen Moorgebiete; hier ist vielmehr eine möglichst unabhängige und unvoreingenommene Datierung entsprechender Erscheinungen (einschliesslich des »Grenzhorizonts«) notwendig.

Eine weitere klimatische Grossgliederung ermöglicht die postglaziale Wärmezeit bzw. die klimatische Revertenz im Sinne v. POST's (1930, 1944) mit ihren regionalen Parallelen. v. POST hat vorgeschlagen, die postarktische Zeit danach in drei Phasen, nämlich die der »zunehmenden, kulminierenden und abnehmenden« Wärme zu gliedern und in der Vegetation »termino-« und »mediokratische« Elemente zu unterscheiden. Diese Gliederung hat den Vorteil, dass sie eine sehr gut begründete, klimageschichlich besonders wichtige Tatsache von weltweiter Geltung betrifft. In der Nomenklatur kann man zudem zu einer einfachen Parallelisierung mit dem Blytt-Sernanderschen System kommen und sollte an dieser auch festhalten, gleichgültig, welche Begrenzung der Perioden sich schliesslich als die zweckmässigste herausstellen wird:

Subatlantikum	=	Nachwärmezeit	
Subboreal	=	Späte	Wärmezeit
Atlantikum	=	Mittlere	Wärmezeit
Boreal	=	Frühe	Wärmezeit
Praeboreal	=	Vorwärmezeit	

Aber so wichtig der postglaziale Temperaturverlauf auch ist, die Temperaturveränderungen sind in den Diagrammen meist nicht so ausgeprägt, dass sie für eine genauere Synchronisierung geeignet wären. Es ist in Mitteleuropa z. B. sehr schwierig, die Wirkungen der klimatischen Revertenz von denen der menschlichen Wirtschaft zu unterscheiden. (Man vergleiche z. B. die Förderung von *Pinus, Picea, Betula* oder *Calluna* im Laufe des letzten Jahrtausends.) Überhaupt sollte man die Revertenz nicht überschätzen. Im letzten Interglazial ist ja gerade eine gewisse Asymmetrie der Vegetations- und Klimaentwicklung von Interesse, mit der sich schon C. A. WEBER und KN. JESSEN befasst haben. Dort, wo andere Wege fehlen, war die v. POST'sche Dreigliederung bis zur Einführung der Radiocarbon-Methode freilich das einzige Mittel zu Synchronisierung (Hawaii, Neuseeland).

v. POST (1930, 1944) hat weiterhin auf die kleineren, kürzeren Klimaschwankungen aufmerksam gemacht, die wahrscheinlich einen Teil der »sekundären« Kurvenschwankungen verursacht haben, die man in Diagrammen mit geringem Probenabstand beobachten kann; sie sollen auf die Interferenz mehrerer Klimarhytmen mit verschiedener Amplitude zurückgehen. v. POST hat vorgeschlagen, sie mit Hilfe sehr dicht gezählter Diagramme von Landschaft zu Landschaft zu verfolgen. Wie besonders die Bemühungen T. NILSSON'S zeigen, ist es leider sehr schwer, den hierfür nötigen, sehr grossen Arbeitsaufwand zu bewältigen und zu so eindeutigen Synchronisierungen zu gelangen, dass sie andere Bearbeiter völlig überzeugen. FAEGRI & IVERSEN warnen wohl mit Recht davor, kurzfristige Schwankungen der Pollenanteile zur Synchronisierung zu benützen, so lange ihre ökologischen Ursachen nicht bekannt sind. Immerhin wird man Erscheinungen wie die vorübergehend höheren *Fagus*-Anteile vor dem endgültigen *Fagus*-Anstieg, auf die SCHMITZ (1951) und OVERBECK (1952) vor kurzem aufmerksam gemacht haben, mit Interesse weiter verfolgen.

Den weitesten Geltungsbereich hätte schliesslich die Verknüpfung der Diagramme mit den eustatischen Schwankungen des Meeresspiegels (v. POST 1944). Darauf kann hier nicht eingegangen werden.

Zu diesen allgemeinen Wegen treten nun noch solche von engerem Geltungsbereich. Sie sollen nicht gesondert besprochen, sondern die heutige Lage getrennt für die einzelnen Perioden gekennzeichnet werden. Dabei können jeweils nur einige wichtige Fragen hervorgehoben werden. Wir wollen mit der jüngsten Periode beginnen.

In der Nachwärmezeit, im Subatlantikum, das man heute meist bis zur Gegenwart reichen lässt, steht uns ausser archäologischen Funden auch die unmittelbare Verknüpfung der Pollendiagramme mit der aus schriftlichen Quellen bekannten Siedlungsgeschichte zur Verfügung. Die Pollenkörner der Getreide und anderer Siedlungszeiger (*Plantago*, *Fagopyrum*, *Centaurea cyanus* u. a.) bezeugen — wie übrigens auch schon in älterer vorgeschichtlicher Zeit — die Entstehung und Ausbreitung der Feldfluren und des Weidelands. Die Methode ist vor allem in jenen Landschaften gut brauchbar, die verhältnismässig spät und dann rasch und intensiv besiedelt worden sind, wie z. B. viele der deutschen Mittelgebirgslandschaften zwischen dem 7. und 14. Jahrhundert n. Chr. Man kann danach das Subatlantikum in Mitteleuropa leicht in zwei Abschnitte (IX, X) unterteilen. Doch kann es sich hierbei um keine endgültige Gliederung handeln. Eine solche wird besser etwa nach den Rekurrenzflächen I–III vorgenommen werden, wie dies z. B. KN. JESSEN in Irland getan hat, oder auch allein nach der Temperaturkurve. v. POST hat gerade in seinen letzten Arbeiten betont, dass die Klimaverschlechterung wohl in Etappen vor sich gegangen sei. Man könnte z. B. die Zeit seit Beginn der grossen Gletschervorstösse im 16. Jahrhundert bis zur Mitte des vergangenen Jahrhunderts herausheben.

Die Späte Wärmezeit, das Subboreal, ist die klassische Periode für die Verknüpfung der Waldgeschichte mit der Archäologie. Zumindest grosse Teile des Neolithikums und die ganze Bronzezeit fallen in diesen Abschnitt, der nach oben durch die in der Regel deutlichste Rekurrenzfläche: RY III, den »Grenzhorizont« C. A. WEBER'S an der Wende der Bronze- zur Eisenzeit um 800–500 v. Chr. begrenzt wird. (Im nordöstlichen Flachland hat sich stattdessen nach GROSS und NIETSCH auch der Abfall der *Corylus*-Kurve unter 10% bewährt.) Das Subboreal ist die wichtigste Leitzone innerhalb des Postglazials. Schwierigkeiten für seine Umgrenzung in den Diagrammen bestehen darin, dass sein (sicher nicht einheitlicher) klimatischer Charakter noch nicht genügend geklärt ist, dass weder die relative Chronologie der typologisch bewerteten archäologischen Funde noch ihr absolutes Alter genügend feststehen, dass der Grenzhorizont mit anderen Rekurrenzflächen verwechselt werden kann und — als scharfe Kontaktfläche — überhaupt nicht streng gleichaltrig sein dürfte. Eine kritische Revision aller vorgeschichtlichen Funde, die mit Pollendiagrammen verknüpft sind, von berufener prähistorischer Seite wäre erwünscht.

Als untere Grenze des Subboreals hat IVERSEN (1941) in den dänischen Pollendiagrammen den Abfall von *Ulmus* (und den Anstieg von *Fraxinus*) gewählt. Ob sich diese Marke über weite Gebiete als synchroner Horizont verwenden lässt, ist insofern noch unklar, als man mit 3 *Ulmus*-Arten mit verschiedenen ökologischen Ansprüchen rechnen muss und an dem Rückgang der Gattung auch die menschliche Besiedlung wenigstens stellenweise mitbeteiligt sein dürfte (Verfütterung des Laubes, vgl. FAEGRI 1944 u. a.; TROELS-SMITH, Vortrag in Kopenhagen 1953). Auch bei den sekundären *Corylus*-Gipfeln des Subboreals ist noch zu klären, wie weit sie auf klimatische bzw. wirtschaftliche Einwirkungen zurückgehen. Welche in den Pollendiagrammen verzeichneten vegetationsgeschichtlichen Vorgänge man zur Grenzziehung Atlantikum/Subboreal wählen soll, bedarf also noch eingehender Untersuchungen. Der Beginn meiner Zone VIII (FIRBAS 1949/52) liegt, wie IVERSEN mit Recht hervorhebt, später als der seinerzeit auf etwa 3000 v. Chr. angesetzte Beginn der Zone VIII von JESSEN. Hingegen kann man die Zonen IX und X der nordwestdeutschen Gliederung von OVERBECK & SCHNEIDER, wie dies neuerdings SCHMITZ (1953) und OVERBECK & GRIÉZ (1954, S. 68) tun, mit dem Subboreal der dänischen Diagramme zur Deckung bringen. (Der für mich massgebende Gesichtspunkt, für den Beginn von VIII einen etwas jüngeren Zeitpunkt — etwa 2500 v. Chr. — zu wählen, war der Wunsch, die Grenze mit Hilfe archäologischer Funde bekannten Alters möglichst oft überprüfen zu können.) Gleichgültig, welche Grenzziehung sich schliesslich als die beste herausstellen sollte, die Ausdrücke »Subboreal« und »Späte Wärmezeit« sollten immer als Synonyma verwendet werden.

Für den Beginn des Atlantikums, der Mittleren Wärmezeit, kann in grossen Teilen Mittel-, Nord- und Westeuropas der Beginn der Massenausbreitung von *Alnus* als Grenze angesetzt werden. Aber auch die rationelle Grenze von *Picea* oder die Überkreuzungen der Kurven von *Corylus*, *Pinus* und des Eichenmischwalds werden herangezogen. Und bedeutsame Vorgänge, vor allem die Massenausbreitung von *Corylus* und das Verhältnis von *Pinus* zu *Betula* stehen auch zur Begrenzung des Boreals, der Frühen Wärmezeit, zur Verfügung. Wie weit diese Vorgänge synchron sind, bleibt aber festzustellen. Gerade, wenn man an z. B. bei *Alnus* wahrscheinliche Zusammenhänge mit der flandrischen und der Litorina-Transgression — direkt oder auf dem Wege über das Klima — denkt, wird man eine zeitliche Verschiebung erwarten. Zudem müssen die Wanderungen der Holzarten auch eine gewisse Zeit benötigt haben. Mit Hilfe der vulkanischen Laacher Tuffschicht kann man z. B. zeigen, dass die Überkreuzung der Kurven von *Pinus* und *Betula* während der Allerödzeit im Süden und Osten früher erfolgt ist als im Nordwesten.

Vor allem die Beschäftigung mit dem Boreal und Atlantikum verstärkt den Wunsch nach weiteren Methoden der Synchronisierung, wenn möglich nach einer von den bisherigen Methoden unabhängigen absoluten Datierung. In dieser Beziehung hat man in Nordeuropa bekanntlich seit langem grosse Erfolge errungen. Im fennoskandischen Hebungsgebiet ist dank der postglazialen Hebung und ihrer Verknüpfung mit der Bändertonchronologie DE GEER's und SAURAMO's ein geschlossenes System der gesamten spät- und postglazialen Landschaftsentwicklung entstanden, das auf wohl begründeten Synchronisierungen über weite Strecken aufgebaut ist. Die britischen Inseln verfügen z. T. über ähnliche Bedingungen. In den Ländern mit vorherrschender postglazialer Küstensenkung bestehen diese günstigen Vorraussetzungen leider nicht. Man hat zwar auch hier jahresgeschichtete Sedimente gefunden, so TAPFER 1940 bei Kiel, WELTEN 1944 im Faulenseemoos in der Schweiz. Besonders WELTEN's Arbeit hat gezeigt, dass die Auswertung solcher Ablagerungen erfolgreich sein kann. Sie macht aber, wenn man Irrtümer vermeiden will, umfangreiche Paralleluntersuchungen nötig, die zur Zeit noch fehlen.

Auch die Dendrochronologie kann vorerst nur zur Lösung von Teilfragen bzw. nur innerhalb des letzten Jahrtausends herangezogen werden. Zumindest scheint es nach den bisherigen Erfahrungen zweifelhaft, dass es bald gelingen könnte, sie über das ganze Postglazial auszudehnen. Teilfragen, die sich auf kurze Zeiträume beziehen, lassen sich mit Hilfe der Jahrringchronologie unter Umständen sehr sicher klären — wie z. B. die Untersuchungen von HUBER & HOLDHEIDE (1942) an der bronzezeitlichen Wasserburg Buchau im Federsee gezeigt haben.

So knüpfen sich heute sehr grosse Erwartungen an die Radiocarbon-Methode. Wir erhoffen von ihr, dass sich mit ihrer Hilfe wenigstens das Alter bestimmter Leitniveaus der Pollendiagramme sicher bestimmen lassen wird, zwischen denen dann mit den bisherigen Mitteln interpoliert werden könnte. Vorerst ist freilich der mittlere Fehler der physikalischen Bestimmung noch so gross (einige Jahrhunderte), die Einsicht in die Bedeutung der verschiedenen möglichen Fehlerquellen noch so gering, dass viele der für die Synchronisierung der postglazialen Diagramme notwendigen Altersbestimmungen nur auf Grund sehr zahlreicher Einzelbestimmungen mit der notwendigen Genauigkeit gewonnen werden könnten.

So lange die Möglichkeiten der Radiocarbon-Methode nicht ausgeschöpft sind, wird man besser davon absehen, eine für die ganze Erde gültige Gliederung des Spät- und Postglazials aufzustellen, deren reizvolle klimageschichtliche Problematik v. Post 1944 umrissen hat. Man wird eine solche Gliederung wohl am besten auf die grossen, in möglichst weiten Gebieten nachweisbaren Klimaschwankungen gründen und dann als Grenzen der einzelnen Abschnitte bestimmte Ereignisse bzw. Jahre wählen, so wie dies etwa de Geer für die Phasen des Eisrückzugs getan hat. Es ist nicht unwahrscheinlich, dass sich hierfür die Perioden des Blytt-Sernander'schen Systems bzw. ihre Korrelate im Temperaturverlauf als am besten geeignet erweisen werden.

Schriftenverzeichnis.

Um Raum zu sparen, sind nur diejenigen Arbeiten angeführt, die in Firbas, Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas nördlich der Alpen I und II, Jena 1949, 1952, noch nicht enthalten sind.

Anderson, E. C., Levi, H. & Tauber, H., 1953. Copenhagen Natural Radiocarbon Measurements, I. Science *118*, No. 3053, 6–11.

Firbas, F., 1953, Das absolute Alter der jüngsten vulkanischen Eruptionen im Bereich des Laacher Sees. Die Naturwissenschaften, *40*, 54–55.

Iversen, J., 1953, Radiocarbon Dating of the Alleröd Period. Science, *118*, No. 3053, 6–11.

Jessen, Kn., & Milthers, V., 1928, Stratigraphical and Paleontological Studies of Interglacial Fresh-water Deposits in Jutland and Northwest Germany. Danmarks geol. Undersøg. II/48, 379 S.

Lang, G., 1952, Zur späteiszeitlichen Vegetations- und Florengeschichte Südwestdeutschlands. Flora, *139*, 243–294.

— 1954, Neue Untersuchungen über die spät- und nacheiszeitliche Vegetationsgeschichte des Schwarzwaldes. I. Der Hotzenwald im Südschwarzwald. Beitr. naturkundl. Forschung in Südwestdeutschland, *13*, 3–42.

Müller, H., 1953, Zur spät- und nacheiszeitlichen Vegetationsgeschichte des mitteldeutschen Trockengebietes. Nova Acta Leopoldina (Halle), N. F. *16*, Nr. 110, 67 S.

Overbeck, Fr., 1952, Das Grosse Moor bei Gifhorn im Wechsel hygrokliner und xerokliner Phasen der nordwestdeutschen Hochmoorentwicklung. Veröff. Niedersächs. Amt Landesplanung u. Statistik. A I, *41*, 63 S.

OVERBECK, FR., & GRIÉZ, I., 1954, Mooruntersuchungen zur Rekurrenzflächenfrage und Siedlungsgeschichte in der Rhön. Flora *141*, 51–94.

SCHMITZ, H., 1953, Die Waldgeschichte Ostholsteins und der zeitliche Verlauf der postglazialen Transgression an der holsteinischen Ostseeküste. Ber. Deutsch. Botan. Ges., *66*, 151–166.

WELTEN, M., 1952, Über die spät- und postglaziale Vegetationsgeschichte des Simmentals. Veröff. Geobot. Inst. Rübel, Zürich, *26*, 135 S.

ZAGWIJN, W. H., 1952, Pollenanalytische Untersuchung einer spätglazialen Seeablagerung aus Tirol. Geologie en Mijnbouw, Nw. ser. 7, *14*, 235–239.

Recurrence-Surfaces*.

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Abstract.

Reflection upon various apects of our knowledge of recurrence-surfaces in peat-bogs suggests a number of matters which call for further investigation. Among them is the nature of the plant communities which formed the old *Sphagnum-Calluna-Eriophorum* peat, evidence for total cessation of bog-growth in the Sub-boreal period, and the extent to which bog-growth can be affected by increased curvature on the one hand, directly by climatic change upon the other. We need to recognise the ecological successions represented in the precursor peat (*Vorlaufstorf*), to recognise how changes in the bog surface may have led prehistoric people to construct trackways over the flooded bogs, and to modify or abandon their methods of land utilization in the face of increasing wetness. And we must finally attempt the correlation of recurrence surfaces over the whole area of their occurence, using the widest available field of scientific evidence.

Throughout the past few years I have found myself often concerned with the problems of recurrence-surfaces in British peat bogs, and although I cannot pretend now to offer any fresh or conclusive evidence about them, there appears to be some case for setting down a body of ideas about their character, together with some comments and queries upon the many explanations of them which have been put forward. What I write is not however to be taken as a comprehensive review, but merely as a series of personal reflections upon that subject.

If recurrence-surfaces (boundary-horizons, Grenzhorizonte) are to be properly understood their consideration must be from the widest possible angle, and it will be necessary to consider their nature, origin, relation to climate and to vegetational processes, as well as their dating.

We need not elaborate WEBER's demonstration of the character of the *Grenzhorizont*, but may recall the form of his explanatory hypothesis, that in the dry Sub-boreal period the bog-surfaces dried out and the older

* The substance of an introduction to the discussion of this subject given at the Third International Conference on Quaternary Vegetational History, Copenhagen; 1953.

peat underwent a secondary humification, whilst little or no peat was added in the dry Sub-boreal climatic conditions; and that rapid peat growth recommenced in the Sub-atlantic period, which opened at the transition from Late Bronze Age to Early Iron Age about 500 or 600 B.C., in north-western Europe.

The humification of the old *Sphagnum-Calluna* peat is now generally taken to be primary and not secondary, the product of raised-bogs growing very slowly and with surfaces (at least seasonally) very dry. It is to be noted that we are still ignorant of the plant communities which formed the old *Sphagnum-Calluna* peat, for macroscopic remains in it are extremely decayed, and no systematic work has been directed to characterising them by detailed analysis of the local component of pollen and spores. It is apparent that *Calluna*, and often *Eriophorum vaginatum* played an important role in such communities.

Although WEBER's view was that peat-growth ceased entirely in the Sub-boreal period, (thus leaving a time gap in the stratigraphic sequence) there is only slight evidence in this sense from the raised bogs of the British Isles, and indeed in those instances where we can be certain of its Sub-boreal age the peat shews very little distinction from that formed in the preceding Atlantic period. Nevertheless, in *late* Sub-boreal time there is evidence in many places of drying-out of bog surfaces: this takes the form of tree layers of birch and pine, layers of *Calluna* and of *Eriophorum vaginatum*, and locally there may be short time-gaps and reworking of peat-surfaces. It is highly probable that the "Upper Forestian" shewn by GEIKIE and LEWIS to be so extensively present in Scottish peat bogs can be referred to this period.

We owe to GRANLUND the demonstration that the sudden supercession of humified old peat by fresh, unhumified younger peat was not the product of one period only, but that at least five such horizons might be recognised in the bogs of southern Sweden. To these GRANLUND attributed the dates 2,300 B.C., 1,200 B.C., 500 B.C., 400 A.D., and 1,200 A.D. Later NILSSON increased the number of consistent recurrence-surfaces to nine.

GRANLUND put forward the hypothesis that under constant climatic conditions there is a limiting height, operating through steepness of marginal curvature, to which raised-bogs can grow, and that this height is greater in atlantic than in drier climates. It is suggested that the bog tends to grow to a limiting steepness of curvature and then passes into what OSVALD has described as a 'Stillstand' condition: active growth is only restored when the climate becomes more atlantic. Although GRANLUND is not precise upon the point, it seems to me to be inherent in this hypothesis that a bog which records a sequence of superposed recurrence-surfaces must have been formed by a climate which progressed, with some halts or recessions, towards always greater oceanicity. One would be much more inclined to accept a hypothesis giving the chief weight to a fluctuating wetness of climate, no doubt with fluctuations of varying period and amplitude, such as Dr. Conway envisaged in her enlightening comment upon von Post's ideas of climatic rythms. (CONWAY, 1948).

Furthermore, in a large raised-bog, say 2 kilometres or more in diameter, an increased height of 50 or 100 cm. in the centre (such a distance as separates one recurrence surface from another), must represent so very slight a change in surface slope at the bog centre that it could not possibly be held responsible for the entire difference between continued growth and total cessation. One has but to stand in the middle of the bog plain of a great undrained Irish bog to realize the force of this contention. Now by contrast with the ineffectiveness of this slightly increased height, how powerful must be the effects upon the central bog surface of those fluctuations of rainfall and evaporation which we *know* to occur year by year, decade by decade, and which we may by inference suppose also to have operated over longer cycles. These must have inevitable effects upon the wetness of the bog-surface, and in face of them I find it unnecessary and indeed misleading, to invoke bog-height as a causative factor in the formation of recurrence-surfaces.

The fact that a view so strongly opposed to GRANLUND's can be proposed, suggests the need for careful analysis of the water-regime of some carefully chosen intact raised-bog, where there can be measured precipitation, evaporation, surface drainage and sub-surface drainage at all seasons of the year, and in years contrasting in their overall wetness. In particular, attention will need specially to be given to the measurement of the volume of water-loss by seepage down through the bog to springs at its base. Failing such detailed knowledge, we can rely only upon circumstantial evidence, and the sum of this seems to me to suggest that in comparison with the direct effects of precipitation and evaporation all drainage losses from the bog are of minor importance in the establishment of phases of surface dryness; an effect associated with the high impermeability of the old *Sphagnum-Calluna* peat. My view of the matter can be illustrated simply by saying that I suggest that if an area in the centre of a living raised bog were enclosed in a glass cylinder extending to the full depth of the deposit, it would, in the course of centuries come to record the same recurrence surfaces within, as in the surrounding bog, although sheltered from all drainage effects save surface ones.

This view need not be more fully supported now, but it will be noted that it rests upon a combination of stratigraphic and surface ecological studies of the raised-bog complex at Tregaron in central Wales, made by V. M. Conway, G. F. Mitchell, myself, *et. al.* (GODWIN & MITCHELL, 1938; GODWIN & CONWAY, 1939). In particular what is there called the 'retardation layer' within the upper young *Sphagnum* peat, is centrally developed in each of three raised-bogs of the system and becomes insignificant marginally: this is not what one would expect if steepened margins are the effective cause of cessation of bog-growth. It is moreover equally pronounced in all these bogs though they differ greatly in size, whereas it would be supposed on the GRANLUND type of hypothesis that the smallest would shew the effect most strongly, and the large one least.

If we accept the notion that the bog-surfaces are directly under climatic control, and that climate is subject to variation of extremely varying degree, we may expect the layers of peat bogs also to exhibit horizons of change of widely varying intensity. A gradual and slight increase of wetness we might well expect to cause no more than an increased extent of pools as against hummocks on the bog-surface, a larger proportion of surface occupied by *Sphagnum cuspidatum* as against active hummock-building *Sphagna*, and perhaps a diminished frequency of *Calluna*. Such might be regarded as a reversible vegetational shift.

When however, we examine the nature of the vegetational change across a typical recurrence-surface and attempt a reconstruction of past events, we are most often struck by the suddenness of change at the boundary. Here is no gradual reversion from dryness to wetness, no slow reversal of vegetational changes, but rather a process of gradual recovery from an event of more catastrophic kind. It would seem that the dry bog surface had been in a Still-stand phase of *Calluna* dominance, with low summer water-levels, little active *Sphagnum* growth and a good deal of bare peat: with increased wetness it was no longer possible to retrace those steps by which the *Callunetum* became established, but instead the bog surfaces became flooded, large permanent pools appeared full of aquatic *Sphagna*, and above the flooded surfaces stood up the decaying old hummocks, now bearing abundant and vigorous *Andromeda polifolia*. Later, many of these hummocks became the centres of active growth, forming large islands of hummock-building *Sphagna* before they could establish themselves in the widespread pools. Finally there followed invasion of the pools by *Scheuchzeria palustris* and *Carex limosa*, and then the establishment of fully active *Regeneration Complex*.

Such a sequence as this can be repeatedly recognised at the recurrence-surfaces of British raised-bogs. The peat between the old peat surface and the new Regeneration Complex peat can well be called "Precursor peat" (*Vorlaufstorf*). Since it covers the depressions before it extends over the old hillocks, its base is not everywhere of the same age, but the range of this age difference may very easily be exaggerated. It should be noted also that the precursor peat is water-filled and loose, its vegetation floating level with the big residual hummocks, but when at some later time it dries out (by bog drainage, consolidation or climatic shift) it will sink down between the old hummocks to give a very curved outline along the peat section, an outline which misrepresents its position during formation.

An extreme instance of flooding of the dry surfaces of ombrogenous bogs is afforded by the raised-bog system in the Somerset Levels of western England. Here the bogs stand on a plain of estuarine clay between great hills of limestone, and hills of alternating clay and limestone, and at the time of the Sub-boreal to Sub-atlantic climatic deterioration the whole valley system became flooded with calcareous water. Thus, in this area the main recurrence-surface came to be represented by the formation of *Cladium-Hypnum* peat, often with much *Myrica* and *Molinia*, directly upon the surface of the old *Sphagnum-Calluna* peat.

Dutch workers have suggested that a recurrence-surface may be produced by a marine transgression, which operates by causing 'backing-up' of fresh water beyond the limits of penetration of salt tidal water. Whether such an effect can be produced depends of course upon the extent to which (short of flooding the bog surfaces) a rise of ground-water level in the valley *can* affect the wetness of the bog-surfaces: we have seen reason to doubt whether this effect will be large.

The evidence from bogs of the Somerset levels calls attention to two directions in which formation of recurrence-surfaces can be closely correlated with the activities of prehistoric peoples. The first of these lies in the strong suggestion that the climatic worsening was directly responsible for the widespread construction of wooden trackways which spanned the wide bog-filled valleys between the flanking hills. The evidence is strong that the trackways are all of the same age (Late Bronze Age, as is shewn by the axe marks on the cut timber), and that they all lie on the surface of the old *Sphagnum-Calluna* peat at the contact surface with the *Cladium-Hypnum* peat. We suppose that the bogs had hitherto been traversible on foot, and that the trackways were improvised to save vastly circuitous routes where previously there had been direct crossings of the valley. So quickly however did the flooding become effective and deep, that the trackways were embedded and preserved long before they could rot or be worn away by use. Such a situation as this inclines one to expect that in suitable circumstances, wooden trackways might also be constructed over other valley bog systems, and that indeed such trackways would tend to be associated directly with recurrence surfaces and consequently to be most frequent at the dates when such were forming. There is some evidence in this sense in England, where wooden causeways of the Fenlands are very frequently of Late Bronze Age date, but systematic analysis of the provenance of trackways is yet to be made.

The second direction in which the formation of recurrence surfaces appears to be bound up with the activities of prehistoric peoples is also indicated by data from the Somerset bogs. Here close analyses of the non-tree pollen shew a close relation between the frequency of "weeds of cultivation" and the bog stratigraphy. Before each of the two clear flooding horizons there is a maximum of these agricultural indicators, but each flooding episode is accompanied by a swift decrease in them. It is evident that the increased wetness suppressed agricultural activity in the region, but it is not apparent whether this was because the valley farmlands became submerged or because the wetness of climate made cultivation of clay soils impossible everywhere, even on the uplands. It will be interesting to see how far comparable effects will be recognised elsewhere in those parts of western Europe where suitably sensitive bogs exist.

In the Somerset Levels a further correlation exists with human activity since the famous 'lake-villages' at Glastonbury and Meare with their very extensive agricultural activities, flourished on the margins of open lakes, and can only have existed whilst lake-levels were stable and low. They are provisionally dated from about 60 B.C. to c. 50 A.D., at which latter time the occupation ended suddenly and for a reason yet unknown. It is significant that the date of 50 A.D. is the approximate date of the upper of the two clear flooding horizons in the raised-bogs, a determination based upon the recent discovery *in situ* of a bronze fibula, and it seems possible that the rising water-levels which flooded the raised bogs also brought to a close the lake-village occupation. We may note that a recurrence-surface of the same approximate date has already been described by NILSSON.

The various historical events associated with the climatic shifts responsible for the alteration of bog-stratigraphy have been set out in the correlation table of fig. 1.

Since recurrence-surfaces on the one hand and tree pollen analysis on the other are both primarily controlled by climatic change, one might suppose that pollen-analysis would be the natural and obvious way of correlating recurrence surfaces across a country or across a region. Although indeed some success has been achieved by this means, substantial difficulties do in fact present themselves. Firstly, the recurrence surfaces fall to a large extent within the period of disforestation by man, and it is often hard to distinguish climatic from anthropogenic effects upon forest composition. Secondly, with alteration of latitude and longitude the expression both of forest composition and of the incidence and nature of recurrence-surfaces will alter: both indeed are inherently subject to the probability that homologous stages at separated sites may not necessarily be of the same age. No less of course is true of the archaeological scales which may alternatively be brought in to supplement our dating of the recurrence surfaces. Radiocarbon dating alone seems to escape these difficulties and we may hope that by its use definite conclusions may soon be reached.

Dr. CONWAY (1948) has done the subject good service by analysing the

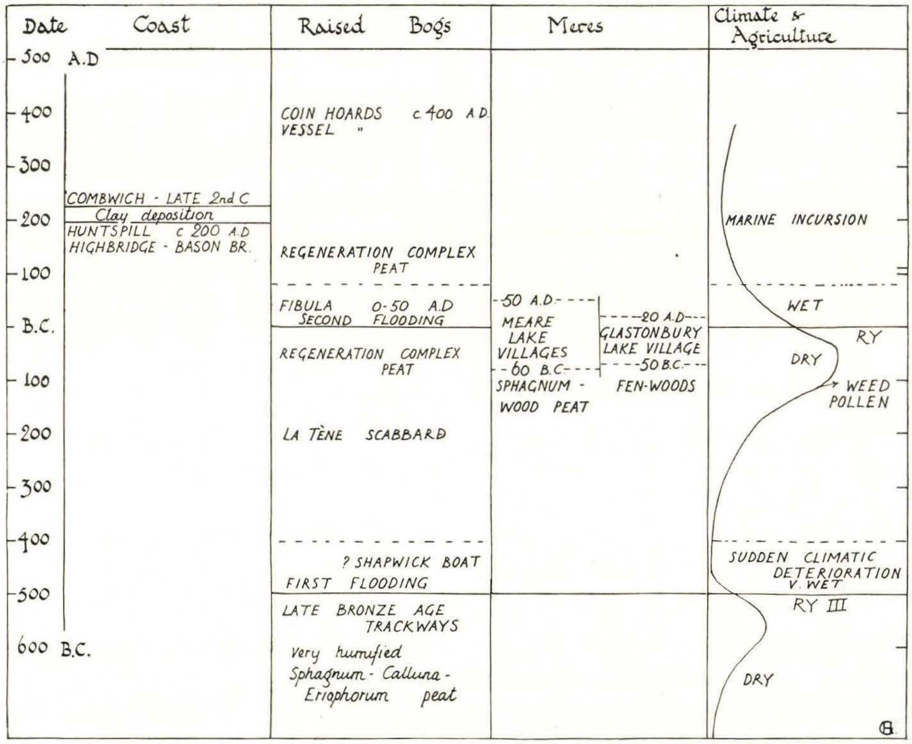

Fig. 1. Correlation of events between the Late Bronze Age and the close of the Romano-British period in the bogs of the Somerset Levels in western England. Weed pollen frequencies are here expressed as percentages of the total tree-pollen.

premises from which we make our mental approach to the whole question of the incidence of recurrence surfaces. She recognises the likelihood that threshold values of climate may exist above which new phases of bog development are initiated, but below which little apparent change accompanies the gradual alteration of the climatic factor. She further shews how, in a climate altering according to a series of fluctuations of differing amplitude and period, phases of coincidence in these fluctuations may lead to threshold values being exceeded. In a causative mechanism of this kind we see the possible cause both of the regularity with which past climatic cycles recur in different regions, and also of the apparently haphazard manner in which sometimes they give rise to recurrence surfaces, at other times not. We are for the first time encouraged to consider how given climatic fluctuations are differently represented in different parts of a region according to local conditions of altitude, topography and situation.

The present difficulty of recognising a given recurrence-surface over a large territory could hardly be better illustrated than by the situation in Ireland. Whereas the most pronounced of the recurrence-surfaces in the north-west coastal regions of the continent is apparently Granlund's RY III, which is known to fall at the opening of the Iron Age, in Ireland JESSEN (1949) has shewn that it is apparently the rule for Late Bronze Age artifacts to occur in relatively unhumified peat *above* the main recurrence-horizon. This clearly implies either that the Bronze Age cultures were delayed in reaching Ireland, or that the recurrence-surface there is earlier than that which seems to be its equivalent further east.

In the light of Dr. CONWAY's analysis it might be reasonable to suppose that the climatic deterioration began about 1000 B.C. everywhere, quickly reached the threshold value for Regeneration Complex bog growth in Ireland and in certain northern and high altitude bogs in England, so initiating a recurrence-surface corresponding approximately to RY IV. In south-western England it seems that there was more delay in reaching that critical stage, so that between 1000 B.C. and 500 B.C. the Somerset raised-bog surfaces mostly remained dry, in places growing slowly if at all, so that late Middle Bronze Age artifacts lay on the dry surfaces and corroded there; somewhat before 500 B.C. flooding affected the bog surfaces, Late Bronze Age trackways were laid down, and were finally covered by *Cladium-Hypnum* peat at the time of RY III. Only locally was the onset of the 'deterioration' marked by changes of stratigraphy at RY IV.

We may wonder whether the most prominent recurrence-surface of bogs on the Continental mainland is necessarily always to be equated with RY III, and the argument we have developed in fact might fit with recent indications by WATERBOLK that renewed peat growth did not take place in some Dutch bogs until as late as RY II.

Since it is not my intention to attempt comprehensiveness in this note, I shall not comment upon the new and useful, but to me unfamiliar, techniques of colorimetric estimation of humification and of Rhizopod analysis. It must content one, in conclusion, to voice two principles which would be readily agreed to by the distinguished quaternary geologist and botanist, KNUD JESSEN, whom we honour in this book; namely that bog-stratigraphy ought to be approached from a knowledge of the ecology and hydrography of existing bogs, and that the investigator should be broad enough in his interests to take account of evidence from all relevant fields of science, whilst retaining his own cautious severity of judgement.

References.

CONWAY, V. M., 1948. von Post's work on climatic rythms. *New Phytol.* 47, 220.

GODWIN, H., 1946. The Relationship of Bog Stratigraphy to Climate-Change and Archaeology. *Proc. Prehist. Soc.* 12, 1.

GODWIN, H., 1948. Studies of the Post-glacial History of British Vegetation. X Correlation between climate, forest composition, prehistoric agriculture and peat stratigraphy in Sub-boreal and Sub-atlantic peats in the Somerset Levels. *Phil. Tr. R.S.* 233, 275.

GODWIN, H. & CONWAY, V. M., 1939. The Ecology of a raised bog near Tregaron, Cardiganshire. *J. Ecol.* 27, 313.

GODWIN, H. & MITCHELL, G. F., 1938. Stratigraphy and development of two raised bogs near Tregaron, Cardiganshire. *New Phytol.* 37, 425.

GRANLUND, E., 1932. De svenska högmossarnas geologi. *Sverig. Geol. Undersökn.* Ser. C. N:o 373. Stockholm.

JESSEN, K., 1949. Studies in the Late Quaternary deposits and flora-history of Ireland. *Proc. R. Irish Acad.* B, 52, 6.

Dansk resumé.

En række forhold vedrørende højmosernes rekurrens-flader er stadig ikke tilstrækkelig klarlagt og trænger til fornyet undersøgelse. Eksempelvis gælder dette arten af de plantesamfund, der har opbygget den ældre *Sphagnum-Calluna-Eriophorum*-tørv, spørgsmålet om en eventuel fuldstændig standsning af mosens vækst i den subboreale periode, såvelsom spørgsmålet om til hvilken grad mosens tilvækst er påvirket af henholdsvis mosens hvælvning på den ene, og af direkte klimapåvirkninger på den anden side. Vi må videre udrede den økologiske sukcession af den såkaldte »forløbertørv« (Vorlaufstorf), få klarhed over hvorledes ændringer i mosernes overflade har ført til konstruktion af forhistoriske vejanlæg over forsumpede moser, og hvorledes den tiltagende fugtighed har medført en ændring i eller opgivelse af jordens udnyttelse. Endelig må vi forsøge at korrelere rekurrensfladerne over hele det geografiske område, hvori de forekommer, under anvendelse af alle de videnskabelige metoder, der står til vor rådighed.

Some Microfossils from Danish Late-Tertiary Lignites

by

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Abstract.

In the introduction an account is given of the more recent literature on the Tertiary lignites of Jutland as to their sedimentation, specimens of macroscopic and microscopic fossils, and the position of the lignites in the geological system. In the following chapter a number of microfossils are described in considerable detail and referred to family or genus (sometimes species) in the natural system of plants. The list (see page 41) comprises 1 alga, 1 moss genus, and 14 phanerogam genera.

Contents.

Introduction.

The year 1909 saw the publication of N. HARTZ's treatise: "Bidrag til Danmarks tertiære og diluviale Flora", a work which widened our knowledge of the Tertiary lignites in Jutland. On the basis of his studies, HARTZ was the first to demonstrate that Jutlandic lignite beds are freshwater sediments. As in the case of German lignite, they were formed in lakes, in which the first sediments were freshwater gyttjas which, as the lakes filled up, became covered with peat. According to whether the swampy or boggy area was more or less wooded the peat deposit contained varying quantities of wood. Thus the plant remains accumulated at or so near to the place where they had grown that the resulting lignite should be described as autochthonous.

This theory was entirely contrary to what had been the general opinion in Denmark from JOHNSTRUP's time up to the beginning of the 20th century, which was that the lignite beds had been formed of driftwood, brought here by rivers from some distance, such as the interior of Europe, and left upon swampy shores near the mouths of the rivers (allochthonous and contemporary marine sediments). HARTZ did not accept this hypothesis but considered Jutlandic lignites to be sediments corresponding to ordinary postglacial and interglacial bogs.

Prior to 1909, only wood remains from the Jutlandic lignite beds had been identified. HARTZ, however, now presented a list of remains of at least 20 species of vascular plants. His list comprised one vascular cryptogam, a *Pteris* species, represented by numerous frond sections, and at least 19 phanerogams, identified from one or more of the following organs found: branches, partly with bark, leaves, fruits or seeds, and pollen. However, several of the species were not placed to definite groups in the natural system of plants and designated, as is the custom in palaeontology, by special names applying to the particular organ which led to the setting up of the species. Ten or eleven of the nineteen phanerogams were identified as to genus, and of these three or four to particular—presumably extinct—Tertiary species. Of the remainder, four were determined as to family or groups of closely related families, while four other species, represented solely by fruits, could not at that time be referred to definite taxonomic groups.

HARTZ himself had identified the macroscopic plant remains, which at that time were practically the only plant fossils engaging the attention of a phytopalaeontologist. He was more concerned with the study of the fossil fruits and seeds than with leaves and leaf impressions, recognizing that plant identifications by means of fruit and seed gave much more exact results than those based solely upon leaf forms (that is to say, if one was sufficiently equipped with both recent and fossil comparative material). He was also aware of the difficulty of identifying many plant fossils from Tertiary sediments, which often required a thorough knowledge of both tropical and subtropical plants of both western and eastern hemispheres.

Microfossil studies, especially pollen and spore analysis, were known to HARTZ, though personally he made no use of the method; at that time it was still in its infancy and about twenty years were to pass before it was adopted in earnest in lignite studies, especially in Germany, the land of the large lignite occurrences. He deeply deplored the fact that an insufficient number of pollen analyses had been made, which meant that the conspicuous advantages of the method were not adequately utilized.

However, HARTZ was able to induce Professor N. G. LAGERHEIM of Stockholm to examine some Jutlandic lignite-gyttja samples for pollen, spores and any other microfossils, an examination that proved to be extremely profitable. Of the 20 vascular plant species entered by HARTZ in his list of species from Jutlandic lignite, at any rate 10 were represented by pollen. At the same time, two of them (*Pinus* and *Betula*) were also present as macrofossils, whereas the other eight were found solely as pollen. Nine species were listed as being represented by seed, fruit or fruit-cluster, and one of them (*Sequoia*) is also listed under branch and leaf finds, and another under pollen (*Pinus*). Now the present author has found further two of these genera (*Alnus* and *Nyssa*) as pollen. Of the remaining 5 species listed under fruit finds, four (*Carpolithes Dalgasii*, *Carp. Johnstrupii*, *Carp.* A and *Carp.*B) must be placed to definite groups within the system before they can be compared with the pollen types found. Only a total of 4 species are listed as leaves and branches, of which 2 (*Betula* and *Sequoia*) have already been mentioned above under pollen or fruits. The fact that not all the 15–16 species determined as to genera have so far been found as pollen or spores is probably due more to lack of familiarity with the pollen of these types than to their possibly sporadic occurrence or complete absence. In a letter to HARTZ, Professor LAGERHEIM himself remarks that in addition to the identified pollen types there "are many curious pollen grains which I have never seen in Quaternary gyttjas".

Whereas HARTZ's macrofossil examination provided evidence almost exclusively of the presence of woody plants in or around Denmark's Tertiary freshwater swamps, LAGERHEIM's microfossil analyses also provide examples of contemporary herbs and cryptogams which have cells capable of being preserved in the peat or gyttja and resisting the action of maceration agents, such as hyphae and spores of pyrenomycetes and remnants of algae, including diatoms, besides pollen.

The above brief statistical comparison of the macro- and microfossil types found, indicates very clearly the advantage of microfossil analysis over macrofossil examination. When interpreting one's results, however, it should be borne in mind that there are limits to what microfossil analysis can do.

The plant remains listed in HARTZ's book from the lignites can tell us nothing definitive of the age of these sediments, as the species shown must be assumed to be a somewhat onesided selection from the accumulation of plant fossils in the lignite: LAGERHEIM's species list from his micro-analyses comprises nothing but North and Central European plant types whose pollen were familiar to him (see above).

Since HARTZ's work, very little of botanical-geological interest has been published about the Danish lignites. In a short article in the German periodical "Braunkohle", 1938, FRANZ KIRCHHEIMER reports on his results—based upon a large German comparative material—arrived at from studies of the macroscopic finds which HARTZ collected and published in his 1909 book. He also re-examines the material from the amber-twig beds in the vicinity of Copenhagen, a material which HARTZ also had described as Tertiary. In several cases he corrects HARTZ's identifications and concludes, from comparisons with the occurrence of these plant fossils in German lignite beds, that at any rate a large proportion of the fossils found in the amber-twig beds must have originated in Upper Oligocene lignite which possibly occurred, or perhaps still occurs, in Denmark. But KIRCHHEIMER is unable to say anything definite as to the age of the Jutlandic lignites.

Opinions among Danish geologists on the age of these lignite beds have fluctuated in the course of time. In 1907 J. P. J. RAVN believed they were Lower Miocene. In 1909 HARTZ, without taking a definite stand on the subject, was inclined to think that the lignite was laid down in the Pliocene. TH. SORGENFREI in 1940 considered the Jutlandic lignite to be much later than the Lower Miocene and, according to an unpublished communication to K. MILTHERS in 1941, placed it to the Pliocene, thereby agreeing with the results of K. DREYER JØRGENSEN's (1940) studies of the occurrence of silicificates in the Tertiary sand beds accompanying the lignite deposits. During and after the Second World War the lignite department of Danmarks Geologiske Undersøgelse (D.G.U.) made a number of borings in Central Jutland. According to K. MILTHERS (1949), these borings show that lignite occurs at any rate in two horizons, viz. an upper one belonging to the later part of the Middle Miocene and a lower one in the Lower Miocene. Between the two horizons there are Middle Miocene marine sediments, at any rate in the western part of the lignite region.

For various reasons it is of importance to be able to differentiate between the two horizons, also in those places where the intermediate marine sediment is absent. If the two lignite horizons can be followed in a series of borings we shall have indications of very great significance, inter alia in forming an opinion as to the tectonic conditions of the region. Or, having bored through a lignite series at a certain depth at some particular place, a series that can be identified, it can be used as a basis for deciding whether there are more lignite deposits to be found at a greater depth, due consideration of course being taken to the stratigraphical conditions as a whole on the spot. Finally, there may be a correlation between the quality of various lignite deposits and their horizon. However, we cannot ignore the possibility that differences in quality may be due—and more probably are due—to facies differences within the same horizon.

Accordingly, in order to derive some advantage from the many excellent boring results from the strata in and between the Jutland lignite regions, strata which are very poor in faunal fossils, it is imperative to be able to distinguish the individual organic horizons. Nowadays for this purpose we have a usually excellent adjuvant in microfossil analysis, especially pollen and spore analysis.

It was only after the lapse of a considerable time that this method of study was introduced for the examination of pre-Quaternary sediments, especially Tertiary series, a new field in which it has scarcely been used for more than 25 years. HARTZ was before his time when previous to 1909 he requested Professor LAGERHEIM to undertake qualitative microfossil analyses of Tertiary lignite. Tertiary pollen analysis made no real advance until about 1930. The first really instructive papers on Tertiary pollen types and their importance to palaeontological and stratigraphical research made their appearance almost simultaneously, e.g. by H.-L. HECK, F. KIRCHHEIMER, R. POTONIÉ, K. RUDOLPH, R. P. WODEHOUSE, H. WOLFF and others. Many others followed later, including papers by a number of pupils of the above workers.

Naturally, attention was drawn to this new research method when during the last world war, in the early forties, lignite quarrying began again in Jutland and the government, at the suggestion of D.G.U., began a systematic search for more deposits through the medium of D.G.U.'s lignite department, which was established for the purpose under the leadership of Dr. KELD MILTHERS. The present writer acted as geological assistant in the investigation for various periods between 1941 and 1949, and he had great hopes of the pollen analysis that was to be applied to the material accumulated.

It was anticipated that by means of these analyses we should be able to discover the individual peculiarities of the various lignite beds or series, such as characteristic pollen types, pollen "associations", or perhaps a characteristic succession in the bed or series. This we hoped would provide us with the means of arriving at a fairly sharp relative age determination of the deposits, not only in each boring but in various borings and deposits.

That stage was not reached while the search for lignite deposits was in progress, however, and pressure of other work has also necessitated the shelving of the subsequent research for long periods at a time.

Wherever lignite deposits were found the borings made it possible to take samples for pollen analysis. The number of these samples was increased considerably by visits to the lignite quarries, where sample series were taken from the lignite sections themselves, often from accompanying gyttja or micaceous clay beds too. In addition, the usually rather low wall sections made it possible to study the stratification and macroscopic structure of the lignite beds and to measure stratum thickness and dip. Furthermore, at two localities (Söby near Kölkær station and Bjerregårde near Studsgård station) the author took sample series representing entire columns through the lignite series there.

The microfossils described in the following are from lignite samples from two localities in Central Jutland, viz. the neighbourhood of Bjerregårde, about $3^1/_2$ km. SW of Studsgård, and from Söby lignite area S of Lake Söby. At the former place the samples were secured from the open section, from the lowest part of the lignite bed quarried there. Those from the Söby area came partly from the only lignite bed—which was woodless—in Boring II, Ark. no. 95.472 (depth 9.3–10.5 m.) and partly from the upper—woodcontaining—bed in Boring VII, Ark. no. 95.477 (depth 8.4–9.7 m.), both on Matr. 26e+f of the parish of Arnborg.

The lignite samples were prepared in the same manner as postglacial peat or gyttja samples after being pulverized to facilitate the action of the maceration agents in the lignite mass. The Söby samples were boiled with KOH and then acetolysed, whereas after treating with KOH the Bjerregårde material was first boiled with 30–40% HF in order to remove any sand or clayey substance and then finished off in the same manner as the other samples. For further details of acetolysis and treatment with hydrofluoric acid, see Fægri & Iversen (1950) p. 62.

The maceration residue was chiefly made up into glycerine preparations; these are so far the most suitable for studying individual microfossils, which can usually be turned as required if the edges are not sealed with wax or in another manner. Before sealing, a small number of pollen grains and spores were transferred individually from these preparations to glycerine-jelly (single pollen preparations).

Tentative examinations of the microfossil content soon made it evident that the density and variety of pollen and spore types differed greatly, but not uniformly from one sample to another. For example, there might be great variation from woodless to wood-containing lignite beds and also within each of these beds. In the majority of cases, however, a very large number of types were represented.

It soon became evident, therefore, that the preliminary object would have to be a most careful qualitative pollen analysis, and for the present to postpone quantitative analysis, i.e. working out the pollen spectrum of the samples, which also meant pollen diagrams for the beds, until the qualitative analysis was nearly terminated. It was also quickly found that a large number of the pollen and spore types came from plants which nowadays have no closely related species or genera in Europe, but either in North America or East Asia or both. Some, however, seem to be quite devoid of closely related forms in the present day.

As a consequence, the following pages and especially the main chapter of the work will be devoted chiefly to qualitative pollen analysis. A description will be given of several microfossils, especially pollen types, found in the lignite deposits of Jutland.

It must be said at once, however, that not much can be concluded from the specimens concerning the vegetation type of the lignite period in Jutland, and less still regarding the climatic conditions. The present material is much too inadequate for that, comprising, as it does, only a small proportion of the microfossils in the lignite deposits; as a whole, only those pollen and spore types are included which the author considers can be referred to more or less comprehensive taxonomic units.

In addition to the types described in the following, the lignites contain a very large number of pollen grains whose identification requires a thorough examination of a comprehensive comparative material of foreign pollen types—an examination which has not yet been made.

In describing the pollen types I have chiefly utilized the terminology employed in JOHS. IVERSEN & J. TROELS-SMITH's "Pollen-morfologiske definitioner og typer", 1950, though some terms are taken from pollen-morphological works by R. P. WODEHOUSE, G. ERDTMAN, etc.

Identification of pollen and spores was made by comparing with recent fresh or dried material, which was treated with KOH, acetolysed and preserved in glycerine-jelly.

I have endeavoured to place the fossils as far into the botanical system as the available modern comparative material will allow. It is possible that a more comprehensive comparative material may lead to closer identification. According to POTONIÉ (1951, pp. 132, 134), however, it has not been possible in a single case definitely to determine the species of pre-Quaternary pollen grains, for which reason he introduced auxiliary names to designate "form species", also within known taxonomic groups. Such a "form species name" must directly signify that it belongs to fossil pollen grains and it may be added to the genus or family name, when the latter is known. For example, *Nyssa-pollenites accessorius* R. Pot. and *Nyssa-poll. analepticus* R. Pot. indicate two form-species within the *Nyssa* genus (e.g. see R. POTONIÉ, P. W. THOMSON and F. THIERGART (1950)). It is possible that in the first instance the finer classification will have no great bearing on the stratigraphy, but there is no saying that in time it might not acquire significance.

The fossils dealt with in the present paper are named after the smallest taxonomic unit—family or genus—to which they may safely be assumed to belong. Where possible, however, the name under which a particular fossil has previously been mentioned or described will also be given.

In some cases the descriptions of the pollen types are accompanied by pictures reproduced from photographs. Most of these photographs were taken with an oil immersion lens Apo Leitz 90×, numerical aperture 1.32, and periplanocular 6×, magnified 500×, whereafter the picture was enlarged 2×, so that the measurements in mm. on the picture correspond to the measurements in μ on the fossil (Plates III–VI).

The purpose of the picture is firstly to illustrate the general morphological characteristics of the grain, and secondly to show details of exine structure and sculpturing. When considered necessary, these details are demonstrated by a series of pictures taken at various focussing levels.

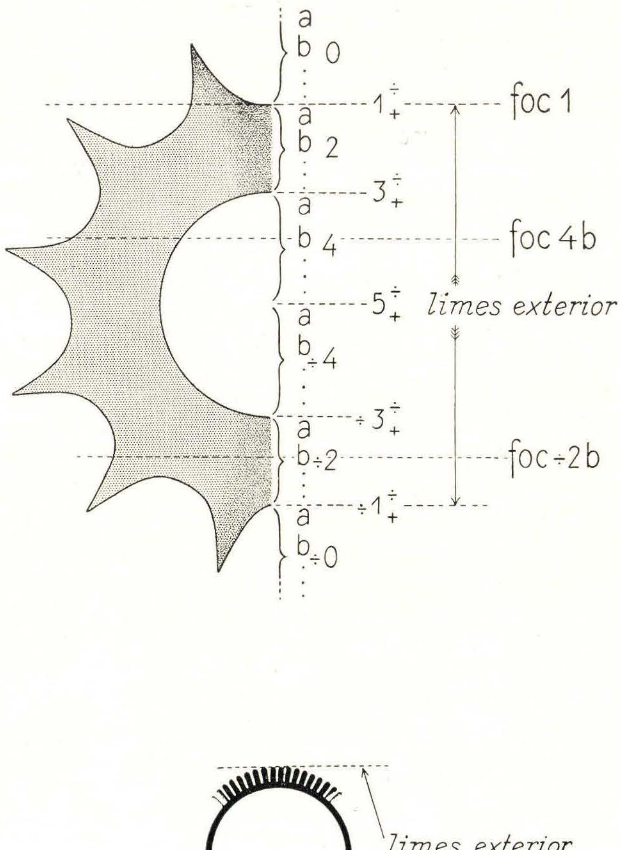


Fig. 1. Above. Schematic section through a pollen grain showing the position of the various focussing levels. (÷ = —).
Below. Schematic illustration of the position of the limes exterior for dense and open types of sculpturing, seen in profile. (From Johs. Iversen & J. Troels-Smith (1950)).

They show, for example, the exine viewed from the surface at different levels and sometimes in optical cross section.

To facilitate comprehension of the position of the various focussing levels (abbrev. foc.) indicated in text and figure captions I reproduce a schematic drawing from IVERSEN & TROELS-SMITH's paper (1950) (Fig. 1, p. 38).

The limes exterior of a pollen grain designates the more or less rotation-ellipsoidal surface which bears the sculptural elements (cf. Fig. 1, upper Fig. and lower part of lower Fig.). In cases where their outer tips—seen in profile—form more than 50 per cent of the outer border line, this line is regarded as the outer border line of the grain and the corresponding more or less rotation-ellipsoidal surface as the limes exterior of the grain (see Fig. 1, upper part of lower Fig.). All pollen measurements refer to this surface.

The position of the foc. of a microscope in relation to the superior or inferior limes exterior of a pollen grain may be indicated by foc. 0 to 5 and foc. —4 to —0 (if required with subdivisions (a, b, c, etc.)), see Fig. 1 above.

Foc. 1, 3, 5, —3 and —1 alone have a definite, fixed position on a particular grain; all other foc. may therefore be altered from one examination to the next, including the subdivisions a, b, c, etc.

The pictures shown in the plates are only a selection from the collection of photographs belonging to the particular pollen type. Our picture library generally contains a series of photographs in 1000× and also 500×. In special cases some of these photographs may be borrowed. The symbol and number of the photo-sheet for the pollen type concerned are shown in the descriptive text under each type and in the explanation of the plates, for instance: DGU b 183 (see explanation of Plate III). This symbol and number must be quoted together with the name of the pollen type when requesting loans. The original photo number for each figure is given in brackets in the explanation of the plates, e.g. (18, 30) (see explanation of Plate III).

Abbreviations and glossary of pollen-morphological terms.

In describing the fossils I have occasionally made use of pollen-morphological terms and abbreviations which may not be sufficiently known or directly comprehensible. I have therefore appended a key to some of the more important of them, here and there to their root. Otherwise the reader is referred to JOHS. IVERSEN & J. TROELS-SMITH (1950) or, as regards the majority of the terms, to K. FÆGRI & JOHS. IVERSEN (1950).

Abbreviations:
ektex. = ektexine
endex. = endexine
ex. = exine

ex.-index = exine index
ex.-M = exine-measurement = exine thickness
foc. = focussing level

Glossary of pollen-morphological terms.

annulus: an annular area around a pore, distinct from the general exine of the pollen grain, characterized by differences in the ektexine.

clavae: club-shaped sculptural elements which in at least one dimension are $\geqq 1\ \mu$ and whose greatest diameter is less than the height. Clavate: type of pollen sculpturing with clavae.

colpus (pl. colpi): germinating furrow; the area on the grain forming, or surrounding, the normal place of emergence of the pollen tube, with a length-breadth index higher than 2.

columella (pl. columellae): ektexine elements (granula) which like columns bear a tectum or form muri.

distal surface: the surface of a pollen grain or spore facing outwards in the tetrad.

exine: the outer, highly resistant layer of the pollen (or spore) wall. It may be simple, in which case it consists of structureless endexine, or complex, when it is built of structureless endexine (inner) and more or less structured ektexine (outer).

exine index: the relative thickness of the exine, i.e. the greatest exine thickness in relation to the greatest equatorial diameter.

foveolate: sculpturing type with holes or pits whose diameter $\geqq 1\ \mu$, but simultaneously $<$ the shortest distance to a neighbouring hole or pit.

granula (sing. granulum): sharply delimited granules, rods or similar structure elements embedded in or on the homogeneous basal substance of the exine (the endexine).

index: figure indicating the ratio of a measurement to the maximum equatorial diameter (cf. exine index, polar area index, shape-class index).

intercolpium: area delimited by neighbouring colpi margins and the lines connecting points of neighbouring colpi.

lumina (sing. lumen): the areas surrounded by muri in a reticulum.

muri: the walls or threads of a reticulum.

oblate: shape-class index 0.75–0.50.

periporate: pollen type with several free pores not equatorially distributed.

polar area: area surrounding a pole and delimited by lines connecting neighbouring furrow ends or touching the nearest margins of neighbouring pores or, if annuli are present, their nearest annulus margins.

polar area index: the ratio of the polar area measurement to the greatest equatorial diameter.

polar area measurement: the longest diagonal or the longest side of a polar area.

pore: area on pollen grain forming, or surrounding, the normal place of emergence of the pollen tube and whose length–breadth index is lower than 2.

proximal surface: the surface of a pollen grain or a spore facing the centre of the tetrad.

psilate: sculpturing type with even, or almost even, surface or with pits $< 1\ \mu$.

reticulum: network formed by regular juxtaposition of elongated sculpturing elements; reticulate: sculpturing type with reticulum; reticulum-lumina: meshes of a reticulum surrounded by muri.

rugulate: sculpturing type with elongated sculpturing elements in irregular or not predominatingly regular arrangement.

scabrate: sculpturing type with fine punctiform sculpturing elements $< 1\ \mu$ in all dimensions.

shape-class index: ratio of length of polar axis to greatest equatorial diameter.

stephanoporate: with more than 3 free pores, equatorially distributed.

subspheroidal: shape class index 1.33–0.75.

tectum: external membranous part of ektexine more or less covering the endexine; also used here when the ektexine elements form a massive layer with the same effect.

tricolporate: pollen type with 3 colpi and 3 pores, the latter centrally in the colpi.

triporate: pollen type with 3 free pores.

verrucae: more or less isodiametric sculpturing elements which in at least one dimension are $\geqq 1\ \mu$ and whose greatest diameter is $\geqq$ the height. The elements are neither distally pointed nor constricted at the base. The ratio of greatest to smallest diameter is < 2; verrucate: sculpturing with verrucae.

vestibulum: more or less sharply delimited small cavity within the pore; vestibulate: type of pore with vestibulum.

Taxonomic description of fossil types.

List of types described.

So far the following microfossils, chiefly pollen forms, have been identified to units—family or genus—in the natural plant system and are described below.

Descriptions.

Algae.

Botryococcaceae.

Botryococcus Braunii Kütz.

Some few cluster-like colonies, exactly like colonies of the alga *Botryococcus Braunii* Kütz from recent freshwater sediments, were observed in samples from the lowest part of the lignite bed at Bjerregårde.

The spherical—ellipsoidal—short pear-shaped segments of the colony are 10–11 μ in diameter and composed of a few (5 to 8) small cornet-shaped capsules which sometimes become shorter towards the centre of the segment. The capsules, which measure 2.8 to 3 μ in diameter, have rounded or often polygonal orifices towards the surface of the segment whereas their pointed bases all converge towards the short stem of the segment. The wall thickness of the capsules is almost equal to the width of their lumen, or somewhat thinner. The size of the colony measures about 24 μ.

This alga, which had already been found by LAGERHEIM in lignite-gyttja from Salten in East Jutland (see HARTZ 1909), seems to be a very persistent form which, at present found living in fresh water, is recorded from Estonia under the name of *Gloeocapsomorpha prisca* in sediments as early as the Ordovician.

The comparative object used was *Botryococcus Braunii* Kütz from postglacial gyttja. The resemblance between the Tertiary and the postglacial material is very close, except that the capsules of the Tertiary material are somewhat smaller.

A picture showing the shape of the colony and its structure is given in TH. M. HARRIS (1938), text figure 2.

Photo-sheet: DGU b 341.

Bryophyta.

Sphagnaceae.

Sphagnum spp.

The mosses are represented by spores which, judging by their shape, agree fully with recent *Sphagnum* spores.

There are both thick-walled and relatively thin-walled forms. The latter are the more frequent and they are usually smooth, though spores with thickened wall areas on the distal surface occur. The thick-walled spore type is always smooth. The circumference is rounded triangular—slightly triangular-circular. On the proximal surface is the triradiate tetrade mark whose three legs extend to about two-thirds of the radius from the centre. The equatorial diameter is 22–23 μ; ex.-M at the equator (thickenings of the wall not included) is 0.5–1.2 μ; ex.-index 0.02–0.05.

Sphagnum has been observed in the materials from both Bjerregårde and the Söby area, but not frequently.

Judging from the pictures the spores correspond to *Sporites stereoides* R. Pot. & Ven. = *Sphagnum-spor. stereoides* R. Pot. & Ven.; see e.g. Pl. XX, Fig. 2 in R. Potonié (1951).

Photo-sheet: DGU b 272 (thin-walled type).

Gymnospermae.

Pinaceae.

Sciadopitys cf. *verticillata* S. & Z.

Plate III, Fig. 7–10.

The more or less spherical pollen grain (42–49 μ in diameter) seems to lack distinct apertures, but within a rather small area the ex. is usually divergent. In this area, which is often somewhat elongated, the endex. is usually thinner than outside the area and the ektex. is more or less reduced with a lower and relatively open sculpturing, or the latter may be almost absent. At this supposed place of emergence of the pollen tube the ex. is often folded or slightly depressed so that in profile the grain here is somewhat flattened.

Outside this area the ex. is distinctly double. It consists of a relatively thin endex. (thickness about 0.5–0.7 μ) and a much thicker ektex. which, outside the aforesaid area, is up to 2.5–3 μ thick. Altogether the ex. is 3.2–3.5 μ in cross section where it is thickest. The ex.-index is moderate (0.06–0.07). The surface of the ex. has a coarse verrucate (-rugulate) sculpturing, with verrucae that are dense, tall, steep-sided and rounded in circumference—but sometimes rather irregular—and with rather rough, dome shaped tops. Outside the spot mentioned their diameter is about 3 μ, decreasing around the spot. Intermittently narrow pits run down into the surface of the verrucae and into the bottom of the narrow channels between them. Sometimes the verrucae seem to be more or less hollow, at others they appear entirely, or partly, solid.

On Pl. III, Fig. 7–10 are photographs taken at various foc. in the wall. Fig. 7 was taken at a plane just above or at the surface of the verrucae, which appear as rounded or oblong bright areas. On Fig. 8 the deepest parts of the narrow channels between the verrucae appear as bright, winding threads which, however, in the middle of the picture disintegrate into dots. Fig. 9 shows the pollen grain in optical section. The rough surface of the verrucae can be seen and the narrow channels, whose bottom seems to lie at about the same level above the surface of the endex., are visible in cross section. Fig. 10 shows part of the wall on the underside of the grain. Parts of the almost unsculptured area, mentioned above, can be seen together with the bases of the verrucae (blurred) bordering it.

These pollen grains conform very closely to the most complete grains of the recent *Sciadopitys verticillata* S. & Z. In addition, however, there are some fossil grains which differ more or less from the form described. However, recent *Sciadopitys* pollen may also vary greatly as regards surface sculpturing, and a number of modifications are encountered.

For example, sometimes the outer parts of the verrucae seem to be lacking, or they appear to be crumbled or shrunken; as a result, only the lower parts of the verrucae are preserved together with the bottom of the narrow channels between them. Fossil grains of similar type might perhaps also be referred to *Sciadopitys*.

Yet, even if a fossil and a recent pollen grain seem to agree in every particular, they cannot be said to belong to the same plant species (cf. POTONIÉ 1951). The same pollen form ("sporomorpha" according to ERDTMAN) may be common to quite a number of species, several genera or, perhaps, even families. For this reason a number of workers, especially R. POTONIÉ and collaborators, have elected to retain the form species names already adopted for the pre-Quaternary pollen fossils, as a kind of species name added to the name of the genus or family to which the form species is assumed to belong. The fossil *Sciadopitys* pollen found in Tertiary sediments was originally given the form species name *Pollenites* (abbreviated *Poll.*) *serratus* R. Pot. & Ven., which has now been adopted by POTONIÉ and his group as a kind of species designation in the latest form of name: *Sciadopitys–poll. serratus* R. Pot. & Ven. It is not conclusive that the pollen type given this name corresponds solely to the recent *Sciadopitys* species; in addition to the present-day species it may comprise one or more extinct ones.

The same thing applies to all other pollen types which have been referred to a natural genus, but where no specific proof can be given that it belongs to a definite living or extinct species, e.g. in the form of macrofossils in conjunction with the pollen. This must be understood throughout, even if no mention is made of it.

Hitherto, *Sciadopitys* has been definitely observed from the Bjerregårde area alone, and there only rarely.

Photo-sheet: DGU b 183.

Angiospermae.

Monocotyledones.

Gramineae.

The pollen grains are exactly similar to the pollen of present-day grasses.

They are more or less spherical, and monoporate with a distinct annulus around the pore. The pores are circular and have been observed solely as diapores (direct holes in the ex.), without operculum. Their diameter varies from 2 to 4 μ, whereas the measurement of the external annular margin may be from 5 to 10 μ. The size of the pollen grains fluctuates considerably within the individual samples, from 28 to about 40 μ. The ex. is double. The homogeneous endex. is sometimes very thin, only a small fraction of the total ex. thickness. In other cases it is thicker and may be almost as thick as the ektex. The latter, in cross-section, is more or less distinctly striated transversally with an almost smooth to more or less crenate external contour. Viewed from the surface the ex. usually has distinct coarse dots (ca. 0.5–0.7 μ in diameter). The surface is psilate or with fine granules $< 1 \mu$ (scabrate). The ex. is 0.6–0.9 μ thick. The ex.-index is small (0.02–0.03).

Grass pollen occurred with a rather scattered distribution in lignite from the Bjerregårde and Söby areas. LAGERHEIM demonstrated its presence in lignite gyttja from Sandfeldgård W of Brande in Central Jutland (see N. HARTZ 1909).

Photo-sheet: DGU b 283.

Dicotyledones.

The majority of the pollen types belong to this group. They are arranged in families as shown on page 42.

Juglandaceae.

Plate IV.

Several of the pollen types found are referred to this family.

Carya sp.

Plate IV, Fig. 9.

The pollen grains closely resemble modern *Carya* pollen.

They are somewhat depressed at the poles (i.e. slightly oblate). Seen from the pole they are circular, sometimes rather bulging around the three pores whose position is slightly displaced away from the equator towards one pole. The greatest equatorial diameter varies between 41 and 48 μ. The highest values were found on pollen treated solely with KOH and acetolysis, whereas the lowest values are of grains previously boiled with HF. This diminishing effect of HF treatment is well known (see B. B. CHRISTENSEN 1946). The pores are circular to slightly elliptic with a greatest diameter of 3.5–4.5 μ. The ex. is tectate, though the distinction between the two layers is not always clear.

At the equator the ektex. is much thicker than the endex., which in a more or less wide belt around the pores seems to be absent or very indistinct. The inner side of the ex. in these areas, which may be partly fused, is more or less rough, sometimes almost fringed in places. The surface is psilate, though possibly the distal ends of the original columellae may rise slightly above the tectum surface. Viewed from the surface the ex. usually has rather crowded, sharply delimited punctae which are bright (indistinct) at high and dark at a lower foc. The greatest diameter of these punctae is about 0.4–0.5 μ. The ex. thickness measured at the equator and midway between the pores is 1.4–1.9 μ, usually 1.4–1.5 μ. The ex. index is low (ca. 0.03). Sometimes the ex. is slightly thickened beyond the margin of the pore, but often it becomes rather thinner when approaching it.

A round, somewhat thin-walled form is shown on Pl. IV, Fig. 9.

Exactly the same characters have been observed in recent *Carya* pollen, of which the comparative material used were *Carya myristicaeformis* Nutt., *C. microcarpa* Nutt. and *C. ovata* (Mill.) K. Koch.

The only difference between the fossil pollen and the comparative material is that the fossil grains are a little smaller than the recent ones and their ex. correspondingly thinner. (The greatest equatorial diameter of the above recent species in the above succession measured was 60–66 μ, 50–60 μ and 57–63 μ respectively; the ex. thickness was 1.8–1.9 μ, 1.8–1.9 μ and 2.1–2.8 μ and the ex.-index 0.03, 0.03 and 0.04 respectively). These size differences between fossil and recent material may possibly be due partly to individual variation (the comparative preparations usually came from a single or very few individuals), or perhaps to unstandardized treatment in the early stages of the investigation.

Carya pollen was found very sparsely in the material from Bjerregårde and the samples from the upper lignite deposits of Söby (Boring VII).

R. Potonié originally named this pollen type *Pollenites simplex* and later (R. Potonié et al. 1950 and R. Potonié 1951) *Carya-poll. simplex* R. Pot.

Photo-sheets: DGU b 202 and 432.

Pterocarya sp.

Plate IV, Fig. 8.

A number of fossil pollen conform in every way to the pollen of modern *Pterocarya*. The grain is oblate with a greatest equatorial diameter varying between 29 and 46 μ. Equally distributed along the equator are 5–7 pores rising somewhat above the general surface of the ex., which gives the grain in the polar aspect a polygonal appearance. The elliptical pores, whose diameter in the equatorial plane measured 2–3.5 μ, are usually so oriented that their longitudinal axes converge in pairs alternately on either side of the equator. The ex. is tectate and, measured midway between the pores, usually 1–1.5 μ in thickness. The ex.-index is low (ca. 0.03). In optical section the wall is not striated tranversely. The ektex. is much thicker than the endex. Around the pores the endex. seems to be absent and here the inner side of the ex. is rough. Although the ektex. in these areas is generally somewhat thickened, the wall is usually more translucent there than elsewhere. This has not been clearly reproduced in the figure.

As in the case of the recent *Pterocarya* pollen, the ex. under and around the pores seems to have been underlain by thickened intine, relatively small in extent, distinctly separated in every case and relatively thick.

Viewed on the surface the ex. mostly has more or less distinct, rather sharply delimited dark (bright at a higher foc.) punctae, ca. 0.5 μ in diameter and with a similar or frequently somewhat greater interval between. As a rule they seem to be fairly coarse and relatively dissociate. The ex. surface is psilate.

The comparative material was pollen of *Pterocarya caucasica*. C. A. Mey. (= *fraxinifolia* Spach) (equatorial diameter somewhat variable, rising to 45 μ) and *P. stenoptera* DC. (equatorial diameter up to 42 μ).

The similarity of the fossil to the modern *Pterocarya* pollen is of a high order; in particular the pollen of recent *Pterocarya caucasica* resembles fossil grains closely.

The pollen type seems to correspond to *Pollenites stellatus* R. Pot. (1934) = *Pterocarya-poll. stellatus* R. Pot. (1950 and 51).

Photo-sheet: DGU b 492.

Much smaller than the above types are two triporate pollen forms which I consider identifiable as *Platycarya* and *Engelhardtia*, though the latter is somewhat uncertain (cf. Pl. IV, Figs. 1–7).

In both forms the pores and their immediate environment seem to have been underlain by thickened intine as in *Pterocarya*, whereby these parts were raised somewhat above the general surface of the grain. As a consequence, the circumference of the grain—in the polar aspect—seems more or less triangular with the pores at the corners.

Those parts of the ex. which in annular belts around the pores covered the intine thickenings, seem more or less distinctly to lack the endex., which may perhaps be just the reason why they are often seen—best in optical section (equatorial section) e.g. Figs. 4 and 7—as more translucent (bright) areas within the pores. In these areas the inner side of the ex. is sometimes rough or even frayed to some extent.

Viewed superficially with a high foc. the wall has distinct bright dots which at a lower foc. become dark, sharply delimited. Whether this is due to a locally very faintly indicated surface sculpturing or an inner columella structure in the wall is a question that must be left in abeyance for the present. In the few so far observed fossil pollen grains of the two types there were some very rare indications of transversal striation in the wall section.

Platycarya spp.

Plate IV, Figs. 1–4.

A characteristic feature of these pollen grains is at least one pair of narrow colpus-like furrows or striae, beginning near the equator on each side of a pore and running in an even curve each over its hemisphere in such a manner that, viewed from the pole, they seem to intersect at almost right angles. Occasionally the furrows may be prolonged beyond the equator, or there may be additional furrows on the opposite side of those pores that are accompanied by a single furrow. In profile these furrows appear as distinct folds in the wall. The grains are distinctly oblate. The equatorial outline is rounded triangular to almost circular with more or less prominent pore areas (cf. Pl. IV, Figs. 3–4 and Figs. 1–2 respectively). The three pores lie at equidistance around the equator and are oblong meridionally.

The ex. is 1–1.2 μ thick. The ex.-index is low—medium (0.04–0.06). In optical section there is only faintly indicated striation, or none at all. The outer contour is smooth or slightly undulating.

In the grains so far examined the greatest equatorial diameter fluctuates between 18 and 24 μ. It is possible that a distinction may be made according to size between two types whose equatorial diameter lies over and under about 20 μ respectively. Moreover, the shape of the equatorial outline is different in the two types (see Pl. IV, Figs. 3–4 and Figs. 1–2 respectively).

Pl. IV, Figs. 1–4 illustrate specimens of the two types. Fig. 1 is a pollen grain of the small type at foc. 2. On Fig. 2 is the same grain at nearly foc. 5. The shape and the course of the furrows are seen. In Fig. 3 and 4 is shown a pollen grain of the larger type at about the same foc. In Fig. 3 the dark dots are seen from the surface—below to the right—and in section—along the furrows on the upper side of the grain. Fig. 4 is the same grain in optical equatorial section; the furrows on both upper and lower side of the grain are also seen. The more translucent areas of the wall around the pores are also visible.

The comparative material used is recent pollen of *Platycarya strobilacea* S. & Z. The diameter measured 16–23 μ, but the great majority were under 20 μ.

The smaller type of the fossil pollen grains is very similar to the comparative species, though possibly the pores are more oblong—slit-shaped in the modern material than in the fossil. The larger fossil grains on the whole also resemble the comparative material so much that I consider both types may be referred to *Platycarya*.

Both were found in very small numbers in lignite from the Bjerregårde area.

Photo-sheets: DGU b 433 and 491.

cf. *Engelhardtia* sp.

Plate IV, Figs. 5–7.

The pollen type referred (with reserve) to this genus has, viewed in the polar aspect, a rounded triangular to almost circular circumference with a pore in each corner at the equator. The grains are more or less oblate and in almost each case it has been possible to examine them only from the pole. The greatest diameter at the equator is 26–27 μ. The pores are circular or faintly elliptic. Measured at the equator the pore diameter is 1.5–2 μ.

Seen in profile the surface is psilate. The ex. is double and tectate with a much thicker ektex. than endex. In optical section the ektex. of the few observed and examined pollen grains has a very indistinct transversal striation which, however, is more distinct inwards (columellae?). It is difficult to ascertain whether the striation continues out to the surface and is perhaps connected with small elevations on the surface or whether it ends in a solid tectum. Superficially the ex. has distinct dots, bright at high foc. and dark at deeper foc. These dots are scattered irregularly; their diameter is about 0.3–0.5 μ and the interstices are of a similar size. In equatorial section within the pores, which are only very faintly prominent or not at all, are seen the aforesaid translucent wall areas which are sharply delimited from the rest of the wall. This is presumably due to the absence of endex. within these areas and not to the ex. as a whole being thinner there. The wall thickness does not begin to decrease until much nearer the pore. The ex. is 1.3–1.5 μ thick. The ex.-index is (small-) medium (ca. 0.05).

Figs. 5–7 on Pl. IV show the same pollen grain photographed at three different foc. On Fig. 5 the microscope was adjusted directly upon or slightly above the pollen surface (foc. 0–1); bright dots are visible. Fig. 6 shows a slightly deeper foc. (foc. 2), and the dots are now dark. On Fig. 7 the grain is seen in optical (equatorial) section (foc. 5). The transversal striation of the wall has not been brought out.

This type was compared first and foremost with recent pollen of *Engelhardtia* species, but also with pollen of various species of *Platycaria, Myrica, Corylus* and *Casuarina*. These are representatives of a number of families which are stated (e.g. by WODEHOUSE 1935) to have inter alia this character in common that their pores are underlain by thickened intine.

Closest similarity seems to be observable in the pollen of some species of *Engelhardtia*, though in most cases these have a fairly distinct columella layer in the inner part of the ektex. It sometimes happens, however, that a transversal striation of the ektex. is just as indistinct as in the case of the fossil pollen. As to the pores, they are somewhat more prominent in the recent pollen than in the fossil.

However, as the fossil material examined is very small and there is not complete agreement with the comparative material employed, this identification must be viewed with some reserve.

The pollen grains were found sparsely in material from Bjerregårde.

Judging from the description and the pictures in POTONIÉ (1934 and 1951) and elsewhere, the pollen type seems to conform to *Pollenites coryphaeus punctatus* R. Pot. (1931 and 1934), which in POTONIÉ (1951) is given the form *Engelhardtioipoll. punctatus* R. Pot., whereas THOMSON (1949) refers to it as cf. *Engelhardtia*-pollen.

Photo-sheet: DGU b 22.

Betulaceae.

This family is definitely represented by the genera *Betula* and *Alnus*. There is a great likeness between the fossil pollen types found and recent pollen of these genera.

Betula sp(p).

The pollen grains referred to this genus, like the modern forms, are sometimes nearly spherical, though most often somewhat oblate. They are triporate with round, more or less prominent pores which are distributed equally in the equatorial plane. In the polar aspect the outline is thus liable to become sub-triangular. The grains are vestibulate, the ex. at the pores being split into two layers, ektex. outermost and endex. innermost. The free part of the ektex. forms the prominent part of the pore area, of which the margin, more or less thickened, forms an annulus surrounding the pore; in these cases this annulus in optical section has the shape of two lips, one on each side of the pore. Where the wall splits the endex. does not extend outwards but projects in the form of a narrow ring into the cell space limiting the vestibule inwards.

The surface of the ex. is psilate. The ex. itself is tectate, consisting of a thin, structureless endex. membrane inside and, on the outside, a thick, solid ektex. layer of crowded and completely fused ektex. elements. The wall in optical section does not—or only very indistinctly—show striation (i.e. columella structure), but seen superficially it usually has distinct punctae; these seem to correspond to structural elements in the wall itself and not merely to sculptural elements on the surface. It is possible, however, that both are faintly indicated. The punctae, whose arrangement is irregular, have a diameter of about 0.3–0.4 μ.

The greatest equatorial diameter—measured between the outer margin of the pore areas—is 25–28 μ, the smallest from HF-treated material, the largest from samples not treated with hydrofluoric acid. The height of the prominent pore areas is 3–4 μ. The ex. thickness is 1.1–1.4 μ and the corresponding ex.-index small to medium (0.04–0.06).

Betula pollen was found scattered in samples from both Bjerregårde and the Söby area. They were already recorded by N. Hartz (1909) from lignite gyttja from Sandfeldgård near Brande, Central Jutland. Hartz also mentioned that he found birch branches with bark and a leaf of *Betula* in similar soil from the Salten section in East Jutland.

For illustration material, see Rudolf (1935), Pl. V, Fig. 11 and especially Potonié, Thomson and Thiergart (1950), Pl. B, Fig. 14 and Kirchheimer (1937), Fig. 51 b. These figures are very like the pollen types found and they are all marked *Betula*.

Photo-sheets: DGU b 42, 52, 452 and 935.

Alnus spp.

This genus too is represented in lignite from both Bjerregårde and the Söby area, but, like the foregoing one, with no high frequency.

The pollen is oblate and stephanoporate, all the pores being situated on the equator. The equatorial outline is polygonal, in each corner having a pore which most often is somewhat oblong meridionally. Often the areas round the apertures are prominent through the presence of annuli and the raised moulding of the ektex. around the pores. As a result, the wall areas between them are concave in the polar aspect. The pores, of which from 4 to 7 have been observed, are vestibulate like those of *Betula*. Radiating from each annulus are four characteristic, curved bands, arci. They begin two on each side of the equator and each arc runs in a greater or smaller curve across the polar area to the annulus of the nearest pore.

The equatorial diameter fluctuates considerably, according to the number of pores, usually being least on those with 4 or 5 pores (24–34 μ, generally 27–28 μ), on an average somewhat larger on the hexaporate (ca. 31–32 μ), whereas the heptaporate are often giants with a diameter of up to 39 μ. The ex. thickness measured midway between the pores may also vary, as also the ex.-index to some extent. For example the following are measures and calculated index numbers for a relatively small number of pollen grains; quadriporate: ex.-M 0.4–0.5 μ, ex.-index 0.02–0.05; pentaporate: ex.-M 0.5–1.0 μ, ex.-index 0.02–0.03; hexaporate: ex.-M 0.7–0.9 μ, ex.-index 0.02–0.03; septaporate: ex.-M 1.0–1.3 μ, ex.-index 0.03.

As with *Betula*, the ex. in section is usually without or with indistinct striation. However, superficially there are distinct punctae which presumably are due to internal structural elements, as the surface seems to be smooth. The endex. seems usually to be thinner than the ektex.

Most of the fossil pollen grains found are very like pollen of *Alnus glutinosa* (L.) Gaertn., though some of the quadriporate—the especially thick-walled—seem to lie outside the range of variation of this recent species.

Hartz (1909) mentions finding remains of *Alnus* female catkins in lignite gyttja from Salten and Silkeborg Sönderskov, East Jutland. This identification, however, was challenged by Kirchheimer (1938), who considered the fossils to be remnants of cones of *Sequoia coutssiae.*

Pictures bearing what seems to be close resemblance to the fossil pollen appear e.g. in Rudolph (1935), Pl. V, Fig. 10, Thiergart (1940), Pl. III, Fig. 18 etc., Potonié, Thomson & Thiergart (1950), Pl. B, Figs. 17 and 18 and Pl. C, Figs. 19 and 20.

These fossil pollen appear under names such as *Alnus* (Rudolph (1935) and Thiergart (1940)), *Alnus* cf. *glutinosa* Gaertn. (pentaporate) and *A*. kefersteinioider Typ = *A.-poll. metaplasmus* R. Pot. (quadriporate) in both Thomson (Pl. B) and Thiergart (Pl. C) (Potonié, Thomson & Thiergart (1950)).

Photo-sheets: DGU b 62, 103, 214, 943 and 954.

Ulmaceae.

Pollen of Ulmaceae were already found by Lagerheim in lignite gyttja from Sandfeldgård West of Brande, Central Jutland. The finds were published by Hartz (1909) as *Ulmus* sp., an identification which must be viewed with some reserve, however, it having turned out that *Ulmus* pollen cannot definitely be distinguished from pollen of certain other Ulmaceae such as some species of *Zelkova*. On the whole, therefore, the fossil pollen described below are identified only as to family.

It is common to the pollen found that they are stephanoporate, but occasionally having one or more pores rather outside the equator. Furthermore they are tectate, more or less oblate in shape, and round the pores the ex. is thickened (annuli), sometimes considerably. The ex. varies a good deal in thickness but is usually relatively thin (ex.-M, measured between the pores, is 0.7–1.5 μ and the ex.-index 0.02–0.04). It is built up of a very thin endex., a thin columella layer and a thick tectum bearing higher or lower sculpturing. Viewed superficially the surface is generally punctate, as a rule most distinctly around the more or less elongate pores.

Two types can be distinguished, however: a, with a rounded equatorial outline (greatest equatorial diameter 34–45 μ) and a low, fine or coarse reticulum over the tectum, as well as pores to the number of 4–6; and b, with a polygonal equatorial outline (greatest equatorial diameter 32–36 μ) and rugulate sculpturing formed of winding ridges which most often are fairly wide and long. The number of pores has been found to be 4–5.

Differing somewhat from the above types is a characteristic, rather markedly oblate form with 4 pores and quadratic equatorial outline. The greatest equatorial diameter is 32–33 μ, the polar axis about 8–10 μ, shape class index about 0.3. Emanating from the fairly well developed annuli and mostly on both sides of the equator are two wide and pronounced, curved bands (exine thickenings (?)—arci) which turn over each to the annulus of the neighbouring pore (cf. the apparently similar phenomenon on *Alnus*). The low sculpturing of the grains is usually rather coarsely verrucate. The ex. is as a rule fairly thin (ex.-M about 0.7 μ, ex.-index about 0.02) and, viewed superficially, is generally distinctly punctate over the entire surface.

This pollen form was found in the Bjerregårde district. It closely resembles recent pollen of *Planera aquatica* J. F. Gmel., though this is somewhat larger than the fossil. As previously mentioned, however, HF, with which the fossil pollen were treated, diminishes the grain size.

Among the majority of type b some of the grains may possibly be classified under *Zelkova*, but the transition between the pollen of this species and that of certain *Ulmus* species seems to be so gradual that for the present I am unable to distinguish the forms one from the other with reasonable certainty.

Type a, on the other hand, is exceedingly like modern pollen of the *Ulmus* species.

Both type a and type b—apart from the *Planera* type—were found in the Bjerregårde and Söby districts.

Illustrations which seemingly correspond to type a are published i.a. in RUDOLPH (1935), Pl. V, Fig. 6 and by THOMSON in POTONIÉ et al. (1950), Pl. B, Fig. 36, whilst figures very like type b will be found i.a. in THIERGART (1940), Pl. II, Fig. 20 = THIERGART in POTONIÉ et al. (1950), Pl. C, Fig. 24.

Photo-sheets: DGU b 391, 455, 494, 923, 925, 941 and 942.

Hamamelidaceae.

Liquidambar sp.

Plate III, Fig. 1.

Pollen grains exactly corresponding to those of *Liquidambar* have been found somewhat scattered in material from the lignite bed at Bjerregårde but are more frequent in samples from the upper (woody) bed at Söby.

On the whole the grains are spherical with a greatest diameter of 28–49 μ (usually 35–43 μ). Here again, HF-treated pollen grains are generally smaller than those simply boiled with KOH and then acetolysed.

The grains are periporate with up to 12–14 circular-oval pores varying in size (sometimes being up to 8 μ in their greatest diameter). The pores are diffusely delimited and with isolated granules or groups of them on the pore membrane. These ektex. elements are not always present, however.

The ex. is intectate (-tectate), finely reticulate–foveolate (or finely pitted psilate). The pits or the lumina of the network measure about 0.7–1 μ in diameter. Between the pits or lumina is one or more rows of columellae. The columella diameter is about 0.3–0.35 μ. The ex. thickness varies considerably, the most frequent measurement being 1.7–2.2 μ. The ex.-index is usually about 0.05 though a few thin-walled grains have been found with an ex. thickness of 1.2–1.5 μ and an ex.-index of 0.03–0.045. Generally speaking the ektex. is thicker than the endex. The thin-walled forms are reticulate-foveolate or, exceptionally, distinctly foveolate.

Pl. III, Fig. 1 shows a *Liquidambar* pollen grain in deep foc. 2 with a pore centrally in the picture. Observe the diffuse limitation of the pore and the isolated granules on the pore membrane.

This pollen type seems to correspond to *Pollenites stigmosus* R. Pot. (see Potonié & Venitz (1934): Zur Mikrobotanik des miozänen Humodils der niderrheinischen Bucht.—Arb. Inst. Paläob. u. Petr. Brennsteine 5, to which reference is made in the following two works) = *Liquidambar-poll. stigmosus* R. Pot. (1950 and 1951).

Photo-sheets: DGU b 31 and 91.

Aquifoliaceae.

Ilex spp.

Plate V.

In material from Jutlandic lignite it is not unusual to find pollen with a structure conforming in every way to that of modern *Ilex* pollen.

The grain is subspheroidal, the polar axis usually being somewhat longer than the equatorial. Viewed in the polar aspect the outline is more or less deeply trilobate or almost circular with less deep indentations. From the shape, number and arrangement of the apertures the grains may be described as tricolp(or)ate. Sometimes in the centre of the colpus—viewed superficially—there is a circular, bright area (a pore?), and a similar impression is received mostly when a colpus is seen in longitudinal section (see e.g. Pl. V, Fig. 9). The rule is, however, for the equatorial area of the colpus to be more or less folded together into a transversal fold across the colpus, which may be due to the weak spot in the ex. around its centre. In this connection compare the term tricolporoidate, used by G. Erdtman (1952). The polar area is small.

The ex. consists of a thick endex. set with club-shaped elements (clavae) standing quite free, varying somewhat in shape and often of very different sizes. The grains are thus intectate and clavate.

At the central part of the intercolpium and around the poles large clavae dominate, though unevenly distributed among them there are usually much shorter and more slender clavae which predominate towards the intercolpium margin. In other words, there is a marginal border differing clearly from the rest of the intercolpium—a margo.

The small clavae almost without exception have spherical heads (diameter ca. 1 μ or less), and the stems may be absent or of various lengths, usually increasing from the margin towards the middle of the intercolpium.

The large clavae may also be unstemmed sometimes or furnished with a shorter or longer stalk (see below), and their thickened parts may be spheres or more irregularly shaped bodies. Seen laterally they may be club, pear or mushroom shaped, but the end view is almost circular, sometimes more or less oblong or polygonal—quite exceptionally slightly curved (sickle to bean shaped).

The latter features are rather frequently observed on the recent species *Ilex aquifolium* L. and *I. serrata* Thunb., whereas pollen of other *Ilex* species examined have more isodiametric clavae.

From a consideration of the shape and size of the clavae and especially of the ratio of the greatest diameter of the large clavae to their height, it seems possible to distinguish between two types: a, an angusticlavate type, where the above ratio usually is less than 1, often just slightly over $^1/_2$, and where the stems of the clavae on an average are as high or higher than the head (see Pl. V, Figs. 5, 7 and 9); and b, a laticlavate type, in which the ratio is 1 or most often more and where the stem is either absent or considerably lower than the head (see Pl. V, Figs. 1–4, 6 and 8). Moreover, the fossil pollen referred to the latter type seem to be divisible into two sub-types: b_1 with large, and b_2 with small grains (see Pl. V, Figs. 4, 6, 8, and Figs. 1–3 respectively).

The following maesurements have been found for pollen grains of the angusticlavate type: polar axis 45–50 μ, greatest equatorial diameter 40–45 μ, height of clavae up to 6 μ, greatest diameter of clavae up to about 3.5 μ (exceptionally to 5 μ). Correspondingly the two types of laticlavate pollen have the following measurements: type b_1, polar axis 40–46 μ, greatest equatorial diameter 32–42 μ, height of clavae up to 5.5 μ, diameter of clavae up to 6 μ (but exceptionally to about 7 μ); type b_2, polar axis 30–35 μ, greatest equatorial diameter about 30 μ, height of clavae up to 3 μ, diameter of clavae up to 4 μ.

The shape-class index for the angusticlavate type is about 1.2 and for both laticlavate types 1.1–1.3. Thus the polar axis is usually rather longer than the greatest equatorial diameter.

On Pl. V is a representative of each of the three *Ilex* types at various foc. and partly in different orientations (see explanation of plate).

The small laticlavate pollen (type b_2) have been compared with recent material of *Ilex aquifolium* L., *I. purpurea* Hassk. and *I. serrata* Thunb. The first two species agree in size with the small fossil grains, whereas *Ilex serrata* is usually smaller still.

The resemblance is closest to *Ilex purpurea* which, like the small fossil grains, has isodiametrical club heads almost exclusively, whereas the other two species differ in having more varying, often heterodiametrical heads.

On the other hand, up to the present I have not succeeded in finding recent pollen material corresponding to the angusticlavate type (type a) or to type b_1 within the laticlavate.

Time will show whether the types separated above are so constant that they will serve as an effective basis for differentiation.

Ilex pollen is fairly common in the lignite of both Bjerregårde and the Söby district.

All the *Ilex* pollen types referred to seem to belong to *Pollenites iliacus* R.Pot. (see POTONIÉ 1934) = *Ilicoipollenites iliacus* R.Pot. (1951).

Photo-sheets: DGU b 21, 102, 152, 922, 924, 933.

Vitaceae.

Vitis sp.

Plate III, Figs. 2–5.

To this genus I have placed some few pollen grains found in lignite from the Bjerregårde area.

Viewed in the equatorial plane the grain is short, lemon-shaped (cf. Figs. 4 and 5), whereas viewed in the polar aspect (i.e. in the equatorial outline) it is sub-triangular with more or less concave sides and deep, rather broad furrows in the corners (cf. Fig. 3). In the base of these furrows are the apertures. The length of the polar axis is 19–21 μ and the greatest equatorial diameter 16–18 μ. Thus the pollen shape is slightly oblong (shape class index 1.15–1.20). The grain is tricolporate with long, narrow (about 1 μ wide) colpi furnished at the equator with circular pores that are about 2 μ in diameter, i.e. broader than the colpi. The latter pass over the pores in the form of somewhat widened furrows. The pore only becomes distinct and circular at a deeper foc.; i.e. the pore is chiefly the result of a hole in, or a thinning of, the endex. At a high foc. the pore is indistinct and blurred. The colpi terminate not far from the pole. The polar area measures 4.5–5 μ and the polar area index is small (about 0.23). The intercolpium is slightly concave, mostly at the equator, whereby the edges of the intercolpium form a thick fold on each side of the colpus (cf. Fig. 3).

The ex. is (1–)1.5 μ thick, being thickest at the poles. The ektex. seems somewhat thicker than the endex. The ex.-index is medium (0.08–0.09). The surface displays a fine reticulate sculpturing, most distinct at the poles and receding towards the equator where it is much fainter or almost faded out. The greatest mesh diameter is in the polar area, about 0.5–0.6 μ, but is often much less. The muri are fairly low.

On focussing the microscope to various depths in the wall, beginning at 0 and moving downwards to 3, with ordinary immersion oil, one sees, uppermost, a bright net with dark lumina, passing downwards into a dark net with bright lumina. With oil immersion both over and under the preparation (as used in microphotography), one sees uppermost a bright net with dark lumina which with deeper foc. changes to bright dots surrounded by a darker, gray net (blurred reproduction on Fig. 2), whereafter still deeper foc. again shows black punctae on a grey background (or surrounded by a grey net). These dark punctae apparently correspond to the bright dots at higher foc.

Whether the dark punctae are columellae or merely the negative image of the reticulum observed at the higher foc. must remain an open question for the moment. In the former case the wall would be tectate with reticulate sculpturing, in the latter it would be intectate reticulate. Deep focussing (with oil both over and under the preparation) often showed the punctae on modern *Vitis* species too, though not in every case. The character was not consistent even on pollen from a definite species.

Pl. III, Figs. 2–5 show a *Vitis* pollen grain in different positions. On Fig. 2 the sculpturing near the pole is seen. The bottom of the lumina appears very faintly as bright dots. On Fig. 3 the ends of the colpi can be seen. Fig. 4 shows a colpus and a pore in equatorial view. Finally, Fig. 5 is a longitudinal section through a colpus and the pore is seen in profile.

The fossil pollen grains agree very well with modern pollen of the *Vitis silvestris* type in cases where the latter occur in a somewhat shrunken state so that the intercolpia are concave. It may appear, however, that the pores of the fossil grains are a little more distinct and more clearly delimited. Moreover, the fossil grains are smaller than the modern pollen of *Vitis vinifera* L. and *V. silvestris* Gmel., which at any rate in part is due to the treating of the fossil grains with HF. The polar axis of the two modern species measures 24–29 μ and (24–) 29–31 μ respectively, whereas the greatest equatorial diameter of both is 22–25 μ. However, pollen of other *Vitis* species or of species of closely related genera differ much more from the fossil grains found.

As far as I know, *Vitis* pollen has not previously been found in late-Tertiary lignite, though seeds and other macrofossils referable to various —some extinct— *Vitis* species are recorded from certain German lignite beds. *Vitis* seeds are also reported by Hartz (1909) from Amber-twig beds in meltwater sand at Copenhagen, and F. Kirchheimer (1938) places them to *Vitis silvestris*. These beds, however, may possibly contain later plant remains besides the Tertiary ones.

From the Eocene Wodehouse (1933) reports *Vitis*-like pollen under the name of *Vitipites dubius* (according to Erdtman 1943).

Photo-sheet: DGU b 393.

Tiliaceae.

Tilia spp.

Plate VI.

So far, linden pollen has been only of sparse occurrence in the present material and only in lignite samples from the Söby area. Hartz (1909) however reports it from Sandfeldgårde West of Brande, Central Jutland.

The grains are quite modern in appearance, both as to type and to the structure and sculpturing of the wall.

They are more or less oblate. At the equator of the grain, of which the greatest measured diameter was 45–50 μ, are 3 regularly distributed, very short colpi, 1.5–2 μ wide, forming entrances to larger or smaller cavities (vestibuli). Except at the very entrance, where the ektex. sometimes turns in a little way (cf. type a below and Pl. VI, Fig. 4), the vestibuli are surrounded by the endex., which is much thickened here. Roughly, the vestibuli have the shape of low truncated cones that are more or less flattened from side to side, especially outwards. Their inside bases are rounded and up to 7–8 μ in diameter (cf. especially type b below and Pl. VI, Figs. 5 and 6).

The structure of the ex. varies so greatly from one grain to another that, after comparing them with the pollen of recent species, one would be inclined to place them to different species. The *Tilia* pollen material examined so far is so restricted, however, that for the present I shall describe merely the differences between two types, designated type a and type b.

Type a.

Plate VI, Figs. 1–4.

The equatorial outline is almost circular to slightly triangular with the apertures *between* the angles. The apertures are slightly projecting or not projecting at all. The endex. thickenings around the vestibuli are very pronounced and bulge well into the interior of the cell. Here the ex. has a thickness of 5–6 μ. At the transition from the thickened to the unthickened part of the endex. and on its inner side there is often a distinct, fairly deep furrow (cf. Fig. 4), the endex. here forming a sharp fold about the vestibulum entrance. This is a very evident example of Potonié's "Quetschfalte" (ruga compressa) (Potonié 1934, p. 21). The external diameter of the inturned endex. "rim" is 15–17 μ.

As indicated above, the ex. is double. The thickness of the endex. outside the vestibulum areas is 1 (–1.5) μ. The ektex., which in this type extends a good way down the vestibulum entrance, is (1.0–)1.5 μ. Thus the ex. as a whole is 2–2.5 μ thick, the ex.-index is small-medium (0.05).

In profile (see Fig. 4) columellae are to be seen, some of them at right angles to the endex. surface, while others are placed obliquely on it. Viewed from above they seem mostly to be arranged in groups. In some cases such a group would seem to be formed by ramification of a single columella. Outwards the columellae of a group fuse with those of the surrounding groups forming a more or less continuous tectum. Over this are ridges (muri), formed of the same columellae (or columella branches). The muri generally are placed over the interstices between the columella groups.

Accordingly, the surface sculpturing is finely reticulate with lumen diameters up to 1 μ or slightly more (see Fig. 1). From the base of the lumina it would seem that narrow, perhaps funnel-shaped pits continue inwards here and there. At a high foc. a single row of fine granules (see Fig. 2) can be seen in the reticulum muri. With a deeper foc., in places, the rows of columellae appear double (see Fig. 3). At a still deeper foc. one sees columellae assembled in the aforesaid groups, one under each lumen of the net. Under the smallest of these the granules in the group are fused at the bottom like branches into a single stem (columellae digitatae). This phenomenon is not clearly visible in the larger groups, in which the granules appear separated throughout. One might think that they too originate from a single trunk, which is, however, branched very early indeed.

This type has been compared inter alia with recent pollen of *Tilia platyphylla* Scop. There is rather good agreement with this species, e.g. as regards size and the rather narrow diameter of the vestibulum besides the structure of the ex. The fossil pollen, however, differs by the more or less distinct furrow in the endex. at the transition between the normal endex. and its thickened part, and by the unusually marked development of this latter part.

Photo-sheet: DGU b 11.

Type b.

Plate VI, Figs. 5–6.

This type is of the same size as type a and in principal of the same structure. The outer contour of the wall section is very slightly crenate. As in the foregoing type the ektex. is usually somewhat thicker than the endex. (about 1.5 μ and 1.0 μ respectively). The total ex. thickness is 2.5–2.8 μ. The ex.-index is small-medium (0.05).

The differences from type a are: The aperture area projecting more, the equatorial outline of the grain is nearly hexagonal. The thickened part of the endex., whose diameter at the equator is 16–18 μ, out to the sides passes smoothly into the unthickened part without step or furrow. Here the thickened endex. pushes the aperture area more outward, thus occupying less room itself in the interior of the cell. The ektex. ends abruptly at the colpus margin and does not extend beyond it. The lumina of the superficial reticulum are smaller than in type a. Furthermore, the groups of columellae described under type a as standing under each lumen in the reticulum in type b are without exception clearly fused proximally into a single stem (cf. e.g. Figs. 3 and 6; the foc. for the latter is a little deeper than for the former).

Type b approaches the modern *Tilia cordata* Mill, though the latter's pollen grains are smaller (usually 37–40 μ, exceptionally to 45 μ) and more irregular in wall structure.

Photo-sheet: DGU b 921.

Nyssaceae.

Nyssa sp(p).

Pollen grains very similar to recent *Nyssa* pollen are not uncommon in lignite samples from both Bjerregårde and the Söby district.

They are subspheroidal. The shape class index varies from something under 1 to about 1.3 but generally lies at about 1.1. The polar axis measures 30–43 μ, exceptionally 49 μ, and the greatest equatorial diameter 27–40 μ. In the polar aspect the grains are sub-triangular with rounded corners and more or less convex sides.

The grains are tricolporate with long, narrow colpi, each situated in the bottom of a furrow and passing the equator in the triangle corner of the polar aspect. The pores are large and circular to slightly elongated, usually equatorially. Along both sides of the colpi—covered by a thin layer of ektex.—and partly under the colpi are structureless thickenings which obviously belong to the endex. like similar phenomena on modern *Nyssa* pollen. G. Erdtman (1952 p. 289) is of a different opinion, as he considers them to be "sexinous thickenings". They are widest and most pronounced towards the equator where, however, owing to the presence of the pore, they are wholly or partly discontinued. In the latter case the pore is sharply delimited along its entire circumference; but if the thickenings are interrupted completely at the equator on the one or on both sides of the pore, the latter's margin at the interrupted places is blurred. The ex. thickenings viewed from the pole can be seen very distinctly—especially near the equator—in the form of inward swellings which unite under the colpus, looking like one continuous invagination of endex. The polar area is medium, its index varying from 0.3 to almost 0.5, but most frequently being under 0.4.

The ex. is generally more or less distinctly double, and up to 2.8 μ thick. The ex.-index is medium (about 0.08). The endex., which may vary in thickness, is mostly 1.0–1.4 μ thick centrally in the intercolpia in the equatorial plane (sometimes it is somewhat thinner). Here the ektex. usually has a thickness of about 1.4 μ and in most cases has a distinct columella layer innermost with a tectum, mostly somewhat thicker, outside it. The relative thicknesses of the two layers varies rather considerably, however. In profile, the tectum may be more or less distinctly striated transversally. In exceptional cases the ektex. may consist exclusively of crowded granules whereby there is scarcely any tectum. Very similar structural modifications can be observed in various comparative preparations from one and the same species of *Nyssa* (see below).

Towards the colpi the layers of the ex. usually become much thinner and gradually the columella layer disappears. Bordering the edges of the intercolpia, however, we find the aforesaid ex. thickenings.

Seen from the surface the columellae are usually distinct, fairly coarse, and distributed without clear arrangement, sometimes crowded, sometimes more scattered. Their diameter is generally 0.5–0.7 μ as far as the largest are concerned, slightly more in exceptional cases.

Viewed in profile the surface is either almost smooth or finely notched, occasionally with shallow and rather fine, rounded bulges between the notches or more irregularly uneven. Viewed superficially one often sees narrow depressions situated over the interstices between the columellae. Close examination still leaves it uncertain whether these are pits or fine perforations. Sometimes there are very few of these fine depressions in the tectum, at others they are close together. Yet the surface usually must be called psilate, but occasionally it has irregular shallow pits or low, fine "warts" (foveolate-scabrate).

On comparing the pollen of this type found in the two different localities, it appears that 1) the grains from Bjerregårde (notwithstanding their HF treatment, which, as shown by Christensen (1946) diminishes one or both dimensions) are occasionally somewhat larger than those from the Söby area, 2) that the material from Söby lignite contains a number of pollen grains with an unusually low shape-class index.

If these differences in size and shape variation between the grains from the two localities are confirmed, they may be referred to two form species.

Practically all the above variations in size, shape, structure and sculpturing have been observed in the only comparative species used, *Nyssa multiflora* Wangenh. (*N. silvatica* Marsh.), which is represented by material from three different localities.

At any rate the majority of the above fossil grains thus conform very closely to modern comparative material. Accordingly I consider the identification as *Nyssa* to be sufficiently well-founded.

Nyssa was already demonstrated in Danish lignite deposits by HARTZ (1909), who reported *Carpolithes nyssoides* (which he regarded as fruits of *Nyssa*) as a common fossil from the Salten section and Silkeborg Sönderskov in East Jutland. F. KIRCHHEIMER (1938) agreed with HARTZ in regarding the latter's find of *Carpolithes nyssoides* as *Nyssa* fruits.

The best pictures known to me of fossils resembling the above pollen type are contained in Fr. THIERGART (1940), Plate III, Figs. 24 and 26. In actual fact, however, there is no really satisfactory illustration of the type in the literature.

Photo-sheets: DGU b 411, 946, 981.

Concluding remarks.

The rather incidental selection of pollen types from Jutlandic Tertiary lignites discussed in the foregoing comprises, in addition to pollen of well-known genera in modern Danish flora, a number of types whose mother organisms no longer grow naturally in this country. Some of them are found farther south in Europe whereas others occur only in other continents, especially America and East Asia.

As my knowledge of exotic pollen types is rather limited as yet, their number in the present list is relatively small, being nearly the same as the number of types representing genera found in the present day flora of Denmark. Regarding the remaining and much larger part of the pollen types in the lignites it is clear that the exotic types will be much more prominent.

A much larger number of the pollen and spore types in the material will have to be dealt with before the pollen analysis of the Danish lignites becomes effective. As far as many of these types are concerned, it must presumably be accomplished by referring them provisionally to purely artificial taxonomic units, though with the constant purpose of bringing the various types as closely as possible in connection with those of the natural system.

In conclusion I would again point out that one should not be misled by the finds recorded here into drawing uncritical, categorical conclusions as to Denmark's climate in the lignite period. The units are too rough and the selection too onesided for that; one's opinion would have to be formed upon a basis comprising the majority of the pollen types, which definitely is not the case here.

The work on which the present paper is a report was done in the Palaeobotanical Department (Moselaboratoriet) of the Geological Survey of Denmark, Charlottenlund, in intimate collaboration with the institution's former Lignite Department (now the Department of Natural Resources). A commencement

was made in 1943, but the greater part of the work was carried out in the winters of 1949–1952.

I have received much help from my colleages at the Geological Survey of Denmark and take the present opportunity to express my gratitude. I wish to direct my thanks to Dr. Keld Milthers, chief of the Department of Natural Resources, and to Dr. Johs. Iversen, chief of the Palaeobotanical Department.

In connection with the procuring of suitable modern comparative material, especially pollen from American and East Asiatic plant forms, I would particularly mention the great help given me by Professor Knud Jessen, Director of the Botanical Gardens of the University, Dr. O. Hagerup, Keeper of the Botanical Museum of the University, and Dr. C. Syrach Larsen, head of the National Arboretum, all of whom gave me carte blanche to collect pollen. I tender special thanks to Miss Jane Gray, now California University, U.S.A., for her co-operation in the collection of pollen and the making of preparations of exotic pollen representatives.

The translation into English was made by Mr. W. E. Calvert, Virum.

Dansk resumé.

Indledningen giver en oversigt over, hvad der i nyere tid er skrevet om de jyske tertiære brunkul — deres aflejringsforhold, de skiftende meninger om deres plads i den geologiske lagserie samt eksempler på fundne makro- og mikrofossiler.

I hovedafsnittet beskrives 16 mikrofossilformer ret indgående og henføres til familie eller oftest slægt (evt. art) i det naturlige plantesystem. Listen — sml. oversigten over de beskrevne typer s. 41 — omfatter 1 alge, 1 mos og 14 fanerogam–slægter.

De behandlede mikrofossiler stammer fra brunkulsprøver fra 2 lokaliteter, nemlig Bjerregårde ved Studsgård og Söby ved Kölkær, begge i Midtjylland.

Efter pulverisering er prøverne kogt med KOH og acetolyseret. Prøverne fra Bjerregårde er desuden forud behandlet med kogende 30–40 % HF.

Pollentyperne er stort set beskrevet under benyttelse af den terminologi, som er fremsat af Johs. Iversen og J. Troels-Smith (1950).

Fossilerne er bestemt ved sammenligning med recent acetolyceret materiale.

For en række pollenformers vedkommende er beskrivelserne ledsaget af fotoreproduktioner (tavle III–VI). I nogle tilfælde viser disse pollenexinen (d.v.s. pollenvæggen) set fra fladen ved forskellige dybdeindstillinger (foc. 1–3), i andre ses væggen i optisk tværsnit (foc. 5), ligesom der er lagt vægt på at illustrere særlige bygningstræk af betydning for identificering og dokumentering. Imidlertid gengiver de viste fotoreproduktioner ikke altid de finere enkeltheder, som kan ses på originalfotografierne. Disse sidste er tilgængelige i Danmarks Geologiske Undersøgelses Moselaboratorium. Numrene på fotograferede pollen er angivet i foreliggende arbejde. Angående beliggenheden af de forskellige dybdeindstillinger (betegnet foc.) i et pollenkorn se fig. 1 på s. 38.

Den i nærværende arbejde fremlagte mikrofossilliste indeholder kun en ringe del af det i brunkullene forekommende mikrofossilmateriale og kan derfor ikke uden videre benyttes til bedømmelse af brunkulstidens vegetations- eller klimaforhold. Af de omtalte mikrofossiler er 5 allerede tidligere fundet i brunkulsgytje af N. G. Lagerheim, Stockholm, og publiceret af N. Hartz (1909).

Alnus og *Nyssa* er nye som pollenfund; men disse slægter er dog allerede tidligere af Hartz fundet i brunkul som makrofossiler. Henførelsen af makrofossilerne til *Alnus* er dog blevet draget i tvivl af F. Kirchheimer (1938).

Helt nye for den danske brunkulsflora er i hvert fald følgende 10 slægter: **Carya*, cf. **Engelhardtia*, **Ilex*, **Liquidambar*, *Planera*, **Platycarya*, **Pterocarya*, **Sciadopitys*, *Sphagnum* og **Vitis*.

De med * betegnede former er gengivet på tavlerne.

References.

D.G.F. = Meddelelser fra Dansk Geologisk Forening. København.

D.G.U. = Danmarks Geologiske Undersøgelses Skrifter. København.

CHRISTENSEN, B. BRORSON 1946: Measurement as a means of identifying fossil pollen. — D.G.U. IV. Rk. Bd. 3. Nr. 2.

ERDTMAN, G. 1943: An introduction to pollen analysis. With 28 plates. — Waltham, Mass. U.S.A.

— 1947: Suggestions for the classification of fossil and recent pollen grains and spores. — Svensk Bot. Tidskr. Bd. 41, s. 104–114. Uppsala.

— 1952: Pollen morphology and plant taxonomy. Angiosperms. (An introduction to palynology. I). With 261 illustrations (or groups of illustrations). — Stockholm.

FÆGRI, KNUT and IVERSEN, JOHS. 1950: Text-book of modern pollen analysis. — Munksgaards Forlag. Copenhagen.

HARRIS, TH. M. 1938: The British Rhaetic flora. — British Museum. London.

HARTZ, N. 1909: Bidrag til Danmarks tertiære og diluviale Flora. With an English summary of the contents. — D.G.U. II. Rk. Nr. 20.

IVERSEN, JOHS. og TROELS-SMITH, J. 1950. Pollenmorfologiske definitioner og typer (Pollenmorphologische Definitionen und Typen) — Ibid. IV. Rk. Bd. 3. Nr. 8.

JØRGENSEN, KN. DREYER 1940: Nye Forsteninger fra Tertiæret ved Esbjerg (Summary of a paper read at the Palaeontological Club, Copenhagen). — D.G.F. Bd. 9, H. 5.

KIRCHHEIMER, F. 1937: Grundzüge einer Pflanzenkunde der deutschen Braunkohlen. — Halle a. Saale.

— 1938: Über das Alter der Braunkohle Jütlands. — Z. Braunkohle, Jahrg. 37, Heft 24, s. 405–409. Halle a. Saale.

MILTHERS, K. 1941: Systematisk Eftersøgning af Brunkul. — Geogr. Tidsskr. Bd. 44, s. 100–117. København.

MILTHERS, K. 1949: Nogle hovedlinier i brunkullenes lejringsforhold. (Summary of a paper read at the Geological Society of Denmark, Copenhagen). — D.G.F. Bd. 11, H. 4.

POTONIÉ, R. 1934: Zur Mikrobotanik der Kohlen und ihrer Verwandten. I. Zur Morphologie der fossilen Pollen und Sporen. II. Zur Mikrobotanik des eocänen Humodils des Geiseltals. — Arb. Inst. f. Paläobot. u. Petrogr. d. Brennsteine, Bd. 4, 6 Taf. Preuss. Geol. L.-A. Berlin.

— 1951: Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs. — Palaeontographica, Bd. 91, Abt. B, S. 131–151, 2 Taf. Stuttgart.

POTONIÉ, R., THOMSON, P. W. und THIERGART, FR. 1950: Zur Nomenklatur und Klassifikation der neogenen Sporomorphen (Pollen und Sporen). — Geol. Jahrb., Bd. 65, s. 35–70, 3 Taf. Hannover/Celle.

RAVN, J. P. J. 1907: Molluskfaunaen i Jyllands Tertiæraflejringer. Résumé en français. — Kgl. Danske Vidensk. Selsk. Skrifter, 7. Rk., nat. og mat. Afd. III. 2. s. 216–384. København.

RUDOLPH, K. 1935: Mikrofloristische Untersuchung tertiärer Ablagerungen im nördlichen Böhmen — Beih. botan. Centralbl., Bd. 54, Abt. B, S. 244–328, 5 Taf. Dresden.

SORGENFREI, TH. 1940: Marint Nedre-Miocæn i Klintinghoved paa Als. — D.G.U. II. Rk. Nr. 65.

THIERGART, FR. 1940: Die Mikropaläontologie als Pollenanalyse im Dienst der Braunkohlenforschung.—Schr. Brennstoff.-Geologie, 13. Heft, 14 Taf. Stuttgart.

THOMSON, P. W. 1949: Alttertiäre Elemente in der Pollenflora der rheinischen Braunkohle und einige stratigrafisch wichtige Pollenformen derselben. — Palaeontographica, Bd. 90, Abt. B, S. 94–98, 1 Taf. Stuttgart.

WODEHOUSE, R. P. 1935: Pollen grains. — Mc. Graw-Hill. New York and London.

Explanation of plates III-VI.

Plate III.

Magnification 1000 ×.

		Photo-sheet No. & (photo No.)	Page
Fig. 1:	*Liquidambar* sp.; Bjerregårde	DGU b 91	52
	Exine at deep foc. 2; a pore in the centre	(9,34)	
Figs. 2–5:	*Vitis* sp.; Bjerregårde	DGU b 393	55
Fig. 2:	Exine near pole at foc. 2[1])	(97,5)	
Fig. 3:	Polar area and grain outline in polar aspect	(97,36)	
Fig. 4:	Colpus + pore, equatorial view	(40,11)	
Fig. 5:	Pollen grain in optical meridional section through a colpus	(40,17)	
Figs. 7–10:	*Sciadopitys* cf. *verticillata* S & Z.; Bjerregårde	DGU b 183	43
Fig. 7:	Exine at foc. 0–1	(18,30)	
Fig. 8:	Exine at foc. 2	(18,33)	
Fig. 9:	Exine at foc. 5	(18,34)	
Fig. 10:	Exine at foc. —3——2	(18,35)	

[1]) In Fig. 2 the finer sculpturing is much reduced by reproduction.

Plate IV.

Magnification 1000 ×.

		Photo-sheet No. & (photo No.)	Page
Figs. 1–4:	*Platycarya* spp.; Bjerregårde		47
Figs. 1–2:	*Platycarya*, small type	DGU b 433	
Fig. 1:	Exine at foc. 2[1])	(95,30 A)	
Fig. 2:	Exine near optical equatorial section, foc. 5	(95,32 A)	
Figs. 3–4:	*Platycarya*, larger type	DGU b 491	
Fig. 3:	Exine at foc. 2[1])	(49,5)	
Fig. 4:	Exine in optical equatorial section, foc. 5	(49,6)	
Figs. 5–7:	cf. *Engelhardtia* sp.; Bjerregårde	DGU b 22	48
Fig. 5:	Exine at foc. 0–1	(2,24)	
Fig. 6:	Exine at foc. 2 (+ 1 in centre)	(2,27)	
Fig. 7:	Exine at foc. 5 (+ 2 in centre)	(2,31)	

[1]) The dark dots at foc. 2 are rather faint in the reproduction.

		Photo-sheet No. & photo No.)	Page
Fig. 8:	*Pterocarya* sp.; Bjerregårde	DGU b 492	46
	Exine in optical equatorial section, foc. 5	(49,15)	
Fig. 9:	*Carya* sp.; Bjerregårde	DGU b 202	45
	Exine in optical equatorial section, foc. 5	(21,5)	

Plate V.

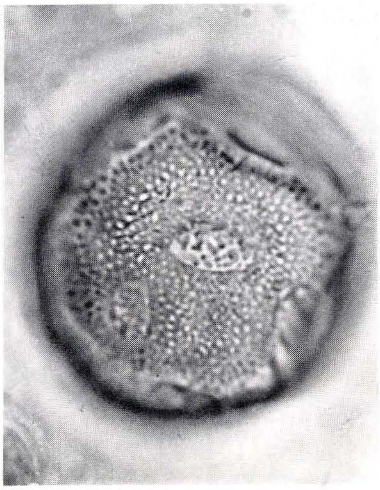
Magnification 1000 ×.

		Photo-sheet No. & (photo No.)	Page
Ilex spp.; Bjerregårde			53
Figs. 1–3:	*Ilex*, type b_2	DGU b 102	
Fig. 1:	Exine at foc. 1	(10,26)	
Fig. 2:	Exine at foc. 2	(10,27)	
Fig. 3:	Exine at foc. 5	(10,28)	
Figs. 4, 6 and 8:	*Ilex*, type b_1	DGU b 152	
Fig. 4:	Left: Clavae on an intercolpium, oblique and partly in profile.		
	Centre: transversal colpus fold	(15,34)	
Fig. 6:	Pollen in optical meridional section	(15,36)	
Fig. 8:	Pollen in optical equatorial section	(15,31)	
Figs. 5, 7 and 9:	*Ilex*, type a	DGU b 924	
Fig. 5:	Small clavae on intercolpium margins (bright) and larger clavae in centre of intercolpium (bright)	(92,31 A)	
Fig. 7:	Small clavae on intercolpium margins at deeper foc. (dark) and larger clavae in centre of intercolpium (bright)	(93,10 A)	
Fig. 9:	Colpus in longitudinal section	(93,11 A)	

Plate VI.

Magnification 1000 ×.

		Photo-sheet No. & (photo No.)	Page
Figs. 1–4:	*Tilia*, type a; Söby	DGU b 11	57
Fig. 1:	Exine at foc. 1	(1,23)	
Fig. 2:	Exine at foc. 2 a	(1,13)	
Fig. 3:	Exine at foc. 2 b	(1,14)	
Fig. 4:	Exine at foc. 5	(1,28)	
Figs. 5–6:	*Tilia*, type b; Söby	DGU b 921	58
Fig. 5:	Exine at foc. 2 a	(92,12 A)	
Fig. 6:	Exine at foc. 2 b–c	(92,15 A)	



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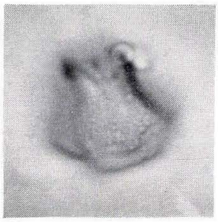

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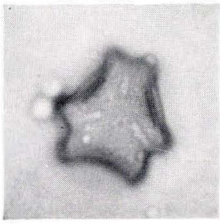

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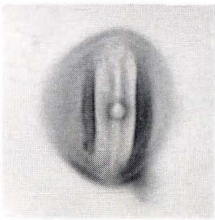

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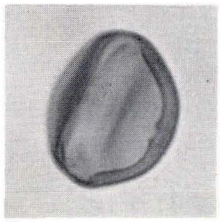

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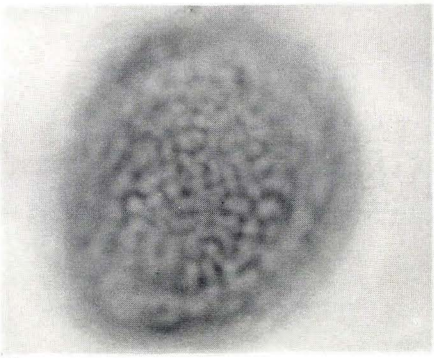

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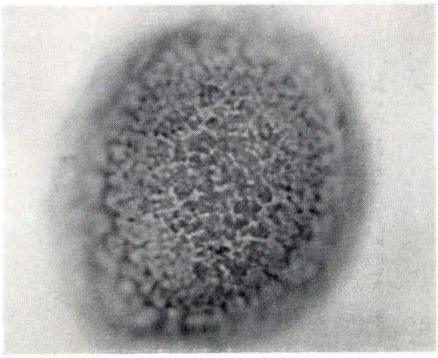

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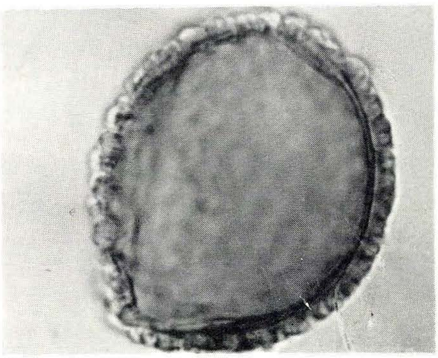

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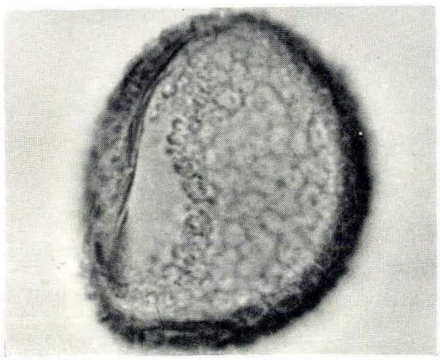
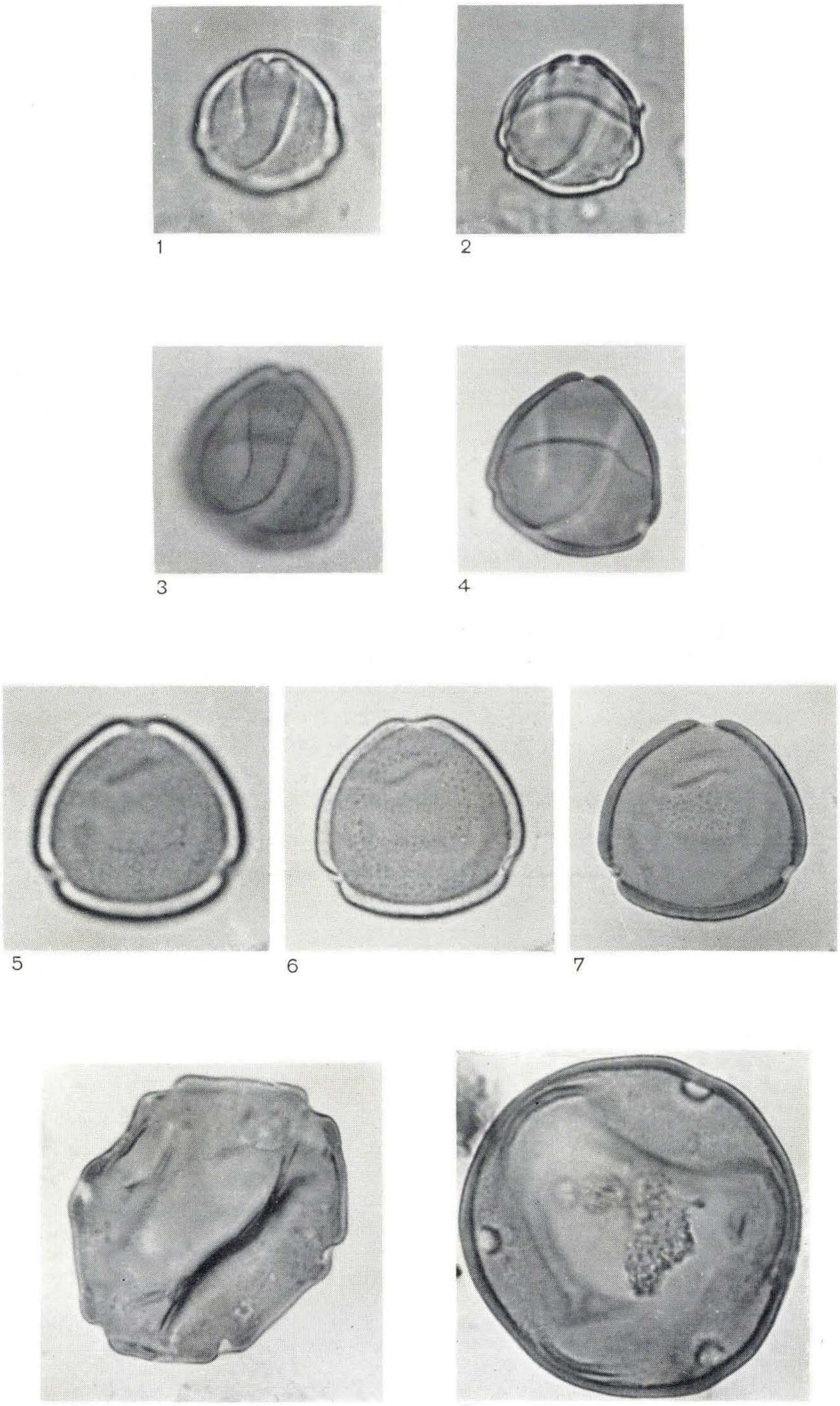
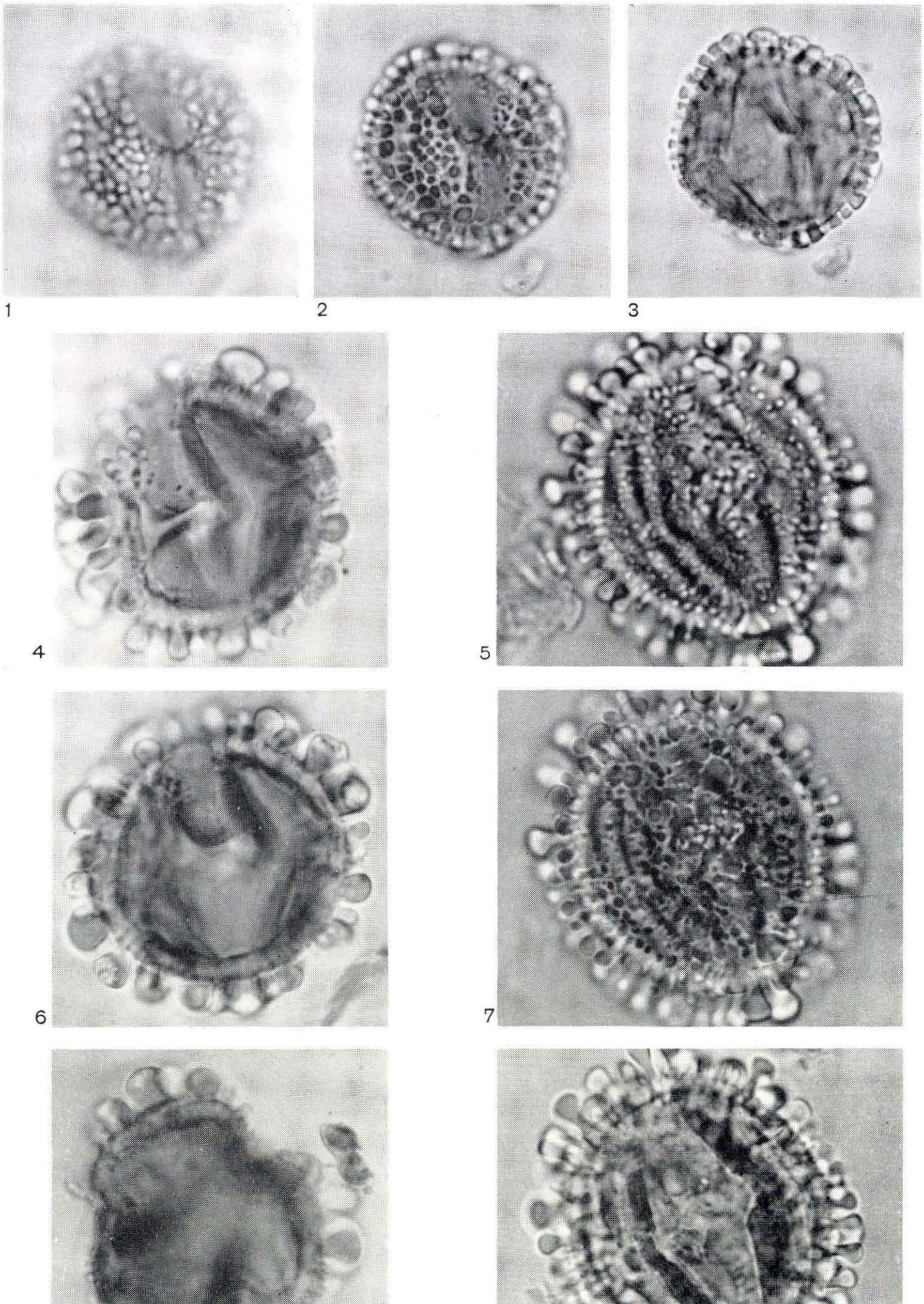


10

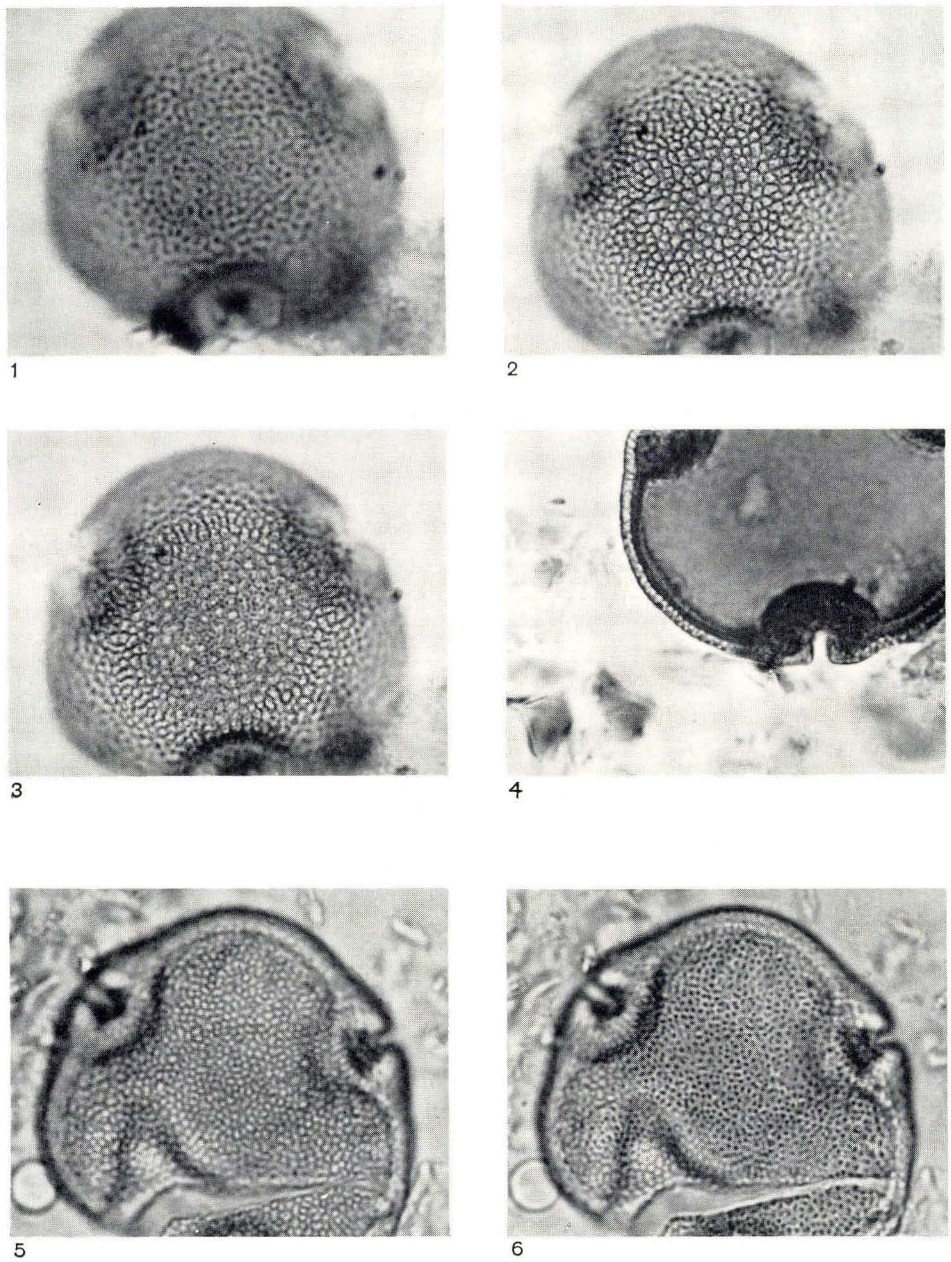
1 *Liquidambar* sp. 2-5 *Vitis* sp. 7-10 *Sciadopitys* cf. *verticillata*.
Explanation see p. 63.



1-4 *Platycarya* spp. 5-7 cf. *Engelhardtia* sp. 8 *Pterocarya* sp. 9 *Carya* sp.
Explanation see p. 63.



Ilex spp. 1-3 type b_2. 4, 6 and 8 type b_1. 5, 7, and 9 type a.
Explanation see p. 64.



Tilia spp. 1-4 type a. 5-6 type b. Explanation see p. 64.

Interglacial Pollen Spectra from Greenland.

By

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Abstract.

The pollen and spore contents of calcareous concretions from two sites in western Greenland have been investigated. The pollen spectra obtained are discussed in relation to postglacial and modern plant distribution. The conclusion is reached that they represent a flora of interglacial age.

It is not uncommon in Greenland to find calcareous concretions containing fossilized marine animals in moraines situated far outside the postglacial ice limit, often high in the mountains. It seems fairly certain that these concretions are of interglacial age. On this assumption their pollen contents offer an opportunity to study the interglacial vegetation. Similar concretions are found in the moraines of glaciers moving down from the inland ice sheet. The marine clay and shells with which they are associated here are undoubtedly postglacial fjord sediments (GRIPP, 1932). The possibility exists, however, that the concretions themselves are of interglacial age, rebedded from older sediments lying farther up the fjords.

A concretion of each of these types has been analyzed for pollen and spores by the author. The first is from Pleistocene or late-glacial moraines at Kapisilik, in the interior of the Godthaab Fjord region (coll. Dr. Johs. Iversen, 1937). The concretion contained the fossilized remains of *Mallotus villosus*, a small fish still to be found in Godthaab Fjord. The matrix was dissolved in hydrofluoric acid, and acetolyzed. Very little pollen was contained in the sample, but fortunately it was well preserved. The sample was divided into two parts, which were analyzed separately (Table 1, columns A and B). The first part (column A) was analyzed by Dr. Johs. Iversen, who has kindly allowed me to use his results. These spectra from Godthaab Fjord are especially valuable: first, because their interglacial origin is fairly sure on geological grounds, and second, because the postglacial vegetational sequence is known for this region (IVERSEN, 1954a). The other specimen studied, a concretion containing *Yoldia hyperborea* Lovén, is of more problematical origin, as it was found upon the ice at Frederikshaab Isblink (material courtesy of Dr. Sigurd Hansen, Geological Survey of Denmark, who collected it in 1930 and made the identification). The sample was treated with HCl, KOH, and HF, and then acetolyzed. The results of the analysis are given in column C, Table 1. The pollen percentages in every case are figured on the basis of a sum including all tree and herb pollen. The spores of *Dryopteris*, *Sphagnum*, and the Lycopodiaceae are not included in the sum.

The samples contained a considerable amount of spruce pollen, which is probably *Picea mariana* (Mill) BSP. A few of the grains could be measured and their size compared to spruce in other fossil material treated in the same way chemically; they were found to fall within the size range of a species that is presumably *Picea mariana* in fossil material from George Reserve, Michigan (S. T. ANDERSEN, personal communication; cp. 1954). Since this spruce species is dominant at the polar tree limit in Labrador today, and is the commonest tree on the peninsula (LOW, 1895, HUSTICH, 1939) it is the species that should be expected in Greenland. It is possible that a statistical error entered into the *Picea* calculations, since, in the absence of great quantities of pollen, the small fragments of air bladders were also counted. These small fragments, which occurred frequently, were arbitrarily reckoned as eight equal to one whole grain. Although it is usually possible to distinguish between fragments of *Picea* and *Pinus*, some may have been misidentified. However, since the fragments account for only a third of the *Picea* percentage, the possible error is probably only a matter of a few percent.

In the sample from Godthaab Fjord *Picea mariana* makes up 15–20% of the total. It is not likely that such large amounts of pollen could have been introduced by long distance transport. In postglacial diagrams from the same part of Greenland (IVERSEN, 1954) the total of coniferous pollen never exceeds 1 or 2%. Even if the forest limit in Labrador were farther north than it is now, it is hardly conceivable that so much *Picea* pollen could have been blown in, especially when *Pinus*, which is much more easily transported (e.g. HESMER, 1933), is found in such small quantities. Is is reasonable to conclude, therefore, that *Picea mariana* grew in Greenland[1]) at the time the deposit was formed.

The sample from Frederikshaab does not present such a clear picture. The possibility of long distance transport cannot be excluded here, especially since there is so much pine. However, the *Picea* percentage seems much too high to be due to pollen from Labrador and adjacent Canada

[1]) Experiments are in progress to determine whether *Picea mariana* can now grow in Greenland. (Prof. C. A. JØRGENSEN, Copenhagen, personal communication).

Table 1.

Species or genus	Percentage Representation		
	Godthaab		Frederiks-haab
	A[1])	B	C
	Σ 135	Σ 234	Σ 292
	%	%	%
Picea mariana (Mill) BSP	20	14	5.5
Pinus	—	1.3	5.5
Alnus crispa (Ait.) Pursh	18	27	37
Betula (dwarf-type)	36	36	31
Salix	1.3	1.7	2.7
Juniperus	1.5	0.8	0.7
Ericaceae	4.5	0.4	—
Empetrum	—	1.7	0.7
Gramineae	11	10	5.5
Cyperaceae	0.7	2.6	7.7
Artemisia	0.7	1.3	1.0
Caryophyllaceae	0.7	—	—
Compositae (*Achillea*-type)	—	0.4	—
Dryas	—	—	0.3
Epilobium	0.7	—	—
Filipendula	0.7	—	—
Plantago maritima (coll.)	0.7	—	—
Rubus-type	—	—	0.3
Rumex acetosella-type	2.2	1.7	0.3
Sedum (*villosa*-type)	—	0.4	—
Thalictrum	—	—	0.3
Xanthium	—	0.4	—
Dryopteris Linnaeana	0.7	—	—
Dryopteris sp.	0.7	0.8	—
Lycopodium cfr. *alpinum/complanatum*	—	—	2.6
Lycopodium annotinum	4.5	2.6	4.1
Lycopodium selago	—	—	2.6
Lycopodium sp.	0.7	—	4.4
Selaginella selaginoides	—	—	0.3
Sphagnum	—	1.3	0.3

[1]) Analysis by Dr. Johs. Iversen.

alone; perhaps part of the pollen is wind-blown from spruce growing in other parts of Greenland—the Godthaab Fjord region, for example. Frederikshaab lies in the coastal zone with low summer temperatures; at the time the sediment was deposited, climatic and edaphic conditions there may not have been favorable to spruce. The sample contains a fair amount of pine pollen—5 %. However, this cannot be taken to mean that pine grew in Greenland at the time. Since pine pollen is so easily transported by wind, we may assume that the pollen was blown in from Labrador and Newfoundland. *Pinus* is now limited to the pergelisol-free soils of southwestern Labrador (Hustich, 1939), but under milder climatic conditions it would undoubtably occur farther north, and thus nearer Greenland, than it does today.

The problem of the identification of the fossil *Alnus* to species was approached by a study of pore-number frequency distribution. In both the samples about 10 % of the alder pollen was 6-pored, 65 % was 5-pored, and 25 % was 4-pored. The pollen of American and European boreal species was studied for comparison (see Fig. 1. and Table 2.). Histograms have been drawn giving the mean distribution in several individuals (where possible, fossil material of a single species was used, as it represents the average of a large number of individuals). Six-pored grains are never or very seldom found in *A. rugosa var. americana*, *A. serrulata*, *A. incana* and *A. glutinosa*. Material of *A. viridis* (Chaix) Lam. and DC had a few percent six-pored grains, but the percentage of 4-pored grains also is lower than that of the fossil material. The pore-number frequency distribution of *Alnus crispa* (Ait.) Pursh, the species now found in Greenland, however, corresponds almost exactly to the *Alnus* from the concretions. It is clear that the alder pollen represents a pure population of *Alnus crispa*.

High *Alnus* frequencies (25 %) characterize the postglacial climatic optimum in Greenland (Iversen, 1954). Here, however, *Alnus* is even more common, making up about 30 to 35 % of the total, and thus indicating a climate considerably warmer than that of today.

In both the samples *Betula* makes up 30 to 35 % of the total. Was this important element shrub-like or arborescent? The identification of *Betula* pollen to species is extremely difficult, and attempts at size frequency distribution statistics are not always conclusive, as the species may have very similar pollen. Statistics are especially difficult to work out for Greenland material, because the taxonomic picture is so confused. However, in the sample from Frederikshaab all *Betula* pollen grains (52) which had not been crushed or distorted were measured. *Alnus* (64 grains) was also measured to give a standard for comparison. The ratio of *Betula* to *Alnus crispa* was calculated to be 1.10. In order to use Eneroth's careful measurements (1951) to calculate modern *Betula-Alnus crispa* ratios, *Alnus crispa* (Ait.) Pursh from three localities was prepared in an

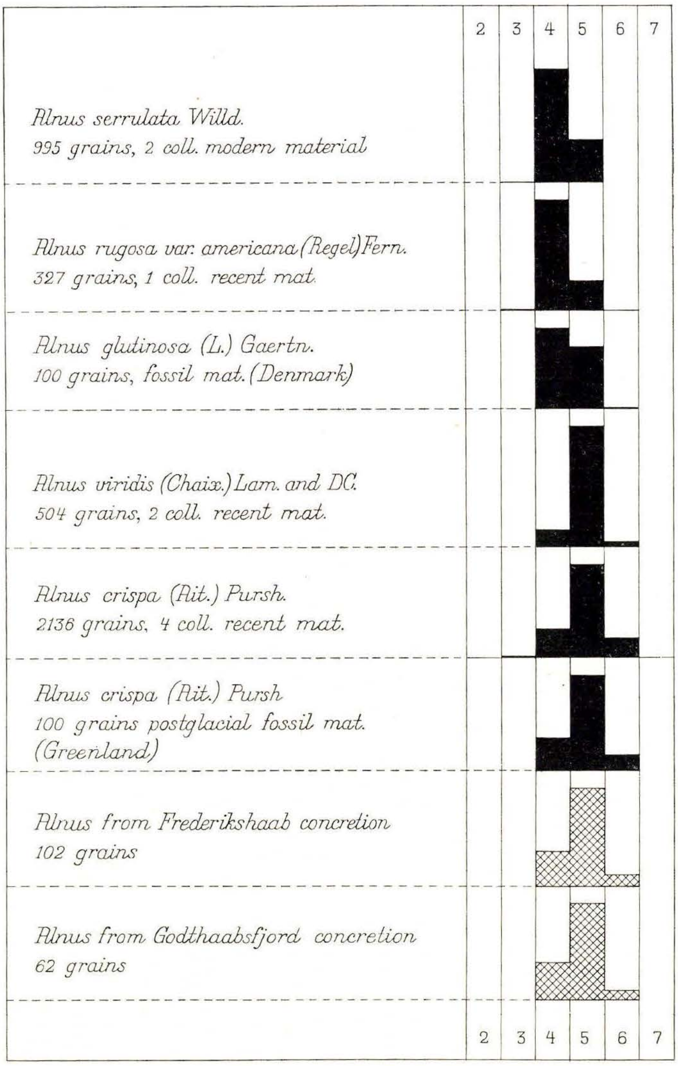

Fig. 1. *Alnus*, pore number frequency distribution (percentages).

identical way and measured (see Table 2). The ratios were then calculated for the *Betula* species now found in Greenland: *B. nana* to *A. crispa*, 1.10; *B. glandulosa* to *A. crispa* 1.15; *B. pubescens* var. *tortuosa* to *A. crispa* 1.47. Admittedly the amount of fossil material measured is rather small, but it is nevertheless conclusive that the fossil *Betula* is of the dwarf birch variety[1]). The arborescent birch, *B. pubescens* var. *tortuosa*, which is found in South Greenland today, is not represented here.

[1]) The American boreal tree birches, *B. lutea* and *B. papyrifera*, have larger pollen than *B. glandulosa*. (S. T. Andersen, personal communication).

Salix is not an important element in the spectra, never reaching values higher than about 3 %. Although identification to species is difficult, it can safely be said that the *Salix* present here is not *Salix herbacea* L.

A single *Dryas* grain was found in the sample from Frederikshaab. *Dryas* is fairly common in Greenland today, preferring basic soils. Its pollen has been found in postglacial deposits (IVERSEN, 1954). Since *Dryas* is not a heavy pollen-producer, it may have been fairly plentiful near the site. Its presence indicates an open vegetation, and perhaps is evidence that soils were not strongly leached.

The presence of *Filipendula* in the sample from Godthaab Fjord is extremely interesting, since the plant is no longer found in Greenland. The relationships of Greenland's flora have long been discussed on the basis of present floral distribution. The present study of fossil material seems to indicate that Greenland has been a meeting ground for European and American types throughout the Pleistocene. *Picea mariana* is a part of the American element which had reached Greenland; *Filipendula* is European. The latter is common as an element in late-glacial pollen diagrams in Europe, where its maximum occurs just at the transition between park-tundra and forest (VAN D. HAMMEN, 1951; IVERSEN, 1954 b). It now ranges in subalpine forest regions of the Scandinavian peninsula, occasionally going above timberline (BLYTT, 1906). Its presence in the Godthaab flora fits in well with the general picture of a subarctic vegetation.

The ocurrence of a single *Xanthium* pollen grain in the Frederikshaab sample[1]) is indeed strange. It is not easy to imagine such a warmth-demanding plant in Greenland. Since the flowers are wind pollinated, however, it seems likely that the pollen was blown in from America. It seems a foreign element here in an otherwise natural and homogeneous flora.

There can be little doubt that the sample from Godthaab Fjord dates from interglacial time. It also seems reasonable to conclude on the basis of the rather high percentages of spruce and alder, and the resemblance of the flora to that from Godthaab Fjord, that the Frederikshaab concretion, too, is of interglacial age. The general impression given by the pollen spectra from the Godthaab Fjord sample is of a semi-closed vegetation with thickets of alder and dwarf birch. On the high plateau conditions were too cold for tree growth; but the slopes down to the fjords, while too steep for heavy forests, supported scattered spruce. The flora was predominantly subarctic and included elements no longer found in Greenland.

The occurrence of warmth-demanding plant species indicates that the climate has been at any rate as warm as in the post-glacial warmth

[1]) Photographs of the *Xanthium* pollen is to be found in the photograph collection of the Geological Survey of Denmark (DGU a 953).

Table 2.

A. *Alnus* pore number frequency distribution:

Species	Σ	2-pored	3-pored	4-pored	5-pored	6-pored	7-pored
Alnus crispa (Ait.) Pursh							
a. Greenland (exact location unknown)	499	1		97	348	53	1
b. Disko, Greenland..................	650	1		18	403	227	1
c. Langanæs, Arsukfjord, Greenland .	452	1	10	169	256	15	1
d. Fiskernæs Fjorden, Greenland.....	535	1	6	107	390	30	1
Fossil *A. crispa*							
a. Postglacial of Kapisilik, Greenland[1])	100			23	66	11	
Fossil *Alnus glutinosa* (L.) Gaertn.							
a. Postglacial (Zone VII) of Horbelev, Falster, Denmark[2]).............	100			56	43	1	
A. incana (L) Moench[3])							
a. Zealand, Denmark................	206		2	100	104		
b. near Oslo, Norway................	283		5	226	52		
c. Södermanland, Sweden............	326			100	219	7	
A. rugosa var. *americana* Fern.							
a. New England, U.S.A..............	327		4	253	69	1	
A. serrulata Willd.							
a. Pennsylvania, U.S.A..............	472		1	330	141		
b. North Carolina, U.S.A	523			360	163		
A. viridis (Chaix) Lam. & DC							
a. Switzerland.......................	235			30	196	9	
b. Tyrol, Austria.....................	269			29	232	8	
Fossil *Alnus*							
Godthaab Fjord, Greenland..........	67			18	45	4	
Frederikshaab Isblink, Greenland.....	102			25	69	8	

B. Modern *Alnus crispa* size frequency distribution:

	Σ	no. of ocular lines ($\delta = 2.86\,\mu$) 5	6	7	8	9	av. size μ
Alnus crispa (Ait.) Pursh							
a. Godthaab Fjord, Greenland........	108	15	47	40	5	1	18.05
b. Ivigtut, Greenland................	100	14	59	25	2		17.59
c. Ontario, Canada..................	100	10	65	25			17.59

[1]) Sample courtesy of Dr. Johs. Iversen, Geological Survey of Denmark.

[2]) Sample courtesy of Mag. Sci. Alfred Andersen, Geological Survey of Denmark.

[3]) No histogram was drawn for this species because of the extreme variability of the individuals studied, which were probably not from natural localities.

period; this is in agreement with interglacial climate e. g. in Denmark, as described by KNUD JESSEN (JESSEN & MILTHERS, 1928).

Of course it is hazardous to generalize too much on the basis of such a small amount of material. But in summary, it may be said conclusively that:

1. The calcareous concretions do not date from postglacial time, but have been rebedded from older, interglacial sediments;
2. During interglacial time the climate was warmer than today;
3. In interglacial times the flora of Greenland included genera no longer found there; among these are elements from both the European and American continents.

This work has been done at the Geological Survey of Denmark, at which I had the privilege to study under the guidance of Dr. Johs. Iversen. I wish to thank Dr. Iversen and Dr. H. Ødum, Direktor of the institute, for the hospitality I have received.

Dansk resumé.

Pollenindholdet af to kalkkonkretioner fra Grønland er undersøgt. Rigelig tilstedeværelse af *Picea* godtgør, at de er af interglacial alder. Pollenspektrene giver et indtryk af Grønlands vegetation og klimatiske forhold i interglacial tid: klimaet var varmere end i nutiden, og floraen har indeholdt arter fra baade Europa (*Filipendula* cf. *ulmaria*) og Amerika (*Picea mariana* (Mill) BSP), som nu er uddøde på Grønland.

References.

ANDERSEN, SVEND TH., 1954. A late-glacial pollen diagram from southern Michigan, U.S.A. Danm. Geol. Unders., II Række, Nr. 80. København.

BLYTT, AXEL, 1906. Haandbog i Norges Flora. Kristiania.

ENEROTH, OLAF, 1951. Undersökning rörande möjligheterna att i fossilt material urskilja de olika *Betula*-arternas pollen. Geol. För. Förhandl. Bd. 73, hft. 3, Nr. 466. Stockholm.

GRIPP, K., 1932. Einige besondere Fossilien in Geschieben aus dem Inlandeis Grönlands. Medd. om Grønland Bd. 91, Nr. 5. København.

HAMMEN, TH. VAN DER, 1951. Late glacial flora and periglacial phenomena in the Netherlands. Eduard Ijdo N.V., Leiden.

HESMER, H., 1933. Die natürliche Bestockung und die Waldentwicklung auf verschiedenartigen markischen Standorten. Zeitschr. f. Forst- u. Jagdwesen 65, 505.

HUSTICH, I., 1939. Notes on the coniferous forest and tree limit on the east coast of Newfoundland-Labrador. Acta Geog. 7, No. 1, Helsinki.

IVERSEN, JOHS., 1954a. Origin of the flora of western Greenland in the light of pollen analysis. Oikos, Copenhagen.

— 1954b. The late-glacial flora of Denmark and its relation to climate and soil. Danm. Geol. Unders., II Række, Nr. 80. København.

JESSEN, KNUD and V. MILTHERS, 1928. Stratigraphical and paleontological studies of interglacial fresh-water deposits in Jutland and Northwest Germany. Danm. Geol. Unders., II Række, Nr. 48. København.

LOW, A. P., 1897. Report on explorations in the Labrador peninsula. Geol. Surv. Canada Ann. Report VIII L.

The Late-Glacial Flora of Ireland

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Abstract.

The paper lists approximately one hundred and twenty plant-fossils which have been identified in late-glacial deposits in Ireland. The plant-lists from four Irish late-glacial localities are described in detail. These lists are compared with lists drawn up in 1950 at three localities in Swedish Lapland at 68° N.

Ever since the systematic collection and identification of plants in the field began in Ireland in the eighteenth century, botanists have wondered at the presence of plants of northern affinities in an island that is almost free from frost and snow. Edward Forbes in his classic paper of 1846 on the Fauna and Flora of the British Isles was the first to bring these speculations into academic form. By the early years of this century Robert Lloyd Praeger had realised that study of the plant fossils in Irish bogs and lakes would throw much light on the problem, and he brought together a reference collection of the seeds and fruits of all the plants in the modern Irish flora. The collection now in the herbarium of the National Museum is a witness to his foresight. Knud Jessen was the first to carry out a systematic search for plant fossils of quaternary age in Ireland, and the zonation of the late-glacial deposits and the list of macroscopic plant-fossils, which he contributed to his joint paper with Farrington on '*The bogs at Ballybetagh near Dublin, with remarks on late-glacial conditions in Ireland*' published in 1934, have proved to be the foundation-stones on which our knowledge of late-glacial conditions in Great Britain and Ireland has been built. Continued study of late-glacial plant-fossils in Ireland has lengthened the list of identifications, and the list and its implications will be discussed in this contribution. Discussion at this stage must, of course, be unsatisfactory, because much more material still awaits collection, and many of the fossils secured have eluded identification.

The list as published here is almost identical with the list already published (Mitchell, 1953). As before, *Polygonum amphibium* is omitted

Number of localities at which identified	General list of late-glacial plants so far identified in Ireland	Record of finds at four localities								
		I		II			III			
		Knocknacran	Mapastown	Knocknacran	Mapastown	Ballybetagh	Knocknacran	Mapastown	Ballybetagh	Drumurcher
	PTERIDOPHYTA									
	EQUISETACEAE									
2	*Equisetum* sp. (Sp)............				rr					
	ISOETACEAE									
1	*Isoetes lacustris* (Sp)..........*									
	LYCOPODIACEAE									
2	*Lycopodium selago* (Sp).......*									
	OPHIOGLOSSACEAE									
1	*Botrychium* sp. (Sp)...........							rr		
	POLYPODIACEAE									
4	*Polypodium vulgare* (Sp)......*				rr					
	SELAGINELLACEAE									
5	*Selaginella selaginoides* (Sp)...*				rr					
	GYMNOSPERMAE									
	CUPRESSACEAE									
9	*Juniperus communis*..........*			rr	c	r		+	r	r
	ANGIOSPERMAE									
	BETULACEAE									
6	*Betula nana*.................*				cc		rr	rr		
3	*nana* x *pubescens*........									
7	*pubescens*.............*			rr	+	+		r		
	CALLITRICHACEAE									
1	† *Callitriche autumnalis* ....*				rr			+		
1	† *stagnalis*..................*							rr		
	CARYOPHYLLACEAE									
7	*Arenaria ciliata*..............*				rr	rr	+	c	c	r
2	*Cerastium arvense*............*						rr		rr	+
2	cf. *cerastoides*.........*								rr	rr
4	*vulgatum* ....*				rr		rr		rr	rr
2	*Lychnis flos-cuculi*............*			rr			+			
1	*Melandrium rubrum*..........*								rr	
3	*Minuartia stricta*.............*						rr		r	
2	*Silene cucubalus*..............*							rr		cc
1	*acaulis*................*									r
1	*Stellaria* cf. *crassifolia*........*									r
	CHENOPODIACEAE									
1	*Atriplex glabriuscula*..........*				rr					
1	*hastata*..............*				rr					
1	cf. *patula*............*									
2	*Chenopodium rubrum*.........*					r				+

			I		II			III			
			Knocknacran	Mapastown	Knocknacran	Mapastown	Ballybetagh	Knocknacran	Mapastown	Ballybetagh	Drumurcher
		CISTACEAE									
3		*Helianthemum canum*......... *				r					
		COMPOSITAE									
3		*Artemisia* sp. (P).............				r			+		
1		*Crepis* cf. *paludosa*........... *				rr					
1		*Hieracium* sp.................				rr					
1		*Taraxacum officinalis* agg..... *							rr		
		CRASSULACEAE									
1		*Sedum* cf. *rosea* (P)							r		
		CRUCIFERAE									
1		*Arabis hirsuta*............... *				rr					
1		cf. *stricta*..............									
3		cf. *Cardaminopsis petraea*..... *						rr	rr	+	
5		*Cochlearia officinalis* agg...... *						c	r	+	+
3		*Draba incana*................ *				r			r	rr	
1		*Nasturtium microphyllum*......				rr					
1		*Rorippa islandica*............ *				r					
		CYPERACEAE									
2		*Carex panicea*............... *								r	
8		*rostrata*................ *							+		
1		*Eleocharis multicaulis*......... *									
2	†	*palustris*........... *							r		
1	†	*uniglumis*.......... *							rr		
8	†	*Schoenoplectus lacustris*....... *			r			rr	r		rr
		DIPSACACEAE									
1		*Succisa pratensis* (P).......... *									
		EMPETRACEAE									
7		*Empetrum nigrum*............ *				r	rr		rr	rr	
		ERICACEAE									
1		*Erica tetralix*................ *									
		HALAGORACEAE									
11	†	*Myriophyllum alterniflorum*... *				r	+				r
4	†	*spicatum*....... *					+				
		HIPPURIDACEAE									
8	†	*Hippuris vulgaris*............ *			r	r			r		rr
		JUNCACEAE									
1		*Luzula* cf. *multiflora*.......... *						rr			
2		*spicata*............... *						rr			rr
		LABIATAE									
1		*Acinos arvensis* .... *								rr	
1		*Clinopodium vulgare* .... *					r			r	
2		*Lycopus europaeus*........... *				rr			rr		

			I		II			III			
			Knocknacran	Mapastown	Knocknacran	Mapastown	Ballybetagh	Knocknacran	Mapastown	Ballybetagh	Drumurcher
		LINACEAE									
2		*Linum catharticum*...........*				r			rr		
		MENYANTHACEAE									
11	†	*Menyanthes trifoliata*.........*						rr	+		
		NYMPHAEACEAE									
1		*Nymphaea alba*..............*									
		ONAGRACEAE									
2		*Epilobium* sp. (P).............									
		PAPILIONACEAE									
1		*Astragalus alpinus* (P)........*		rr							
		PLANTAGINACEAE									
5	†	*Littorella uniflora*............*			r	rr	r		rr		
1		*Plantago maritima* (P)........*				rr					
		PLUMBAGINACEAE									
5		*Armeria mariiima*............*							c	c	c
		POLYGONACEAE									
2		*Oxyria digyna*...............*								rr	cc
1		*Polygonum nodosum*..........*									
7		*Rumex acetosa*...............*				rr	rr	rr	rr		cc
1		*acetosella*.............*						r			
1		*crispus*...............*					rr				
4		*tenuifolius*.............						r	+	c	r
		PORTULACEAE									
1		*Montia lamprosperma*.........*									
		POTAMOGETONACEAE									
2	†	*Potamogeton alpinus* ....*									+
1	†	*crispus*..................*									r
3	†	*filiformis*.................*					+		r		
1	†	*friesii*...................*									c
1	†	cf. *gramineus*.............*							rr		
6	†	*natans*..................*					c		r	r	rr
3	†	*obtusifolius*...............*					+		rr		c
1	†	*pectinatus*................*							r		
2	†	*perfoliatus*................*							rr		+
5	†	*praelongus*................*				rr	c				rr
2	†	*pusillus*..................*					rr				+
1	†	cf. x *zizii* ....*							rr		
		RANUNCULACEAE									
2		*Caltha palustris*..............*									+
5		*Ranunculus acris*.............*					r	+	r		
14		sub-gen. *Batrachium*...........			r	c	cc	+	cc	r	cc

		Knocknacran	Mapastown	Knocknacran	Mapastown	Ballybetagh	Knocknacran	Mapastown	Ballybetagh	Drumurcher
10	*Ranunculus flammula*.........*			r			r	r		
1	*lingua*...........*									
8	*repens*...........*			r	rr	+	r		+	rr
3	cf. *reptans*........*						+			
2	*sceleratus*.........*									
8	*Thalictrum alpinum*..........*				rr	rr	r			+
1	*minus*............*									
	Rosaceae									
3	*Dryas octopetala*..............*				+			r		+
3	*Filipendula ulmaria*..........*									
1	*Geum rivale* or *urbanum*........						rr			
3	*Potentilla anserina*...........*				r					
1	*erecta*..............*							rr		
9	*palustris*...........*		r	rr	+			r		
1	*Rubus* cf. *saxatilis*............*				rr					
	Rubiaceae									
1	*Galium uliginosum*...........*									
1	*verum* ....*			rr						
	Salicaceae									
1	*Salix* cf. *aurita*..............*					rr				
14	*herbacea*...............*	rr	rr	r		cc	r	cc	cc	c
2	cf. *phylicifolia*..........*					r				rr
1	*repens*.................*				+					
1	*viminalis*..............*				c					
	Saxifragaceae									
1	*Saxifraga cespitosa* or *rosacea*..*									
1	*oppositifolia*..............*							rr		
2	cf. *rosacea*.................								+	
2	sp. Sect. *Dactyloides*.......*				r					r
	Sparganiaceae									
2	*Sparganium angustifolium* ...*									
2	† *minimum*.................*					rr				
1	*ramosum* ssp *neglectum*.....*									
	Umbelliferae									
3	*Angelica sylvestris*............*									
	Violaceae				rr					
8	*Viola palustris* s. l............*			rr		r		r	+	
	Zannichelliaceae									
5	† *Zannichellia palustris* var. *pedunculata* ....*			r				rr		
	Number of species identified with reasonable certainty (marked thus *).................. 105	1	3	14	39	25	23	44	24	34
	Number of genera identified... 70									

because it is not precisely dated; *Carex aquatilis* or *bigelowii* (II), *Carex* cf. *pilulifera* (III), *Epilobium* sp. (II), *Mentha* sp. (II, III) and *Stellaria* sp. (III) are omitted because the identifications are not precise. Gramineae are also omitted because in most cases the identification cannot be carried beyond that of the family. It should not be overloooked that grass-pollen is common in all three late-glacial zones, and in Zone II contributes up to 66 % of the total pollen of all terrestrial plants. *Succisa pratensis*, omitted in error from the previous list, is now included; *Hippophaë rhamnoides*, formerly included, is omitted as there is no evidence that the very few pollen-grains of this plant that have been found originated in the country. *Pinus sylvestris* is also omitted for the same reason. In the list the symbol P or Sp follows the name of all plants whose identification is based on pollen or spores only.

Late-glacial material has been collected at nineteen localities, and the column to the left of the list shows the number of localities at which each plant has been recorded. From some localities only small amounts of material were taken, at others the deposits were reasonably well sampled. Four of the latter localities have been chosen, and in the columns to the right of the list an attempt has been made to indicate the relative proportions of the identified material collected from each late-glacial zone. The key to the symbols used is as follows:

rr = 1–2 specimens, r = 3–5 specimens, + = 6–25 specimens, c = 26–50 specimens, cc = more than 50 specimens.

The nomenclature used is that of the *Flora of the British Isles* (CLAPHAM et al. 1952).

When we consider the vicissitudes that plant material had to surmount before it could become fossilised, we can conclude that any plant that was recorded at five or more of the localities must have been widely distributed in late-glacial Ireland. Thus most of the late-glacial ponds and lakes would have had *Myriophyllum alterniflorum*, *Potamogeton natans*, *P. praelongus* and *Zannichellia palustris* var. *pedunculata* growing in them. In the shallower water and round the margins *Carices* (including *C. rostrata*), *Hippuris vulgaris*, *Littorella uniflora*, *Menyanthes trifoliata*, *Potentilla palustris*, *Ranunculus* sub-gen. *Batrachium*, *R. flammula*, *Schoenoplectus lacustris* and *Viola palustris* would have been growing. Grassy meadows must have covered much of the drier ground, with *Ranunculus acris*, *R. repens* and *Rumex acetosa* scattered through the grass. On rocky or steeply sloping ground there would have been scattered plants of *Arenaria ciliata*, *Armeria maritima*, *Cochlearia officinalis*, and *Thalictrum alpinum*. It is more difficult to assess the status of the woody plants; *Betula pubescens* would have sought the more sheltered localities, but *B. nana* and *Juniperus communis* would have been widely distributed. *Empetrum nigrum* may have formed closed heaths, especially in western regions, and *Salix herbacea* (which must have been very widely distributed) was probably concentrated in the snow-patches.

Salix herbacea was recorded at no less than fourteen of the nineteen localities, whereas *Dryas octopetala* was recorded at only three. JESSEN was thus fully justified in speaking of Upper and Lower Salix herbacea-clays in Ireland, rather than of Upper and Lower Dryas-clays as is the usage in Denmark.

The four localities listed in detail all lie in eastern Ireland. Knocknacran Td., Co. Monaghan (MITCHELL, 1951 & 1953, No. 63) lies at an altitude of 60 m. The underlying rock is a Triassic marl with beds of gypsum. The thin overlying boulder-clay has been carried in from the north and is relatively non-calcareous. The lacustrine deposits from which fossils of Zones I, II and III were obtained are calcareous, and the calcareous nature of the deposits contrasts with the somewhat calcifuge aspect of the flora collected. *Dryas octopetala* was not recorded, one seed of *Luzula spicata* was found together with two other seeds less certainly referred to *L. multiflora*. *Rumex acetosa*, *acetosella* and *tenuifolius* were all present, though *Oxyria digyna* was not recorded. Five species of Caryophyllaceae were noted. Radio-carbon dating has given an age of 11,310 $\pm$ 720 years to the deposit of Zone II (LIBBY, 1952).

Mapastown Td., Co. Louth (MITCHELL, 1953, No. 97) lies at an altitude of 30 m. The underlying rock is a Silurian slate, and the superficial deposits are outwash gravels containing slate, limestone and igneous rocks. The lacustrine deposits from which fossils of Zones I, II and III were obtained are calcareous, and calcifuge plants were not prominent. This was a very favoured locality. In late-glacial time gravel ridges must have formed ideal habitats for many plants, and the pools which separated the ridges easily trapped the plant fossils. Only one seed of *Rumex acetosa* and two of *R. tenuifolius* were found. On the other hand there were leaves of *Helianthemum canum* and *Dryas octopetala* and seeds of *Linum catharticum*. At this site only two Caryophyllaceae were recorded; *Arenaria ciliata* was common, but *Silene cucubalus* was represented only by two seeds. (It may be noted that *Arenaria ciliata* was widely distributed in late-glacial Ireland, being recorded at seven localities—to-day it is found at one locality only).

Ballybetagh, Co. Dublin (JESSEN & FARRINGTON, 1936, MITCHELL, 1953, No. 19) lies at an altitude of 220 m. Here there is a steep-sided glacial drainage channel cut through granite of Devonian age; calcareous boulder clay lies on the floor of the channel. At this site there was no fossiliferous deposit of Zone I; fossils were collected from a calcareous lacustrine mud of Zone II, and from a solifluction deposit without, or very poor in, calcium carbonate of Zone III. Here the flora lacked any definite stamp. One damaged perianth of *Oxyria digyna* was found, one perianth of *Rumex acetosa* and several fruits of *Rumex tenuifolius*. *Dryas octopetala* was not recorded, but a crucifer that was almost certainly *Cardaminopsis petraea*, and the labiates, *Acinos arvensis* and *Clinopodium vulgare*, suggested calcicole conditions. Six species of Caryophyllaceae were noted; of these *Melandrium rubrum* occurred only at this site.

Drumurcher Td., Co. Monaghan (MITCHELL, 1951 & 1953, No. 64) lies at an altitude of 90 m. The underlying rock is a Silurian slate, and a non-calcareous outwash gravel lies in a valley at the foot of a rock slope. During Zone III pools formed on the surface of the gravel, and plant-fossils were collected from the non-calcareous muds of the pools. The flora was calcifuge. Almost one hundred perianths of *Oxyria digyna* and two hundred perianths of *Rumex acetosa* were found, *Rumex tenuifolius* and *Luzula spicata* were present, but only thirteen fragments were assigned to *Dryas octopetala*. Eight types of Caryophyllaceae were noted; of these *Silene cucubalus* was especially common, and *Arenaria ciliata* rare.

Of the plants in the main list the identification of one hundred and five species has been taken as sufficiently precise to allow the geographical distribution of these plants to be considered (in the list these plants are marked by an asterisk). The plants have been classified according to the system used by HULTÉN in his *Atlas över växternas utbredning i Norden*, and the classes employed and the numbers of plants assigned to them will be found in a table on page 84.

As many of the land-plants whose fossil remains have been discovered in late-glacial deposits in Ireland must have grown on well-drained slopes, when in Swedish Lapland in 1950 I took opportunity with Professor A. R. CLAPHAM of the University of Sheffield to study the vegetation of some well-drained slopes. The localities were all at 68° 25 N, but varied considerably in height and substratum. At Kapparåsen there was a calcareous morainic slope facing south at an altitude of 480 m; at Katterjokk there was a non-calcareous morainic slope facing east at an altitude of 520 m.; in the Kåppasjåkk valley west of the summit of Nuolja there was a non-calcareous morainic slope facing south-east at an altitude of 760 m. The following list shows the plants that were noted by Professor Clapham. Again the plants whose identification was sufficiently precise to allow them to be classified geographically are marked with an asterisk, and the classes employed and the numbers assigned to them will be found in the table on page 81-82.

To compare the vegetation of these modern slopes in Lapland with the vegetation of the slopes of late-glacial Ireland the list of plants recorded at the four chosen localities was taken, and from the list plants that grow in water or in very wet places were excluded. The excluded plants are marked † in the list of Irish late-glacial plants. Sixty-three plants remained and these have been classified in the same geographical manner.

List of plants recorded on morainic slopes in Lapland	Kapparåsen	Katterjokk	Kåppasjåkk
PTERIDOPHYTA			
EQUISETACEAE			
Equisetum arvense .... *	+		
palustre .... *	+	+	
pratense .... *	+	+	
variegatum .... *	+		
LYCOPODIACEAE			
Lycopodium alpinum .... *		+	
SELAGINELLACEAE			
Selaginella selaginoides .... *	+		
GYMNOSPERMAE			
CUPRESSACEAE			
Juniperus communis .... *			+
ANGIOSPERMAE			
BETULACEAE			
Betula nana .... *	+	+	+
pubescens .... *	+		+
CAMPANULACEAE			
Campanula rotundifolia .... *	+		
CARYOPHYLLACEAE			
Cerastium alpinum .... *	+		
cerastoides .... *		+	
Minuartia biflora .... *			+
sp.	+		
Silene acaulis .... *	+		
Viscaria alpina .... *			+
COMPOSITAE			
Antennaria alpina .... *			+
Erigeron acris var. *politus* .... *	+		
Gnaphalium supinum .... *		+	+
Hieracium alpinum .... *		+	+
sp.	+		+
Saussurea alpina .... *	+		
Solidago virgaurea .... *	+	+	+
Taraxacum cf. *croceum* .... *	+		
officinale .... *	+	+	
CRUCIFERAE			
Cardamine bellidifolia .... *			+
Draba cf. *rupestris* .... *	+		
CYPERACEAE			
Carex bigelowii .... *		+	
curta .... *		+	
capillaris .... *	+		
dioica .... *	+		

	Kapparåsen	Katterjokk	Kåppasjåkk
juncella *		+	
lachenalii *		+	
norvegica *	+		
rupestris *	+		
Kobresia myosuroides *	+		
EMPETRACEAE			
Empetrum hermaphroditum *		+	+
ERICACEAE			
Cassiope hypnoides *		+	
Loiseluria procumbens *		+	
Phyllodoce coerulea *		+	
GERANIACEAE			
Geranium sylvaticum *	+		
GRAMINEAE			
Agropyron latiglume *	+		
x *caninum*	+		
Anthoxanthum odoratum *		+	
Calamagrostis neglecta *		+	
purpurea *	+		
Deschampsia atropurpurea *			+
flexuosa *		+	
Festuca ovina *	+		+
vivipara	+		
Phleum commutatum *		+	
Poa alpina *	+	+	
Trisetum spicatum *	+		+
JUNCACEAE			
Juncus arcticus *	+		
filiformis *		+	
trifidus *		+	+
triglumis *	+		
Luzula spicata *			+
LENTIBULARIACEAE			
Pinguicula alpina *	+		
LILIACEAE			
Tofieldia pusilla *	+		
ONAGRACEAE			
Epilobium anagallidifolium *		+	
PAPILIONACEAE			
Astragalus alpinus *	+		
frigidus *	+		
PARNASSIACEAE			
Parnassia palustris *	+		

	Kapparåsen	Katterjokk	Kåppasjåkk
Polygonaceae			
Oxyria digyna.......................*		+	+
Polygonum viviparum.................*	+	+	
Rumex acetosa.......................*		+	+
Ranunculaceae			
Caltha palustris......................*		+	
Ranunculus acris.....................*	+		
glacialis.................*			+
Thalictrum alpinum..................*	+		
Trollius europaeus...................*	+		
Rosaceae			
Dryas octopetala......................*	+		
Potentilla crantzii....................*	+		
palustris...................*		+	
Rubus saxatilis......................*	+		
Sibbaldia procumbens.................*		+	
Salicaceae			
Salix glauca.........................*	+	+	
hastata........................*	+		
herbacea.......................*		+	+
lanata.........................*	+		
x *hastata*.................	+		
lapponum......................*			+
myrsinites......................*	+		
phylicifolia.....................*	+	+	
x *glauca*.............	+	+	
Salix reticulata.......................*	+		
Saxifragaceae			
Saxifraga aizoides....................*	+		
oppositifolia................*	+		
Scrophulariaceae			
Bartsia alpina........................*	+		
Euphrasia frigida....................*	+		
Veronica alpina......................*		+	+
Umbelliferae			
Angelica archangelica.................*	+		
Vacciniaceae			
Vaccinium myrillus..................*		+	+
uliginosum................*		+	+
vitis-idea..................*			+
Violaceae			
Viola biflora.........................*	+		
Number of species identified with reasonable certainty (marked thus *) 91	59	38	26

Thus the following table shows the groups into which the plants were classified. The column to the left of the list shows the way the ninety-one plants recorded on the slopes in Lapland are distributed through the groups. The first column on the right shows the way the one hundred and five plants recorded in late-glacial Ireland are distributed, and the second column on the right shows the way the sixty-three plants of Irish late-glacial slopes are distributed.

Modern Lapland Slopes		Late-Glacial Ireland	Late-Glacial Irish Slopes
1	Arctic circum-polar	—	—
49	Arctic-montane, including mountains of Europe	15	13
5	Arctic-montane, excluding mountains of Europe	1	1
13	Boreal-circumpolar	31	13
12	Boreal-montane	10	5
—	Circum-polar shore and sub-oceanic	2	1
5	Eurasiatic *s. l.*	24	17
—	Atlantic and sub-atlantic	7	1
—	West European continental	1	1
—	Continental	3	3
2	Scattered areas	2	1
2	Culture	8	7
1	Endemic	—	—
1	Not classified	1	—
91		105	63

The table, of course, emphasises the fact that there was an important arctic-montane element present in the Irish late-glacial flora. This element is under-represented in the table because several plants such as *Polygonum viviparum* and *Saxifraga aizoides* which were noted on the Lapland slopes still grow in Ireland, even though their fossil remains have not yet been discovered in Irish late-glacial deposits. But it also makes it clear that other elements which are less strongly represented on the Lapland slopes to-day were present in late-glacial Ireland. The boreal-circumpolar element was stronger in Ireland than in Lapland, and a large number of Eurasiatic plants were present in late-glacial Ireland whereas only a very small number grow in Lapland to-day. Oceanic influence is demonstrable in the Irish late-glacial flora, and the plants of southern affinity can be isolated to form quite a striking list—*Acinos arvensis*, *Artemisia* sp., *Callitriche stagnalis*, *Clinopodium vulgare*, *Eleocharis multicaulis*, *Erica tetralix*, *Helianthemum canum*, *Littorella uniflora*, *Lycopus europaeus Mentha*, sp., *Nasturtium microphyllum*, *Potamo-*

geton crispus, *P. friesii*, *P. pectinatus*, *Ranunculus lingua*, *Salix* cf. *aurita*, *S. repens*, *Sparganium ramosum* ssp. *neglectum* and *Zannichellia palustris* var. *pedunculata*. We must agree with JESSEN and IVERSEN that we should not allow ourselves to be dazzled by the arctic-montane element in the late-glacial flora, but should realise that this flora was a very rich one which has no real parallel in high altitudes or high latitudes to-day.

We must also agree with GODWIN that many of the plants we call 'weeds' to-day (HULTÉN's *Mycket starkt kulturspridda växter*) have a distinguished history which carries them back at least to late-glacial time. The plants entered under the heading 'Culture' in the table are *Atriplex* cf. *patula*, *Cerastium arvense*, *C. vulgatum*, *Chenopodium rubrum*, *Polygonum nodosum*, *Potentilla anserina*, *Ranunculus repens* and *Rumex crispus*. They are probably plants of young, open soils and do not necessarily only find favourable conditions where cultivation is practised.

To-day the Reindeer lives only in the tundras of the north. The late-glacial Ireland in which the Reindeer and the Giant Deer lived was certainly very different from the tundras. To-day thanks to the work of JESSEN and those he has inspired we are beginning to form an impression of the late-glacial vegetation of north-west Europe. But we should remember that we have, as yet, no concept of the vegetation of southern France when the Reindeer was common in that country, towards the end of the Ice Age.

References

CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F. 1952: *Flora of the British Isles.* — Cambridge.

DEGERBØL, M. & IVERSEN, J. 1945: The Bison in Denmark. — *Danm. Geol. Undersøg.* II R., No. 73. København.

FORBES, E. 1846: On the Connection between the Distribution of the Existing Fauna and Flora of the British Isles, and the Geographical Changes. — *Mem. Geol. Surv., Gt. Britain* I, p. 336–432. London.

GODWIN, H. 1949: The Spreading of the British Flora. *Journ. Ecol.*, XXXVII, p. 140–147.

HULTÉN, E. 1950: *Atlas över Växternas Utbredning i Norden.* Stockholm.

JESSEN, K. 1949: Studies in Late Quaternary Deposits and Flora-History of Ireland. — *Proc. Roy. Ir. Acad.*, LII, B, No. 6. Dublin.

JESSEN, K. & FARRINGTON, A. 1938: The Bogs at Ballybetagh, near Dublin, with remarks on Late-glacial conditions in Ireland. *Proc. Roy. Ir. Acad.*, XLIV, B, No. 10. Dublin.

LIBBY, W. F. 1952: *Radiocarbon Dating.* Chicago.

MITCHELL, G. F. 1951: Studies in Irish Quaternary Deposits: No. 7. Proc. Roy. Ir. Acad., LIII, B. No. 11. Dublin.

— 1953: Further Identifications of Macroscopic Plant Fossils from Irish Quaternary Deposits especially from a Late-glacial Deposit at Mapastown, Co. Louth. *Proc. Roy. Ir. Acad.*, LV, B, No. 12. Dublin.

Dansk resumé.

Afhandlingen indeholder en fortegnelse over på det nærmeste 120 forskellige plantefossiler, der er påvist i senglaciale aflejringer på Irland. Plantelister fra 4 irske senglaciale lokaliteter omtales mere detailleret. Disse lister sammenlignes med floralister fra tre lokaliteter i Svensk Lapland ved 68° N.

De senglaciale lister fra Irland og de recente lister fra Lapland er analyserede efter Hultén's principper. Sammenlignet med vore dages Lapland var det arktisk-montane element i det senglaciale Irland svagere, og det boreal-montane stærkere repræsenteret, ligesom der fandtes et betydeligt eurasiatisk (s. l.) element.

The Late-Glacial Flora of Denmark and its Relation to Climate and Soil.

By

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Abstract.

This paper gives a survey of the Danish late-glacial flora as it appears on the basis of the entire material to hand. Recent pollen research has added an element of southern and south-eastern plant species to the well known arctic-alpine and boreal flora elements. The flora indicates a generally subarctic climate, though temperate in parts of the Alleröd period and low-arctic in a short period between the Bölling and the Allerödperiod. It also indicates a slightly oceanic climate, though with rather dry and sunny summers and moderately cold and moist winters. The late-glacial period was the great time of heliophytes, and many light requiring plant species which are now never found together grew side by side: plants today found on the tundra and in the alpine region, on the steppes, on bare lime-stone rocks, on dunes or as weeds in cultivated fields.—The paper contains a list of all vascular plant species so far demonstrated in Danish late-glacial sediments.

Contents.

Introduction.

A. G. NATHORST and JAPETUS STEENSTRUP were the first who, in the year 1871, brought to light glacial plants from Danish bog deposits; but it was NICOLAUS HARTZ who subsequently initiated the earnest study of the Danish glacial flora. The discovery of the Alleröd oscillation (HARTZ and MILTHERS 1901) marked an important scientific progress, and in his "Contribution to the Late-glacial Flora and Fauna of Denmark" (1902), HARTZ gave the first—and hitherto the only—survey of our late-glacial flora. Apart from mosses and other lower plants, the list contains about 50 vascular plant species; a number of these would however properly be referred to early postglacial time, now that the stratigraphic borderlines were more sharply defined.

Clear borderlines were established when KNUD JESSEN introduced the pollen statistical method, and in his zone system of the Danish pollen diagrams (JESSEN 1935) the late-glacial period comprises the first three zones: I Older Dryas period, II Alleröd period, III Younger Dryas period. JESSEN also studied the macrofossils and through his investigations the knowledge of the late-glacial flora was considerably augmented. Among other contributions MATHIESSEN'S (1925) is worthy of note.

While, formerly, the knowledge of the late-glacial flowering plants was almost entirely based upon finds of macro-fossils, the advance in the last two decades is first and foremost due to a close study of the pollen flora. The list of plant species has greatly increased and a characteristic change has occurred in the composition of the known flora: pollen analysis has brought to the late-glacial flora a new element of southern or south-eastern species, which are not encountered in the polar zone nor in the Scandinavian mountain regions.

On the other hand, pollen analysis confirmed in its principal features HARTZ'S and JESSEN'S conception of the vegetational development, while, at the same time, it has given a more precise and detailed picture of the succession. In the lake Böllingsö on the borderline of the last glaciation, in addition to the Alleröd oscillation, evidence is found of an earlier oscillation, the Bölling oscillation (IVERSEN 1942), reflected e. g. in a transient advance of the forest.

At the end of this paper is found a list of all vascular plant species identified in Danish late-glacial deposits up to the present date. I have indicated for each species whether it has been demonstrated by macrofossils, pollen, or both. The macrofossil finds have been collated on the basis of published data (HARTZ 1902; JESSEN 1920, 1923, 1924, 1928; MATHIESSEN 1925; BRANDT 1954; and JESSEN in NORDMANN 1922, MILTHERS 1925, A. JESSEN 1935; BRANDT in IVERSEN 1946).

Plant species demonstrated only by pollen are included only if the occurrence is substantiated by retention of the slides or by microphotographs. Usually we have taken about 12 Leica exposures representing a series of diverse "optical sections" and frequently also two or three different aspects of the grain. The most significant pictures from every set are enlarged and mounted on sheets of pasteboard, one sheet for every fossil grain, as shown in plate VII. Pollen grains, documented in the "photoherbarium" in this way, have been listed by numbers on p. 119. By means of these numbers other investigators, who wish to scrutinize the determinations, can borrow the sheets in question on application. The bulk of the photographic work has been skilfully prepared by Mr. H. Krog, M. Sc.

All pollen analyses have been carried out at Danmarks Geologiske Undersøgelse by myself and my collaborators, H. Krog, and Svend Th. Andersen, M. Sc. For the determinations I assume personal responsibility; all important pollen finds I have scrutinized repeatedly under the microscope, which was possible since the preparations are retained. Many of the pollen finds are mentioned here for the first time, but some have previously been published and discussed (Iversen 1944, 1946, 1947, 1951, Krog 1954).

My studies of the late-glacial vegetation has been supported by a grant from the Carlsberg Fond, for which I want to express my respectful thanks.

Temperature.

A. *General remarks.*

The main trend in the alternating course of the late-glacial vegetational development was determined in its fundamental features by the fluctuating temperature. Opinions of the late-glacial temperature climate have varied greatly. Originally Nathorst (1870, 1891) postulated that the climate had been high-arctic in southern Sweden during the time of the

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Plate VII. Micro-photographs of a fossil grain of *Pleurospermum austriacum*, Younger Dryas Period, Bornholm. Oil immersion, numer. apert. 1.32. Green filter.

Example of a sheet of micro-photographs as documentation of the late-glacial pollen finds. The number of this sheet is DGU a 613. With regard to the entire photo-material see the list page 119. Details of the pollen grain are found on the label above (region, bog, number and depth of sample, treatment, analyst, number of the sheet etc.) At the side of each photo is information as to focus. Below each photo is the number of the exposure of the Leica film (e.g. film 61, exposure 29). The pictures are twice enlarged photos.

The block has been reduced to $^2/_3$. The original size of the sheet is 25×18 cm., that of the pollen grain $27 \times 22\ \mu$.

rapid melting of the ice, while GUNNAR ANDERSSON (1903), referring to the numerous remains of hydrophytes always found together with those of arctic plants even in the deepest layers of freshwater clay, assumed low-arctic temperature conditions (July temperature rising from 6° C. to 9° C.).

JOHANSEN (1904, 1906) from his studies on the fossil freshwater mollusc-fauna in the same plant-bearing strata postulated even more favourable temperature conditions. He considered the July temperature during the late-glacial period to have varied between 8° C. and 14° C. The highest of these temperatures applied to the Alleröd time, to which ANDERSSON later (1909) ascribed a temperature of about 12° C.

JOHANSEN's conception was criticized in a keen debate in the Geological Society of Denmark (cf. Meddelelser fra Dansk Geologisk Foren., no. 12, 1906); of greatest importance is WESENBERG-LUND's argument that the higher altitude of the sun on our latitudes has resulted in a higher temperature of the late-glacial shallow lakes than is the case at present in the arctic zone, where the altitude of the sun is low. Aquatic organisms would accordingly be quite unsuited as indicators of the macroclimate.

The point maintained by WESENBERG-LUND provided a natural explanation of the peculiar contrast which seemed to exist within the late-glacial flora and fauna: the occurrence of arctic terrestrials side by side with temperate molluscs and aquatics. Indeed, WESENBERG-LUND's conception became prevalent in Scandinavia. Nevertheless it cannot be said that the question was solved. One of the difficulties, already stressed by WESENBERG-LUND, is the incompleteness of our knowledge of the distribution of freshwater organisms in arctic and sub-arctic regions. Our present knowledge is still incomplete, nevertheless we know enough, I think, to check WESENBERG-LUND's theory, and this I have tried to do, in so far as the higher waterplants are concerned.

If the altitude of the sun is of special importance to the distribution of waterplants, one would expect, as stressed by BROCKMANN-JEROSCH (1909), that waterplants, as compared with terrestrials, should be found at higher altitudes in the central-European mountains than in Scandinavia. According to GUNNAR SAMUELSSON (1934) the following waterplants are found in the alpine zone of Sweden: *Callitriche verna*, *Hippuris vulgaris*, *Isoëtes lacustris*, *Potamogeton filiformis*, *P. pusillus*, *Ranunculus confervoides*, *R. reptans* and a few other plants (*Ranunculus hyperboreus*, *R. peltatus*, *Sparganium hyperboreum* and *Subularia*) which are absent from or rare in the Alps.

Dr. W. LÜDI, Zürich, has been so kind as to give me a list of waterplants which have been found in the alpine zone in the Swiss Alps, i.e. above the *Larix-Pinus cembra* zone (or a corresponding zone), which according to LÜDI may be compared with the Scandinavian sub-alpine birch-zone. The list is very similar to SAMUELSSON's from Sweden, namely: *Callitriche verna*, *Isoëtes lacustris*, *Potamogeton filiformis*, *P. pusillus*, *Ranunculus confervoides*, and *Sparganium angustifolium*. The agreement is striking, and it may be accidental that *Hippuris* is not recorded from the Swiss alpine zone, and that *Sparganium angustifolium* is not reported from the Scandinavian alpine zone. This confirms BROCKMANN-JEROSCH's statement that waterplants, compared with terrestrials, do not occur at higher altitudes in Switzerland than in Sweden, despite the higher altitude of the sun during the summer.

Another and even more significant check of WESENBERG-LUND's theory may be obtained by a study of the hydrophyte flora of arctic and sub-arctic Eastern Canada, since the modern borderline between the arctic and sub-arctic zones in this region is situated at the latitude of Copenhagen. If the high altitude of the sun be responsible for the occurrence of thermophilous water-plants in the Danish late-glacial lakes, we may indeed expect to find thermophilous waterplants also in the shallow lakes of arctic Eastern Canada. In order to get the most up-to-date information about the distribution of the aquatics in this region I contacted Dr. A. E. PORSILD, Ottawa, and he was so kind as to send me his unpublished distribution maps of all the plant species in question. It appears from these and from Dr. PORSILD's letter, that only *Callitriche verna*, *Hippuris vulgaris*, *Sparganium hyperboreum*, *Potamogeton filiformis*, *Ranunculus confervoides* and *R. hyperboreus* are found north of the tree line; these are exactly the same species found in the arctic zone of Lapland (cf. the maps in SAMUELSSON 1934 and HULTEN 1950).

Dr. PORSILD writes in his letter: "When we examine plant distribution maps of North America, we find that our aquatic plants pretty much follow the usual pattern for widely distributed plants and that most of them extend north to the tree line which in Canada runs in a pretty straight line from the Mackenzie Delta to the foot of James Bay, or from lat. 68° 40 to 52°—a difference in latitude as from Cape Farewell to Thule. This certainly would suggest that at least as regards its ability to heat the water of a pond in high latitudes the relative low altitude of the sun is compensated for by the long day".

It appears from these facts, that WESENBERG-LUND's theory has received no confirmation in the recent distribution of the waterplants. Most likely PORSILD is right in his tentative assumption expressed in the last sentence cited above. That would mean that molluscs, most probably, would follow the same rule as waterplants. On the other hand one can, so far, not exclude the possibility that waterplants in the far north are favoured directly by the long days, which enables them to assimilate during a longer time than at lower latitudes. In this case the possibility remains that mollucs, contrary to waterplants, behave as involved in WESENBERG-LUND's theory. It remains for the zoologists and limnologists to solve this question.

To sum up, it may be said conclusively that the distribution of waterplants is not seriously effected by the altitude of the sun. This means that they are of no less value as indicators of temperature conditions than are terrestrial plants, actually, in some respects, they are superior*). The spreading of waterplants is unrivaled in its speed. Furthermore most aquatics behave like pioneer plants; they need no maturing of the soil,

*) In a quite recent paper SZAFER (1954, p. 194–198) draws attention to another important aspect of the problem, which also emphasizes the importance of waterplants as thermic indicators. SZAFER points out "that the vegetation of the stagnant water, being above all a reflection of their thermal climate, is a better index of the influence of the regional (zonal) climate of the vegetation than the extremely differentiated vegetation of the land". "This statement can be fully applied only in relation to a defined "biological type" of lakes, which is the reflection of edaphic conditions", e.g. the eutrophic (alcaline) type.

but will find ideal living conditions in a lake immediately after it has been created. Aquatics, therefore, will react much more quickly to an improvement in climate than most terrestrial plants. Another advantage is the fact that the recent distribution of the waterplants is generally very wide. They are not hampered by competition from forest trees, as all heliophilous terrestrial plants are. The difficulty is only that of getting reliable information of the recent distribution of fruiting (not sterile!) aquatics.

Only edaphic factors, especially lack of lime, may restrict the area of sensitive waterplants so severely that we have no guarantee that their recent distribution allows climatic conclusions. The great majority of Danish late-glacial lakes were alkaline originally (see below), and most of them were rich in lime, while today such lakes are of rather limited occurrence in arctic and subarctic Scandinavia. We, therefore, must be very cautious when using pronounced alkaliphilous waterplants as climatic indicators. Hence e.g. *Myriophyllum spicatum* and *Potamogeton compressus* are not reliable, while e.g. *Nymphaea*, *Nuphar*, *Potamogeton natans* and *Typha latifolia* are not restricted in their distribution by this factor and are accordingly more reliable. The whole question is dealt with in a competent way by SAMUELSSON (1934). The same difficulty is, of course, met with when dealing with the distribution of strongly calciphilous terrestrials.

Another difficulty arises in the case of heliophilous plants, and here it is very significant that most arctic-alpine plant species are distinctly heliophilous. This means that their distribution inside the timber line is seriously hampered by the shade of the forest. It was unjustified to consider the arctic terrestrials as more reliable temperature indicators than the waterplants, when the disharmonious evidence of these plants was discussed in the beginning of this century.

In the following we shall deal with the temperature climate in the various late-glacial periods, as it is indicated by the much enlarged material of to-day. I have divided the plants into four ecological groups: 1) trees and bushes, 2) waterplants, 3) shade-tolerant herbs and dwarf bushes, 4) heliophilous herbs and dwarf bushes. Only plants of the first group may be expected to give reliable information about the macroclimate, as measured by the meteorologists. The plants of the other groups are strongly influenced by local conditions, since they can take advantage of the favourable microclimate near the ground and may be protected in the winter by snow. The last group is regarded as most unreliable. We shall study the evidence of temperature climate within each group separately.

The terms arctic (alpine) and subarctic (subalpine) are used in accordance with HUSTICH's (1953) definition. The subarctic, or subalpine, zone covers the region between the continuous forest and the polar, or alpine, limit of trees ("tree-line"). This zone covers, according to HUSTICH, the Scandinavian subalpine zone, the birch zone. It also corresponds with the lyesotundra ("forest-tundra") of the Russian and presumably more or less with our late-glacial "park-tundra". It should, however, be noted that the term subalpine in the Alps is used in a wider sense, since it includes the continuous *Picea*-forest.

B. *Late-glacial periods.*

Zone Ia. Daniglacial tundra period.

Before the late-glacial increase of temperature began, i.e. during the pleni-glacial period of VAN DER HAMMEN (1951), or the full-glacial of GODWIN (1953), a true arctic climate prevailed in the western parts of Jutland, which were not covered by ice. Unfortunately, no reliable organic sediments from the pleni-glacial are known in Denmark. The late-glacial period begins where the first signs of an amelioration in climate appears at the end of the pleni-glacial. VAN DER HAMMEN claims that a rise in the *Artemisia*-curve in his region marks the beginning of the late-glacial period.

The deepest samples of the bottom clay in the lake Böllingsö must then be referred to the pleni-glacial. The overwhelming majority of all pollen here is rebedded and of pre-quaternary age. The reliable pollen flora is, however, of arctic character. Besides grasses (dominant) and sedges the following plant species have been demonstrated: *Armeria maritima*, *Artemisia* sp., *Campanula* sp., *Dryas octopetala*, *Galium* sp., *Parnassia palustris*, *Plantago maritima*, *Sagina* cf. *procumbens*, *Salix herbacea*, *Saxifraga* cf. *oppositifolia*, *Selaginella selaginoides* and *Thalictrum* sp. A pollen grain of *Hippophaë* may be due to long-distance transport from the south. This flora-list corresponds very well with the pollen flora found by VAN DER HAMMEN in organic layers from the middle of the last glacial period.

In the diagram from Böllingsö published earlier (1942, 1947) the *Artemisia* curve rises strongly at the bottom; the deepest analysis (395 cm.) thus belongs to the pleni-glacial period sensu VAN DER HAMMEN. The diagram in this paper (plate X) is late-glacial throughout, as the frequency of *Artemisia* is already high in the deepest analysis.

In the next analysis *Hippophaë* appears ($3^0/_0$). This shrub has never been found in the arctic nor in the alpine zone. To be sure, NORDHAGEN (1921 p. 129) in Salten, N. Norway, has found it up to the forest-limit (600 m.), but it was completely sterile there as well as at an altitude of 4–500 m. According to GAMS (1943) *Hippophaë* never reaches the tree limit in the Alps, and it fails to flower already long before the subalpine zone is reached. We must, therefore, conclude that the climate already had a sub-arctic character in zone Ia, even if a treeless tundra prevailed. Also the pollen occurrence of *Plantago media* is worth mentioning.

Zone Ib. Bölling period.

A sharp rise of the birch curve marks the beginning of zone Ib. Size measurements of the pollen grains of birch prove that most of them must belong to tree birches, and this horizon, therefore, indicates that birch trees (*Betula pubescens* s. l.) have immigrated. The vegetation type can now be characterized as a park-tundra.

The Bölling oscillation, in our country, is so far only studied in the dried up lake Böllingsö. We have complete pollen diagrams from three different borings, the most recent, prepared by H. Krog, being unpublished; the diagrams are quite consistent. Outside Denmark the Bölling oscillation has been demonstrated in Holland by van d. Hammen (1951) and in central Germany by H. Müller (1954); there seems little doubt that the oscillation registered in these diagrams actually is the same.

The only phanerophytes so far demonstrated in this period are, at Böllingsö, *Betula pubescens*, *Hippophaë*, and *Sorbus aucuparia*. They indicate a temperature in July a little above 10° C.

The water vegetation was rich; up to 20% of *Potamogeton* pollen was found. Four species of *Potamogeton* were demonstrated (cf. Brandt 1954); fruitstones of *P. praelongus* were especially common. This species was widely distributed in late-glacial time; to-day it does not reach the tree limit, neither in Scandinavia nor in the Alps. According to information from Dr. A. E. Porsild *P. praelongus* is not found in arctic Canada, and there is only one record near the tree limit. Especially important is the fact that this species is generally sterile near its northern limit in Canada. Like the phanerophytes, then, this species indicates sub-arctic temperature conditions, as do pollen finds of *Centaurea scabiosa* and *Filipendula*.

Zone Ic. Older Dryas period.

After the Bölling period the thermophilous phanerophytes (*Betula pubescens* s. l. and *Hippophaë*) disappear and again we have a treeless tundra vegetation. We may assume a July temperature below 10° C. The aquatic vegetation is poor now, the *Potamogeton* curve showing a very steep decline together with the epiphytic diatoms. A few pollen grains of *Myriophyllum spicatum* were found. This species is scarcely found beyond the tree-limit to-day (except the American var. *exalbescens*), but it must be considered a rather unreliable temperature indicator, since it is a strongly alkaliphilous species, the distribution of which is quite dependent on the presence of lime (cf. Samuelsson 1934, p. 56). Van der Hammen (1951) has *Myriophyllum* pollen in a number of pleniglacial analyses.

In the pollen diagrams we have put the end of zone I where a sharp increase in the frequency of tree pollen indicates the immigration of forest trees, or—in the case of the Bölling diagram—where the rise of the tree pollen curve exceeds the maximum values in the Bölling period. It must, however, be stressed that the zone-border I–II is scarcely synchronous. There can be no doubt that the border-line is older in Western Jutland than in the Danish islands. This appears from several facts, of which we shall here mention only one.

In the eastern part of Denmark, the flora of the Older Dryas period (zone Ic), at any rate in its later stages, is not at all of purely arctic character as is the case in zone Ic in the Bölling deposits, and in the Netherlands (cf. van der Hammen 1952). Besides *Pontamogeton praelongus* we have several finds of terrestrial plants indicating sub-arctic climatic conditions when the Older Dryas clay of the Danish islands was deposited. *Hippophaë rhamnoides* has in all these diagrams its maximum occurrence early in zone I before the rise of the birch curve (cf. plate XI, and also e.g. plate XII in Krog 1954). Flowering *Hippophaë* has today not been found even in the sub-alpine zone, as already mentioned. Pollen of another pioneer tree, *Sorbus aria* cf. *rupicola*, has been demonstrated early in zone I (Bornholm); also a series of more or less thermophilous, shade-tolerant herbs (*Filipendula* cf. *ulmaria*, *Fragaria* cf. *vesca*, *Pleurospermum austriacum*). At the transition between the Older Dryas and the Alleröd periods the heliophilous herbs *Gypsophila fastigiata*, *Centaurea cyanus* and *C. scabiosa* are found, also the waterplant *Nymphaea Candida*, which only quite exceptionally reaches the sub-alpine zone in Scandinavia (Samuelsson 1934 p. 74).

We have no facts as to where the margin of the glacier was located during the time of zone I. It seems obvious that zone Ia is of Dani-glacial age, but it has not yet been established whether the "living" ice retreated from the whole country during the Bölling oscillation. If so, the climatic deterioration between the Bölling and the Alleröd periods may correspond to the stillstand line of the ice which runs through Scania from NW to SE along Hallandsåsen and Linderödåsen. This line, according to Antevs (1926), separates the Dani-glacial and the Gothi-glacial retreat. But the Scanian stillstand line may also be younger than zone Ic in the Bölling diagram. At any rate we must assume sub-arctic temperature conditions during the Dani-glacial retreat of the ice, otherwise it would be difficult to understand how the retreat could have been so rapid as is implied by the thick varves and the short life-time of the Danish ice-dammed lakes (see Hansen 1940).

Zone II. Alleröd period.

Except on Bornholm, birch (*Betula pubescens aggr.*) was the dominating forest tree in Denmark during the Alleröd period. The sub-arctic birch-zone in Scandinavia is composed of *B. tortuosa*, while *B. pubescens*—like *Pinus silvestris*—in Scandinavia demands a July temperature of about 12° C. Unfortunately the two closely related birch species are not distinguished in the Danish material. The birch of the park-tundra may have been *Betula tortuosa*, but it is almost certain that the rather dense birch-forest of the later part of the Alleröd period chiefly consisted of *B. pubescens* s. str. FÆGRI's (1935) size-statistical investigation of birch pollen from Alleröd gyttja in Jæren (Western Norway) also shows predominance of *Betula pubescens* (not *B. tortuosa*); and in Holstein, according to SCHÜTRUMPF (1943), besides *B. pubescens* even *B. verrucosa*, which is more thermophilous than *Pinus silvestris*, was present in the earliest late-glacial birch-forest. That would mean that the Alleröd birch forest cannot be compared with the sub-arctic and sub-alpine birch zone of Scandinavia, which is composed of *B. tortuosa* only. Birch has a greater migration speed than pine; during a climatic improvement it will quickly occupy the region in front of the earlier forest line, and the advance of pine will then be severely hampered by the birch forest, even if temperature conditions are favourable. This has been the case in preboreal time, which certainly had no sub-arctic climate, and, I think, also in the Alleröd period.

On the other hand, our diagram from Bornholm (plate XI) has no indication of any late-glacial birch forest zone. It could be demonstrated by size-measurements that the maximum of birch pollen before the pine rise is due to *Betula nana*. Even in the Alleröd-layer most birch pollen is of dwarf-birch, and macroscopically *Betula nana* is very common in the Alleröd layers of Bornholm, while broad leaved birches are not demonstrated with the exception of one single piece of bark (GRÖNWALL og MILTHERS 1916). In this respect Bornholm deviates remarkably from the rest of the country.

Populus-pollen is found in the Alleröd gyttja, but is scarce. To-day, aspen grows up to the polar tree-limit. But according to KIHLMANN (1890–92, p. 223) it is dwarfed and sterile even in the sub-arctic forest of Lapland.

It will appear from what has been said above that the Alleröd climate in the southern part of Denmark was probably more favourable than the prevalence of birch might indicate. The slowness of the progress of pine in the greatest part of Denmark is scarcely climatically conditioned. From the rather dense birch forest in southern Denmark and at any rate from the pine forest on Bornholm we are entitled to conclude that the July temperature was above 12° C.

Among the aquatics a series of distinctly thermophilous plants has been demonstrated, e.g. *Oenanthe aquatica*, *Typha latitolia*, *Scirpus lacustris*, *Nuphar pumilum* and *Nymphaea candida*. *Oenanthe aquatica* is to-day a distinct lowland plant which, in Scandinavia, does not reach beyond the 15° C. July isotherm. This old find (HARTZ 1902) looks rather queer, but the determination of the seeds, at any rate, is confirmed by Miss

I. Brandt, who has scrutinized the specimens still found in the collections of the Geological Survey of Denmark. *Typha latifolia* is also thermophilous; in Scandinavia it does not exceed 14° C. and in the Alps it scarcely reaches an altitude of 1000 m., that is about 1000 m. beneath tree limit. The species is not alkaliphilous. Only a few pollen grains are found. *Scirpus lacustris* in Scandinavia reaches the 13° C. July isotherm. In the Alps, according to information from Dr. Lüdi, it ceases several hundred meters beneath the forest limit, and it is sterile at the highest occurrences. Thus the aquatics indicate a temperate climate in the optimal phase of the Alleröd-period.

A thermophilous shade tolerant terrestrial is *Solanum dulcamara*, the pollen of which is found in Alleröd deposits. In Scandinavia it has a distribution similar to that of e.g. *Tilia cordata* in that it does not extend beyond the July isotherm of 13° and is very rare beyond the 14° C. isotherm. In the Alps the vertical distribution is rather like that of *Corylus*; according to Lüdi the highest locality known in Switzerland is 1700 m. (Unterengadin and Wallis). The corresponding figure for *Corylus* in Unterengadin is 1650 m. (Braun & Rübel 1932–34), in Wallis 1850 m. (Gams 1927). These are only rare occurrences; *Solanum dulcamara* must, however, have been frequent in the Alleröd period, since we have pollen finds from several localities and this entomophilous species certainly has no good pollen dispersal. The frequent occurrence of *Solanum dulcamara* in the Alleröd period, therefore, indicates a temperate climate, probably a July temperature of about 13°–14° C.

The majority of the heliophilous and thermophilous plants from the Alleröd layer have no temperature conditioned vertical or horizontal limits in Scandinavia, and some are quite absent to-day. Here we shall only mention *Seseli Libanotis* and *Jasione montana*. *Seseli* is in Graubünden (Ober-Engadin) found up to 1780 m. (Braun & Rübel 1932–34); local forest limit (*Pinus cembra* Larx) about 2300, *Pinus silvestris* 2100 m. *Jasione montana* reaches only 1410 m. in Graubünden and 700 m. in South Norway. Both may, accordingly, be characterized as temperate.

It is always difficult to draw reliable climatic conclusions on the basis of fossil finds, especially when edaphic and other factors were very different from what they are to-day. This certainly has been the case in the late-glacial period. On the other hand the reliability of the conclusions is strengthened, when the climatic indication given by the fossil flora is the same within diverse ecological groups of plant species. We have seen that whether we consider trees and shrubs, waterplants, shade tolerant terrestrials or heliophilous plants we find clear indications of a temperate, not a sub-arctic climate in the Alleröd period. If the recent distribution of these thermophilous plants is significant, we must assume that the July temperature in the late Alleröd was about 13° C. or 14° C.

This is in agreement with A. C. JOHANSEN'S conclusions from the molluscs found in these layers. Opponents of JOHANSEN'S view cited the occurrence of arctic-alpine plant fossils. We shall later scrutinize whether these finds harmonize with the evidence of the thermophilous organisms or not. Here we shall just mention that the truely arctic-alpine plant species are missing in deposits from the Alleröd period proper.

FIRBAS (1949 p. 287; cf. also LANG 1951) discusses the temperature conditions of the Alleröd period in Southern Germany on the basis of the upper limit of the pine in Schwarzwald during that time. He concludes that the July temperature has only been about $2^1/_2$° C. lower than to-day. This figure for the July temperature formerly seemed surprisingly high, but it is confirmed by the new material from Denmark discussed above, and it is no longer necessary to assume a considerable temperature depression in the Baltic region caused by the ice sheet in Middle Sweden.

Zone III. Younger Dryas period.

The climatic deterioration of zone III manifests itself in the pollen diagrams by a sudden decline of birch and pine and a corresponding rise of the curves for *Artemisia*, grasses, sedges and other herbaceous plants, except for the relatively thermophilous herbs *Urtica* (CHRISTENSEN 1949, KROG 1954) and *Filipendula* (see plate X and XI, also KROG 1954 plate XII, this issue), which show a decline.

When at its minimum, *Filipendula* pollen is very scarce indeed, though it may be demonstrated by comprehensive countings. In Scandinavia *Filipendula ulmaria* to-day is found in the sub-alpine zone, exceptionally it may even be met with a trifle above tree limit. In the Alps it does not reach tree limit (BRAUN & RÜBEL l.c.). The same applies to the shade tolerant *Pleurospermum austriacum*, the pollen of which has been found in zone III. The pine curve in the Bornholm diagrams indicates that pine did not completely disappear in zone III and the same applies to birch in the southern part of Denmark. We may conclude that, in this region, sub-arctic conditions prevailed during the whole Younger Dryas period and that the July temperature was approximately 10° C., when at its minimum. This again corresponds very well with FIRBAS' (1949 p. 288) view, that the July temperature in Southern Germany was about $5{,}_6$–7° C. lower than to-day.

Zone III–IV. Transition.

At the end of the Younger Dryas period the temperature seems to have risen so quickly that the forest development could not keep step with the climatic improvement. We, therefore, have a transitional zone where the forest is still very open, though the climate was already favourable. The rise in temperature is in most diagrams (cf. plate X and XI) initiated by a very distinct rise in the *Filipendula* curve, in North Jutland also in the *Empetrum* curve. The transition zone itself is usually characterized by a very pronounced maximum in the juniper curve. In some diagrams (e.g. IVERSEN 1946, fig. 9) we have also ample *Populus* pollen in the juniper zone. It is well known that *Populus* is difficult to eradicate, and we may assume that, unlike most *Betula pubescens*, it persisted in its old Alleröd localities, though in dwarfed sterile specimens. When the temperature rose, it grew up again together with juniper and before birch was able to reappear from its refuges.

Thermophilous waterplants quickly immigrated as soon as the temperature rose at the end of the Younger Dryas period. Besides *Scirpus lacustris* and *Typha latifolia*, already known from the Alleröd period, also *Ceratophyllum*, *Utricularia intermedia*, and *Myriophyllum verticillatum* appeared before the forest had recovered, and *Cladium mariscus* only a little later. GUNNAR ANDERSSON (1909, p. 36), who had already noticed the early immigration of *Cladium*, deduced from this that the climatic requirements of *Cladium* might have changed since that time, but since other waterplants react in exactly the same way, it is much more likely that the evidence of these quickly dispersed species is correct, while the response of the forest was delayed.

C. *The arctic-alpine flora element.*

In the preceeding paragraphs we have discussed the late-glacial temperature climate mainly on the basis of thermophilous plants demonstrated. It remains to see whether the arctic-alpine element harmonizes with the result obtained. The following list embraces all distinctly arctic-alpine species that have been found so far in Danish late-glacial deposits.

Oxyria digyna	*Salix reticulata*
Salix herbacea	*Saxifraga oppositifolia*
Salix cf. *polaris*	*Silene acaulis*

All these species (dating of *Silene acaulis* not quite certain) have been demonstrated in the Older Dryas period, but not in the Alleröd layers proper, though a few of them have been found in transitional zones between I and II. On the other hand, they make a come-back in the Younger Dryas period, so that DAHL (1951, p. 48) is mistaken, when he assumes that these species, or some of them, became extinct already in the Alleröd period. Strangely enough, they are not found in late-glacial deposits north of Scania, nevertheless they must have survived the Alleröd interval in South Scandinavia. According to DAHL (l. c.) a. o., arctic-alpine plants are able to tolerate an oceanic-temperate climate better than a continental. We may, therefore, assume that the species mentioned have had their best conditions for survival during the Alleröd period near Skagerak, where the summer temperature was lowered by the sea.

Salix polaris is the only late-glacial plant species, which is not commonly found in the subarctic and subalpine zone of Scandinavia to-day. It has, however, been doubted whether the late-glacial "*Salix polaris*" is really identical with the recent species (G. E Du Rietz). However this may be, one should not put undue stress on the occurrence of this single species when discussing late-glacial temperature conditions. *Salix polaris* is strongly heliophilous and also calciphilous, its recent distribution in Scandinavia is therefore scarcely a reliable indication of its temperature requirements. The raw, calcareous, unstable soil which prevailed in late-glacial Denmark, has certainly suited such a calciphilous pioneer plant as *Salix polaris* much better than conditions in the recent subalpine zone in Scandinavia.

A number of late-glacial plant species, which are often classified as arctic-alpine but are frequently found also in the boreal conifer forest zone (e.g. *Arctostaphylos alpinus*, *Astragalus alpinus*, *Bartschia alpina*, *Dryas octopetala*, *Ranunculus hyperboreus*, *Saussurea alpina*) are not included in the list above, since they are rather indifferent as to temperature.

D. *Winter temperature.*

We know very little about the winter temperature in late-glacial time, as we have no reliable indicators among the plants demonstrated.

To be sure, a few species are found whose recent distribution is continental; but only *Pleurospermum austriacum* has a western limit which may be conditioned by winter temperature. In broad features this limit follows the —2° C. January isotherm; the total range extending from about —35° C. to —2° C. January temperature.

Pleurospermum austriacum s. l. is an asiatic plant, sparce in Europe; from Scandinavia only one isolated occurrence is known. The map fig. 1 is taken from Horn af Rantzien (1946), who has given a valuable account of the taxonomy, distribution and ecology of this interesting species. In experiments, Hegi (1926) and Horn af Rantzien (l. c.) have found that the germination percentage of the seeds was extremely low (0–2 %). One might assume that the seeds require low temperatures in winter to enable them to germinate. This would explain the western limit of our species. It is of interest that, according to Horn af Rantzien, nearly all Swedish localities are in ravines; it is a well known fact that particularly low minimum temperatures prevail in ravines, where the cold air will flow down.

The find of the very characteristic *Pleurospermum* pollen (see plate VII) in late-glacial samples from Bornholm and Zealand was a surprise; it

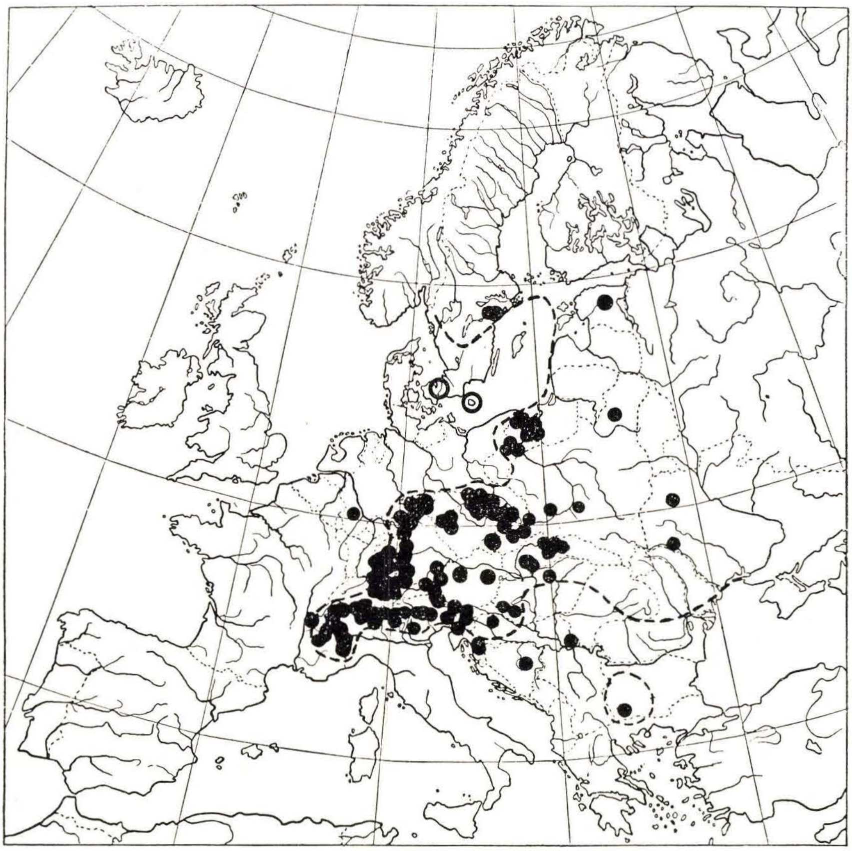


Fig. 1. Distribution of *Pleurospermum austriacum* ssp. *eu-austriacum*, from HORN AF RANTZIEN 1946. This area only includes the western-most part of the total area of *Pl. austriacum*; other varieties extend the area from eastern Europe up to eastern Asia (cf. the map fig. 2 in HORN AF RANTZIEN 1946).
The circles, not filled in, indicate our pollen finds; the broken line is the —2° C. January isotherm. The isolated dot in Western Germany is a mountain occurrence, i.e. on the top of Rhön.

proves that the isolated localities in the Baltic region must be regarded as relics from a continuous distribution in late-glacial time; the same applies to the other European localities. *Pleurospermum* pollen should be looked for in late-glacial deposits from other countries.

Nevertheless, the late-glacial temperature climate cannot have been continental. The Danish late-glacial *Armeria* finds do not belong to the continental *A. scabra*, but to the rather oceanic *A. maritima* s. l.

As formerly pointed out (IVERSEN 1940), the circumpolar, arctic *Armeria scabra* differs from the European *A. maritima* (syn. *A. vulgaris* Willd.), the former having monomorphic, the latter dimorphic pollen grains. *Armeria maritima* s. l. is rather variable and several ecotypes may be distinguished.

Most interesting is an alpine, cushion forming type, which is found on the mountain tops of Ireland, Scotland, the Færoes and Iceland, but not in the Scandinavian mountains. The late-glacial *Armeria* was most common in the coldest phases of the late-glacial period, and it may therefore correspond to the alpine type.

All European fossil *Armeria*, so far demonstrated, is dimorphic (IVERSEN 1942; SZAFER 1945; JESSEN 1949; CONOLLY, GODWIN & MEGAW 1950; STEUSLOFF 1951; LANG 1952).

Armeria maritima s.l. is not found outside the —8° C. January isotherme, the whole range extending from about —8° C. to +8° C. January temperature (cf. the map in IVERSEN 1940, fig. 10). That would mean that even when coldest, at the end of the pleni-glacial, and in the zone Ic, the January temperatures were not below —8° C. If we assume that the January temperature was 2° C. higher in zone III, and we take the requirement of *Pleurospermum* into consideration, we may assume a January temperature in Bornholm somewhere between —2° C. and —6° C., while the July temperature may have been about 11° C. According to this rough estimate the temperature climate would be slightly oceanic. *Jasione montana* is another sub-atlantic, late-glacial species; only one pollen grain has been found in Alleröd gyttja (Funen).

E. *The Juniperus curve.*

Of particular interest is the pollen curve of juniper in the late-glacial diagrams. Unfortunately juniper pollen has only begun to be counted rather recently, but the material so far available (see the diagrams in IVERSEN 1946, VAN DER HAMMEN 1951, ZAGWIJN 1952, KROG 1954 and the present diagram plate XI), embracing also unpublished diagrams, strongly emphasizes the great importance of juniper in the development of the late-glacial vegetation.

Very simple is the trend of the juniper-curve in an unpublished diagram from East-Prussia. Here we have low values in zone II and IV, and a clear maximum in zone III. Also in ZAGWIJN's diagram from Tyrol the juniper-curve is very low in zone II and IV; in zone III, it is high at the beginning and very high at the end of the period, but has a minimum in the middle, i.e. the coldest part of it. The same development is visible in the diagram from Bornholm (plate XI), and here it is a repetition of what had taken place already once before, in the first part of the Alleröd zone.

The explanation is given by the ecology of juniper. In the lowarctic (lowalpine) and subarctic (subalpine) zones juniper is found as a dwarf-shrub only, quite dependent on snow cover, all branches that reach above the snow during the winter, when the earth is frozen, being killed by the wind (see KIHLMANN 1890–92). The dwarfed juniper flowers abundantly, but of course much more pollen is produced and dispersed from high bushes. Thus, a rise in the juniper curve may indicate an improvement in the climate, which enables the juniper to extend beyond the snow-cover without injury. On the other hand, juniper is suppressed when the forest becomes dense. A high juniper curve in late-glacial diagrams, therefore, indicates the borderline between the subarctic, open park-tundra and the temperate, dense forest.

In all Danish pollen diagrams the juniper curve does not reach its absolute maximum till the zone-border III–IV; the same is the case in ZAGWIJN's diagram from Tyrol. At this time juniper must have been the predominant plant in large regions. Pollen analysis from a recent gyttja from a valley in Greenland, in which *Juniperus* is frequent, but dwarfed, showed only 3% juniper pollen; in the Bornholm diagram the highest value was 54% of all pollen.

Precipitation.

a. *Snow cover.*

One might expect that, consistent with the slightly oceanic temperature climate, the late-glacial winters in Denmark would be rich in snow. As a matter of fact, *Salix herbacea* and *S. polaris*, which are often found in deposits from zone I and II, are well known snow patch plants ("chianophilous" species*)). Nevertheless one can scarcely draw the conclusion that snow patches had great extension in the zones I and II, partly because pollen of *Salix herbacea* + *S. polaris* is rather scarce in Danish late-glacial deposits, and partly because both *Salix polaris* and *S. herbacea* are not restricted to snow patches, but are also met with where only little snow is found (see e.g. HEDBERG, MÅRTENSSON & RYDBERG 1952, p. 91–92), though here they are less abundant. *Oxyria digyna* is probably a more exclusive snow-patch plant, but its pollen is not often met with in late-glacial analyses, despite the fact that *Oxyria* is anemophilous and a great pollen producer. The same applies to another chianophilous plant species, *Rumex acetosa*, the pollen of which is remarkably rare in our late-glacial deposits, unlike pollen of *R. acetosella* + *R. thyrsiflorus*, two species (their pollen is indistinguishable) which are not chianophilous.

On the other hand a number of plants are demonstrated which do not tolerate more than a thin and transient snow cover ("chianophobous" species), e.g. *Arctostaphylos uva-ursi*, *A. alpina*, and *Dryas octopetala*. Also *Hippophaë rhamnoides* (GAMS 1943) and other heliophytes of southern type may be called chianophobous. We are, therefore, entitled

*) Information concerning chianophilous and chianophobous plant species is found e.g. in NORDHAGEN 1943.

to assume that, though the winters cannot have been dry, the precipitation during the winter months may have been only moderately high. That there has been more snow in Ireland appears from the flora demonstrated by JESSEN (1949) and MITCHELL (1953); chianophilous species were much more common, chianophobous less common than in Denmark. The abundance of *Salix herbacea* pollen in analyses from zone I in western Norway also indicates rather much snow, as pointed out by FÆGRI (1953), who also draws attention to the possibility that the Ice age periglacial vegetation in Europe may be divided in a western area, where chianophilous plant communities have played a great part, and an eastern one, where plant communities have been more steppe-like.

b. *Late-glacial steppe plants.*

The occurrence of late-glacial animals and plants more or less connected with steppes (cf. DEGERBØL & IVERSEN 1945, IVERSEN 1951) indicates rather dry summers. Most significant is the demonstration of *Ephedra* cf. *distachya*, which has been discussed in an earlier paper (1951). We may now be fairly certain that *Ephedra* really lived here in late-glacial times (see below). *Ephedra distachya* is, like *Hippophaë*, quite indifferent as regards temperature, but it seems to require both climatic and edaphic dryness (see GAMS 1952).

By courtesy of Professor F. LONA and Professor V. MARCHESONI, I have visited the station of *Ephedra* at Trento (S. Alps). *Ephedra* grows here abundantly on a very steep precipice, rooted in fissures, facing NW or W, not, as usually, S. Due to overhanging rock the locality was very dry, though it had rained recently. Dryness may be even more decisive than full illumination as, according to GAMS (1927), *Ephedra* may grow as undershrub in very dry and open pine woods. The recent European localities of *Ephedra distachya* are very warm, but in Siberia it is found beyond the polar circle and in Tibet it is reported from the alpine zone.

It has been maintained (e.g. GAMS 1927) that the high percentages of *Artemisia* pollen, often found in late-glacial deposits, indicate steppes, and it is true that the late-glacial *Artemisia* frequencies show an increase from the oceanic West to the continental East of Europe, and also from North to South. Unfortunately, we are so far unable to make quite reliable identifications of *Artemisia* pollen as to species, though the fossil material appears to embrace various types (cf. ERDTMAN 1949, STRAKA 1952). Most species require a dry climate; this applies to the arctic-subarctic *A. borealis* and the rather thermophilous *A. campestris*, *A. rupestris* and *A. laciniata*, which may all have occurred in late-glacial time. Only *A. vulgaris* is indifferent, and unfortunately we cannot exclude this species in our material, while ERDTMAN (1949) also states that the major part of *Artemisia* grains met with in late-glacial samples in a series from Sweden (Mt. Omberg) was of *A. vulgaris*-type.

Finally the demonstration of *Gypsophila fastigiata* and *Seseli libanotis* in Bornholm (zone II) and that of *Bupleurum* sp. (most probably *B. falcatum* or *B. longifolium*) in Zealand and Lolland is worth mentioning; they all seem to require a rather dry climate and are usually referred to the "xero-therms".

During the glacial period many continental plants greatly extended their area westwards, as pointed out by GAMS (1952); Steppe plants have been demonstrated as far to the west as the Netherlands (see FLORSCHÜTZ 1951). The Danish late-glacial steppe-plants must be viewed on the background of this development.

c. *The Ephedra problem.*

When the first late-glacial pollen grain of *Ephedra* was found by BRORSON CHRISTENSEN in a Scanian Alleröd layer it was supposed to be redeposited from pre-Quaternary layers (CHRISTENSEN 1949). This possibility could, however, be disregarded, when quite a number of pollen grains of *Ephedra* cf. *distachya* were found in pure Alleröd-gyttja from Bornholm (IVERSEN 1951). At that time, one could not exclude the possibility that the pollen grains were due to long-distance transport by air currents from SE, though various facts were not consistent with that explanation. Subsequently, *Ephedra* pollen has been found also in late-glacial deposits in South Germany (LANG 1951) and the Alps (WELTEN 1952, ZAGWIJN 1952); of special interest is the finding of *Ephedra* cf. *distachya* pollen in postglacial deposits from the continental S-Norway (HAFSTEN 1953) and from the Great Alvar on Öland (one grain from boreal and three from atlantic time.) Both areas are particularly well suited as postglacial refuge areas for a steppe plant such as *Ephedra*; especially is this true for the Great Alvar, which is actually the most famous relic area for steppe plants in Northern Europe. A postglacial occurrence of *Ephedra* as a late-glacial relic on Öland's alvar is perfectly reasonable, while the assumption of long-distance transport meets great difficulties, since Europe as a whole was densely forested in atlantic times.

• To-day the Great Alvar is a vast tree-bare lime-stone pavement, covered by *Helianthemum-Artemisia* heath containing a strange mixture of arctic-alpine plants (e.g. *Viscaria alpina, Poa alpina*) and several steppe plants (e.g. *Artemisia laciniata, A. rupestris, Ranunculus illyricus, Plantago tenuiflora*). A great part of this flora must have survived from late-glacial time, and it was to study the survival problem that I procured a series of postglacial sediments from a supposed fissure in lime-stone situated in Möcklemossan, which is a part of the Great Alvar. The pollen diagram, prepared by SV. TH. ANDERSEN, shows that the Alvar in boreal and atlantic time was covered by a rather open forest; elements of the recent alvar—especially *Artemisia* and *Juniperus*—were present, but scarce. Only one pollen grain of the anemophilous *Helianthemum oelandicum* was found while 4 pollen grains of *Ephedra* cf. *distachya* were demonstrated. Obviously *Ephedra distachya* survived the first part of postglacial time on the Alvar together with other steppe-plants, favoured by the dry climate of the island (precipitation to-day 450 mm. pr. ann.) and by the edaphic conditions, which hamper the forest and create small open rock areas with a network of fissures, in which *Ephedra* could root. Unlike other late-glacial steppe plants, however, *Ephedra* finally succumbed. It may be noticed, that some of the famous rarities in the Alvar vegetation (e.g. *Fumana procumbens*, *Globularia vulgaris*, and *Hornungia petraea*) are among the characteristic plant species, which according to GAMS (1927) are associated with *Ephedra* in the Alps.

Light.

Light conditions were exceptionally good in late-glacial times, and this was, of course, the result of the restricted tree growth. The latter fact was partly conditioned by the cool climate in connection with strong winds, but also another factor, namely the rather unstable, raw soil, deficient in humus, has certainly contributed to this (see below).

The late-glacial period, therefore, was the great time of heliophytes. Even in the first part of the Alleröd period many open spots were still left, though the climate favoured forest growth. Some of the most interesting thermophilous light demanding plants are demonstrated in deposits from this time.

The late-glacial flora of heliophytes has a curious mixed composition, arctic-alpine plants being found together with steppe plants, plants from the dunes, and plants which are now known as weeds, as will appear from the following list.

1. Arctic-subarctic heliophytes:

   Arctostaphylos alpina, *Dryas octopetala*, *Salix herbacea*, *S. polaris*, *S. reticulata*, *Saxifraga oppositifolia*, *Silene acaulis*.

2. Plants from steppes, sunny calcareous slopes, limestone rocks and dunes:

   Allium cf. *schoenoprasum*, *Anthyllis vulneraria*, *Artemisia* ssp., *Bupleurum* sp., *Centaurea scabiosa*, *Ephedra* cf. *distachya*, *Gypsophila fastigiata*, *Helianthemum nummularium*. *H. oelandicum*, *Hippophaë rhamnoides*, *Jasione montana*, *Lotus* cf. *corniculatus*, *Pimpinella saxifraga*, *Plantago maritima* (inland type), *P. media*, cf. *Salsola kali*, *Sanguisorba minor*, *Seseli Libanotis*.

3. Plants to-day known as weeds (cf. GODWIN 1949).

Centaurea cyanus, Chenopodiaceae, Euphorbia sp., *Galeopsis* sp., *Plantago major, Polygonum aviculare, Sonchus arvensis vel asper.*

For most of these plants light is a factor of greater importance then temperature.

Soil.

When the inland ice receded from Denmark, it passed through a stage of stagnation, and gradually, as the dead ice melted, the landscape emerged. We know, however, that so late as in early boreal time (zone V) lakes were formed as a result of the melting of burried ice masses (e.g. Lake Tinglev, cf. A. ANDERSEN 1954). This means that through the whole late-glacial time the ground was rather unstable, and landslides often occurred.

The unstable, raw soil, deficient in humus, favoured pioneer plants, and most of the heliophytes mentioned in the previous chapter belong to this category. Actually the vegetation of the Older Dryas period, in eastern and northern Denmark, may be characterized as a pioneer vegetation rather than anything else (cf. ERDTMAN 1946). It is very characteristic that *Hippophaë rhamnoides*, and, on Bornholm, *Sorbus aria* cf. var. *rupicula*, both true pioneer plants, are the first phanerophytes which appear in zone I,—a good while before the arrival of *Betula pubescens* and *Pinus silvestris*.

Of great interest in this connection is AICHINGER's (1951) description of the pioneer vegetation of the great mountain slide area at the foot of the Villacher Alps. In these limestone screes *Sorbus aria* is an importent pioneer plant together with *Dryas octopetala, Arctostaphylos Uva-ursi*,— and the mediterranean *Fraxinus ornus* and *Pinus nigra!* This shows how independant *Dryas octopetala* is of temperature.

A corresponding mixture of southern and northern plant species is, e.g., found in the great landslides of Leine in southern, continental Norway, described by NORDHAGEN (1921); the ground is calcareous boulder clay. Many late-glacial plants are found in the list, e.g. *Anthyllis vulneraria, Astragulus alpinus, Centaurea Scabiosa, Lotus corniculatus, Plantago media, Rumex acetosella*, and *Saxifraga aizoides*. We have here an illustration of the vegetation of the raw calcareous boulder clay of the late-glacial Danish landscape.

The virgin soil of the late-glacial period had undergone no leaching process and was, therefore, even in sandy regions, neutral or slightly acid only. This appears from the fact that even in the poor and today very acid sand plains around the lake Böllingsö heath of *Helianthemum oelandicum* and *Dryas octopetala* was found during the Older Dryas and the Alleröd period. First at the end of the latter this calciphilous heath was replaced by the acidophilous *Empetrum* heath, apparently due to the leaching of the soil (cf. GROSS 1937). Also to-day the flora of young, non-calcareous drift, left behind by the retreating glacier, contrasts with the surrounding area in the presence of calciphilous species (see e.g. FÆGRI 1933, p. 151, LÜDI 1945).

The same change from alkaline or neutral to acid can be demonstrated in lakes which are now acid. The lake Madumsö, south of Aalborg, is to-day a very acid lake (pH about 4,6) of the Lobelia-Isoëtes type; carpets of *Sphagnum subsecundum* are found beneath the *Isoëtes lacustris* zone. No species of *Potamogeton*, *Myriophyllum* or any other "Elodeids" may thrive in this acidotrophic lake. In late-glacial time, however, the lake was of the ordinary alkaline or neutral type with a plankton of *Chlorophyceae* and a submersed vegetation of *Potamogeton*. The usual lake-development from oligotrophic to eutrophic conditions (DEEVEY 1953), thus, in this case, is reversed, due to the leaching of the sandy surroundings of the lake.

Only the meagre Jutish "hill-islands" from the penultimate glaciation had, even in late-glacial time, no calciphilous vegetation. This appears from JESSEN'S (JESSEN & MILTHERS 1928, p. 117) late-glacial flora lists from Solsö; *Dryas* was not found, while a series of acidophilous plant species, otherwise not found or scarce in late-glacial deposits (e.g. *Eriophorum vaginatum*, *Calluna*, *Viola palustris*) were fairly common.

Extinction of the late-glacial flora.

The rich late-glacial flora was severely reduced in the beginning of the postglacial period. Some plant species were eradicated by the climatic change itself; this applies e.g. to *Oxyria digyna*, which is rather shade tolerant. The great majority of the late-glacial heliophytes, however, succumbed in the shade of the postglacial forest; light, not temperature, being the decisive factor.

On places were local soil conditions prevented tree-growth late-glacial heliophytes might find refuges, e.g. near the coast of the sea, on dunes, and on bare rocks. Rich indeed is the late-glacial relic flora on the Swedish islands Öland and Gotland, where the number of late-glacial species is very great and the vegetation of huge areas is stamped by these species. Compared with these islands even the most important refuge areas in Denmark (Bornholm, and the limestone and chalk areas in Mön, Zealand and North-Jutland) are but poor.

A new era dawned for this hard pressed flora when the forest was cleared by man. A considerable part of the flora of our pastures and roadsides are descendents of the late-glacial flora, though most species are, no doubt, crossed with types of foreign origin.

References.

D.G.F. = Meddelelser fra Dansk Geologisk Forening. København.
D.G.U. = Danmarks Geologiske Undersøgelse. København.
G.F.F. = Geologiska Föreningen i Stockholms Förhandlingar. Stockholm.
S.G.U. = Sveriges Geologiska Undersökning. Stockholm.

AICHINGER, ERWIN, 1951. Lehrwanderungen in das Bergsturzgebiet der Schütt am Südfuss der Villacher Alpe. Angewandte Pflanzensoziologie. IV. Wien.

ANDERSEN, ALFRED, 1954. Two Standard Pollen Diagrams from South Jutland. D.G.U. II. R. Nr. 80.

ANDERSSON, GUNNAR, 1903. Klimatet i Sverige efter istiden. Nordisk tidsskr., H. 1. Stockholm.

— 1909. The climate of Sweden in the Late-Quaternary period. S.G.U. Ser. C. No. 218.

ANTEVS, ERNST, 1926. Sista istäckets försvinnande i Nordamerika. Ymer. *46*, 2–3. Stockholm.

BRANDT, INGER 1954. Late-glacial macroscopic plant remains from Böllingsö. D.G.U. II. R. Nr. 80.

BRAUN-BLANQUET, J. & RÜBEL, E. 1932–34. Flora von Graubünden. Veröff. Geobot. Instit. Rübel in Zürich. H. 7. Bern u. Berlin.

BROCKMANN-JEROSCH, H., 1919. Weitere Gesichtspunkte zur Beurteilung der Dryasflora. Vierteljahrsschr. d. Naturforsch. Gesellsch. in Zürich. *64*. Zürich.

CHRISTENSEN, B. BRORSON, 1949. Pollenanalytisk datering af en rensdyrknogle fra Nebbe Mosse, Ö. Vemmerlöv Socken. K. HUMAN. Vetenskapss. Lund Årsber. 1948–1949, *5*. Lund.

CONOLLY, A. P., H. GODWIN & E. M. MEGAW, 1950. Studies in the Post-Glacial History of British Vegetation. XI. Late-Glacial deposits in Cornwall. Phil. Trans. Royal Soc. London. Ser. B. *234*. London.

DAHL, EILIF, 1951. On the relation between summer temperature and the distribution of alpine vascular plants in the lowlands of Fennoscandia. Oikos *3*, 1. Copenhagen.

DEGERBØL, M. & JOHS. IVERSEN, 1945. The Bison in Denmark. D.G.U. II. R. *73*.

DEEVEY, EDWARD S., 1953. Paleolimnology and Climate. In: Climatic Change. Evidence, causes, and effects. Edited by Harlow Shapley. Cambridge, Mass.

ERDTMAN, G. 1946. Palynologiska synspunkter på pionjärfasen i den svenska florans indvandringshistoria. Svensk Botan. Tidskr. *40*. Uppsala.

— 1949. Palynological aspects of the pioneer phase in the immigration of the Swedish Flora. II. Identification of Pollen Grains in Late-Glacial Samples from Mt. Omberg, Ostrogothia. Svensk Botan. Tidskr. *43*, 1. Uppsala.

FIRBAS, F. 1949. Waldgeschichte Mitteleuropas. Bd. 1. Allgemeine Waldgeschichte. Gustav Fischer. Jena.

FLORSCHÜTZ, F., 1951. De flora van het Turbantien tot het Laat-Glaciaal. Geologie en Mijnbouw, 1951, No. 9.

FÆGRI, KNUT, 1933. Über die Längenvariationen einiger Gletscher des Jostedalsbre und die dadurch bedingten Pflanzensukzessionen. Bergens Mus. Årbok, naturv. rekke *7*. Bergen.

— 1935. Quartärgeologische Untersuchungen im westlichen Norwegen. 1. Über zwei präboreale Klimaschwankungen im südwestlichen Teil. Bergens Mus. Årbok, naturv. r. *8*. Bergen.

— 1953. On the peri-glacial flora of Jæren. With notes on the morphology of the *Salix* pollen grain. Norsk Geografisk Tidsskrift. *14*, 1–4. Oslo.

GAMS, H., 1927. Von den Follatéres zur Dent de Morcles. Beitr. z. geobotan. Landesaufn. *15*, Bern.

— 1943. Der Sanddorn (Hippophaë Rhamnoides L.) im Alpengebiet. Beih. Bot. Cbl. *62*, B. Dresden.

GAMS, H., 1952. Das Meerträubl (*Ephedra*) und seine Ausbreitung in Europa. Jahrb. d. Vereins z. Schutze d. Alpenpflanzen und -Tiere. München.

GODWIN, H., 1949. The spreading of the British Flora. Considered in relation to conditions of the Late-Glacial period. Journ. of Ecology. *37*, 1. Cambridge.

— 1953, British Vegetation in the Full-Glacial and the Late-Glacial Periods. "The Changing Flora of Britain" (Edited by J. E. Lousley). Arbroath.

GROSS, H. 1937. Nachweis der Allerödschwankung im süd- und ostbaltischen Gebiet. Beih. Bot. Cbl. *57*, B.

GRÖNWALL, K. A. & V. MILTHERS, 1916. Beskrivelse til Geologisk Kort over Danmark. Kortbladet Bornholm. D.G.U. I. R. Nr. 13.

HAFSTEN, ULF. 1953. Nyopdagede pionérplanter i Norge efter Istiden. Naturen, No. 16.

HAMMEN, T. VAN DER, 1951. Late-glacial Flora and Periglacial Phenomena in the Netherlands. Leidse Geolog. Mededelingen *17*. Leiden.

— 1952. Dating and Correlation of Periglacial deposits in Middle and Western Europe. Geologie en Mijnbouw. Nw. serie, Nr. 9. 14. Jaarg.

HANSEN, SIGURD, 1940. Varvighed i danske og skaanske senglaciale Aflejringer. D.G.U. II. R. *63*.

HARTZ, N., 1902. Bidrag til Danmarks senglaciale Flora og Fauna. D.G.U. II. R. Nr. 11.

— & V. MILTHERS, 1901. Det senglaciale Ler i Allerød Teglværksgrav. D.G.F. No. 8.

HEDBERG, O., O. MÅRTENSSON & ST. RYDBERG, 1952. Botanical investigations in the Pältsa region of northernmost Sweden. Botan. Notiser. Suppl. *3*, 2. Lund.

HEGI, G. 1926. Illustrierte Flora von Mitteleuropa, *5*, 2. München.

HORN AF RANTZIEN, H., 1946. Om *Pleurospermum austriacum* (L.) Hoffm. Emend. Turez., dess taxonomi, utbredning och ekologi. Svensk Botan. Tidskr. *40*, 2. Uppsala.

HULTÉN, ERIC, 1950. Atlas över växternas utbretning i Norden. Stockholm.

HUSTICH, I., 1953. The boreal limits of conifers. "Arctic". *6*, 2. Ottawa.

IVERSEN, JOHS. 1936. Sekundäres Pollen als Fehlerquelle. Eine Korrektionsmethode zur Pollenanalyse minerogener Sedimente. D.G.U. IV. R. *4*, 2.

— 1940. Blütenbiologische Studien. I. Dimorphie und Monomorphie bei *Armeria*. Kgl. Dansk Vidensk. Selsk. Biol. Medd. *15*, 8. København.

— 1942. En pollenanalytisk Tidsfæstelse af Ferskvandslagene ved Nørre Lyngby. D.G.F. *10*, 2.

— 1944. *Helianthemum* som fossil Glacialplante i Danmark. G.F.F. *66*.

— 1946. Geologisk Datering af en senglacial Boplads ved Bromme. Aarb. f. Nordisk Oldkynd. og Historie 1946. København.

— 1947. *Centaurea cyanus* pollen in Danish late-glacial deposits. D.G.F. *11*, 2.

— 1951. Steppeelementer i den senglaciale Flora og Fauna. D.G.F. *12*.

JESSEN, AXEL, 1935. Beskrivelse til Geologisk Kort over Danmark. Kortbladet Haderslev. D.G.U. I. R. Nr. 17.

JESSEN, KNUD, 1920. Moseundersøgelser i det nordøstlige Sjælland. D.G.U. II. R. *34*.

— 1923. En undersøisk Mose i Rungsted Havn. D.G.U. IV. R. *1*, 18.

— 1924. Et Bjørnefund i Allerødgytje. D.G.F. *6*.

— 1935. The composition of the forest in Northern Europe in epipaleolithic time. Kgl. Danske Vidensk. Selsk. Biol. Medd. *12*, 1. København.

— 1949. Studies in Late Quaternary Deposits and Flora-History of Ireland. Proceed. Royal Irish Academy. *52*, B, 6. Dublin.

— & V. MILTHERS, 1928. Stratigraphical and Paleontological studies of Interglacial Fresh-water Deposits in Jutland and Northwest Germany. D.G.U. II. R. *48*.

JOHANSEN, A. C., 1904. Om den fossile kvartære Molluskfauna i Danmark og dens Relationer til Forandringer i Klimaet. Dissert. København 1904.

— C. WESENBERG-LUND and others, 1906: Den senglaciale Temperaturoscillation (Discussion). D.G.F. Nr. 12.

Kihlmann, O. 1890–92. Pflanzenbiologische Studien aus Russisch-Lappland. Acta Soc. pro Fauna et Flora Fennica. *4*, 3. Helsingfors.

Krog, H., 1954. Pollen analytical investigation of a C_{14}-dated Alleröd section from Ruds Vedby. D.G.U. II. R. Nr. 80.

Lang, G., 1951. Nachweis von *Ephedra* im südwestdeutschen Spätglazial. Naturwiss. *38*. Berlin.

— 1952. Zur späteiszeitlichen Vegetations- und Florengeschichte Südwestdeutschlands. Flora *139*.

Lüdi, W., 1945. Besiedlung und Vegetationsentwicklung auf den jungen Seitenmoränen des grossen Aletschgletschers. E. Rübel und W. Lüdi, Bericht über das Geobotanische Forschungsinstitut Rübel in Zürich für das Jahr 1944. Zürich.

Mathiessen, F. J. 1925. Om nogle arktiske Planterester fra Møens Klint. D.G.F. *6*.

Milthers, V., 1925. Beskrivelse til det geologiske Kortblad Bække. D.G.U. I. R., 15.

Mitchell, F., 1954. The Late-Glacial Flora of Ireland. D.G.U. II. R. Nr. 80.

Müller, H. 1953. Zur spät- und nacheiszeitlichen Vegetationsgeschichte des mitteldeutschen Trockengebietes. Nova Acta Leopoldina. Neue Folge *16*, Nr. 110.

Nathorst, A. G., 1870. Om några arktiska växtlämningar i en sötvattenslera vid Alnarp i Skåne. Lunds Univ. Årsskr. *7*. Lund.

— 1891. Über den gegenwärtigen Standpunkt unserer Kenntnis von dem Vorkommen fossiler Glazialpflanzen. Bih. t. K. Vetenskaps Akad. Handl. *17*, Afd. III. Stockholm.

— 1910. Spätglaziale Süsswasserablagerungen mit arktischen Pflanzenresten in Schonen. G.F.F. *32*.

Nordhagen, Rolf, 1921. Kalktufstudier i Guldbrandsdalen. Videnskapsselsk. Skrifter, I. Mat.-Naturv. Klasse, 1921, 9. Kristiania.

— 1943. Sikilsdalen og Norges fjellbeiter. En plantesociologisk monografi. Bergens Museums Skrifter. Nr. 22. Bergen.

Nordmann, V., 1922. Nye Iagttagelser over den glaciale, isdæmmede Sø ved Stenstrup på Fyn. D.G.U. IV. R. *1*, 17.

Samuelsson, G. 1934. Die Verbreitung der höheren Wasserpflanzen in Nordeuropa (Fennoskandien und Dänemark). Acta Phytogeographica Suecica. *6*. Uppsala.

Schütrumpf, R. 1943. Die pollenanalytische Untersuchung der Rentierjägerfundstätte Stellmoor in Holstein. In: A. Rust, Die alt- und mittelsteinzeitlichen Funde von Stellmoor. Neumünster.

Steusloff, U., 1951. Neue Beobachtungen und Erkentnisse über Flora (*Potamogeton vaginatus*; *Armeria iverseni*; Moose; Zwergweiden, Fauna (Mollusken; *Oribus*) und Klimageschichte (Allerödphase) des Würmperiglaziales in der Niederterasse der Emscher und der Lippe. Abh. Landesmus. f. Naturkunde. Münster in Westf. *14*.

Straka, Herbert, 1952. Zur spätquartären Vegetationsgeschichte der Vulkaneifel. Arb. Rhein. Landeskunde, H. I. Bonn.

Szafer, W., 1945. The fossil *Armeria* in the European Pleistocene especially in Poland. Starunia. No. 20. Kraków.

— 1954. Pliocene Flora from the vicinity of Czorsztyn (West Carpathians) and its relationship to the Pleistocene. (English summary p. 179–230). Instytut Geologiczny. Prace. Tom XI. Wydawnictwa Geologiczne. Warszawa.

Welten, Max, 1952. Über die spät- und postglaziale Vegetationsgeschichte des Simmentals. Veröff. Geobotan. Instituts Rübel in Zürich. 26. H. Bern u. Stuttgart.

Wesenberg-Lund, C., 1909. Om Limnologiens Betydning for Kvartærgeologien, særlig med Hensyn til postglaciale Tidsbestemmelser og Temperaturangivelser. G.F.F. *3*.

Zagwijn, W. H., 1952. Pollenanalytische Untersuchung einer spätglazialen Seeablagerung aus Tirol. Geologie en Mijnbouw, Nw, serie. Nr. 7, 14. Jaarg.

Dansk resumé.

Der gives en oversigt over den danske senglaciale flora som den tegner sig på grundlag af tidligere undersøgelser over makrofossiler (Hartz, Knud Jessen o. a.) og de seneste års indgående studium af pollenfloraen. Principielt har pollenanalysen bekræftet den hidtidige opfattelse af den senglaciale vegetationsudvikling, dog er det sydlige element i floraen, der tidligere alene repræsenteredes af vandplanter, blevet stærkt forøget og et helt nyt element af sydøstlige og østlige plantearter er kommet til (*Ephedra distachya, Hippophaë rhamnoides, Gypsophila fastigiata, Pleurospermum austriacum, Centaurea cyanus, Helianthemum oelandicum* o. a.). Det arktisk-subarktiske element er derved trådt noget i baggrunden, især i Allerödperioden, hvis flora må karakteriseres som tempereret (*Solanum dulcamara, Typha latifolia, Oenanthe aquatica* o. a.). Vegetationen i den forudgående Bölling-oscillation har haft et subarktisk præg (»Parktundra«) ligesom vegetationen i den Yngre Dryasperiode. Kun i et kort tidsrum mellem Bölling- og Alleröd-perioderne har klimaet åbenbart været rent arktisk. Floraen i det ældre Dryasler på Øerne er en ren pionerflora, der i den øvre del allerede indeholder en række relativ termophile arter, der viser at fraværet af trævækst skyldes forsinket indvandring. Pollenanalysen synes således at bekræfte de klimatiske slutninger, som A. C. Johansen i sin tid drog af molluskernes fordeling i vore senglaciale aflejringer.

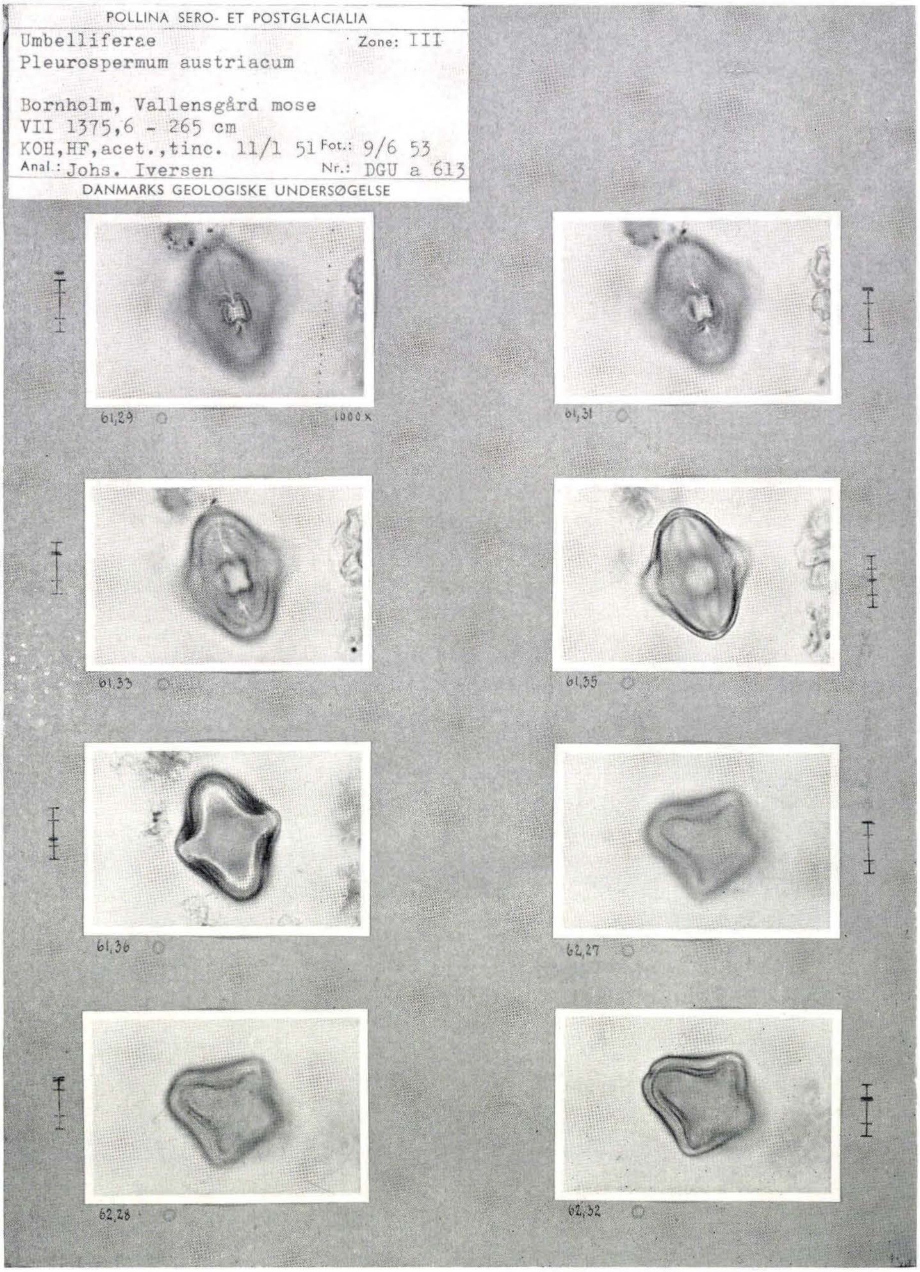
Af den samtidige forekomst af *Armeria maritima* s. l. (der har dimorfe pollen i modsætning til de arktisk-kontinentale *Armeria*-former) og *Pleurospermum austriacum* sluttes, at de senglaciale vintre i Yngre og Ældre Dryastid nok har været koldere end idag, men klimaet har i temperaturmæssig henseende været svagt oceanisk ligesom det nuværende.

En vurdering af hyppigheden af henholdsvis chianophile (sneelskende) og chianophobe (sneskyende) plantearter i den senglaciale flora fører til den slutning, at nedbøren om vinteren har været moderat. Steppeelementet i den senglaciale flora tyder på tørre, solrige somre, men kan ikke tages til indtægt for antagelsen af et egentligt steppeklima.

Vegetationens åbenhed og de specielle jordbundsforhold har ved siden af klimaet haft afgørende betydning for den senglaciale floras sammensætning. Et vigtigt karaktertræk ved jordbunden i tidlig senglacial tid er betinget af, at udvaskningsprocesserne endnu ikke har gjort sig gældende. Selv på de jydske hedesletter voksede *Dryas, Helianthemum oelandicum, Hippophaë* og andre kalkelskende planter. Først i slutningen af Alleröd perioden afløstes her *Dryas-Helianthemum*-heden af *Empetrum*-hede, der dog heller ikke var så sur og gold som nutidens *Calluna*-hede.

Den rige senglaciale flora af solplanter skyggedes hurtigt bort, da skoven bredte sig over landet i begyndelsen af den postglaciale periode. Kun hvor specielle jordbundsforhold hemmede skoven fandt senglaciale planter refugier, hvor de kunne holde sig gennem skovtiden. De rigeste refugieområder ligger på Öland og Gotland; i Danmark har især Bornholm, men også kridt- og kalkområderne på Mön, Sjælland og i Nordjylland været tilflugtsteder for senglaciale relikter. Mange af disse sidste har efter menneskets skovrydninger bredt sig henover det åbne land og krydset sig med indslæbte former, således at de nu har mistet deres reliktkarakter.

Til slut gives en liste over de hidtil påviste senglaciale karplantearter. Den omfatter 100 slægter; 124 arter anses for tilstrækkelig sikkert bestemte. 59 plantearter er kun påvist som pollen, for alle disse foreligger dokumentationsmateriale i form af seriefotografier (cf. tavle VII og s. 119) eller præparater.


POLLINA SERO- ET POSTGLACIALIA
Umbelliferae
Zone: III
Pleurospermum austriacum
Bornholm, Vallensgård mose
VII 1375,6 - 265 cm
KOH,HF,acet.,tinc. 11/1 51
Fot.: 9/6 53
Anal.: Johs. Iversen
Nr.: DGU a 613
DANMARKS GEOLOGISKE UNDERSØGELSE
61,29
1000×
61,31
61,33
61,35
61,36
62,27
62,28
62,32

* Species identification fairly reliable
** Species identification reliable

( ) species identification uncertain
[ ] pollen may be transported from a long distance or be derived
1 one grain
× more than one grain
→ transition to next zone F: photo, see p. 119

	f = fruits, seeds veg = leafs etc. s = spores p = pollen	Ia	Ib	Ic			II			III			
		Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
PTERIDOPHYTA													
EQUISETACEAE													
Equisetum spp.	s	×	×	×	×	×	×	×	×	×	×	×	
LYCOPODIACEAE													
Lycopodium cf. *complanatum* .. *	s	..	..	1	..	..	..	×	..	..	..	..	
— *annotinum* **	s	..	×	..	[×]	1	×	×	×	×	×	1	
— *clavatum* **	s	..	..	..	..	..	..	..	×	1	..	1	F
— *selago* **	s	..	..	..	..	..	1	..	..	×	1	..	
OPHIOGLOSSACEAE													
Botrychium cf. *Lunaria* *	s	..	..	1	×	×	×	×	×	×	×	×	
— cf. *multifidum*	s	..	..	..	..	..	..	1	1	..	..	..	F
											→		
Ophioglossum vulgatum **	s	..	..	..	..	..	..	..	..	..	×	..	
POLYPODIACEAE													
Cystopteris fragilis **	s	..	..	..	..	..	1	..	1	..	..	..	F
Polypodium vulgare **	s	..	..	..	..	..	1	..	..	..	..	..	F
Thelypteris Dryopteris **	s	..	[×]	[×]	×	..	×	×	×	×	×	×	F
(= *Dryopteris Linneana*)										→			
— cf. *Phegopteris*[1]) *	s	..	..	..	..	..	..	..	..	1	..	..	
SELAGINELLACEAE													
Selaginella selaginoides **	s	×	×	×	×	..	×	×	×	×	×	×	
GYMNOSPERMAE													
CUPRESSACEAE													
Juniperus communis **	f p	×	×	×	×	×	×	×	×	×	×	×	F
EPHEDRACEAE													
Ephedra distachya s. l. *	p	..	..	..	..	[1]	1	×	×	..	1	1	F
PINACEAE										↔			
Pinus silvestris **	p	[×]	[×]	[×]	[×]	[×]	×	×	×	×	×	×	
ANGIOSPERMAE													
BETULACEAE													
Betula nana **	f p	×	×	×	×	×	×	×	×	×	×	×	
— *nana* × *pubescens*	f	..	..	..	..	..	..	..	..	..	..	..	
— *pubescens* s. l. **	f p	..	×	[×]	[×]	[×]	×	×	×	×	×	×	
CALLITRICHACEAE													
Callitriche hermaphroditica ... **	f	..	..	..	×	..	..	..	..	..	×	..	
(= *C. autumnalis*)													
CAMPANULACEAE													
Campanula cf. *rotundifolia*[1]) .. *	p	..	..	..	..	1	1	1	..	1	..	..	F
Jasione montana **	p	..	..	..	..	..	..	1	..	..	..	..	F
CARYOPHYLLACEAE						→							
Gypsophila fastigiata **	p	..	..	..	..	1	..	..	..	..	..	..	F
Sagina cf. *procumbens*	p	1	..	..	..	..	..	..	..	..	..	..	F
Silene acaulis[2]) **	f	..	..	..	..	..	..	..	..	..	..	..	
cf. *Viscaria*	p	..	..	..	..	..	..	..	..	..	1	..	F
CERATOPHYLLACEAE										→			
Ceratophyllum demersum *	trich.	..	..	..	..	..	..	..	..	×	..	..	F
CHENOPODIACEAE													

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** Species identification reliable

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[ ] pollen may be transported from a long distance or be derived
1 one grain
× more than one grain
→ transition to next zone
F: photo, see p. 119

	f = fruits, seeds veg = leafs etc.	s = spores p = pollen	Ia	Ib	Ic			II			III			
			Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
Chenopodium + *Atriplex*......		p	[×]	×	×	×	×	×	×	×	×	×	×	
							→							
cf. *Salsola kali*.............*		p	..	..	..	..	×	..	..	..	..	..	..	F
CISTACEAE														
Helianthemum cf. *canum*......		p	..	..	..	..	..	1		..	..	..	..	F
— *nummularium* s. l.......**		p	(1)	..	..	1	×	..	..	×	..	×	..	F
— *oelandicum* s. l.........**		p	..	×	×	×	×	×	×	×	×	×	×	F
COMPOSITAE														
Artemisia spp................		p	×	×	×	×	×	×	×	×	×	×	×	
						→	→							
Centaurea cyanus...........**		p	..	..	..	1	1	..	×	..	..	..	..	F
										←				
— *scabiosa*...............**		p	..	1	..	..	..	..	..	1	..	1	..	F
Cirsium cf. *arvense*[1]) ....*		p	..	..	..	..	..	..	1	..	..	..	..	F
— cf. *heterophyllum*[1])		p	..	..	..	..	..	..	1	..	..	..	..	F
— cf. *vulgare*[1])		p	..	..	..	..	..	..	..	1	..	..	..	F
Crepis cf. *paludosa*..........*		p	..	..	..	..	..	..	..	1	..	..	..	F
Saussurea alpina............**		p	..	..	..	..	..	..	×	..	..	×	..	F
Sonchus asper vel arvensis......		p	..	..	..	..	..	..	..	..	..	..	1	F
CRASSULACEAE														
Sedum sp....................		p	..	1	..	×	×	×	..	..	..	..	..	
CYPERACEAE														
Carex cf. *aquatilis*............	f		..	..	..	..	..	..	..	..	..	×	..	
— *rostrata*................**	f		..	..	..	×	..	×	×	..	..	×	..	
— *vesicaria*...............**	f		..	..	..	..	..	..	×	..	..	..	..	
Eriophorum vaginatum[2]).....**	f		..	..	..	..	..	..	..	..	..	..	..	
Heleocharis palustris.........**	f		..	..	..	..	..	×	..	..	..	..	..	
												→	→	
Scirpus lacustris............**	f	p	..	..	..	..	..	..	×	×	..	×	×	F
— *silvaticus*..............**	f		..	..	..	×	..	..	..	..	..	..	..	
ELAEAGNACEAE														
Hippophaë Rhamnoides......**		p	×	×	×	×	×	×	×	×	1	×	..	
EMPETRACEAE														
Empetrum nigrum...........**	f	p	..	[×]	..	×	×	×	×	×	×	×	×	
ERICACEAE														
Arctostaphylos alpina........**	f		..	..	..	..	..	..	..	..	..	×	..	
— *Uva-ursi*...............**	f		..	..	..	..	..	..	×	..	..	×	..	
Calluna vulgaris............**	veg	p	..	..	..	[×]	..	×	×	1	×	×	×	
Vaccinium uliginosum.......**	veg		..	..	..	..	..	..	×	..	..	..	..	
EUPHORBIACEAE														
Euphorbia sp................		p	..	..	..	..	..	..	..	×	..	..	..	F
GENTIANACEAE														
Gentiana Pneumonanthe......**		p	..	..	..	..	..	..	1	..	..	..	..	F
Gentianella cf. *Amarella* s. l. ..		p	..	..	..	..	..	..	..	1	..	..	..	F
— cf. *campestris* s. l.........		p	..	..	..	..	..	1	..	..	..	..	..	F
Sweertia perennis..........**		p	..	..	..	..	..	..	1	..	..	..	..	F

* Species identification fairly reliable ** Species identification reliable	f = fruits, seeds veg = leafs etc. s = spores p = pollen	( ) species identification uncertain [ ] pollen may be transported from a long distance or be derived 1 one grain × more than one grain → transition to next zone F: photo, see p. 119											
		Ia	Ib	Ic			II			III			
		Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
GERANIACEAE													
Geranium cf. *silvaticum*[1]) ....*	p	..	..	..	..	..	..	..	..	..	1	..	F
GRAMINEAE													
Agropyrum sp.[3])	veg	..	..	..	..	×	..	..	..	..	..	..	F
cf. *Elymus arenarius*.........*	p	..	1	..	..	1	1	1	..	→ 1	..	..	
HALORAGACEAE													
Myriophyllum alterniflorum..**	p	..	..	..	..	..	1	..	..	→ ×	→ ×	..	
— *spicatum*..............**	f p	×	×	×	×	×	×	×	×	×	×	×	F
— *verticillatum*...........**	p	..	..	..	..	..	..	..	..	..	→ ×	..	
HIPPURIDACEAE													
Hippuris vulgaris...........**	f p	..	..	..	×	..	..	×	1	→ 1	×	..	
JUNCAGINACEAE													
Triglochin maritimum........**	f	..	..	..	..	..	..	..	..	..	×	..	
LABIATEAE													
Galeopsis cf. *tetrahit*..........	p	..	..	..	→ 1	..	..	..	..	..	..	..	
cf. *Origanum vulgare*..........	p	..	..	..	..	→ 1	..	..	..	..	..	..	
LEGUMINOSAE													
Anthyllis vulneraria.........**	p	..	..	..	..	..	1	..	..	..	..	..	F
Astragalus alpinus..........**	p	..	..	×	×	..	×	×	..	..	×	×	F
— cf. *arenarius*.............	p	..	..	..	1	..	..	1	..	..	..	..	F
— cf. *danicus*.............*	p	..	..	..	..	..	..	..	..	..	..	1	F
— cf. *frigidus*...............	p	..	..	..	..	..	..	..	1	..	..	×	F
Lotus cf. *corniculatus*........*	p	..	..	..	..	..	..	..	..	..	..	×	F
Oxytropis campestris type	p	..	..	..	..	..	1	..	..	..	..	1	F
LENTIBULARIACEAE													
Utricularia cf. *intermedia* .....*	p	..	..	..	..	..	..	..	..	..	→ ×	..	F
— cf. *vulgaris*	p	..	..	..	..	..	..	..	..	..	→	..	F
LILIACEAE											×		
Tofieldia....................	p	..	..	..	1	..	..	..	..	..	1	..	F
Allium cf. *Schoenoprasum*[1]) ..*	p	..	..	..	..	→ 1	..	1	..	..	..	..	F
MENYANTHACEAE													
Menyanthes trifoliata........**	f p	..	..	..	×	..	×	×	1	×	×	..	
NYMPHAEACEAE													
Nuphar pumilum...........**	f p	..	..	..	..	..	..	×	..	..	..	..	F
Nymphaea alba.............**	f	..	..	..	..	..	..	..	..	..	×	..	
— *candida*...............**	p	..	..	..	→ ×	..	..	×	×	..	↔ ×	..	F
ONAGRACEAE													
Chamaenerium angustifolium...**	p	..	..	..	..	..	1	×	..	1	..	..	F
PLANTAGINACEAE													
Plantago alpina[4]) ....*	p	..	..	..	1	..	..	..	..	..	..	..	F
— *lanceolata*................	p	..	..	..	..	[1]	..	..	..	[1]	..	..	F
— *major*..................*	p	..	..	..	..	1	..	×	..	..	..	×	F

( ) species identification uncertain
[ ] pollen may be transported from a long distance or be derived
1 one grain
× more than one grain
→ transition to next zone
F: photo, see p. 119

* Species identification fairly reliable
** Species identification reliable

	f = fruits, seeds veg = leafs e.t.c. s = spores p = pollen	Ia	Ib	Ic			II			III			
		Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
Plantago maritima . . . . **	p	1	×	×	×	×	×	×	×	..	×	×	F
— *media* . . . . **	p	1	..	1	×	1	×	×	×	..	1	×	F
PLUMBAGINACEAE													
Armeria maritima . . . . **	f p	×	1	×	×	..	×	..	..	×	×	×	F
POLEMONIACEAE													
Polemonium cf. *coeruleum* . . . . *	p	..	..	..	..	..	..	..	..	×	..	..	F
POLYGONACEAE													
Polygonum aviculare . . . . **	p	..	..	..	..	×	1	..	×	..	..	..	F
— *Bistorta vel viviparum*	p	..	..	..	..	..	..	..	..	×	×	×	F
							→						
Oxyria digyna . . . . **	p	..	..	..	..	1	×	..	..	×	×	1	F
Rumex acetosa . . . . **	p	..	..	..	..	..	..	1	..	..	1	×	F
— *acetosella vel thyrsiflorus* . . .	p	×	×	×	×	×	×	×	×	×	×	×	F
— cf. *domesticus*	..	..	..	..	..	..	..	1	..	..	..	..	F
POTAMOGETONACEAE													
Potamogeton alpinus . . . . **	f	..		..	..	..	..	×	..	..	..	..	
— *filiformis* . . . . **	f (p)	(×)	(1)	×	×	×	×	×	..	×	×	..	
— *Friesii* . . . . **	f	..	..	..	..	..	×	..	..	..	..	..	
— *gramineus* . . . . **	f	..	..	..	..	..	..	..	..	..	..	..	
— *natans* . . . . **	f	..	..	..	..	..	..	..	..	..	×	..	
— cf. *obtusifolius*	f	..	..	×	×	..	..	..	..	..	..	..	
— *perfoliatus* . . . . **	f	..	×	..	..	..	×	..	..	..	..	..	
— *praelongus* . . . . **	f	×	×	..	×	..	×	×	×	..	×	..	
— *pusillus* . . . . **	f	..	..	..	..	..	..	..	..	..	..	..	
— *zosterifolius* . . . . **	f	..	..	..	[×]	..	..	×	..	..	..	..	
— *zizii* . . . . **	f	..	..	..	..	..	..	×	..	..	..	..	
RANUNCULACEAE													
Caltha palustris . . . . **	f p	..	..	..	..	1	×	×	×	×	×	1	F
Ranunculus cf. *confervoides* . . . *	f	..	..	..	×	..	..	×	..	..	×	..	
— *flammula* (incl. ssp. *reptans*) . . . . **	p	..	..	..	..	..	..	..	1	..	..	..	
— *hyperboreus*[2]) . . . . **	f	..	..	..	..	..	..	..	..	..	..	..	
											→		
— cf. *lingua* . . . . *	p	..	..	..	..	..	..	..	..	..	×	..	
— *peltatus* aggr . . . . **	p	..	..	..	..	..	..	..	×	..	1	×	F
— *repens*[2]) . . . . **	f	..	..	..	..	..	..	..	..	..	..	..	
Thalictrum sp.	p	×	×	×	×	×	×	×	×	×	×	×	
						→			←				
cf. *Helleborus viridis*	p	..	..	..	..	1	..	..	1	..	..	..	F
RHAMNACEAE													
cf. *Rhamnus frangula*	p	..	..	..	..	..	..	..	..	1	..	..	
ROSACEAE													
Dryas octopetala . . . . **	f p	×	×	×	×	×	×	×	×	×	×	×	F
Filipendula cf. *ulmaria* . . . . . . *	p	..	×	..	×	×	×	×	×	×	×	×	
Fragaria cf. *vesca*	p	..	..	..	..	1	..	..	..	..	..	..	F
												→	
Geum rivale[5]) . . . . **	f (p)	..	(1)	..	(1)	(1)	..	..	..	..	(1)	(1)	F

* Species identification fairly reliable
** Species identification reliable

( ) species identification uncertain
[ ] pollen may be transported from a long distance or be derived
1 one grain
× more than one grain
→ transition to next zone F: photo, see p. 119

	f = fruits, seeds veg = leafs etc. s = spores p = pollen	Ia	Ib	Ic			II			III			
		Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
Potentilla erecta[2]) .... **	f	..	..	..	..	..	..	..	..	..	..	..	
— *palustris*............... **	f p	..	×	×	..	..	×	×	×	..	..	(×)	F
											→		
Prunus padus.............. **	p	..	..	..	..	..	..	1	..	..	1	..	F
Rubus chamaemorus......... **	p	..	..	..	1	..	..	..	..	..	..	..	F
— *idaeus*[2]) .... **	f	..	..	..	..	..	..	..	..	..	..	..	
— *saxatilis*............... **	f (p)	..	..	..	..	..	..	×	..	..	..	..	F
											→		
Sanguisorba minor.......... **	p	..	..	..	..	..	1	×	..	..	1	..	F
— *officinalis*.............. **	p	..	..	..	..	..	..	..	..	1	1	..	F
									←				
Sorbus aria cf. ssp. *rupicola*.. **	p	..	..	..	..	×	..	..	×	..	..	..	F
— *aucuparia*.............. **	p	..	1	..	..	..	..	×	..	..	..	..	F
— cf. *intermedia*............	p	..	..	..	..	..	..	..	1	..	..	..	
RUBIACEAE													
Galium sp....................	p	×	×	×	×	×	×	×	×	×	×	×	
SALICACEAE										→			
Populus tremula............ **	p	..	..	..	..	[1]	×	×	×	×	×	×	
Salix cf. *caprea*............. *	veg	..	..	..	..	..	..	×	..	..	..	..	
— *herbacea* .... **	veg p	×	..	×	..	×	..	..	..	×	..	×	F
— cf. *phylicifolia*.......... *	veg	..	..	..	×	..	..	..	..	..	×	..	
— cf. *polaris*.............. *	veg (p)	×	×	×	×	×	..	..	..	×	×	×	F
— *reticulata*.............. **	veg	..	..	×	×	×	..	..	..	..	×	×	
— cf. *arbuscula*............	veg	..	..	..	..	..	..	..	×	..	..	..	
SAXIFRAGACEAE													
Parnassia palustris.......... **	p	×	1	..	×	..	..	1	..	..	..	..	F
Saxifraga cf. *aizoides*.........	p	..	..	..	1	(×)	..	..	..	..	..	..	F
— *hirculus* .... **	p	..	..	..	..	..	×	..	..	1	..	..	F
— *oppositifolia*............ **	veg (p)	(×)	(×)	(1)	×	(×)	..	..	..	..	×	(×)	
— *stellaris*-type............	p	..	..	..	..	..	..	1	..	..	..	..	F
SCROPHULARIACEAE													
cf. *Bartschia alpina*.......... *	p	..	(1)	..	..	..	..	1	1	..	..	..	F
Melampyrum sp..............	p	..	..	..	..	..	..	1	×	..	..	..	F
Pedicularis sp................	p	..	..	..	..	..	1	..	..	..	..	1	
SOLANACEAE													
Solanum dulcamara .... **	p	..	..	..	..	..	..	×	×	..	..	..	F
SPARGANIACEAE													
Sparganium angustifolium ... **	f (p)	..	..	..	..	(×)	..	×	..	..	..	..	
— cf. *simplex*...............	p	..	..	..	..	..	..	..	1	..	..	×	
— sp.......................	p	×	×	×	..	..	..	..	..	..	..	..	
TYPHACEAE												→	
Typha latifolia .... **	p	..	..	..	..	..	1	×	..	..	..	×	F
UMBELLIFERAE													
Angelica sp[1])	p	..	..	..	..	..	..	..	..	..	..	..	
Bupleurum cf. *falcatum*.......	p	..	..	..	..	..	..	×	..	..	..	..	F
Carum carvi................ **	p	..	..	..	..	1	..	..	..	..	..	..	F
											→		
cf. *Falcaria*[1])	p	..	..	..	..	..	..	..	1	..	1	..	F

( ) species identification uncertain
[ ] pollen may be transported from a long distance or be derived
1 one grain
× more than one grain
→ transition to next zone   F: photo, see p. 119

* Species identification fairly reliable
** Species identification reliable

	f = fruits, seeds veg = leafs etc. s = spores p = pollen	Ia	Ib	Ic			II			III			
		Böllingsö	Böllingsö	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	Jutland	Zealand etc.	Bornholm	
cf. *Heracleum Sphondylium* ..*	p	..	..	..	..	..	..	..	1	..	..	..	F
						→							
Pimpinella cf. *saxifraga*......*	p	..	..	..	..	×	..	..	..	..	..	..	F
— cf. *magna*..............*	p	..	..	..	1	..	..	..	..	..	..	..	
Pleurospermum austriacum...**	p	..	..	..	1	..	..	..	..	..	..	1	F
cf. *Seseli Libanotis* ....*	p	..	..	..	..	..	..	..	×	..	..	..	F
Oenanthe aquatica..........**	f	..	..	..	..	..	..	×	..	..	..	..	
URTICACEAE										→	→	→	
Urtica dioeca...............**	f p	..	..	..	×	1	1	×	×	×	×	×	F
VALERIANACEAE						→					→		
Valeriana officinalis aggr....**	p	..	..	..	..	1	..	1	..	..	×	1	F
VIOLACEAE													
Viola palustris[1]) ....**	f	..	..	..	..	..	..	..	..	..	..	..	

[1]) Investigation not finished.

[2]) Finds not exactly dated.

[3]) Investigation by Miss I. Brandt not finished.

[4]) Morphologically *Plantago coronopus* is also possible.

[5]) Reliable finds not exactly dated.

Photomicrographs.

Photomicrographs of late-glacial pollenfinds from the following species are on file at the Geological Survey of Denmark. Each number (e.g. DGU a 312) indicates one sheet with several enlarged photographs (× 1000). Optical equipment: Leitz Ortholux, oil immersion, numerical apert. 1.32. Usually a green filter has been used, in special cases a red filter. Two pollen grains (NMM 621, 632) are photographed at the Bog Laboratory of the National Museum. — Colleagues who want to scrutinize the determination of some grains may borrow the sheets in question.

Allium cf. *Schoenoprasum*	DGU a 846, 922
Anthyllis vulneraria	DGU a 123
Armeria maritima	DGU a 53, 603, 824
Astragulus alpinus	DGU a 182, 369, 373, 381, 401, 402, 421, 481
— cf. *arenarius*	DGU a 385, 412
— cf. *danicus*	DGU a 621
— cf. *frigidus*	DGU a 642, 694
Bartschia alpina	DGU a 842
Botrychium cf. *multifidum*	DGU a 701
Bupleurum cf. *falcatum*	DGU a 913
Caltha palustris	DGU a 691
Campanula rotundifolia	DGU a 461, 513,
Carum carvi	DGU a 882, 911
Centaurea cyanus	DGU a 171, NMM 621, 632
— *scabiosa*	DGU a 202, 222
Ceratophyllum demersum	DGU a 781
Chamaenerium angustifolium	DGU a 491, 483
Cirsium cf. *arvense*	DGU a 534
— cf. *heterophyllum*	DGU a 533
— cf. *vulgare*	DGU a 734
Crepis cf. *paludosa*	DGU a 722
Cystopteris fragilis	DGU a 712
Dryas octopetala	DGU a 651, 652
Ephedra distachya	DGU a 101, 102, 103, 151, 152, 191
Euphorbia sp.	DGU a 11
Falcaria(?) sp.	DGU a 602, 874
Fragaria cf. *vesca*	DGU a 792
Gentiana pneumonanthe	DGU a 482
Gentianella cf. *Amarella* aggr.	DGU a 673
— cf. *campestris* aggr.	DGU a 233
Geranium cf. *silvaticum*	DGU a 601
Geum cf. *rivale*	DGU a 224, 571
Gypsophila fastigiata	DGU a 863
Helleborus(?) cf. *viridis*	DGU a 711, 721
Helianthemum cf. *canum*	DGU a 671,
— *nummularium* s. l.	DGU a 211, 591
— *oelandicum* s. l.	DGU a 192, 671
Heracleum spondylium	DGU a 13
Jasione montana	DGU a 821
Juniperus cf. *communis*	DGU a 21
Lotus cf. *corniculatus*	DGU a 122
Lycopodium clavatum	DGU a 713
Melampyrum sp.	DGU a 714
Myriophyllum spicatum	DGU a 823
Nuphar pumilum	DGU a 844
Nymphaea candida	DGU a 702
Oxyria digyna	DGU a 822
Oxytropis campestris-type	DGU a 451, 562, 593
Parnassia palustris	DGU a 71, 72, 75, 452
Pimpinella cf. *saxifraga*	DGU a 864
Plantago cf. *alpina*	DGU a 402
— *lanceolata*	DGU a 241, 242
— *major*	DGU a 283, 611, 903
— *maritima*	DGU a 261, 264, 271, 291, 382
— *media*	DGU a 252, 262, 263 272, 281
Pleurospermum austriacum	DGU a 612, 912
Polemonium cf. *coeruleum*	DGU a 61, 511
Polygonum aviculare	DGU a 12, 772
— *Bistorta vel viviparum*	DGU a 31, 181
Polypodium vulgare	DGU a 782
Potentilla cf. *palustris*	DGU a 303, 371
Prunus padus	DGU a 352, 523
Ranunculus peltatus aggr.	DGU a 661
Rubus chamaemorus	DGU a 901
— cf. *saxatilis*	DGU a 811, 812
Rumex acetosa	DGU a 612
— *acetosella vel thyrsiflorus*	DGU a 442, 592
— cf. *domesticus*	DGU a 791
Sagina cf. *procumbens*	DGU a 873
Salix cf. *herbacea*	DGU a 682
— cf. *polaris*	DGU a 683
Salsola kali	DGU a 213, 214, 861
Sanguisorba minor	DGU a 62, 163, 382, 411
— *officinalis*	DGU a 131
Saussurea alpina	DGU a 215, 532, 535
Saxifraga hirculus	DGU a 471
— cf. *oppositifolia*	DGU a 845, 862, 923
— *stellaris*-type	DGU a 853
Scirpus lacustris	DGU a 841
Seseli Libanotis	DGU a 883
Solanum dulcamara	DGU a 121, 574, 801
Sonchus asper vel arvensis	DGU a 681
Sorbus aria cf. ssp. *rupicula*	DGU a 173, 174, 175, 211
— *aucuparia*	DGU a 871
Sweertia perennis	DGU a 161
Thelypteris Dryopteris (= *Dryopteris Linnaeanum*)	DGU a 663, 664
Tofieldia sp.	DGU a 33, 563
Typha latifolia	DGU a 715
Urtica dioeca	DGU a 312
Utricularia intermedia	DGU a 793
— *vulgaris*	DGU a 512
Valeriana officinalis aggr.	DGU a 312
Viscaria(?)	DGU a 881

Pollen Analytical Investigation of a C^{14}-dated Alleröd Section from Ruds Vedby.

By

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Abstract.

An exposed Alleröd section in Ruds Vedby, western Zealand, has provided material for C^{14}-datings published elsewhere. This section is described here in full and a detailed pollen diagram from the section is given and discussed. The results of the C^{14}-datings are touched upon briefly.

Contents.

The Alleröd Section in Ruds Vedby.

When, in 1951, the Carbon^{14} laboratory in Copenhagen was going to be started, it was a matter of urgency to find suitable material for the dating of late-glacial deposits which had been definitely dated in other ways, and after due consideration Ruds Vedby Brickwork's clay pit was chosen as the most suitable site. Here was the possibility of getting a series of samples suitable for pollen analysis and, at the same time, to obtain a series of samples of sufficient size and of different organic material, from well defined and sufficiently thin layers for C^{14}-dating.

The results of the C^{14}-datings were published in 1953 (ANDERSON, LEVI & TAUBER; IVERSEN) but only a summary was given on the stratigraphy and the pollen analytical investigation of the Alleröd section. The following paper, however, will present these investigations in greater detail.

Ruds Vedby Brickwork's clay pit is situated in western Zealand about 15 km. N of Slagelse. An exposed Alleröd section has been known here for about 25 years, and it has been favoured as an object for geological excursions during this time because of its splendid conformity with the conditions of the classic locality—Alleröd Brickwork's clay pit (Hartz & Milthers 1901). Late-glacial deposits with well developed Alleröd horizons can be found in numerous places in Denmark, but it is rare, however, to find so fine a profile as this one, which has been exposed and accessible for so many years.

The district round Ruds Vedby is an ordinary undulating morainic country similar to many other places in eastern Denmark. The site of the present clay pit did not, apparently, differ essentially from its surroundings, the whole district being mapped as boulder clay during the geological mapping before 1900, and not till after 1900 was it discovered that rather large quantities of stoneless clay, suitable for brick making, covered this place. First and foremost, the clay and the condition of it aroused the interest of geologists and in this way the Alleröd layers were discovered. Most parts of the stoneless clay are very clearly laminated and there can be no doubt that this laminated clay was deposited in an ice-dammed lake during the melting-away of the last inland ice. Concerning the laminated glacial clay opinions have differed widely, Sigurd Hansen (1940, p. 274) holding that this clay is not truly varved, while by S. A. Andersen (1941) it is regarded as very conspicuously varved. This discussion is of no interest here but has given rise to a paper by S. A. Andersen (1941), which also presents the main points in the geological development of the place. The description is well illustrated by a section drawn to scale.

The original surface of the clay pit was fairly even, but everywhere the stoneless clay is underlain by boulder clay, which has an undulating surface with scattered hollows and little hills. The stoneless clay in a fairly constant thickness lies concordant to the surface of the boulder clay, thus reproducing on its surface the surface of the boulder clay. Varying quantities of ice are supposed, by Andersen, to have been contained in the boulder clay at the initial stage of the ice lake, and during the slow melting away of the ice the overlying clay has gradually sunk in and filled up the hollows, thus forming the very uneven surface. The hollows formed in this way have become small lakes, in which the proper late-glacial layers have been deposited—during Older and Younger Dryas Time clay (mainly, in all probability, washed out from the laminated glacial clay which at that time formed hills between the basins)—and during Alleröd Time mainly gyttja.

From this it may be understood that the possibility of finding Alleröd layers is restricted to these small basins which constitute only a minor part of the former ice lake basin. Furthermore, should an Alleröd section appear during the digging of brickwork clay, it would soon be obliterated as the work proceeded. Since the investigations by HANSEN and ANDERSEN (partly carried out 1927–28, published later) the appearance of the clay pit in Ruds Vedby has changed much and the sections described by these authors have been dug away. New ones have appeared, however, and during the last few years a section with a thicker Alleröd layer than

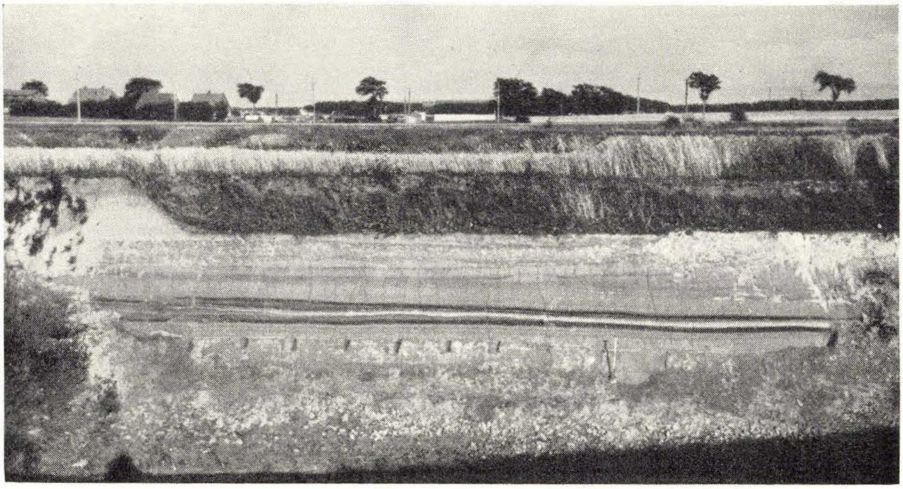

Fig. 1. Section from Ruds Vedby Brickwork's clay pit. The Alleröd layers appear as two dark lines (gyttja), separated by a light one. The samples for C^{14}-dating and pollen analysis were taken at the place marked by the spade.

formerly known from this place has been left untouched, because the clay here is too rich in lime and organic material for brickwork purposes.

The wall of this section faces west so that its length lies N–S. It is here possible to follow an Alleröd horizon over a distance of about 15 m. (fig. 1). The Alleröd layers appear, especially on the right in the picture (S), as two dark lines (gyttja) separated by a light one (lake marl), but the dark lines increase in thickness to the left (N) and gradually converge, while the light one thins out and disappears. The total thickness of the layers also increases a little and by levelling it was seen that the height, both of the lower and upper border of the layers, increases slightly towards the northern end. This shows that the former lake basin in which the layers were formed, that is at the place where the profile has been exposed, had its greatest depth in the southern part, where, it may also be observed, the series of layers are most regular. It was decided, therefore, to take the samples from this part of the section (marked by the spade in fig. 1). The upper part of the Younger Dryas clay and post glacial deposits formerly covering the late-glacial layers

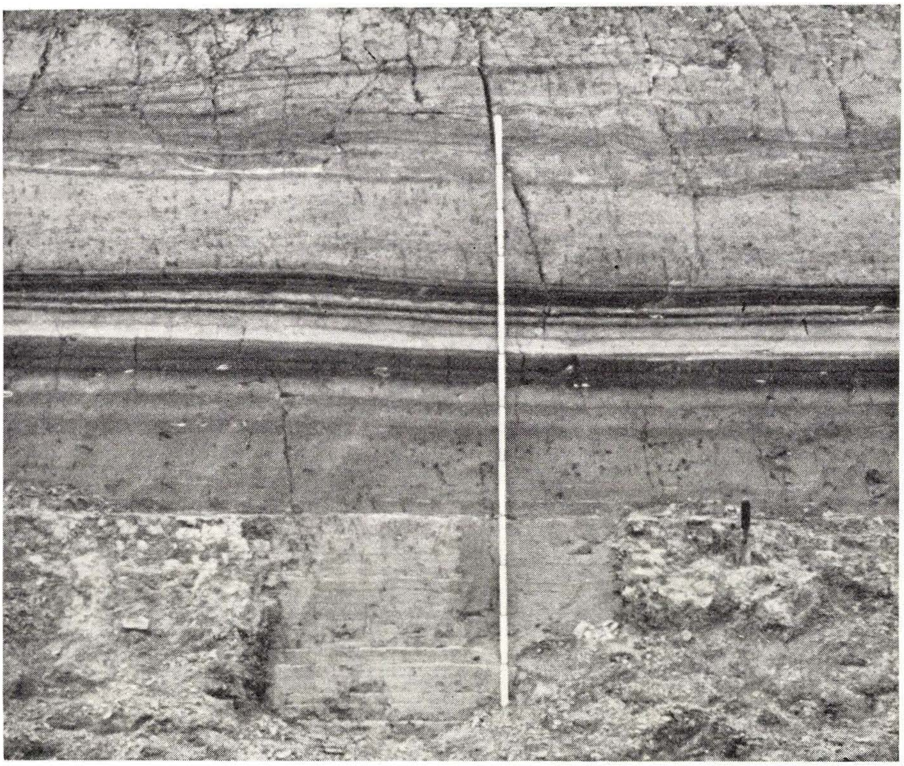

Fig. 2. The part of the section from which the samples for C^{14}-dating and pollen analysis were taken. The length of the rule is 2 m.

have been removed but the thickness of the Younger Dryas clay may be estimated to be about 3–4 metres.

The sequence of the layers yielding the samples for C^{14}-dating and pollen analysis is described in the following from the top downwards (cp. fig. 2). Somewhat unpractically, it must be admitted, as far as the description is concerned, the zero-line was placed, intentionally, at the lowest part of the section.

? –245	cm.	Dug away.
245 – 77½	,,	Stoneless clay, in the topmost part yellow-brown, weathered, downwards yellowish-grey, at the bottom blue-grey and unweathered. The layer 146–113 cm. rich in alternating peaty and finegrained sandy stripes. The lowest 4–5 cm. containing gyttja.
77½– 77	,,	Black drift gyttja, that is to say gyttja rich in floated organic material.
77 – 75½	,,	Blue-grey to blue-black calcareous clay gyttja.
75½– 74½	,,	Black-brown drift gyttja rich in wood remains.

$74\frac{1}{2}$– 70	cm.	Very clearly laminated gyttja with changing content of drift (floated material), lime and a little clay. Colour varying between whitish-grey, grey and grey-black.
70 – 55	,,	Whitish-yellow lake marl; two grey-black stripes containing drift gyttja at 68–66 cm. and 64–63 cm.
55 – 53	,,	Grey calcareous gyttja.
53 – 42	,,	Olive-grey detritus gyttja, slightly clayish.
42 – 37	,,	Grey clay gyttja.
37 – 34	,,	Olive-grey clay gyttja containing fine sand.
34 – 30	,,	Stoneless grey-blue clay.
30 – 28	,,	Fine-sandy olive-grey clay containing gyttja.
28 – ?	,,	Stoneless grey-blue clay. Except for the upper few cm. this clay is noticeably laminated with numerous stripes of fine sand, in most cases exceedingly thin. The first clear sand stripes are found at 17, 12, 8 and 3 cm. The clearly laminated clay with fine-sand stripes is glacial clay (deposited in the ice-dammed lake) while the overlying clay must be classified as Older Dryas clay or slope-washed clay. It is not possible, however, at this place to point out any clear limit between these two kinds of clay.

Shells of *Anodonta* are found scattered in the two strata 30–28 and 37–34 cm. but in no other part of the clay below the gyttja layers are molluscs found. On the other hand, varying quantities of molluscs occur in most parts of the series of layers above and especially is the lake marl rich in shells. *Anodonta* and *Sphaeriidae* predominate.

For taking the samples for C^{14}-determination a rectangular hole of 1–2 meters square was dug. As the digging progressed the surface of layers chosen for samples was laid bare and cleaned, and then the layer was sliced off with a thickness of $\frac{1}{2}$–1 cm. The C^{14}-samples which were dated are indicated on the pollen diagram pl. XII at the extreme left.

Rebedded Pollen. Construction of the Diagram.

In order to make a better comparison between any measurements that might be made the pollen samples were all treated in the same way. They were first treated with HF (gently boiled for 3–15 minutes depending upon the quantity of mineral material), then acetolysed and after a short boil up in KOH they were washed with water and glycerin. Finally they were stained with fuchsin.

As was expected the very clayey samples contained great numbers of rebedded, secondary, pollen grains. Iversen (1936, 1942), however, has shown that in many cases it will be possible to eliminate this source of error, so serious for a pollen diagram, if the number and composition percent of the secondary pollen types occurring are known. In this case it might seem possible, from the lowermost part of the glacial clay, to get a sample whose content of pollen grains must be expected exclusively, or almost so, to be of secondary origin. It must be expected, furthermore, that these pollen types and the distribution of them will be the same, on the whole, as found in any other clayey stratum in the section, because all clay in the various strata of the clay pit must have its origin from morainic material. Such a sample has been taken from the bottom of the clay pit a few m. from the section investigated. The sample was relatively rich in pollen grains and its pollen spectrum is shown in tab. I, col. 1. In the upper part are given those types which are definitely secondary and the percentage calculation is based on their total. Below this group a spore type and "Hystrix" are given which might both be included in the total. In the lower part of the table are recorded those types occurring as both primary and secondary. The terms "Triangularia" and "Hystrix" are used in the same way as by IVERSEN (1936, 1942)[1]). P/P, 1 and P/P, 2 are two groups comprising pollen grains belonging to the *Pinus-Picea-Abies* group (mainly *Pinus*) but differing from *Pinus silvestris*.

During the countings of the samples which form the pollen diagram all pollen types definitely acknowledged as secondary were separated. After having finished the countings all the secondary pollen was put together and a percentage calculation was made on this basis. The result is shown in tab. I, col. 2.

The two pollen spectra recorded in the table agree particularly well in most details and I had no hesitation in using the sample just mentioned as a basis of subtraction for those samples containing both primary and secondary pollen. It should be added that for those samples with high content of secondary pollen the composition has been checked and in every case a satisfactory agreement was found. It must be noted that a few pollen types, other than those recorded in tab. I, were found in the sample from the glacial clay, viz. *Caryophyllaceae*, *Compositae Liguliflorae* and *Tubuliflorae*, *Umbelliferae*, *Dryopteris Linnaeanum* (= *Thelypteris Dryopteris*) and *Selaginella Selaginoides*. They appeared very sparsely, their total only covering 1.2%. Among these, *Selaginella* is, doubtless,

[1]) The group "Hystrix" includes different types. One of these shows similarity to cysts from a single species of dinoflagellate studied by NORDLI (1951). BRAARUD (1945), however, has photographs of other dinoflagellate cysts (3 species) which show no resemblance to any type of "Hystrix". So far too little is known about the cysts of dinoflagellates, and it is not possible from these papers to decide if any type of "Hystrix" may be identical with any cyst of dinoflagellates. Cfr. also ERDTMAN 1954.

	1	2
Fagus	—	×
Alnus	13	11
Corylus-type	27	27
Quercetum Mixtum	2.7	1.9
Carya, Pterocary, Carpinus	2.8	1.9
Rhus-type	1.3	1.6
Castanea-type	0.6	0.9
Juglans	0.1	0.1
Nyssa	0.4	0.3
"Triangularia"	0.2	0.8
Tsuga	0.4	0.2
Seqoia-type	1.4	1.2
Pinus Haploxylon-type	6.5	5.6
P/P, 1	20	24
P/P, 2	24	24
Pollen total	1055	2643
Thelypteris palustris-type	2.7	3.3
"Hystrix"	24	22
Salix	0.5	
Betula	19	
Pinus silvestris-type	28	
Ericales	1.8	
Gramineae	11	
Cyperaceae	6	
Artemisia	1.2	
Chenopodiaceae	1.3	
Sphagnum	12	

Tab. I. Column 1 shows the pollen spectrum of a sample of glacial clay from the bottom of the clay pit. Col. 2 shows a spectrum based on the total of the definitely secondary types from all samples in the pollen diagram.

primary but regarding the others it is difficult to decide if a few may be primary or they are all secondary. It must be expected that among those types recorded in the lower part of the table, especially *Salix*, *Gramineae* and *Cyperaceae*, some pollen grains may originate in primary occurrence but statistically it will be of too little importance to influence the shape of the curves in the diagram. Finally a great "varia" group comprising indeterminable pollen grains and spores, most of them very badly preserved, was separated. It is very difficult to fix a line of demarkation for this group and for this reason it has not been included in the subtraction calculation.

On the pollen diagram, pl. XII, is shown, on the extreme right, the curve for the secondary, rebedded, pollen calculated on the total of primary and secondary pollen, after having made the subtraction in the way indicated by Iversen. When this curve is compared with the profile diagram on the left showing the stratigraphy of the section it is clearly seen that much secondary pollen corresponds to a high clay content. It should be noticed that inclusion of the "varia" group in the calculation would involve higher values for secondary pollen at all points along the curve.

For some time it has been common practice in late-glacial pollen diagrams to include pollen from both trees and herbaceous plants in the total on which the percentage calculation is based, and the same principle has been followed here. Usually, however, only pollen from wind pollinated terrestrial plants is included, but here pollen from insect pollinated plants and spores from *Pteridophytae* have also been included in the total. On the other hand, pollen and spores from water- and swamp-plants have not been included. In most cases it is easy to decide whether a pollen or spore type belongs to the terrestrial or the aquatic group, but doubt can occur when it is not possible to refer a type to genus or species. In *Umbelliferae*, for instance, both land- and water-plants are found and therefore pollen from this family has not been included in the total.

The pollen diagram itself has been constructed according to the principle used by Iversen several times in late-glacial diagrams, only differing in a few points. In the left is a main diagram (A) giving an immediate impression of the oscillations between the pollen originating from trees (white area), shrubs and dwarf shrubs (dotted area) and herbaceous plants (hatched area). The trees include *Populus*, *Pinus* and *Betula*, the curves for which are recorded within the area of the tree group. *Salix*, *Juniperus*, *Hippophaë*, *Helianthemum* and *Ericales* are classified under group heading "shrubs" (incl. dwarf shrubs). Silhouette curves for these, except for *Ericales*, are given on the right with the same dotting as the total curve, in so far as space permits. Where the curve is too thin it has been filled out in black. The demarkation of the herbaceous plants has already been mentioned and the curves for the most important of these are given in the same way on the right, under heading B, partly as symbol curves and partly in silhouette form. In a table further on all other pollen and spore occurrences are recorded. All curves for pollen and spores are drawn to the same scale to permit of direct comparison over the entire diagram, but some of the silhouette curves are, in addition, drawn to a scale of 5 : 1 in order to give a better impression of their course.

The Pollen Diagram (pl. XII).

In the main diagram is seen the typical development of a Danish pollen diagram including the pollen zones I–III (the zonal division according to Knud Jessen (1935), I Older Dryas, II Alleröd, III Younger Dryas).

The pollen zones appear at both sides of the diagram. In the zones I and III the curve for herbaceous pollen shows very high values compared with zone II, especially the middle which is, doubtless, the warmest part. The tree curve, on the other hand, has just the opposite course with its highest values in zone II; in this curve *Betula* is the decisive factor.

As in most other eastern Danish diagrams only a small part of zone I is represented. To be sure, pollen of primary origin can be pointed out in strata lower than those included in the diagram, thus, for example, rather much *Artemisia* is found in a sample from 0 cm.; however, rebedded pollen predominates to such a degree that much time will be required and it will be very difficult to carry out reliable countings. Finally, these clay strata in zone I were doubtless deposited in the course of a very short time, so that analyses of samples only a few cm. lower than those recorded here cannot be expected to give new information of essential importance.

Except at the bottom the pine curve shows but little variation throughout the entire diagram and *Pinus* has hardly, at any point of time during the late glacial period, been of any real significance at this place. In the lower part of zone I *Betula* is but slightly represented and probably birch did not invade the region until a time almost corresponding to the lowermost analysis in the diagram. Abruptly the curve rises, however, signifying that birch has spread quickly. Where, in zone I, *Pinus* and *Betula* are absent or only represented to a minor degree the *Salix* curve has a remarkable maximum. The relatively high frequencies of the *Hippophaë* curve in the first phases of zone I, where trees are still of but little importance, is a feature characteristic of most Danish late-glacial diagrams. In the same way, *Helianthemum* most frequently exhibits characteristic occurrence in older parts of late-glacial time, frequently—as here—towards the end of zone I and the beginning of zone II. It is seen that among the true herbaceous plants *Gramineae* and *Cyperaceae* produce the greatest quantity of pollen, but also *Artemisia* plays an important rôle, especially at the beginning. Although relatively sparsely represented *Dryas* and *Plantago maritima* show characteristic occurrences limited to zone I and the beginning of zone II.

Alleröd time, zone II, as a whole, is distinguished by the increase of the *Betula* curve at the expense of the herb pollen, especially that of *Gramineae*, *Cyperaceae* and *Artemisia*. In addition, the curves for *Populus*, *Juniperus*, *Filipendula* and *Urtica* show distinct maxima, and finally rebedded pollen shows a pronounced minimum. The small quantity of rebedded pollen indicates that the supply of clay to the basin was slight and this, again, is conditioned by the fact that the vegetation was dense enough to prevent—either wholly or in part—an outwash of clay from the surface.

In most of IVERSEN's late-glacial diagrams *Betula* has a definitely forked graph in Alleröd time, indicating two warmer periods separated by a cooler one. Provided the same division were used here the first *Betula* maximum (and herb pollen minimum) would have to be placed at about 56 cm., at the beginning of what is here called II a, and the second maximum would have to cover what is here called II b. This parallelization may be right but it is not quite clear and therefore zone II has here been divided into 3 sections, a, b and c, according to a principle differing slightly from that just mentioned. II b, then, will be the warmest part of Allerød time with a minimum of herb pollen. At the same time *Populus*, *Filipendula* and *Urtica*, all of them requiring a relatively warm climate, have their most frequent occurrence.

The shape of the curve for *Betula* in zone II is very irregular. This can not be caused by statistical uncertainty, because the number of pollen grains counted per analysis was, on an average, rather high, c. 700–1000. Therefore this irregularity must be explained by local oscillations of the tree and shrub growth in the immediate neighbourhood. This explanation sounds very reasonable when it is remembered that this basin was only one out of several small ponds lying in a clayey, hilly country with a shrub growth consisting of birch, willow and juniper, growing right up to the water's edge. A rather large content of twigs and small sticks (no doubt mainly *Salix*) in some of the upper strata of zone II, washed into the basin from the immediate surroundings, are evidence that conditions like these prevailed at that time.

Until the beginning of zone II b the *Salix* curve oscillates the opposite way to *Betula*; presumably these oscillations are climatically conditioned. The great *Salix* maximum, however, in the upper part of zone II b and in zone II c, must be local, determined by soil and moisture conditions at that particular place. As mentioned above, a rather thick willow copse probably grew around the edges of the basin.

The curve for *Juniperus* shows in zone II a a clear increase, resulting in a pronounced maximum in zone II b. An abrupt fall, however, terminates the maximum towards the end of zone II b, and throughout the rest of the diagram the juniper curve is more or less uniform, with fairly low values. The explanation of this peculiar course may be that the conspicous rise is caused by the better climatic conditions in zone II, which still persist, even after the fall. However, juniper requires much light and possibly the effect of shade from the other tree- and shrub-vegetation has reduced flowering but not prevented the growth already existing from continuing for some time.

Some of the features distinguishing zone III are the same as those found in zone I. The *Betula* curve is pressed back, especially by *Gramineae* and *Cyperaceae*, and *Populus*, *Filipendula* and *Urtica* show a marked decline. The *Artemisia* curve shows a small but definite rise and *Hippophaë* and *Helianthemum* appear again, although very sparsely. *Dryopteris Linnaeanum* (= *Thelypteris Dryopteris*) is found throughout zone II—in II a only in small quantities but more generally in II b and c; in zone III, however, it has a pronounced rise. From other Danish diagrams, e.g. Harndrup (DEGERBØL & IVERSEN 1945), a similar curve with a maximum in the first part of zone III is known. In zone II climatic conditions must have been excellent for *Dryopteris Linnaeanum* but most probably the effect of shade reduced the spore production, so that light conditions and not climate is the real reason for the maximum in the beginning of zone III.

Remarks upon some of the Plant Species demonstrated.

The above should be sufficient to give the diagram its exact position in the development, as far as it is known, of the late-glacial period. Beyond this, however, some remarks must be made on a series of pollen types, recorded either in the diagram or in tab. II. A washing sample from the layer 74½–75½ cm. has yielded some macro fossils, identified by Miss INGER BRANDT, M. S., and they, also, will be dealt with.

A great number of the pollen types found are briefly described in the keys given by FÆGRI & IVERSEN (1950), but the identification has, in every case, been based on comparison with modern pollen. Some of the pollen grains found have been photographed, both in support of and as a documentation of the determination. For economic and space reasons none of these pictures have been published, but they are available in the collection of pollen photographs to be found at the Geological Survey of Denmark. Where a photographed pollen grain is mentioned in the following it will be marked in the text by the photo-no. of the grain in question, for ex. (phot. DGU a 811). Information concerning plant distribution within Fennoscandia referred to in the following is mainly based on E. HULTÉN (1950). The nomenclature is the same as used by HYLANDER (1941). The late glacial occurrence of most plants mentioned here has been dealt with by IVERSEN (1954) in a broader connection than here.

Astragalus alpinus. One pollen grain from the transition between zone I and II has been attributed to this species. At the present time *A. alpinus* is an arctic montane species with a circumpolar distribution and it is widely distributed in the Scandinavian mountains. In the last few years the presence in Denmark of a rather large number of pollen grains of *Astragalus alpinus* from zone I–III has been proved, and in Ireland one grain is known from zone I (MITCHELL 1953).

Betula. In the stratum 74½–75½ cm. were found several fruits of *Betula*, most of them belonging to *B. pubescens*. It was not possible to prove that

B. nana was present but as the state of preservation was bad, *B. nana* cannot with certainty be excluded. Size measurements of birch pollen have been made in 7 different samples from zone II: 2 from IIa, 4 from IIb and 1 from IIc. In every case 100 grains were measured. The results of the measurements were surprisingly uniform: it was not possible to point out any difference in size from sample to sample and no tendency for them to be distributed according to different size orders could be observed. From this result it would appear that broad leafed birch predominated throughout Alleröd time at this place. It may be mentioned that corresponding measurements from Bornholm (Iversen 1954) indicate, on the contrary, a preponderance of *B. nana* in zone II. In most other places in Denmark, however, broad leafed birch seems to have been in the majority in zone II.

Botrychium. Most of the spores found agree fairly well with *B. Lunaria* which, at the present time, is widely distributed both in Denmark and Fennoscandia. However, the various species of this genus are closely related to each other and difficult to identify from the spores. Scattered occurrence of *Botrychium* spores, as here, will be seen in most Danish late-glacial diagrams.

Campanula. One pollen grain from zone II b (phot. DGU a 461). Identification of species was not possible, but it agrees with *C. rotundifolia*, the occurrence of which would be likely. Species other than this must also be considered.

Caryophyllaceae. Among the relatively few pollen grains belonging to this family a single one has been attributed to cfr. *Viscaria* (76 cm. (phot. DGUa 881)).

Compositae. Most pollen grains belong to the sub-family *Tubuliflorae*. Two of these are of the same type as *Cirsium* (73 cm. and 68 cm. (phot. DGU a 533 and 534)) and 6 grains are classed as *Saussurea alpina*. Regarding the latter, determination in two cases may be regarded as certain (76 cm. and 68 cm., phot DGU a 535 and 532), while the remaining four can only be termed cfr. *S. alpina*.

Dryas octopetala. As the occurrence of this plant has given rise to the term Dryas Period it has been a little unsatisfactory, hitherto, not to find its pollen in late-glacial deposits. However, the main reason is, no doubt, that the pollen grains were relatively difficult to identify. Furthermore, it is insect pollinated, so that only small quantities of pollen can be expected. In a late-glacial diagram from Scania, however, Brorson-Christensen (1949) has been able to record it and he has given a fairly thorough description of its pollen. In his diagram *Dryas* has a clear maximum in zone I. In the present case, also—as well as in other late-glacial deposits during recent years—it has been possible to include *Dryas*. Although the occurrence is slight it will be seen that it is restricted

Tab. II.

Occurrences of pollen and spores which are not recorded in the pollen diagram.

Zone	Depth in cm.	*Botrychium*	*Calluna*	*Caryophyllaceae*	*Chenopodiaceae*	*Compositae* *Tubuliflorae*	*Compositae* Cfr. *Saussurea*	*Compositae* *Liguliflorae*	*Empetrum*	*Epilobium*	*Equisetum*	*Hippuris*	*Menyanthes*	*Myriophyllum spicatum*	*Potamogeton*	*Potentilla*	*Ranunculaceae*	*Rubus*	*Selaginella*	*Sparganium*	*Sphagnum*	*Umbelliferae*	
	90	—	—	0.4	—	0.9	—	—	—	—	6.4	—	—	—	2.1	0.2	0.4	—	—	0.2	—	0.6	*Plantago* sp. 0.2
III	85	0.2	—	—	1.3	1.3	0.2	—	—	—	8.1	—	—	—	2.0	0.2	—	—	—	—	—	1.2	*Isoëtes* 0.2
	80	0.5	—	—	0.2	0.5	—	—	0.7	—	5.5	—	—	—	12	—	0.2	—	—	—	—	1.0	*Cruciferae* 0.2
	77½	—	—	—	0.6	0.6	0.2	—	0.6	—	15	0.4	—	—	2.0	0.4	0.9	—	—	—	1.5	1.9	*Lycopod. Sel.* 0.2
	76	—	0.1	0.3	0.3	0.3	0.2	—	0.2	—	14	0.2	0.1	0.2	0.8	0.3	0.6	—	—	—	—	1.3	
II c	75	—	—	—	0.5	0.1	—	—	0.2	0,1	16	0.2	0.1	—	1.9	0.3	0.7	—	—	—	0.3	2.2	*Plantago media* 0.1; *Gentiana Pneum.* 0.1
	73	—	—	0.1	0.4	0.2	—	—	0.4	—	14	—	0.1	0.1	1.5	0.4	0.7	0.1	0.1	—	0.6	2.1	*Typha lat.* 0.1
	71	—	—	—	—	—	—	—	0.4	0,1	12	0.1	—	0.1	7.0	0.5	1.2	0.1	—	—	0.7	2.2	*Rumex* cfr. *domest.* 0.1
	69	0.1	—	—	0.3	—	—	—	0.3	—	9.8	0.1	0.1	—	2.3	0.1	0.1	0.5	—	—	0.4	1.0	
	68	—	—	0.1	0.5	0.1	0.1	—	0.2	0,1	13	0.1	0.1	—	1.2	—	—	—	—	—	1.1	1.1	
	67	—	—	—	0.4	—	—	—	0.2	—	11	—	0.2	—	1.9	0.1	—	0.1	—	—	0.9	1.0	
	66	—	—	—	0.2	—	—	—	—	—	24	—	0.2	—	6.7	0.1	—	0.1	—	—	0.7	0.3	*Geum* 0.1
	65	—	—	—	0.1	—	—	0.1	0.1	—	26	0.2	0.1	—	4.1	0.1	—	0,1	—	—	1.3	0.4	
	63½	—	0.1	—	0.2	—	—	—	0.2	—	35	0.1	—	—	5.2	0.1	0.1	0.1	—	—	0.6	0.8	*Lycopod. annot.* 0.1
II b	62	—	—	—	0.1	—	—	—	0.4	—	20	—	—	—	14	—	0.1	—	—	—	0.9	0.8	*Lycopod. annot.* 0.1
	59½	—	—	—	0.1	—	—	—	—	—	13	—	0.1	—	4.9	—	0.1	0.2	—	—	1.2	0.7	
	58	—	—	—	—	—	—	—	0.4	—	3.1	—	—	—	13	0.1	0.4	—	—	—	0.8	0.6	*Lycopod. Sel.* 0.1
	56	—	0.1	0.1	0.1	—	—	—	0.4	—	7.9	—	—	—	12	0.2	0.2	0.1	—	—	0.1	0.6	*Solanum Dulc.* 0.1; *Ephedra* cfr. *dist.* 0.1; *Vaccinium*-typ. 0.1
	54½	—	—	—	0.5	0.1	—	—	0.2	—	7.5	—	—	—	22	0.2	0.6	0.1	—	—	1.3	0.9	
	53½	—	—	—	0.1	0.1	0.1	—	0.3	—	5.8	—	—	0.1	62	—	2.8	—	—	—	0.1	0.6	
	51	0.1	—	—	0.3	—	—	—	0.2	—	6.4	0.3	—	—	24	—	2.6	0.1	0.2	—	0.8	1.0	*Lycopod. annot.* 0.1
	48½	—	—	—	0.4	—	—	—	—	—	12	0.1	—	—	9.7	0.1	2.3	—	0.1	—	1.2	0.9	
II a	47	—	—	—	0.4	—	—	0.2	0.2	—	15	—	0.2	—	10	—	0.9	—	—	—	0.7	0.9	*Solanum Dulc.* 0.2
	45	0.3	—	—	—	—	—	—	0.3	—	19	—	—	0.3	6.2	—	0.7	—	—	—	0.8	0.4	*Campanula* 0.1
	43	—	—	—	0.3	—	—	—	—	—	10	—	—	0.1	1.0	—	1.8	—	—	—	0.5	0.3	
	39½	—	—	—	0.7	0.2	—	—	0.6	—	1.8	—	—	0.1	2.4	—	0.7	—	0.1	0.1	—	0,2	*Astragalus alp.* 0.1; *Saxifraga opposit.*-typ. 0.1; *Lycopod.* cfr. *compl.* 0.1
	36	0.2	—	—	1.1	0.7	—	—	—	—	1.6	—	—	—	23	—	—	—	—	—	—	0.4	*Plantago media* 0.2
I	32	0.4	—	—	2.1	0.8	—	—	—	—	1.4	—	—	—	7.0	—	0.2	—	—	0.2	—	0.6	*Armeria* 0.2; (*Ephedra* sp. 0.2)
	29	—	—	0.2	—	1.2	—	—	0.2	—	2.2	—	—	—	8.0	—	0.2	—	—	—	—	0.4	*Plantago* cfr. *media* 0.2
	24	—	—	—	—	—	—	—	—	—	6.6	—	—	—	0.3	0.3	—	—	—	0.3	—	—	*Parnassia* 0.7; (*Ephedra* spp. 1.0)

—almost entirely—to zone I, thus agreeing with the curve of Brorson-Christensen and with the idea of a *Dryas* period. Concerning zone III it is impossible to judge here because this zone is represented by too few samples.

Ephedra. One pollen grain of *E.* cfr. *distachya* from zone II b. Rebedded pollen was not found in this sample and the occurrence here is in full accordance with what is otherwise known about the appearence of *Ephedra* pollen in other Danish deposits (Iversen 1951, 1954). In zone I 3 grains were found (1 from 32 cm., 2 from 24 cm.) resembling *E. distachya* somewhat but not identical with it. The *E. strobilacea*-type is also represented, by one pollen grain from 24 cm. (phot. DGU a 431). The last four mentioned originate from the lowest samples in zone I which contain very much secondary pollen and there can hardly be any doubt that they are secondary. Pollen grains of the genus *Ephedra* have been found in tertiary lignite in Germany (Thiergart 1940) and, likewise, a single grain of the *E. strobilacea*-type has been found in tertiary lignite from Denmark (P. Ingwersen, personal communication). A secondary occurrence in the late-glacial clay is thus probable, even though it was not found in the sample from the bottom of the clay pit.

Filipendula. It has not been possible to distinguish between *F. Ulmaria* and *F. vulgaris.* According to its character and distribution the former must be expected to have had good conditions during Alleröd time and it will be reasonable to assume that most of the finds in this case, at any rate, will be *F. Ulmaria.*

Gentiana Pneumonanthe. One pollen grain from zone II b (phot. DGU a 482). Pollen grains of this species are among the largest in *Gentianaceae*, they are clearly and sharply striated and have numerous fine perforations. At the present time the distribution of the species within Scandinavia is confined to the south, where it occurs only in the most southerly part of Norway and the most south-westerly part of Sweden. Towards the east, however, it continues into Siberia and we have a few scattered occurrences in east Fennoscandia. As far as is known there is no preceeding record of this species from late glacial time.

Geum sp. One pollen grain from zone II b (phot. DGU a 571).

Helianthemum. All pollen grains found must be attributed to *H. oelandicum* s. l. which seems to predominate everywhere in Danish late-glacial deposits, while *H.* cfr. *nummularium* is found only here and there (cp. Iversen 1944).

Isoëtes sp. A single micro spore from zone III. Normally this plant is connected with markedly oligotrofic water but the content of water plants here clearly indicates eutrofic water and the occurrence of *Isoëtes* looks very peculiar. As only this single spore has been found a secondary occurrence cannot be entirely excluded. Another possible explanation is the relatively slight competition from other plants.

Lycopodium. The spores found are distributed in the following way: *L. annotinum* 3 (zone IIa and IIb), *L.* cfr. *complanatum* 1 (zone I/II) and *L. Selago* 2 (zone IIb and III).

Menyanthes trifoliata. Some seeds from the stratum 74½–75½ cm. The occurrence of pollen seems restricted to zone II.

Parnassia palustris. Two pollen grains from the lowest analysis in zone I. Other pollen grains than these of the same species, found in other Danish samples from zone I, have been photographed.

Plantago. *Pl. maritima* has already been mentioned. One of these pollen grains has been photographed (DGU a 271). Two grains of *Pl. media* are recorded, from zone IIc (phot. DGU a 272) and zone I, and one grain of *Pl.* cfr. *media* from zone I (phot. DGU a 281). One grain of *Plantago* sp. was found in zone III.

Potamogeton. Several fruit stones of *P. natans* in the stratum 74½–75½ cm. The genus *Potamogeton* is by RAUNKIÆR divided into the sub-genera *Eupotamogeton* and *Coleogeton* and it is also possible to follow this distinction in the pollen (IVERSEN 1946, p. 224). With the exception of two all the pollen grains found belong to the sub-genus *Eupotamogeton* to which, among others, *P. natans* belongs. The two pollen grains of *Coleogeton* are both from zone IIa. *P. filiformis* and *P. pectinatus* are the most important species in *Coleogeton*. The first is often found in late-glacial deposits while the latter has not been found so far.

Potentilla. It has not been possible to make any determination of species. Most probably the majority of the pollen grains belong to *P. palustris*. One grain of *P.* cfr. *palustris* from zone IIb has been photographed (DGU a 303).

Ranunculaceae. One pollen grain of *Caltha palustris* from zone IIc. The other grains, for the main part at least, must be classified as belonging to the same group as that to which *Batrachium* belongs, but no attempt at a more definite determination was made. One seed af *Batrachium* sp. was found in the layer 74½–75½ cm.

Rubus. 15 pollen grains which are classified as *R. arcticus* vel. *saxatilis* were found in zone II—mainly IIb. Three of them have been photographed (DGU a 802, 811 and 812). These pollen grains are relatively small, on an average about 25 μ in length, and they have a fine foveolate-reticulate sculpture, frequently arranged in a striate-rugulate pattern. Pores may be indicated, to a greater or lesser degree, by constriction of the furrow. These pollen grains agree perfectly with *R. arcticus* and *saxatilis*, while all other *Rosaceae* examined must be excluded. *R. arcticus* and *saxatilis* resemble each other so much that it is hardly possible to make a determination of species on the basis of a single grain. But measurements of modern pollen grains of the two species from different localities showed that the polar area of *R. arcticus* was generally considerably larger than that of *R. saxatilis*. The polar area index (FÆGRI & IVERSEN 1950, p. 29) varied in the two species in the following way: *R. saxatilis* 17–37, more than 30 was unusual, *R. arcticus* 26–52, less than 30 was unusual. Among the 15 pollen grains found here 12 had a polar area index varying from 17 to 25, and the figures for the last 3 were 26, 31 and 35. This result indicates that most of the pollen grains belong to *R. saxatilis* but it does not exclude the possibility of *R. arcticus* being represented. Macroscopic remains of *R. saxatilis* have been found on one occasion in strata from Alleröd time (HARTZ & MILTHERS 1901) while *R. arcticus* has never been found.

Rumex. The curve in the diagram shows the *R. Acetosa-Acetosella* type, to which also *R. thyrsiflorus* belongs, and no determination of species has been attempted. One grain of *R.* cfr. *domesticus* was found in zone IIc (phot. DGU a 791). The pollen grains of this species are larger than those belonging to the type mentioned above but they rather closely resemble *R. aquaticus*, *Hydrolapathum* and *obtusifolius*. At the present time *R. domesticus* is found right up to the northernmost parts of Scandinavia.

Solanum Dulcamara. Two pollen grains from 47 cm. (phot. DGU a 801) and 56 cm., zone IIa and IIb respectively. The grains of this species are recognized especially by the small size, the very marked transversal furrows and the smooth surface. At the present time the distribution of the species within Scandinavia is entirely confined to the southern parts and it is, doubtless, one of the plants which, in Alleröd time, demanded the greatest warmth.

Sparganium. The few pollen grains found all originate from the cooler periods of late-glacial time. By aid of the distribution of columellae it is possible, to a certain degree, to divide the genus into different groups. Any exact determination of species has not been attempted here but it was evident that at least two different species were present.

Typha latifolia. One pollen tetrad from zone IIc. This species has a southern distribution similar to *Solanum Dulcamara*.

Urtica. One seed of *U. dioeca* from the stratum 74½–75½ cm. Pollen grains of *U. urens* and *dioeca* can be distinguished from each other by the columellae which in the former are more distinct and more regularly distributed. A more thorough examination of a number of late-glacial pollen grains of *Urtica* showed that only *U. dioeca* was present. BRORSON-CHRISTENSEN (1949) has a pollen curve for *U.* cfr. *dioeca* from Scania and he also has a maximum in zone II. Seeds of *Urtica dioeca* have been found before in Danish Alleröd strata (e.g. K. JESSEN 1924).

Remains of Fishes.

In the samples for C^{14}-determination from zone II a few macroscopic remains of two species of fish were found.

Esox lucius, pike. Articulare and one fragment of frontale from the stratum 74½–75½ cm.

Perca fluviatilis, perch. A few scales from the strata 54–55 cm. and 66–68 cm.

Both species are frequently found in late-glacial fresh water deposits.

C^{14}-datings.

Ruds Vedby is not, it must be admitted, the place one would choose when it is a question of obtaining as varied a representation as possible of the late-glacial flora. The soil conditions, especially, are too unfavourable for that. The purpose of the investigation, however, was—first and foremost—to obtain as accurate a dating as possible of the late-glacial strata, partly by means of pollen analysis, partly by C^{14}-dating. The pollen analytical dating has been discussed in the foregoing but the C^{14}-dating is dealt with elsewhere, both as regards the more technical side (ANDERSON, LEVI & TAUBER 1953) and the geological significance of the dating (IVERSEN 1953). The following report of the C^{14}-dating, therefore, will be fairly brief and it is entirely based on these two papers.

The purpose of the C^{14}-measurements was not alone to obtain exact determinations of age but also, as far as possible, to examine the suitability of different geological deposits for this dating method. Deposits rich in lime were of special interest because the lime in one and the same stratum may have different origins and thus different original contents of C^{14}. Concerning this problem it is sufficient to say that the calcareous sediments from Ruds Vedby, according to the results obtained, gave the same dates as wood.

The boundary between zone II and III is well defined in Danish pollen diagrams; it is entirely climatically conditioned and has not been influenced by the immigration of plants to various places at various times, wherefore it must be synchronous everywhere. Therefore, special care has been devoted to this horizon, the end of Alleröd time, in order to obtain a dating as exact as possible. Very large samples were taken from the stratum 74½–75½ cm. and in the laboratory they were separated, by washing, into pure wood and peaty mud. Samples of lake marl were taken from the stratum 72–73 cm. Three age-determinations were made from the wood sample, one determination from each of the other two, and the mean of these 5 determinations gave as a result 10.830 ± 200 years in absolute age. Determinations made with underlying samples from zone II showed an increasing age with increasing depth and as a consequence of these dates the duration of Alleröd time can be fixed at 1000 years, at least (cp. the figures in the first column of the diagram, pl. XII).

The C^{14}-datings from the Alleröd layers in Ruds Vedby give—in connection with other C^{14}-datings, both from Denmark and elsewhere—the final proof of synchronism of Alleröd time wherever it has been demonstrated.

In connection with the C^{14}-measurements from Ruds Vedby measurements of samples from lake Böllingsö in Jutland were also made. One of these samples originated from the zone border III/IV, the transition from late to postglacial time, and this sample was dated as 10.300±350 years. This result is, fundamentally, in agreement with the Swedish varved clay chronology.

Dansk resumé.

Ruds Vedby teglværksgrav i Vestsjælland har gennem adskillige år været et yndet mål for geologiske ekskursioner, fordi der her findes et åbent Allerödprofil, som viser smuk overensstemmelse med lagfølgen i det klassiske profil fra Alleröd i Nordsjælland. Profilet har flg. udseende (smlgn. fig. 1 og 2): Bundlagene består af stærkt lagdelt issøler, som øverst går over i nedskylsler (Ældre Dryasler). Øverst i nedskylsleret findes to tynde, gytjeholdige striber med skaller af *Anodonta*. Herovenpå følger Allerödlagene, et 25—50 cm tykt lag af organiske dannelser, overvejende gytje. På fig. 1 ses de som to mørke bånd adskilt af en lysere stribe (kalkgytje), der kiler ud mod venstre. Ovenpå Allerödlagene følger nedskylsler fra Yngre Dryastid. En fyldigere beskrivelse af de geologiske forhold i Ruds Vedby teglværksgrav findes hos S. A. ANDERSEN (1941).

Fra dette profil blev der i 1951 udtaget prøver til C^{14}-datering og pollenanalyse. På grundlag heraf er der udarbejdet et pollendiagram. Diagrammet er vist på tavle XII, og yderst til venstre er indsat resultaterne af C^{14}-dateringen. På begge sider af diagrammet er angivet en zoneinddeling (I: Ældre Dryas, II: Alleröd, III: Yngre Dryas). Pollendiagrammet har et for danske senglaciale diagrammer typisk kurveforløb. Urtepollenkurven udviser i zonerne I og III meget store værdier sammenlignet med forholdene i zone II, specielt i dennes midterste og utvivlsomt varmeste del. Træpollenkurvens store værdier i zone II er især betinget af birkens (*Betula*) store hyppighed. Blandt urterne spiller græsser (*Gramineae*) og halvgræsser (*Cyperaceae*) den største rolle, og i zone I har bynke (*Artemisia*) en stor betydning. I zone I må desuden bemærkes karakteristiske, om end ret små, forekomster af *Hippophaë*, *Plantago maritima*, *Dryas* og *Helianthemum*. Allerödtiden viser, foruden det tidligere nævnte, karakteristiske maxima for bævreasp (*Populus*), enebær (*Juniperus*), mjødurt (*Filipendula*) og nælde (*Urtica*). Fra samme periode må nævnes enkelte fund af pollenkorn af *Ephedra* cfr. *distachya*, *Gentiana Pneumonanthe*, *Solanum Dulcamara* og *Typha latifolia*, alle relativt varmekrævende planter.

Lerlagene, specielt fra zone I, havde et stort indhold af sekundært, omlejret, pollen, som det imidlertid var muligt at udskille fra det primære pollen — ved en særlig subtraktionsberegning på grundlag af sammenligning med en prøve af issøler fra bunden af teglværksgraven. Længst tilhøjre i diagrammet, under C, viser en kurve det procentiske indhold af sekundært pollen. Denne kurve giver samtidig et udmærket udtryk for de forskellige aflejringers lerindhold. Kurvens udprægede minimum i zone II er udtryk for ringe lertilførsel til det daværende bassin, hvilket især er betinget af, at vegetationen i omgivelserne nu var så tæt, at den helt eller delvis hindrede nedbøren i at bortskylle leret fra jordoverfladen.

Der fandtes i Allerödlagene enkelte makroskopiske rester af gedde og aborre.

C^{14}-dateringens resultater er publiceret tidligere (ANDERSON, LEVI & TAUBER 1953, IVERSEN 1953), men skal her kort nævnes.

Grænsen mellem Alleröd og Yngre Dryas er ved C^{14}-dateringen ofret særlig omhu, fordi denne grænse i danske pollendiagrammer plejer at være vel markeret, og fordi den må anses for overalt at være synchron. Gennemsnittet af 5 målinger af prøver fra Allerödtidens slutning gav som resultat 10.830$\pm$200 år i absolut alder. Bestemmelser udført på underliggende prøver i zone II viste stigende alder med tiltagende dybde, og på grundlag af disse dateringer må Allerödtidens varighed ansættes til mindst 1000 år. Disse og andre C^{14}-dateringer giver tilsammen det endelige bevis for, at Allerödtiden er synchron overalt, hvor den er påvist.

I forbindelse med C^{14}-målingerne fra Ruds Vedby blev også foretaget målinger af prøver fra Böllingsö i Jylland, bl. a. af en prøve fra overgangen mellem sen- og postglacialtid. Resultatet af denne måling (10.300$\pm$350 år) viser principiel overensstemmelse med den svenske varvkronologi.

References.

D.G.F. = Meddelelser fra Dansk Geologisk Forening (Bulletin of the Geological Society of Denmark). København.

D.G.U. = Danmarks Geologiske Undersøgelse (Geological Survey of Denmark). København.

ANDERSEN, S. A. 1941: Om Aarsvarvene ved Ruds Vedby og nogle Bemærkninger om Aarsvarvene i Danmark. D.G.F. Bd. 10.

ANDERSON, E. C., LEVI, HILDE & TAUBER, H. 1953: Copenhagen natural radiocarbon measurements, I. Science. Vol. 118. New York, N. Y.

BRAARUD, TRYGVE. 1945: Morphological observations on marine dinoflagellate cultures. Det Norske Vidensk.-Akad. i Oslo. Avh. I. Mat.-Naturv. Kl. 1944. No. 11.

BRORSON-CHRISTENSEN, B. 1949: Pollenanalytisk datering af en rensdyrknogle fra Nebbe Mosse, Ö. Vemmelöv Socken. In: C. A. ALTHIN, B. BRORSON-CHRISTENSEN & H. BERLIN: Renfundet från Nebbe Mosse och Sveriges senglaciala bebyggelse. K. Hum. Vetenskapssamf. i Lund Årsberättelse 1948–49, V.

DEGERBØL, MAGNUS, & IVERSEN, JOHS. 1945: The Bison in Denmark. D.G.U. II. Rk. Nr. 73.

ERDTMAN, G. 1950: On pollen grains and dinoflagellate cysts in the firth of Gullmarn, SW. Sweden. Botan. Notiser. Lund.

FÆGRI, KNUT, & IVERSEN, JOHS. 1950: Textbook of modern pollen analysis. Copenhagen.

HANSEN, SIGURD. 1940: Varvighed i danske og skaanske senglaciale Aflejringer. With an English summary. D.G.U. II. Rk. Nr. 63.

HARTZ, N. & MILTHERS, V. 1901: Det senglaciale Ler i Allerød Teglværksgrav. D.G.F. Bd. 2.

HULTÉN, ERIC. 1950: Atlas över växternas utbredning i Norden. Atlas of the distribution of vascular plants in NW-Europe. Stockholm.

HYLANDER, NIELS. 1941: Förteckning över Skandinaviens växter. 1. Kärlväxter. Utgiven av Lunds Botaniska Förening. Lund.

IVERSEN, JOHS. 1936: Sekundäres Pollen als Fehlerquelle. D.G.U. IV. Rk. Bd. 2. Nr. 15.
— 1942: En pollenanalytisk Tidsfæstelse af Ferskvandslagene ved Nørre Lyngby. D.G.F. Bd. 10.
— 1944: *Helianthemum* som fossil Glacialplante i Danmark. Geol. Fören. i Stockh. Förh. Bd. 66, Hft. 4. Stockholm.
— 1946: Geologisk Datering af en senglacial Boplads ved Bromme. Aarb. f. nordisk Oldkyndighed og Historie. København.
— 1951: Steppeelementer i den senglaciale Flora og Fauna. D.G.F. Bd. 12.
— 1953. Radiocarbon dating of the Alleröd period. Science. Vol. 118. New York, N. Y.
— 1954: The late-glacial flora of Denmark and its relation to climate and soil. D.G.U. II. Rk. Nr. 80.
JESSEN, KNUD. 1924: Et Bjørnefund i Allerødgytje. D.G.F. Bd. 6.
— 1935: Archaeological dating in the history of North Jutland's vegetation. Acta Archaeol. Vol. V. København.
MITCHELL, G. F. 1953: Studies in Irish Quaternary deposits: No. 8. Proc. Roy. Ir. Acad. 55, B, No. 12.
NORDLI, ERLING. 1951: Resting spores in *Goniaulax polyedra* Stein. Nytt Magasin for Naturvidenskapene. Bd. 88. Oslo.
THIERGART, FRIEDRICH. 1940: Die Mikropaläontologie als Pollenanalyse im Dienst der Braunkohlenforschung. Schriften aus d. Geb. d. Brennstoff-Geologie. Hft. 13. Stuttgart.

A late-glacial pollen diagram from southern Michigan, U. S. A.

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Abstract.

A pollen diagram representing 14 feet of clay and clay-gyttja at the bottom of a postglacial deposit from a pond in Livingstone Co., Michigan, is presented. The pollen contents of the samples seem to indicate a mixture of two vegetation types, a northwestern one (*Picea* dominant, *Pinus* and *Abies* absent), and a southern one (with *Quercus, Carya, Ulmus, Fraxinus* etc.). The theory is advanced that the deciduous forest tree pollen is rebedded from older, interglacial deposits. A reconstruction of the real vegetation is attempted and its striking similarity to the contemporary late-glacial vegetation in N.W.-Europe pointed out. Its possible importance for the immigration of Cordilleran relics now found in eastern America is discussed. An attempt of correlation with other late-glacial sequences is made.

Distribution patterns of plant species are in certain cases difficult to understand in the light of present day environmental conditions and dispersal possibilities alone, and plant geographers have to resort to the events of vegetational history for more satisfactory explanations. Dealing with such problems FERNALD in his famous work (FERNALD 1925) postulated that the presence of an allogenous flora at certain localities in eastern America could only be explained by assuming that these species are there relics of great age. During the Pleistocene glaciations, according to FERNALD, they persisted as nunatak survivors and as such lost their ability later to extend their area (cp. CAIN 1940). In view of new geological and other evidence many of FERNALD's postulations have not proved tenable, and this complex problem is still not clearly understood (see a recent review by SCOGGAN 1950).

In the relic East-American flora FERNALD distinguished a Cordilleran element. These plants have a wide distribution in the Rocky Mountains to-day; some of them make a jump of several thousand km to their eastern occurrences, mostly around the Gulf of St. Lawrence, while others have a few stations in the intervening area, especially in the Upper Great Lakes region (cp. FERNALD 1935). Concerning such species it has been suggested (MARIE VICTORIN 1925, 1938, ROUSSEAU 1933, 1950, see also BÖCHER 1951) that they together with arctic plants inhabited an unforested belt, which during the Wisconsin glaciation extended south of the ice border across the continent east of the Rocky Mountains. Under such conditions these plants would find the necessary migration possibilities, as they are often of pioneer character and unable to compete in closed communities. As they followed the retreating ice northward, they would become isolated at the present day relic localities, which seem particularly favourable for their preservation during postglacial time. According to the hypothesis of ROUSSEAU (1933), "— — la cause de l'isolement, au lieu d'être la progression du glacier vers le sud, serait la montée vers le nord d'une végétation luxuriante."

Geological evidence of frost action south of the Wisconsin ice in North America is plentiful (SMITH 1949, DENNY 1951), but so far however paleobotany has given little support to the reality of ROUSSEAU's concept of a "corridor désertique bordant le glacier" or the "kind of sidewalk extending from the Rockies to the Gulf of St. Lawrence" as pictured by MARIE VICTORIN. On the contrary, there is evidence which apparently points in the opposite direction. One such is the famous Two Creeks forest bed on the west shore of Lake Michigan (see location on fig. 1) described by WILSON (1932, 1936). Here a vegetation of *Picea glauca* grew close enough to the ice front to be overridden by the Mankato readvance and buried under glacial drift, and it may be implied that no space was left for an unforested belt (cp. COOPER 1942). Also pollen analysis has given evidence, which may seem negative. Pollen diagrams from the glaciated area and its vicinity to the south invariably start with a spruce zone (POTZGER 1946, 1951 and earlier, SEARS 1942, DEEVEY 1949); and it is usually inferred that the oldest vegetation was a forest of the spruce-fir (*Picea-Abies*) type.

The discrepancy may not be so serious, however, as "spruce pollen zone" may not necessarily indicate a "spruce forest". As explorations in more recent years have shown, the northern zone of coniferous vegetation across Canada can hardly be termed forest as the stands are here very open giving ample space and light for the ground vegetation (see descriptions by RAUP 1941, 1946, HUSTICH 1950, HARE 1950, DANSEREAU 1944, 1951). A vegetation like this, however, will not show up in the pollen diagrams if they are confined to tree pollen alone, but indications may be found if also other associates are included in the analyses. In northern Europe such a park-like vegetation (with birch instead of spruce) characterized the periglacial area in the same period, its associates proving to be light-requiring plants, among which *Juniperus*, *Artemisia*, grasses and sedges were of particular importance (see recent summaries by FIRBAS 1950, GODWIN 1947, VAN DER HAMMEN 1951, IVERSEN 1954). Of great interest is therefore DEEVEY's recent demonstration that a vegetation rich in herbs prevailed during the lower part of the spruce zone in central Maine in easternmost United States (DEEVEY 1951).

The present author has had the privilege to spend some time with Professor STANLEY A. CAIN at the University of Michigan, U. S. A. During this period a pollen profile of 40 feet of lake sediment representing the entire postglacial forest period was investigated. A continuation downward through clay sediments was obtained by drilling from the ice during the winter and these samples covering 14 feet were brought back and subsequently analysed in Copenhagen by the author. They form the basis of the present work. A few additional samples obtained later by Dr. Cain in an effort to extend the series further down proved younger than the oldest sample already obtained.

The author wishes to express his gratitude to Dr. Cain for allowing this part of our material to be published at the present occassion, to Direktør, Dr. H. Ødum for being allowed to do part of the work at Danmarks Geologiske Undersøgelse, to Afdelingsgeolog J. Troels-Smith for letting the author use the facilities of the Bog Laboratory, Nationalmuseet, when working there, and especially to Dr. Johs. Iversen for his unfailing interest in the work. Dr. G. Erdtman, Palynological Laboratory, Bromma, has offered valuable private information on modern pollen, and Dr. E. Hultén, Naturhistoriska Riksmuseet, Stockholm, has provided modern pollen of *Elaeagnus commutata*, for which the author's thanks are expressed.

The analysis of the clay samples has shown them to be subject to one of the most serious sources of error in pollen analysis, the probable influx of rebedded material from older pollen-containing deposits (cp. FÆGRI and IVERSEN 1950, and below). Its elimination on an exact basis according to IVERSEN's method is not possible at the present. Nevertheless the problems indicated and some interesting pollen finds seem to justify a presentation of the material and an attempt to discuss the real composition of the contemporary vegetation.

The pollen samples were obtained in a small pond in the Edwin S. George Reserve in Livingstone County, Michigan (see location on map fig. 1), owned by the University of Michigan. It is presumably a kettlehole, situated in an interlobate area of the Cary substage of the Wisconsin glaciation (see fig. 1). The deepest level reached was 57 feet below the present water surface, and it seems improbable that the lake sediments

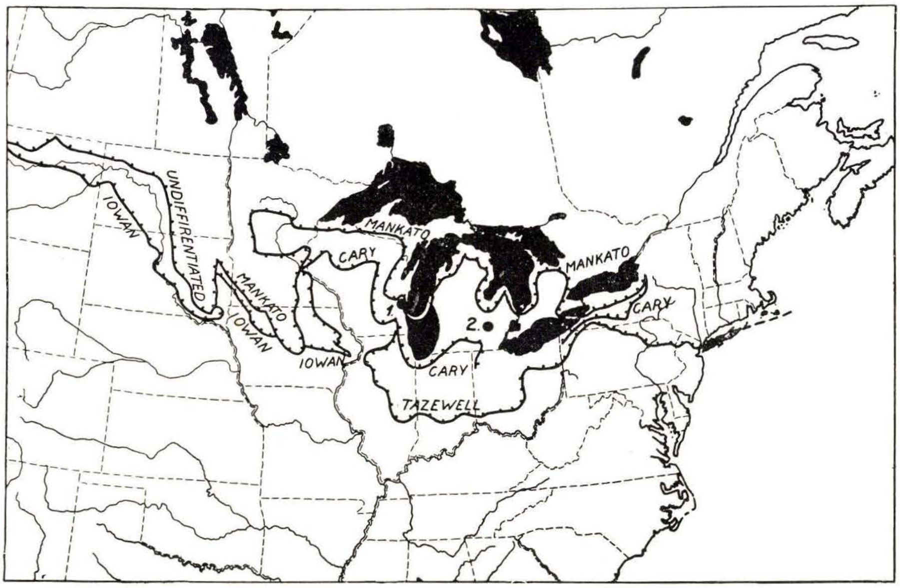


Fig. 1. The main stages of Wisconsin glaciation in central–eastern North America. 1, Two Creeks locality. 2, Location of pollen series from the George Reserve. Data from FLINT and others 1945 (a few revisions have appeared in FLINT 1953).

reach much deeper. The pond to-day is rather shallow, almost 50 feet of sediment being deposited on top of the oldest sample, and is now surrounded by a local swamp forest of *Acer rubrum*, *Populus tremuloides*, and *Larix laricina*. According to the pollen diagram no local swamp vegetation developed until sometime during the postglacial period (about the 25 foot level), and the pollen production of the local vegetation of swamp trees, grasses, sedges, and water plants plays a minor rôle even in the subrecent pollen spectra.

The samples were obtained by a peat borer of the Hiller type. They consist of the following sediments,

55–47 feet. Clay with very little organic content. Stiff and plastic. Colour light grey-yellowish.

46–42 feet. Clay gyttja. Soft and elastic, colour dark grey-yellowish. It gradually changes to organogenic sediment (gyttja) which constitutes the upward continuation of the series.

All samples were subjected to treatment with potassium hydroxyde, hydrofluoric acid, acetolysis mixture, and staining with safranin.

The results of the pollen analyses are presented in a diagram on plate XIII, diagram 1. In the pollen totals forming the bases of the percentages are included all arboreal pollen (AP) and the sum of windpollinated herbs (NAP). The identifications of forest tree pollen are based on the author's collaboration with Cain, during which a large material of modern pollen was investigated; all other identifications were checked with modern pollen. Size-statistical data on the *Picea* pollen indicate the precence of two species with *Picea glauca* dominant; they will be published by Cain and the author together with data on modern pollen. Below are given a few notes on the identification of some critical pollen types (cp. also Erdtman 1943, 1952, Fægri and Iversen 1950).

Juniperus-Thuja. Juniper pollen is indistinguishable from that of *Thuja occidentalis.* As will be discussed below (page 150) it seems most likely that *Juniperus* is the one represented in the fossil material here presented.

Populus. In the identification of *Populus* the author has been rather conservative, causing, as it has proved later, its curve to be too low, and that of the *Cyperaceae*, accordingly, too high.

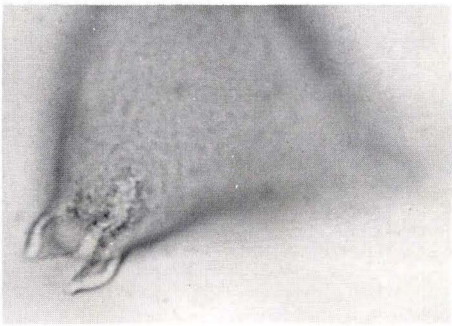
Ostrya-Carpinus. The pollen grains of the North American species (*O. virginiana* (Mill.) K. Koch and *C. caroliana* Walt.) are indistinguishable from each other.

Elaeagnaceae. The pollen grains of this group were treated by Erdtman (1952). *Shepherdia canadensis* (L) Nutt. is readily distinguished. The pollen grains of *Elaeagnus commutata* Bernh. and *Shepherdia argentea* Nutt. have the protruding pores so typical of this family (cp. *Hippophaë*). They are best distinguished from each other by the size of the polar area, the colpi of *Elaeagnus* being extremely short (cp. plate VIII). Five grains of *Elaeagnus commutata* were found, two in the 55 foot sample, and the others in samples from other borings placed in relation to the series by pollen analyses (figures in parenthesis in the pollen diagrams). One of the fossil grains is illustrated on plate VIII.

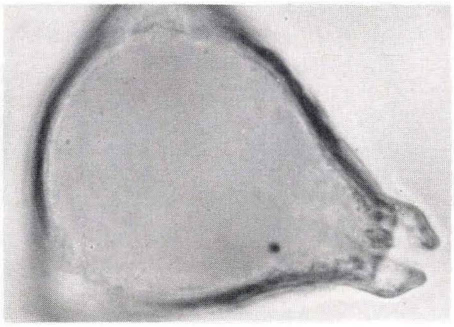
Saxifraga. Pollen grains of *S. oppositifolia* type are well known from late-glacial deposits. To this type also belong S. *aizoides* L., S. *Aizoon* Jacq. and S. *tricuspidata* Rottb. The grain found resembles the last of these very well.

Only a few of the fossil pollen finds are illustrated here. Photomicrographs of the following grains are on file at the Geological Survey of Denmark (D.G.U.). *Rumex* (*acetosella* type), DGU a 951; *Pulsatilla,* DGU a 745; *Elaeagnus commutata,* DGU a 744, a 851, *Polemonium,* DGU a 741, a 921; *Linnaea borealis,* DGU a 746.

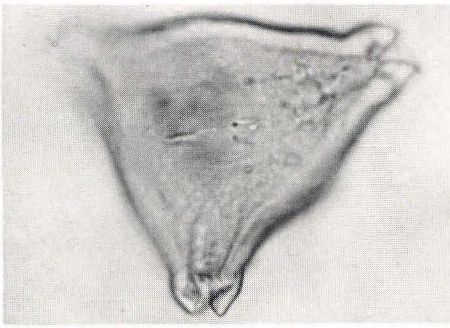
Before the pollen curves of plate XIII, diagram 1 are discussed, attention is called to the character of the sediments (cp. the description above and plate XIII). Any European student of Pleistocene deposits finding such a clay sediment at the bottom of a gyttja deposit representing the post-glacial period, would suspect it of being late-glacial, that is, contemporary with a forestless period when the climate was severe enough for slope-washed clay and sand to dominate the lake deposit. Where no actual permafrost can be demonstrated intensive solifluction according to Troll (1944) is characteristic of climates with long periods of alternating frost and thaw. In boulder clay areas in Denmark there seems to have been a close correlation between severity of climate and the mode of sedimentation in small lakes as revealed by detailed stratigraphical and pollen-



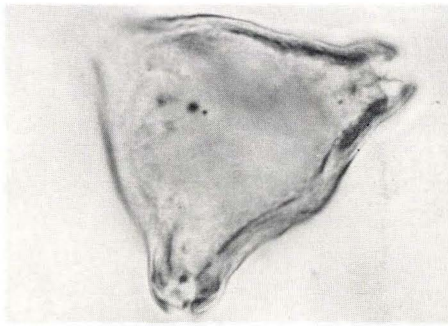
1a



1b



2a



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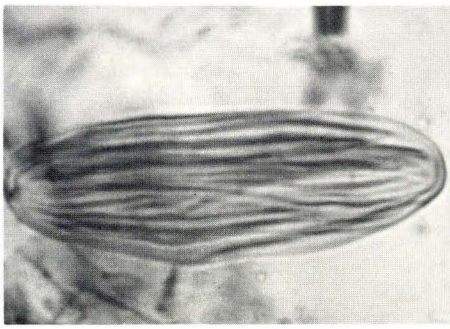

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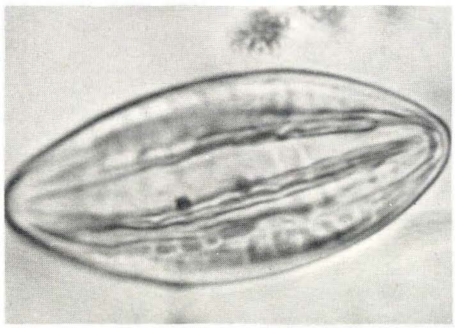

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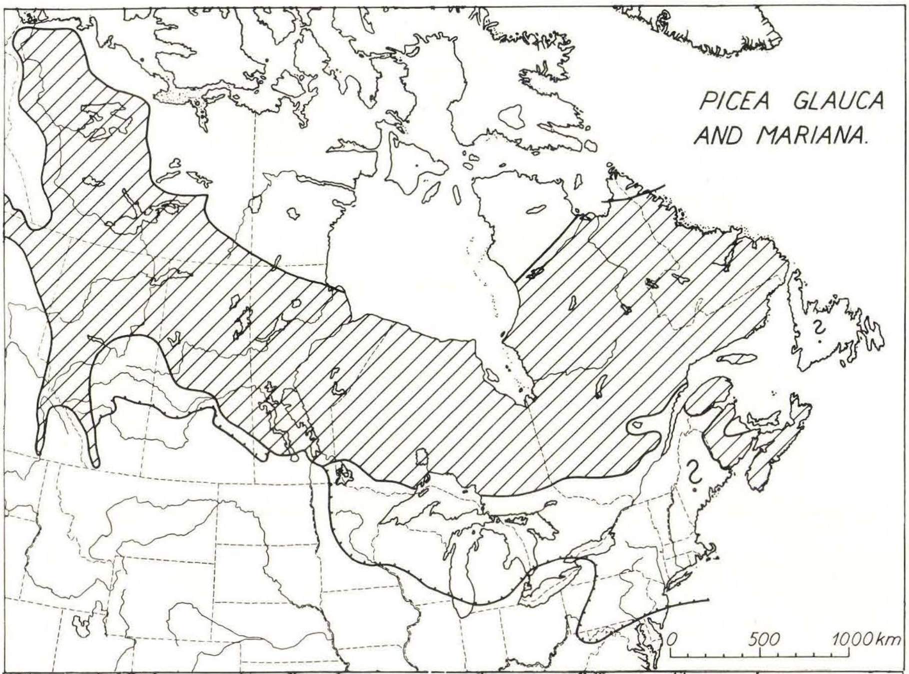
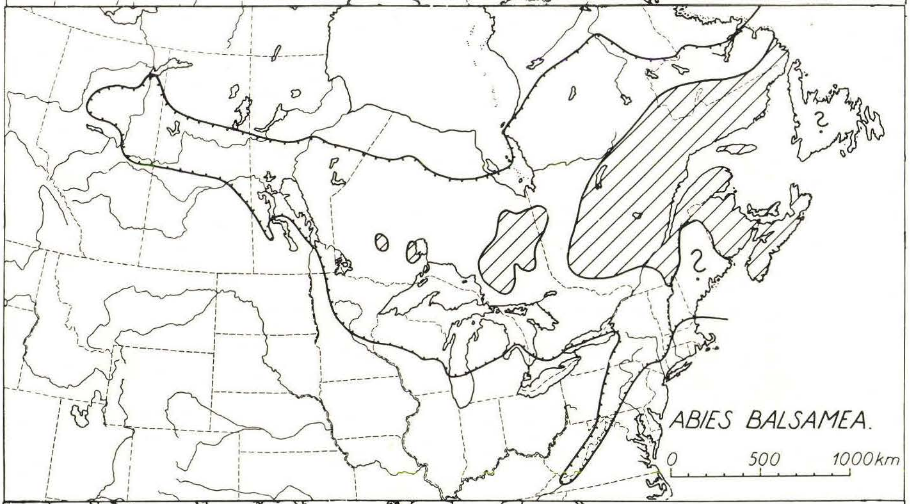
1a-b. *Elaeagnus commutata*, modern. 2a-b. *Elaeagnus commutata*, fossil. 3. *Ephedra* sp. (*Torreyana* type), fossil. 4. *Ephedra* sp. (*nevadensis* type), fossil. Explanation on p. 155.

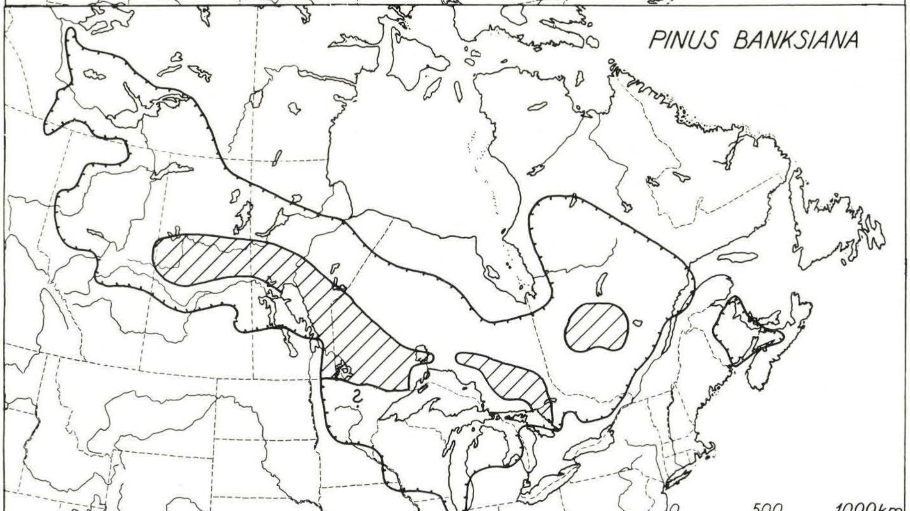
analytical studies of late-glacial deposits (cp. IVERSEN 1947, 1954, plate X). Also DEEVEY (1951 p. 197) seems to be of the opinion that a band of marly sediment intercalated between clay deposits at the bottom of his New England diagrams indicates an ameliorated climate with subsequent change back to cold conditions and clay sedimentation probably during a new ice advance. At the transition to the postglacial (forest) period organic sediment almost invariably replaces clay. One would, therefore, not hesitate to suppose that the clay sediment at the 55–47 foot levels in the diagram presented here was deposited during an unfavourable period, and that the gradual change to organic sediment indicates a definite amelioration of conditions.

Turning to the pollen diagram, however, the picture seems much confused. The composite diagram (A) shows the relative values of arboreal pollen (white area) and herb pollen (hatched area), and curves for *Picea* and *Pinus*, the dominants of the spruce and the pine pollen zones. *Picea* dominates untill it is replaced by *Pinus* in the top sample. It has a maximum of 50% at 55 feet, then declines to values around 30%, and, as the sediment changes from clay to clay-gyttja, rises to another maximum around 40%. In the clay samples *Pinus* is extremely low (1–2%). Such low values of pine, one of the most prolific pollen producers of all trees, show that it can hardly have grown in the region at that time. The herb pollen frequency is relatively high in the clay, it declines in the clay-gyttja and remains insignificant in the gyttja series following above. In the clay high frequency is obtained by a series of southern deciduous forest tree genera, of which *Quercus*, *Ulmus*, *Fraxinus* and *Ostrya-Carpinus* dominate, while others like *Carya*, *Fagus*, *Acer saccharum*, *Juglans* and *Celtis* obtain lower values, but occur constantly. In these samples also pollen of *Juniperus* (-*Thuja?*) and *Populus* is frequent, while that of *Shepherdia canadensis*, *Salix*, *Betula*, *Abies*, *Larix* and *Alnus* occurs rarely or only occasionally.

For a discussion of the pollen flora of the clay samples the present day distribution of *Picea*, *Abies* and *Pinus banksiana*, the northernmost of the American pine species, is illustrated in fig. 2. On basis of the maps of HALLIDAY and BROWN (1943) are shown the areas where these genera obtain the highest population intensities in per cent of the tree stands. The *Picea* species constitute the main part of the boreal forest across northern Canada reaching the Arctic while the northern boundary of *Pinus* is found several hundred miles south of the forest border. In the southern parts of the boreal forest *Pinus* reaches highest frequency (besides P. *banksiana* also P. *strobus* and P. *resinosa* are widespread), and this is also the area, where *Abies balsamea* (cp. fig. 2), *Tsuga canadensis* and *Betula lutea* occur abundantly ("région laurentienne" of MARIE-VICTORIN 1935 and RAYMOND 1950). The absence, or rarity, of these


PICEA GLAUCA
AND MARIANA.
0 500 1000 km


ABIES BALSAMEA.
0 500 1000 km


PINUS BANKSIANA
0 500 1000 km

genera in the clay samples below 46 feet apparently indicates that the spruce vegetation of this period was of a northern (and western) type in terms of present day conditions, confirmed by the pollen finds of such northern plants as *Saxifraga* sp. and *Linnaea borealis*. Very strange is therefore the abundance of pollen from the southern deciduous forest tree genera, all indicators of the Great Lakes-St. Lawrence forest or even more southern communities. Fig. 3 gives the northernmost boundaries of ten such genera, all occuring in the clay samples. Of these *Fraxinus* and *Ulmus* today reach into the area of general *Picea* dominance. *Quercus*, *Acer* and *Ostrya* barely touch this area, and *Fagus*, *Juglans*, *Carya* and *Celtis* are restricted to areas, where *Picea* is of very little importance in the general vegetation. Their northernmost occurrences are of a relic character (cp. DANSEREAU 1943, 1944), and are restricted to the zone where *Pinus* species, *Abies* and others are abundant (cp. also HARE 1950). Altogether the general impression given by the flora of these clay pollen samples is that of a mixture of two communities, which are ecologically difficult to reconcile. If the climate of the spruce period was genial enough for the southern deciduous trees, why are then *Pinus*, *Abies* and *Tsuga* so rare? One may suspect that the southern deciduous forest tree pollen somehow is foreign in the pollen contents of the samples. Significant is the decrease of all these genera in the clay gyttja samples. If these southern trees really belonged to the contemporary vegetation, one would certainly expect them to profit by the amelioration in climate indicated instead of declining.

One explanation might be contamination of the samples with material from the postglacial series above in spite of precautions taken during boring operations. The possibility can be ruled out, however, on the ground that pine pollen is so rare in the clay samples. In case of any contamination from younger deposits much pollen from the six feet of sediment, in which pine reaches a maximum of 70 % of all pollen, would inevitably have been carried down too.

One might also think that the foreign pollen was windborne from more southern localities. Such far-distance transportation may play an important part in tundra areas to-day (AARIO 1940), but again the very low frequency of pine pollen in the samples in question excludes the possibility. If so much pollen from deciduous forest trees was transported from the south by air currents, pine pollen in large quantities would certainly be present too.

Only one explanation remains, the possibility that pollen from some

Fig. 2. Distribution in North America of *Picea* species (*glauca* and *mariana*), *Abies balsamea*, and *Pinus banksiana*. Hatched areas indicates population intensities for *Picea* above 30 %, for *Abies* above 10 %, for *Pinus* above 20 % (data for Canada only). Data from HALLIDAY and BROWN 1943, and MUNNS 1938.

interglacial deposit mixed into the moraine was carried into the lake together with the slope-washed clay. This source of error in pollen analysis was demonstrated by IVERSEN (1936, cp. FÆGRI and IVERSEN 1950), and the frequent occurrence of rebedded pollen in clay sediments within the glaciated region of Northwest Europe is now generally recognized (e.g. SAURAMO 1949). Deposits from warm interglacials are numerous within the glaciated area of North America (cp. FLINT 1947), and it seems very likely that material from such a lake or bog was picked up by the Wisconsin ice and mixed into the moraine laid down around the locality here studied. This assumption would fully explain the fact that the pollen frequencies of all the southern deciduous tree genera decrease above the 47-foot level parallel to the decrease of clay content in the samples. Incidentally the same community of southern genera (*Quercus*, *Carya*, *Ostrya-Carpinus*, *Ulmus*, *Fraxinus* etc.) is met with in samples from later postglacial stages of the lake (above the pine period). Some such could very likely have grown around a lake during the last interglacial period, thus becoming the source of the pollen occurring as rebedded in the clay samples.

Diagram 1 C shows a curve for the summation of genera considered constituents of the rebedded material (including *Quercus*, *Carya*, *Fagus*, *Acer*, *Juglans*, *Ulmus*, *Fraxinus*, *Ostrya-Carpinus*, *Celtis*, *Liquidambar* and *Vitis*). It shows low frequency in the bottom sample (15 %), rises to values of 30–40 %, and, above 47 feet, decreases to 10 %. If this pollen material is rebedded, these genera are, of course, of no significance for the description of the contemporary vegetation, and must be eliminated from the pollen analyses, the basic assumption being, that the rebedded pollen constitutes a vegetational entity (i.e. a deciduous forest community), in which the important members of the actual flora such as *Picea*, *Juniperus* (*-Thuja*), *Shepherdia*, *Elaeagnus*, *Artemisia* and others do not belong. However this may be, the new picture obtained rests on circumstantial evidence only, but is substantiated by its close similarity to the well-known late-glacial vegetation in Europe. One must keep in mind that some curves may still represent rebedded pollen (*Populus*, *Corylus*, *Betula*, *Ambrosia*). Occasionally late-glacial deposits that are purely organic and devoid of contamination are found, and it is hoped that with good luck such will be found in this part of North America and give a more objective picture of the vegetation of this period.

In the recalculated pollen diagram (plate XIII, diagram 2) the spruce-dominated zone is divided into two subzones, the lower one comprising the samples 55–47 feet and the upper 46–43 feet. The lower subzone comprising the clay samples is dominated by *Picea* (40-60 %), and is characterized by high frequencies of *Juniperus* (?) (10–15 %), *Populus*

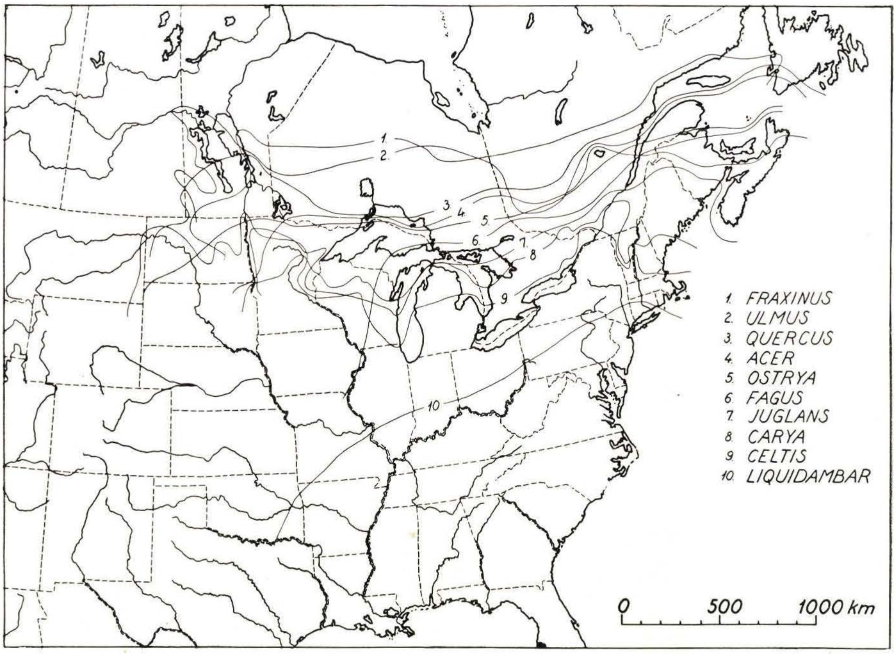


Fig. 3. Northernmost boundaries of 10 deciduous forest tree genera represented i the pollen samples. Redrawn after base maps in MUNNS 1938 of the folowing species: *Fraxinus nigra*, *Ulmus americana*, *Quercus macrocarpa* and *borealis*, *Acer saccharum*, *Ostrya virginiana*, *Fagus grandifolia*, *Juglans cinera*, *Carya cordiformis*, *Celtis occidentalis*, *Liquidambar styraciflua*.

(5 %), *Gramineae* (5 %), *Cyperaceae* (15–20 %), *Artemisia* (10 %) and *Ambrosia* (2–3 %). The total of herbs constitutes 30–35 % of the pollen total. Constantly occuring is *Shepherdia canadensis*, and more occasional are *Elaeagnus commutata*, *Linnaea borealis*, *Saxifraga* sp., *Polemonium*, *Botrychium*, *Rumex* species of the section *acetosella*, and *Pulsatilla*. Some of the spruce pollen may have been wind-transported from spruce forests to the south, but its actual presence in the neighbourhood is demonstrated by the finds of stomata from *Picea* needles (cp. TRAUTMANN 1953) at all levels. An open tree stand is indicated by the light-requiring *Juniperus*(?), *Shepherdia canadensis* and the abundant herbs, especially *Artemisia*. *Shepherdia canadensis* is a low shrub now growing especially in openings of the northern spruce forests and of widespread occurrence; its southern limit to-day is just south of Michigan. *Elaeagnus commutata* is widespread in the Rocky Mountains reaching from Yukon to Utah and Wyoming and has a few isolated stations in Manitoba, Ontario, Quebec and the Gaspé Peninsula, where it is a typical pioneer plant of open habitats on dry unstable soil. *Linnaea borealis* (var. *americana*) is widespread in the northern coniferous forest and transgresses

northward into the tundra. Also *Saxifraga triscupidata*, which is widespread in the Arctic, is characteristic of openings of the northern forests (Rydberg 1922, Marie-Victorin 1935, Raup 1947, Scoggan 1950). As above mentioned, fir (*Abies balsamea*) is almost absent from this vegetation. Its importance in the North American spruce pollen zone seems to have been overestimated (cp. the revised diagrams of Potzger (1946) and also Deevey's New England diagrams (1951)). To-day this mesophytic species reaches the polar forest border in Quebec-Labrador, where precipitation is high, and its highest concentration is in southeastern Canada, (cp. fig. 2). It does not, however, reach far into the Northwest where precipitation is low and summer droughts are frequent (cp. Halliday and Brown 1943, Sanderson 1948), and its rarity in the spruce pollen zone may well indicate that the climate of this period was drier than earlier realized.

The resemblence to the contemporary European vegetation growing under similar conditions near the border of a continental ice sheet is striking and in the author's opinion it substantiates the separation of primary and rebedded pollen types. Common to both areas are the high frequencies of herb pollen, especially *Artemisia*, and the occurrence of *Chenopodiaceae*, *Botrychium*, *Saxifraga* species, the *Rumex* species and, incidentally, also *Polemonium* (Allison, Godwin and Warren 1952, Iversen 1954). The question whether *Juniperus* or *Thuja* is represented in the material from Michigan cannot be decided definitely, but the pollen curve looks exactly like that of *Juniperus* in many European diagrams with a pronounced maximum just at the point, where the herb pollen curve drops off (van der Hammen 1951, Zagwijn 1952, Iversen 1954). Also species of the *Elaeagnaceae* seem to have been characteristic of these pioneer communities (in Europe *Hippophaë rhamnoides*, in Michigan *Shepherdia canadensis* and *Elaegnus commutata*).

At the bottom of the diagram (at 55–54 feet) *Picea* is as high as 60 %, and the herb pollen curves are low. The frequency of rebedded pollen is as low as 15 % in the 55-foot sample (see plate XIII C) indicating a lessened influx of slope-washed material (cp. Iversen 1953). Altogether a less cold climate is indicated, and it seems very natural to compare it with the Two Creeks warmth interval. The lower values of *Picea* in the samples 52–47 feet indicates a more sparse tree vegetation due, then, to climatic deterioration during the Mankato readvance. This readvance seems to have been a vigorous one; it stopped at the Port Huron moraine 100 km to the north, although further westwards it reached lower latitudes (cp. fig. 1). By radiocarbon dating the Two Creeks interstadial has proved synchronous with the Allerød warmth oscillation in North Europe (pollen zone II of the Jessen system), the date being approximately 11,000 years ago (FLINT and DEEVEY 1951, IVERSEN 1953). If this is reliable the Mankato readvance and the tundra-like vegetation represented in the samples 53–47 feet is contemporary with the Younger Dryas period or JESSEN's pollen zone III.

The upper part of the spruce zone (46–43 feet, plate XIII) is transitional to the pine period. Organic material now dominates the sediment, and influx of rebedded pollen is declining. The pinus curve starts rising and there is an increase of *Picea, Abies, Larix* and *Alnus* (and *Sphagnum*), all of which disappear as *Pinus* reaches full dominance at 42 feet. The herb pollen total and *Juniperus* (?) drop off during this period indicating a denser tree stand. Altogether an improvement of conditions and probably slightly moister climate seem indicated. *Abies* (and *Alnus*) show a similar maximum in DEEVEY's New England diagrams (1951, zone A3) intercalated between the level, where the herb pollen total reaches "normal" values (below 10%), and the pine period.

The interpretation of this fossil material as given above is on many points yet open to question, but it seems the one that best fits all the facts presented. If the picture is true this late-glacial plant community conforms very well with the ideas of a periglacial forestless vegetation suggested by the botanists cited in the introduction (page 141). The theory of a connection with the Rocky Mountains open for the migration of pioneer plants across the continent as late as the retreat of the Wisconsin ice is supported, as also demonstrated by the fossil finds of *Elaeagnus commutata*, one of the famous Cordilleran relics in Eastern North America. Following the example of DEEVEY (1951) a tentative correlation table (fig. 4) for the glacial chronology in North America, and the vegetational development of the George Reserve area, central Maine and Northwest Europe is ventured, but it must be regarded as merely a working hypothesis until, eventually, stronger evidence is at hand.

Postscript.

After the manuscript was written, the author, while going over a large number of slides, found five pollen grains of *Ephedra* spp., one in the 45 foot-, three in the 46 foot- and one in the 55 foot-sample. Both main types described by WODEHOUSE (1935) were found, so at least two species are represented (see plate VIII). To-day *Ephedra* species in North America are restricted to the southern parts of the Rocky Mountain chain (CUTLER 1939). In northern Europe *Ephedra*, which to-day is not found north of the Alps, has proved to have been widespread although rare during the late-glacial, and it seems that the thermal requirements of these plants may not be very specific (IVERSEN 1951, 1954, LANG

Glacial chronology in North America	George Reserve, southern Michigan	Zonation in Maine (DEEVEY 1951)		Zonation in Northwest Europe (JESSEN 1949. cp. DEEVEY 1951).	
	pine maximum	B	pine maximum	V	Boreal
	Picea dominant, *Pinus* rising, increase of *Abies*, *Larix* and *Alnus*, NAP falls	A	*Abies* and *Betula* rise, *Alnus* max. *Picea* maximum *Betula* rises, NAP falls	IV	Pre-Boreal
Mankato readvance	*Picea* decreases, NAP high. Parklike vegetation	L3	NAP higher	III	Younger *Dryas* or *Salix herbacea* period
Two Creeks interval	*Picea* dom. NAP low (only the top of the period represented). Basin filled by dead ice?	L2	NAP lower, *Picea* and *Betula* rise	II	Alleröd warmth oscillation
Cary substage		L1	NAP high, long distance transport of tree pollen	I	Older *Dryas* or *Salix herbacea* period.

Fig. 4.

1951, HAFSTEN 1953, see also GAMS 1952). As the late-glacial vegetation of southern Michigan was interpreted above stressing the low competition pressure, that seems to have existed, we must consider the possibility that these steppe and desert plants actually grew there too, although possibly as rare plants on some edaphically favourable spot with strong insolation.

Dansk resumé.

For at kunne forklare den reliktagtige forekomst i det østlige Nordamerika af en række planter, der nu ellers har deres hovedudbredelse i RockyMountains, anses det af visse forfattere nødvendigt at antage, at de under sidste istid havde en sammenhængende udbredelse i et skovløst bælte, som strakte sig tværs over kontinentet syd for isranden; men denne teori har med en enkelt undtagelse (DEEVEY 1951) ikke fundet støtte i det palæobotaniske materiale.

En serie prøver af ler og lergytje, som danner den nedre fortsættelse af en postglacial gytjeaflejring i en lille sø i det sydlige Michigan i det centrale U. S. A., er blevet pollenanalyseret, og diagrammet præsenteres (se tavle II). Prøvernes indhold af pollen repræsenterer en blanding af en nordvestlig og en sydøstlig vegetationstype, og tilstedeværelsen af omlejret interglacialt pollen, således som det er kendt fra senglaciale aflejringer herhjemme (IVERSEN), sandsynliggøres. Det sekundære pollen søges udskilt, og det resulterende billede synes bekræftet ved sin slående lighed med den velkendte senglaciale vegetation i Nordvesteuropa. Vegetationens åbne og tørre karakter og tilstedeværelsen af pionérplanter, specielt *Elaeagnus commutata*, en af de omtalte i Østamerika reliktagtige arter, støtter de nævnte teorier om disse planters tidligere vide udbredelse. Overraskende er fundene af mindst to arter af ørken- og steppeplanten *Ephedra*, som også er kendt fra den senglaciale vegetation herhjemme (IVERSEN, LANG, HAFSTEN). En Korrelation med senglaciale serier fra Nordamerika (WILSON, DEEVEY) og Nordeuropa (JESSEN) er forsøgt, idet spor af Two Creeks—Allerød Oscillationen menes påvist i diagrammet.

Literature.

AARIO, L. 1940: Waldgrenzen und subrezente Pollenspektren in Petsamo Lappland. Ann. Acad. Scient. Fenn. Ser. A. Tom. LIV, Nr. 8. Helsinki.

ALLISON, J, GODWIN, H., and WARREN, S. H. 1952: Late-glacial deposits at Nazeing in the Lea Valley, North London. Royal Soc. London, Philos. Tr., Ser. B, Vol. 236. London.

BÖCHER, T. W. 1951: Distributions of plants in the circumpolar area in relation to ecological and historical factors. Jour. Ecol., Vol. 39. Cambridge.

CAIN, S. A. 1940: Some observations on the concept of species senescense. Ecology, Vol. 21. Durham, NC.

COOPER, W. S. 1942: Vegetation of the Prince William Sound region, Alaska, with a brief excursion into post-Pleistocene climatic history. Ecol. Monogr., Vol. 12. Durham, N.C.

CUTLER, H. C. 1939: Monograph of the North American species of the genus *Ephedra*. Missouri Bot. Gard., Ann. Vol. 26. Fulton, Mo.

DANSEREAU, P. 1943: L'érablière laurentienne. I. Inst. Bot. Univ. Montréal, No. 45.

— 1944: Les érablières de la Gaspésie et les fluctuations du climat. Inst. Bot. Univ. Montréal, Contrib., No. 51. Montréal.

— 1951: Description and recording of vegetation upon a structural basis. Ecology, Vol. 32. Durham, N.C.

DEEVEY, E. S. 1949: Biogeography of the Pleistocene. Geol. Soc. America, Bull. Vol. 60.

— 1951: Late-glacial and postglacial pollen diagrams from Maine. Am. Jour. Sci., Vol. 249. Baltimore, Md.

DENNY, C. S. 1951: Pleistocene frost action near the border of the Wisconsin drift in Pennsylvania. Ohio Jour. Sci., Vol. LI. Columbus, O.

ERDTMAN, G. 1943: An introduction to pollen-analysis. Waltham, Mass.

— 1952: Pollen morphology and plant taxonomy. Angiosperms. Stockholm and Waltham.

FERNALD, M. L. 1925: Persistence of plants in unglaciated areas of boreal America. Am. Acad. Arts Sci., Mem., Vol. 15.

— 1935: Critical plants of the Upper Great Lakes region of Ontario and Michigan. Rhodora, Vol. 37. Lancaster, Pa.

FIRBAS, F. 1950: The late-glacial vegetation of central Europe. New Phytol., Vol. 49. London.

Flint, R. F. 1947: Glacial geology and the Pleistocene epoch. New York and London.
— 1953: Probable Wisconsin substages in northeastern United States and southeastern Canada. Geol. Soc. Am., Bull., Vol. 64. Baltimore, Md.
Flint, R. F. and others 1945: Glacial map of North America. Geol. Soc. Am., Spec. Papers., Vol. 60. Baltimore, Md.
Flint, R. F. and Deevey, E. S. 1951: Radiocarbon dating of late-Pleistocene events. Am. Jour. Sci., Vol. 249. New Haven, Conn.
Fægri, K., and Iversen, J. 1950: Textbook of modern pollen-analysis. Copenhagen.
Gams, H. 1952: Das Meerträubl (*Ephedra*) und seine Ausbreitung in Europa. Jahrb. des Vereins zum Schutze der Alpenpfl. und -Tiere. München.
Godwin, H. 1947: The late-glacial period. Sci. Progress, No. 138. New Haven, Conn.
Hafsten, U. 1953: Nyoppdagede pionérplanter i Norge etter istiden. Naturen, No. 16. Bergen and København.
Halliday, W. E. D., and Brown, A. W. A. 1943: The distribution of some important forest trees in Canada. Ecology, Vol. 24. Durham, N.C.
Hammen, T. van der. 1951: Late-glacial flora and periglacial phenomena in the Netherlands. Leidse Geol. Medd., Deel XVII. Leiden.
Hare, F. H. 1950: Climate and zonal divisions of the boreal forest formation in eastern Canada. Geog. Rev., Vol. 40. Burlington, Vt.
Hustich, I. 1950: On the forest geography of the Labrador peninsula. Acta Geog. 10. Helsinki.
Iversen, J. 1936: Sekundäres Pollen als Fehlerqulle. Eine Korrektionsmetode zur Pollenanalyse minerogener Sedimente. Danm. Geol. Unders., IV Række, Bd. 2, Nr. 15. København.
— 1947: Plantevaekst, Dyreliv og Klima i det senglaciale Danmark. Geol. Fören. Stockh., Förh., Bd. 69. Stockholm.
— 1951: Steppeelementer i den senglaciale Flora og Fauna. Dansk Geol. Foren., Medd., Bd. 12. København.
— 1953: Radiocarbon dating of the Allerød period. Science, Vol. 118. New York, N.Y.
— 1954: The late-glacial flora of Denmark and its relation to climate and soil. Danm. Geol. Unders. II Række, Nr. 80. København.
Jessen, K. 1949: Studies in the late Quaternary deposits and flora history of Ireland. Royal Irish Acad., Proc., Vol. 52, Sect. B, No. 6. Dublin and London.
Lang, G. 1951: Nachweis von *Ephedra* im südwestdeutschen Spätglazial. Die Naturwissenschaften, Bd. 38. Berlin.
Munns, E. N. 1938: The distribution of important forest trees of the United States. U. S. Dept. of Agric., Misc. Publ., Vol. 287. Washington, DC.
Marie-Victorin, F. 1925: Sur quelques Composées nouvelles, rares ou critiques du Québec oriental. Inst. Bot. Univ. Montréal, Contrib., No. 5. Montréal.
— 1935: Flore Laurentienne. Montréal.
— 1938: Phytogeographical problems of eastern Canada. Am. Midl. Naturalist, Vol. 19. Notre Dame, Ind.
Potzger, J. E. 1946: Phytosociology of the primeval forest in Central-Northern Wisconsin and Upper Michigan, and a brief post-glacial history of the Lake Forest formation. Ecol. Monogr., Vol. 16. Durham N.C.
— 1951: The fossil record near the glacial border. Ohio Jour. Sci., Vol. LI. Columbus, O.
Raup, H. 1934: Phytogeographic studies in the Peace and upper Liard River regions. Arnold Arb., Contr., 6. Jamaica Plain, Mass.
— 1941: Botanical problems in boreal America. Bot. Rev., Vol. 7. New York, N.Y.
— 1946: Phytogeographic studies in the Athabaska-Great Slave Lake region II. Forests. Arnold Arb., Jour. Vol. 27. Jamaica Plain, Mass.
— 1947: The botany of southwestern Mackenzie. Sargentia, Vol. 6. Jamaica Plain, Mass.

RAYMOND, M. 1950: Esquisse phytogéographique du Québec. Jardin Bot. Montréal, Mem., No. 5. Montréal.

ROUSSEAU, J. 1933: Les Astragalus du Québec et leurs alliés immédiats. Lab. Bot. Univ. Montréal, Contr., No. 24. Montréal.

— 1950: Cheminements botaniques à travers Anticosti. Can. Jour. Research, Ser. C. Vol. 28. Ottawa.

RYDBERG, P. A. 1922: Flora of the Rocky Mountains and adjacent plains. New York.

SANDERSON, M. 1948: Drought in the Canadian Northwest. Geog. Rev., Vol. 38. Burlington, Vt.

SAURAMO, M. 1949: Das dritte Scharnier der fennoskandischen Landhebung. Soc. Sci. Fenn. Jahrb. 27 B. Helsinki.

SCOGGAN, H. J. 1950: The flora of Bic and the Gaspé peninsula, Quebec. Nat. Mus. Canada, Bull. No. 115. Ottowa.

SEARS, P. B. 1942: Forest sequences in the north central states. Bot. Gazette Vol. 103. Chicago, Ill.

SMITH, H. T. U. 1949: Physical effects of Pleistocene climatic changes in nonglaciated areas: Eolian phenomena, frost action, and stream terracing. Geol. Soc. Am., Bull., Vol. 60. Baltimore, Md.

TRAUTMANN, W. 1953: Zur Unterscheidung fossiler Spaltöffnungen der mitteleuropäischen Coniferen. Flora, Bd. 140. Jena.

TROLL, C. 1944: Strukturböden, Solifluktion und Frostklimate der Erde. Geol. Rundschau, Bd. XXXIV. Stuttgart.

WILSON, L. R. 1932: The Two Creeks forest bed, Manitowoc County, Wisconsin. Wisc. Acad. Sci., Trans., Vol. 27. Madison, Wisc.

— 1936: Further fossil studies of the Two Creeks forest bed, Manitowoc County, Wisconsin. Torrey Bot. Club, Bull., Vol. 63. New York, N.Y.

WODEHOUSE R. P. 1935: Pollen grains. New York and London.

ZAGWIJN, W. H. 1952: Pollenanalytische Untersuchung einer spätglazialen Seeablagerung aus Tirol. Geol. en Mijngeb., Nw. Serie Nr. 7, 14. Jahrg. Leiden.

Explanation of Plate VIII.

1 a-b. *Elaeagnus commutata* Bernh. Modern pollen grain, coll. from Sweetwater Co., Wyoming. Treated with KOH and acetolysis mixture. 1000 ×. Phot. S. Th. Andersen.

2 a-b. *Elaeagnus commutata* Bernh. Fossil pollen grain from the George Reserve, Livingstone Co., Michigan, sample at 55 feet. Treated with KOH, HF, and acetolysis mixture. 1000 ×. (The size is smaller than that of the modern material, due to fossilization and the different chemical treatment). DGU a 851, phot. H. Krog & S. Th. Andersen.

3. *Ephedra* sp. (*Torreyana*-type). Fossil pollen grain from the George Reserve, sample at 45 feet. Treated with KOH, HF, and acetolysis mixture. 1000 ×. DGU a 853, phot. H. Krog & S. Th. Andersen.

4. *Ephedra* sp. (*nevadensis*-type). Fossil pollen grain from the George Reserve, sample at 55 feet. Treated with KOH, HF, and acetolysis mixture. 1000 ×. DGU a 852, phot. H. Krog & S. Th. Andersen.

Late-glacial Macroscopic Plant Remains from Böllingsö.

By

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Abstract.

Pollen-analytically dated washing-samples from borings in the central part of the dried-up lake Böllingsö have been analyzed. A list of the fossils appears on page 157.

Right on the margin of the last glaciation in Central Jutland lies the now dried-up lake Böllingsö. Its basin, about 1 km. in diameter, was formed by a meltwater river in the beginning of the Daniglacial period. Deposited on its bottom is a very complete series of late-glacial sediments which, stratigraphically and pollen-analytically, give evidence of a transient climatic improvement prior to the Allerød Oscillation, the so-called Bölling Oscillation (JOHS. IVERSEN 1942).

When Dr. Johs. Iversen in 1946 continued his investigations in Böllingsö, a series of washing-samples was taken in conjunction with the pollen-sample series; the contents of plant remains in these samples will be described briefly in the following.

The samples, 38 in all, were taken from 6 boring points in a line across the central part of the basin. They were secured with an ordinary Hiller peat borer and, after being treated briefly with diluted nitric acid, they were suspended in water from the well of a farm outside of the investigation area.

The result of the macrofossil analysis is given in the table on page 157. The dating of the samples is based partly upon orientative microscopic analyses (by Dr. Johs. Iversen) parallel with the field work, partly upon an unpublished pollen diagram from one of the boring points (analyzed by H. Krog, M.Sc.). As the samples were secured in the field they were also dated stratigraphically. The subsequent establishment of the pollen-analytical zone boundaries showed that in general they coincided with the strati-

Table 1. List of fossils.

Abbreviations: f=fruits, fl=catkin-scales of birch, fst=fruitstones, l=leaves, s=seeds, sh=shoots, sp=spores.

Pollen analytical zones		Oldest Dryas period	Bölling period	Older Dryas period	Alleröd period		Younger Dryas period
		I a	I b	I c	II a	II b	III
Total vertical lengths of boring cores, in cm.		163	52	60	108	103	105
Batrachium sp.	f	..	..	..	1	..	3
Betula nana	f	1	2	1	6	..	1
» »	fl	..	..	1	3	..	..
» »	l	..	..	..	..	..	1
» sp.	f	..	..	..	2	..	..
Carex distigmaticae	f	..	..	..	..	2	4
» *tristigmaticae*	f	..	..	..	..	2	11
Caryophyllaceae	s	1	..	..	3	..	..
Dryas octopetala	l	..	1	..	..	..	1
Empetrum nigrum	fst	..	..	..	1	2	3
» »	sh	..	..	..	..	1	..
Potamogeton filiformis	fst	..	..	1	5	1	..
» *perfoliatus*	fst	..	1	..	7	..	..
» *praelongus*	fst	7*	14	..	6	..	..
» spp.	fst	..	4	..	1	..	..
Potentilla palustris	f	..	1	..	..	..	..
Salix herbacea	l	..	..	1	..	..	..
» cf. *polaris*	l	2	1	5	..	..	1
Characeae	sp	..	32	1	..	1	..

graphical boundaries. Below each of the pollen-analytical zones the quantity of material is indicated by the total lengths of the cores. The number of fruits, leaves, etc. from the various zones is also given.

As was to be anticipated, these samples from the middle of a fair-sized lake basin are rather poor in macroscopic plant remains. On the other hand, pollen-dating of such samples is more reliable than of samples from the rich strata near the shore. This investigation has provided a reliable dating of the occurrence of three species of *Potamogeton* which cannot be distinguished pollen-analytically, viz. *P. filiformis*, *P. perfoliatus* and *P. praelongus*.

*) all found in one sampling core, the uppermost part of which touched the border of zone I b.

The fruits and leaves of terrestrial plants contained in the samples can only give an incomplete picture of the general vegetation, whereas one may presume that the local lacustrine vegetation is well represented, qualitatively and quantitatively, by the fruits found; therefore, although the material on the whole is not especially large, one may conclude that the three *Potamogeton* species mentioned above played a considerable rôle in the flora during the Bölling period (Zone I b) and the first phase of the Alleröd period (Zone II a). Still another *Potamogeton* species is represented by 4 fruits which, however, could not be identified.

The three species of *Potamogeton* mentioned have a wide distribution northwards; they occur almost everywhere in Scandinavia, growing fairly high up in the mountains. As to Dalarne-Jemtland it has been reported that *P. filiformis* reaches up to 1,000 metres, *P. perfoliatus* to 820 metres and *P. praelongus* to 760 metres (SAMUELSSON 1934), but whether they bear fruit or not at these levels has not been stated. *Potamogeton filiformis* also grows in Arctic regions: it has been found with ripe fruits in northeastern Greenland as far north as lat. 74° N. (GELTING 1934). *Potamogeton perfoliatus* and *P. praelongus* do not seem to have been observed in purely Arctic regions; they both grow in Iceland (GRÖNTVED 1942), but not in Greenland.

Judging from these distribution reports, the presence of fruits of *Potamogeton praelongus* at the transition to Zone I b (the Bölling period) suggests that the climate cannot have been really Arctic at that time.

Referenecs.

GELTING, PAUL. 1934. Studies on the Vascular Plants of East Greenland between Franz Joseph Fjord and Dove Bay. Meddelelser om Grønland. Bd. 101, Nr. 2. København.

GRÖNTVED, JOHS. 1942. The Pteridophyta and Spermatophyta of Iceland. The Botany of Iceland. Vol. IV, Part I. Copenhagen, London.

IVERSEN, JOHS. 1942. En pollenanalytisk Tidsfæstelse af Ferskvandslagene ved Nørre Lyngby. Meddelelser fra Dansk Geologisk Forening. Bd. 10, Hf. 2. København.

SAMUELSSON, GUNNAR. 1934. Die Verbreitung der höheren Wasserpflanzen in Nordeuropa (Fennoskandien und Dänemark). Acta Phytogeographica Suecica. VI. Uppsala.

Dansk resumé.

Der er analyseret 38 slæmmeprøver fra 6 boringer gennem de senglaciale lag i den centrale del af den udtørrede Böllingsö. Tabellen side 157 viser resultatet af makrofossilanalysen. Under hver af de pollenanalytiske zoner er mængden af slæmmet materiale angivet ved de sammenlagte længder af de prøver, der er udtaget af tørveborets kammer. Analyserne viser, at *Potamogeton praelongus* og *P. perfoliatus* har spillet en væsentlig rolle i zone I b (Bölling-perioden) og zone II a (Alleröd-perioden). På grundlag af disse arters nuværende udbredelse mod nord formodes det, at klimaet allerede ved overgangen til zone I b ikke har været rent arktisk.

A Pollen Analytical Dating of Maglemose Finds from the Bog Aamosen, Zealand.

By

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Abstract.

The present paper contains the dating by pollen analysis of a large flint pick and a Maglemose site.

The pollen-analytical zone borders IV to VII, as established by KNUD JESSEN, are subjected to renewed consideration, and arguments are stated in favour of a different definition of zone borders V–VI and VI–VII.

A summary is given of mesolithic finds from the periods mentioned above, dated by pollen analysis.

Contents.

Introduction.

More than a hundred years have passed since archaeology and natural science began to co-operate in this country. This co-operation, like all real teamwork, has proved highly beneficial to both parties. Often archaeology has offered valuable assistance to natural science, when the finding of antiquities in geological deposits of various types has led to their archaeological dating. On the other hand, natural science has not only thrown light on the prevalent natural environment of different prehistoric culture periods, but has also led to geological datings of finds which it was difficult, or at the moment impossible, to date by means of archaeology.

The following is an account of the dating of a rare type of artifact to which, until now, it has not been possible to give an exact archaeological dating.

The object in question is one of the so-called "large flint picks" (Fig. 1), which was found by KNUD ANDERSEN in the mid-Zealand bog Aamosen, whose wealth in cultural remains seems inexhaustible.

In conclusion, a summary is given of the results of the investigation.

I. The Stratigraphical and Pollen-analytical Investigation.

A. Verup Mose, Flint pick.

As for conditions connected with the discovery of the flint pick, as well as the archaeological aspects of the case, here is the statement of the finder KNUD ANDERSEN:

"In the spring of 1951, Brovad canal in Aamosen was deepened, and in the summer of that year a heavy flint pick was found incorporated in the western brink of the canal. There was no culture layer, but near the pick were a couple of primary flakes, and besides, in the earth dug from the canal were found a number of big blades. A few trial cuts into the east side of the canal showed a thin culture layer with some flint debris and quite a bit of charcoal. The place of discovery was marked, and a few weeks later a series of pollen samples were taken. The Verup settlement, a Maglemose site, is situated about twenty metres east of the canal; judging from the position of the find, the possibility exists that the flint pick belongs to this settlement.

The heavy picks are conspicuous and easily recognizable artifacts. Strangely enough only a few specimens are known, hardly more than 30 or 40 from this country, 15 of which were found in Aamosen, and it has been difficult to place them within any definite culture group. They were first mentioned in "Aarbøger for nordisk oldkyndighed" 1896, p. 341–345, in which SOPHUS MÜLLER describes seven specimens, stating the theory that they belong to the period between the kitchen middens and the Late Stone Age. In "Nordiske fortidsminder" III, 3 pp. 19, 25, 28, and 69, T. MATHIASSEN deals with the picks originating from the great excavations in Aamosen; he classes them with the earlier part of the Øgårde settlement. A description of the type is given in "Danske oldsager" I, no. 45 (MATHIASSEN 1948).

The implement here depicted (Fig. 1) is typical, it is 245 mm. long, 59 mm. broad, and 51 mm. thick; the point, however, is broken off, so that its total length must have been c. 280 mm. The points of the well-preserved specimens are blunt and never approach anything like real edges. The implement was shaped by blows from four angles; the under side is formed by two planes. In other flints this side may be approximately plane, for which reason they are sometimes called triangular.

Finds recovered in Aamosen since 1943 corroborate the supposition that

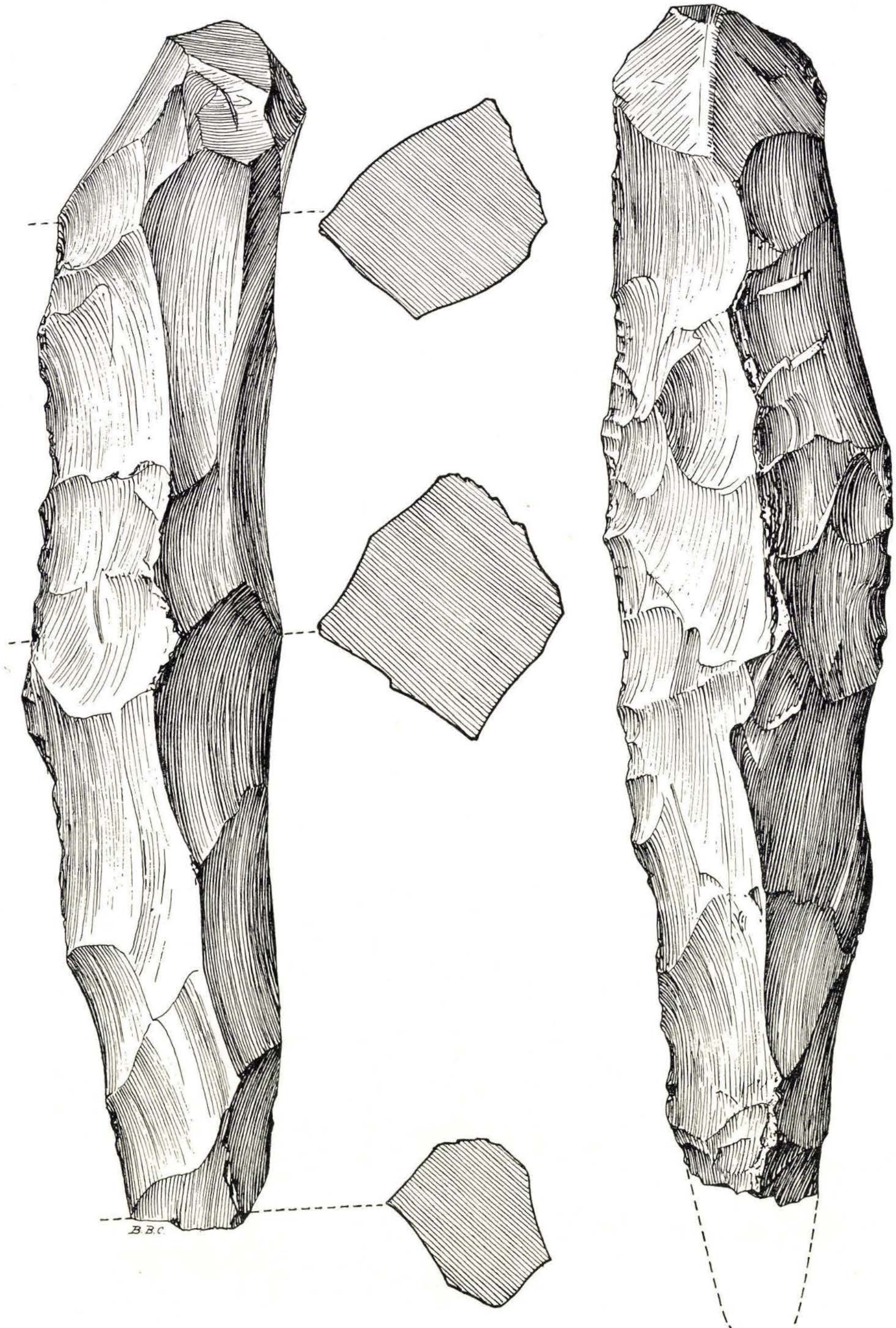

Fig. 1. Large flint pick. Nilöse komplexet, Nilöse S., Merlöse H, Holbæk A. — 2/3.
Reproduced from drawing by B. Brorson Christensen.

this type of artifact belongs to the so-called old coastal culture, or in other words, the earliest phase, or the forerunner, of the typical Ertebølle culture. It has proved possible to divide the old coastal culture into two subcategories, one of which is characterized by oblique arrow heads, some transverse arrow heads and numerous end-of-blade scrapers etc., whereas the other, which is doubtless of later date, also has numerous keeled scrapers (which, however, are hardly ever made of regular handled cores), besides a few triangular microliths. The large flint picks belong to the former category."

On the 3rd of August 1951 the place of discovery was visited by KNUD ANDERSEN, J. TROELS-SMITH and the author, and a geological investigation was undertaken by the two latter.

A vertical section was cleaned up, after which a series of pollen samples were taken at maximum intervals of 3 cm. between the single samples; in addition, a section description was worked out. Owing to the high water level of the canal, the height of the section was only c. 0.50 m., and the term surface refers neither to the former nor to the present bog surface, but to the surface of the section point. In the section description the characterization and composition of the various layers are indicated by a number of symbols, as defined by J. TROELS-SMITH (1954a).

The sequence of layers, beginning at the surface, was this:

c2. 0.00 to 0.21 m.: swamp peat. lim.sup. 4,
nig. 3, strf. 2, elas. 2–3, sicc. 2, color: blackich brown, struc.: felted. Composition: $Th^1 2$, *Dl* +, *Dh* +, *Dg* 1, $Ld^2 1$.—*Th*: rootfelt and herbaceous roots. *Dl*: small twigs of *Alnus*. *Dh*: leaves of *Salix* sp., fragment of *Nymphaea* rhizome. Fv: fruits of *Scirpus* sp.

c1. 0.21 to 0.28 m.: swamp peat with slight content of lake marl. lim. sup. 1,
nig. 3, strf. +, elas. 2–3, sicc. 2, color: black brownish, struc.: highly felted.
Composition: $Th^1 2$, *Dl* +, *Dg* 1, $Ld^2 1$, *Lc* +, [β +].—*Th*: rootfelt, vertical yellow herbaceous roots. *Dl*: a few small twigs. The lake marl occurs in small blots scattered in horizontal layers, in which is found [β +].

b2. 0.28 to 0.325 m.: lake marl containing swamp peat. lim.sup. 1,
nig. 2–3, strf. 1–2, sicc. 2, color: black brownish, struc.: felted. Composition: $Th^1 2$, *Dh* +, Ld° +, *Lc* 2, [β +].—*Th*: rootfelt, a few thin, yellow herbaceous roots, one rhizome of *Phragmites*. *Dh*: fragments of *Thelypteris* leaf stalks.

b1. 0.325 to 0.39 m.: lake marl with numerous smears of the layer above it. lim.sup. 1,
color: brownish, grey-speckled.
Composition of lake marl: as the layer below it.

a. 0.39 m. to 0.00 m.: lake marl. lim.sup. 2,
nig. +, strf. 2, elas. +, sicc. 2, color: greyish white, occasionally with slight greenish tinge, struc.: gritty.
Composition: Th° +, $Ld^\circ 1$, *Lc* 3, [α +].—*Th*: a few rootlets, a few vertical, yellow herbaceous roots. Fa: shells of *Bithynia tentaculata* + operculum of these.

The position of the flint pick was 0.02 to 0.07 m. below the surface, and its longitudinal axis was very nearly horizontal. The implement was thus completely incorporated in a felted swamp peat containing a slight quantity of gyttja.

The analyses of the pollen samples were made by the author in Nationalmuseets Moselaboratorium (Bog Laboratory of the National Museum) about New Year 1953, with the exception of analyses no. 4, 5, 7, 9, and 10, which were made in December 1953 and January 1954. All samples were in the same condition as when they were taken. Boiling and preparation were made in accordance with the usual method of the Laboratory (cp. J. TROELS-SMITH, 1954b). The analyses were made on acetolysed and stained material. All pollen and spores which occur are counted, besides a number of other micro-fossils. Important pollen grains and spores and rare or unknown types (X-pollen) have been measured and recorded, to be at hand for documentation or further study. Besides, in each sample at least a hundred *Corylus* pollen grains have been measured as a basis for size comparison; also, all grains of *Gramineae* and *Typha* have been measured.

The statistical results of the countings have been delineated in two diagrams—a main diagram and a survey diagram. The nomenclature used is that of HYLANDER (1941).

The Main Diagram (Plate XIV, Fig. 1). The basic sum is the sum of all pollen from trees and bushes.

On the extreme left are shown the curves of common forest trees, among which *Corylus* is included; a joint curve is given for the trees of the Oak-Mixed-Forest. In the next two columns this curve is differentiated, being expressed first in percentages and then, because of *Fraxinus*, in rates per thousand; after that the less frequent trees and shrubs, together with *Hedera* and *Viscum*, are shown in silhouette curves. The degree of destruction (cp. TROELS-SMITH, 1941a, p. 138), indicated graphically after the column showing zone borders, has been calculated in order to give more reliable evidence of the state of preservation than would be possible through a general estimate. Here, the following method has been used in calculation: Pollen grains of *Tilia*, *Ulmus*, *Betula*, *Alnus*, *Corylus*, and *Gramineae* showing signs of destruction are expressed as percentages of Σ *Tilia*, *Ulmus*, *Betula*, *Alnus*, *Corylus*, and *Gramineae*. *Quercus*, *Pinus*, and *Cyperaceae* are not included in the calculation, as faint marks of destruction are hardly discernible in these types of pollen.

The next part of the diagram gives silhouette curves for herbaceous phanerogams, which are arranged alphabetically, no matter whether the determinations refer to family, genus, or species.

Archegoniatae are arranged on similar lines in the following part of the diagram, and the curve for *Pediastrum* is given last.

In the section column (symbols, cf. TROELS-SMITH, 1954a), the flint pick is marked as a hatched rectangle, whereas the black column facing the diagram indicates the presence of microscopically found charcoal dust.

The Survey Diagram (Plate XIV, Fig. 2) is a juxtaposition of six diagrams (I to VI).

I. The classical pollen diagram (v. POST 1916), in which *Corylus* is excluded from the basic sum comprising pollen grains of common forest trees. This diagram has been included to serve as a comparison with other diagrams based on the same method of calculation.

II. "Reduced" diagram. Here the basic pollen sum is Σ *Betula*:4, *Corylus*:4, *Fraxinus*, *Pinus*:4, *Quercus*, *Tilia*, *Ulmus*, *Hedera*, and *Viscum*[1]) (= ΣII). *Alnus* and *Salix* have been kept apart from the sum as they often express purely local conditions, thus giving an incorrect regional forest picture (WELTEN 1947). By reducing the large-scale pollen producers (cf. IVERSEN 1947, p. 241), we can get nearer to a correct picture of the proportional composition of the forest, and it must be assumed that the curves of the diagram express the forest development more exactly than the curves of the classical diagram. The first part of the diagram shows the curves of trees included in the basic sum, besides the curve of the Oak-Mixed-Forest; an exception to this is *Fraxinus*, which is shown in the next column. Finally, in the two following columns are shown the curves of *Hedera* and *Viscum*.

III. The curve of *Alnus*:4 calculated on the basis of ΣII + Σ*Alnus*:4. Owing to the fact that *Alnus* must be regarded as an exceptionally large pollen-producer, the number of alder pollen has been reduced to one-fourth (cp. FÆGRI & IVERSEN 1950, p. 87).

IV. The curve of *Salix* calculated on the basis of ΣII + Σ*Salix*.

V. Diagram showing the varying relations between the Oak-Mixed-Forest—including *Corylus* at reduced value—and *Betula* and *Pinus*. The two latter have also been reduced to one-fourth. In addition, two curves have been inserted to show the relation between *Corylus*:4 and the rest of the Oak-Mixed-Forest. The basic sum is Σ QM + *Betula*: 4 + *Corylus*: 4 + *Pinus*: 4.

VI. Special diagram for the Oak-Mixed-Forest including *Corylus*: 4. Basis of calculation Σ QM + *Corylus*: 4. The diagram shows the course of the curves of Oak-Mixed-Forest constituents, included to give a picture of the competition within the Oak-Mixed-Forest.

The Pollen-Analytical Investigation (Plate XIV, Fig. 1, and Fig. 2, II). It is quite obvious from the curves that the diagram may be naturally divided into two parts, the lower part comprising analyses 1 to 4, and the upper comprising no.s 5 to 17.

In the lower part *Corylus* dominates in the forest. *Pinus* and *Betula*

[1]) *Populus* has been excluded from the basic sum to make possible a direct comparison with diagrams in which *Populus* is not counted.

are falling. The occurence of *Quercus* and *Ulmus* is insignificant, yet constant, and *Alnus* does not appear till analyses 3 and 4. *Populus* has its maximum at this point of the diagram, amounting to nearly 4 per cent. *Salix*, *Sorbus*, and *Juniperus* occur constantly; also *Viburnum opulus* is found. Herbaceous pollen occurs in small, constant quantities, consisting almost exclusively of Gramineae and Cyperaceae. Furthermore there are regular occurrences of *Artemisia*, *Calluna*, *Humulus*, Umbelliferae, and *Urtica*, besides *Filipendula Ulmaria*, which has its maximum in the lower part of the diagram. Among the marsh plants determinable with certainty, *Cladium Mariscus*, *Typha latifolia*, and *Thelypteris palustris* are found. *Potamogeton* dominates among the aquatics. *Pediastrum* is only found in very moderate quantities. The small numbers of local pollen suggest that sedimentation took place in an open lake, or at some distance from the margin of the lake, which agrees very well with the character of the sediment.

In the upper part of the diagram the pollen flora changes. It is true that *Pinus* and *Betula* retain constant values, but there is a gradual fall of *Corylus* in favour of the Oak-Mixed-Forest. Here, *Quercus* and *Ulmus* suddenly rise, and at the same time *Fraxinus* and *Tilia* appear. *Alnus* is increasing, and among the rarer trees and shrubs *Populus* declines slowly, but steadily; the others hold their ground, and, what is very important, *Hedera* and *Viscum* make their appearance in the forest. Among the terrestrial herbs two things are noteworthy: *Pteridium aquilinum* has a continuous curve through the upper part of the diagram and *Filipendula* decreases.

As a whole, the pollen frequency of herbaceous plants shows a strong and gradual increase until analysis 13, after which there is a slight decline. The increase applies, above all, to Cyperaceae; there is a distinct rise of *Cladium* and *Typha*, and *Nymphaea* has a closed, slightly rising curve, apparently at the cost of *Potamogeton*. Altogether, compared with the lower part of the diagram, only *Filipendula* decreases, all the others retaining status quo or rising slightly, and a number of new species appear, many of which live in moist soil or in swamps. There is a violent increase of *Thelypteris*, which culminates at analysis 10. *Pediastrum* has an equally violent increase, obtaining its maximum values after the culmination of *Thelypteris*.

The changes in the forest picture mentioned above seem to indicate a change of climate, or rather, that an improvement of climate has reached such values as to make it possible for *Hedera* and *Viscum* to grow and blossom there. At the same time there is a change in the local production of pollen, explainable through the fact that, owing to the filling up of the lake, the margin zone has passed the analysis site, or that the water level of the lake has sunk so that filling up has begun here. The degree of destruction indicates that the place may have been dry during brief periods. The course of the curves in the topmost analyses may suggest that local moistness has increased in this part.

The sediments show a similar change: from almost pure lake marl they change gradually into deposits containing more gyttja and swamp peat.—The rise of the water level, however, which is indicated in the uppermost analyses (cp. the settlement diagram), cannot be ascertained in the deposit.

B. Verup I, Stone Age Settlement.

The excavation was made by C. L. VEBÆK in the periods Aug. 12th to 21st, 1943, and May 9th to 29th, 1944. The find is registered in the National Museum as no. A 41935, and an account of the excavation has been made by C. L. VEBÆK (Journ. no. 108/46).

KNUD ANDERSEN, who has examined the material, gives the following statement:

"The Verup settlement, to which the flint pick is correlated through pollen analysis, was excavated by C. L. VEBÆK during 1943 and 1944, that is, before the refined excavation methods, elaborated by the Bog Laboratory of the National Museum, came into regular use. This is the more unfortunate as the find must have been of rather complex origin, the fact being that first three flint accumulations were found, to which a fourth was added later on. During the excavation two culture layers were distinguished in the refuse layers in the margin of the site, whereas in the central area it was, apparently, not possible to separate them. Thus, in the opinion of the excavator, only a rather small part of the artifacts can be segregated. However, it is possible to say something about the placing of the settlement in relation to other more easily determinable finds, because of a considerable similarity between the types of artifact of the Verup find and those of the two floors of Ulkestrup Lyng described in "Fra Nationalmuseets Arbejdsmark" 1951, p. 69 sq. If these floors are correlated with BECKER's division of the Maglemose culture (Årbøger 1951, p. 143), they fit into the end of his second period (floor I) and his third period (floor II). The lower culture layer of the Verup settlement is probably not quite free from contamination; yet there are very good reasons to correlate it with floor I, which is the earlier, as not only the microliths (many broad triangles and rather few lanceolates), but also the handled cores and the blades correspond to the artifacts found in the floor. The upper culture layer is no doubt contaminated, even if the greater part of it agrees quite well with the material found in floor II. As already mentioned, the artifacts found in the main squares cannot be separated into a lower and an upper layer; however, nearly all of them must be of the same age as the material recovered from the two culture layers segregated from the refuse layer in the margin of the settlement. Still, a few things occur, e. g. a couple of handled cores which, probably, are of slightly later date than the bulk of the artifacts. None of the artifacts of the Verup find can be referred naturally to the old coastal culture, for which reason it must be assumed that the flint pick belongs to a neighbouring settlement, as yet unknown."

The geological field work was carried out in 1943 by TROELS-SMITH assisted by ALFRED ANDERSEN. The results of this work are a number of pollen series from open sections, accompanied by section descriptions; however, there are no detailed measurings of the sections along their entire length. The series analysed, which is marked P 33, originates from a trial ditch, one metre in breadth and running from north to south, which led through the settlement. P 33 was the point of the excavation which was farthest removed from the central area towards the north; and the culture traces found must be regarded as refuse thrown out from the settlement. In this connection it should be noted that P 33 is situated ca. 50 m. north-east of the finding-place of the flint pick. The following section description, which only comprises the part of the section interesting in this connection, has the same system of symbols as given in the section description from the flint pick.

The sequence of layers, beginning at the surface, was this:

e. 0.335 to 0.625 m.: swamp peat containing gyttja. lim.sup. 1,
color: blackish brown.
Composition: $Th^2 2$, *Dl* +, *Dh* +, *Dg* 1, $Ld^2 1$.

d. 0.625 to 0.735 m.: coarse detritus gyttja with swamp peat. lim.sup. 1,
color: blackish brown.
Composition: $Th^1 1$, *Dl* +, *Dh* +, *Dg* 1, $Ld^2 2$.

c. 0.735 to 0.88 m.: swamp peat containing gyttja. lim.sup. 1,
color: dark brown.
Composition: $Th^1 2$, *Dl* +, *Dh* +, *Dg* 1, $Ld^2 1$.

b. 0.88 to 0.98 m.: lake marl with swamp peat. lim.sup. 1,
color: dark brown. Composition: $Th^1 2$, *Dh* +, Ld° +, *Lc* 2, [β +].

a. 0.98 to 0.00 m.: lake marl. lim.sup. 2,
color: greyish white, greenish. Composition: Th° +, $Ld^\circ 1$, *Lc* 3, [α +].

In the reproduction of the section through symbols are added the culture traces found at the excavation of that square metre of the ditch which is situated between P 32 and P 33, in such a way that an abscissa of 0.5 mm. indicates one piece of flint or charcoal. First the flint is marked through hatching, after that the charcoal is marked in black.

The laboratory examination was made in Nationalmuseets Moselaboratorium during the autumn of 1944 and the winter of 1945. In each sample, part of the counted material was treated with KOH and stained, and part was just acetolysed. The total of tree pollen, exclusive of *Corylus*, is at least 500 in each fraction, i. e. altogether at least 1000 grains of tree pollen, exclusive of *Corylus*, in each analysis. In each fraction statistical measurements of *Corylus* were carried out separately. As regards other conditions, as well as the construction of diagrams, reference may be given to the corresponding parts of the flint pick description (p. 163 sq.)

The Pollen Analytical Investigation (Plate XV, Fig. 3, and Fig. 4, II).

The course of curves in analyses 1 to 6 corresponds exactly to the course just mentioned in the lower part of the flint pick diagram (anal. 1 to 4). Deviations, however, are found among the rarer species, particularly as regards *Populus* and *Juniperus*. This is due to the fact that the Verup diagram was made nearly ten years ago[1]).

The next part of the diagram consists of analyses 7 to 19. Throughout that part, the Oak-Mixed-Forest shows a gently rising curve, introduced by a sudden rise of *Quercus* and *Ulmus* and the beginning of a closed curve for *Tilia*. Corresponding to this, the *Corylus* curve falls gently. *Betula* remains nearly constant, and *Pinus* is falling, whereas *Alnus* shows a gentle rise. *Hedera* and *Viscum* both appear in analysis no. 8. In analysis 9 is found a pollen grain of *Prunus* cfr. *padus*[2]).

The curves of herbaceous pollen are not quite so uniform. The Cyperaceae curve shows a slight rise, gentle and constant until analysis 11, after which it falls, reaching a minimum at no. 17. In analyses 18 and 19 another rise begins, far more rapid than the first. The curve of Gramineae shows a similar gentle rise until analyses 14 to 15. After that there is a sudden marked rise in analysis 16, and this position is kept up in the following analyses. Measurings and morphological examinations show that the Gramineae curve is due almost exclusively to *Phragmites* pollen. *Nymphaea*, which is found in almost constant quantities throughout that part, dominates among the aquatics. The *Thelypteris* curve is similar to the Cyperaceae curve, which it reproduces on an enlarged scale. *Pediastrum* proves antagonistic compared with Cyperaceae and *Thelypteris*, by having a distinct maximum where the latter are falling. Accordingly, this part of the pollen diagram indicates the filling up of the lake, interrupted, as it seems, by a slight and transient rise of the water level.

The sediments are quite in accordance with this, as analyses 14, 15,

[1]) At that time, in the Bog Laboratory of the National Museum, preparations of KOH-treated stained material, or acetolysed material, were considered the best possible. Experience and examinations, however, have shown that the great content of detritus in the KOH-treated material conceals many pollen grains, or makes it impossible to arrive at a reliable determination, and that acetolysed, stained material affords the highest degree of security as regards the observation of very small and thin-walled pollen grains. Thus, *Juniperus* pollen in which only a few *gemmae* are preserved (IVERSEN & TROELS-SMITH 1950) will be undeterminable in preparations of any density. The same thing applies to *Populus*. The absence of *Populus* in analysis 6 is due to the fact that this analysis was the first to be counted in the diagram, and it was not till the following analyses that I began to differentiate a special group from that of Cyperaceae. This type was given the name of "Pseudo Cyp.", and was later determined as *Populus tremula* (for further details, cp. JOHS. IVERSEN 1946, p. 223).

[2]) Macroscopic finds cp. JESSEN (1920, p. 203).

16, and 17 originate from a deposit containing more gyttja than the layers above and below.

Analyses 20, 21, and 22 comprise the uppermost part of the diagram. By now, the curve of the Oak-Mixed-Forest has reached its maximum values in the diagram, and in accordance with this, the *Corylus* curve has fallen to a minimum. Altogether the course of forest tree curves is steady, with constant values, giving the impression that a state of balance has been reached between the trees of the forest.

The Cyperaceae curve continues its violent rise. The curve of Gramineae shows a slight decline, whereas there is a strong increase for *Urtica* and *Typha*. The *Thelypteris* curve corresponds perfectly to the curve of Cyperaceae, and the *Pediastrum* curve continues the fall already begun.

It appears from the curves of herbaceous pollen that the local filling up is setting in with a vengeance. The degree of destruction, which was negligible in the previous part[1]), is increasing, reaching 40 per cent in analysis 22, for which reason the counting of samples above is made difficult and highly unreliable. The high degree of destruction suggests that, at times, the place may have been rather dry, which agrees very well with the fact that the sediment contains more swamp peat and shows a higher degree of humification than anywhere else in the section.

C. The Mutual Relations of the Verup Diagrams.

In the interpretation of the two pollen diagrams treated above, we are favoured by the fact that the diagrams reflect original conditions of nature not contaminated by cultural operations, due either to agriculture or cattle breeding. As the two diagrams were taken in the immediate neighbourhood of human habitation, it may after all be possible that the lives and doings of the inhabitants have left such marks on the vegetation as may be recognized through the pollen diagrams. The pollen of *Chenopodiaceae*, e. g., have been regarded as indicative of mesolithic inland cultures (cp. Iversen 1941, p. 39; Troels-Smith 1942a, p. 191; Nilsson 1948, p. 10; Mikkelsen 1949, p. 19). The diagram of the Verup settlement shows a handsome agreement between the occurrence of this pollen type and the habitation. The flint pick diagram, on the other hand, shows that pollen of *Chenopodium* type occurs chiefly before the habitation, whereas it does not occur at all in its final phase. In the case

[1]) Judging from the diagrams, the pollen destruction of layers c_1 and c_2 in the flint pick diagram seems to be far more considerable than in the corresponding settlement layer c. No doubt this difference is due to the better preparation technique used for the flint pick diagram, and clearly illustrates the advantages of acetolysed, stained material with regard to the observation of details.

of this diagram, therefore, Chenopodiaceae pollen must be left out of consideration as a culture indicator. MIKKELSEN (1949, p. 19) assumes that the occurrence of *Artemisia* pollen may in a similar manner be correlated with mesolithic culture; the regular occurrence of *Artemisia* pollen, however, in both of the present diagrams does not support the theory.

IVERSEN (1949, p. 9) establishes a parallel between *Urtica dioeca* and Chenopodiaceae as indicators of mesolothic settlement. In the two uppermost analyses of the settlement diagram, there is a sudden strong rise in the *Urtica* curve. *Urtica* pollen does not occur in the lowermost part of this diagram and only very sparsely in the central part. In the second diagram the same conditions are reflected. Here *Urtica* pollen occur sparsely in the lower part and somewhat more frequently in the upper part. Without doubt, the species of *Urtica* occurring in Verup is *U. dioeca*. This species is highly nitrophilous; it is, however, also found at a certain stage of vegetational succession in a hydrosere, and its marked rise in our diagrams need not be due to the nitrogenous soil of the deserted habitation, even though that seems the most probable cause. In a pollen diagram form Weiher, Switzerland (TROELS-SMITH 1954b) a maximum of *Lemna* pollen is found corresponding with a culture horizon, and diagrams, as yet unpublished, from Aamosen, Zealand, show a similar correlation. *Lemna* prefers highly nutritious still water (cp. SAMUELSSON 1934, p. 106; IVERSEN & SIGURD OLSEN 1943) and would presumably be favoured in the neighbourhood of human habitation. It would appear that with the mention of the single pollen grain of *Lemna* found in analysis 21 of the settlement diagram, the last slender chances of finding culture traces in the curves of the diagram are exhausted.

In this connection, however, attention should be drawn to the two pollen grains of *Carex* cfr. *hirta* in flint pick analyses 3 and 15. The two pollen grains in question are in every respect identical with *Carex hirta* pollen, which appears to be rather characteristic, but the material for comparison found in the Laboratory is still not sufficient to exclude all other pollen grains of Cyperaceae type. As *Carex hirta* prefers to grow in places influenced by human activity (GRAM & JESSEN 1949, p. 237) an eye should also be kept on this pollen type in the future.

As already mentioned, the course of the curves in the lower part of the two diagrams is nearly identical (flint pick anal. 1 to 4 and settlement anal. 1 to 6). The section column displays a similar concordance in that the bottom layers a (anal. 1 & 2 of the flint pick diagram and anal. 1 to 3 of the settlement diagram) contain almost pure lake marl, after which follows lake marl containing swamp peat, subdivided, in the flint pick section, into two layers: b_1 (anal. 3 & 4) and b_2 (anal. 5 & 6). The composition of b_1 shows that the transition from a to b (anal. 4 to

7) is more gradual than it appears from the settlement section. Probably the difference between the two sections does not really exist, but is only an expression of the increasing intensity with which sections have been measured during the period of 1943 to 1951.

In the following part of the diagrams the tree pollen curves also agree very well, though the progress is quicker in the settlement diagram (anal. 7 to 19) than in the flint pick diagram (anal. 5 to 17). This must be due to the fact that filling up occurred more rapidly at the flint pick site than at the settlement. This appears clearly from a comparison between the curves of herbaceous pollen. Thus, judging from the diagrams the uppermost analysis of the flint pick diagram must be regarded as earlier than analysis no. 13 of the settlement diagram.

The layer c of the settlement (anal. 8 to 13) corresponds to layers c_1 (anal. 7 to 9) and c_2 (anal. 10 to 17) of the flint pick diagram, a similar differentiation having been made here as in the case of layer b. Layers d (anal. 14 to 17) and e (anal. 18 to 22), however, only occur in the settlement section.

If we try to find a synchronous level in the two diagrams, the border between the two lower parts of the diagram, here discussed, must be considered the one best marked out as far as pollen analysis is concerned. Here, a sudden rise sets in in the curves of *Alnus* and the Oak-Mixed-Forest, contemporaneous with the first occurrence of *Hedera* and *Viscum*. This level corresponds to the pollen-analytical zone border V–VI according to JESSEN (1935b, p. 187). Probably the first occurrence of charcoal in the two diagrams also marks a synchronous level.

From the facts available, the Verup settlement must be classed among the so-called swamp settlements, so frequent in Aamosen (cp. MATHIASSEN 1943, p. 129). Conditions of the Verup settlement suggest that people settled, presumably in summer, on the comparatively dry bog area not far from what was then the border of a lake. The place was used for a number of years until at last it was given up owing to increasing wetness. After some time the wetness decreased, and the place was found suited for habitation once more.

By now, it only remains to find the correct position in the settlement diagram of the part of the diagram that is situated round the flint pick.

First, however, it should be examined whether the flint pick is contemporaneous with the sediments into which it is incorporated. It must be taken for granted that the implement was deposited later than the underlying sediment; still, as it is a single find, it cannot be precluded that the implement is of an earlier date than the sediment on which it rests[1]). No details of the section suggest that the flint pick was buried; besides, the fact that its longitudinal axis was almost horizontal, does

[1]) cp. TROELS-SMITH 1942 a, p. 187 sq.

not favour the theory that it was intentionally thrust or pressed into the deposit. The only possibility remaining, then, is that owing to its weight the pick may have sunk down into earlier deposits. As already mentioned, the layer c_2, into which the flint pick was incorporated, is felted swamp peat with a slight gyttja content. The problem is therefore: Was this swamp peat after all a swamp peat from the outset, or, was it a gyttja deposit which developed the character of swamp peat by being permeated with the rootlets and rhizomes of a later vegetation?

The large quantities of local herbaceous pollen—mainly pollen of Cyperaceae—all through the deposit, certainly suggest that the original sediment was in fact swamp peat. The extent to which an object with a fairly large sufface, like that of the flint pick, has sunk down will not, presumably, amount to many centimetres in the fresh swamp peat, and considering the strong compression of the layers during the long space of time which has since then expired, it is reasonable to assume that the flint pick is contemporaneous with, or possibly older than, the surrounding swamp peat. Analyses 14 to 17 of the flint pick diagram have very nearly the same pollen spectrum; this spectrum corresponds to analysis 12 of the settlement diagram. In other words, the flint pick was deposited at the same time as the earliest culture layer of Verup I.

Before determining the pollen-analytical age of the flint pick more exactly in relation to other Maglemose finds dated through pollen-analysis, it will be advisable to subject the two zone borders, V–VI and VI–VII (KNUD JESSEN 1935b), which both occur in the Verup diagrams, to a closer examination. The establishment of these zone borders has caused certain difficulties to several pollen analysts, and in order to elucidate the problem on a broader basis, some previously published pollen diagrams of more recent date will be brought into the discussion.

II. Discussion of Zone Borders V–VI and VI–VII (*ex* KNUD JESSEN).

A. Comparison Diagrams.

Langesø, Funen (Plate XVI, Fig. 5).

The investigation was carried out by ALFRED ANDERSEN (1946). The section was made by boring, and the sequence of layers in the part which is of interest here, is this:

0 = the surface of the ground.
4.50 to 8.82 m.: "brown lake mud."
8.82 to 9.17 m.: "grey lake mud containing slight quantity of clay and sand."
9.17 to 9.50 m.: "black lake mud."

The symbols of the section column have been approximately translated into the system of symbols used in the previous chapter; further, to make direct comparisons with the Verup diagrams possible, analyses 9 to 30 (counting from below) have been converted. This conversion does not claim to be mathematically correct, being based only on a careful measuring of the curves of the original diagram. However, deviations expressed in percentages will be so slight that the degree of exactness must be considered fully sufficient to serve the present purpose. The five diagrams reproduced here correspond to diagrams II to VI in the Verup survey diagrams.

As for the course of curves, as well as for the interpretation given by ALFRED ANDERSEN, reference is made to his publication. Here it should only be noted that the sediment is highly homogeneous all through the diagram, and that *Hedera* occurs for the first time (analysis no. 21) at exactly the point when the curve of the Oak-Mixed-Forest shows a violent rise. The absence of *Viscum* may be due to statistical causes (cp. IVERSEN 1944, p. 465). The position of the rational *Alnus* limit (cp. v. POST 1916 p. 456) is between analyses 25 and 26, and the curve of the Oak-Mixed-Forest reaches its maximum values in analysis no. 26 and subsequent analyses.

Even, Zealand (Plate XVI, Fig. 6).

The investigation was carried out by MIKKELSEN (1949, p. 53 sq., Bp. 21, Plate VIII). The section was made by boring. The sequence of layers is reckoned from the normal water level of the lake. The following parts of the section are of interest here:

E[1]). 7.38 to 7.85 m.: "Olive-grey-green *Cardium* clay-gyttja. The gyttja less clayey. A few shells and shell fragments of *Mytilus edulis* and *Hydrobia ulvae*. Uppermost: also fragments of *Cardium edule*."

E. 7.85 to 8.09 m.: "Dark olive-grey-green gyttja. R 1. F 1–2. Seeds of *Najas marina*."

H. 8.09 to 8.11 m.: "Dark olive-grey-brown gyttja. Shells of *Valvata piscinalis*, *V. cristata* and *Limnaea ovata*."

K. 8.11 to 8.50 m.: "Brown rootlet peat. R 2. F 0–1. Uppermost H 8–9. Lowest H 5."

K. 8.50 to 9.30 m.: "Dark reddish-brown *Cladium* peat. H 8–9. R 1. Many fruits and rhizomes of *Cladium mariscus*."

L. 9.30 to 11.60 m.: "Chalk gyttja with numerous fragments of *Bythinia tentaculata*, *Planorbis vortex* and other fresh-water molluscs. The colour uppermost yellow-white, then pink to rose alternating with green. Lowest the gyttja olive-green-grey."

The symbols are translated and the diagram converted, as mentioned under the Langesø diagram. The few single finds of *Picea*, *Fagus*, and *Carpinus* are not included in the calculation. The numbers of the spectra

[1]) Section description and diagram show that the E-layers of the section description ought in fact to be termed F (misprint?)

correspond to those of the standard diagram. The part of the section discussed here consists of a number of deposits of various types, but judging from section and diagram the sedimentation seems to have been continuous. The possibility of a hiatus, however, exists at the transition from the highly humified radicel peat of layer K to the overlying gyttja of layer H. The rational limit of the Oak-Mixed-Forest lies between analyses 55 and 56. *Hedera* and *Viscum* both occur for the first time in analysis no. 52; but the pollen total given indicates that the absence of *Hedera* and *Viscum* in analyses 54 and 55 may be due to statistical causes. The rational *Alnus* limit has a higher position than the first occurrence of *Hedera* and *Viscum*, and from analysis no. 48 on the Oak-Mixed-Forest reaches its maximum values.

Stevningen, Funen (Plate XVII, Fig. 7).

The investigation was carried out by TAGE NILSSON (1948, p. 7 sq., Pl. I). The section was made by boring, and the part of it which will be treated here, consists of the layers F, G, H, and I.

The stratigraphy is as follows (beginning at the surface):

0 = surface of the ground.
"F. 206 to 488 cm.: Detritus gyttja, brown. In the upper part, above 320 cm., gradually increasing frequencies of fern spores (maximum in the layer 230 to 265 cm.) and *Typha latifolia* (pollen), and decreasing values of *Pediastrum*. The content of filaments of Nymphaeaceae exceptionally large at the top (206 to 225 cm.); here also unusually numerous sponge spiculae.
G. 488 to 508 cm.: Fine detritus gyttja, grey brown.
H. 508 to 534 cm.: Algae-gyttja, green brown. The lowermost 8 cm. sandy. At the level of 530 cm. pollen of *Nymphæa*.
I. 534 to 544 cm.: Clay-gyttja, sandy, gray green."

Section and diagram have been converted on lines similar to those previously mentioned. In this case, however, it is made more difficult because the sum of tree pollen is not indicated in the individual analyses. For practical reasons, therefore, the sum has been estimated at 100 in all analyses; the sums resulting from the reduction can be used only to estimate the relative reliability of the analyses, not that of the diagram as a whole. The numbering of the analyses has been made from the bottom layer upwards. No details in section or diagram suggest interruption of the sedimentation within this part of the diagram. The Oak-Mixed-Forest shows a steep rise at analyses 15 and 16, and in no. 15 appears the first trace of *Hedera*. The rational *Alnus* limit is found at analyses 17 and 18, and the Oak-Mixed-Forest reaches its maximum values in analysis no. 29 and upwards. Despite the fact that many grains were counted, no *Viscum* is recorded in the diagram.

Holmegårds Mose, Zealand (Plate XVII, Fig. 8).

The investigation was carried out by TAGE NILSSON (1947). The following is an examination of a fragment of the diagram from Holmegårds Mose, Western dwelling-place P. 1. The section was made by boring. The layers B, C, D, E, F, and G are of interest here. Beginning at the surface (0–point), the sequence of layers is the following:

"B. 80 to 120 cm.: Sphagnum birch forest peat, with *Phragmites*.
C. 120 to 152 cm.: Swamp dy, with some remains of *Phragmites* and *Dryopteris thelypteris*.
D. 152 to 206 cm.: Magnocaricetum peat, with remains of *Phragmites* and *Dryopteris thelypteris*, in the lowermost part also *Cladium mariscus*. At the top of the layer (about 15 cm.) pieces of charcoal, indicating the presence of a culture layer.
E. 206 to 228 cm.: Cladium peat, with remains of Carices, *Phragmites* and *Dryopteris thelypteris*.
F. 228 to 233 cm.: Shell-gyttja, brown, with some rootlets grown down from the above layer.
G. 233 to 272 cm.: Lime-gyttja, grey."

The conversion and the numbering were made in the same way as in the Stevningen diagram, and the same conditions apply here. The two occurrences of *Picea* are not included in the calculation. As for details about the course of curves, as well as TAGE NILSSON's interpretation, see the publication. Facts emphasized here are: the position of the rational *Alnus* limit is higher in the diagram than the rational limit of the Oak-Mixed-Forest, which has its maximum values at analysis 21 and subsequent analyses. One remarkable point is the absence of *Fraxinus* all through this part of the diagram. Unfortunately, *Hedera* and *Viscum* were not recognized at the time.

B. Discussion.

The course of curves in the pollen diagrams illustrates the immigration of plants after the Glacial period, as well as the subsequent development of vegetation. All things considered, this picture of vegetation reflects the climatic development which has taken place since those days. Hence, through the division of diagrams into characteristic pollen zones, it has been attempted to group these in such a way that the climatic aspect became apparent. By restricting the field of research to a minor area which is phytogeographically homogeneous, it will be possible to connect the diagrams in regard to time with a fair margin of security, whereas correlations over large distances must always be regarded with some reservation. A change of climate need not involve the same botanical changes within a major area, and the interval of

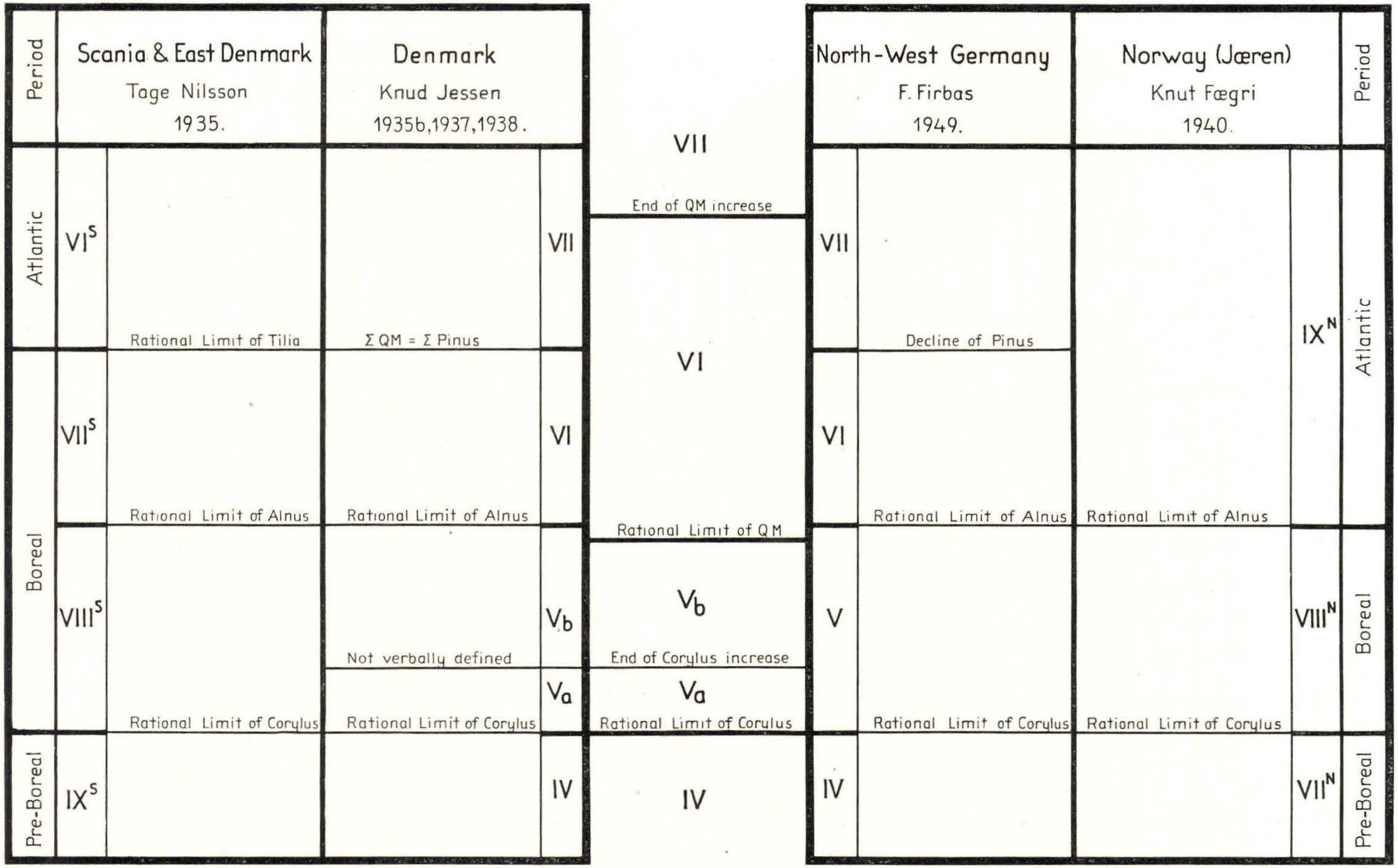

Fig. 2. Diagram of some pollen zone border definitions.

time necessary for vegetation to stabilize itself after a change of climate will depend on the ecology of the different plants.

The diagrams here displayed are all from East Denmark. In each of the survey diagrams, two sets of zone borders are indicated. In those previously published, the borders of the original publication are found on the left, whereas the borders discussed in the present thesis are seen on the right. For better orientation, a diagram has been added showing different sets of zone borders and indicating the criteria employed by the respective authors (Fig. 2).

Investigators are universally agreed as to the zone border fixed between pre-Boreal and Boreal periods (IV–V, ex KNUD JESSEN). Almost as universal is the agreement regarding the following, later, zone border (V–VI, ex KNUD JESSEN). In practice, however, it appears very difficult indeed to fix this border in the diagrams. As a rule, the rational *Alnus* limit is extremely well marked out, so that this level is easily determined; no problems arise until this level is correlated with the other curves of the diagram. In the present diagrams the rational *Alnus* limit coincides in a few cases (Verup) with the rational limit of the Oak-Mixed-Forest, whereas in others its position is higher; in fact, in the Langesø diagram it is even higher than the zone border VI–VII (JESSEN). On the other hand, the rational limit of *Alnus* may also be found below that of the Oak-Mixed-Forest (NILSSON 1935, Plate VI, 11 and 17; Plate VII, 9).

These facts automatically raise the problem whether it is reasonable to employ the *Alnus* limit as a zone border. We must consider the question whether the rational *Alnus* limit can be regarded as a synchronous level in our diagrams.

The first occurrence of *Hedera* and *Viscum* in the diagrams coincides with the rational limit of the Oak-Mixed-Forest, affording strong evidence in support of the theory that this limit is actually a synchronous level, due to climatic causes. At the same point of the diagrams is seen the empirical limit of *Tilia*, and in diagrams in which sufficient tree pollen (1000 or 2000 grains per analysis) has been counted, *Fraxinus*, too, will form a closed curve from this level. According to IVERSEN'S studies (1944, p. 463 sq.), the simultaneous appearance of *Hedera* and *Viscum* in the diagrams may, no doubt, be considered evidence of the fact that at this time a considerable improvement of climate set in, or that an improvement previously begun exceeded certain threshold values of vital importance to *Hedera* and *Viscum*.

The only *Alnus* species which can be considered within the present area is *Alnus glutinosa*; and judging from the distribution of this species today, compared with that of *Hedera* and *Viscum*, it is obvious that the anomalies regarding the position of the rational *Alnus* limit in the diagram cannot have been caused by conditions of temperature.

As for power of dispersal and age of maturity, *Alnus glutinosa* is in a favourable position compared with the trees of the Oak-Mixed-Forest, FIRBAS (1949, p. 192 sq.) holds that the irregular occurrence of *Alnus glutinosa* is due to its need for moist soil, or at least, for a soil in which the ground water level is not far from the surface. *Alnus glutinosa* will occur but sparsely in places where the right soil conditions are not found; otherwise it will assert itself quickly. Thus, a rise of the water level, whether this be due to increased precipitation, less evaporation, or lack of drainage, may create places for *Alnus* to grow. On the other hand, a fall of the water level, regardless of its cause, may lead to the very same result by drying up swamps, or filling up lakes.

The fact that the occurrence of alder is so vitally dependent on local factors, involves that it cannot register the universal climatic fluctuations in a clear way.

It would be more natural to regard the first simultaneous occurrence of *Hedera* and *Viscum* as the mark of a zone border; this however, requires the counting of at least 1000 grains of tree pollen in each analysis. As this condition has but rarely been fulfilled, nor in all probability will always be, it will be more useful to regard the rational limit of the Oak-Mixed-Forest as a zone border, as has already been done ina few cases (cp. MIKKELSEN 1948, p. 18).

A glance at the diagram indicating zone borders (Fig. 2) will show that all uniformity comes to an end at zone border VI–VII ex KNUD JESSEN. Here, however, we shall discuss only the criteria on the basis of which JESSEN and NILSSON have fixed this zone border. According to NILSSON, zone border VII^{S}–VI^{S} = VI–VII ex JESSEN is placed at the rational limit of *Tilia*. In the Verup settlement diagram, the position of this level cannot be ascertained from the gently rising curve of *Tilia*. Whether it can be demonstrated in other diagrams is hard to tell until diagrams are available which are statistically sound, seeing that little profit is to be derived from interpreting more or less accidental rises and falls of percentages.

According to JESSEN, zone border VI–VII is situated at that point in the diagrams where the rising curve of the Oak-Mixed-Forest intersects the falling curve of *Pinus*. In the diagrams published by JESSEN, *Corylus* (in correspondence with v. POST, 1916) is kept apart from the basic sum, *Corylus* being regarded as belonging to the shrub layer in the forest, whereas in the diagrams here published, as well as in the diagrams of other localities here reproduced, *Corylus* is included in the basic sum at reduced values. This has been done on the plea that *Corylus* is integral to the natural cycle of forest succession, and takes part in the common struggle for "a place in the sun" (cp. FÆGRI & IVERSEN 1950, pp. 68 and 88).

Judging by diagrams II and V in the survey diagrams, the intersection of the curves of QM and *Pinus* does not, however, primarily depend on the competition between *Pinus* and the Oak-Mixed-Forest, but on the competition between QM and *Corylus*, seeing that in this part of the diagrams the *Pinus* curve shows constant, or only slightly falling, values. A parallel deflection of the *Pinus* curve will move the intersection point of the curves so that at a locality which, for some reason or other, has an exceptionally high percentage of *Pinus*, the position of the intersection point will be higher in the diagram than at a locality with a lower percentage of *Pinus*. Attention has previously been called to this fact by NILSSON (1947, p. 206). Thus it cannot be taken for granted that the intersection point between the *Pinus* curve and the Oak-Mixed-Forest curve occurs at synchronous levels in the diagrams.

Judging from the present diagrams, the intersection point of the *Pinus* and the QM curves is situated somewhere during a development beginning with a sudden rise of the QM curve and ending when it regains constant values.

The part of the diagram where QM is rising and *Corylus* falling should be regarded as an entirety, and no zone border should be fixed until this natural development has come to an end. This implies that zone border VI–VII should be placed at the point where the rise of the QM curve ceases (cp. FÆGRI & IVERSEN 1950, p. 110 sq.).

Several attempts have previously been made to divide the single pollen-analytical zones into sub-zones. Many of these secondary borders have been fixed from fluctuations of the curve of a single species of tree. According to the pollen-analytical material which has up to now been published, such secondary borders must be regarded with scepticism; besides, in most cases, they will hardly stand up against closer scrutiny. Within the period here treated, however, one secondary border must be considered reliable, namely that dividing zone V into sub-zones Va and Vb (JESSEN 1937). The border is fixed at the point where the rise of the *Corylus* curve ends. The boundary Va–Vb is, in principle, analogous with zone boundary VI–VII as defined above.

The zone borders here suggested are entered into the space between the two halves of the diagram Fig. 2.

A glance at the Langesö diagram (Plate XVI, Fig. 5) at once reveals the conspicuous feature that the diagram picture contains an element of rhytm, to the effect that periods in which the courses of curves are comparatively parallel, alternate with periods in which some of the curves intersect. To put it differently: it seems that a process of alternation takes place between fairly constant conditions in the composition of the forest, and periods characterized by great changes of the forest picture. After the balanced conditions of zone IV, in which *Betula* is completely dominant, while *Pinus* and *Corylus* occur in slight quantities, the picture suddenly changes. There is a strong increase of *Corylus*, *Pinus* rises, whereas *Betula* falls. This is the position of zone borders IV–V. The development now begun continues until *Corylus* dominates, and *Betula* has had a strong decline. *Pinus* is declining once more, the Oak-Mixed-Forest appears, and we cross the border between Va and Vb. By now the forest seems, as it were, to have stopped reacting to the impulse which started the development at zone boundary IV–V, and throughout subzone Vb conditions seem to be stabilized among the forest trees. But then the process repeats itself. Just as *Betula* was ousted by *Corylus*, the latter now has to yield to the trees of the Oak-Mixed-Forest. The whole of this development takes place in zone VI, and it is not until a new balance has been established that we enter zone VII. It appears from diagram V of the Langesø survey diagram that *Pinus* holds its ground all along from border Va–Vb to the top of the diagram. This also applies to *Betula*, which holds out until border VI–VII, when it is hard pressed by rapidly advancing *Alnus*, which at once suppresses the last remnants of *Salix*. On the whole, the main impression left upon the observer is that from the border between Va and Vb onward, the Oak-Mixed-Forest, including *Corylus*, has gained complete supremacy of the forest, and the development of the forest is from now on characterized by the competition between the elements of QM. The courses of curves in diagram VI illustrate this competition, and though the picture of curves may seem confused, the main result is clear: *Corylus* must yield to the other trees of the Oak-Mixed-Forest. It is equally obvious, though, that in the case of this diagram, the curves of the components of QM proper cannot be used as a basis for further division into subzones.

At zone border VI–VII the curves again register sudden changes. This level is situated at 6.50 m. below the surface, and if it is borne in mind that the section was bored with a HILLER sampler, the chamber length of which is 0.5 m., the thought arises whether there may have been any irregularities in connection with the boring, as e. g. that a tube length of sample is missing at this point of the section[1]).

The Even diagram (Plate XVI, Fig. 6) shows extremely great similarity with the Langesø diagram with regard to the main features pointed out here. Some of the details also correspond. Thus in both diagrams there is a distinct increase of *Pinus* in zone Va. In the case of the Even diagram, MIKKELSEN states the theory that the subsequent sudden fall

[1]) From a later statement kindly forwarded by ALFRED ANDERSEN, it appears from the record of the Langesö investigation that at the level of 6.50 m. below the surface, the boring was moved to another point owing to difficulties at the original boring-point.

of the *Pinus* curve (see the original diagram) accompanied by a corresponding rise of *Betula*, may be due to a forest fire. The course of curves in the reduced diagram (Plate XVI, Fig. 6, II) does not support this assumption. Besides, one might expect an increase of herbaceous pollen as the first reaction after a forest fire. The diagram shows no such increase of herbaceous pollen, and as, moreover, the level in question does not seem to have contained any finds of charcoal dust, the interpretation suggested seems to be illfounded.

As for zone border VIIa–VIIb, as indicated by MIKKELSEN, attention is called to the possibility that the distinct fall of the *Pinus* curve on which MIKKELSEN bases the establishment of this boundary, is probably due to the fact that the sediment at this level changes its character from that of highly humified radicel peat with great pollen destruction, to slighly humified gyttja with well-preserved pollen.

By comparing the *Pinus* curve of diagram V with the section column, it appears that the distinct rise of the *Pinus* curve within zones VI and VII corresponds to the two extremely humified layers of Cladium peat and radicel peat.

It will not be defensible in this diagram, either, to base the establishment of zone borders on fluctuations of the single curves of QM constituents (see diagram VI).

The rather confused course of the curves of zone IV within diagram VI may be due to the exceedingly small number of pollen grains on which the calculation is based.

The Stevningen diagram (Plate XVII, Fig. 7) may also be divided into the same main parts as the Langesø and Even diagrams. It would have been of great value to the assessment of the course of curves in the diagram, if the number of pollen grains counted had been stated; it will now be impossible to discuss the course of curves within the Oak-Mixed-Forest proper.

The Holmegårds Mose diagram (Plate XVII, Fig. 8) shows a more irregular course of curves than the diagrams of the other localities. Still, the same main features are recognizable.

TAGE NILSSON points out the favouring of the *Pinus* curve through pollen destruction of the highly humified swamp peat formations, and the abnormally high percentages of *Tilia* are explained partly in the same way. It is reasonable to believe, though, that the statistical defects from which the countings seem to suffer, may have contributed essentially to the irregular course of the curves.

Accordingly, the course of the curves in the diagram is based on evidence so insufficient that it would be risky to regard fluctuations in the curves of the individual species of QM trees as criteria of zone borders.

The Verup diagrams, too, within their more restricted space of time, display the same fundamental characteristics.

The diagrams here discussed thus present the picture of forest development within the area in question, a picture uniform with regard to main features, though perhaps in some details incorrect or blurred owing to dissimilarities of sedimentation, pollen destruction, or insufficiency of countings.

The forest development described above may have been caused by sudden climatic changes; but it is just as reasonable to assume that the change of climate was gradual. Each single forest tree species possesses a rather high degree of climatic amplitude; however, if certain threshold values are exceeded, a development is started which will continue for some time until sooner or later a new state of balance is restored, which manifests itself in a new type of forest, dominating in its turn until yet another group of threshold values are exceeded. This process, of course, is not nearly so simple as the rough outline given above might suggest, seeing that climate is only one of the factors—an important factor, it is true—of that complex of elements which determine the development of the forest.

III. Pollen-Analytical Dating of Mesolithic Finds.

By converting previously published diagrams in accordance with the principles used in the Verup diagrams, an attempt will be made to place a number of mesolithic finds dated through pollen analysis, in relation to the zone borders here proposed. The varying degree of security with which the individual finds have been placed within the diagrams, is due to the fact that the pollen analyses on which the calculations are based, are not homogenous (Fig. 3).

One point, however, should be more closely discussed. According to the diagram there seems to be some divergence between the dating of the Holmegård West settlement, as dated by Knud Jessen and Tage Nilsson respectively. This need not indicate any unreliability of the pollen-analytical method. Nilsson's section was made by boring, and the culture layer is marked as a horizon with "several pieces of charcoal". Investigations carried out by Troels-Smith in Holmegård bog prove that within a single group of settlements it has been possible to segregate up to eight settlement layers, more or less displaced with regard to time and space, which implies different kinds of overlapping, periodic as well as regional. Investigations carried out for years in the bog Aamosen have yielded the hard-earned experience that only minute measurings of open sections are able to prove whether two culture layers are identical, even within very short distances.—From the material at hand,

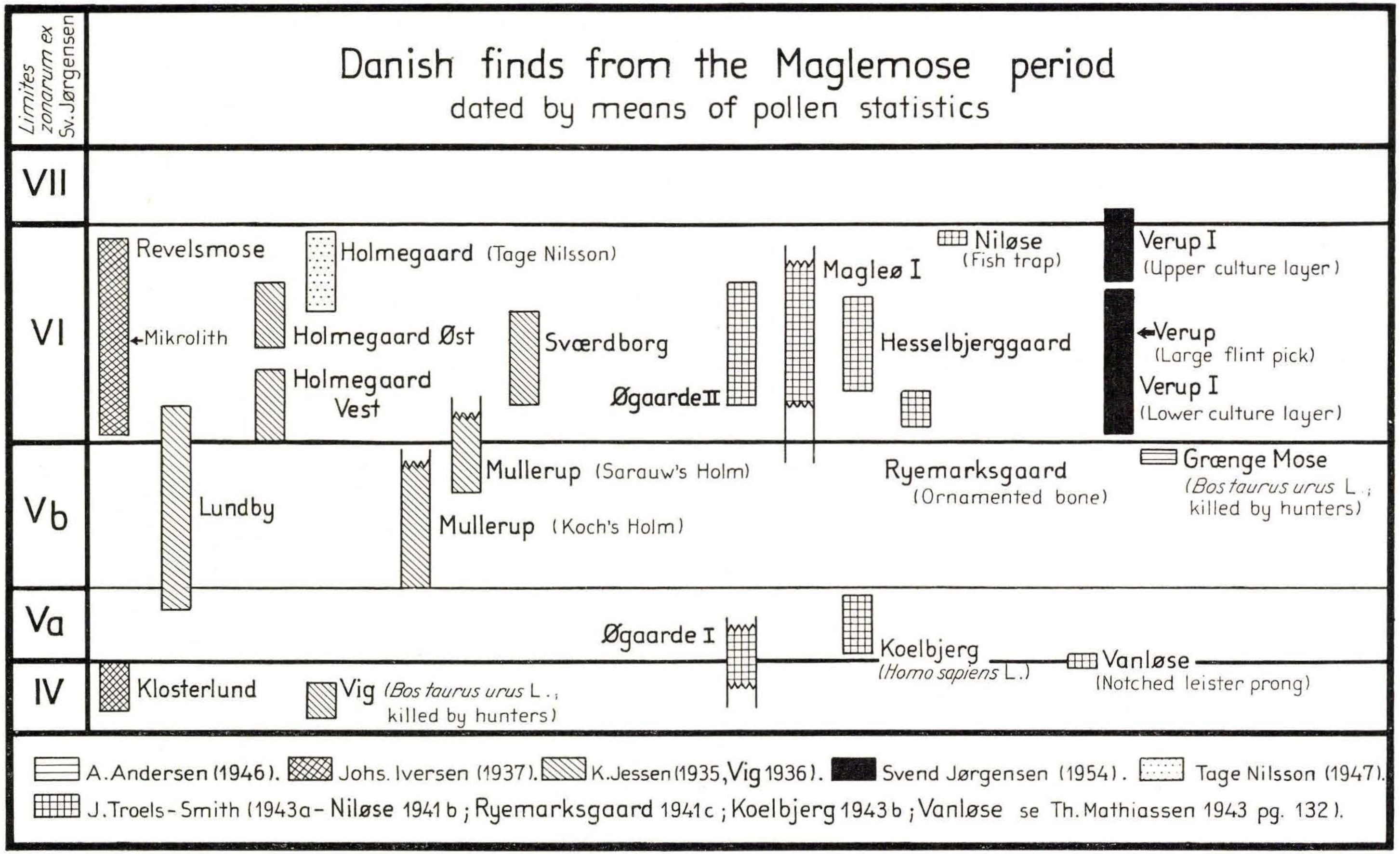

Fig. 3. Diagram of Maglemose finds.

it is most reasonable to assume that the culture horizon dated by NILSSON is not identical with the Holmegård West settlement as dated by JESSEN.

From the diagram here worked out it appears that the number of settlements increased gradually from the last phase of the pre-Boreal period all through zone V, culminating just when the Oak-Mixed-Forest began to leave its mark on the forest picture. As the deciduous high forest spread and the forest grew darker, habitation thinned out, and according to a theory previously stated (TROELS-SMITH 1942b), the decreasing number of hunting game in the forest, now closed and with hardly any grass growing in it, is the actual reason why the Maglemose hunters gave up their inland stations in search of new and better hunting grounds. Thus, the lower culture layer of Verup I belongs to the optimum, and the upper layer to the final phase, of the Maglemose culture.

From the facts available, then, it seems fair to believe that the flint pick was either dropped, or thrown away for some reason, at a date when, to our present knowledge, the Maglemose culture flourished; consequently the implement must be contemporaneous with, or earlier than, the many settlements marking the climax of the Maglemose period.— It is to be regretted, however, that the archaeological determination of the two Verup culture layers should be founded on such a slender basis, as only an insignificant part of the excavated material originates from the recognizable culture layers of the refuse area, a fact which calls for thoroughness of method, no less within archaeological than within geological field investigations.

The translation of this paper into English was made by Olaf Lindum.

Dansk resumé.

En pollenanalytisk Datering af Maglemose-Fund fra den sjællandske Aamose.

I Foraaret 1951 blev der i Verup Mose, en Del af den sjællandske Aamose, fundet et „stort Spidsvaaben af Flint" (Fig. 1). Typen er beskrevet i „Danske Oldsager I" under Nr. 45 (MATHIASSEN 1948). Fundet er gjort af Lektor KNUD ANDERSEN, og Fundstedet ligger i umiddelbar Nærhed af en Maglemose-Boplads, Verup I, som er blevet udgravet af C. L. VEBÆK i 1943 og 1944. Finderen af Spidsvaabnet har bearbejdet det udgravede Oldsagsmateriale fra Bopladsen. Paa denne findes 2 Kulturlag, et nedre og et øvre, som KNUD ANDERSEN efter Oldsagstyperne parallelliserer henholdsvis med Periode 2 og Periode 3 af Maglemosekulturen efter BECKERS Inddeling (Aarbøger 1951). Med Støtte af andre Fund fra Aamosen henfører Finderen Spidsvaabnet til „gammel Kystkultur" — et muligt Forstadie til den egentlige Ertebøllekultur.

Fra Spidsvaabnets Fundsted foreligger en Profilbeskrivelse, og et Pollendiagram er udarbejdet (Tavle XIV, Fig. 1). Det samme foreligger fra Bopladsen (Tavle XV, Fig. 3.) For at komme nærmere til de rigtige Forhold i Skovens Sammensætning er der udarbejdet „reducerede" Diagrammer (Tavle XIV, Fig. 2, II og Tavle XV, Fig. 4, II). I disse indgaar *Corylus* i Beregningssummen, medens de stærkt lokalt betingede Træer, *Alnus* og *Salix* er holdt udenfor denne, og de store Pollenproducenter, *Betula, Corylus* og *Pinus* er reduceret til $^1/_4$.

Ligeledes er udregnet Diagrammer, der viser Forskydningerne mellem Egeblandingsskoven (incl. *Corylus*/4) og *Betula*/4 og *Pinus*/4 (Tavle XIV, Fig. 2, V og Tavle XV, Fig. 4, V).

Endelig er der udregnet Diagrammer, som viser Konkurrencen mellem Egeblandingsskovens Træer, hvortil *Corylus* er regnet med reduceret Værdi (Tavle XIV, Fig. 2, VI og Tavle XV, Fig. 4, VI).

Det fremgaar af saavel Sedimenter som af Pollendiagrammer, at i det Tidsrum Diagrammerne dækker — Zone V, Zone VI og Begyndelsen af Zone VII efter Knud Jessen — er den oprindelige Sø groet stærkt til, men at denne Tilgroning er stagneret eller endog er afløst af en Vandstandsstigning, som hovedsagelig ligger i Tidsrummet mellem de to Bebyggelser paa Bopladsen. En Sammenligning mellem Diagrammerne godtgør tillige, at Spidsvaabnet maa være samtidigt med eller ældre end den yngste Del af det nedre Kulturlag paa Bopladsen.

I Verup-Diagrammerne forekommer som nævnt de af Knud Jessen fastsatte Zonegrænser V-VI og VI-VII. Da disse Grænser tildigere har været under Debat, vil det i denne Sammenhæng være af Interesse at underkaste dem en fornyet Granskning. For at skaffe et større Materiale er 4 tidligere publicerede, nyere Pollendiagrammer fra Øst-Danmark omregnet efter de samme Principper som Oversigtsdiagrammerne fra Verup. Følgende Diagrammer er omregnet: Langesö, Fyn (Alfred Andersen 1946) Tavle XVI, Fig. 5, Even (Valdemar Mikkelsen 1949) Tavle XVI, Fig. 6, Stevningen, Fyn (Tage Nilsson 1948) Tavle XVII, Fig. 7 og Holmegaards Mose (Tage Nilsson 1947) Tavle XVII, Fig. 8.

Paa Fig. 2 vises et Skema over forskellige Sæt af Zonegrænser og de Kriterier, de respektive Autores angiver.

Som det fremgaar af Fig. 2 er der almindelig Enighed om at anvende den rationelle *Alnus*-grænse som Zonegrænse (V-VI Jessen). Den rationelle *Alnus*-grænse ligger i Reglen efter den rationelle Grænse for Egeblandingsskoven, undertiden falder disse to Grænser sammen, men i nogle Diagrammer kan den rationelle *Alnus*-grænse ogsaa ligge før Egeblandingsskovens rationelle Grænse.

Da den rationelle Grænse for Egeblandingsskoven imidlertid falder sammen med den første samtidige Forekomst af *Hedera* og *Viscum* er der god Grund til at anse denne Grænse for et klimatisk betinget synkront Niveau i Diagrammerne, og den er da at foretrække for den stærkt lokalt betingede *Alnus*-grænse.

Zonegrænsen VI-VII sættes efter Jessen, hvor den stigende Kurve for Egeblandingsskoven skærer den faldende *Pinus*-Kurve, medens den efter Nilsson sættes ved den rationelle Grænse for *Tilia*. Efter de foreliggende Diagrammer at dømme er ingen af de to nævnte Kriterier velegnede. I begge Tilfælde ligger den nævnte Grænse et eller andet Sted i et jævnt Udviklingsforløb, der begynder ved den rationelle Grænse for Egeblandingsskoven og som vedvarer indtil Egeblandingsskovens Kurve har naaet maximale Værdier. Det vil da være rimeligt at betragte dette Afsnit som en Helhed og sætte Zonegrænsen VI-VII, hvor Stigningen af Egeblandingsskovens Kurve ophører. Paa Fig. 2 er de her foreslaaede Grænser indtegnet mellem Skemaets to Halvdele.

I Fig. 3 er der gjort et Forsøg paa at indordne de indtil nu pollenanalytisk daterede danske Fund fra Maglemose Tid efter de her foreslaaede Zonegrænser.

References.

Aarb. = Aarbøger for Nordisk Oldkyndighed og Historie, København.

D. G. F. = Meddelelser fra Dansk Geologisk Forening, København.

D. G. U. = Danmarks Geologiske Undersøgelse, København.

G. F. F. = Geologiska föreningen i Stockholms Förhandlingar, Stockholm.

ANDERSEN, ALFRED, 1946: Langesø-Egnens Plantevækst efter Istiden. Hans Berner Schilden Holsten & Albert Fabritius: Lehnsbaron Hans Berner Schilden Holsten's Slægtebog. København.

ANDERSEN, A. & MØLLER, K., 1946: Fund af Urokse (Bos taurus urus L.) i Grænge Mose paa Lolland. D.G.U., IV. Række, Bd. 3, Nr. 1.

ANDERSEN, KNUD, 1951: Hytter fra Maglemosetiden. Danmarks ældste Boliger. Fra Nationalmuseets Arbejdsmark 1951. København.

BECKER, C. J., 1952: Maglemosekultur paa Bornholm. Aarb. 1951.

FIRBAS, FRANZ, 1949: Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas nördlich der Alpen. Erster Band: Allgemeine Waldgeschichte. Verlag von Gustav Fischer. Jena.

FÆGRI, KNUT, 1940: Quartärgeologische Untersuchungen im westlichen Norwegen. II. Zur spätquartären Geschichte Jærens. Bergens Museums Årbok 1939-40. Naturvit. rekke Nr. 7. Bergen.

FÆGRI, K. & IVERSEN, JOHS., 1950: Text-Book of modern Pollen Analysis. Ejnar Munksgaard, Copenhagen.

GRAM, K. & JESSEN, KNUD, 1949: Vilde Planter i Norden. Anden udvidede og forbedrede Udgave. I. Bind. G.E.C. Gads Forlag, København.

HULTÉN, ERIC, 1950: Atlas över växternas utbredning i Norden. Fanerogamer och ormbunksväxter. Generalstabens litograf. anst. förlag. Stockholm.

HYLANDER, NILS, 1941: Förteckning över Skandinaviens Växter. 1. Kärlväxter. Tredje Upplagan. Utgiven av Lunds Botan. Fören. Lund.

IVERSEN, JOHS., 1941: Landnam i Danmarks Stenalder. En pollenanalytisk Undersøgelse over det første Landbrugs Indvirkning paa Vegetationsudviklingen. Land Occupation in Denmarks' Stone Age. A Pollen-Analytical Study of the Influence of Farmer Culture on the Vegetational Development. D.G.U., II. Række, Nr. 66.

— 1944: Viscum, Hedera, and Ilex as climate indicators. G.F.F., Bd. 66, H. 3.

— 1946: Geologisk Datering af en senglacial Boplads ved Bromme. Aarb. 1946.

— 1947: Discussion at the meeting: Nordisk kvartärgeologisk möte. 1945. G.F.F., Bd. 69, H. 2, pag. 241.

— 1949: The Influence of Prehistoric Man on Vegetation. D.G.U., IV. Række, Bd. 3, Nr. 6.

IVERSEN, JOHS. & FÆGRI, KNUT, 1950: Text-Book of Modern Pollen Analysis. Ejnar Munksgaard, Copenhagen.

IVERSEN, JOHS. & OLSEN, SIGURD, 1943: Die Verbreitung der Wasserpflanzen in Relation zur Chemie des Wassers. Botanisk Tidsskrift, Bd. 46. H. 2. København.

IVERSEN, JOHS. & TROELS-SMITH, J., 1950: Pollenmorfologiske definitioner og typer. Pollenmorphologische Definitionen und Typen. D.G.U., IV. Række, Bd. 3, Nr. 8.

JESSEN, KNUD, 1920: Moseundersøgelser i det nordøstlige Sjælland. Med Bemærkninger om Træers og Buskes Indvandring og Vegetationens Historie. D.G.U. II. Række, Nr. 34.

JESSEN, KNUD, 1935: The Composition of the Forest in Northern Europe in Epipalæolithic Time. Det Kgl. Danske Vidensk. Selskab. Biolog. Meddel. XII, 1. København.
— 1935b: Archaeological Dating in the History of North Jutland's Vegetation. Acta Archaeologica, Vol. V, Fasc. 3. København.
— 1937: Litorinasænkningen ved Klintesø i pollenfloristisk Belysning. D.G.F. Bind 9, Hefte 2.
— 1938: Some west baltic pollen diagrams. Quartär, Band I. Berlin.
JESSEN, KNUD & GRAM, K., 1949: Vilde Planter i Norden. 2. Udgave. I. Bind. G.E.C. Gads Forlag. København.
MATHIASSEN, THERKEL, 1943: Stenalderbopladser i Aamosen. Nordiske Fortidsminder. III. Bind 3. København.
— 1948: Danske Oldsager. I. Ældre Stenalder. Gyldendalske Boghandel, Nordisk Forlag. København.
MIKKELSEN, VALDEMAR M., 1949: Præstø Fjord. The Development of the Post-Glacial Vegetation and a Contribution to the History of the Baltic Sea. Dansk Botan. Arkiv. Bd. 13, Nr. 5. København.
MÜLLER, SOPHUS, 1886: Nye Stenalders Former. Aarb. 1886.
NILSSON, TAGE, 1935: Die pollenanalytische Zonengliederung der spät- und postglazialen Bildungen Schonens. Meddel. Lunds Geolog.-Mineralog. Institut. N:o 61. Bd. 57, H. 3.
— 1947: A Pollen-Analytical Investigation of Holmegaards Mose with Considerations as to the Age of the Dwelling-Places of the Maglemosean Period in Denmark and Surrounding Areas. D.G.F., Bd. 11, H. 2.
— 1948: On the Application of the Scanian Post-Glacial Zone System to Danish Pollen-Diagrams. Det Kgl. Danske Vidensk. Selskab. Biolog. Skrifter, Bd. V, Nr. 5. København.
NORDMANN, V., 1936: Menneskets Indvandring til Norden. D.G.U., III. Række, Nr. 27.
OLSEN, SIGURD & IVERSEN, JOHS., 1943: Die Verbreitung der Wasserpflanzen in Relation zur Chemie des Wassers. Botanisk Tidsskrift, Bd. 46. København.
VON POST, LENNART, 1916: Skogsträdpollen i sydsvenska torvmosselagerföljder. Forh. ved 16. skand. naturforskermöte 1916. Kristiania.
SAMUELSSON, GUNNAR, 1934: Die Verbreitung der höheren Wasserpflanzen in Nordeuropa (Fennoskandien und Dänemark). Acta Phytogeographica Suecica VI. Uppsala.
TROELS-SMITH, J., 1941a: Geological Dating of a Reindeer Antler Hammer from Vedbæk. Acta Archaeologica, Vol. XII, Fasc. 3. Kbhvn.
— 1941b: Pollenanalytisk Datering af tre Fiskeruser. Résumé en francais. Aarb. 1941.
— 1941c: Pollenanalytisk Tidsbestemmelse af Urokseknoglen med Mennesketegninger fra Ryemarksgaard. THERKEL MATHIASSEN: Vore ældste Menneskefremstillinger. Fra Nationalmuseets Arbejdsmark 1941. København.
— 1942a: Geologisk Datering af Dyrholm-Fundet. Det Kongelige Danske Videnskabernes Selskab, arkæologisk-kunsthistoriske Skrifter, Bd. I, Nr. 1. København.
— 1942b: Foredrag om de foreløbige Resultater af de geologisk-arkæologiske Undersøgelser i Aamosen. D.G.F., Bd. 10, pag. 271-276.
— 1943a: Geologiske Dateringer af Bopladser i Aamosen. En foreløbig Meddelelse. Résumé en francais. Nordiske Fortidsminder III, 3. København.
— 1943b: Geologisk Datering af Koelbjerg Skelettet. Aarb. 1943.
— 1954a: Karakterisering af løse Jordarter. D.G.U., IV. Række, Bd. 3, Nr. 10.
— 1954b: Pollenanalytische Untersuchungen zu einigen schweizerischen Pfahlbauproblemen. Pfahlbaufestschrift 1954.
TROELS-SMITH, J. & IVERSEN, JOHS., 1950: Pollenmorfologiske definitioner og typer. Pollenmorphologische Definitionen und Typen. D.G.U., IV. Række, Bd. 3, Nr. 8.
WELTEN, M., 1947: Pollenanalytisch-stratigraphische Untersuchungen und chronologische Bestimmungen am Pfahlbau Burgäschisee Ost. Stephan Pinösch: Der Pfahlbau Burgäschisee Ost. Jahrb. für Solothurnische Geschichte, 20. Bd. Solothurn.

Two Standard Pollen Diagrams from South Jutland.

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Abstract.

The author presents pollen diagrams from two localities in South Jutland, 1) Lake Tinglev situated in an infertile out-wash plain, and 2) Bundsö, a lake in a fertile boulder clay region (see the map Fig. 1). After examining the diagrams the author makes a comparison between them, in which he points out i. a. the marked difference due to the fact that the Bundsö diagram is greatly influenced by culture, whereas this factor is remarkably little noticeable in the diagram from Lake Tinglev (apart from the Sub-Atlantic part of it). Thus the early periods of the latter diagram reveal how the forest develops when conditions are natural.

Contents.

Introduction.

One of the principal purposes of pollen analysis is to clarify the evolution of the vegetation during past ages. For Denmark, we have gradually become familiar with the broad outlines of the changes that have taken place in the vegetational picture since the melting of the ice at the close of the Glacial Period, and already in 1935 KNUD JESSEN set up nine pollen zones (I—IX) which are still applied to Danish diagrams. But even though the main features are the same everywhere in the country, there are some variations from one part to another and many details call for elucidation.

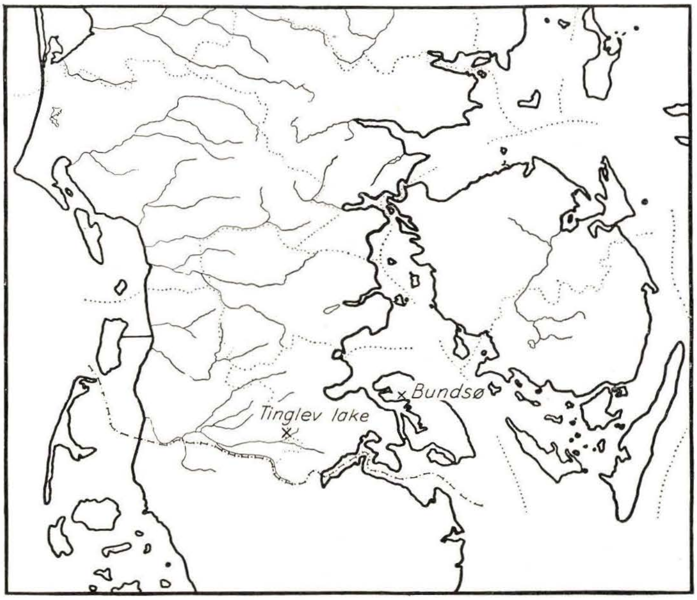

Fig. 1. Map showing the two localities.

In the course of time a large number of pollen diagrams have been drawn up for various parts of the country, but as a general rule they refer only to short sections of the postglacial era, having usually been prepared for some particular purpose. For all specialized pollen statistical investigations it would, however, be a great benefit if more comprehensive diagrams, "standard diagrams", covering the various regions of our country, were available. To qualify as "Standard" a diagram must extend over the longest period of time possible and it must reflect the evolution of the vegetation within a region of fair size. For this reason, the sample series on which it is to be based must be taken at a place where the influence of local factors is at a minimum, for example from the middle of a large lake basin. Only very few such standard diagrams have been published, drawn up along more modern lines, taking due regard not only to the pollen of trees and shrubs but also to that of the herbaceous plants.

Accordingly, the present work is an attempt at filling that hiatus in respect to South Jutland, and I hope to have opportunities later on of presenting standard diagrams for other parts of Denmark as well.

The two South Jutland localities which have provided the pollen series for these analyses are Lake Tinglev, representing the western infertile part of the province, and the lake Bundsö, on the fertile island of Als. Both lakes are dried up, so that the bog drill was easy to use. The work in Lake Tinglev was done in 1941 and 1942 by Drs. Sigurd Hansen and Johs. Iversen, who made borings at several places and obtained sample series from suitable spots. In Bundsö the borings were made in the summer of 1948 by Dr. IVERSEN and the writer.

If it has been decided to publish these two pollen diagrams together, the reason is that they form an excellent supplement to each other. The Lake Tinglev diagram is practically free of cultural influences in the early periods, whereas the Bundsö diagram is affected by this factor to an unusual degree. Furthermore, as already indicated, whilst Lake Tinglev is situated on the anything but fertile out-wash plain, Bundsö is surrounded by fertile boulder clay soils.

Before going through the various diagrams I shall describe briefly how the percentages were calculated. In most earlier diagrams the sum of the arboreal pollen (AP) except hazel was employed as the basis for these calculations (cf. v. POST 1918, p. 442). In accordance with IVERSEN & FÆGRI (1950) in the present paper hazel is, however, included in the AP. In the following, then, it is to be understood that the term AP always embodies *Corylus*.

It will be seen that the diagrams are divided into two sections, A and B, A comprising trees (AP), B herbaceous plants and low shrubs (NAP). All the curves are plotted on percentages. In Section A these percentages are worked out on the basis of the sum of AP, but in Section B the pollen count of the particular species is added to AP in every case, and the resulting value is employed as the basis for calculation. Thus, where HP signifies the absolute pollen number of a species, the percentage is:

$$\frac{100 \times HP}{AP + HP}$$

Lake Tinglev.

This locality is situated about 1 km. SW of the station of Tinglev. It is completely surrounded by the out-wash plain. On a map dated 1828 are shown two basins of almost equal size, joined by a narrow waterway. During the first World War the place was drained by ditches, causing a lowering of the water level, and now the lake is a swamp with a vegetation of *Phragmites*, *Typha*, *Sparganium ramosum*, species of *Carex*, *Rumex Hydrolapathum*, *Ranunculus lingua*, *Caltha palustris*, *Galium palustre*, *Cicuta virosa* and other swamp plants. The bottom, covered with water here and there, is very soft and impossible to walk upon; boring had to proceed from a flat-bottomed boat. At about the narrowest part of the former lake there is now a railway embankment, which serves further to mark the separation into a northern and a southern part. In the following these two basins will be called Tinglev Nörresö and Söndersö respectively.

Two sample series have been analyzed, one main series from Nörresö and a smaller one from Söndersö. The latter, representing merely the upper strata down to a depth of 2 metres, is included as a supplement to the former, which apparently does not reach up so high. The two borings lie about 600 metres apart.

The following section was recorded from the boring in Nörresö:

0– 60 cm.	water
60–169 cm.	telmatic fen peat with *Menyanthes* and *Carex*
169–200 cm.	calcareous gyttja
200–550 cm.	lake marl
550–600 cm.	slightly sandy calcareous gyttja
600–700 cm.	sandy, grey gyttja
700–780 cm.	do, but without sand, lighter downwards
780–800 cm.	peaty, sandy and gravelly stratum with wood of *Pinus*
800–(805 cm.)	gravelly sand.

The supplementary boring in Söndersö gave:

0–28 cm.	water
28–ca. 60 cm.	fine-sandy diatom gyttja
ca. 60–80 cm.	sandy calcareous gyttja with molluscs
80–125 cm.	calcareous gyttja with molluscs
125–(200 cm.)	lake marl

The diagram from Tinglev Nörresö (Plate XVIII) shows that sedimentation did not begin until relatively late, i. e. in the beginning of the Boreal Period (Zone V), as shown by the *Corylus* curve which is still fairly low, and by the dominant *Pinus* and *Betula*.

The fact that in such a deep basin there are no deposits from earlier periods may possibly be due to circumstances similar to those demonstrated by Hartz (1912) in late-glacial sediments. Directly overlying the moraine he found first terrestrial, then limnic Alleröd strata, whereas Older Dryas was lacking. Hartz's explanation is that when the ice-sheet was waning at the close of the Glacial Age, it left behind a large ice core covered by a moraine sheet. The moraine cover would gradually acquire a growth of vegetation, and mould was formed. In the warm Alleröd time the lump of ice finally melted and the overlying deposits sank down. As a result, the spot became a water-filled basin, and on its bottom gyttja formed over the Alleröd mould.

In Tinglev Nörresö a thin bed of peat (780–800 cm.) lying directly on the sand is observed. This deposit, which was encountered in several borings in both Nörre- and Söndersö and which sometimes is somewhat mould- like in character below, corresponds to Hartz's Alleröd mould. However, the lump of ice that caused the forming of Lake Tinglev did not melt away completely until the Boreal Period (Zone V) at the earliest.

Before that the moraine above it was covered with vegetation, and in the early forest period, even trees grew above the ice remnant as the presence of *Pinus* wood in the peat layer demonstrates. This latter deposit must have been formed while the ice was melting, when the ground surface subsided and turned into a depression filled with water. In it peat was formed at first, and later, when the depth became greater, gyttja was deposited.

For the rest, Zone V in the Nörresö diagram presents a normal picture, with a high *Pinus* curve and very soon considerable *Corylus* values too, whilst the *Betula* curve decreases and the Oak Mixed Forest as yet is quite insignificant; the first faint traces of *Alnus* appear in the closing phase of the zone. The rise of the *Alnus* curve marks the transition to Zone VI, in which the Oak Mixed Forest increases whilst *Betula*, *Pinus* and *Corylus* describe a steady fall. According to JESSEN (1935), the boundary between VI and VII is placed where the ratio of *Pinus* to the Oak Mixed Forest acquires the value of 1. Zone VII (Atlantic Period) is characterized by a very gradual fall of *Pinus* and by decreasing *Betula* and *Corylus* curves, though these two are more oscillating, a fairly quiet and uniform curve for *Alnus* and a smooth increase of the Oak Mixed Forest, the latter due especially to the curve of the oak itself. Here *Fraxinus* does not begin to appear until the beginning of Zone VII, whereas normally it occurs somewhat earlier. Pollen of *Viscum* and *Hedera* has a sporadic occurrence. The latter already made its appearance at the beginning of Zone VI.

I have placed the lower boundary of Zone VIII, Sub-Boreal Period, in conformity with IVERSEN (1941) where the *Ulmus* curve begins to fall, whilst *Quercus* simultaneously rises. Following shortly above the zone boundary is the first vague sign of a land occupation (IVERSEN 1941), manifested by a slight decrease for elm and oak, whereas *Tilia* and *Fraxinus* show scarcely any reaction. *Betula*, which usually increases, is also unaffected, whereas *Corylus* and *Alnus* display slight, temporary increases. A little higher up the diagram (at 245 cm.) the curves describe exactly the same course as those just mentioned, i. e. another sign of a clearance, though only faint.

Together with the first land occupation we find a few pollen grains of *Plantago lanceolata*, and this typical agricultural indicator occurs continuously, increasing somewhat upwards in the diagram. A single pollen grain of *Plantago major* was found at 235 cm. Among other weeds—though they also occur in earlier periods—mention should be made of *Rumex Acetocella* and *Artemisia*. These too occur only in small numbers throughout the greater part of Zone VIII (Sub-Boreal Period) and react but very feebly to the two weak clearing phases. *Plantago lanceolata* and the other weeds mentioned have a slight, transitory increase towards the boundary between Zones VIII and IX together with a small regression for the Oak Mixed Forest, a picture suggesting that culture is now approaching nearer.

All in all it will be seen that during the greater part of the Sub-Boreal Period there was no culture, or at any rate extremely little, in the immediate environs of Lake Tinglev. It is presumable that the faint signs of culture influence were due to more remote forest clearances. As a matter of fact, a study of archaeological finds and graves leaves the definite impression that the area is particularly poor in relics from the Stone Age. For example, there are no dolmens or passage graves, nor have any single-grave mounds been recorded (cf. maps in Brøndsted 1938 and Glob 1945). Southwest, west and north of Lake Tinglev, however, there are some groups of tumuli, mostly undated, but a small number which have been dated prove to have belonged mainly to the Bronze Age. This would seem to indicate a Bronze Age settlement in the vicinity, and perhaps this is what is reflected in the aforesaid increase of weed pollen towards the close of Zone VIII.

The boundary between Zones VIII and IX has been placed where the *Fagus* curve goes beyond 1 per cent. As already mentioned, the Nörresö diagram does not reach so far up in time as would have been desirable, and therefore it must be extended by means of a small diagram from Söndersö (Plate XVIII). In fitting them together it must be observed that whereas the upper deposit in Nörresö is fen peat, in Söndersö it is gyttja, which means that sedimentation proceeded at a much faster rate in the former than in the latter. As a consequence, the Sub-Atlantic part of the Nörresö diagram must actually correspond only to the lower 15–20 cm. of Zone IX in Söndersö. If this is borne in mind the two diagrams fit very well together. The most noteworthy difference is the *Fraxinus* curve, which is very low in the Nörresö diagram but relatively high at the beginning of Zone IX in the diagram from Söndersö. Local factors would doubtless account for this.

In addition to the rise of the beech curve, the outstanding features of Zone IX are a slight advance for *Pinus*, an increase by *Betula*, a decrease by *Alnus*, and a regression by hazel and Oak Mixed Forest which are gradually displaced by beech. As regards culture, it is now evident that a settlement has been formed in the neighbourhood, as the curves for weed pollen rise more or less abruptly. This is clear especially in the Nörresö diagram and it is observable that there was a strong cultural influence as from 120 cm. and upwards. This may perhaps be due to the Tinglev settlement itself, as names ending in -lev are considered to be typical of the period of the great migrations, i. e. 4th—6th century A. D. (Hald 1947). It will also be noticed that the curves for *Pteridium* and especially *Calluna* on the whole keep pace with the weed plants.

The explanation of this must be that these two plants had good chances of finding favourable conditions of growth in the meagre, sandy fields which were very liable to run wild with heather if left to themselves for a few years. Only very few cereal pollen grains were found, from which it is assumed that rye-growing in the area did not begin until later, because the cultivation of this anemophilous cereal would otherwise have left traces in the form of larger quantities of pollen.

In this connection there are grounds for examining the curve for grasses (*Gramineae*), for the reason that it might also be thought likely to register culture phenomena such as common pastures, etc. In the Nörresö diagram at the bottom there is a maximum, presumably due to a *Phragmites* vegetation which formed the peat deposit underlying the gyttja. From there upwards the *Gramineae* curve records low percentages and marked regularity until the lake began to be overgrown shortly prior to Zone IX. Then comes a vigorous increase and from now on through the remainder of the diagram the curve is high. We must assume that the Sub-Atlantic culture maximum also contributed towards raising the *Gramineae* percentage, but if so the fact is quite concealed, as it was relatively unimportant compared with the enormous increase caused by local succession. The same thing is observable in the Söndersö diagram, though the rise of the *Gramineae* curve seems to occur somewhat later there.

In addition to the grasses, the overgrowing of the lake was registered by other plants, first and foremost the *Cyperaceae* (presumably *Scirpus lacustris*), whose curve on the whole follows that of the *Gramineae*. *Typha latifolia* occurs together with the *Cyperaceae*, a little later *Sparganium* and some *Umbelliferae*, then *Galium palustre* and *Menyanthes* and finally *Ranunculaceae*. This succession applies to Nörresö. During Zone IX Söndersö had some overgrowth along the banks, as is proved by the *Gramineae* and *Cyperaceae* curves, but out in the lake there was open water, though shallow. It is observed that in the upper strata here we find pollen of *Nuphar* and *Nymphaea* as well as the characteristic hairs of *Ceratophyllum*.

Bundsö.

About 4 kilometres SSE of Nordborg, on the island of Als, the lake Bundsö lies in the centre of a fertile tract of moraine land. It is the innermost part of a former sea-arm which in Litorina time forced its way into a small tunnel valley. The connecting waterway to the sea was very slender and in historic time the entrance was closed off by the building of two dams at the narrow points at Mjelsgård and Broballe. On Meyer's map dated 1649 (Meyer & Danckwert 1652), Bundsö is accordingly shown as a lake, and again on the 1783 map of the Royal Academy of

Science. P. SCHMIDT (1949) states that the lake was artificially drained in 1846–47 and turned into a meadow.

In 1888 a settlement from the late Passage-Grave Period was discovered at the east end of Bundsö and several archaeological excavations have been made there, most recently in 1933 and 1935 by Nationalmuseet (see MATHIASSEN, TH., JESSEN, K. & DEGERBØL, M., 1939). In conjunction with these excavations the geological features were examined by Danmarks Geologiske Undersøgelse (see JESSEN 1939).

In the summer of 1948 Dr. JOHS. IVERSEN and the writer made a boring in the middle of the basin just N of the boundary between the parishes of Oksböl and Hagenbjerg. We bored down to 910 cm. and recorded the following strata:

0–ca. 20 cm.	mould
ca. 20–75.5 cm.	greyish-green, fine-sandy freshwater gyttja
75.5–190 cm.	marine, greyish-green sandy gyttja with molluscs, especially *Mytilus* and *Cardium*
190–814 cm.	marine clayey and sandy gyttja with molluscs (especially *Mytilus* and *Cardium*), the sand content decreasing downwards and the mollusc content increasing
814–855 cm.	light greyish-brown clayey and sandy freshwater gyttja
855–892 cm.	do, with small stones and increasing sand content downwards
892–(910 cm.)	boulder clay

The diagram Plate XIX shows that sedimentation began late, i. e .a good way into Zone VII (Atlantic Period). No doubt this is connected with the rise of the sea level in the Litorina Period, which in turn caused a rise in the ground water level as a whole. At the 814 cm. level the salt water broke in, and this was followed by the long sea-water period which continued into historic time until the embankments mentioned were built. The transgression which was thus involved will presumably correspond to IVERSEN's third salt-water phase in Lake Söborg, Söborg III (IVERSEN 1937) just prior to the *Ulmus* fall.

In the Atlantic section of the diagram (Zone VII) it is observable that most of the curves pursue a rather smooth course. *Pinus* and *Betula* have low and fairly equal values, the *Alnus* curve falls towards the close of the period and at the same time the Mixed Oak Forest rises steadily. *Ulmus* has relatively high values while the *Fraxinus* curve, which below is quite insignificant, rises a good deal towards the end of Zone VII. Small quantities of *Viscum* and *Hedera* pollen occur here and there.

The border between the Atlantic and Sub-Boreal Periods (Zones VII and VIII) is placed as usual at the steep fall in the *Ulmus* curve; shortly afterwards, considerable changes begin to appear in the picture of the forest. We get a very well marked and typical "land occupation phase", of which the features are a recession by the Mixed Oak Forest and a temporary advance, first of birch and a little later of hazel. Simultaneously, *Plantago lanceolata* appears in relatively large numbers, together with *Plantago major*, *Cerealia*, *Rumex Acetosella*, and *Artemisia*. The two latter plants are also present earlier, but with quite insignificant values.

This first culture period is brief; the weeds soon decrease and the Mixed Oak Forest advances again. This is best seen from the "curve" for the sum of the agricultural indicators, shown as a hatched area together with the *Gramineae* curve. The forest is given but a short time in which to regenerate, however, for a new clearance follows soon, describing a course similar to the former one. Nevertheless it is worth noting that this time the clearance seems to have been more effective than during the first land occupation, as witness e. g. the higher values of *Plantago lanceolata* and *Gramineae* and the fact that the temporary advance of birch is almost absent this time, perhaps because of greater numbers of livestock (cf. TROELS-SMITH 1942 p. 175). By the way, as the diagram shows, this culture phase is divided into two, there being a slight advance of the Mixed Oak Forest in the middle and a corresponding temporary decrease of the plants conditioned by culture.

The actual conclusion of clearance phase 2 does not arrive until the 548 cm. level, where the Mixed Oak Forest for the last time reaches full but very brief regeneration and where weed pollen is extremely scarce. At this point there is a very marked peak on the *Ulmus* curve, a somewhat surprising occurrence as otherwise the elm, after the fall at the first land occupation, usually remains at very low values. The question of contamination while boring, however, may be ruled out, since the peat drill on the way down passed only through deposits with low *Ulmus* percentages.

The diagram then makes it evident that after the last-mentioned culture minimum there was a new advance for agriculture and the Mixed Oak Forest was again displaced. A long period follows in which the influence of culture fluctuates somewhat but is never entirely absent. Immediately above the border between Zones VIII and IX, where the beech begins to assert itself, there is a considerable advance for the agricultural indicators and a decline for the Mixed Oak Forest. The end of this phase does not occur until well into Zone IX; there the weeds gradually recede until they almost disappear at about 133 cm. In conformity with this culture minimum the beech multiplies strongly and from then on continues to be the dominant forest tree.

After maintaining high values for some time the beech is compelled to retire again, on account of a new and vigorous culture advance which now begins. It will be noted that the silhouette for *Cerealia* now reaches a significant maximum, the explanation of which must be that rye, which in contrast to the other cereals is wind-pollinated, had been introduced into the area. In Denmark no rye has been found until just after the birth of Christ, and it only acquires importance a few centuries later (JESSEN 1945). The probable reason why it seems to arrive at Bundsö at a still later date is that *Secale* is cultivated especially on poorer soil and the fertile soil of Als was less suitable for rye-growing.

Another interesting plant whose pollen occurs in the upper culture maximum is the cornflower, *Centaurea Cyanus*. Pollen of this plant has been found in the late-glacial period (IVERSEN 1947), but after that it seems to have disappeared throughout the postglacial Period until the late Sub-Atlantic. At any rate, it does not become common until the Middle Ages, according to Mikkelsen (1952) after about 1300. It is associated with cornfields, especially winter-sown fields, so it is natural that in Bundsö it appears together with a maximum for pollen of cereals, which means rye.

The *Gramineae* curve will be seen together with the aforesaid hatched area, giving the sum of the agricultural indicators. In the present case this includes *Cerealia*, *Plantago lanceolata* and *major*, *Rumex Acetosella*, *Centaurea Cyanus*, *Polygonum aviculare* and *Artemisia*, as well as a few rare weed pollen types not shown in the diagram but appearing in Table III. The grasses are not included, but the two curves are combined in order to show how closely—one might almost say to the smallest detail—they conform. This is connected with the facts that as a whole the *Gramineae* curve registers pastures and that the most significant of the species mentioned, *Plantago lanceolata*, also grows chiefly on pastures.

On the right of the *Gramineae* curve is a series of silhouettes which more or less adhere to the same rhythm as the culture indicators proper. These are *Humulus/Cannabis*, *Urtica*, *Liguliflorae* and *Tubuliflorae* as well as *Pteridium*. *Humulus/Cannabis* is particularly interesting. The pollen of the two plants is put together, because so far it has been impossible to distinguish them morphologically. It will be seen that this pollen type is very sporadic and numerically low through the early periods, and that it is only with the last culture maximum that the *Humulus/Cannabis* silhouette also ascends sharply. Presumably this can only mean that one of the two plants was grown; but which?

Through the medium of extensive studies, especially philological, it seems to have been established that *Cannabis*, originally a wild plant on the steppes of Central Asia, was late in reaching Northern Europe (HOOPS 1905). There are signs, however, that the Anglo-Saxons knew it prior to their emigration to England (about 450 A. D.). In this connection it should be mentioned that to my knowledge no pre-Sub-Atlantic hemp has been found in Central or Northern Europe. In Denmark, however, some hemp seeds were found in a bog at Brörup, in South Jutland, presumably dating from early Sub-Atlantic time (JESSEN 1948). *Cannabis* fruits were also found at Trelleborg, in Zealand; they may perhaps date from the Viking Age but may also be later (ibid.). Viking Age finds were also made in Sweden (Birka, according to HALD 1950) and Norway (Oseberg ship, HOLMBOE 1921). Hemp is also known to have been grown in Norway in the 13th century and in fact as late as in the 18th century.

We may thus take it for granted that the pollen of this type from earlier periods must be of the hop. This plant originally was wild in Denmark. *Humulus* seeds, dated to the close of the Ancylus Period (Zone VI), were found by K. JESSEN (1920), while its pollen occurs as early as in Zone IV, i. e. the beginning of the forest period (ANDERSEN and MØLLER 1946). We know nothing of when the cultivation of the hop began in Denmark, but there is written evidence of it in Germany in the 9th century (LIND 1918), in Sweden 1291 (SCHÜBELER 1886) and in Norway 1341 (ibid.). In Denmark, hops are mentioned by HENRIK HARPESTRENG in the 13th century (Edition 1908, p. 90), but this source does not say whether or not it was cultivated in Denmark then. The probability is, however, that the plant began to be grown at any rate just as early in Denmark as in her northern neighbouring countries. Accordingly, judging by all the evidence both plants were grown in Denmark in the Middle Ages and later.

In order to clarify the question of whether the maximum in the Bundsö diagram may be assigned to *Cannabis* or *Humulus*, one might take measurements of the critical pollen type and of recent pollen of the two plants and compare the values arrived at. This method was employed by FRÖMAN (1939) with good results, for he found that *Cannabis* pollen was distinctly larger than *Humulus* pollen. Similiar studies were also attempted in this case, but since the fossil grains of the type mentioned were all more or less folded, it proved to be impossible to get a completely reliable measurement. MAX WELTEN (1952) suggest there is a difference in the size of the pores of the two species, but I have been unable to verify any such difference. In order to solve the problem we must therefore proceed along entirely different lines.

Hops are generally grown for the purpose of providing the flavour for beer. Only the female plants are required, for they alone bear the cones used in brewing. Hemp, on the other hand, is grown for its fibres, which are obtained from both male and female plants. Hops (both sexes) are supposed to have been put to similar use in earlier times (i. a. in Sweden, according to FRÖMAN 1939, p. 96) but it is doubtful if this was ever a common custom, and to my knowledge there is nothing to show that the hop has ever been used for spinning in Denmark.

Another thing which may possibly give a hint is an observation from the late 1600's. This is from a manuscript written by CLEMENS PEDERSEN, resident curate in Hagenbjerg, NE of Bundsö (1658–1685), which contains, i. a., recipes for some household remedies. One of these mentions, among other ingredients which should be used, "item det, som affaldes af Hampen, når den tærskes" ("in addition, that which left over from hemp, when it is threshed", RABEN 1926, p. 44). This can perhaps be taken to mean that the cultivation of hemp was not unknown in the region at the close of the seventeenth century. As will later be shown, the *Humulus/Cannabis* maximum seems to correspond to just this period.

Moreover, closer study shows that the male plants (the pollen producers) of the hop are actually rare. WINGE (1937) found that the male percentage in *Humulus Lupulus*, though fluctuating, had a very low average on the whole (about 10% males), whereas for *Cannabis* it was much higher (about 42% male plants). Thus there is every probability that the last big advance of the pollen type in question actually records the cultivation of hemp (cf. also WELTEN 1952, p. 107–108).

As already stated, Bundsö began as a freshwater lake but soon became salt (brackish!), a state which persisted until communication with the sea was interrupted in the Sub-Atlantic Period. It would be interesting to ascertain exactly when this interruption took place. According to P. SCHMIDT (1949), the records of Nordborg church contain a note that an embankment was built at Mjelsgård in 1590, and the local historian CHRISTIAN KNUDSEN concurs (also according to P. SCHMIDT) by stating that Duke HANS THE YOUNGER built dams at Mjelsgård and Broballe in the close of the 16th century. In SCHMIDT's opinion, however, there was a bridge or embankment earlier at Broballe, on the assumption that there must have been some traffic between the two halves of Oksböl parish, that south of the firth with the towns of Mjels and Broballe, and that on the north with the parish town of Oksböl. However, there is apparently no evidence of an actual embankment earlier than the Duke's. Communication across the firth no doubt proceeded via a bridge, as indeed the name Broballe seems to suggest (Bro = bridge).

Thus there is great probability that the change from salt- to fresh-water, recorded so distinctly in the diagram, took place sometime about the year 1600. Next, it will seem reasonable to assume that the culture minimum a little lower down corresponds to the depression years of the 14th century, when the plague, the Black Death, devastated the country. It is furthermore to be seen that the last great culture advance, with the growing of rye, hemp, etc., took place presumably in the years shortly after 1600.

Now to examine what changes occurred in the vegetation in conjunction with the transformation of Bundsö from a lake to a sea-arm and back again. The characteristic feature of the first freshwater period is the *Nuphar* hairs, the curious hairs on water-lily leaves which are found much more frequently than the pollen of these plants. They disappear abruptly when the salt-water breaks in. Exactly the same happens with the fresh water alga *Botryococcus*. Another plant that was present at the beginning is *Potamogeton*[1]), though it is not so specific to freshwater as *Nuphar* and *Botryococcus*. Some species of *Potamogeton* can live in both fresh and brackish water, so there is nothing remarkable in pollen of these plants being encountered now and then all through the long brackish-water period. On the other hand, the diagram reveals that *Chenopodiaceae*, *Ruppia* and "*Hystrix*" only begin together with the coming of the salt water. The last-mentioned seems to form a fairly heterogeneous group of salt water organisms whose taxonomic position has not yet been fully clarified. *Chenopodiaceae* may occur as shore plants and as weeds inland, where e. g. in the Atlantic Period they are often associated with the Mesolithic settlements. However, it would seem that there were no such settlements at Bundsö in the freshwater period, for which reason the goosefoot pollen there appears for the first time at the beginning of the salt-water phase.

The lake having been cut off from the sea in the Sub-Atlantic Period, the aquatic vegetation changes again. *Botryococcus* reappears in great frequency. *Myriophyllum spicatum*, which was not found in the first lake period, now is common and a maximum of *Potamogeton* shows that these plants thrive better now than in the brackish-water period. *Ruppia* and *Hystrix* continue with small values for a short time, which seems to suggest that the enclosing was not wholly effective; the inference is that salt-water still made its way into the basin now and then in times of storm or flood-tide. That something of the kind did in fact occur in more recent time is evidenced by the inundation in 1872, when salt-water made its way right into the then dried-up basin of Bundsö. This may be the reason why *Nuphar* made no reappearance, as according to OSTENFELD (1918, p. 233), this plant cannot tolerate a salinity of over $1^0/_{00}$. *Botryococcus*, on the other hand, is less sensitive—again according to what OSTENFELD (1918) found in Randers Fjord. The *Chenopodiaceae* also persist through this latter period, presumably due to their presence in the form of weeds. Nevertheless, it is rather strange to observe the marked increase at the end when the agricultural indicators proper recede.

As already stated, K. JESSEN (1939) published a diagram from the east end of the lake adjacent to the settlement. On important points that diagram differs from the one now presented. The assumption is that this is due to the fact that the salt-water, when it made its way into the east

[1]) This refers solely to the section *Eu-Potamogeton*, but not to *Coleogeton*, which comprises *Potamogeton pectinatus* and *filiformis*.

end of the lake, eroded and redeposited some earlier local peat deposits. This is suggested i. a. by the high *Pinus* and *Salix* percentages in the lowest part of Zone VII and by the surprisingly high *Tilia* curve. This also explains the strange fact that the transgression here, apparently, began at a very early juncture (in the beginning of Zone VII). It can be seen from the new diagram that the transgression in fact did not occur until the close of VII at a time which corresponds better to what would be expected according to other investigations in the region.

Comparison of the Tinglev and Bundsö Diagrams.

The earliest zones in the Tinglev diagram have no parallel in the diagram from Bundsö, which does not begin until the latter half of Zone VII. In this section, up to the border to VIII the diagrams lend themselves to considerable correlation. For example, there is close similarity with regard to the curves for *Pinus*, *Betula*, *Ulmus*, *Quercus*, *Tilia* and *Fraxinus*. The fact that the curves for *Betula* and *Pinus* are on the whole higher in the Tinglev than in the Bundsö diagram, whereas the reverse is observable with *Ulmus*, for example, may presumably be explained by the difference between the poor, sandy soil at Tinglev and the fertile, more clayey soil in Als. The border between Zones VII and VIII forms the demarcation in the two diagrams above which the important difference begins. As stated, the border itself is placed at the decline of the *Ulmus* curve. *Hedera*, which in these diagrams is very sparsely represented on the whole, displays no clear reaction at the zone border, whereas in diagrams from other parts of the country it is possible to observe a fall of the *Hedera* curve simultaneously with that of *Ulmus*. This indicates a drop in the winter temperature, which Iversen (1941) suggests may also have been the cause of the decline of the elm. Another theory was advanced by J. Troels-Smith (1953) to the effect that the farmer culture proper, supposedly introduced by a freshly immigrated people, was preceded by a semi-agricultural phase. According to Troels-Smith it represented a population, which together with hunting and fishing was engaged in a little tilling and animal husbandry, where elm leaves and twigs formed a large part of the fodder. This was supposed to be the explanation for the recession of the elm. This theory is supported i.a. by the fact that very small quantities of pollen of *Plantago lanceolata* and *major* were found at the time when the first *Ulmus* fall is registered but before the actual land occupation. It is impossible to say if there was a semi-agricultural phase at Tinglev or Bundsö. The diagrams reveal no traces of any, but the question can only be settled by more complete investigations than the present.

Whereas the land occupation phases proper were reflected very clearly and distinctly in Bundsö, this is nothing like the case in Lake Tinglev where the reactions are very faint among both weeds and forest trees. It would thus seem evident that what can be seen is nothing but vague repercussions of forest clearances far from the locality. One thing that has the same implication is that in the entire Nörresö diagram only a single pollen grain of *Plantago major* (at 235 cm.) is recorded—a plant closely connected with Neolithic settlements.

Accordingly, in the Tinglev diagram (apart from Zone IX) we are afforded a picture of how the forest develops when there is very little interference by man. For example, we observe how smoothly and regularly the *Tilia* curve runs, how from the first vague traces in Zone VI it increases quite gradually in the beginning of VII, whereafter for a long time it maintains an almost constant but not especially high value. Towards the end of the Sub-Boreal Period (Zone VIII) it descends again quite smoothly until it almost disappears at the transition to the Sub-Atlantic Period (Zone IX) when culture begins. The ash curve has a very similar though less steady course, whereas the oak's curve shows small irregularities.

In Bundsö the situation is that all the species of the Mixed Oak Forest decrease sharply at the first land occupation. But whereas oak and ash regenerate subsequently as soon as the opportunity appears, the linden has received a blow from which it never recovers. Almost the same may be said about the elm except for one case already referred to (at 548 cm.), when it has a quite temporary increase.

Shortly before Zone IX the Tinglev diagram also marks its first considerable culture advance, and thereafter the development, thus started, continues, to culminate a little way into the Sub-Atlantic Period.

The low values recorded by the beech curve just above the border between Zones VIII and IX in Bundsö must presumably have been due to the very intensive culture which also seems to have affected the Mixed Oak Forest. Something of the same kind is also to be seen in Tinglev Nörresö. In the Söndersö diagram for the sake of comparison one might look at the small section (15–20 cm.) above the zone border, in time no doubt corresponding to the part of Zone IX appearing in the diagram from Nörresö. Here the *Fagus* percentages are rather higher, which may mean that the cultural influence is less than in Nörresö, as also indicated by the lower percentages for weed pollen.

Also of interest is the contrast between *Plantago lanceolata* and *Rumex Acetosella* in the Bundsö and Tinglev diagrams. *Rumex Acetosella* is chiefly associated with sandy and often more or less lime-poor soil, which does not apply to *Plantago*. In Zone IX of the diagrams, where there are strong cultural influences at both places, we see in fact how *Rumex* reaches much higher values at Tinglev than at Bundsö, whereas with *Plantago*

Table I. Tinglev Nörresö.

Pollen and spores not included in the diagram.
(The figures give percentages).

Depth in cm.	*Acer*	*Rhamnus Frangula*	*Polygonum Persicaria*-type	*Erodium cicutarium*	*Rhinanthus*-type	*Jasione montana*	*Liguliflorae*	*Tubuliflorae*	*Caryophyllaceae*	*Cruciferae*	*Urtica*	*Humulus Lupulus*	*Vaccinium*-type	*Empetrum nigrum*	*Plantago maritima*	*Litorella uniflora*	*Epilobium*	*Thalictrum*	*Potentilla*	*Valeriana*	*Lythrum salicaria*	*Filipendula Ulmaria*	*Lysimachia thyrsiflora*	*Mentha*-type	*Rumex Hydrolapathum*	*Nymphaea alba*	*Polypodium vulgare*
65						0,2	0,4	2	0,9	2				0,2	0,2				0,4			0,4					
85				0,2		0,2	0,4	0,7	3,5			0,2			0,2				0,6								
105		0,2	0,4			0,2	0,2	0,6	1,5	0,4	1	0,2		0,2			0,6		0,4	0,2	0,2	0,6		0,2	0,2	0,2	
120					0,2				0,4	0,4	0,2							0,2	0,4	0,2		0,2					
135								1	2	0,2	0,2								0,4			0,6					
145								0,5		0,8		0,2		0,3					0,2			0,2					
155								0,1	0,1	0,1		0,3		0,1								0,1					0,1
170								0,3		0,1	0,3											0,1					
180							0,1															0,1					0,2
195							0,1												0,1			0,1	0,1				0,3
215								0,2	0,1																		0,1
225								0,1						0,1													0,1
235														0,1								0,2					
245																									0,1		
255	0,1							0,1																			
265						0,1		0,1		0,1	0,1	0,2										0,1					
275								0,2			0,1											0,1					0,3
285								0,1			0,1			0,1								0,1					0,1
295								0,1	0,1	0,1																0,1	0,1
305								0,1	0,1	0,1	0,3	0,2		0,1								0,1					
315								0,1																			0,1
325								0,1	0,1			0,1		0,2		0,1						0,1				0,2	0,1
335								0,1						0,1													
345								0,1			0,1			0,1				0,1									0,1
355								0,2														0,1					0,2
365												0,1														0,1	
375								0,1				0,1														0,1	
395																						0,1				0,1	
410								0,1						0,1													0,1
430																						0,1					
445							0,1	0,1				0,1															
465											0,2																
485														0,1													
500											0,1	0,1															
520																											
540											0,1							0,1				0,2					
560												0,1															
580								0,1				0,1		0,1													
600								0,1																			
620																											
640								0,1			0,1												0,1				
660												0,1															
680								0,2				0,3		0,1				0,1									
700													0,1														
720								0,3																			
740																											
760											0,1											0,1				0,1	
770																											
785							0,2	0,2																			
795																						0,2					

Table II. Tinglev Söndersö.

Pollen and spores not included in the diagram.
(The figures give percentages).

Depth in cm.	*Spergula arvensis*	*Galeopsis*	*Liguliflorae*	*Tubuliflorae*	*Caryophyllaceae*	*Cruciferae*	*Campanula*	*Urtica*	*Humulus Lupulus*	*Empetrum nigrum*	*Mercurialis perennis*	*Epilobium*	*Potentilla*	*Filipendula Ulmaria*	*Rumex Hydrolapathum*	*Eu-Potamogeton*	*Polypodium vulgare*
35	...	...	0,3	0,9	0,2	1	...	0,7	0,2	...	...	...	0,5	...	...	0,2	0,2
45	0,2	...	...	0,2	0,2	0,2	...	...	...	...	...	...	0,2	...	...	...	0,4
55	...	...	0,2	0,2	0,2	...	...	1,5	...	0,2	0,2	...	0,4	0,4	...	...	...
65	...	...	0,2	0,2	0,2	0,2	...	0,5	...	...	...	...	...	0,2	0,2	...	...
75	...	0,2	0,6	0,4	...	0,2	...	...	...	...	...	...	...	...	0,2	...	...
85	...	0,2	0,2	0,2	0,5	0,3	...	0,4	...	...	...	...	...	...	0,2	...	0,2
95	...	...	0,3	...	0,7	0,5	0,2	...	...	...	...	...	0,2	...	...	...	...
105	...	...	0,2	0,2	0,2	0,2	...	...	0,3	...	...	...	0,2	...	...	...	...
115	...	...	0,3	0,5	0,2	0,2	...	0,5	...	...	...	...	0,2	...	...	...	...
120	...	...	0,4	1	0,2	0,7	...	0,9	...	0,4	...	0,2	...	...	...	...	0,2
125	...	...	...	...	...	...	...	0,3	...	...	...	...	...	...	...	...	...
135	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,3
145	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
160	...	...	...	0,3	...	...	...	0,7	...	...	...	...	...	...	...	...	...
180	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	...	...
195	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	0,3	0,2

the opposite is the case. This is an expression of the difference between the meagre, sandy fields at Tinglev and the more fertile soil in Als.

Another plant which also registers the difference in the nature of the soil at the two places is *Calluna*, which naturally prefers the outwash plains of the Tinglev area. By the way, the Tinglev diagrams agree with Jonassen (1950) in showing that heather only acquires real importance in the Sub-Atlantic Period.

In the Bundsö diagram it will be observed that there is a silhouette for *Populus*, but none in the diagram from Lake Tinglev. This does not mean that the aspen did not grow in the latter locality, but merely that the greater part of the samples from Tinglev were analyzed some years back before I was familiar with *Populus* pollen.

It is a defect in these diagrams, of course, that they do not span the whole of the late-glacial and postglacial periods, lacking as they do the lowest zones. However, for the periods which these diagrams cover they provide a readable picture of the development of the vegetation in South Jutland, where the forest stood most of the time untouched and also where man early and severely influenced the vegetation.

Table III. Bundsö.

Pollen and spores not included in the diagram.
(The figures give percentages).

Depth in cm.	*Acer*	*Sorbus aucuparia*	*Polygonum Persicaria*-type	*Trifolium repens*	*Trifolium* cf. *pratense*	*Jasione montana*	*Camelina*-type	*Rhinanthus*-type	*Cruciferae*	*Caryophyllaceae*	*Mercurialis perennis*	*Thalictrum*	*Potentilla*	*Filipendula Ulmaria*	*Umbelliferae*	*Ranunculus*-type	*Galium*-type	*Mentha*-type	*Sparganium*	*Typha latifolia*	*Rumex Hydrolapathum*	*Nymphaea alba*	*Potamogeton* sect. *Coleogeton*	*Plantago maritima*	*Triglochin maritima*	*Polypodium vulgare*
20	...	...	0,2	...	...	...	...	...	1	...	...	0,2	...	0,8	0,6	...	...	...	...	...	...	...	...	0,2	0,2	...
35	...	...	...	...	...	...	...	...	0,6	0,2	...	...	...	0,6	0,2	2	0,2	...	0,2	...	...	...	0,8	0,2	...	0,2
55	...	...	0,4	...	...	...	0,2	...	0,2	0,2	...	...	0,4	0,4	0,4	0,2	0,2	...	...	...	...	...	0,7	...	0,2	...
73	...	...	...	...	...	...	0,2	0,2	...	0,3	...	...	...	...	...	...	...	0,2	...	...	...	...	0,2	...	0,5	...
83	...	...	...	...	...	...	...	...	0,3	...	...	...	...	0,2	...	0,2	...	...	0,2	...	...	...	...	...	0,3	0,2
93	...	...	...	...	...	...	...	...	...	0,1	...	...	...	0,1	...	...	...	...	0,1	...	...	...	0,1	0,3	0,1	0,3
113	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...
133	0,4	...	...	...	...	...	...	...	...	...	...	...	...	0,4	0,2	0,2	...	...	0,4	...	...	...	0,4	0,2	...	...
153	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	...
168	...	...	...	...	...	...	...	...	0,2	...	...	...	0,3	0,3	0,2	...	0,5	...	...	...	...	...	...	0,5	0,2	...
188	...	...	0,3	...	...	...	...	...	0,4	...	...	...	0,1	0,4	0,3	...	...	...	...	...	...	...	0,1	0,6	0,1	0,3
208	...	...	...	...	...	...	...	...	0,4	0,2	...	...	...	0,4	0,4	0,4	...	...	...	0,2	...	...	...	0,8	0,2	...
228	...	...	...	...	...	...	...	...	1,5	...	...	...	0,5	0,7	0,3	0,7	0,3	...	0,2	...	...	...	...	1	0,2	...
248	0,2	...	...	...	...	...	...	...	0,8	0,2	0,2	...	0,2	...	0,6	0,8	...	...	...	0,2	...	...	...	...	0,6	...
273	...	...	...	...	...	...	...	...	1,5	0,4	...	...	0,4	0,2	0,9	0,4	0,4	...	...	0,4	...	...	...	0,9	...	0,2
288	...	...	0,6	...	...	...	...	...	0,6	0,3	...	...	0,2	0,2	0,5	0,2	0,2	...	...	...	...	...	...	0,2	...	...
308	...	...	0,2	...	0,2	...	0,2	...	0,2	0,4	...	...	0,2	0,6	1	0,4	0,4	...	...	...	...	...	0,2	1,5	...	0,2
328	...	...	0,2	...	0,2	...	...	...	0,3	...	0,2	...	...	0,5	0,5	0,2	0,2	...	...	...	...	...	0,3	0,2	...	...
348	...	...	...	...	...	0,2	...	...	0,5	...	...	...	0,2	0,5	0,2	0,3	0,3	...	0,2	...	...	...	...	0,5	...	...
368	...	0,2	...	...	...	0,2	...	...	...	...	...	0,2	...	0,7	0,2	...	...	...	...	...	...	...	0,2	0,2	0,7	0,2
383	...	...	...	...	...	...	...	...	0,2	...	...	...	...	0,5	...	...	0,2	...	0,2	...	...	...	...	...	0,3	...
398	...	0,2	0,2	...	...	...	...	...	...	0,2	...	...	...	0,2	...	...	0,2	...	...	...	...	...	...	...	...	0,2
413	...	...	...	...	...	...	...	...	...	...	...	...	0,2	0,3	0,6	...	0,2	0,2	...	...	...	...	...	...	0,5	...
428	0,2	...	...	...	...	...	...	...	...	...	0,2	...	...	0,2	0,2	0,2	...	...	...	...	...	...	...	...	...	...
443	0,1	...	...	...	...	...	...	...	...	0,1	...	...	...	0,6	0,3	0,1	0,1	0,1	0,1	...	...	...	...	0,3	0,3	...
463	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...
478	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...
498	...	0,2	...	...	...	...	...	...	...	...	0,3	...	...	0,3	...	0,5	...	...	...	...	...	...	...	0,3	0,2	...
518	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	...	...	...
528	0,1	...	...	...	...	...	...	...	...	...	0,3	...	...	0,3	...	0,1	...	...	0,1	...	...	...	...	...	...	...
533	...	...	...	+	...	...	...	...	...	+	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...
543	0,3	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	0,6
548	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,3
553	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1
563	...	...	...	...	...	...	...	...	0,4	0,2	...	...	...	0,2	...	...	...	...	0,4	0,2	...	...	...	0,6	...	...
573	...	...	...	...	...	...	...	...	0,6	...	...	...	...	0,3	...	0,3	...	...	...	...	...	...	...	...	0,1	...
578	0,2	...	...	...	...	...	...	...	0,2	...	...	...	...	0,2	...	...	...	...	...	0,2	...	...	...	0,3	...	...

Table III. Bundsö. (cont.).

Depth in cm.	*Acer*	*Sorbus aucuparia*	*Polygonum Persicaria*-type	*Trifolium repens*	*Trifolium* cf. *pratense*	*Jasione montana*	*Camelina*-type	*Rhinanthus*-type	*Cruciferae*	*Caryophyllaceae*	*Mercurialis perennis*	*Thalictrum*	*Potentilla*	*Filipendula Ulmaria*	*Umbelliferae*	*Ranunculus*-type	*Galium*-type	*Mentha*-type	*Sparganium*	*Typha latifolia*	*Rumex Hydrolapathum*	*Nymphaea alba*	*Potamogeton* sect. *Coleogeton*	*Plantago maritima*	*Triglochin maritima*	*Polypodium vulgare*
588	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	0,1	...	...	...	...	...	...	...	...	...	0,3
593	0,2	...	...	...	...	...	...	...	...	...	...	...	...	0,2	0,2	0,2	...	...	...	...	...	...	...	...	...	...
603	...	...	...	0,1	...	...	...	...	...	...	...	...	...	0,1	0,4	...	...	...	...	...	0,1	...	...	0,1	...	...
613	...	...	...	...	...	...	...	...	0,1	0,1	...	...	...	...	0,3	...	...	...	...	...	...	...	0,1	0,1	0,4	...
623	...	...	...	0,3	...	...	...	...	...	0,1	0,1	...	0,1	...	0,1	...	...	...	...	...	...	...	...	0,1	0,1	...
633	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	0,1	...	...	...	...	...	...	0,2	0,5	...
638	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	0,1	0,2	...
643	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,3	...
653	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	0,7	...
668	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	1,5	...
678	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...	...	0,7	...
683	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	0,5	...
688	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	0,1	0,9	...
693	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	0,5	0,1
698	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,3	...
703	...	...	...	...	...	...	...	...	1,5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	0,5	...
713	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	0,1	...	...	0,1	...	...	...	...	...	1,5	...
718	...	...	...	...	...	...	...	...	...	...	...	...	+	...	+	...	...	...	...	...	...	...	...	...	0,6	0,1
728	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	0,6	...
738	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	0,1	...	...	...	...	...	0,7	...
753	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	0,6	0,1
768	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	2	...
778	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	...	0,7	...
788	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	0,1	...	...	...	1,5	...
798	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	0,1	...	...	...	...	...	0,1	...	0,4	0,1
808	...	...	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	...	...	...	...	...	...	0,2	...	0,4	...
814	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	0,4	...	...	...	0,1	...	...	0,1
823	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,5	...	...	...	...
833	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	...	...	...	...	...	...	...	0,2	...	...	0,1	0,1
843	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
853	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	0,3	...	...	...	...	...	...	...
863	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	0,2	...	0,2	...	...	...	...
873	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,3	0,1	...	...	...	...	...	...
883	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	...	...	0,1	...	...	0,1	...	...	...	...
888	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	...	0,2	...	...	...	...
892	...	...	...	...	...	...	...	...	...	...	...	...	0,1	...	0,1	0,1	...	...	0,5	...	...	...	...	...	...	...

I must thank Dr. SIGURD HANSEN and Dr. JOHS. IVERSEN for permission to make use of the material from Lake Tinglev. I am also grateful to the latter for his advice and assistance in the analytical work. Miss INGEBORG FREDERIKSEN, drew the diagrams and the translation into English was made by Mr. W. E. CALVERT.

Dansk resumé.

Der er fremstillet normaldiagrammer 1) fra Tinglev sø i den centrale del af Sønderjylland og 2) fra Bundsö på Als. Den første, som naturligt falder i en nordlig og en sydlig del, ligger i en ufrugtbar egn omgivet af hedesletter. Der er udarbejdet et hoveddiagram (fra Nörresö) samt et lille supplerende diagram (fra Söndersö). Nörresö-diagrammet udmærker sig især ved, at det, bortset fra zone IX, er næsten uden kulturpåvirkning. At sedimentationen først begynder i boreal tid (zone V) forklares ved antagelse af en isblok efterladt indlejret i morænen, da isen trak sig tilbage ved slutningen af sidste istid. Efterhånden som temperaturen steg, smeltede den indlejrede iskærne, hvorved de dækkende jordlag sank ned, og søen dannedes (jf. HARTZ 1912). Smeltningsprocessen afsluttedes tidligst i begyndelsen af boreal tid. Ved denne antagelse forklares det lille tørvelag under gytjen (780—800 cm), hvori der fandtes ved af fyr, som tyder på, at fyrreskoven, før isklumpen smeltede, har vokset hen over denne. I begyndelsen af subboreal tid (zone VIII) ses ganske svage spor af »landnam« (jf. IVERSEN 1941). Det drejer sig her øjensynlig om fjerne skovrydninger og først umiddelbart før zonegrænsen VIII—IX er der tegn på kultur på selve egnen (se navnlig silhouetten for Lancetbladet-Vejbred, *Plantago lanceolata*, og Rødknæ, *Rumex Acetosella*). Den således påbegyndte udvikling fortsættes i subatlantisk tid (zone IX), hvor kulturen går yderligere stærkt frem. Lyng (*Calluna*) kommer først til at spille en rolle i subatlantisk tid (jf. JONASSEN 1950).

Længst til højre i diagrammet ses en række silhouetter, som registrerer den efterhånden fremadskridende tilgroning. Medens væksten af den herunder dannede sumptørv åbenbart er foregået ret hurtigt, er den tilsvarende sedimentation i Tinglev Söndersö sket betydelig langsommere, idet der her er tale om en gytjeaflejring. Derfor svarer formentlig hele den subatlantiske del af Nörresö-diagrammet kun til den allernederste del af zone IX i Söndersö, et forhold, som må tages i betragtning ved sammenstillingen af de to diagrammer.

Bundsö ligger i en lille tunneldal og er omgivet af et frugtbart morænelandskab. Også her begynder sedimentationen sent (i atlantisk tid). Den stigning af grundvandet, som da foregår, skyldes formentlig en tilsvarende stigning af havet. I slutningen af atlantisk tid trænger det salte vand ind i Bundsö. Derpå følger den lange fjordperiode, som afsluttes o. år 1600, da der bygges dæmninger, som afspærrer søen fra havet. Omkring 1847 sker en kunstig udtørring af Bundsö.

Kort efter zonegrænsen VII—VIII begynder kulturen at gøre sig gældende, idet det første landnam sætter ind med de dertil hørende karakteristiske kurveforløb i træpollendiagrammet og med den første optræden af *Plantago lanceolata*, P. *major* samt *Cerealia* (korn). I diagrammet ses sammen med kurven for græsser (*Gramineae*) et skraveret areal, som angiver den samlede sum af landbrugsindikatorer (*Cerealia*, *Plantago lanceolata* og *major*, *Rumex Acetosella*, *Centaurea Cyanus*, *Polygonum aviculare* og *Artemisia*). Ved at følge denne »samlekurve« ser man, hvorledes kulturpåvirkningen fortsætter i den følgende tid omend

med vekslende intensitet. Af træpollendiagrammet ses, hvorledes egeblandingsskoven regenererer mere eller mindre fuldstændigt i de korte mellemrum mellem kulturfremstødene, der svækker den. Under det store kulturminimum i subatlantisk tid får bøgen, hvis kurve indtil da har ligget temmelig lavt, en chance og rykker kraftigt frem. Det er sandsynligt, at disse forandringer foregår under nedgangsperioden i 1300-årene, da Den sorte Død hjemsøger landet. En støtte for denne antagelse er, at den lidt højere liggende overgang fra salt til fersk sedimentation som nævnt synes at foregå o. år 1600, idet det vides, at hertug Hans d. Yngre i 1590 lod bygge to dæmninger over fjorden, hvorved Bundsö blev afspærret fra havet.

Foruden de nævnte landbrugsindikatorer i snævreste forstand findes en række andre planter, som er mere eller mindre nær knyttet til kulturen. Dette gælder først og fremmest græsser (*Gramineae*), hvis kurve, som det ses, nøje følger den ovenfor omtalte »samlekurve«. Denne præges navnlig af *Plantago lanceolata*, som er en typisk overdrevsplante, og alt tyder således på, at overdrevskultur er blevet drevet i stor stil. Blandt de andre kulturtilknyttede planter, hvis silhouetter ses til højre for *Gramine*-kurven, bemærkes især *Humulus/Cannabis*-silhouetten, hvis udprægede maximum øverst i diagrammet tyder på dyrkning af en af disse plantearter. De to pollentyper synes ikke at kunne kendes fra hinanden rent morfologisk, og heller ikke ved målinger har det vist sig muligt med sikkerhed at afgøre, om det drejer sig om humle (*Humulus*) eller hamp (*Cannabis*). Imidlertid er det ved dyrkning af humle (til ølbrygning) som bekendt kun hunplanterne, der lægges vægt på, medens man ved dyrkning af hamp (til taver) bruger både han- og hunplanter. Ydermere er hankønsprocenten hos *Humulus* meget lav (ca. 10 %), medens den hos *Cannabis* er betydelig højere (ca. 42 %). Der er derfor overvejende sandsynlighed for, at det nævnte maximum registrerer en dyrkning af hamp, som efter beliggenheden i diagrammet må have fundet sted i tiden kort efter år 1600.

Silhouetterne længst til højre i diagrammet giver ved deres vekslen udtryk for søens skiften fra fersk til salt og tilbage igen.

Til slut er foretaget en sammenstilling af Tinglev- og Bundsö-diagrammerne, hvor der navnlig gøres opmærksom på forskellen inden for zone VIII, hvor Tinglev-diagrammet kun viser ganske minimal kulturpåvirkning, medens diagrammet fra Bundsö er overordentlig stærkt præget af menneskets indgriben.

References.

D.G.U. = Danmarks Geologiske Undersøgelse (Geological Survey of Denmark). København.

D.G.F. = Meddelelser fra Dansk Geologisk Forening (Bulletin of the Geological Society of Denmark). København.

Andersen, Alfred & Møller, Kjeld, 1946: Fund af Urokse (Bos taurus urus L.) i Grænge Mose paa Lolland. D.G.U. IV. rk., bd. 3, nr. 1.

Brøndsted, Johs., 1938: Danmarks Oldtid, I. Stenalderen. København.

Fægri, K. & Iversen, Johs., 1950: Text-Book of Modern Pollen Analysis. Copenhagen.

Fröman, I., 1939: Die Hölzer des Rades und der Hopfenfund. Cf. v. Post, L., Oldeberg, A. & Frøman, I., 1939.

Glob, P. V., 1945: Studier over den jyske Enkeltgravskultur. Aarb. f. nord. Oldk. og Hist. 1944. København.

Hald, Kristian, 1947: Stednavne og Bebyggelse paa Als. Sønderj. Aarb. 1947, 1–22. Aabenraa.

Harpestreng: Gamle danske Urtebøger, Stenbøger og Kogebøger. Edition by Marius Kristensen. København 1908.

HALD, MARGRETHE, 1950: Olddanske Tekstiler. København.
HARTZ, N., 1912: Allerød-Gytje und Allerød-Mull. D.G.F. bd. 4, 85–92.
HOLMBOE, JENS, 1921: Nytteplanter og Ugræs i Osebergfundet. »Osebergfundet« V, 32–35. Kristiania.
HOOPS, J., 1905: Waldbäume und Kulturpflanzen im germanischen Altertum. Strassburg.
IVERSEN, JOHS., 1937: Undersøgelser over Litorinatransgressioner i Danmark. D.G.F. bd. 9, 223–232.
— 1941: Landnam i Danmarks Stenalder. Land Occupation in Denmark's Stone Age. D.G.U. II. rk., nr. 66.
— 1947: Centaurea cyanus Pollen in Danish Late-Glacial Deposits. D.G.F., bd. 11, 197–200.
JESSEN, AXEL, 1945: Beskrivelse til Geologisk Kort over Danmark. Kortbladet Sønderborg. D.G.U. I. rk., nr. 20.
JESSEN, KNUD, 1920: Moseundersøgelser i det nordøstlige Sjælland. D.G.U. II. rk., nr. 34.
— 1935: Archaeological Dating in the History of North Jutland's Vegetation. Acta Archaeologica Vol. V, Fasc. 3. København.
— 1939: Bundsøkulturens pollendiagramatiske Stilling. Cf. MATHIASSEN, TH., JESSEN, K. og DEGERBØL, M., 1939.
— 1945: The Environment and Dating of the Vebbestrup Plough. Acta Archaeologica Vol. XVI, Fasc. 1–3. København.
— 1948: Om Naturforholdene ved Trelleborg og Forbruget af Træ ved Borgens Opførelse. In POUL NØRLUND: Trelleborg. Nord. Fortidsm. bd. IV, hf. 1, 163–179. København.
JONASSEN, H., 1950: Recent Pollensedimentation and Jutland Heath Diagrams. Dansk Bot. Arkiv bd. 13, nr. 7. Copenhagen.
LIND, JENS, 1918: Om Lægeplanter i danske Klosterhaver og Klosterbøger. København.
MATHIASSEN, TH., JESSEN, K. & DEGERBØL, M., 1939: Bundsø, en Yngre Stenalders Boplads paa Als. Aarb. f. nord. Oldk. og Hist. 1939. 1. halvbd. København.
MEYER, JOHS. & DANCKWERT, CASPER, 1652: Newe Landesbeschreibung der zwei Hertzogthümer Schleswig und Holstein.
MIKKELSEN, VALDEMAR M., 1952: Pollenanalytiske Undersøgelser ved Bolle. In AXEL STEENSBERG: Bondehuse og Vandmøller i Danmark gennem 2000 Aar. Arkæologiske Landsbyundersøgelser I. København.
OSTENFELD, C. H., 1918: Randersdalens Plantevækst. In A. C. JOHANSEN: Randers Fjords Naturhistorie. 155–270. København.
v. POST, LENNART, 1918: Skogsträdpollen i sydsvenska torvmosselagerföljder. Forh. ved 16. skand. naturforskermöte 1916. 433–465. Kristiania.
v. POST, L., OLDEBERG, A. & FRÖMAN, I., 1939: Ein eisenzeitliches Rad aus dem Filaren-See in Södermanland, Schweden. Kungl. Vitterhets Hist. och Antikvitets Akad. Handl., Del 46: I. Stockholm.
RABEN, J., 1926: Havnbjerg Kirke og gamle Minder fra Havnbjerg og Oksbøl Sogne. »Fra Als og Sundeved« 1. hefte. Sønderborg.
SCHMIDT, P., 1949: Bundsøs Historie. Dansk Hjemstavn. Nr. 11, 23–24. Tønder.
SCHÜBELER, F. C., 1886: Norges Væxtrige. Bd. I. Christiania.
TROELS-SMITH, J., 1942: Geologisk Datering af Dyrholm-Fundet. Kgl. Danske Vidensk. Selsk. arkæolog.-kunsthist. Skr. bd. 1, nr. 1. København.
— 1953: Ertebøllekultur – Bondekultur. Resultater af de sidste 10 Aars Undersøgelser i Aamosen, Vestsjælland. Aarb. f. nord. Oldk. og Hist. 1953. København.
WELTEN, MAX. 1952: Über die spät- und postglaciale Vegetationsgeschichte des Simmentals. Veröffentl. d. Geobot. Inst. Rübel in Zürich. 26. Heft. Bern.
WINGE, Ø., 1937: Arvelighedslære. København.

Studies on the sub-atlantic history of Bornholm's vegetation.

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Abstract.

The paper contains two pollen diagrams from deposits on Bornholm that were mainly laid down in sub-atlantic time. It is proved that *Fagus* has grown on the island since the beginning of the sub-atlantic period. While *Fagus* is the dominant forest tree in other parts of Denmark, it is *Carpinus* that characterizes the forests of Bornholm. The varying influence of human agencies on the forest of Bornholm during sub-atlantic time is shown. It seems that *Carpinus* is especially likely to suffer badly from the influence of cattle. The investigation suggests that the heath-areas on the central part of Bornholm (Höjlyngen) owe their expansion in the Middle Ages and the following centuries to cattle husbandry. The investigation tends to show periods of enhanced precipitation corresponding in time to RY I, II, and III.

Contents.

I Introduction.

The question whether *Fagus* is or has been indigenous to Bornholm has been discussed for rather a long time (e.g. E. HANSEN, 1943 and 1953). A final solution was, however, impossible, as bogs with sub-atlantic layers were not investigated. The reason for this was that most of the bogs on Bornholm have had their upper layers removed by intensive peat-cutting. In 1942 I was lucky enough to find a peatbog—Græssöen— in the forest Almindingen in the central part of Bornholm, where at least a part of the bog was undisturbed by peat-cutting. Furthermore I have investigated the deposits in a little lake—the Ankermyr—in the forest Slotslyngen on North Bornholm, where at least a part of the sub-atlantic layers was found. The results prove, among other things, that *Fagus* has grown on Bornholm since the beginning of sub-atlantic time.

Financial aid to these investigations was received from the Carlsberg Foundation and I beg to tender my respectful thanks to the governors of this institution. It is my very pleasant duty to thank Professor Knud Jessen for his valuable help. Some years ago Professor Jessen (unpublished) investigated several bogs on Bornholm, and I was able to use his results. Professor Jessen's results were of particular value to me in my search for suitable bogs. May I ask Dr. Johs. Iversen to accept my best thanks for his valuable help in determining several pollengrains. I am indeed most grateful to Dr. E. Deevey for his good linguistic help.

II Græssöen in Almindingen (Central Bornholm).

Græssöen is a small bog situated about 200 metres southeast of the ruins of the medieval castle Lilleborg and about 300 metres northwest of the Gamleborg, a somewhat older fortification. Græssöen, the surface of which lies about 100 metres above the level of the sea, is situated in a depression in an area of rocky hills, which are elevated 120–130 metres above sea-level. Another depression in the vicinity contains the lake near Lilleborg. These two depressions are connected by a narrow valley whose floor forms a threshold some few metres above the common levels of the bog and the lake. Another narrow valley with a low threshold separating it from Græssöen leads from this bog eastwards to a valley which is tributary to Ekkodalen. A ditch leads from the lake near Lilleborg across Græssöen and through the lower valley toward the east.

In the southern part of Græssöen no peat has been cut, but the bog surface is now covered by forest. In 1943 I made a section across this southern part. This section, somewhat simplified, is shown in fig. 3, Plate XX. From P 3 in the middle of the section bigger samples for mechanical analyses were taken. These analyses were carried out in 1947 at Professor Knud Jessen's laboratory by P. Wolthers, M.sc. The results are given in table II, pag. 225. P 3 is the site of the pollen diagram, fig. 1, Plate XX, and table III, pag. 226.

The pollengrains in the boreal layers are poorly preserved and may have been partly destroyed, so the analyses from these layers are included only to give the main outline of the development of the bog.

a. The development of the bog.

The bog rests on a layer of sand except in the western part, where there is a depression underlain by sandy clay. In late-glacial and early pre-boreal time this depression held a lake in which *Potamogeton natans*, *P. praelongus*, *P. perfoliatus*, and *Typha latifolia* grew. In boreal time, after the lake was filled with mud, it was covered with a swamp of *Carex riparia*, *C. rostrata*, *Menyanthes*, and *Lycopus*, and a *Carex*-peat was formed. By the end of boreal time the surface of the bog became dry enough to allow *Alnus* and *Salix* to grow on it, and a wood peat was formed. From analysis 39 in the pollen diagram (i.e. in the beginning of atlantic time, cf., however, page 215) the peat-formation became rather slow and the peat of that time contains some clay washed from the surrounding area. The wood peat from the first part of sub-boreal time is somewhat clayey too, but during the sub-boreal period the content of clay diminished and the peat from the close of that period, mainly formed by *Alnus*, is clayless. From the beginning of the sub-atlantic period the peat again becomes clayey, and it contains, in contrast to the peat from the preceding period, fruits of *Carex rostrata* (cf. table II, and the pollen diagram, analyses 28–30), showing that this plant became common on the bog. *Frangula alnus*, too, invaded the bog (cf. the pollen diagram, analyses 29–30). This increased wetness of the bog does not last throughout zone IX a.

The surface of the bog again became drier and *Quercus* became predominant on it. Abundant stumps of oak in the peat give evidence of this, as does the very strong maximum of oak-pollen from this period. At the transition to zone IX b the oak-forest on the bog was replaced by alder, and mosses (including *Sphagnum cuspidatum*) invaded the bog-surface. In the next phase (from analysis 20) the bog was transformed to a swamp dominated by *Equisetum limosum*. The swamp was very wet, as both *Potamogeton* and *Nymphaea* were able to grow in it. Fruits of *Potamogeton natans* were found in the peat (cf. table II) and the pollen diagram shows a maximum of *Potamogeton*. *Typha latifolia* had a maximum at the same time. The swamping of the bog began with a phase in which alder replaced oak, and then came the great increase which made it possible for *Potamogeton* to grow in the swamp. I think that the increase of wetness on the bog at that time was caused by changes in the climate (cf. page 214), because it seems impossible that this gradual increase was due to peat-cutting in the preceding part of the Iron Age.

Eventually the *Equisetum*-swamp was overgrown by *Sphagnum*. The pollen diagram shows the different phases of this process. At the same time that the curve for *Potamogeton* declines, that for *Cyperaceae* increases greatly. Fruits of *Carex rostrata* are very abundant in this layer, showing that the *Equisetum*-swamp was replaced by a *Carex rostrata*-*Sphagnum* community. The pollen diagram (and fruits as well, cf. table II) shows that *Hydrocotyle* contributed to the vegetation. In analysis 15 the rhizopods *Amphitrema*, *Assulina* and *Arcella*, which demand a high humidity in the soil, have a maximum. *Menyanthes*, too, was a member of this plant community. From analysis 8 and upwards (cf. table III) pollentetrads of *Drosera* were found in the peat. From about analysis 6 the peat becomes more humified, undoubtedly an evidence of drier conditions on the bog-surface.

It cannot be said with certainty when the bog stopped growing. Hans Rømer, forest supervisor of Almindingen between 1800 and 1836 and recreator of this big forest, planted spruce in Almindingen in the beginning of the 19th century. The pollen diagram does not reflect these spruce plantations, which shows that no peat was formed after that time. At least the western part of the ditch from the Lilleborg through Græssöen was made by Rømer (cf. ZARTMANN 1935, pag. 247), and as there is no evidence of any late swamping of Græssöen, I think that already at that time the eastern part of the ditch was dug, too, leading the water from Græssöen eastwards. These conditions permitted trees to be planted on the bog and stopped its growth.

b. Evidence of changes in precipitation.

The wood peat from boreal time contained no clay, while the atlantic and early sub-boreal wood peat was clayey. The wood peat from the later part of the sub-boreal period again is devoid of clay. The peat from the first part of sub-atlantic time (until the beginning of the rye-curve, i.e. about the beginning of our era) contains some clay, while the peat-layers formed after that time are clayless. The reasons for these changes in mineral deposition will be discussed in the following pages.

No streams run through the depression in which the bog is situated. Hence the clay cannot have been brought to the bog by any watercourses. Most likely the clay is due to the erosion of the surrounding area by rainwater. The content of clay in late-glacial deposits is at least partly due to similar processes (cf. e.g. IVERSEN 1947, page 67). In postglacial time, however, the cover of vegetation is normally too dense to allow such erosion by precipitation. Possibly the sparse cover of vegetation on Bornholm in the periods with sedimentation of clay could be due to human influence, but at least a part of the lowest layer of clayey peat is older than the neolithic land occupation, and similar clay-layers are only quite exceptionally known form other parts of Denmark. Hence I think the cause of the clay deposition is rooted in a special kind of landscape which is common on Bornholm and not in other parts of Denmark. At many places on Bornholm the surface consists of bare rock or rock only covered by a thin layer of decomposed granite. This layer is covered by vegetation, but during heavy rainfalls the small streams of rainwater may destroy it locally, and sand and clay will be transported into the depressions in which the bogs are situated. Most likely the clay-layers in Græssöen bear witness to periods when such erosion was accelerated. Hence the change from boreal peat without clay to atlantic peat with clay can have been caused by the increase of precipitation, well known from other investigations, that occurred in the atlantic period. During the drier sub-boreal period the peat again becomes free of clay, but the increased precipitation in the beginning of the sub-atlantic period, which caused RY III in the raised bogs, caused the upper clay-layer in Græssöen. The fact that *Carex rostrata* at that time became common on the bog shows that the bog surface became wetter, probably because of the enhanced precipitation.

The increased wetness on the bog does not, however, last during the whole of zone IX a. The fact that *Quercus* replaced *Carex rostrata* as a dominating plant on the bog surface about the time of Christ shows that the surface must have become drier than before. The disappearance of clay in the peat is in accord with this. The conditions on and around Græssöen fit with the general belief that the period after the beginning of our era was characterized by a drier and perhaps warmer climate than the period before (cf. GRANLUND, 1932).

In the beginning of zone IX b the wetness on the bog surface again increased. In the first phase alder replaced oak on the bog and in the next the bog became covered by an *Equisetum limosum*-swamp, in which true aquatics such as *Potamogeton* and *Nymphaea* were able to grow. Throughout most or all of postglacial time the depression containing Græssöen has certainly lacked both inlet and outlet. The threshold in the valley leading toward the east may have acted as a regulating factor on the water-table in the depression. The rise of the water-table in the beginning of IX b cannot be explained solely by a rise of the threshold, e.g. as a result of peat-formation in the valley. It is necessary to reckon with the possibility that the bog at that time was supplied with more water from the surroundings. Considering the topography of the area, the increased amount of water from the surroundings can only be explained by an increased precipitation. Investigations of raised bogs (e.g. GRANLUND 1932) show that about AD 400 there was an increased precipitation, marked by the occurrence of RY II. It is reasonable to suppose that the swamping of Græssöen in the beginning of IX b is contemporaneous with RY II.

After the overgrowth of the *Equisetum*-swamp Græssöen was transformed to a *Sphagnum*-bog. The peat from the first phase is only slightly humified, showing that the bog surface was very wet because of a rather high precipitation. The upper part of the *Sphagnum*-peat is a bit more humified (H 5–6) showing a decreased precipitation. As it will be shown later, analyses 4 and 5 most probably correspond to the time of the castle Lilleborg (about AD 1190–1259). If that is the case, the level of the swamping corresponding to RY I (about AD 1300) should be a bit above analysis 4, but no traces of this swamping are to be found, as the peat above is humified as much as that below. This can, however, be a result of the later planting of trees on the bog.

c. Vegetational history of the surrounding area.

The zones IV–VIII are used in the same manner as in KNUD JESSEN 1935. The pollengrains in the lower part of the wood peat (dated to the boreal period, IV–VI) are very much corroded, and it is possible that the limit VI/VII is placed somewhat too high in the diagram. The subzonation of zone IX is in accordance with earlier papers of the present writer (MIKKELSEN 1949 and 1952). The transition VIII/IXa is marked by the beginning of the continuous curve of *Fagus* (and, especially on Bornholm, by the curve of *Carpinus*). It is further characterized by the increase of the curves for the culture-pollen which in most diagrams shows the beginning of the Iron Age. The limit IXa/IXb is placed at the level of the swamping that is believed to be contemporaneous with RY II, somewhat after the beginning of the *Secale*-curve. The border IXb/IXc is characterized by the beginning of the continuous curve for *Centaurea cyanus*, which must correspond in time to RY I.

The pollen diagram (fig. 1, Plate XX) does not tell much about the history of the forest in the time before the sub-boreal period.

The beginning of agriculture, as reported in IVERSEN's paper on land occupation (1941), is marked by the occurrence of pollengrains of cereals (*Cerealia*) and of the usual weed-plants, namely *Plantago*, *Rumex*, *Artemisia*, *Chenopodiaceae*, and *Urtica*; the pollen diagram gives no curves for the two lastmentioned, but the percentages are given in table III, page 226.

In sub-boreal time the values for culture-pollen are very low showing only small clearances in the neighbourhood. The surrounding forest was dominated by *Quercus*, but *Tilia* was also of some importance.

IXa. In the beginning of the sub-atlantic period parts of the forest in the neighbourhood were cleared. The pollen-curves for oak and lime decrease notably, while the curves for *Cerealia*, *Artemisia*, *Rumex*, *Plantago* and wild grasses (sm. Gramineae) rise sharply.

Likewise the curve for the entomogamous *Compositae*, cf. table III, shows a considerable maximum. The same is the case at the levels where the later maxima of culture-pollen occur. At the same time as the forest clearance in the beginning of the Iron Age the curve for *Ericales* shows that heath occupied relatively restricted areas.

The rise in the *Pinus*-curve indicates diminished production of forest-tree pollen in the vicinity. One may suspect that most of the pollengrains of *Pinus* found in sub-atlantic layers on Bornholm were transported by air from far away. The decrease in the local production of forest-tree pollen, which lasted during the whole clearance period, possibly reflects the fact that Iron Age people produced open areas with fields and commons. In sub-boreal time, on the other hand, the decrease in the local production of forest-treepollen occurred only in the first stage of the clearance period, because people at that time were most interested in open woods with birch and hazel, where the cattle could feed (cf. IVERSEN 1949). From the time when the first traces of rye are to be found in the diagram (i.e. about 0 AD) the curves for culture-pollen decrease. It is, however, impossible to say whether this is a consequence of the conquest of the fields and commons by forest, or only an artifact conditioned by the great production of pollen of oak on the bog itself.

It can, however, be mentioned that VIGGO NIELSEN, M. A., has found that the Iron Age fields on the Blemmelyng (SW of Almindingen) were abandoned about the time of Christ (not yet published, except in a newspaper). The results from Almindingen together with this tend to show that fields on sandy soil were abandoned on Bornholm at that time. Perhaps the people on Bornholm were not able to cultivate the clayey soil in the first, humid period of the Iron Age, but were compelled to cultivate the sandy soils of the Blemmelyng and Almindingen. When the climate about 0 AD became more warm and dry, the people were able to utilize the better soil, the sandy fields being abandoned and covered, at least for some time, by heath. In the vicinity of the Lilleborg the heath areas rapidly grew up to forest, and undoubtedly the same was the case in other localities.

Simultaneously with the decrease in the curves for culture-pollen the curve for *Carpinus* increases rapidly. Pollengrains of *Carpinus* were found in the close of sub-boreal time but first became important about the beginning of our era, when *Carpinus* must have been the predominating tree in Almindingen, along with *Quercus*. On the other hand *Fagus*, which appeared at the same time as *Carpinus*, did not reach any importance in Almindingen in any period.

IX b. In the beginning of this zone (i.e. in the beginning of Late Iron Age) the diagram has considerable maxima for culture-pollen showing that in this time, too, open land with fields and commons and small areas of heath could be found. The greatest area of the neighbouring ground, however, was covered by forest dominated by *Quercus* and *Carpinus*.

The diagram, especially section C, shows that the area of forest decreased somewhat during IX b. The heath area increased but was still without real importance. In the later part of IX b the diagram has two remarkable maxima of culture-pollen. Simultaneous with these maxima there are maxima of *Melampyrum cf. pratense*. The last of these maxima of culture-pollen is possibly synchronous with the castle Lilleborg. The king of Denmark founded this castle about AD 1190. It was only used for a short time, as it was conquered and burned in 1259, when the king was fighting the archbishop of Lund, who had the bigger castle Hammershus on North Bornholm. Recent investigations of the ruins of the Lilleborg have shown i.a. stables. The cattle implied by this discovery must have had a great influence on the neighbouring forest, which must be detectible in the pollen diagram from Græssöen close to the Lilleborg. From the later part of the Middle Ages no cultivation is known from this area, which until the time of Rømer (about AD 1800) was the only part of Almindingen that still contained some forest. This tends to show that the analyses 4 and 5 in the diagram are contemporaneous with the Lilleborg. In accord with this is the fact that pollengrains of *Centaurea cyanus* were found in the analyses 1 to 4. In an earlier paper (Mikkelsen, 1952) it is shown that *Centaurea cyanus* became common in Denmark about AD 1300. In the diagram from Græssöen single pollengrains of cornflower were found in the Late Iron Age, analyses 14 and 16. No pollengrains of cornflower, however, were found in analyses 5 to 13, even though several slides were examined in addition to those used for the counts. If the dating of the earlier occurrences is valid, *Centaurea cyanus* has been on Bornholm since Late Iron Age, but only became common in the period after AD 12–1300, just as in the other parts of Denmark.

At the time when the Lilleborg was built and the forest was cut down (analyses 4 and 5), *Carpinus* suffered a loss from which it seems never to have recovered. Heather was spreading rapidly and great areas became covered by heath.

The penultimate maximum of culture-pollen in IX b may reflect the use of the fortification Gamleborg, but apart from the fact that it was reinforced some time possibly in the 11th century, very little is known about the history and the use of this place. It is therefore impossible to correlate it with the pollen diagram.

IX c. The time after the Lilleborg was burned was characterized by the fact that birch spread vigorously in the forest, while *Carpinus* decreased and became without importance. But it was heath and not forest that conquered most of the abandoned fields. This fact tends to show that the climate at that time was rather atlantic, perhaps conditioned by the climatic change which at other localities is demonstrated by RY I. In Jutland, too, the heath increased much at that time (cf. Jonassen, 1950).

In the first centuries after 1300 there was no cultivation of fields in the area, but Almindingen without doubt was used as pasture for cattle.

The uppermost analysis in the diagram again shows cultivation by the increase in the curves for *Cerealia* and wild grasses. This may show the expansion of the fields on the big commons of Höjlyngen (including Almindingen) which began in the first half of the 16th century, after the herring fisheries, which in the preceding centuries were the principal industry of Bornholm, lost their importance. This cultivation of land, formerly used as commons, assumed such great dimensions, that the governor of Bornholm in 1552 forbade any new cultivation, as he thought it threatened the welfare of the cattle on the commons (cf. ZARTMANN, 1934, pag. 142).

d. The "Bornholm-clay".

KNUD JESSEN has shown that most of the bogs on Bornholm were covered by a layer of clay containing some organic matter (the "Bornholm-clay"). I found the same layer in the bogs I investigated. Græssöen contains such a layer of clay, but it is covered by peat. This clay-layer was laid down from atlantic time until some time in the sub-atlantic period. The sections from the bogs investigated by KNUD JESSEN (e.g. the Aaremyre) are similar to the lower part of the Græssöen section. ZARTMANN (1935, pag. 247) tells us that Rømer had peat cut in the Aaremyre, and it is reasonable to think that here and in most other bogs on Bornholm the upper layers of peat were cut away. Græssöen alone was left undisturbed. Before the woods were planted on Bornholm in the 19th century this island was very poor in forest. It is likely that the relatively few bogs on Bornholm were intensively utilized for peat-cutting in the centuries before.

An explanation of the formation of the clay layer in the bogs on Bornholm is given above (page 213).

III The Ankermyr in Slotslyngen (North Bornholm).

The lake Ankermyr is situated in the forest Slotslyngen about 800 metres east of the ruins of the castle Hammershus on North Bornholm. The lake is only about 60 metres long and about 30 metres broad. The surface is about 80 metres above sea-level and the lake is surrounded by rocky hills which reach about 90 metres above sea-level. From the southern end a narrow valley leads to lower areas. Towards the east the lake is limited by a perpendicular wall of granite, but on the other sides there is a narrow zone with shallow waters covered by *Equisetum limosum*. The depth of water in the open areas is about 3 metres.

a. The development of the lake.

The lake was investigated in 1951. The deepest layer found was laminated clay. Upon this was sedimented clayey mud from the Alleröd period and clay-mud from the Younger Dryas period. At the transition to the postglacial period the sediment changes to nekron-mud (gyttja). This layer forms a horizontal layer through the lake between 4.1 metres and 3.5 metres below the surface of the lake. The pollen analyses from the nekron-mud are very similar, only the upper one being shown in the diagram, fig. 2, Plate XX, analysis 10. It is late pre-boreal. The lowest one differs from it by containing more *Juniperus* and less *Populus*, and belongs to early pre-boreal time. Upon this pre-boreal gyttja is deposited a layer of 0.5 metres olive-grey-green, slightly clayey mud (gyttja). The upper 10 centimetres of it contained so much water that no samples for pollen analysis could be taken. The pollen diagram from the lower 40 centimetres shows that this gyttja was formed in late sub-atlantic time, probably in the Middle Ages and in later time (cf. below). Hence there is a lacuna in the deposits corresponding to about 8000 years. This lacuna may be due to peat-cutting. It is most probable that the lake in the period after pre-boreal time became overgrown with a bog. In the Middle Ages, perhaps in the first time of Hammershus (i.e. in the 13 th century), as much peat from the bog was removed as the level of ground-water permitted. The peat above 3.5 metres below the recent surface of the lake was cut away. Some muddy peat that may belong to atlantic time was found in an earlier investigation between some boulders near the eastern shore. The samples were not good enough for a confident dating, and this peat was not found again in 1951, so I think it can only be found in the narrow spaces between the boulders.

After this peat-cutting the lake was recreated. The lowest 20 centimetres of the gyttja that was deposited in it contained rather much "dy"; on the other hand larger remains of plants were absent. The content of pollen shows, however, that *Potamogeton*, *Myriophyllum alterniflorum*, and *Nymphaea alba* lived in the lake. After analysis 4 *Myriophyllum alterniflorum* predominated and simultaneously *Equisetum limosum* and *Litorella uniflora* invaded the shores.

The appearance of cornflower and the proportion between forest and open land tends to show that the level between analyses 4 and 5 can be dated to about AD 1300.

The fact that *Equisetum limosum* and *Litorella* were absent and *Myriophyllum* sparse before about AD 1300 implies the absence of shallow water in the lake, because these species demand shallow water to grow in. The Ankermyr of today has a zone of shallow water and even a rise of the water-table up to the threshold in the valley leading southward will leave the lake with some areas of shallow water. But if the water-table in the lake were lowered about 0.5 metres, the lake would be without shallow water. Hence it is reasonable to suppose that before about AD 1300 the water-table in the lake was lower than it is to day. Evidently the narrow zone along the south, west and north shore of the lake was dry and perhaps covered by alder, while the shore shelved too steeply for *Equisetum* to grow. It is very likely that the expansion of *Equisetum* beginning in analysis 4 is due to the flooding of the present narrow zone. This rise of the water-table, which created suitable habitats for *Equisetum* and *Litorella*, as mentioned before, is dated to about AD 1300 and may have the same causes as the contemporaneous RY I.

b. History of vegetation in the surrounding area.

IX b. The analyses 9 to 5 in the pollen diagram (fig. 2, Plate XX) show that the surrounding area in that period was covered by an open forest dominated by *Quercus*, with *Carpinus* and *Fagus* playing quite subordinate roles just as in Almindingen after the destruction of the Lilleborg.

The climate of this period was favorable on North Bornholm, as indicated by the occurrence of *Viscum*, two pollengrains of which were found in the deposits. As the lake is without inlets and is very well protected against wind, older peat which may have been suspended in the water of the lake just after the peat-cutting would have been deposited during a rather short time. The content of clay in the gyttja was undoubtedly washed out from the weathered rocks nearby, and implies no redeposition of older sediments. Hence it is unlikely that the pollengrains of *Viscum* found in the Ankermyr can have been redeposited from earlier peat or gyttja.

The content of culture-pollen shows that there were some clearings in the vicinity, but probably they were small and scattered. Both *Juniperus* and *Calluna* were without importance at that time.

IX c. From analysis 4 and upwards the vegetation in the surrounding area changed, just as did the vegetation in the lake itself. Section C in the diagram shows the decrease of the forest. The other sections of the diagram show increasing amounts for *Juniperus*, *Ericales*, wild grasses and culture-pollen. Large areas in the neighbourhood were cleared of forest, and fields and commons expanded their areas, as did heath.

Centaurea cyanus appeared for the first time in analysis 5 and is present in all of the analyses from 5 to 1, but despite examination of several supplementary slides containing several thousand tree pollengrains it was not found in analyses 6 to 10. Comparing this with the diagram from Græssöen it is most probable that the transition IX b–IX c (about AD 1300) falls between analysis 4 and 5 in the Ankermyr diagram. The evidence of changing water level, as inferred in the foregoing discussion of the water plants, points to a climatic change corresponding to RY I at this level, and thus strengthens the dating.

The castle Hammershus was founded by the archbishop of Lund about 1250. From then until AD 1327 the archbishops and the kings of Denmark fought for the possession of this castle, which dominated the whole island after the destruction of Lilleborg. In 1327 the archbishop won possession of the whole island (Zartmann 1934, pag. 80). Presumably it was not until that time that cultivation of the Hammershus holdings began. The decrease of forest in the beginning of zone IX c should reflect this increase of agriculture and the attendant cattle husbandry. During the following centuries *Calluna-Juniperus* heath expanded in Slotslyngen until the reforestation began in the 19th century.

IV General remarks on the sub-atlantic vegetation on Bornholm.

a. *Fagus silvatica.*

The oldest *Fagus* pollengrains on Bornholm occur in the uppermost sub-boreal deposits. From the beginning of sub-atlantic time the pollen gives a continuous curve and in Almindingen generally makes up between 1 and 2 % of the forest-tree pollen. In North Bornholm the percentage is considerably lower. The presence of amounts greater than 1 % even in periods of great local pollen production (e.g. fig. 1, Plate XX, analyses 22–27) strongly suggest that *Fagus* actually grew in Almindingen from the beginning of sub-atlantic time. On the other hand it is less certain that *Fagus* lived in Slotslyngen, where its pollen curve, at least in the later part of sub-atlantic time, generally lies below 0.5 %.

A higher value for *Fagus* (i.e. 4.5 %) is only found at a time (fig. 1, Plate XX, analysis 5) when the proportion of *Pinus* grains indicates that pollen transported by air from far away played an especially prominent role. It is therefore of interest to know whether it is theoretically possible that all the pollengrains of *Fagus* on Bornholm could be due to long-distance transport, e.g. from the mainland.

In periods of major forest clearance the proportion of *Pinus* pollen, which at other times is rather low, increases considerably. This tends to show that at least a good deal, perhaps all, of the *Pinus* pollen is due to transportation from afar. If *Pinus* was present on Bornholm in sub-atlantic time it can only have been on a very small scale. If that is the case the amount of *Pinus* pollen is an index of long-distance transport of pollen.

Far-travelled beech pollen on Bornholm can either originate from Northern Germany or from Southern Sweden. Pollen diagrams from Northern Germany (Firbas 1949) show that the values for *Pinus* are generally about ten times as high as the values for *Fagus*. If *Fagus* were as easily carried as *Pinus*, each *Fagus* pollengrain arriving on Bornholm from Germany would be accompanied by 10 grains of *Pinus*. Investigations on pollen transport (e.g. Jonassen 1950) indicate that *Pinus* is transported much more easily than *Fagus*, so in fact each *Fagus* from Germany must bring along more than 10 *Pinus* pollen.

The other possible source is Southern Sweden. If neither *Fagus* nor *Pinus* grew on Bornholm, a pollen diagram from the sediments on the bottom of the Baltic Sea, between Bornholm and Sweden, should give the ratio of *Pinus* to *Fagus* in the pollen transported from Sweden. In an unpublished diagram from Station 8, about 12 km north of the northern point of Bornholm, 12 samples from sub-atlantic time have been analysed. These analyses fall in two groups, an upper section with much *Fagus*, which appears to belong to zones IX b and c, and a lower one containing only a few *Fagus*, which may belong to zone IX a. Table I (pag. 222) shows that in St. 8 the zone IX a samples have in average 24.6 *Pinus* for each grain of *Fagus*, while IX b and c have 6.4 *Pinus* for each *Fagus*. The corresponding value for Græssöen in IX a is 3.1 *Pinus* for each *Fagus*. Even if this ratio is based on rather small totals there can be little doubt that there is far too little *Pinus* pollen on Bornholm in IX a for the *Fagus* pollen to have originated either in Sweden or Germany. *Fagus* must therefore have grown in Almindingen in IX a (i.e. Early Iron Age).

In IX b and c the values of the ratio for Station 8 and for Græssöen are almost equal, while the Ankermyr has considerably more *Pinus* pollen

Table I. Relation between number of pollengrains of *Fagus* and *Pinus* in sub-atlantic layers from Bornholm and from the Baltic Sea off Bornholm.

	IX a (About 400 BC-AD 400)			IX b and IX c (About AD 400-recent time)		
	Total of *Pinus*	Total of *Fagus*	Number of *Pinus* for each *Fagus*	Total of *Pinus*	Total of *Fagus*	Number of *Pinus* for each *Fagus*
Ankermyr				342	12	28.5
Græssöen	198	64	3.1	1097	177	6.2
St. 8. Baltic Sea	548	22	24.6	519	81	6.4

for each *Fagus*. If the pollengrains of *Fagus* were as easily carried as those of *Pinus*, table I gives no evidence of *Fagus* living on Bornholm in IX b and c, because the pollengrains found might have been carried by air from afar as were those of Station 8. In that case, however, one should have expected far more *Fagus* in the Ankermyr, the ratio of which is in accord with the supposition that *Pinus* is carried more easily than *Fagus*. Thus the data in table I indicate that *Fagus* continued to grow in Almindingen in the Late Iron Age and in the Middle Ages, as it had during the Early Iron Age. On the other hand the very high *Pinus*-*Fagus* ratio for the Ankermyr suggests that beech can hardly have been present there, whereas some pines may well have grown in the vicinity. But if we admit that pine may have grown on Bornholm, a *Pinus*-*Fagus* ratio as low as 3.2 would argue even more strongly that the *Fagus* of Græssöen must have been growing locally.

Hence it can be considered as proved, that *Fagus* has grown on Bornholm since the beginning of the Iron Age. It is not implied, however, that it was an important forest tree, either in Almindingen or in Slotslyngen. *Carpinus*, not *Fagus*, was the dominant tree on Bornholm in sub-atlantic time.

b. Carpinus betulus.

In the beginning of the sub-atlantic period *Carpinus* amounts to about 1% of the tree-pollen, but in the period about the beginning of our era the curve increases to about 10 %, showing that *Carpinus* at that time became common in Almindingen. Even in the period when *Quercus* grew on the bog the proportion of *Carpinus* is only a little below 10. In analysis 17 *Carpinus* reaches 18 %, decreasing thereafter to about 7 % in analyses 13–15. The minimum is contemporaneous with maxima for *Betula, Ericales,* and wild grasses, which suggest a deleterious effect of human activity on *Carpinus*. After this temporary setback *Carpinus* increases again and attains values of about 20 % in the period just before the major clearing which is dated to the time of Lilleborg. The foundation and use of the castle seem to have been catastrophic for *Carpinus* in Almindingen. After this period *Carpinus* only reaches 2–3 %, while both *Ericales* and *Betula* attain great maxima. In accordance with this fact it is without importance in the Ankermyr diagram, which corresponds in time to the period after the time of Lilleborg.

It is probable that since about AD 1300 the central part of Bornholm (called Höjlyngen, which included Almindingen and Slotslyngen), has been used as pasture for cattle on an extensive scale. This may well have caused the decrease of *Carpinus*. Today *Carpinus* is very common in the forests if Bornholm, but this may be related to the fact that since the 19th century the forests have been protected against cattle.

In her work on the Federsee Inge Müller (1947) showed, in apparent contrast to the results reported here, that the occurrence of *Carpinus* pollen was contemporaneous with the occurrence of culture-pollen. However, at least in the periods before the sub-atlantic her values for *Carpinus* pollen are too small for statistical significance, though they suggest that *Carpinus* grains are among those grains of distant origin that increase automatically during phases of extensive forest clearance. The sub-atlantic increase of *Carpinus* in her diagrams may be real, and yet the explanation may not be cultural, but climatic.

In East Prussia *Carpinus* was most common in areas that have been subject to extremely little human interference (Firbas, 1949, p. 265).

At any rate, the present investigation tends to show that the consequence of clearing, at least when accompanied by cattle husbandry, is not an increase but a decrease of *Carpinus*.

c. *The heath-vegetation.*

Zartmann (1934–35) and other authors describe Höjlyngen (i.e. the central part of the island formerly covered by heath, shrubs and commons and used as pasture for cattle) as having existed from time immemorial. It cannot be said that the diagrams presented in this paper give the definitive picture of the history of Höjlyngen, especially as Græssöen is situated in the outskirts of the only part of Central Bornholm where remnants of a forest still existed in the beginning of the 19th century.

Both diagrams, however, show that the heath on Bornholm, just as in other parts of Denmark, is due to human agencies. Already in Iron Age some parts of Almindingen were occupied by heath, but only after the foundation of the Lilleborg about AD 1200, did the heath become the dominant community in the vicinity. Likewise on North Bornholm the heath vegetation did not become widespread until the cultivation of the Hammershus lands in the 14th century.

The great expansion of the cattle husbandry on Bornholm in the centuries after about AD 1300 no doubt dealt the final blow to the remnants of forest which earlier covered Central Bornholm and changed the area to that Höjlyng which is known from the 19th century.

d. Notes on other plants.

Viscum album. Mistletoe was common in other parts of Denmark in atlantic and sub-boreal time (Iversen 1944, Mikkelsen 1949), and is known from the same periods on Bornholm. On Bornholm (figs. 1, 2, Plate XX) it also grew as late as in the close of IX b (about AD 1200) as pollengrains are found in the Ankermyr from that time. The area round the Ankermyr, with its many small hills and valleys, includes many sheltered and warm localities where mistletoe could thrive during a favorable period. The findings tend to show that the period just before RY I was rather favorable —a fact which, together with the political situation of that time, may have influenced the great expansion of farming in the 12th and 13th centuries in Denmark.

Hedera helix. Today this species flowers abundantly on Bornholm, and findings of its pollengrains (figs. 1, 2, Plate XX) show that it has done so through-out sub-atlantic time.

Lonicera periclymenum. Pollengrains of this species are seldom found in peat or mud deposits. It is, however, found in both localities on Bornholm (table III—IV). In Græssöen it was found in analyses 21 and 22, which belong ot the humid period just after RY II. In the Ankermyr it was found in both zone IX b and IX c, but in this locality I think it has climbed in the cracks in the rock on the eastern side at least since the Middle Ages just as it does today. From this habitat the pollengrains will fall directly into the lake.

Centaurea cyanus. In earlier papers (Mikkelsen 1949 and 1952) it is shown that cornflower only became common in Denmark after about 1300, while no find is known which can be dated with certainty to an older part of the postglacial period. On Bornholm *Centaurea cyanus* became common in the first half of the 13th century, i.e. almost at the same time as in other parts of Denmark. On Bornholm, however, *Centaurea cyanus* was represented in analyses which presumably date from the Late Iron Age, but only by a single pollengrain in each of two analyses. This

Table II. List of plants found as macrofossils in profile P 3 in Græssöen.

+: present, c: common.

Pollen-zones	IV				VI	VII-VIII	IXa	IXb	IXb	IXb-c
Depth below surface	295–285	285–250	250–235	235–220	220–200	200–152	152–112	112–85	85–30	30–0
Betula pubescens	+	+	..	..	+	..	+	..	+	+
,, *pubescens* × *pendula*	+	..	+	..	..	..	..	..	+	+
Carex canescens	..	..	..	..	..	..	..	..	+	..
,, *cf. paniculata*	..	..	..	..	..	..	+	..	..	..
,, *riparia*	..	c	+	..	..	..	..	..	..	..
,, *rostrata*	..	+	..	..	+	..	c	c	c	..
,, *cf. vesicaria*	+	..	..	..	..	..	..	..	..	..
Carpinus betulus	..	..	..	..	..	..	..	+	..	..
Equisetum limosum	..	..	..	..	..	+	..	c	..	..
Hydrocotyle vulgaris	..	..	..	..	..	..	..	..	+	..
Lycopus europaeus	..	..	+	..	..	..	..	+	..	..
Menyanthes trifoliata	+	c	c	+	..	..	..	..	..	..
Myriophyllum sp.	+	..	..	..	..	..	..	..	..	..
Phragmites communis	..	..	..	..	..	..	..	..	+	..
Potamogeton natans	c	..	..	..	..	+	+	c	..	..
,, *perfoliatus*	c	..	..	..	..	..	..	..	..	..
,, *praelongus*	+	..	..	..	..	..	..	..	..	..
Potentilla palustris	..	..	..	..	..	..	..	+	+	..
Quercus sp.	..	..	..	..	..	..	c	..	..	..
Salix caprea	..	..	..	..	+	..	..	..	..	..
Cenococcum graniforme	..	..	..	..	..	+	+	..	..	..

tends to show that *Centaurea cyanus* was present on Bornholm since Late Iron Age, but was very rare until about AD 1300.

Fagopyrum has been cultivated on Bornholm since the close of the Iron Age, as its pollengrains are present in analyses from the close of IX b as well as from IX c (tables III—IV).

Helianthemum nummularium. When the open land became more wide-spread in the neighbourhood of Græssöen during the Late Iron Age, *Helianthemum* became rather common (table III). Pollengrains of this species are found in several analyses in the diagram from Græssöen from analysis 11 and upwards.

Juglans. Table III shows that pollengrains of *Juglans* are found in three analyses from Græssöen. It can not be said with certainty that these pollengrains are not transported by air, e.g. from Germany. Today *Juglans* is rather common in gardens on Bornholm, and it is possible that the above mentioned finds mean what they seem to, that *Juglans* has been cultivated on Bornholm since the first centuries A.D. (Roman Iron Age).

Table III. Supplement to the pollen diagrams from Græssöen (fig. 1, Plate XX). The percentages are calculated for a total that includes the total of AP+the species in question.

Analysis No.	*Acer sp.*	*Centaurea jacea*	*Chenopodiaceae*	*Compositae, Liguliflorae*	*Compositae, Tubuliflorae*	*Cruciferae (Sinapis-type)*	*Drosera sp.*	*Dryopteris sp.*	*Fagopyrum sp.*	*Filipendula sp.*	*Helianthemum nummularium*
1			0.2	0.2	0.4			1			
2			0.2					1		0.2	
3			0.2	2.0	0.6		0.2	2			0.2
4			0.2	1.1	0.2	0.2	0.2	2		0.6	
5			0.6	1.4		0.2	0.2	11		0.6	
6			0.2					2		0.2	
7				0.2				3		0.4	
8			0.2	0.2	0.5	0.2	0.2	3	0.2	0.5	0.2
9			0.2	3.6	2.0	0.2		5		0.6	
10			0.4	3.3	0.6	0.8		4		1.3	0.2
11			0.2					5		0.2	0.2
12			0.5	0.3	0.5			5		0.2	
13		0.2		0.4	0.9	0.2		1		1.1	
14					0.4	0.2		3		0.6	
15			0.2	0.2	0.2	0.2		3		0.2	
16					0.2	0.2		5			
17			0.2	0.4	0.2	0.2		4		0.4	
18			0.2	0.2	0.3			6		0.2	
19				0.2	0.2			8			
20				0.2		0.2		7		0.2	
21				0.2				17			
22		+	0.3					19		0.6	
23				0.2	0.2			20		0.2	
24			0.1					5		0.1	
25				0.1				7		0.6	
26				0.4				6		1.2	
27								8		0.9	
28					0.2			11		1.4	
29	0.2		0.6		1.9			6		6.3	
30			0.2	0.2				16		1.0	
31			0.2	0.2				14		1.7	
32	0.7							20		1.0	
33			0.2					27		1.1	
34	0.2							23		0.6	
35	0.4							23		0.6	
36								16		0.2	
37	0.2		0.2					21		0.2	
38								23		0.4	
39								20		0.2	
40			0.5	2.5				34			
41								58		0.5	
42								17		2.0	
43								13		4.0	
44			0.5					2		2.5	

The AP totals are listed in the pollen diagrams. The sign + signifies that the pollengrains were found in a larger sample than the one for which the total AP is given.

Jasione montana	*Juglans sp.*	*Lonicera periclymenum*	*Lycopodium sp.*	*Ophioglossum vulgatum*	*Polygonum cf. aviculare*	*Polygonum persicaria*	*Polypodium vulgare*	*Pteridium aquilinum*	*Rhamnus catharticus*	*Urtica sp.*	*Viburnum opulus*	Zone
								0.2				
0.2			0.2					0.2				IXc
0.2				0.2	0.2							
							0.2			0.3		
								0.2				
										0.6		
				0.4				0.6				
			0.3	0.2			0.2	0.2		0.3		
				0.4	0.2		0.2	0.4				
	0.2			0.6			0.2	0.2	0.2	0.8		
								0.2				IXb
			0.5					0.2		0.3		
			0.2							0.9		
				0.2				0.2		0.4		
			0.2							0.2		
								0.2		0.2		
			0.4							0.2		
							0.2	0.3		0.2		
	0.2							0.2		0.5		
0.2												
		0.2					0.5					
		+					0.2					
							0.2					
	0.1											
			0.1									
										0.1		
												IXa
			0.7									
			0.4							0.2	0.2	
						0.2		0.4				
							0.2	0.4				
												VIII
							0.2	0.2				
							0.6					
							0.2				0.2	
												VII
								0.2				VI
												IV

Table IV Ankermyr (fig. 2, Plate XX). Cf. table III.

Analysis No.	*Centaurea jacea*	*Chenopodiaceae*	*Compositae, Liguliflorae*	*Compositae, Tubuliflorae*	*Convolvulus arvensis*	*Cruciferae (Sinapis-type)*	*Dryopteris sp.*	*Fagopyrum sp.*	*Filipendula sp.*	Zone
1		0.3	0.3	0.3		0.3	5			
2		0.3	0.3				7			IXc
3			0.7	0.9		0.3	8		0.9	
4			0.5			0.5	5		0.5	
5	+		0.3			+	8		0.7	
6	+		0.3				6	+	0.6	
7				0.2	+		6		0.2	IXb
8				0.2			8			
9			0.2				7		0.8	
10							14		3.0	

Analysis Nr.	*Lonicera periclymenum*	*Lycopodium sp.*	*Ophioglossum vulgatum*	*Polygonum cf. aviculare*	*Polygonum persicaria*	*Polypodium vulgare*	*Pteridium aquilinum*	*Urtica sp.*	Zone
1						0.3		0.3	
2	0.3	0.3		0.3	0.3	1.0	0.3	0.3	IXc
3						0.6		0.9	
4						0.2		0.2	
5	0.3		+			0.3			
6						0.3	0.3	+	
7						0.6			IXb
8	+					0.4	0.2		
9			+			0.4	0.2		
10									

V References.

D.G.U. = Danmarks Geologiske Undersøgelse. København.
S.G.U. = Sveriges Geologiska Undersökning. Stockholm.

FIRBAS, F. 1949: Waldgeschichte Mitteleuropas. Jena.

GRANLUND, E. 1932: De svenska högmossarnas geologi. S. G. U. Ser. C. No. 373.

HANSEN, E. 1943: Historiske optegnelser om trævæksten på Bornholm. Dansk Skovforenings Tidsskrift. København.

— 1953: Historiske optegnelser om trævæksten på Bornholm. Bornholmske Samlinger Bd. 33. Rønne.

IVERSEN, JOHS. 1941: Landnam i Danmarks Stenalder. D. G. U. II rk. nr. 66.
— 1944: Viscum, Hedera and Ilex as Climate Indicators. Geol. Fören. Förhandl., Bd. 66. Stockholm.
— 1947: Plantevaekst, Dyreliv og Klima i det senglaciale Danmark. Geol. Fören. Förh. Bd. 69. Stockholm.
— 1949: The Influence of Prehistoric Man on Vegetation. D. G. U. IV. rk., Bd. 3. nr. 6.
JESSEN, KNUD. 1935: Archaeological Dating in the History of North Jutland's Vegetation. Acta Archaeologica Vol. V. Fase 3. København.
JONASSEN, H. 1950: Recent Pollen Sedimentation and Jutland Heath Diagrams. Dansk Botanisk Arkiv. 13. 7. København.
LIND, TH. 1936: Bornholms Oldtid. Min Hjemstavn. Nr. 1. Bornholm. København.
— 1936: Middelalderlige Borge. ibid.
MIKKELSEN, V. M. 1949: Præstø Fjord. The development of the post glacial vegetation and a contribution to the history of the Baltic Sea. Dansk Botanisk Arkiv. 13.5. København.
— 1952: Pollenanalytiske undersøgelser ved Bolle. In A. Steensberg: Bondehuse og Vandmøller i Danmark gennem 2000 År. København.
MÜLLER, INGE. 1947: Der pollenanalytische Nachweis der menschlichen Besiedlung im Federsee- und Bodenseegebiet. Planta 35.
ZARTMANN, M. K. 1934: Borringholmerens Historiebog. 1. og 2. bog. Rønne.
— 1935: Borringholmerens Historiebog. 3. og 4. bog. Rønne.

VI Dansk resumé.

Der forelægges to bornholmske pollendiagrammer, væsentlig omfattende subatlantisk tid. Det påvises, at *Fagus* er et oprindeligt skovtræ på Bornholm; men medens *Fagus* karakteriserer skovene i det øvrige Danmark i subatlantisk tid, er det *Carpinus*, der karakteriserer de bornholmske skove i denne periode. Der gøres rede for menneskets varierende indflydelse på de bornholmske skove i Jærnalder og Middelalder. Undersøgelsen tyder på, at *Carpinus* lider stærkt ved kulturindgreb (især kvæggræsning). De foreliggende diagrammer viser, at de udstrakte hedearealer i Bornholms centrale del (Höjlyngen) først er opstået i subatlantisk tid, vistnok i Middelalderen (i det 13.–14. århundrede).

Undersøgelsen sandsynliggør fugtighedsforøgelser svarende til GRANLUNDS RY I, RY II og RY III.

On age and origin of the beech forest (*Fagus silvatica* L.) at Lygrefjorden, near Bergen (Norway).

By

KNUT FÆGRI.

Abstract

1. Pollen analyses from four deposits within the beech forest area in Alversund on the W coast of Norway (lat 60° 30′–40′) show that beech established itself after the area had been settled.

2. The oldest archaeological finds go back to ca. 500 AD.

3. Beech probably arrived between 500 and 1000 AD.

4. As the oldest beech occurrences are apparently situated rather far from the shore, beech was probably planted intentionally.

5. Attention is drawn to the possible connection between the beech forest and the neighbouring royal residence at Seim, the royal family coming from Vestfold, the only area in Norway where spontaneous beech was plentiful.

Contents

Introduction.

Far, far away from all other spontaneous beech there is a small forest of this tree near Bergen. It has been known by botanists since the end of the 18th century[1]), and has been visited by many. Opinions about age and origin of the forest have been offered repeatedly, ranging from the concept of recent introduction by man to that of relics of a former continuous Norwegian distribution. However, the last original contribution towards these problems was made by HOLMBOE 45 years ago. Since then methods have been developed, which warrant a certain optimism with regard to the possibilities of a more exact dating than was possible at that time. In the following I shall try to make such a dating.

In the European North beech has always been considered the tree of Denmark. I can find no more fitting contribution for a presentation volume to the leader of Danish pollen analysis than just a small contribution towards the history of the migrations of the beech.

General descriptions of the beech forest at Lygrefjorden have been given both by HOLMBOE (1908) and HØEG (1924): consequently I have considered it superfluous to give a detailed account. It suffices to state that the forest is situated at the western coast of Norway, latitude 60° 30′–40′ N, some 330 km, as the crow flies, from the nearest occurrence of spontaneous beech. It should be noted, though, that in many localities in between, along the Norwegian coast, beech thrives excellently and has spread from recent plantations into the surrounding vegetation (cf. HOLMBOE 1925).

In our area the beech forest occupies the middle part of one of the many peninsulae characterising the landscape. The extent of the forest has apparently not changed very much during the last 40–50 years. But as far as one may conclude from on one hand HOLMBOE's and HØEG's general descriptions, and on the other hand a general impression of conditions to-day, the forest seems to be in a better state than previously (cf. fig. 2). If this is the case, it is probably an effect of the last 50 years' agitation for afforestation and for better forest management. It should be noted that the spread of the beech is partly checked by cultivated fields. In other places, e.g. at the hill to the left in fig. 3, there is a distinct zone of small beeches outside the beech forest proper. The map of the

[1]) Nevertheless this very interesting NW extreme of the beech area is sometimes forgotten by non-Norwegian botanists. In the stately beech-forest volume published by the RÜBEL institute (1932), this occurrence is not mentioned with one word. For the understanding of the ecologic range of beech the forest it is of the greatest importance.—HULTEN's map (1950 nr. 600), while correct in this respect, is in other ways rather misleading as far as Norway is concerned. Neither for spontaneous nor for cultivated beech are the localities correct. My map, fig. 1 A, has been prepared from HØEG's data for Norway, and LINDQVIST's for the adjacent part of Sweden.—Our locality has been variously designated: the forest is situated in the parish of Alversund, more specifically in the chapelry of Seim. I have here used HOLMBOE's neutral designation: near Lygrefjorden, because the forest is sloping towards that fjord. Present spelling: Lurefjorden.

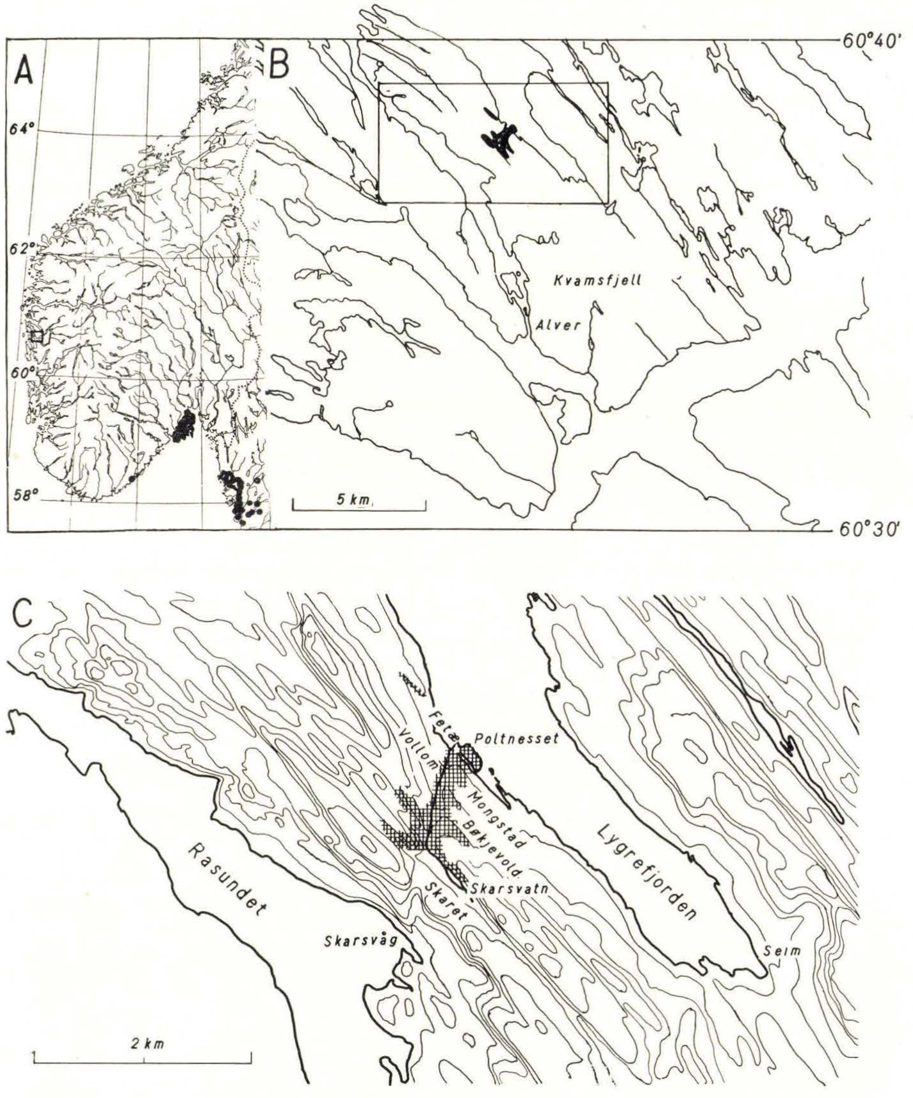

Fig. 1. A. Distribution of beech in Norway and adjacent parts of Sweden. B–C. Distribution of beech in Alversund. Reproduced from the maps of Norges geografiske oppmåling, by permission.

distribution of the beech within the area (fig. 1 C) was made from airplane (as originally indicated by LINDQVIST 1931). In the difficult terrain it is the only way to locate the trees. Some beeches detected from the plane further south, at Elsås, proved to have been planted, self-sown seedlings having been moved from the forest. The isolated, northernmost field is now smaller than suggested by HOLMBOE's admittedly very schematic map (1908 p. 5). It mainly consists of a number of trees grow-

Fig. 2. From the edge of beech forest near Mongstad.

ing in a thin row in one of the almost vertical cliffs that are so abundant here. I doubt if the occurrence has ever been more plentiful. Local tradition confirms this opinion; recent spread from the original row of trees is noted in many places. The pollen diagrams show greater incidence of beech in sub-recent that in recent samples. I believe that this is due to greater production of other pollen types in recent samples, not to lower production of beech pollen.

Sociologically, beech appears under a diversity of conditions, from isolated trees scattered in a mixed forest with *Betula alba* (*s. l.*), *Populus tremula*, *Sorbus aucuparia*, *Fraxinus excelsior*, *etc.* to dense, pure beech forest with tall, erect stems and practically without undergrowth. In the densest parts the soil is either bare or is covered by beech and *Sorbus aucuparia* seedlings plus some mosses. However, these very interesting problems cannot be discussed at any length here.

I want to stress that owing to the peculiar geologic structure of the area (cf. KOLDERUP and KOLDERUP 1940) ecologic conditions are extremely variable within small distances. The bed-rock forms a series of ribs, between which there are very narrow, steep-sided valleys. The western sides of the ribs are almost vertical, whereas the eastern sides slope more gradually towards the fjord. Consequently the valleys are assymetrical and the fields are exposed towards north-east. The system of ribs running NW–SE fills the whole peninsula except for one break, viz. at Skaret ("the Gorge"), the only reasonable crossing between Lygrefjorden and Rasundet. It will be seen that the beech forest is restricted to the vicinity of this passage across the peninsula.—

For the dating of the beech forest we proviously possessed very few data, the most important of which is the farm name *Bøkjevold*. The name refers to the existence of beech, and it occurs for the first time in 1611 (MAGNUS OLSEN—RYGH 1910). Consequently the beech must be older than that. On the other hand HOLMBOE's investigation of a small bog at Poltnesset gave evidence that beech did not grow there until a comparatively late date.

Archaeological conditions.

Before taking up the main theme of my investigation, viz. the pollen analyses, it may be useful to summarise what is known about the archaeological conditions within the area. The dating of the origin of the forest will rest on archaeological evidence. As far as place-names are concerned, the central, original farm seems to be Vollom (cf. MAGNUS OLSEN—RYGH l. c.). The names of the surrounding farms are formally younger. The group of farms in and around the beech forest is rather isolated from other habitation, and it is quite conceivable that it has developed from one original farm. LITLESKARE (1925 p. 17) maintains that Okse (Øksa) was the original farm.

The archaeological evidence does not disagree with this concept, but it does not point to Vollom or Okse as the primary settlement. Archaeologically Skaret is distinctly the most important with not inconsiderable finds both from Older and Younger Iron Age[1]).

The former ones are two Migration Age grave finds (one cairn and one mound) described by LORANGE (1884 p. 101 and 1886 p. 86); the latter is a grave find from the Viking Age, described by BØE (1933 p. 6). The only other archaelogical find of any significance within this neighbourhood is an unsubstantiated report of an Iron Age grave at Mongstad, discovered and destroyed before 1824 (NICOLAYSEN 1862–66 p. 397).

It should be kept in mind that settlement in this area is on the whole

[1]) My thanks are due to Mr. PER FETT, curator of the University archaeological museum, for help in this matter.—It should be remarked that the mutual age relations between Skaret and Vollom are not considered by MAGNUS OLSEN-RYGH l.c.

very young. Within the parish of Alversund a few scattered Stone Age finds have been made, but they are astonishingly few and insignificant. A single Bronze Age grave has been reported from Kvamsfjeld further south, rather far from the beech forest. There can be no doubt that the lateness of settling here must be due both to a relatively poor bed-rock and an unfavorable exposition (towards NE).

If we return now to Skaret, the reason why this site was preferred is a matter of conjecture more than of knowledge, but it is not improbable that the facilities for crossing the peninsula were important. No doubt the passage between the two fjords through the gorge has been utilised as long as people have travelled in these districts. It should be remembered that both north and south of Rasundet there are strong currents which can be rather unpleasant to pass with a small boat. Skaret, or more specifically its western harbour, Skarsvågen, is situated about midway between the two currents. The relation of this passage to the central place, Ålfitæ, will be considered later.

Even on the more favorable SW-exposed side of the peninsula settlement seems, on the whole, to be very young. Archaeological finds are few, and place-names indicate that most farms were cleared very late, the only exception being Alver (Alviðr). It should not be over-looked that systematic archaeological surveys have not been carried out in the district. Finds may be more plentiful than we know to-day.

Pollen-analytic investigations.

1. Skarsvatnet. Within the beech forest area there is only one basin that immediately presents itself as being suitable for a pollen-analytic investigation, viz. Skarsvatnet (fig. 3). This is a long, narrow lake which occupies the deepest part of one of the valleys running NW–SE, more specifically the one towards which the fields of the farm Skaret slope. The lake has lost about half of its original area by filling-in from both ends, whereas the sides are too steep for any hydrosere to start there. The bog in the northern end apparently had dammed the lake. Recently this dam has been cut through, and peat has been cut from parts of the bog. The outlet has even been lowered below the original level by cutting through a rock threshold. The amount of lowering is rather small.

The first series of samples were collected from the lake bottom immediately outside the present northern shore[1]). The vegetation consisted of abundant *Potamogeton natans* with scattered *Callitriche*, *Juncus supinus*, *Equisetum limosum*, and *Carex rostrata*. The steep precipice to the NE of the lake is covered by a mixed deciduous forest: much *Populus*

[1]) During field work I have been assisted by a number of my collaborators from the University botanical museum, Bergen.

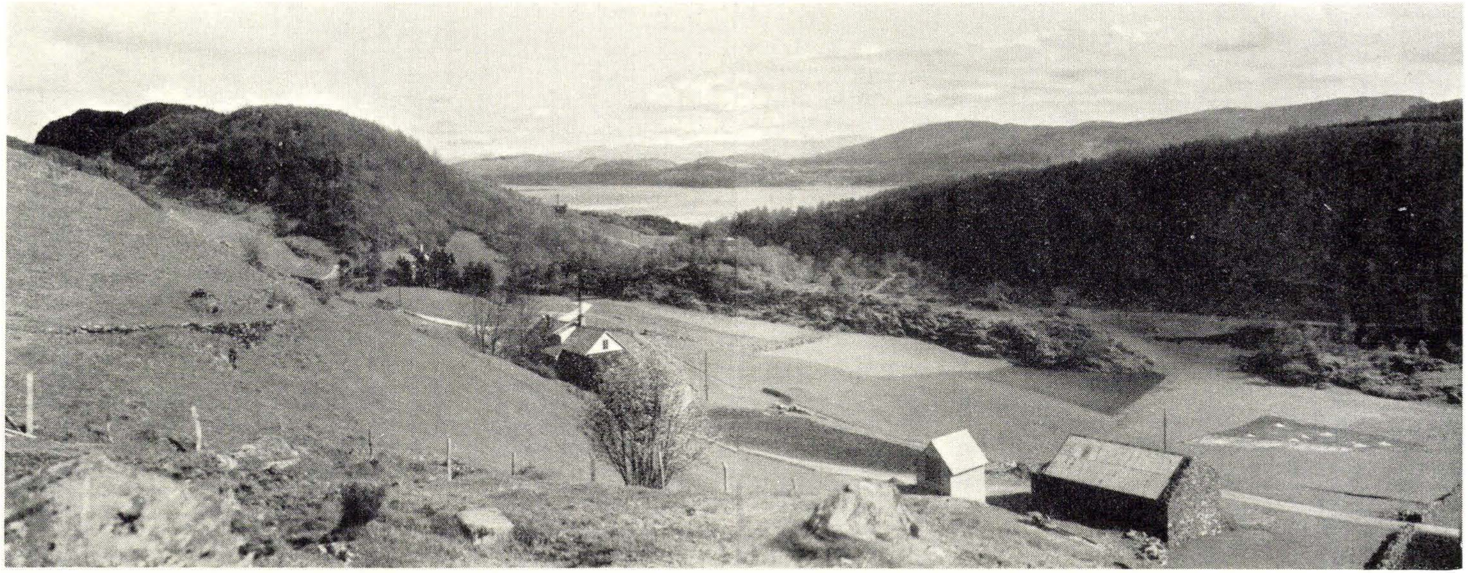

Fig. 3. Skarsvatn (right) and part of the beech forest area seen from the ridge W of Skaret. The pass across the peninsula is seen in the middle left background. The round hill to the left is covered by beech forest.

and *Corylus,* some beech, oak, and birch with *Rhamnus frangula etc.* in between. Apart from the little hill with birches and *Calluna* heath seen in the middle of fig. 3, the SE surroundings of the lake are cultivated fields (hay and potatoes).

Skarsvatn is situated some 100 m above sea level, above the marine limit.

The lake bottom was situated 40 cm below the water surface, and the deposit stretched downwards to 590 cm, thus apparently a very nice series. The lake bottom was rock. Owing to the nature of the Hiller sampler the lowermost decimetre of the deposit was not accessible. For our primary problem this is of no importance.

Unfortunately it proved that the sediments were not as good as one could have expected, and especially in the lowermost part corrosion was very bad indeed. So bad it was that the distinction between *Betula* and *Corylus* was in many cases far from certain. However, there can be no doubt about the main features of the pollen diagram (pl. XXI)[1]): the rise of the *Alnus* curve at 535 cm marks the beginning of zone VII[2]), the Atlantic period. It is preceded by the usual late Boreal "tail" of the curve. I want to point out the very late *Pinus* maximum, which is apparently even later than at Jæren and Bømlo. This confirms the rule of the gradual delay of this important pollen-analytic level towards NW (Fægri 1944 p. 29). Owing to corrosion of the pollen grains I dare not insist too strongly upon the actual curves of *Corylus* and *Betula*, but I do not think the diagram reaches beyond the Boreal period. Incidentally, it should be noted that since the beginning of the Atlantic period there has hardly ever been a spontaneous pine forest in the neighbourhood. On its immigration beech had to compete with other deciduous trees, but not with pine forest.

Both *QM* and *Corylus* come to a minimum about 125 cm, and I find it reasonable to suppose than the zone transition VIII–IX is situated here. It is possible that the minimum at 125 cm is caused by overrepresentation of *Betula,* and that the real transition is to be placed $^1/_2$ m further down, where the NAP curve rises. As it is not possible to date the beech from this diagram anyhow, the exact location of the zone transition is not too important in this case. The *Alnus* maximum near the zone transition may be local, and I dare not draw any conclusion from the details of the curves.

The border between the two intermediate zones is most probably

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[1]) For practical reasons the depth scales of the diagrams have been varied, cf. the depth figures.

[1]) In accordance with the general agreement at the Copenhagen conference of pollen analysts (August 1953) I have adopted Jessen's zone system, although the distinction between his zones V and VI cannot be traced in western Norway.

located at 350 cm, where *Ulmus* comes down from a distinct maximum, and *Tilia* makes its first appearance (apart from some scattered grains near the bottom of the diagram). The dominance sequence: *Betula—Pinus—Alnus—Ulmus—Tilia* is very characteristic, and returns in another combination (the Bøkjevold diagram, cf. below).

The *Fagus* curve of the main diagram is practically non-existant. The small percentages we find in zone IX are just as we should expect them if beech did *not* occur locally (cf. similar curves in FÆGRI 1950).

It seemed improbable that the rich occurrence of beech, both in the cliff beyond the lake and on the hill to the north, should not be represented in the pollen rain, so a turf was at a later visit cut from the growing *Sphagnum* bog some 20 m from the edge of the water. This turf, 30 cm deep, gave a pollen diagram with a nice beech curve, thus proving that the series from the lake had been truncated. As, however, the two diagrams did not join, I was forced to collect a third series, more or less in the same spot as the second one, and reaching down one metre. This diagram—the upper 15 cm of which are identical with the second one—is reproduced here together with the main diagram. It is a very bad diagram, completely destroyed by over-representation of *Alnus*, which evidently formed a carr on the bog.

The first problem concerns the joining up of the two diagrams. Unfortunately, the sub-Atlantic diagram is rather deficient in characteristics, and the only curve that can help us, is the *Tilia* curve. It will be seen that this is situated at ca. 1% in the main diagram, and in the auxiliary diagram below 75 cm. At this level there is a transition, and in younger strata practically no *Tilia* occurs. Nor is it found in the second diagram, which has not been reproduced here. Consequently the auxiliary diagram above 75 cm must be younger than the main diagram. —Now beech does not occur locally, i.e. in the immediate surroundings of the lake, until 20 cm—at a point when the pine curve has already started to rise. This rise of the pine curve is a very young phenomenon (cfr. curves in FÆGRI 1950), and dates the local beech to the last 150 years or so. It should be remembered that this concerns flowering beech.

Now as to the registration of settlement in the Skarsvatn diagram there is not much to be seen, and quite especially the NAP part of the auxiliary diagram is completely destroyed by local over-representation. However, the rather consistent occurrence of *Plantago lanceolata* in the main diagram above 80 cm should not be under-rated. Skaret is situated so far from other known centres of cultivation that a consistent representation of *Plantago* must be taken to indicate local settlement. The level of 80 cm would then presumably correspond to ca. 500 A. D. Thus we may conclude that beech had not established itself in this region until some part of the forest had been cleared and farming had started.

However, the beech values down to 40 cm are too high to be ascribable to long-distance transport. Beech must have occurred in the more distant neighborhood of Skarsvatn for some time and arrived at its present western boundary very recently, most probably from the east.

2. Poltnesset The next pollen diagram (pl. XXI) to be considered comes from the small bog at Poltnesset, the one which HOLMBOE also investigated. It is the only bog to be found within the beech forest, but it is not really suitable for pollen-analytic purposes, being very small, some 40 m long, 25 m broad with just the faintest suggestion of a peripherical drainage system, and completely surrounded by beech forest. However, birches and alders are invading the bog and make themselves strongly felt in the recent pollen spectra.—It is obvious that the pollen diagram from such a small bog, situated in the forest, must be subject to very strong local influence.

Poltnesset is a small rocky hill, connected with the mainland by a sandy shore bar. Otherwise it is surrounded by the sea. With the exception of the extreme edges, Poltnesset is now completely covered by dense beech forest, in some parts of considerable dimensions.

With the Hiller sampler a series was collected from the centre of the bog, down to 200 cm. The bottom consisted of marine mud upon and partly alternating with coarse marine shell marl. Above that there was something resembling magnocaricion peat, and above that again a slightly humified *Sphagnum* peat. HOLMBOE's investigation took place near the edge of the bog, which accounts for the different stratigraphy of his section.

The bog is situated 5.45 m above sea level, the brook draining it passing over a rock threshold at 4.20 m, now covered by peat. It is also possible that I did not succeed in finding just the deepest cut under the peat cover. At any rate the surface of the marine mud is more or less level with the outlet.

The bottom sample is dominated by *Pinus*, the regular overrepresentation in marine deposits. Three samples with dominating *Alnus* indicate alder forest (HOLMBOE 1908 p. 18: 45 cm *Alnus* peat).—Following the other curves we find that the *QM* curve is consistently low, below 3 %, except for the three bottom samples. It is hardly unreasonable to assume that these three samples represent the last of the warmth period, consequently we have the zone transition VIII–IX between 150 and 160 cm. For the rise of the land this gives us some 4 metres for the last 2500 years, or provided it has proceeded with constant speed, ca. 1.6 mm/year. A similar rate of regression of the sea during the same period has been calculated from independent sources both at Bømlo and at Karmøy (FÆGRI 1944 p. 45). Unfortunately no modern investigation of the rise of the land during the post-glacial period has been published from the Bergen area. KALDHOL (1941 p. 64) gives the altitude of the Tapes line af Fannebust, some 12 km due north, to 10.3 m. While this figure is quite probable, it does not help us very much.

Pollen analyses from the lower part of the supposed magnocaricion peat gave an astonishing result: spores of *Lycopodium annotinum* outnumbered everything else. The plant community must have been a moist *L. annotinum* meadow, or perhaps rather a moist forest with *L. annotinum* covering the bottom. This community was later drowned, first by a *Sphagnum* peat with magnocaricion remains (possibly not telmatic, as suggested by the diagram), and later by a moist *Sphagnum* peat. The increasing wetness in this case is most probably due to blocking of the outlet, not to climatic changes.

Beech pollen appears for the first time at 100 cm, preceded by minute quantities in the samples immediately below[1]). The beech curve remains uniformly low until the topmost 30 cm, indicating that Poltnesset got its present vegetational character very recently, and later than other places in the area.

The earliest *Plantago lanceolata* pollen grains were observed at 140 cm, together with grains of *Cerealia* type (owing to the vicinity of the seashore I dare not exclude the possibility of *Elymus*, although there are very few, if any, suitable habitats for that species just here). At 135 cm there were also grains of *Rumex subgen. Lapathum*, which I have not observed here except in connexion with other types of "cultivation pollen". *Subgen. Acetosa* is so frequent throughout the whole series both in this basin and the other ones, that it cannot be used as a cultivation indicator.

The diagram shows that beech came some time after the area was originally settled. As the growth rates of the layers of this deposit are so different, it is hardly possible to say anything more about the dating here.

3. Vollom[2]). Having exhausted the possibilities offered by regular

[1]) The sample at 115 cm was abnormal, giving the following count: P $2^1/_2$, B 70, A 245, Q 11, Co 31, Gram 7, Vacc 37, *Calluna* 11, Filic 94, *L. annotinum* 73. After the complete count had been interrupted, a partial one was continued, until some 4000 AP had been seen. Two *Fagus* pollen grains were observed, thus giving a percentage of 0.05. As, however, the local over-representation has made all percentages more or less misleading, it may be more important to note that there were one grain of *Juglans* and one of *Picea* in the same sample. Even if it is not possible, even under much more favorable circumstances, to decide with certainty by means of pollen analysis alone whether a wind-pollinated species occurred locally or not, the probability that beech occurred at the 115 cm level must be considered very low. And the occurrences at the two following levels, calculated on resp. 1750 and 1290 AP grains, are hardly more significant.

[2]) The property boundaries are rather complicated and the localities 3 and 4 may have been assigned to the wrong farms.

bogs, I had to look for material of less orthodox character, and decided to have a try at the raw humus of a moist place in the forest bottom on the hill-side leading down to the sea opposite Poltnesset. A not too good, rather mixed beech forest covers most of the slope between the present road and the sea. The ground is rocky and the soil generally very shallow. Field vegetation is comparatively rich, dominated by *Vaccinium myrtillus etc.*

The site selected for sampling was a ca. 1 m^2 great patch of *Molinia*, within which there was in a single place 36 cm of humus, underlain by partly disintegrated boulders. Altitude 32 m, probably below the marine limit (the boulders were rounded), but the shore-line passed this level long before the period that interests us in this connexion.

The idea of investigating pollen-analytically forest bottom raw humus is not new, and I got my nearest inspiration from similar analyses carried out by Dr. Iversen and his collaborators in the forest Draved, Denmark. The humus in my samples proved to contain great quantities of (in most cases) excellently preserved pollen grains.

It is obvious that a pollen diagram from a deposit of this nature is even more locally influenced than diagrams from small bogs of the Poltnesset type. The interpretation of the diagrams must therefore base itself upon the assumption that they reflect the vegetational changes of a very small area only, a small patch of vegetation subject to all kinds of accidental influences. Unnecessary to say, a thorough knowledge of botanical and ecological problems is a *conditio sine qua non* for a sensible evaluation of the data from such diagrams.

Our diagram from Vollom (pl. XXI) gives a rather uniform picture, and there can be no doubt that this raw humus formation is of sub-Atlantic age. Also in this case we find that settlement—indicated by pollen grains of *Polygonum persicaria* type, *Cerealia*, and *Plantago lanceolata*—starts at 32 cm, some time after the commencement of the sub-Atlantic period, and that the beech comes at 26 cm, some time later.

The course of the *Fagus* curve in this diagram is rather like that in the Poltnesset diagram: a rapid recent expansion after a long period during which beech was present, but did not occur locally (locally here meaning within the nearest 50 or 100 metres). There are some small maxima of the curve, but they probably are more or less accidental.

Even if it has no direct bearing upon the problem of dating the immigration or introduction of beech, it is of a certain interest to analyse more thoroughly what has happened to the Vollom diagram site since the introduction of agriculture. The NAP curve in the "Total" diagram shows that on the whole the hill-side has been forested. There is a small NAP maximum at 26 cm, and there is another, more pronounced, at 12–20 cm. There are two small *Cyperaceae* maxima at the beginning and end of this NAP maximum; otherwise the unchanged NAP diagram indicates that the maximum is not caused by over-representation of some NAP type. It must be due to a smaller production of AP, i.e. to the disappearance of parts of the (flowering) forest. Another indicator of the same is the Juniper maximum at 16–18 cm. Juniper does not flower properly in the shadow of a forest, consequently there must have been open fields around our locality. Another interesting indicator is *Succisa pratensis*[1]).

In western Norway this species scarcely occurs in a natural forest, but if the forest is opened and at the same time grazed, it will appear, often in great profusion. It belongs to the normal constituents of pastures and not too poor heaths in western Norway (Fægri 1952 b p. 100). I think we may consider *Succisa* in this case essentially a grazing indicator, and the the curve as an indication that the local forest was temporarily destroyed by grazing animals (a sub-Boreal occurrence of *Succisa* in Skarsvatnet is not due to grazing). It should be noted that *Succisa* appears abundantly in the diagram after the first, small NAP maximum. At the same time *QM* virtually disappears. There must have been at least some selective clearing of the forest at 26 cm. As could be expected, the *Corylus* curve is less clear. Apparently *Corylus* survived the forest clearings better than *QM* and was finally crowded out by the advancing beech.

Whereas all these curves fit into the same general pattern, there is one little curve which I cannot interpret at present: the occurrence of *Selaginella*[1]). *Succisa* is above all characteristic of acid soil, and there is nothing else to indicate that the soil was not distinctly acid. *Except Selaginella*, which is a certain indicator of sub-neutral or at any rate not distinctly acid water, and is generally characteristic of slightly moister conditions. A similar, rather paradoxical occurrence of *Selaginella* was met with in Skutlestjern (Fægri 1950), but is was easier to understand in that case. It is conceivable that our little swamp became wetter (cp. the following diagram) but I have given up to find an explanation of the apparent change of pH. In Skarsvatn some few *Selaginella* spores were found in a similar position.

The second NAP maximum also includes one sample, 16 cm, with lower NAP values. It is very interesting to note that this is due to a strong representation of *Fagus*. Apparently, at the border of this open or half-open grazing ground a beech has been able to establish itself near

[1]) In the diagram *Succisa* (like *Selaginella*) is represented in percentages of a total consisting of AP, ordinary NAP, entomogamous species, and spores. In order to check that the *Succisa* curve is not a function of forest density, I have also calculated *Succisa* in per cent of NAP+entomoganous—with the same result, apart from a more exaggerated maximum in the lower part.—In forest bottom diagrams fern spores play a very great part. As they are without any relevance to our problem, I have not included them here.

our locality. But the beech forest did not establish itself until the final establishment at 10 cm. It should be noted that when the open vegetation was again replaced by forest, it was replaced by the present beech forest.

4. *Bøkjevold.* A fourth locality has also been investigated, rather accidentally at first. Waiting for a foresters' excursion to arrive to the beech forest area, I chanced upon a narrow valley or rather a gorge running in the general NW–SE direction. The bottom of the gorge sloped a little towards NW and SE, thus forming a pass, the highest part of which was approximately horizontal for 30 m. Breadth: 6 m. Some birches filled the gorge, with a soft carpet of *Polytrichum commune* in the bottom. The rock rib to the northeast of the locality was covered by a low birch forest with scattered small beeches. This forest connected with the main beech forest, otherwise the locality was surrounded by hay-fields.

The humus layer proved to be exceptionally deep. As I had only a small spade, I could not reach further down than 45 cm. As the analysis of this deposit gave rather interesting results, I later tried to supplement the series down to the bottom, which the Hiller sampler reached at 95 cm(!).

The deposit, especially the lower part, was dark brown to blackish, greasy without recognisable vegetable remains. By boiling with KOH it dissolved completely, leaving practically nothing but spores and pollen grains.

The diagram (pl. XXI) shows extreme variations, as one might expect where local influence is as dominating as in this place.

The *Betula* maximum at 50 cm was originally interpreted as being identical with part of the *Betula*-dominated top of the diagram, and an overlap was presumed. However, a third visit to the locality gave a second series which was continuous down to 60 cm. The samples were collected by digging, and at the same time a check was made that the original stratification had not been disturbed. This second series, which is not reproduced here, gave the same *Betula* maximum in the same position.

The diagram is characterised by very high *QM* values, higher than any ones previously observed in western Norway with the exception of the oak forest bottom of Bø, Jæren (Fægri 1940, pl. IV). The *Tilia* values are very high, and there can be no doubt that the immediate surroundings of the gorge were covered by an almost pure *QM* forest, at times with very great proportions of lime. Now, one might imagine that such a local *QM* dominance might occur at favourable periods of the sub-Atlantic Age, but I find it extremely difficult to conceive such a rich lime forest in these poor surroundings. It should be remembered that in the very favourable SW-exposed steep hill-side above Skarsvatnet, *Tilia* was far from common even during period VIII.

A closer examination of the bottom of the diagram reveals the following sequence: *Betula—Pinus—Alnus—QM*, and within the *QM*: *Ulmus —Tilia—Quercus*. Even if the *QM* comes a little earlier in relation to the *Alnus* maximum than one would expect, the similarity between these sequences and those of zones V–VIII both in Skarsvatn and in other diagrams from western Norway, is so striking that I cannot escape the conclusion that our deposit dates back to the end of the Boreal period.

But one problem remains: the location of zone transition VIII–IX. The obvious place to look for it would be at 30 cm, where *Quercus* gives way to *Betula*. Whereas I still dare not exclude this possibility, there are a few features that do not fit in too well with such an interpretation. E.g. we find quite substantial representation of cultivation pollen all the way down to 30 cm, which is not in accordance with such a dating—if we presume clearance to have taken place ca. 1000 years later. If we presume a hiatus in the series, it would account for the discrepancy, but we may also explain the observation by the assumption that the zone transition is to be placed at 50 cm, and that the second *QM* maximum (with comparatively little *Tilia*) represents a favourable phase of the sub-Atlantic period, such as the Roman Iron Age (cf. FÆGRI 1940).

In the absence of archaeological evidence it is not easy to find out about this, but I have tried to follow the curve of the long-distance transported sub-Atlantic flora elements, *Picea*, *Fagus*, and *Carpinus*. Previous investigations (FÆGRI 1950) have shown that there is a rather consistent incidence of these pollen types during zone IX, with a small maximum near the zone transition. In the southernmost part of Norway, close to the Middle European areas of these species, values are comparatively high. In western Norway they are much lower, but it will be seen that there is a consistent representation all the way down to 55 cm. The figures quoted in the *QM* diagram are based upon a calculated *AP* total of 3000–3500 per spectrum.

There is an apparent drop of the values at 30 cm, but this is not real. Logically it is wrong to calculate long-distance pollen as part of the AP—its incidence is inversely proportional with the density of the forest, and it should therefore be calculated with the NAP, which is also an inverse function of the density of the forest. It will be seen that in spite of the rather great statistical uncertainly the *Fagus* values in relation to NAP between 30 and 55 cm are very constant, with a maximum at the bottom. If we accept the zone transition of 50 cm, the upper *QM* period should probably correspond to the Roman Iron Age, and comes to an end at the beginning of the cultivation period, either for climatic reasons or because the oak forest was cleared away. The consistent cultivation pollen curve begins here, in accordance with archaeological data (oldest finds from the Migration Period). And we further see that *Fagus* appears a short time later. The very small number of cultivation pollen met with further down (counted with *Fagus etc.*) are such as we may expect some distance away from the cultivation centres—which must have existed in different places in Nordhordland.

It is rather unexpected to find a forest bottom soil which has been accumulating more or less constantly since the Boreal period. I do not know any similar case from literature (cfr. FIRBAS & BROIHAN 1936).

The upper part of the deposit has a lighter brownish colour and the texture is a little coarser, not as smeary as in the lower part. After KOH treatment the microscopic picture shows some more vegetable debris than further down. There are also some very interesting micro-fossils in this part, viz. *Desmidiaceae* and copepod spermatophors. They have been entered in the diagram together with *Sphagnum* spores, calculated on a total basis, including entomogamous species, spores, and desmids and spermatophors. The desmids were mainly *Euastrum* species, organisms that are for their subsistence dependent on open water. Thus we find that during the later part of the sub-Atlantic period the ground has been very wet, and has dried up only recently as an effect either of climatic changes or cultivation measures. Compare the dominance of *Cyperaceae* in the NAP diagram. It is significant that the desmids, demanding greater moisture, appear after the *Cyperaceae*. *Sphagnum* and spermatophores show similar curves, even if their occurrence is less striking than that of the desmids.

Generally a deposit of 95 cm would be considered as a peat. However, the microscopic picture indicates that the mother-formation for a greater part of the period was not what we would consider a bog. Even in the uppermost part containing desmids, the remains of bog plants are far from mumerous. However, between 5 and 20 cm we may consider the deposit a highly humified peat. The rest is a forest bottom humus.—It should be noted that these forest humus deposits differ very much e.g. from those discussed by TRAUTMANN (1952) by containing no minerogeneous matter. Thus we may conclude that no rain-worms have been active, which is, of course, a very important point when diagrams are to be used in analysis of vegetational history.

Discussion.

By extra-ordinary misfortune none of the four diagrams reproduced here gives fully adequate possibilities for dating the beech forest. In the Vollom diagram we may have lost the beginning of zone IX. In Skarsvatnet we did not catch properly the beginning of the beech curve, and at Poltnesset again we have the difficulty that the growth rate of the deposit has been very variable. The Bøkjevold diagram gives the best dating, but the foundation of the dating is not as strong as one might have wished.

Two points are at any rate indisputable: 1. The beech immigrated during the sub-Atlantic period, thus very late, as conceived by both HOLMBOE and HØEG. 2. The beech came to the region after the establishment of agriculture. Also we know 3. that it must have been there in 1611. These are the dates, the rest must perforce be conjectural.

A direct calculation from the Vollom diagram, presuming constant rate of growth and beginning of the diagram 2500 years ago, would give us A. D. 200 for the fist appearance of beech. The calculation is obviously erroneous, giving too old date because we probably miss the oldest parts of the period, and because the growth of the deposit was more rapid in later years. However, it may serve as an indication of the oldest possible date.

If we now return to our archaeological data, we possess no finds older than the Migration Age, ca. 500 A. D. If this means that the region was not settled before that time, we have a very useful indication level in our diagram, viz. the beginning of the cultivation curve. In that case the beech must be younger than the date mentioned. On the other hand it should not be much younger, which would give us a time interval between 500 and 1000 A. D.

The problem of the *origin* of the beech growing in such an isolated position also presents itself. The possibility of natural dispersal has been discussed, even if most investigators have considered it rather improbable. The only possible means of transportation would have been the sea, and we possess evidence of dispersal over similar distances (e.g. *Euphorbia palustris* at Fedje, FÆGRI 1952 a). In that case one should expect a gradual dispersal from the sea-shore. As we have seen, this is not the case: the sea-shore diagrams (Poltnesset, Vollom) indicate that beech grew somewhere else in the region before establishing itself in these places. One should expect the same to be the case if beech seeds had been transported by man more or less accidentally, e.g. some kind of packing material in Viking ships. In the Bøkjevold diagram there is no "tail" to the *Fagus* curve, and, if we presume that the registration is continuous, this may be taken as an indication that beech started here. The extremely local character of the diagram should be kept in mind. If, however, beech started at Bøkjevold, the conclusion seems inevitable that it was originally planted. And it is difficult to assume that planting was not intentional.

We do not know whether planting was made for aesthetic purposes or for utilitarian ones. One may ask if beech should have such practical advantages that it would be an inducement to introduce the tree. As swine-fodder its nuts are not superior to those of the indigenous oak, and to a modern mind practical reasons do not seem to be very strong for planting the tree. Things may have appeared in a different light then, and we should not, I think, underrate the sentimental factor. Anyhow, the purposeful planting of a tree like beech, which does not give any material dividend for years and perhaps not within the life-time of the person who planted it, throws light on an unexpected side of the character of our forefathers.

We possess one curious evidence that people have been interested in our beech occurrence, viz. the old skiprede-name[1]) *Olendefit*, covering just the area around Lygrefjorden. The name refers to the shore-bar connecting Poltnesset with the mainland (BULL 1920 p. 123, LITLESKARE 1925), present name Fetæ or Ålfetæ. This marks Olendefit a rather unique exception among the skiprede-names in western Norway, which were generally the "name of the fjord around which the skiprede is situated, the valley or island of which it consists, the farm that is most centrally situated" (BULL l.c.p. 142 orig. Norwegian). But Fetæ is neither, it is just a shore bar with good accomodation for a boat-house (about which there are to-day traditions cf. LITLESKARE l.c.p. 11). One should have expected a name like Lygra or Seim skiprede.

Even if Fetæ provides a good site for a boat-house, there certainly are other places within the district where the boat-house could be erected e.g. at Seim. The skiprede institution in western Norway goes back to the reign of Håkon the Good (ca. 950, cf. BULL l.c. p. 38), and when Håkon prefered to name the skiprede not after his own residence, but after Ålfetæ, it indicates that this place was of importance, greater than that provided by its central position. Perhaps the passage through Skaret comes in here again.

As a name Olendefit has a special interest for our problem, because LITLESKARE has derived it from olden = oak or beech nuts, and maintains that "beech (and oak) leaves and nuts in the autumn drifted down the brook and at high tide was washed in heaps on to the shores of Fetæ" (l.c. p. 11, orig. Norw.) I have not seen beech nuts being washed ashore at Fetæ (because very few nuts were produced last year) but at a visit in December 1953 I found a solid mass of beech leaves along the shore, and new ones were contantly brough down by the little brook from Skarsvatnet. Our foremost authority on place-names, professor MAGNUS OLSEN, has kindly informed me (in letter) that he finds LITLESKARE's interpretation acceptable.

The next question is whether *olden* in this case would mean oak or

[1]) The skiprede originally comprised the area providing one ship for the militia, later it became an administrative unit in taxation *etc.* cf. BULL 1920.

beech nuts. According to the pollen diagram, oak has not been particularly abundant, even if the Skarsvatn early sub-Atlantic percentages are a good deal higher than the present ones. But I do not think it probable that there should have been such an abundance of nuts of the rather commonplace oak as to give a name to the shore bar. If we then assume that the first part of the skiprede name conceals the more exotic beech, we must also assume that beech has been comparatively well established when the name was given to the skiprede, and that it occupied a prominent place in the minds of those who gave the name.

However, these observations can hardly be used for dating our beech forest. Even if the skiprede organisation goes back to ca. 950 A. D., we have no guarantee that the names have not changed later[1]).—To this comes the additional uncertainty if the first part of the name really refers to beech.

Discussing the possible origin of the beech forest it is tempting to mention (as has been done before) that there is only a distance of 3 km from Bøkjevoll to Seim (Sæheim), one of the royal residences during the late 9th and early 10th centuries (Harald Hårfagre's saga, chapter 38). Even if we should not forget king Håkon Adalsteinsfostre and his connexion with the royal house of England, we should perhaps stress even more that the Norwegian royal family descended from Vestfold, the centre of beech in Norway.

It is noteworthy that evidently the horticultural standard in Vestfold was very high. In the Oseberg find (9th century) we have remains of a great number of cultivated plants (HOLMBOE 1920). Perhaps even the famous walnut-shell came from an indigenous tree. In the Oseberg find some wooden objects were made from beech (HØEG l.c. p. 162), which (according to unpublished investigations by Miss KARI EGEDE LARSSEN) grew plentifully in parts of Vestfold at that time. So beech was well known to the Vestfold kings as a useful tree.

Planting of beech may have been a link in a greater plan, initiated by the King, or a courtier (hirdmann) may have had his private lot at Bøkjevold, and for utilitarian or sentimental reasons introduced the tree from his native region.—So perhaps we may return to WULFSBERG's concept of "a bearded Viking in a generous mood" planting our beech, whether he had fetched his seeds in Vestfold, in Denmark or elsewhere.

References.

BØE, J. 1933: Bergens Museums tilvekst av oldsaker 1933. — Bergens Mus. årb. 1933. Hist.-antikv. rk. nr. 3. Bergen.

[1]) Illnes has prevented me from finding out when Olendefit was mentioned for the first time. It certainly was much later than 950.

FIRBAS, F. und BROIHAN, F. 1936: Das Alter der Trockentorfschichten im Hils. — Planta 26 p. 291. Berlin.
FÆGRI, K. 1940: Quartärgeologische Untersuchungen im westlichen Norwegen. II. Zur spätquartären Geschichte Jærens. — Bergens Mus. årb. 1939–40. Natv. rk. nr. 7. Bergen.
— 1944: Studies on the Pleistocene of western Norway. III. Bømlo. — Ibid. 1943, nr. 8.
— 1950: Ibid. IV. On the immigration of *Picea Abies* (L.) Karst. — Univers. Bergen årb. 1949. Natv. rk. nr. 1. Bergen.
— 1952 a: Et merkelig funn av *Euphorbia palustris*. — Blyttia 10 p. 121. Oslo.
— 1952 b: Bedømmelse av lyngmark for granplanting. — Tidsskr. f. skogbruk 1952 p. 99. Oslo.
HOLMBOE, J. 1908: Bøgeskogen ved Lygrefjord i Nordhordland. — Bergens Mus. Aarb. 1908. nr. 13. Bergen.
— 1921: Nytteplanter og ugræs i Osebergfundet. — Osebergfundet, V, Kristiania.
— 1925: Plantet og selvsaadd bøk paa Vestlandet. — Naturen 49 p. 166. Bergen.
HULTÉN, E. 1950: Atlas över växternas utbredning i Norden. — Stockholm.
HØEG, O. A. 1924: Bøken i Norge. — Tidsskr. f. skogbruk 32 p. 61. Oslo.
KALDHOL, H. 1941: Terasse- og strandlinjemålinger fra Sunnfjord til Rogaland. — Hellesylt.
KOLDERUP, C. F. & KOLDERUP, N.-H. 1940: Geology of the Bergen arc system. — Bergens Mus. skr. 20. Bergen.
LINDQUIST, B. 1931: Den skandinaviska bokskogens biologi. — Svenska Skogsvårdsfören. tidskr. 1931 p. 179. Stockholm.
LITLESKARE, J. 1925: Øydejorder, gløymde gardsnamn og burttynte gardar i Nordhordland. — Oslo 1925.
LORANGE, A. 1884 (1886): Fortegnelse over de i 1882 (1884) til Bergens Museum indkomne sager ældre end reformationen. — Aarsberetning for 1883 (1885) fra For. t. norske fortidsminnesm. bevaring. Kristiania.
NICOLAYSEN, N. 1862–66: Norske fornlevninger. — Kristiania.
OLSEN, MAGNUS and RYGH, O. 1910: Gaardnavne i Søndre Bergenhus Amt. — Kristiania (Fabritius).
RÜBEL, E. 1932: Die Buchenwälder Europas. — Veröff. geobot. Inst. Rübel 8. Zürich.
SNORRE STURLASON: Norske kongesagaer. — Storms utgave. Kristiania (Stenersen) 1899.
TRAUTMANN, W. 1952: Pollenanalytische Untersuchungen über die Fichtenwälder des bayerischen Waldes. — Planta 41 p. 83. Berlin.

Norsk resumé.

1. Pollenanalytiske undersøkelser av 4 avleiringer i og nær bøkeskogsområdet i Alversund nord for Bergen viser at bøken først kom til området etter at åkerbruket var begynt.
2. De eldste arkeologiske funn i området kan dateres til ca. 500 e. Kr.
3. Bøkens ankomst kan sannsynligvis settes til en gang i tiden 500–1000.
4. De eldste bøkeforekomstene synes å ligge et stykke fra kysten, det antas derfor at bøken oprinnelig er plantet.
5. Det er nærliggende å henvise til en mulig forbindelse mellom bøkeskogen i Alversund og den nærliggende kongsgård på Seim, og til det forhold at ynglingeetten kom fra Vestfold der bøken på det tidspunkt var vel etablert.

Prehistoric Food Plants and Weeds in Denmark

A Survey of Archaeobotanical Research 1923—1954.

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Abstract.

Since the publication in 1923 of DET DANSKE MARKUKRUDTS HISTORIE by KNUD JESSEN and JENS LIND much work has been done towards the elucidation of the interdependence between man and plants in prehistoric Denmark. This paper deals with the results of the investigation of carbonized plant material and the stomach contents of bog corpses made available and dated by archaeology during the last three decades. The species established in fifteen prehistoric finds are put together in the list, excepting the cereals which are mentioned in the notes concerning the archaeological contexts.

The publication about three decades ago of the first comprehensive survey of the history of the Danish field weeds (KNUD JESSEN and JENS LIND 1922–23) was a milestone in the research dealing with flora history. It is an elaborate compilation of facts as recorded by the classical writers, the mediaeval patres, and scholars of more recent times, supplemented by information derived from early herbaria. To this fund of knowledge were appended the results of recent investigation of bog fossils, mediaeval midden deposits, and a few cases of carbonized plant remains from archaeologically dated prehistoric sites. Even after the elapse of more than thirty years this work remains an indispensable guide to the student of the history of the weeds.

However, since that time Danish science has made great advances in probing into the history of the flora. The new science of pollen analysis, introduced into this country by KNUD JESSEN (JESSEN 1920), and greatly enriched by himself and his associates, has contributed very considerably to our knowledge of the development of the flora since Denmark first became inhabitable to plants.

Carbonized plant remains and imprints of grain and seeds in baked pottery, made available and dated by archaeology, are other sources which were exploited by KNUD JESSEN, and more recently also by his collaborators, and which have added to the general picture of the flora of the past, principally that of the arable land, weeds as well as cultivated plants.

Less frequent, but no less important, is material derived from the stomachs of the prehistoric corpses found preserved in the peat of the bogs. Here we may gain information not only of the vegetation of the cultivated soil, but also of other types of stations, and, what is of special interest, we obtain a singularly intimate insight into the rôle played by the gathering of vegetable food at a time when agriculture was already long established in this country and might have been expected to cover the needs of the population.

This line of research, the ultimate goal of which is the elucidation of the symbiosis between man and plant, based upon archaeological evidence, will here be referred to as archaeobotany.

To make available in one place all the dated identifications, accomplished by this discipline since the appearance of JESSEN & LIND 1922–23, is the main purpose of this communication.

The origin of the material and the methods of the two branches of research, pollen analysis (combined with the study of macro-fossils) and archaeobotany, are normally very different, and since their results cover different areas they supplement each other in a most harmonious way. Whereas pollen analysis picks up the tracks of the flora following the recession of the glaciers, archaeobotany can seldom obtain material earlier than the introduction of agriculture. However, even when the two branches cover the same period their results may take different forms. Pollen analysis is able to draw up a very extensive picture of the prehistoric flora, comprising trees, shrubs, and herbs, and thus on the one hand delineate the natural background of the existence of man, and on the other indicate the effects on the spontaneous vegetation of the activities of man (IVERSEN 1941). To the archaeobotanist is left the task of pointing out which species were exploited by man, gathered in the wood or meadow for technical or nutritional purposes, directly cultivated, or gathered for additional food on the fallow field and elsewhere, as evinced by archaeological contexts.

In certain cases the pollen itself does not permit discrimination between the species within a genus, or perhaps not even the genera within a family. Very often the seeds or fruits are distinctly different in genera the pollen of which is indistinguishable, and this is where archaeobotany may add to the general conclusions. This is especially applicable to the cereals; for the pollen shape of the different cereals is, with the exception of rye, rather alike, and in fact indistinguishable from that of several wild grasses, while their fruits and inflorescence parts may permit satisfactory identification of species and, sometimes, variety, even when in the carbonized state. The same situation is met with in other sections of the flora.

This paper deals mainly with the carbonized material and the three bog corpses which are at present available, identifications of imprints being only mentioned in isolated instances. The general investigation of grain imprints in Danish prehistoric pottery, carried out by SARAUW, JESSEN, and HELBAEK, is well advanced, but still far from complete (HATT 1937).

In prehistoric times, as to-day, life was to a very large extent dependent upon vegetable matter, for food as well as for technical purposes. Here we shall, however, disregard vegetable raw material used for construction, except that the thatch from Fjand is included in the plant list and deserves mention because it proved to consist partly of the threshed plants of species which were habitually gathered, primarily for their edible fruits and seeds.

The identification of these carbonized masses of stems and leaves is in many cases quite impossible, but when the seeds and fruits of the cereals, the *Polygonaceae*, *Chenopodium*, and *Spergula* are encountered among the burnt thatch we may conclude that they could only have got there still adhering to the mother plant. Incidentally, the thatch from Fjand consisted mainly of the vegetative parts of dune and shore vegetation, judging by countless fragments of the characteristic leaves and fruits of *Ammophila*, the fruits of *Carex arenaria*, and unspecified seeds of *Juncus*. These three plants are entered in our plant list, but they did not occur in connection with food remains. The plant list for Aggersborg also comprises species which were obviously used for thatch or wall lining (JESSEN 1954).

The results of the botanical investigation of some of the finds mentioned in the following archaeological notes have already been published, others are here touched upon for the first time. The Vallhagar find is included on account of its geographical affinity to the Bornholm deposits. In spite of a conspicuous difference between the plant list from Österbölle, published in 1938, and the present list, the material is the same, only it was recently re-examined with application of better optics and advanced methods. Several species which were already then suspected, but not published for lack of certainty, have been met with in other finds and their identity confirmed. The writer is pleased to take this opportunity to correct an earlier error; the pale remains from Tollund originally identified as *Setaria pumila* (HELBÆK 1950) have proved to belong to *Echinochloa crus-galli*.

The following notes record the essential facts concerning the archaeological finds which have provided the material contained in the plant list. The finds are listed according to the prehistoric period to which they have been referred archaeologically. The Early Iron Age finds are not in chronological order since it is at present impossible to establish their precise relative age.

The Grauballe corpse is not dated at all, but it seems reasonable to refer it roughly to the same period to which the two other corpses are dated, and it has therefore been put down along with them.

Regarding the actual date of the material it would suffice to remember that the pre-Roman Iron Age (PRIA) is considered to last from 500–400 B. C. up to the beginning of our era, The Roman Iron Age from about the birth of Christ to about 400 A. D., divided into an earlier (ERIA) and a later (LRIA) phase, approximately equally long. The two centuries following are designated as the Early Germanic Iron Age (EGIA). The Viking Period (VP), to which Aggersborg is assigned, comprises the two last centuries of the first millennium A. D.

In the plant list the periods are abbreviated as above in brackets; EN means Early Neolithic (Dolmen Period), MN Middle Neolithic (Passage Grave Period), and EBA Early Bronze Age.

The main cereals are not entered in the list, but their occurrence is mentioned in the archaeological notes.

Barkær.

Extensive habitation site of the Early Neolithic, situated in a sandy locality on the shores of Kolindsund, a narrow sound dried up in recent times, which cut through the peninsula of Djursland in eastern Jutland. Excavated by the National Museum (P. V. GLOB) from 1930 to 1948. (GLOB 1949).

No carbonized material was recovered, but, judging by a few imprints, Emmer and barley were cultivated. Here was found the only imprint of *Allium ursinum* hitherto identified. (Pl. IX, fig. 1).

Bundsö.

Large occupation site of the Middle Neolithic in the island of Als, close to the eastern shore of southern Jutland. The excavation was carried out from 1928 to 1935 by HELWEG MIKKELSEN and the National Museum (T. MATHIASSEN). Eincorn, Emmer, Bread or Club wheat, and barley were identified. (MATHIASSEN 1939, JESSEN 1939).

Nörre Sandegaard.

In northern Bornholm, in a sandy locality, traces of human activity were investigated between 1948 and 1951, indicating intermittent occupation from the Maglemose to the Viking Period. In the course of the excavation, carried out by the National Museum (C. J. BECKER), two shallow pits were encountered among numerous disturbances of the surface of the subsoil, containing carbonized apples, Emmer, Eincorn, Bread or Club wheat, and barley.

The actual date of the plant material is as yet undecided, but being sealed by an Early Bronze Age paving it must be of that period or earlier. (Becker 1951 a, Helbæk 1952).

Görding.

Habitation site dated to the second phase of the pre-Roman Iron Age, situated in the sandy tract at the estuary of Storaa and Damhusaa, at the eastern shore of Nissum Bredning in north-western Jutland. Excavated in 1949 by the National Museum (Knud Thorvildsen). Carbonized remains of a meal were found in a pot, consisting of barley and weeds. (Becker 1951 b, Helbæk 1951 b).

Borremose.

Corpse of a man of the Early Roman Iron Age, found in a peat bog in northern Jutland, in 1946. Small amount of stomach content was recovered. Dated by pollen analysis (Alfred Andersen). No cereals identified. (Thorvildsen 1947, Brandt 1950).

Tollund.

Corpse found in 1950 in a peat bog near Silkeborg in central Jutland. The date is not archaeologically established, but on the basis of the stomach contents it is estimated to be roughly contemporary with the Borremose corpse. The stomach was absolutely sealed, and the whole content was part of the last meal. Of cereals only barley was identified. (Thorvildsen 1950, Helbæk 1950, 1951 a).

Grauballe.

Corpse found in 1952 in a bog in the vicinity of Tollund bog, and presumably not earlier than the two above mentioned corpses. The rather extensive stomach content consisted of Spelt, Emmer?, and barley.

The investigation of the stomach content is not quite complete, and the find has not been published. The writer is grateful to Forhistorisk Museum, Aarhus, and to P. V. Glob, for permission to mention his own findings up to now.

Alrum.

Burnt house of the Early Roman Iron Age, situated in the sandy tracts near the west coast of central Jutland, excavated in 1939 by Gudmund Hatt and Hans Helbæk.

Very large amounts of carbonized cereals were recovered, comprising barley, oats, and Bread or Club wheat. Of particular interest was a heap of fruits of *Polygonum lapathifolium*, amounting to about one litre, evidently gathered separately for food. (Hatt 1940, 1941, 1943).

FJAND.

Large village, obviously established late in the pre-Roman Iron Age and continuing its existence some time into the Early Roman Iron Age. The material of our list comes from houses of its later phase. Excavated by GUDMUND HATT from 1934 to 1940. The site stands near the southern shore of Nissum Bredning in north-western Jutland, in a very poor, sand-drifted locality. The main crops were barley and oats; rye occurs sporadically among the 15–16 litres of carbonized grain. A heap of over one and a half litre of pure *Chenopodium* seeds was recovered, demonstrating the separate gathering (or cultivation?) of these seeds for food. (HATT 1940, 1941, 1943).

The writer wishes to convey his tanks to GUDMUND HATT for permission to publish separately his own observations on the plant material from this site and Alrum.

Ginderup.

Village not far from the west coast of Thy in northern Jutland, excavated from 1922 to 1929 by the National Museum (HANS KJÆR). In a burnt house of the Early Roman Iron Age considerable quantities of carbonized barley, oats, and seeds were recovered. Here for the first time in Denmark deposits of prehistoric *Camelina* and *Spergula* seeds were found. (It should be mentioned that since then it has been discovered that *Camelina* and *Spergula* were introduced into Denmark during the Late Bronze Age and the pre-Roman Iron Age respectively). (KJÆR 1925, 1928, 1930. JESSEN 1933).

Österbölle.

Burnt house of a village of the Early Roman Iron Age excavated in 1936 by GUDMUND HATT, in the moor country of Himmerland in northern Jutland. Large amounts of carbonized barley, linseed, and *Camelina* seeds, as also some rye and oats, were recovered. The plant material was recently re-examined and the list of species extended. (Evidence of the cultivation in the Late Bronze Age of flax has since then been gained from imprints). (HATT 1938. HELBÆK 1938).

Dalshöj.

A burnt house dated to the Early Roman Iron Age, situated in fertile land in eastern Bornholm. Excavated in 1950 by the National Museum (O. KLINDT-JENSEN). About 30 litres of carbonized cereals were recovered, mainly Emmer, Eincorn?, and barley. (KLINDT-JENSEN 1951).

The writer wishes to extend his thanks to the excavator for permission to report on the plant material from this site and Sorte Muld.

Fredsö.

Ruin of a burnt house of the Late Roman Iron Age excavated in 1928 by the National Museum (G. HATT) in the island of Mors in northern Jutland.

KNUD JESSEN identified wheat and barley (HATT 1931).

After the publication of the find the present writer found a pea in an earth sample from a post hole at the site. Since this is the only Danish find of an actual pea seed of prehistoric times it is entered in the plant list.

Vallhagar, Gotland.

A house of a Late Roman Iron Age village, destroyed by fire, excavated between 1946 and 1949, under the direction of Mårten Stenberger, Uppsala. Per Lundström was responsible for the excavation of the particular house containing the grain. The carbonized cereals consisted of Eincorn, Emmer, Spelt, barley, and rye. (STENBERGER et al., in press. HELBÆK in press).

Sorte Muld.

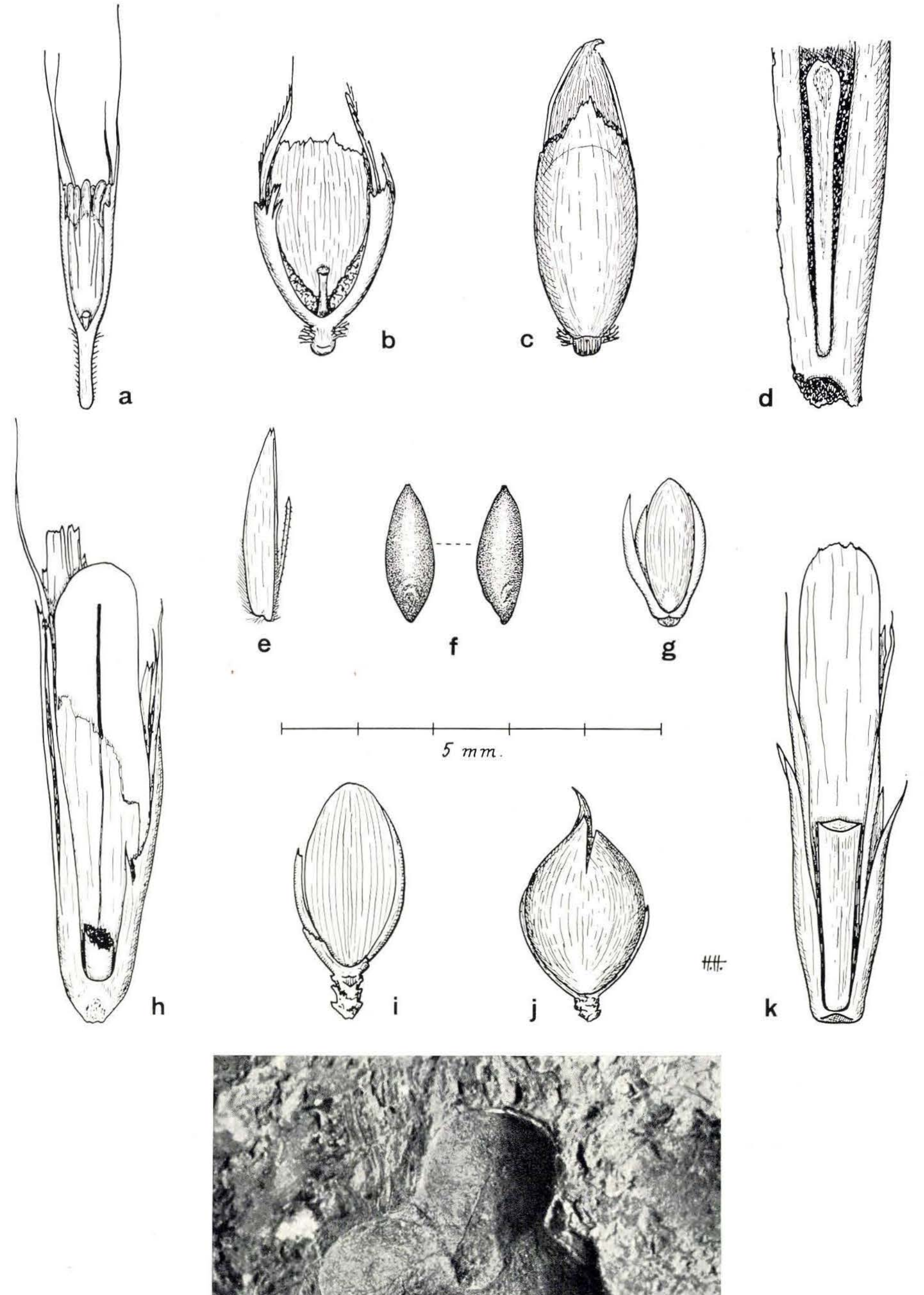
Burnt house of the Early Germanic Iron Age excavated in 1949 by the National Museum (O. KLINDT-JENSEN) in the same general area as Dalshöj. Only a very small amount of carbonized plant remains was recovered, dispersed all over the floor, but the find belongs to the richest on record as regards the number of species involved. Bread or Club wheat, barley, rye, and oats were identified. (KLINDT-JENSEN 1951).

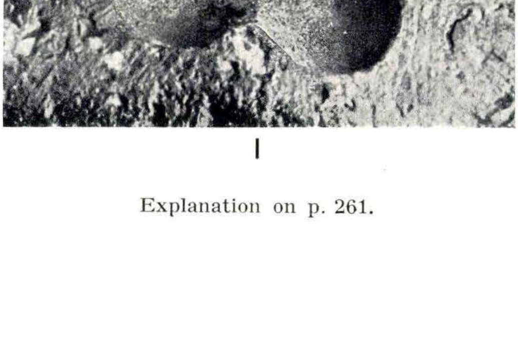
Aggersborg.

Village of the end of the first millennium A. D., found beneath the Viking Period military camp of Aggersborg on the northern shore of the Limfjord in northern Jutland. Excavated in 1949 by the National Museum (C. G. SCHULTZ). Carbonized plant remains were found in numerous refuse pits, comprising barley, oats, and rye. (SCHULTZ 1949. JESSEN 1954).

No claim is made that the plant list given below is complete with reference to the botanical material upon which this paper is based. In the unpublished finds more identifications may be anticipated before the work is finished, but since in living science no specific situation can ever be final we may as well include all that is known at present.

In order to give the reader an impression of the unique state of preservation of the stomach material some of the grass florets from Grauballe are illustrated in Pl. IX. Here the imprint of *Allium ursinum* is also depicted.





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Explanation on p. 261.

Plant List.

· = one or a few specimens
·· = many specimens
··· = very many specimens
(?) = genus, but not species ascertained
? = identification uncertain

Locality (see pp. 253–6)	Barkær	Bundsö	Sandegaard	Görding	Borremose	Tollund	Grauballe	Österbölle	Alrum	Fjand	Ginderup	Dalshöj	Vallhagar	Sorte Muld	Aggersborg
Period (see p. 253)	EN	MN	EBA	PRIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	LRIA	EGIA	VP
Ranunculus acris L.							··	··							
Ranunculus repens L.							·						·		
Fumaria officinalis L.				··			·				·	·	·		·
Brassica campestris L.			··		·	(?)		·		·	··				
Sinapis arvensis L.								·				·			
Raphanus raphanistrum L.		·													·
Lepidium campestre (L.) R. Br.								?							
Lepidium latifolium L.				·			·								
Isatis tinctoria L.											··				
Thlaspi arvense L.						·	·				·				
Capsella bursa-pastoris (L.) Moench				··		·	·	·		·				·	
Erysimum cheiranthoides L.				·		·	·	·						··	
Camelina linicola Sch. et Sp.				··	··	···	·	···	···	··	···	·	·		
Viola canina L.								·							
Viola arvensis Murr.				·		··	·							·	
Hypericum perforatum L.													·		
Silene sp.								·							
Melandrium sp.								·							
Agrostemma githago L.														··	·
Cerastium caespitosum Gilib.							·			·					
Stellaria media L.				··		·	·	·		··	·		··	···	·
Stellaria graminea L.							·								·
Spergula arvensis L.				···	···	···	···	···	···	···	···	·		·	··
Scleranthus annuus L.			·	··			·	·			··				
Montia lamprosperma Cham.										··					
Chenopodium album L.		···		···	···	···	··	···		···	··	··	··	···	···
Chenopodium sp.							·								
Atriplex patula L.										·				·	(?)
Linum usitatissimum L.						···	··	···	···	···	·	··	·		
Geranium pusillum Burm.													··		
Trifolium pratense L.														·	
Trifolium arvense L.							·			··					
Trifolium repens L.								·					·		
Trifolium cf. dubium Sibth.															·
Vicia tetrasperma (L.) Moench												(?)			
Vicia hirsuta (L.) Koch													·		···
Vicia cracca L.											(?)		·		

Locality (see pp. 253–6)	Barkær	Bundsö	Sandegaard	Gördning	Borremose	Tollund	Grauballe	Österbölle	Alrum	Fjand	Ginderup	Dalshöj	Vallhagar	Sorte Muld	Aggersborg
Period (see p. 253)	EN	MN	EBA	PRIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	ERIA	LRIA	EGIA	VP
Vicia angustifolia L.															...
Pisum sativum L.[1])															
Rubus ideaus L.		...													
Potentilla anserina L.							(?)			.					
Potentilla argentea L.							.								
Potentilla erecta (L.) Hampe										.					.
Aphanes arvensis L.							.								
Crataegus sp.			.												
Pyrus malus L.		.	...					.							
Daucus carota L.													.		
Euphorbia helioscopia L.													..		
Polygonum aviculare agg.					.		.	...		.	.	.		..	..
Polygonum lapathifolium agg.[2])				...	...	...	...	...	...	...	...	..	(?)	...	...
Polygonum persicaria L.				..			..	.		.	..				
Polygonum hydropiper L.														.	
Polygonum convolvulus L.				...	.	..	..	...		..	..	..	...	...	..
Rumex acetosella L.				.	...	.	...	...		..					..
Rumex acetosa L.						(?)									
Rumex crispus L.							.	(?)						(?)	
Rumex obtusifolius L.															..
Myrica gale L.															.
Oxycoccus quadripetalus Gilib.					.										
Myosotis arvensis (L.) Hill							.							.	
Solanum nigrum L.				.			..								
Veronica chamaedrys L.														.	
Veronica serpyllifolia L.							.								
Veronica polita Fr.				.										..	
Rhinanthus cf. minor L.							.								
Odontites rubra Gilib.															...
Mentha arvensis L.[3])								...							
Brunella vulgaris L.							..							.	
Stachys arvensis L.								.						.	
Lamium sp.													.		
Galeopsis ladanum L.								..		.			..		
Galeopsis tetrahit agg.[4])						..	..	..			..	.	...	..	(?)
Plantago lanceolata L.			.	.		.	...	.				.	.	.	.
Plantago major L.							..							.	
Plantago cf. *coronopus* L.														.	
Galium palustre L.															.
Galium spurium L.												..	...	...	
Galium aparine L.												.	.		
Achillea millefolium L.							.								
Matricaria inodora L.							.								

Locality (see pp. 253–6) Period (see p. 253)	EN Barkær	MN Bundsö	EBA Sandegaard	PRIA Gördning	ERIA Borremose	ERIA Tollund	ERIA Grauballe	ERIA Österbölle	ERIA Alrum	ERIA Fjand	ERIA Ginderup	ERIA Dalshöj	LRIA Vallhagar	EGIA Sorte Muld	VP Aggersborg
Chrysanthemum leucanthemum L.				.											..
Artemisia vulgaris L.													.		
Artemisia campestris L.								.						.	
Circium cf. heterophyllum (L.) Hill															.
Lapsana communis L.							.						.		
Leontodon autumnalis L.							.	.							
Sonchus asper (L.) Hill							.								
Sonchus oleraceus L.					.			.							
Hieracium umbellatum L.												.			
Crepis capillaris (L.) Wallr.							.								
Crepis tectorum L.							..	.						.	
Allium ursinum L.	.														
Juncus filiformis L.															..
Juncus spp.					.					...					
Luzula campestris (L.) DC.							.							.	
Heleocharis palustris (L.) R. Br.					(?)					...		.			
Scirpus tabernaemontani Palla.											.				...
Scirpus sp.												.			
Carex arenaria L.										...					
Carex spp.				.			.	.		.		.		.	
Phragmites communis Trin.							.								.
Molinia coerulea (L.) Moench.															.
Sieglingia decumbens (L.) Bernh.							.	..						.	
Lolium perenne L.					(?)		...	..		..		.	.	..	
Lolium remotum Schr.							(?)	(?)							
Poa nemoralis L.							.								
Poa sp.				.	.		.	.		..				.	
Bromus mollis L.								...							
Bromus sp.		..					...			..			..	..	
Agropyron caninum R. et S.							..								
Avena fatua L.						(?)	.	.		.	.	...	...		
Holcus lanatus L.					(?)		...								
Deschampsia caespitosa (L.) Beauv.							..								
Ammophila arenaria (L.) Link.										...					
Phleum spp.[5])		...		.			.	..		..		.		..	
Panicum miliaceum L.			.												
Echinochloa crus-galli (L.) Beauv.						.	..								
Setaria viridis (L.) Beauv.							.					..		..	
Setaria italica (L.) Beauv.												..		..	

1) carbonized seed in Late Roman Iron Age site at Fredsö (cf. p. 256)
2) comprising *P. lapathifolium* L., *P. nodosum* Pers., *P. tomentosum* Schrank
3) morphologically *M. aquatica* L. is also possible.
4) comprising *G. tetrahit* L., *G. bifida* Boenn., *G. speciosa* Mill.
5) the material contains *P. arenarium* L. and *P. nodosum* L., and possibly *P. pratense* L.

References.

Aarbøger = Aarbøger for Nordisk Oldkyndighed og Historie. København.
DGU. = Danmarks Geologiske Undersøgelse. København.
Arbm. = Fra Nationalmuseets Arbejdsmark. København.

BECKER, C. J. 1951 a: Maglemosekultur paa Bornholm. Engl. Sum. Aarbøger, p. 96 ff.
— 1951 b: Førromersk Jernalder i Danmark. Finska Fornm. Fören. Tidssk. Helsingfors.
BRANDT, I. 1950: Planterester i et Moselig fra Borremose. Engl. Sum. Aarbøger, p. 342 ff.
GLOB, P. V. 1949: Barkær, Danmarks ældste Landsby. Arbm., p. 5 ff.
HATT, G. 1931: En Brandtomt af et Jernalderhus paa Mors. French Sum. Aarbøger, p. 83 ff.
— 1937: Landbrug i Danmarks Oldtid. København.
— 1938: Jernalders Bopladser i Himmerland. French Sum. Aarbøger, p. 119 ff.
— 1940: En vestjydsk Landsby fra ældre Jernalder. Nord. Tidssk. Stockholm.
— 1941: Forhistoriske Plovfurer i Jylland. French Sum. Aarbøger, p. 155 ff.
— 1943: Jydsk Bondeliv i ældre Jernalder. København.
HELBÆK, H. Planteavl. (in HATT 1938) French Sum. Aarbøger, p. 216 ff.
— 1950: Botanical Study of the Stomach Contents of the Tollund Man. Aarbøger, p. 329 ff.
— 1951 a: Et vegetarisk Maaltid fra Jernalderen. Naturhist. Tid. p. 75 ff. København.
— 1951 b: Ukrudtsfrø som Næringsmiddel i førromersk Jernalder. Engl. Sum. Kuml, p. 65 ff. Aarhus.
— 1952: Preserved Apples and Panicum in the Prehistoric Site at Nørre Sandegaard in Bornholm. Acta Archaeol., p. 107 ff. København.
— in press: The Botany of the Iron Age Vallhagar Field. (cf. Stenberger et al., in press, Stockholm).
IVERSEN, J. 1941: Land Occupation in Denmark's Stone Age. DGU. II, 66.
JESSEN, K. 1920: Moseundersøgelser i det nordøstlige Sjælland. DGU. II, 34.
— 1933: Planterester fra den ældre Jernalder i Thy. Germ. Sum. Bot. Tidssk., p. 257 ff. København.
— 1939: Bundsø II. Kornfund. French Sum. Aarbøger, p. 65 ff.
— 1954: Plantefund fra Vikingetiden i Danmark. Engl. Sum. Bot. Tidssk., p. 125 ff. København.
JESSEN, K. og LIND, J. 1922–23: Det Danske Markukrudts Historie. Kgl. Dan. Vid. Selsk. Skr., Nat. Mat. 8, VIII. København.
KJÆR, H. 1925: Vor Oldtids Mindesmærker. København.
— 1928: Oldtidshuse ved Ginderup i Thy. Arbm., p. 7 ff.
— 1930: En ny Hustomt paa Oldtidsbopladsen ved Ginderup. Arbm., p. 19 ff.
KLINDT-JENSEN, O. 1951: Freds- og Krigstid i Bornholms Jernalder. Arbm., p. 16 ff.
MATHIASSEN, T. 1939: Bundsø I. Bopladsen og Oldsagerne. French sum. Aarbøger, p. 65 ff.
SCHULTZ, C. G. 1949: Aggersborg. Vikingelejren ved Limfjorden. Arbm., p. 91 ff.
STENBERGER, M. et al. in press: Vallhagar. A Migration Period Site on Gotland, Sweden. Stockholm.
THORVILDSEN, K. 1947: Moseliget fra Borremose i Himmerland. Arbm., p. 57 ff.
— 1950: Moseliget fra Tollund. Engl. sum. Aarbøger, p. 311 ff.

Dansk resumé.

Fra sine tidligste Arbejdsaar har KNUD JESSEN interesseret sig særligt for Floraens Historie, specielt den Del af Floraen, der skylder menneskelig Virksomhed sin Status i Danmark. Hans MOSEUNDERSØGELSER (1920) og MARK-

UKRUDTETS HISTORIE (JESSEN og LIND 1922–23) var banebrydende Eksponenter for denne Interesse.

I de forløbne Aar er meget Arbejde blevet lagt i Studiet af Planternes Indvandringshistorie og af Menneskets Udnyttelse af og Indflydelse paa Vegetationen. Ved personlige Arbejder saavel som ved Opmuntring og praktisk Støtte til sine yngre Medarbejdere har KNUD JESSEN medvirket meget væsentligt til de betydelige Resultater, der er opnaaet indenfor dette Felt.

Nærværende Arbejde er tænkt som et Supplement til MARKUKRUDTETS HISTORIE, opnaaet ved Undersøgelse af det Plantemateriale, som Arkæologien har bragt for Dagen og dateret. Listen omfatter Arter, som Mennesker har dyrket eller samlet til Føde og tekniske Formaal, idet dog Resultaterne af Trækulsanalyser ikke er medtaget. De i de samme Fund optrædende Kornarter er kun nævnt i de arkæologiske Noter.

Listen er i Hovedsagen baseret paa Bestemmelser af forkullede Planterester og af Maveindholdet i Moselig. Disse sidste Undersøgelser er af overordentlig stor Betydning ikke alene ved Fundenes fortræffelige Bevaringstilstand, men ogsaa fordi de tillader os at skønne hvilken Rolle Indsamlingen af Frø af Ukrudt spillede her i Landet saa sent som omkring Kristi Fødsel. En Generalundersøgelse af danske Korn- og Frøaftryk i Keramik, der har staaet paa i over 50 Aar, er endnu ikke gennemført, hvorfor dens Resultater ikke er indføjet her. En Undtagelse udgøres af et Dyssetids Aftryk af *Allium ursinum*. Dette publiceres og illustreres nu for første Gang, fordi det er det eneste morfologisk utvetydige Bevis for denne Arts Forekomst i Danmark i forhistorisk Tid.

De vedføjede Tegninger af Græsser fra et Moselig skulde tjene som Illustration af disse Funds store diagnostiske Værdi.

Drawings (Grauballe) 10 diam.

a. Floret of *Phragmites communis*, ventral view.
b. Palea and portion of lemma of *Sieglingia decumbens*, distal view.
c. Floret of *Sieglingia decumbens*, dorsal view.
d. Lower portion of *Avena fatua* floret, ventral view.
e. Floret of *Poa nemoralis*, lateral view.
f. Grain of *Deschampsia caespitosa*, dorsal and lateral view.
g. Palea and margins of lemma of *Setaria viridis*, distal view.
h. Floret with caryopsis of *Agropyron caninum*, ventral view.
i. Palea with remains of lemma of *Echinochloa crus-galli*, distal view.
j. Spikelet of *Echinochloa crus-galli*, dorsal view. The sterile floret is visible behind the fertile one.
k. Floret of *Lolium perenne*, ventral view. This is an unusually long rachilla.
l. Imprint of fruit of *Allium ursinum*, Barkær. Base with pedicle scar. 6 diam. (Photo Hans Helbæk).

Om barkebrød og treslaget alm i kulturhistorisk belysning

Ethnobotanical studies on barkbread and the employment of wych-elm under natural husbandry.

Av

ROLF NORDHAGEN.

Botanisk Hage, Oslo.

With a Summary in English.

Innhold.

Uttrykket »barkebrødstider« kjenner vi alle; men neppe noen av oss forbinder noe konkret, eller la meg si: positivt rystende, ved dette ordet. FRIDTJOF NANSEN hadde omkring 1921 anledning til å studere hungersnøden i Volgadistriktene på nært hold, og har skildret den. Fullt så galt har det trolig aldri vært i Norden, selv ikke i Norge. Men det finnes rystende skildringer av nød også i nordiske kildeskrifter, selv så sent som fra forrige århundre (jfr. NILS KEYLAND: Svensk Allmogekost 1919).

Barkebrødets saga i Norge skulle egentlig min avdøde kollega og venn professor JENS HOLMBOE ha skrevet. Assistert av sin vaktmester OLAF HANSSEN samlet HOLMBOE i 1932—33, og for en vesentlig del på sykesengen, materiale til en slik bok. Men han kom ikke langt. Da han døde i 1943 etterlot han seg en meget verdifull samling excerpter fra norsk topografisk og historisk litteratur, og den korrespondanse om barkebrød som han hadde innledet særlig med gamle folk i norske bygder. Dessuten en oversikt over »barkebrød-fakta« fra alle Norges fylker, fra Østfold og Sørlandets fylker i syd til Finnmark i nord. Men bortsett fra dette arkivmateriale, som oppbevares på Botanisk Museum i Oslo, finnes der i HOLMBOES etterlatenskaper ikke noe utkast til en avhandling, heller ikke noen historikk med nordisk eller europeisk perspektiv.

I. Innledning.

Barkebrød er bare ett av de mange surrogater som folk siden kornavlens innførelse har tydd til i mangel på kornmel. Imidlertid er det sannsynlig at visse naturfolk som aldri har forstått den kunst å bake brød, har nyttet bark til føde på annen måte. Dette forhold vil bli streifet nedenfor. Selv i de europeiske land hvor barkemel har vært et vanlig surrogat, har folk prøvd å utnytte det som overhodet kan høstes på en åker, til det ytterste før de grep til bark. I denne forbindelse må jeg oppholde meg litt ved halm, lettkorn, agner og såer (*såer*, pluralis av *så(d)* f. = g. norsk *sáð* f., brukes i norsk gjerne om bruddstykker av agner henholdsvis kornskall, det samme gjelder dansk *såer* og svensk *sådor*).

Når våre forfedre hadde tersket sitt korn, ble halmen fjernet. Resten, som i norske og svenske dialekter og i eldre dansk kalles *drose* (*dråse*), i norske også *viste*, ble renset, slik at den verdifulle del av avlingen ble skilt fra den mindreverdige del. Dette kunne skje på tre forskjellige måter: ved hjelp av en kasteskovl, et kornsåll eller et drøftetrau. Ved bruk av kasteskovl satte vedkommende person seg gjerne på en lav krakk på kornlåvens gulv foran det usorterte materiale (drosen) og kastet dette skovlevis f. eks. i retning av låveveggen. Det tyngste og beste korn (på norsk *stridkornet*), som flyr lengst, samlet seg da nærmest veggen. Agner, såer og halmbiter som er lettest, falt ned nærmest kasteren, og mellom de to yttergrenser ville da på den distale side hope seg opp noenlunde brukbart korn (på norsk *matkorn*), på den proksimale side det dårligste (*lettkorn*). Fremgangsmåten er nøye skildret i VISTED og STIGUM: Vår gamle bondekultur (Oslo 1951—53).

I vanlige, gode år ble lettkornet fôret opp på husdyrene i stall og fjøs. Men i dårlige år, og særlig i nødsår, ble lettkornet malt enten på håndkvern eller bekkekvern, og melet brukt til grøt og flatbrød. I virkelige nødsår var selv lettkorn en herlighet, og for å drøye det brukte folk å male såer, agner og halm (særlig den delen av kornstråene som sitter oppe i selve kornakset eller straks nedenfor dette). Det beste korn, stridkornet, ble først og fremst reservert til såkorn, og visstnok bare i særlig gode år malt til mel. Dette gjelder Norge i gammel tid. En gammel, egentlig nordnorsk betegnelse på godt korn og mel er *Gudslån* (ɔ: lån fra Gud; jfr. AASEN 1873).

Hvilken skala av elendighet brødfremstillingen bød på i uår, ser man kanskje best av svensken MAXIMILIAN AXELSON's beretning (1852) om en reise han omkring 1850 gjorde i Värmland og de svenske Finnskogene.

Han regner her opp 13 slags nødbrød, ordnet etter tiltagende simpelhet: (1) Dråsebrød, ble bakt av rugmel+finmalte agner. Det ble regnet for å være det beste. (2.) Hakkebrød, her ble hele kornakset og halvparten av halmen hakket opp og malt. (3.) Islandsmosebrød, ble fremstilt av islandslav eller brødlav (*Cetraria islandica*), tilsatt en del kornmel. Denne brødtype var velkjent også i Norge i det 18. og 19. århundre. (4.) Seljebladbrød, ble laget av seljeblad (*Salix caprea*), som var høstet og tørret ved sankthanstid, senere malt og blandet med $^1/_3$ bygg- eller havremel, ofte lettkornmel. Er også kjent fra Norge. (5.) Homrebrød. I dette tilfelle ble frøkapslene av dyrket lin (*Linum usitatissimum*) tørket, malt og tilsatt litt kornmel. (6.) Barkebrød, ble laget av furubarkmel (*Pinus silvestris*) under tilsetning av $^1/_3$—$^1/_2$ bygg- eller havremel. Jeg kommer nedenfor tilbake til denne brødtype. (7.) Benbrød. I dette tilfelle ble husdyrknokler kokt ut, knust, tørket og malt. Litt kornmel ble tilsatt. Har også vært brukt i Norge. (8.) Syregressbrød, ble laget av *Rumex*-frukter + de påsittende blomsterdekkblad. Man brukte i første rekke fruktene av *Rumex domesticus*, *R. obtusifolius*, *R. crispus* og *R. aquaticus*, men også *R. acetosa* coll. Hele fruktstanden ble rispet av med hånden, og materialet tørket og malt på kvern. Dette syre-melet skal ha hatt en syrlig smak og virket forstoppende (J. F. WALLENIUS 1782 p. 13; MANNINEN 1931 p. 33); det ble blandet med byggmel, om slikt fantes i huset. Syregressbrød har vært velkjent også over store deler av Finnland og Norge. (9.) Gressbrød, det ble laget av nyspiret, finhakket, tørket gress fra engene under tilsetning av litt kornmel. (10.) Halmbrød. Her grep man til den nedre del av halmen, som tidligere var blitt vraket. Den ble finhakket og malt, etterpå tilsatt en ringe porsjon kornmel. Dette slags brød omtales også i norske kilder. (11.) Agnbrød, ble utelukkende laget av siktede agner (såer), som etterpå ble tørket og malt, og tilsatt litt lettkornmel. Har vært meget brukt også i Norge. Tilsetning av agner og såer (*agnar eða sáðir*) til brødet omtales allerede i Kongespeilet, som også har en passus om at *sáðir* i uår kan være kostbarere enn rent korn i normale år. Ellers nevnes såer alt i Edda-diktet Rigsþula under skildringen av trælenes kost: »økkvinn hleif, þungan ok þykkvan, þrunginn *sáðum*« (citert etter MAGNUS OLSEN 1949 p. 200). (12.) Grønbrød. Dette ble fremstilt av røslyng (*Calluna vulgaris*), som i Värmland ifølge AXELSON kalles *grön*. Lyngen ble skåret med sigd, hakket, tørket på badstue og malt, og litt lettkornmel ble tilsatt. Grønbrødet var ifølge AXELSON det nest dårligste. Om det har vært brukt i Norge, er uvisst; men fra den danske ekspert H. P. HANSEN i Herning har jeg nylig fått vite at i Jyllands hedeegne har folk i nødstider brukt »lyngbrom« (blad og skudd av lyng) til å drøye rugmelet med. (Ellers finnes der i Danmark så å si ingen barkebrødstradisjoner; man vet bare om et eneste tilfelle hvor aspebark [*Populus tremula*] forsøksvis har vært malt til mel for å drøye kornmelet)[1]. (13.) Barksøbb. Dette er ifølge AXELSON elendighetens ytterste grense. Barksøbb ble utelukkende bakt av furubarkmel, og det måtte bakes i langt tykkere leiver (dansk og svensk: lev) enn alle de 12 foregående sorter, da det nesten var uråd for kvinnene å få deigen til å henge sammen. — Ellers har brøddeig vært drøyet ved tilsetning av mange andre vegetabilier enn de ovenfor nevnte (jfr. KEYLAND og MANNINEN op. cit.).

Jeg kan bare tilføye at enkelte steder i Norge har man i fortvilelse prøvd å blande vedaske i melet; men folk ble så syke at de sluttet med det. Ved Degerfors i Västerbotten i Sverige har folk faktisk brukt en egen jordart til å drøye melet med (KEYLAND p. 132). Men dette er et unntak. I Øst-Europas tettbefolkede strøk, derimot, har i nødsår 16—20 % aske, sand eller jord vært en fast bestanddel i brødet. Dette var tilfelle så sent som under Nansens reise i 1921. Ifølge A. MAURIZIO (1927) inneholdt vanlige »hungerbrød« fra Volga-traktene 10,8 % vann, 17,2 % aske og sand, 33 % malte oljekaker og ugressfrø, og 39 % rugmel. I en enkelt av de prøver som MAURIZIO analyserte, gikk askegehalten opp i 64 %. Så hård har nøden vært i skogbare, tett befolkede land.

II. Litt historikk.

Ifølge F. C. SCHÜBELER (1886) skal de eldste opplysninger om bark som menneskeføde stå hos den greske historieskriver HERODOT. Professor EMIL SMITH, Oslo, har nylig vært så elskverdig å oversette vedkommende avsnitt fra gresk til mitt bruk. Det står i bok 8 om XERXES' soldater at de under tilbaketoget gjennom Thessalia, Makedonia og Thrakia »først røvet og spiste opp innbyggernes grøde. Hvis de ikke fant grøde, spiste de opp gresset som vokste opp av jorden, og barken på trærne som de skrellet av (egentlig »rundt«) — — —, såvel av dyrkede som av ville trær, og de lot ikke noe ligge igjen. Dette gjorde de av hunger. Pest og dysenteri overfalt hæren underveis og voldte ødeleggelse«. EMIL SMITH har også gjort meg oppmerksom på følgende passus hos POLYBIOS i samband med skildringen av Hannibal-krigene: »Innbyggerne i Petelia (i Syd-Italia) som bevarte sin troskap mot romerne, viste så stor standhaftighet da de ble beleiret av Hannibal, at de etter å ha spist opp huder (alt lær) i byen og fortært barken og de spede kvistene på alle trær i byen, og i 11 måneder utholdt beleiringen uten at noen kom dem til unnsetning, overga seg, med romernes billiggelse.« — PLUTARCHOS beretter om ANTONIUS: »Han var den gang et eksempel for sine soldater ved at han, etter så megen luksus og vellevnet, drakk bedervet vann og lot seg servere ville grønsaker (eller frukter). Det fortelles at det også ble spist bark.«

[1]) jfr. H. P. HANSEN: De gamle fortalte. I. (1939 p. 113) og Fra gamle Dage. I. (1921 p. 114), dessuten: Hyrdeliv på Heden (1941 p. 117 og 122).

Hva Mellom-Europa angår, så har jeg ennå ikke hatt tid til å etterlyse eventuelle barkebrødstradisjoner. BROCKMANN-JEROSCH (1918) har i Schweiz funnet »Andeutungen dafür, dass die Weisstannenrinde (*Abies alba*) zu menschlicher Nahrung gedient hat. Leider kann ich darüber nichts näheres berichten«. Personlig er jeg ikke i tvil om at man f. eks. i det gamle Østerrike-Ungarn, liksom i Russland og Polen, har brukt almebark til menneskeføde. I en fransk bok av MAXIME DU CAMPS fra 1874, som SCHÜBELER citerer, leser man at jordarbeiderne (les laboureurs) i Dauphiné i året 1675 ikke hadde annet å leve av enn markens urter og trærnes bark (l'écorce des arbres). Og i EUGÈNE ROLLANDS store verk om franske plantenavn (Tome X, 1913) anføres et interessant navn på almetreet, nemlig *arbre au pauvre homme*. Det er nevnt i en bok av BASTIEN fra 1809, og må oversettes med »fattigmannstre« eller »fattigfolks tre«. I lys av hva jeg senere skal berette, sier dette navnet ganske meget.

For Øst-Europas vedkommende må der, i henhold til A. MAURIZIO's bok »Die Geschichte unserer Pflanzennahrung etc.« (1927), eksistere en ganske vidtløftig kildeskrift-litteratur om nødmat trykt på russisk, særlig fra forrige århundre. I de russiske departementsguvernørers og undersøkelseskommisjoners innberetninger passerer omtrent de samme surrogater revy som i M. AXELSONS skildring fra Värmland og Finnskogene; listen kan suppleres med *Chenopodium*-frø, *Polygonum*-frukter, eikenøtter, oljekaker og aske. Meget interessant er det at almebark nevnes om og om igjen som brød- eller melsurrogat i denne russisk-polske litteratur.

For Nord-Russlands, Lappmarkenes og Øst-Finnlands vedkommende har vi sikre vitnesbyrd om at brød, grøt og suppe laget av furubark har vært ikke bare nødmat, men temmelig vanlig kost i det 18., 19. og et stykke inn i det 20. århundre. Således beretter LUNDIUS (SIRELIUS op. cit.) fra begynnelsen av 1700-talet at lappene flår av barken ved midtsommertid med en lang kniv av ben. »Stykkene, som er ca. 2 alen lange, legges sammenpakket i en stor grop i jorden. Tett opp til denne brenner man så i 1—4 døgn store stokker, slik at ilden slår gjennom jorden. Barken blir da rød; etterpå tas den opp, blir tørket og til sist stampet på et reinsdyrskinn til et fint mel, som om sommeren blandes i reinmelk og gir en delikat rett.«

I U. T. SIRELIUS: »Finlands folkliga kultur« (trykt på finsk 1919, senere oversatt og stensilert på svensk) finner man mange interessante ting om barkebrød. Først fortelles det om samojedene, at de alt i mai samler sevjelaget (sav) av visse trær, som de siden tørker, støter istykker, blander med vanlig mel og steker til brød. SIRELIUS citerer dernest en finsk forfatter PAULAHARJU, som, uten å nevne noe bestemt finsk distrikt, skriver følgende: »Et par uker før sankthans ble der holdt såkalte furudager (*petäjäpäivet*), da hele gårdsfolket tidlig på morgenen dro til skogs. Furu-trærne ble felt på moen, og barken avskallet med kniv (verktøyet er avbildet på bokens fig. 242 og 243) i flak på 4—5 kvarts bredde (fig. 424). Når kvelden kom, ble det ytterste grønne laget skallet løs sammen med den hårde ytterbarken, og harpiksen vridd ut gjennom kvisthullene.« Med hensyn til tilberedningen, så citerer SIRELIUS en bok av svensken CARL MENANDER fra 1742: »Barken legges på kull i en ovn eller holdes mot stokkild til den blir brun på begge sider; samtidig svulmer den opp og kommer liksom i en slags gjæring, da også kvaen brennes ut av den. Stykkene tørkes siden grundig, støtes fint og knuses til mel«. Denne støtingen foregikk i en stamp (i boken avbildet på fig. 248). Barkemelet ble så lagt på et slags filter laget av halm i et trau, og overhelt med kokende vann, som tok bort kvaesmaken. Brøddeigen kunne lages bare av barkemel alene; men hvis det fantes rug- eller havremel, laget man først en surdeig av dette, og til sist ble det fuktede barkemelet blandet oppi. De ferdigstekte brød hadde form av tynne kaker (fig. 245, 246). Om høsten ble deigen drøyet ut ved tilsetning av bær (*Vaccinium vitis-idaea* og *Rubus chamaemorus*), hvis der da i det hele tatt var bærår.

Bark og barkebrød har i Finnland, særlig i grensetraktene mot Russland, liksom i Nord-Russland vært brukt meget lenger enn SIRELIUS lar leseren få inntrykk av. I Russisk Karelen traff de norske professorer J. A. FRIIS og L. KR. DAA i 1867 folk i ødemarken som skrellet furubark direkte av levende trær, skrapte bort ytterlaget og spiste resten med velbehag eller la de oppskårne biter i den fiskesuppen de kokte. Dette omtales i de to nordmenns reiseberetninger fra 1871 og 1870. Meget verdifulle opplysninger og citater finnes i I. MANNINEN »Überreste der Sammlerstufe und die Notnahrung aus dem Pflanzenreich bei den nordeurasischen, vorzugsweise den finnischen Völkern« (1931). Han uttaler at de *finske lapper* (samer) alltid har betraktet og fremdeles betrakter blødningssaften av furu, som de ofte tapper direkte av treet over i munnen, som en lekkerbisken. Dessuten har preparert, stampet furubark vært laget til grøt under tilsetning av fiskefett eller reinsdyrtalg. »Heutzutage gibt man ausserdem gewöhnlich auch Roggenmehl hinein, ja sogar mehr als Rindenmehl. Diesen fettigen Rindenbrei essen die Lappen als Abendspeise.« Manninen uttaler videre: »In Inari und Schwedisch Lappland buk man einen Kuchen aus Kiefernrinde und richtigem Mehl. Oft verlängerte man die Fleisch- oder Fischsuppe mit einer Handvoll zerstampften Rinde. Besonders in Russisch-Lappland hat die Verwertung der Kiefernrinde auch heutzutage eine sehr wichtige Bedeutung in der Speisewirtschaft.« Manninen, som skrev dette i 1931, citerer her T. J. ITKONEN: Suomen lappalaiset bd. I.

Om *karelene* uttaler han at de, i henhold til publikasjoner av finske og russiske forfattere fra 1929, fremdeles bruker furubark til føde. Fra årene 1856 og 1883 citerer han fra russisk litteratur beretninger om at *syrjenene* lager brød av furubarkmel, eller de setter furubarkmel til en syret deig laget av byggmel; særlig skal forbruket av furubark ha vært oppsiktsvekkende stort ved det øvre løp av floden Vytshegda og i landsbyene hos de sydlige syrjener. — Russeren POPOV forteller i 1883 om *permjakene* ved Vischera at de av nabofolkene hadde fått oppnavnet *katš-šoijas* (»Kiefernrindenesser«). — Fra kretsen Valdai i guvernementet Novgorod beretter FENOMENOV om *russerne* at bare i en enkelt landsby kunne folk hugge tusener av unge furutrær for å få tak i sevjelaget. »Gewöhnlich schabt man den Saft im Walde direkt in den Mund ab. Bisweilen zieht man den erstarrten Saft in langen Streifen von den Bäumen los und nimmt ihn mit nach Hause« (»Saft« betyr her sevjelaget eller innerbarken). MANNINEN viser også ved citater fra eldre og nyere litteratur at *samojeder*, *tunguser* og *jakuter* bruker furubark til mel, og lager en merkelig grøt ved å røre melet ut i en spesiell form for surmelk som har vært oppbevaret et helt år; denne deigen blir så kokt i vann.

Av særlig stor interesse er MANNINENS beretning om de erfaringer han selv gjorde på en reise sommeren 1919 til noen avsides liggende *finske* landsbyer i Ilomantsi (ved Finnlands østgrense). Furubarkmelets sørgelige følger for folkehelsen var slående. »Da man zwei Winter und einen Sommer sein Leben zum grössten Teil mit Hilfe von Kiefernrinde gefristet hatte, war ein so grosser Ausfall an Aufbaustoffen des Körpers eingetreten, dass es schwer war, diese wieder zu ersetzen. Der Appetit dieser Leute schien unstillbar zu sein. »Die Kiefer zerbrach uns, wir müssen unendlich essen«, erklärten die Unglücklichen sehr bezeichnend.« I en note fortsetter MANNINEN: »Übermässiger, längere Zeit andauernder Gebrauch von Kiefernrinde neben anderer knapper Nahrung liess Beine und Bauch anschwellen. Ich sah kleine Kinder, deren Bauch erschreckend gross und hart wie ein mit Steinen vollgestopfter Sack herabhing. Viele Kinder konnten nicht aufstehen, sie lagen nur da. »Und wenn man auch noch so fest mit einer Rute auf den Rücken geschlagen hätte — so schilderte ein Mann aus dem Dorf Kuolismaa seinen Zustand — so hätte man doch keinen Schritt machen können, so geschwollen waren die Füsse« (op. cit. p. 45—46).

Fra guvernementet Vjatka beretter RYTSCHKOW (»Tagebuch über eine Reise durch versch. Prov. d. russ. Reichs in d. J. 1769, 1770 und 1771«, trykt i Riga 1774) om *russerne* at de laget runde, tynne kaker av enten rent furubarkmel eller blandingsmel, og at dette brødet virket særlig avkreftende på barn.

Ellers uttaler MANNINEN at for de finsk-ugriske folk har, ved siden av furubark, bare innerbarken av bjørk (*Betula*) vært av en viss betydning som føde. Ellers fører hans historikk oss helt fram til hungersnøden i Russland 1921 og Nansens reise: »Als in Russland im Winter 1921—22 die furchtbarste Hungersnot herrschte, ass man im wotjakischen Gebiete ganz allgemein Surrogate; schon im Frühjahr 1921 begann man allgemein Eicheln und Ulmenrinde als Nahrung zu gebrauchen« (sperret R. N.). Men ennå så sent som i mars 1934 brakte Oslo-avisene telegrammer fra Litauen om at folk i Vilna-distriktet, iallfall enkelte steder, var nødt til å bake barkebrød.

I Asia har barken av flere *Ulmus*-arter vært brukt til mat, både i Himalaya og China. Av FREDERIK PORTER SMITHS bok »Contributions towards the Materia Medica and Natural History of China« (Shanghai 1871) fremgår det at kineserne bruker barken, bladene og fruktene av to forskjellige almearter som surrogat for korn. I 1947 skrev den kinesiske botaniker P'EJ en avhandling om denne sak, så SMITHS anførsler er blitt fullt ut bekreftet. — Av min kollega professor GEORG MORGENSTIERNE har jeg fått den opplysning at en engelsk forsker GRIERSON i en bok gjør oppmerksom på at et bestemt folkelig navn på en alm (trolig *Ulmus carpinifolia*) omtales fra Kashmir under hungersnøden 1877—1879 i samband med nødmat, fordøyelsesbesværligheter, sykdom og død.

I Nord-Amerika har visse indianerstammer spist innerbarken av »slippery elm«, *Ulmus fulva*, uten noen som helst tilberedning (jfr. Deutsche Pharmazeutische Zeitung 1874).

Av den vitenskapelige litteratur jeg hittil er kommet over, har jeg fått det inntrykk at det er i China, Russland, Polen, Finnland, Norge og Sverige at bark av forskjellige slags trær har holdt seg lengst på spisesedlen i historisk nyere tid. Av MAURIZIOS bok fremgår det at de eneste sikre og de fyldigste opplysninger om tilberedning av bark til mel og fremstilling av barkebrød er å finne i nordisk litteratur. Han selv gjør sig imidlertid skyldig i mange misforståelser av språklig og botanisk art.

Holder vi oss til Den skandinaviske halvøy, har vi iallfall ett arkeologisk funn av barkebrød å støtte oss til: i nærheten av Söderköping i Östergötland ble det i 1911 funnet et noe forkullet brødstykke i en mannsgrav fra vikingetiden. Funnet dateres til tiden ca. 800—ca. 1050. Stykket, som er avbildet hos KEYLAND (op. cit. bind I, fig. 82) var 6 cm i diameter og 1,7 cm tykt, og nærmest kakeformet. Ved mikroskopisk undersøkelse ble det slått fast at brødet var laget av furubarkmel og ertemel (*Pisum arvense*) i blanding. Det må ha vært temmelig kraftig og stramt på smaken!

Ellers er det her fristende å gå litt inn på Sigvat Skalds berømte lausavise fra den danske kongesønns Svein Knutssøns og hans mors Alfíva's regjeringstid (1030—1035). Det var Alfíva, Knut den stores angelsaksiske frille, som fikk skylden for uårene i Norge den gang, og Sigvats hån er rettet mot henne. Hans vise begynner slik:

»Alfívu mun ævi
ungr drengr muna lengi,
es oxamat ǫtum
inni, skaf sem hafrar« osv.

Historikeren P. A. MUNCH oversatte dette slik:

»Alfivas old vil sikkert
ynglingen lenge minnes
da oksemat vi åt,
ja selv skav som bukker.
Annet var det da den edle Olav
styrte landet osv.«

Skav er oppskavet bark og kvist, og kan følgelig symbolisere barkebrød.

Visen er senest behandlet av MAGNUS OLSEN i »Skaldevers om nødsår nordenfjells« (1945, 1949), og han vil helst oversette grunnteksten annerledes: »Den unge mann vil lenge minnes Alfíva-tiden, da vi inne spiste oksemat (ɔ: ved husbondens bord), som bukkene eter skav (i uthuset eller i marken); noget annet var det da Olav — han som der stod skrekk av — rådet for landet; enhver kunde da glede sig over kornet som var tørket i stakk« (Sigvat hadde av kong Olav fått en gård i Trøndelag; i den tiden var det gode år, og kongens menn hadde levd standsmessig). Imidlertid mister i denne tydning passusen om skav og bukkene sin slagkraft, for det normale på Sigvats tid liksom i vår egen tid er at geitene eter bark f. eks. om vinteren og i vårmånedene. Folk som holder geiter, kjører ofte fram hele lass med kvist foran geitefjøset eller i tunet, slik at dyrene kan få gnage av hjertens lyst; og geitene fôres også inne med ris og kvist (*beit* i norske dialekter). — Så vidt jeg kan forstå, er det ikke noe i veien for å oppfatte *skaf* som fortsatt objekt etter *oxamat*, og i denne tydning blir det en sterk pejorativ stigning i Sigvats mesterverk: fra oksens kost (agner og såer) føres vi til geitebukkens; den må nøye seg bare med skav (= bark, kvist). Av alle våre husdyr er jo geitene de nøysomste og igrunnen de minst ansette; de har til alle tider stått meget lavere på rangstigen enn oksen (avlsoksen eller den kastrerte okse). Mot bakgrunn av det svenske barkebrødsfunn fra vikingetiden virker P. A. MUNCH's fortolkning tiltalende; men det er en mangel at han i sin oversettelse ikke har fått med »inne« (ɔ: ved husbondens eget bord, i motsetning til »ute« ɔ: blant trælene; jfr. MAGNUS OLSEN op. cit. p. 200—201), for dette lille ordet gir spottevisen en særlig slagkraft.

KEYLAND citerer ellers en svensk kilde som nevner barkebrød fra Gottland under nødsåret 1310. — LUDVIG HOLBERG vet å fortelle at Christopher av Bayern ble kalt »barkkongen« under sin regjeringstid som svensk konge (1441—1448). Dette har nok Holberg hentet fra Karlskrönikan, hvor økenavnet forklares således (KEYLAND p. 127):

»ä men han war, tha war stor hunger,
ty honom hatade badhe gamal oc unger;
böndher oc bokarla alla
honom barkakonung kalla«.

Det kan ikke ha vært hyggelig å være konge i tider da skylden for uår ble lagt på landets monark!

De eldste sikre historiske opplysninger om bruk av barkebrød i Norge har vi fra Romsdalen (kongebrev 1591), Namdalen (Namdalsbeskrivelse 1597) og Vest-Agder, alle fra 1590-årene. Mest kjent er vel PEDER CLAUSSØN FRIIS' uttalelse: »Nu, anno 1596, 97 og 98 er dette tre (almen) kommet udi høj Pris her paa Agdesiden for de mange Menneskers liv som det reddede udi Hungers Tid og Nød, thi for her var ikke Korn, Rug eller Mjel at bekomme her i Landet«. — Fra 1600-årene har vi en serie med kongebrev, klageskrifter osv. fra de forskjelligste deler av Norge, hvor barkebrød nevnes, således i 1691 fra Asker og Bærum nær Oslo. Ellers er det særlig i det 18. og de første decennier av det 19. århundre at kildene flyter rikest, noe som særlig historikeren, professor JACOB WORM-MÜLLER har vist i sin doktoravhandling fra 1918. Også i avdøde dr. med. FREDRIK GRØNS bøker om kostholdet i Norge (1926; 1941) finnes viktige citater og opplysninger.

Ved hjelp av JENS HOLMBOES etterlatte excerpter har jeg prøvd å finne svar på spørsmålet: hvor lenge har barkebrød vært brukt i Norge henimot nåtiden? Sammenfattende kan en si at det finnes mange autentiske beretninger om at barkebrød holdt seg på spisesedlen til 1860—70-årene. I Indre Sunnfjord og i Korgen i Nordland ble barkemel henholdsvis av alm og furu brukt til 1890—1895. Som et kuriosum kan jeg nevne at Botanisk Museum i Oslo i sitt arkiv har et brev skrevet i 1933 av en agronom i Arnafjord, Vik i Sogn, der han forteller at helt fram til årene mellom 1905 og den første verdenskrig ble det i Arnafjord tatt bark og kvist av alm og malt til mel, som igjen ble blandet med byggmel og bakt til flatbrød. Denne agronom, som er født i 1898, kan selv huske fra sine yngre år at slikt flatbrød var i bruk. — I 1932—33 var det enkelte gamle mennesker i Haus herred, Hordaland, som husket at de hadde spist eller sett barkebrød i sin barndom (Bot. Museums arkiv).

Fra Øst-Finnmark foreligger det opplysninger om at en skoltelapp i Pasvikdalen laget seg furubarkmel så sent som i 1910. Dette omtales av geografen V. TANNER i en avhandling fra 1929; han kjente selv vedkommende mann.

III. Hva slags bark brukte de nordiske folk i nødsår?

Av HOLMBOES notater fremgår det at det har vært spist barkebrød i samtlige norske fylker helt fram til nødsårene før 1814, og mange steder enda lenger. I de deler av Norge hvor det fantes viltvoksende eller plantet alm, *Ulmus glabra*, ble almebark alltid foretrukket. Men det er vesentlig Norges kysttrakter, fra Oslofjorden til Nordland, som har og har hatt forholdsvis meget alm. I innlandet østenfjells, særlig i høyereliggende trakter, og i Indre Trøndelag, Nordland, Troms og Finnmark er det, på samme måte som i Svensk Norrland og Finnland, furubark (*Pinus silvestris*) folk har brukt. Selv i trakter der det vokser alm, har folk ofte måttet blande opp almemelet med furubarkmel.

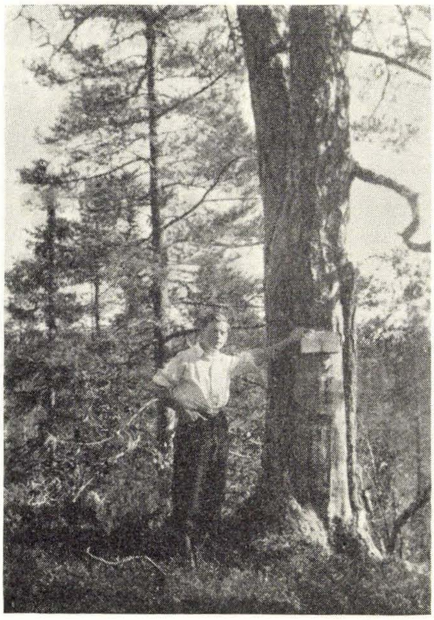


Fig. 1. Fredet furu (*Pinus silvestris*) i skogstrekning tilhørende gården Øvre Volden, Åsen, Nord-Trøndelag. På stammen står et gammelt tre-skilt påskrevet »Bark tatt i nødsårene 1808—1812«. Foto Arne Høeg, Trondheim, 22/9 1934.

Når enkelte kilder nevner granbark (*Picea abies*), så tror jeg at dette i mange tilfelle skyldes feil erindring. Men særlig fra Gudbrandsdalen nevnes granbark såpass ofte at man trolig må akseptere den muntlige tradisjon. En forfatter som IVAR KLEIVEN uttaler at granbarken skal ha vært værre enn all annen bark; det har visstnok bare vært i den bitreste nød at folk brukte den. — Særlig fra Nord-Norges kysttrakter, f. eks. fra Troms fylke, nevnes innerbarken av asp (*Populus tremula*) og bjørk (*Betula*-arter). Ellers har leilighetsvis også barken av lind (*Tilia cordata*), selje (*Salix caprea*) og andre *Salix*-arter, kanskje også av bøk (*Fagus silvatica*) vært brukt; men alt dette har uten tvil vært surrogater for almebark henholdsvis furubark. På Nordiska Museet i Stockholm finnes, ifølge KEYLAND, en prøve av bjørkebarkmel fra Jemtland. Det har trolig vært meget beskt på grunn av betulininnholdet.

Om furubarkens innhøsting, preparering, tørking, stamping, tresking og malning til mel er vi godt underrettet takket være både finske, svenske og norske kilder. Særlig verdifull er KEYLANDS recensjon av eldre svensk litteratur (op. cit. p. 111—133). Ellers har folk flest feilaktige forestillinger hva dette kapitel angår. Det var i første rekke furutopp og

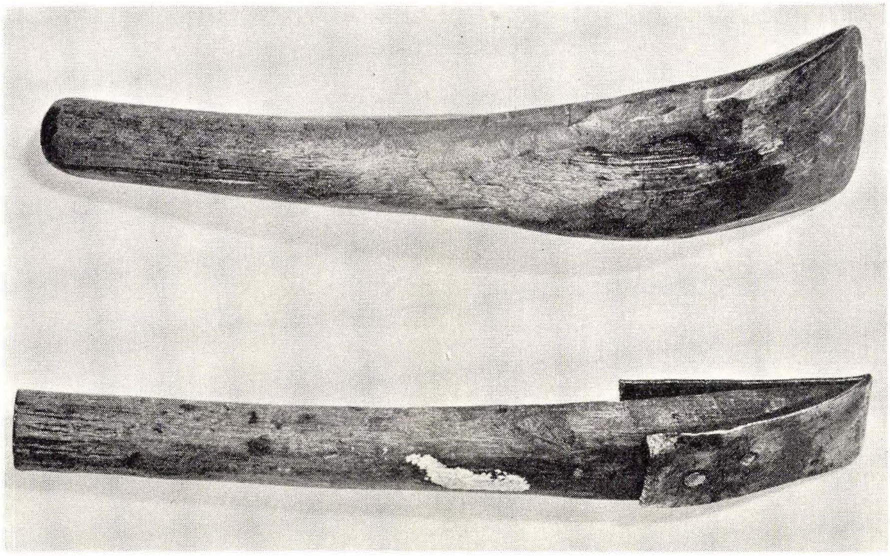


Fig. 2. To redskaper av tre, det nedre med påsatt egg av jern, til å flekke bark med. Kalles i Norge *løype, kytel, kjutul, tykjel.* Andre typer med eller uten skafthylse, til dels av elgshorn eller reinshorn, er avbildet hos NILS KEYLAND (1919).

ungfuru som ble brukt; stammens diameter skulle helst ikke være mer enn 15—30 cm, og det skulle være rankvoksen, kvistfri furu. I Øvre Gudbrandsdalen kalles ungfuru *gulberkjing* fordi den har gul bark, og da trærne gjerne ble hugget før barken ble skrellet løs, kan man lett forstå hvor ødeleggende denne barkflekkingen var for ungskogen — det var gulberkjingen det gikk ut over. Fra Lom og Skjåk forteller IVAR KLEIVEN at 1836 var et slemt år: »De va' ei fæl ti' — og slik som det såg ut ette! Ette heile Kvittingsli'n va' gulberkjingen ne'hogge og flekt så de' lyste på di kvite tree kvar du såg av.« — Fra sin reise i Lom i august 1832 skriver zoologen L. ESMARK at den ødeleggelse hungeren hadde anrettet i de omliggende skoger var så stor at man »formedelst Dynger af afbarkede Trær ofte knapt kunde trænge ind« i dem. — Fra sin Iter Dalecarlicum anfører LINNÉ (1734) at han i Älvdalen allesteds så barkhesjer og flekkede, nedhugne furutrær »till otrolig myckenhet« (ÄHRLINGS utgave 1889 p. 277).

På de felte stammene ble barken skrellet av ved hjelp av et eget redskap; det kan minne om en meisel, et skavjern eller en skraper (fig. 2), ofte med et ganske langt håndtak. Det har i norske dialekter hatt mange forskjellige navn f. eks. *løype* (til verbet *løypa* »flekke bark«). Nordenfjells ble det ofte kalt *kytel* eller *kjutul*, fra Sverige anføres *kytte* og *kute*. TORP (1919) antyder at disse ordene kanskje har sin opprinnelse i latin *cultellus* »kniv« (jfr. fransk *couteau*). Sannsynligheten taler for at redskapsnavnet er meget gammelt i norsk og svensk. Ved omstilling (metatese) er fremgått *tykjel* (Namdalen) og *tykel* i svenske dialekter. Redskapet var ofte, men slett ikke alltid, utstyrt med skafthylse og stundom egg av jern. Ellers er formen variabel, og stundom er skaftet eller hylsen så lang at redskapet minner om en liten spade. Barkflekkingen kunne en da utføre i stående stilling, med furustammen hvilende på marken (omtalt og avbildet fra Dalarna av PERSSON 1932). Redskapet ble laget av tre eller elgshorn, i Nord-Skandinavia og i de finske og russiske lappmarker av reinshorn og visstnok fortrinsvis av det korte, brede, flate horn som mange reinsbukker har fremme i pannen (i visse norske dialekter kalt *brunnfjøl*). Ifølge L. L. LÆSTADIUS (KEYLAND p. 131) kalles et slikt verktøy av reinshorn av den svensktalende befolkning i Svensk Lappland *käckla*. Bilder av disse redskaper, og av en Enare – same som skaller av furubark, finnes i T. J. ITKONEN: Suomen lappalaiset bd. I p. 288 ff. (fig. 105, 106 og 107). I denne sammenheng kunne det ha vært på sin plass å diskutere enkelte forhistoriske redskaper av horn eller ben som dels har vært klassifisert som »nett-stikker« (til å tre fiskegarn innpå, før eller etter bruken), dels som bark-verktøy; men jeg skal her ikke våge meg inn på arkeologiens enemerker.

Fra Särna (Dalarna), som jo opprinnelig var en norsk bygd, opplyses at karfolkene med et tildannet ljåblad eller en grov kniv skar innsnitt på tvers av de felte furustammer med ca. 1 m.s mellomrom. Etterpå ble det skåret et innsnitt på langs, og så skrellet man barken løs mellom to og to tversgående innsnitt ved hjelp av en *tykel*.

Forstandige folk hentet alltid furubark i *håballen* (svenske dial. *hobal*), det vil si i tiden mellom vårarbeidet og høyslåtten. I Helgeland talte folk til og med om *fureborkonna* (NILS LID 1934; jfr. *furudagene* hos SIRELIUS, på finsk *petäjäpäivet*). På denne tid var barken best og dessuten lettest å løype. Da barkstrimlene var tunge, ble de ofte hengt opp til tørk ute i marken; plugger ble f. eks. slått inn i to trær som sto nær hverandre, og så ble det lagt opp horisontale stenger mellom pluggene, aldeles som hesjer. Over disse ble barken hengt. Stundom ble tørkingen foretatt i egne skur. Det må ha vært noe av et »svinearbeid« når en tenker på all harpiksen. I et julenummer av Hernösandsposten for året 1906 har den kjente språkforsker og folklorist E. MODIN skrevet en viktig artikkel om »Nödår och nödbröd i Norrland« (citert hos KEYLAND p. 94). Han opplyser her at til en middels stor familie medgikk årlig 200 furutrær, som ga 5—6 hesjer med grovrenset bark.

Etter at barken var kjørt eller båret hjem, begynte et møysommelig skrapingsarbeid. Med egne kniver ble den grove, gulrøde ytterbarken og den grønne innerbarken fjernet, dessuten det egentlige sevjelaget på strimlenes innerside og all merkbar kvae. Man fikk da tilbake tynne plater av den bleke innerbarken, som så ble kuttet opp i mindre stykker eller flak (fig. 3).

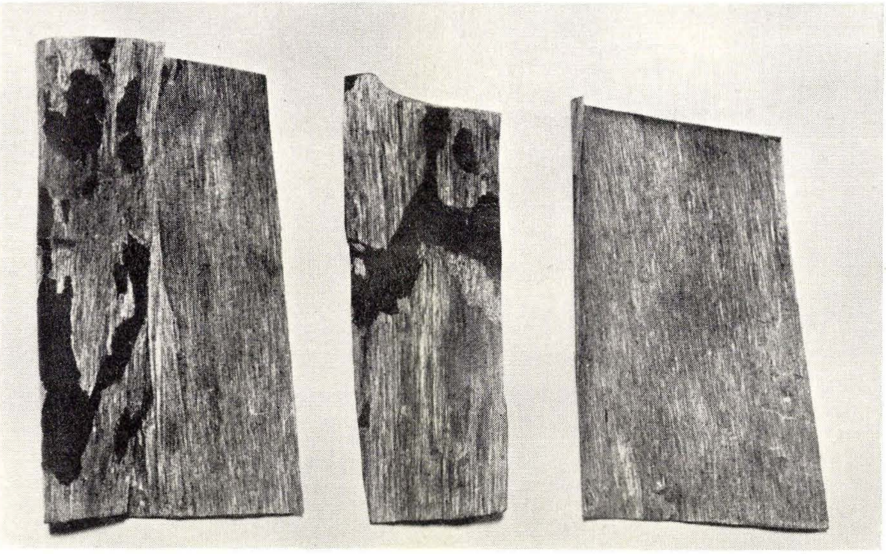


Fig. 3. Stykker av renset innerbark av furu (*Pinus silvestris*) beregnet på fremstilling av furubark-mel. De mørke (brune) partier er tynne flak av korkvev som ikke er blitt fjernet under skrapingen. Stykket til venstre er foldet inn på langs. Professor F. C. SCHÜBELERS samling. Skriver seg fra Finnskogene i Hedmark fylke, trolig fra 1860—1870-årene. (Foto Bergljot Mauritz).
(Kopien viser preparatene i nat. størrelse.)

Ifølge enkelte kilder ble denne rensede bark lagt i rennende vann i flere døgn, ja i inntil 3 uker, helst i en bekk eller kilde, forat beske stoffer skulle bli vasket ut mest mulig. Andre hevder at utvanningen først foregikk med skåldhett vann etter at barken var malt til mel, eller at det ble foretatt flere utvanninger, til og med før barken var skrapt. Folk måtte ofte holde vakt over slik renset bark som lå i vann; fattige mennesker som ikke eide skog selv, var nemlig desperate i nødsår, og stjal som ravner. — Særlig i svenske og finske kildeskrifter nevnes at folk varmet opp den preparerte bark over trekull (glohauger) eller holdt den opp til stokkild for å drive ut kvaen og gjøre barken mer porøs og sprø.

Den utvannede bark ble tørket på nytt, siden brukket opp og lagt i en tønne eller stamp, og bearbeidet med en spade eller en støter (jfr. fig. 248 hos SIRELIUS, og KEYLANDS skildring fra Jemtland av *barskbägar* p. 134—136 og fig. 48). Eller barken ble tersket på låvegulvet med det samme redskap som brukes til korntersking. Det findelte materiale ble til sist (hvis folk hadde krefter til det) fraktet til badstuen og sprøtørket, og endelig malt til mel, enten på håndkvern eller bekkekvern. — Botanisk Museum i Oslo har en prøve fra Finnskogene i Hedmark fylke; den skriver seg fra F. C. SCHÜBELERS innsamlinger i siste halvdel av forrige århundre. Ellers har denne forsker påfallende lite å fortelle om bruk av furubark.

— Enkelte steder i Norge har tørket og småknust furubark vært lokal handelsvare; således opplyser en mann fra Hattfjelldal i Nordland i et brev til Bot. Museum (han var født i 1851) at slik bark ble betalt med 1 ort pr. våg.

Amanuensis FINN-EGIL ECKBLAD har foretatt en mikroskopisk-anatomisk undersøkelse av SCHÜBELERS prøve av furubarkmel fra Finnskogene. Han uttaler: »Prøven er temmelig ensartet lysebrun. Melet er laget ved oppflisning av barken parallelt med stammens overflate. De enkelte brokker er flate, tangentiale utsnitt av barken. Hvorledes barken har sett ut i radial- og tverrsnitt, kan en derfor ikke se av melprøven. Imidlertid ses tydelig både vertikale og horisontale parenkymceller. De siste representerer margstrålene, og inneholder undertiden harpiksganger. Særlig tydelige blir parenkymcellene ved tilsetning av jod-jodkalium, som viser de store mengder stivelseskorn. Ved sammenligning med de plater av tørret, preparert innerbark som likeens finnes i SCHÜBELERS samling, og som melet er laget av, blir anatomien lettere å forstå. Platene er ca. 1 mm tykke, og må ha vært ganske myke før de ble tørket, da et par av dem har vært brettet helt sammen. Platene er åpenbart fremkommet som tangentiale avskrellinger, dette ser en av den makroskopiske struktur og av margstrålenes retning. De siste er sterkt buktet, og ses på tverrsnitt å gå fra den ene bredsiden til den andre. Buktingen er årsak til at margstrålene ses i lengdesnitt både på tangential- og radialsnitt. — Gjennomgående er de to bredsider på hver enkelt plate forskjellige, idet det på den ene sitter rester av k o r k i mørkere flak. Hos unge furustammer dannes korkkambiet som en ring fra det 3. eller 4. subepidermale lag. Men som kjent dannes det hos eldre stammer uregelmessige, isolerte, sekundære korkkambier lenger inne. Utenfor disse blir det da liggende deler av silvevet, som etter hvert dør og forandres. Korkcellene får sterkt fortykkede vegger og blir til steinkork. — Ved den mikroskopiske analyse av innerbarkplatene viste det seg at disse, bortsett fra de tynne flak av kork, utelukkende består av s i l v e v og m a r g s t r å l e r. Bare hist og her ses spor etter en begynnende forvedning (floroglucin-saltsyre-reaksjon på lignin), og da alltid i den del som ligger nærmest korklaget. Korkkambiet er synlig på innsiden av korkcellene; dette viser at korklaget er knyttet til vedkommende innerbarkplates ytterside. Imidlertid gir celleveggene en treg, men likevel tydelig cellulose-reaksjon. Karakteristisk er videre den store mengde s t i v e l s e s k o r n. Disse er lokalisert dels til de vertikale parenkymceller, dels til de horisontale margstråler. Silrørenes vegger viser i tverrsnitt et rynket omriss, noe som dokumenterer at de ikke kan være nydannet. Heller ikke her (jfr. under alm) er altså siste års sildel kommet med.

De mikroskopiske data viser altså at man til barkebrød av furu nyttet de indre deler av den sekundære bark. Høyst sannsynlig holdt man seg innenfor de innerste korklag, slik at melet for en overveiende del kom til å bestå av ennå levende deler av silvevet. De korklag som kom med ved barkflekkingen, ble trolig senere omhyggelig skrapt av. I SCHÜBELERS melprøve finnes, som ovenfor nevnt, overhodet ikke spor av korkceller«. ECKBLAD uttaler ellers at av de to melprøver som finnes på Bot. Museum, er furubarkmelet rikest på stivelse. »Det synes derfor klart at stivelsesmengden ikke har vært utslagsgivende når folk har foretrukket almebarkmel fremfor furubarkmel, men at andre faktorer har spilt inn« (jfr. almen nedenfor).

Så lenge det fantes kornmel i huset, ble barkemel aldri brukt alene. Det var sikkert et meget vanskelig arbeid for kvinnene å lage furubarkbrød (se avsnitt IV nedenfor). Her vil jeg med én gang innskyte den bemerkning at barkebrød, slik som det omtales i nordiske kilder, alltid ble stekt som flatbrød eller knekkebrød; det var et ugjæret brød[1]). Stundom ble det stekt i gryte, eller på panne i jernringer; men som oftest var fremgangsmåten den samme som ved flatbrødbaking. Barkemelet ble eltet til en deig i et trau under stadig tilsetning av kokhett vann; så ble deigen slått opp på et bord og kjevlet ut, og stekt på helle eller »takke«. Stundom har folk også brukt et slags vaffeljern (KEYLAND; PERSSON). I Dalarna ble deigen ofte klappet sammen til en sylinder, og ved hjelp av en lintråd ble denne delt på tvers i »etasjer«, som så ble stekt på ovn eller takke. — Hvorledes fremgangsmåten var f. eks. i middelalderen og forhistorisk tid, vet vi ikke noe om; men funnet fra Östergötland tyder på at barkebrød opprinnelig ble bakt som små kaker og stekt på rist.

At dette furubarkbrødet har krevd en robust fordøyelse, er tydelig nok. Det fremkalte kolikk og kardialgi. Professor ZETTERSTEDT sier i sin interessante reiseberetning fra Syd-Lappland 1832 at furubrødet smaker »vedervärdigt« for den som ikke er vant ved det. — I sin beskrivelse over Trysil prestegjeld fra 1784 (trykt 1797—98) uttaler presten AXEL CHRISTIAN SMITH at Trysil er barkebrødets rette fedreland, men også at »Barke- eller Avnebrødet maa være den hungrige Mave en af de Herrer Jobs Trøstere.« — ANDERS J. RETZIUS (1806) uttaler følgende om furubarkbrødet: »En usel föda, hvarmed de knapt kunna uppehålla livet, och hvaraf de altid, när de någon tid deraf lefvat, få en upblåst kropp, blek eller svartblå hy, stora och hårda magar, förstoppning och til slut vattensot, som ändar eländet.« At dette brødet svekket folks motstands-

[1]) At man også i Norden har brukt den metode å blande furubarkmel i en syret deig av kornmel for å spare på det siste (jfr. MANNINENS uttalelse om anvendelse av barkemel hos syrjenene i Russland, citert ovenfor), ses av RETZIUS' bok (p. 519).

kraft og gjorde dem til et lett bytte for alskens epidemier, særlig dysenteri, kan ikke være tvilsomt. KEYLAND anser likevel RETZIUS' karakteristikk for å være overdrevent pessimistisk. I det 18. århundre fikk barkebrødet direkte skylden for dysenteri, og etter hva ernæringsfysiologen, professor RAGNAR NICOLAYSEN, Oslo, har fortalt meg, eksisterer det en slags hunger-dysenteri som ikke er bakteriell, men iallfall delvis en avitaminose (vitaminmangel). At imidlertid furubarkmel inneholder en del C-vitamin, og i noen grad forhindrer skjørbuk, ble påvist av dr. JOHAN URBYE i 1937.

En sjelden gang får barkebrødet ros. En dansk hærfører skal i begynnelsen av 1500-tallet ha sagt om de seirrike dalkarlar: »Fanden maa stride med et Folk som æder Bark og drikker Vand!« (citert hos KEYLAND etter en kilde fra 1843). Dette må helst tas som en kompliment til dalkarlarna og ikke til brødet.

La oss høre hva en høy norsk militær 200 år senere har å si om barkebrødet: I 1742 skriver major DE SEUE i et et brev, datert Vestby i Smålenene 24. april, til generalmajor HUITFELDT på Elingård, at han, DE SEUE, har over 22 mann i sitt kompani som er så medtatt av sult at de ikke er istand til å utføre noe som helst militærarbeid. Noen forteller at de har spist barkebrød og drukket vann til i over 2 måneder. Rett som det var, hendte det at soldatene falt sammen under eksersisen (disse opplysninger har jeg fra en artikkel »Hardår i gamle dager« av CARSTEN BØRGE, trykt i »Arbeiderbladet« i Oslo den 17. november 1934).

Når GERHARD SCHØNING i 1770-årene fra Trøndelag skriver at for folk i Selbu er brød av furubark en delikatesse, så har jeg vanskelig for å tro ham. Men av ECKBLADS utredning (se ovenfor) kan man trekke den slutning at hvis folk ikke la tilstrekkelig arbeid på barkens rensning, ville melet bli rikt på korkceller (og eventuelt harpiksholdige fragment); at det brødet som da ble bakt, var usundt, synes opplagt. Men der har tydeligvis vært kvalitetsforskjell, og jo mer avkreftet folk var i nødsår, desto mindre arbeid la de vel på barkens rensning. — Atskillige forfattere, både finske og norske, hevder at folk i det 18. og 19. århundre fortsatte med å bruke barkemel i brødet selv i gode år for å holde magen så å si i trening, og dette var vel i og for seg klokt. Forstandige folk hadde også alltid et lager av finstampet bark eller av barkemel stående på stabburet forat ikke nøden skulle komme brått over dem. — Av både norske og svenske kilder fremgår det at barkemel i ikke liten utstrekning også har vært brukt til grøt og velling.

Jeg skal ikke her forsøke å mane fram hungersnødens spøkelse. Jeg vil bare nevne at en rekke forfattere fra slutten av 1700-tallet og begynnelsen av 1800-tallet uttaler at i innlandsbygdene var nøden synlig på lang avstand: skogen var i en miserabel forfatning; det lå tett i tett med hvite, avbarkede furutrær på marken, ofte så tett at det var vanskelig å komme fram. Og hesjer med furubark var alltid et forvarsel om at kom man til en gård eller husmannsplass, ville man treffe utmagrede mennesker i den bitreste nød, og oftest sykdom og død. MAXIMILIAN AXELSONS skildring fra Värmland og Finnskogene ca. 1850 og MANNINENS opptegnelser fra Ilomantsi 1919 er sikkert ikke overdrevne.

IV. Almebarkens fordeler som melsurrogat i forhold til furubark.

I Norge er visstnok PEDER CLAUSSØN FRIIS (1545—1614) den første som uttrykkelig nevner almen (*Ulmus glabra*) i samband med barkebrød. Han skriver, som før nevnt, at i årene 1596—97 og 1598 ble almebark brukt både av fattig og rik som nødhjelp for korn på »Agdesiden«. Fra 1631 og fremover til nødsårene 1812—13 har vi i norsk litteratur en lang rekke opplysninger om uår, barkebrød og alm. I 1762 skriver således presten HERMAN RUGE i en avhandling om skogplantning: »Naar Nøden driver Menneskene til at spise Barkbrød, vil jeg mindst ynke dem som have Barkmel af Alm til Brød.« Og samme år står det i »Svensk Hushålls-magazin« at almebark var så alminnelig brukt som erstatning for korn i Båhuslen at det nå (1762) bare finnes få almetrær tilbake. Ellers har vi en mengde direkte og indirekte vitnesbyrd om almebarkens fortreffelighet sammenlignet med furubarkens. Naturlig nok skriver de fleste av disse beretninger seg fra nødsårene 1812—13. Jeg skal her nevne noen eksempler av litt forskjellig art.

Fra utskiftningsformann TORLEIF P. P. SPILLING, Kristiansand, har Botanisk Museum mottatt et brev, datert desember 1932. Han skriver her: »Det er ikke helt ualminnelig her på Sørlandet at den såkalte »basteskog« (alm og lind) fra gammelt ligger i fellesskap til samtlige bruk i ett og samme gårdsnummer. — — — Hva almen angår, har jeg oppfattet forholdet som et uttrykk for treets gamle betydning for folkenæringen i vanskelige tider. Den gamle betydning av alme- og basteskog er nå en saga blot. Under utskiftningsforretninger oppheves alltid dette fellesskap, idet skoggrunneieren fremtidig blir eneeier av all skog og skoggrunn innen sitt område. — I de senere år har der i min praksis kun forekommet ytterst få tilfelle av ovennevnte art (almetreet). Fra omrking 1909: Langerak i Bygland herred. Fra iår, 1932, Feland i Spangereid herred. På sistnevnte sted eier gårdens 2 oppsittere 4 stykker almetrær felles og stående i det ene bruks skoggrunnsstrekning.«

Jeg gjør nå et sprang til Osterøya i Haus, nord for Bergen. I et brev som professor J. M. THUNÆS ved Norges Landbrukshøyskole skrev til vaktmester OLAF HANSSEN i desember 1932, står: »På gården Vikne, beliggende ved sjøen på vestsiden av Osterøya i Haus i Hordaland, fortalte en gammel mann meg for omtrent 20 år siden at der på et av Viknebrukene stod et almetre som tilhørte et bruk på gården Nordre Veset,

Fig. 4. Parti av den bekjente »almeskog« (*Ulmus glabra*) ved Ytre Kroken, Hafslo i Sogn. Sogneprest SØREN FRIIS skriver i sin beskrivelse fra 1816 at almeskogen »bruges af Eyerne fornemmelig til Foder for Creaturene, som og mange fattige faae Tilladelse deraf at tage Brød-Surrogat« (Manuskr. Norske Riksarkiv, publisert av statsarkivar J. J. S. FRIIS). Gouache av JOH. FLINTOE 1816. Trestammene viser tydelige spor etter generasjoners bruk. I forgrunnen til høyre *Aconitum septentrionale*. Almeskogen eksisterer fremdeles.

Fig. 5. Gammel alm, kalt »Synneva-almen«, Folkedal, Hardanger. Står i en fjellkløft og er bare tilgjengelig ovenfra (man må heise seg ned i et langt tau). Bærer spor etter langvarig bruk. Er trolig identisk med det av TH. S. HAUKENÆS omtalte tre (1885). Foto lektor J. HAUKANES 1930.

som ligger over $^1/_2$ mils vei derfra, inne på øya i ca. 300 m.s høyde over havet. Her har vi altså en levning fra en ordning til hjelp i nødsår (gården Vikne ble offentlig utskiftet i 1922, men bruksretten ble vel da glemt). Et av brukene heter *Ålmane*« (= almene, bestemt form pluralis av alm).

Ellers fremgår det av HOLMBOE's notater fra norsk topografisk litteratur at almen iallfall lokalt er blitt helt eller delvis utryddet i visse strøk som følge av voldsom pågang i nødsår. Dette gjelder særlig Østlandets store dalfører og Trøndelag. Jeg selv har i årenes løp botanisert meget i Mjøstraktene og Gudbrandsdalen, og det har slått meg hvor sparsomt almen opptrer her, i betraktning av at den har sin nordgrense på Østlandet nær Otta stasjon og i Jutulhugget ved Barkald i Nordre Østerdalen. Fra Sylling, Spydeberg, Jevnaker, Ringebu og mange andre steder østenfjells, og fra Selbu og flere steder i Trøndelag, har vi autentiske opplysninger om tilbakegang eller utryddelse av alm fra slutten av 1700-tallet og fram til 1812—1813. —Fra Sunnfjord finnes en opplysning om at i 1812 ble 1 våg almebark betalt med 3 ort og 12 skilling.

Et interessant avsnitt om almen finner vi i MARCUS SCHNABEL's »Udkast til Beskrivelse over Hardanger« 1781 (jeg holder meg her til Olafsens utgave av 1912): »Almetrærne, som i Hardanger er almindelige, holdes av Bønderne i stor Ære og blir av en del plantet« (også fra Håvin i Telemark og flere andre steder har vi sikre opplysninger om plantning av almetrær nær husene på gårdsbruk). »Hvilken Pris man her sætter paa de gamle, ved Gaarden staaende Almetrær — som ofte har været kollede og ofte er hule indeni, men dog endnu har Frodighed nok til at sætte nye Grene — kan sluttes deraf, at da der paa Gaarden Bagne i juni 1724 blev holdt Stevnings-Forretning, blev i samme Akkord indført at en *Alm-Stuv*, der stod paa den Manden tildelte Gaard, og som utgjorde Halvdelen af den hele Gaard, skulde være delt til Brug i 4 Parter ligesom hele Jorden, og *han* have den halve Del, men de øvrige hver en Fjerdedel.« Av Botanisk Museums arkiv fremgår at der i Norge finnes bevaret et ganske stort antall almetræer som ifølge tradisjonen ble flekket i nødsårene omkring 1812.

I en bok av TH. S. HAUKENÆS fra 1885 om »Natur, Folkeliv og Folketro i Hardanger« fortelles det om en mann som skulle gifte bort sin søster, og gjerne ville gi henne en skikkelig gave. Han valgte å forære henne en prektig alm, som imidlertid sto i en avsides liggende fjellkløft; ja, treet var bare tilgjengelig ovenifra hvis man heiste seg ned i et 30—40 favner langt reip. I fortellingen heter det at gaven ble mottatt med stor glede og takk, og at den siden ble »flittig brukt.« Det er mulig at dette treet ennå eksisterer (se fig. 5 med forklaring).

I motsetning til furu-, gran- og bjørkebark inneholder almebarken ikke harpiks, og i motsetning til f. eks. eike-bark, som er voldsomt rik på garvesyre og ubrukelig til mat, inneholder almebark beskjedne mengder garvesyre, og smaker derfor bare svakt sammensnerpende. Den anbefales ikke til garving. Til dette kommer at innerbarken av alm foruten stivelse og eggehvitestoffer også inneholder planteslim. Vi er her ved et viktig punkt: en av de største vanskeligheter ved baking av nødbrød, er å få deigen til å henge sammen, slik at den kan kjevles ut. Furubarken inneholder praktisk talt ikke noe klebestoff. Hos våre kornslag er det eggehvitestoffer i det modne frøs ytre lag som gir melet glúten (klebestoff), og allerbest i denne henseende er hvete, dernest rug.

[Å skaffe klebestoff til deig av furubarkmel i nødsår har uten tvil vært et stort problem for kvinnene. Av Botanisk Museums arkiv fremgår det at man har kokt en grøt av syreblad (*Rumex acetosa*) og blandet med furubarkmel. Meget interessant er en opplysning fra Folla i Nord-Trønde-

Fig. 6. Velbrukte almetrær (»Nestås-almane«) i et stygt elvegjel på Haukanes, Hardanger. Foto lektor J. HAUKANES 1930.

lag om at folk kokte uttrekk av en urt »fjellbue« og satte til deigen; denne urten skal inneholde et limaktig stoff. En prøve i arkivet viser *Gnaphalium norvegicum* (*bue* er i Nord-Norge *Artemisia vulgaris*; *fjellbue* har lodne blad og små kurver som en *Artemisia*, og den har vel fått dette navnet av denne grunn og fordi den i motsetning til den nevnte *Artemisia* opptrer til fjells). Også den lyse, indre delen av turt-stengler (*Mulgedium alpinum*) og røttene og rotstokkene av geiterams (*Chamaenerium angustifolium*) har været kokt, og vesken brukt som tilsetning til furubark-mel ved brødfremstilling.]

Barken av visstnok alle de 15 forskjellige alme-arter som i vår tid finnes på kloden, inneholder eiendommelige celler med slim i celleveggene. Setter man vann til pulverisert innerbark av alm, omdanner denne seg i løpet av kort tid til en limaktig, sleip masse. Allermest fremtredende er dette hos den nordamerikanske art *Ulmus fulva*, som kalles »slippery elm«. Dens pulveriserte bark anvendes i farmasien og har et ganske stort indikasjonsområde i amerikansk og europeisk medisin.

Av de europeiske alme-arter er barken av *Ulmus carpinifolia* (= *U. campestris*), en sydlandsk art som ikke finnes i Norge, overordentlig slimrik, og den har helt siden den klassiske oldtid vært brukt til medisin bl. a. fordi den også virker adstringerende f. eks. på sår (se siste avsnitt). Den har også like til vår tid funnet anvendelse som slimdroge i europeisk farmasi, men er nå utkonkurrert av *Ulmus fulva*.

I virkeligheten er den i Norge viltvoksende alm, *Ulmus glabra*, den av de europeiske arter som har den slimfattigste bark; men ikke desto mindre er den alle andre nordiske trær overlegen når det gjelder fremstilling av barkebrød. Til alle årstider kan man lett overbevise seg om *Ulmus glabra*-barkens slimrikdom: man flekker barken av unge skudd og legger strimlene i lunkent vann i 24 timer. Lar man vannet bare dekke strimlene i vedkommende kar, vil det anta en limaktig konsistens. Slimet har en særmerkt, men ikke sterk lukt, som minner noe om duften fra et ølfat.

Et av de strøk i Norge som har, og har hatt, særlig meget alm, er Nedre Romsdal og Eikisdalen. I en rekke kilder fortelles det at folk fra Øvre Gudbrandsdalen (Lom, Dovre og Lesja) dro til Romsdalen i nødsår for å kjøpe eller bytte til seg almebark. Og fra Rogaland i sør til Møre i nord finnes det beretninger om at fiskerbefolkningen fra de ytre kystdistrikter i nødsår har søkt inn i fjordene med sin beste fisk, særlig laks, for å bytte til seg almebark. — Særlig Eikisdalen er i denne sammenheng interessant. Overgartner SØREN STEINSVOLL i Botanisk Hage på Tøyen forteller at folk i nabobygdene kalte Eikisdalen »Almebrød-Kanaan«. En utmerket mann i Eikisdalen, som jeg selv kjenner, TROND UTIGARD, forteller følgende: På forsommeren da almen slapp barken godt, tok folk hjem den barken de ville ha til folkemat. De tok da de frodigste, unge, 2—3 år gamle kvistene og renningene, hugget dem av, og flådde løs barken. Så fjernet de med kniv den gråbrune ytre hinnen på yttersiden av barkstrimlene; den måtte vekk, ellers ble »mjølet ikkje etande«. Så hakket de disse renskrapte strimlene så små som de kunne[1]), og la det hele utover et gulv hvor solen slapp til; der lå småbitene til de var knastørre. (Råmaterialet kunne selvsagt også tørkes på badstue). Så fylte de materialet i sekker og fraktet til kvernen, og malte det idet de tok bort »skaketeinen« og sto foran melkisten og karet materialet med hendene ned i kvernøyet. Så hadde de »almemjøl«. En prøve fra SCHÜBELERS samling viser at fargen er rødgul. Folk blandet dette med bygg- eller havremel eller blandkornmel; men i dårlige år var det alltid lettkornmel som ble brukt sammen med almemel til flatbrød, sier Utigard.

[1]) gjerne med et eget redskap, ofte et gammelt ljåblad på et hakkebrett med en arreteringsmekanisme i form av en kroket treplugg (Bot. Museums samling, se fig. 8).

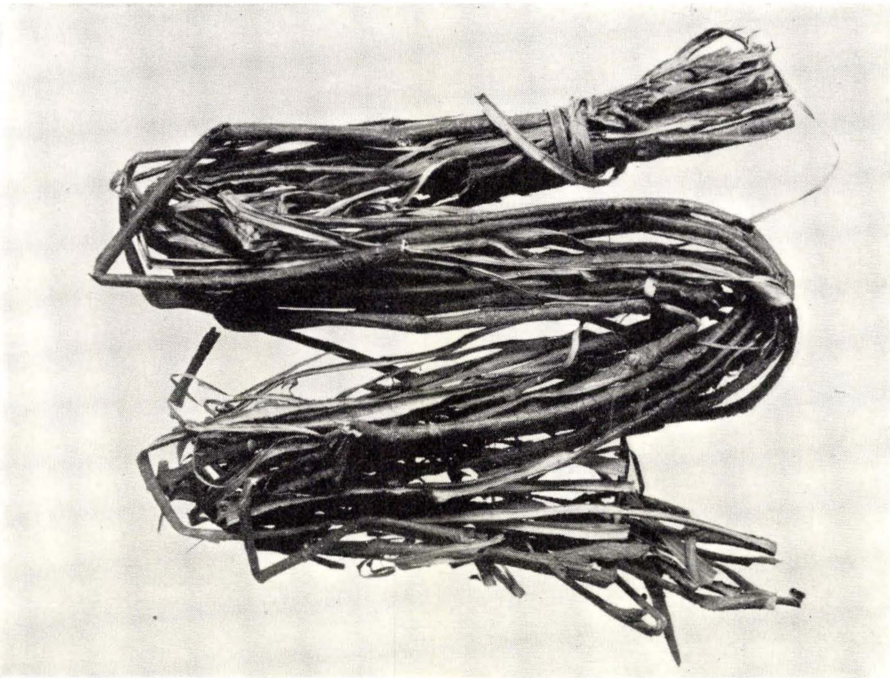


Fig. 7. Knippe av almebark-strimler (råvare), beregnet på fremstilling av almemel. På disse strimler er ennå ikke korklaget og den klorofyllholdige primærbark fjernet. Innsendt fra Eikisdalen, Møre og Romsdal fylke, av TROND UTIGARD 1933. Botanisk Museums samlinger, Oslo.

På Vestlandet har tørkingen av almebarkstrimlene budt på visse vanskeligheter grunnet den store nedbør og luftfuktighet, iallfall i de ytre fjordstrøk. Av Botanisk Museums arkiv kan man se at en mann i Tafjord, nordligst på Sunnmøre, har sendt museet en merkelig kiste eller et kar, laget av en eneste, grov furustamme ved uthuling. Kisten, som i vedkommende dialekt kalles *brydja*, skal ifølge tradisjonen ha vært brukt ute i marken i nødsår ved barkflekking av alm. Barkstrimlene ble lagt oppi denne *brydja* sammen med opphetede steiner, og det hele dekket til med et låkk og et klede. Barken skulle da bli særlig god (utvilsomt fordi alt slimstoffet ved denne fremgangsmåte ble reddet fra utvaskning og forurensning i regnvær). Sannsynligheten taler for at denne sjeldne og sikkert meget gamle gjenstand er havnet på Norsk Folkemuseum.

Amanuensis FINN-EGIL ECKBLAD har foretatt en nærmere undersøkelse av to alm-preparater som finnes i professor SCHÜBELERS etterlatte samling på Botanisk Museum i Oslo. Begge er fra Ullensvang i Hardanger, men ikke påført noe årstall. Det ene viser 3 almebarkremser,

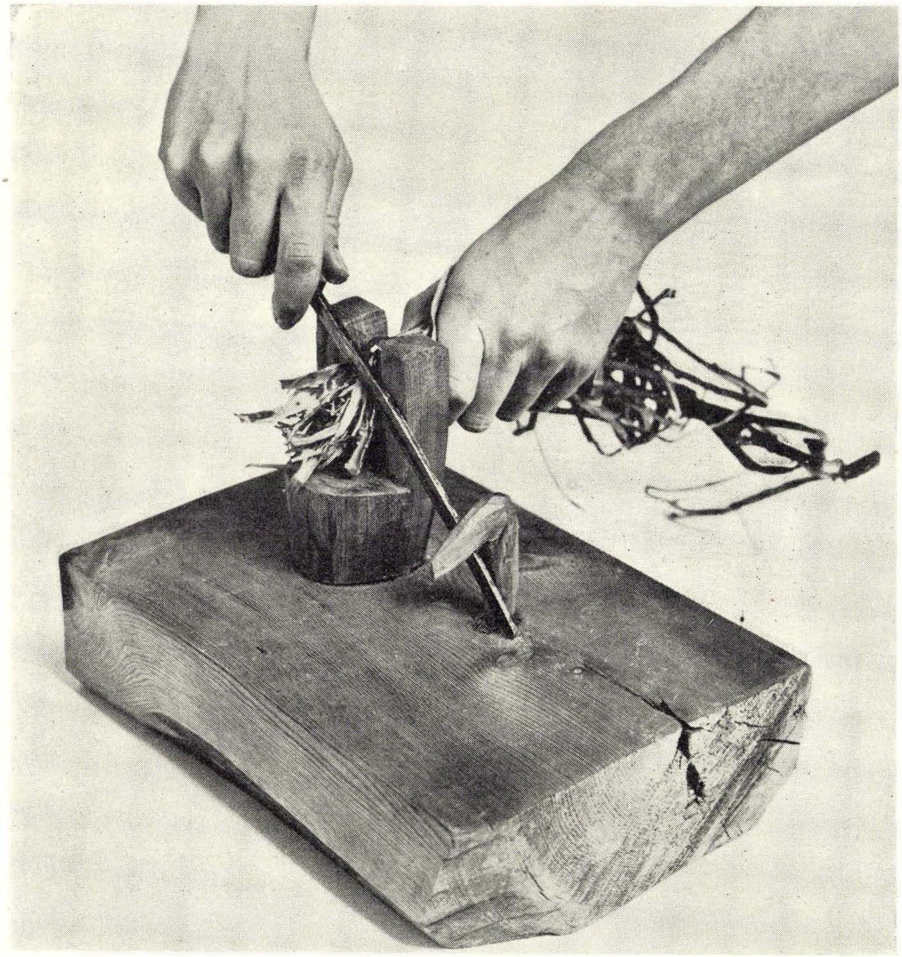


Fig. 8. Enkelt apparat til å kutte opp almebarkstrimler i småbiter før tørkingen. Skjærekniven er et utslitt ljåblad. (Barkstrimlene på bildet er ennå ikke befridd for kork; dette ble gjort ved skraping med kniv). Laget etter erindringen av TROND UTIGARD, Eikisdalen, Møre og Romsdal fylke, 1933. Botanisk Museums samlinger, Oslo.

som ved inntørring har rullet seg sammen på tvers av lengderetningen. De er flekket av almekvister eller renninger som knapt kan ha vært mer enn 3 år gamle, og de bekrefter riktigheten av TROND UTIGARDS opplysninger fra Eikisdalen. Den andre prøven er av almebarkmel. Den viser tydelig tendens til å flokke seg sammen i løse baller, og dette skyldes ifølge ECKBLAD de lange seigbastfibrene, som lett filtrer seg inn i hverandre. Personlig har jeg fått det inntrykk at denne melprøven ikke er helt typisk, men snarest er en rest som er blitt stående igjen etter at den mer verdifulle, pulveraktige del av melet er blitt frasiktet. ECKBLAD uttaler: »Bortsett fra bastfibrene finnes der åpenbart en del silparenkym, margstråleparenkym og silrør. I preparatet er imidlertid disse elementer ikke lette å bli klok på. Dessuten forekommer noen store slimholdige celler (jfr. E. RAMSTAD 1940), noe som er særlig karakteristisk for alm. Imidlertid er de av TROND UTIGARD innsendte barkstrimler fra Eikisdalen viktige; jeg har også etterprøvd disse på friske, unge almekvister i mars 1954. Både makroskopisk og mikroskopisk er det lett å se at barken ved snitting med kniv og avrivning med hånden spaltes løs i skillet mellom siste og nest siste års sildel. Når en så etterpå vil fjerne barkens mørke ytre lag fra det lyse indre ved skraping med kniv, skjer den nye spaltning i skillet mellom primær og sekundær bark. Noen biter av den primære bark blir ofte sittende igjen på den sekundære; men disse fjernes vel ved etterbehandlingen. Det som nyttes til almebarkmel, er altså praktisk talt hele den sekundære bark; denne inneholder nøyaktig de samme elementer som melprøven fra Ullensvang. Karakteristisk for denne er at den ikke viser det ringeste spor av hverken kork- eller vedelementer. Selv om den foreliggende prøve kanskje ikke er helt representativ — den virker noe »mager« — er det ikke tvil om at barkemel av alm ble laget av den sekundære bark. Angående næringsmengden, så bør dette spørsmål overlates en kjemiker. Det eneste jeg har kunnet fastslå ved de enkle midler som står til min disposisjon, er et visst innhold av stivelse i parenkymvevene. Stivelseskornene er ganske små, og den totale mengde av stivelse synes å være langt mindre enn i de undersøkte preparater av furu fra Finnskogene.« —

Med hensyn til de slimholdige celler uttaler RAMSTAD (1940) at de hos *Ulmus glabra* (R. bruker navnet *U. montana*) fortrinsvis finnes i den primære bark; de opptrer også hist og her i den sekundære bark, men bare i de først dannede lag. Etter hvert som tykkelsestilveksten skrider fram, opphører dannelsen av slimførende celler fullstendig, i motsetning til forholdet hos *Ulmus carpinifolia* (av RAMSTAD kalt *U. campestris*). Disse av RAMSTAD beskrevne forhold gir oss en naturlig forklaring på den av TROND UTIGARD omtalte sedvane, nemlig at bare barken av 2—3 år gamle almegrener og skudd ble brukt til barkemel. Folk i norske bygder må utvilsomt meget tidlig ha oppdaget at bare ung almebark gir mel og deig med klebestoff. Ellers tyder enkelte opplysninger som finnes i Bot. Museums arkiv, på at folk i ekstreme nødsår også har flekket bark av selve almestammene; men dette har trolig vært gjort i desperasjon, og av ukyndige folk.

For om mulig å skaffe sikre opplysninger om almeslimets kjemiske sammensetning, henvendte jeg meg i 1953 til mine kolleger ved Farmasøytisk Institutt, Universitetet i Oslo. Sannsynligheten talte for at man hos vår hjemlige alm ville finne lignende kulhydrater som de av GILL, HIRST, JONES og HOUGH påviste d-galacturonsyre, d-galactose, 3-methyl-d-galactose og l-rhamnose i barkslimet av den amerikanske *Ulmus fulva*

(1939; 1946; 1951). Etter oppfordring fra professor A. NORDAL tok cand. pharm. fru DAGRUN ØISETH fatt på oppgaven. Som råmateriale ble benyttet barken fra unge grener og kvister av *Ulmus glabra*, innsamlet fra viltvoksende trær på Tørtberg i Stor-Oslo. Fru ØISETH har godhetsfullt stilt et resymé av sine undersøkelser til disposisjon for denne avhandling:

»Barken viste seg å inneholde slimceller både i primær- og sekundærbarken, minst i den siste. Slimet ble isolert av et vandig uttrekk ved felling med alkohol. Fellingen var hvit, »pussegarnlignende«, og utgjorde etter tørring 2 % av den friske bark (denne var på forhånd befridd for kork). Som nedenstående tabell viser, fikk jeg nøyaktig kvalitativ overensstemmelse i forhold til de hydrolyseprodukter som HIRST, JONES & HOUGH har påvist hos *Ulmus fulva*. Jeg var spesielt interessert i å undersøke om 3-methylgalactose også fantes blant hydrolyseproduktene fra *U. glabra*, og det lyktes meg ganske riktig å påvise en mono-methylgalactose som oppførte seg papirkromatografisk overensstemmende med 3-methylgalactose fra *U. fulva*. — Uoverensstemmelsen i tabellen for de siste tre komponenter behøver ikke å bety at sammensetningen er forskjellig, idet så meget her kan spille inn. Planteslim er en vanskelig stoffgruppe å arbeide med, bl. a. fordi man ikke ved vanlige metoder kan avgjøre hvor vidt slimet er rent eller består av flere komponenter. — Ved den kvantitative undersøkelse anvendte jeg samme metodikk som HIRST & al. Mine resultater avviker ikke meget fra det som er funnet for *U. fulva*.

Ekvivalentvektene, som gir uttrykk for uronsyreinnholdet, er av samme størrelsesorden (med den metode vi har til rådighet, kan vi ikke gjøre regning med større nøyaktighet enn $\pm 20\,\%$).

3—Methylgalactose-innholdet stemmer overens ifølge methoxylbestemmelsen. Avvikelsen som fåes etter den annen metode, legger jeg mindre vekt på, idet en methoxylbestemmelse i dette tilfelle nok gir et sikrere uttrykk for innholdet av methoxylsukker.

Rhamnose-innholdet avviker betydelig, og av den grunn kan jeg ikke trekke den konklusjon at slimene er identiske. På den annen side kan den lave verdi jeg har fått, skyldes at hydrolysen ikke er ført så langt som for *Ulmus fulva's* vedkommende, tross samme behandlingsmåte. Rhamnosen er nemlig meget fast bundet i slimmolekylet.

Etter en rask undersøkelse i tilgjengelig litteratur angående spørsmålet om organismen kan nyttiggjøre seg et slikt slim, har jeg bare funnet følgende (i referat fra E. RAMSTADS forelesninger): »De fleste mucilaginosa er fordøyelige, og er da på produksjonsstedet mer eller mindre i bruk som næringsmidler (Gummi Arabicum, Salep, Agar, Carrageen).«

Ifølge RAMSTAD (1940) inneholder barkparenkymet hos *Ulmus glabra* foruten stivelse også en stor mengde oljedråper. Legger vi nå sammen hva vi idag vet om almebarkens kjemi, så ser vi at den inneholder

Sammenligning mellem hydrolysert slim fra *Ulmus glabra* og *Ulmus fulva*.

1: Egne undersøkelser.
2: Undersøkelser utført av Hirst, Hough og Jones; J. chem. Soc., 1951 p. 323—25.

	Kvalitativ bestemmelse			Kvantitativ bestemmelse					
	Papirkromatografi		Papirkrom. samt isolering	Papirkromatografi, perjodsyreoksydasjon		(Mikro-Zeisel) Methoxylbest.		Ekvivalentvekt (titr. m. alkali)	
	1.		2.	1.	2.	1.	2.	1.	2.
	U. glabra	U. fulva	U. fulva	U. glabra	U. fulva	U. glabra	U. fulva	U. glabra	U. fulva
Galacturonsyre	+	+	+					402, tilsv. 43.8% uronsyre	452, tilsv. 38.9% uronsyre
Galactose	+	+	+	22.4%	21.6%				
3-Methylgalactose	+	+	+	16.8%	26.8%	3.2%—OCH_3 tilsv. 18.2% 3M-g	3.3%—OCH_3 tilsv. 18.7% 3M-g.		
Rhamnose	+	+	+	16.1%	25.2%				
(Arabinose?)	(spor)	(spor)							
(Fukose?)			(spor)						
(Glukose?)			(spor)						
To ikke identifiserte stoffer	(spor)	(spor)							

(1.) stivelse; (2.) planteslim, som ved hydrolyse leverer fordøyelige kulhydrater; (3.) fet olje, og (4.) eggehvitestoffer (disse må finnes i silrørene). Innerbarken av *Ulmus glabra* må følgelig være et ganske høyverdig næringsmiddel. Til dette kommer, som en vesentlig fordel i forhold til f. eks. furubarkmel, det allerede ovenfor nevnte forhold at almemel ved tilsetning av vann gir en deig som takket være slimet er seig og kan kjevles ut. Dette forhold gjør også at almebarkmel er meget verdifullt som tilsetning til lettkornmel, agnemel, halmmel, furubarkmel og andre surrogater som har lite eller overhodet ikke noe klebestoff i seg. Endelig har almebark det store fortrin fremfor furubark at den ikke trenger å vaskes ut, ja en utvaskning (utvanning) vil føre til at de verdifulle slimkomponentene går tapt.

Av kildene fremgår det at almeflatbrødet hadde en noe besk og sammensnerpende smak, men det roses som langt bedre og sundere enn alle andre slags nødbrød. En prøve som TROND UTIGARD selv har bakt etter gammel oppskrift (50 % byggmel og 50 % almemel) og skjenket Botanisk Museum i Oslo, har en mild smak. På tungen og ganen virker det omtrent som havreflatbrød. Fargen er imidlertid mørkere. Jeg har prøvd å bestemme fargen etter MAERZ & PAUL: A Dictionary of Color (1950), og er blitt stående ved plate 13, 7, A—D (French Beige — Oakbuff). I dette tilfelle er almemel også brukt som »breidemjøl« under bakingen.

I de deler av vårt land der almen er eller har vært viltvoksende, har den vært mat-reserven. Og da det er de 2—3 år gamle grenene eller renningene som gir det beste melet, har folk direkte hatt fordel av å beskjære almen (fig. 5 og 6), eller som det heter i norske dialekter: å *styva, kolla, kylla* eller *pila*. Det siste, *pila*, brukes meget på Nordmøre. Dette verbet betyr egentlig »plukke av, skrelle« og svarer til engelsk *to peel*. Ifølge ALF TORP (1919) dreier det seg om et gammelt lånord, latin *pilare*. I Sunndalen og Todalen heter en kappet alm en *almpil*.

Selv om folk i Norge i vår tid ikke lenger bruker almebark til mel, griper bondekvinnene særlig på Vestlandet av og til fremdeles til almebarken, nemlig for å få f. eks. byggmel eller havremel av ringe kvalitet til å henge sammen når de skal bake flatbrød. Meget av det kornet som berges i norske bygder også i vår tid, er i enkelte år mer eller mindre frostskadet eller dårlig »matet«, og det har ringe bakeevne. Over store deler av vårt land har bondekvinnene brukt følgende fremgangsmåte: barkstrimler av alm blir lagt i lunkent vann et eller et par døgn; de skiller da ut en masse slim, og denne vesken blir brukt til å kna deigen i. Almen gir *seiga* eller *seige*, som det heter. I Indre Sogn (Vassbygdi i Aurland) kjenner jeg folk som like til for få år siden har brukt alm på denne måten (jfr. også VE op. cit. p. 77). Allerede MARCUS SCHNABEL forteller at en slik barkstrimmel kalles *seiglengje* i Hardanger. Også i Sverige har almen vært brukt på samme måte (RETZIUS 1806 p. 746).

Jeg mener at i lys av de mange autentiske beretninger om bruk av almebark til menneskemat som foreligger fra Russland og Polen, fra China og andre deler av Asia, og de holdepunkter vi har også i Frankrike (se ovenfor), kan bruken av almebark til mel ikke være noen spesifikt norsk eller nordgermansk oppfinnelse. Jeg er overbevist om at vi her står overfor noe uhyre gammelt, en ærverdig kulturarv. Interessant nok er Norge det land i Norden som lengst har holdt på denne arv.

V. Andre eksempler på bruk av alm i dagliglivet under naturalhusholdning.

Det slimete, litt søte uttrekket eller utkoket som ung almebark gir med vann, har overalt i Norge, iallfall i gammel tid, vært brukt som drikke til å fete kalver med. Ifølge HANS ROSS (1895) kalles det *almekvamp* eller i visse sørnorske dialekter *åmekvamp*; om selve tillagningen brukes verbet å *kvampa*. Andre navn er *almelog*, *ålmelog*. Fra Seljord i Telemark omtales dette fôrmidlet av H. J. WILLE 1786 under navnet *Alme-Qværv*. De eldste opplysninger har jeg funnet i CHRISTEN JENSON's bekjente bok »Den norske Dictionarium eller Glosebog« fra år 1646. Han var prest i Sunnfjord på Vestlandet. Under *a* leser vi: »*Alm:* er it slags Træ / huis grene gifuis Fæ om Vinteren / oc er saa gaat som Høe / men Barcken aftagen gifuet smaa Kalfue. Oc skal den Barck tagis aff huer andet Aars *Alme* / eller 3die Aars *Alm*; er det eldre / tiener det icke. Kaldis ellers *Kalffue Korg* / som kneptis sive persis i Vand til Kalffue; och gifuis dem at Dricke« (p. 4). Ordet *korg* eller *korge* i norske dialekter brukes mest om »bunnfall, berme«. Verbet *å knepte* betyr »å kryste, knuge, trykke sammen« (AASEN 1873). — Sannsynligheten taler for at dette fetningsmidlet fremdeles er i bruk i Norge. I lys av RAMSTADS resultater (1940) med hensyn til slimcellenes forekomst i barken, er Jensøns angivelse (2—3 år gamle skudd) interessant.

Mange steder har almebarken vært, og er fremdeles, et slags nytelsesmiddel. Ungdomen skjærer biter av den og tygger i sevjetiden om våren. Flere af mine kolleger ved Universitetet i Oslo kjenner denne bruk fra Vestlandet. Men den er også kjent fra Northumberland og strøket mellom Durham og Berwick i Storbritannia: her kalles alm av barn og ungdom for *chew-bark* (BRITTEN & HOLLAND 1878). Ellers har det hittil ikke lykkes meg å finne angivelser om bruk av bark som melsurrogat i britisk litteratur. Hverken FUSSELL (1949) eller ASHLEY (1928) nevner barkebrød.

Almens blad og kvister (løv) og bark regnes over hele Norge for å være et førsteklasses husdyrfôr. De fleste kjenner det norske ordtaket »rogn føder, men alm gjøder«, som iallfall er kjent fra 1760-årene[1]), men sikkert er meget gammelt. I Norge har almen vært »høstet« på to forskjellige måter. Om sommeren ble den »lauvet«, det vil si at de unge kvistene med påsittende grønne blad ble skåret av med lauvkniv (*snidil*), og etterpå buntet sammen til *kjerv*, som ble stablet opp eller hengt opp i det fri til tørk. Fra Hardanger anfører ALV AKSNES (manuskript, Bot. Museum, 1951) *lauving*, *kjerving*, *logging* (av *lauvging*), *alming* som vanlige appellativer. *Alming* brukes likevel bare på enkelte steder der det vokser særlig meget alm. Ellers er vel *lauving* og *lauvtaking* de vanligste betegnelser.

Imidlertid ble (og blir fremdeles) almen i likhet med mange andre løvtrær også høstet på ettervinteren og i sevjetiden om våren. I Hardanger kalles dette arbeid *marking*, andre steder i Norge trolig *rising*. Som ved lauving blir stammer og grener hugget med øks; men for almens vedkommende lager man så *ris* n. eller *beit* f. (også *sveig*, *sveigja*) på den måten at de årsgamle eller 2—3 år gamle kvistene blir knekket over med hånden i passende lengder og buntet sammen. I Indre Sogn kalles slike bunter for *pjaggar* (VE l. c.); i Hardanger blir materialet ikke buntet sammen. Dette vinter- og vårfôret av alm (*almeris*) brukes nesten bare til kuene, som eter knoppene, barken og de tynneste kvistene. I Hardanger blir dessuten de unge almebladene på forsommeren »strøket« (*stroke*) av renningene og brukt i frisk tilstand som grisefôr. Det samme er tilfelle i Schweiz (BROCKMANN-JEROSCH 1918).

Jeg selv har i ca. 20 år botanisert meget på Vestlandet, særlig i Sogn og Fjordane, men også i Møre og Romsdal fylke, og jeg har ennå ikke sett et almetre, det være seg nær bebyggelse eller i utmark, som ikke har båret eldre eller yngre spor etter lauving og rising (se fig. 4—6). Jeg har også hørt at hjorten skal være særlig begjærlig etter almebark, noe som allerede omtales av RETZIUS fra Sverige (1806 p. 746).

Det er ingen overdrivelse å si at almen i Norge har vært et slags »kulturtre«. Den har også mange steder vært plantet ved hus og på innmark, og den har vært behandlet og beskåret på en spesielt omhyggelig måte. I visse deler av Norge har folk ansett det for å være galt eller farlig å felle almetrær og bruke trevirket f. eks. til ski. Herredsskogmester EINAR STOLTENBERG, Fyresdal, har gjort meg bekjent med slike ordtak fra Telemark, Numedal og Eiker som: »*Faen sitter* (*eller står*) *bakpå almeski*«, eller: »*Den som renner seg ihel på almeski, kjem lukt i helvete*« osv.Hvis man spør folk om årsaken til denne tro, svarer de fleste at almeski er så glatte at det ville være farlig (»speelegt«) å renne på dem. Men dette er utvilsomt et påfunn fra nyere tid. (Interessant nok finnes de samme talemåter

[1]) Av biskop Johan Ernst Gunnerus (Flora Norvegica 1766) oversatt til latin således: »*Aucuparia alit, saginat Ulmus*«. I visse strøk av Norge erstattes *rogn* i dette ordtaket av *ask* (STOLTENBERG 1947).

enkelte steder i Norge også om ski laget av rogneved. Men rognen [Sorbus aucuparia] var jo i gammel tid det gjeveste man hadde til *skav* for kreaturene, der hvor ikke alm fantes. Rognen har dessuten vært et trolldomstre, så det er forståelig at der både til alm og rogn har knyttet seg iallfall en mild form for tabu). — På den annen side vet vi at trevirke av alm har vært brukt til fremstilling av buer til å skyte med; i skaldekvad er nemlig *almr* en kjenning for »bue«, og *almþing* en kjenning for »strid«. Hvor vidt det i våre museer, særlig de arkeologiske, er påvist større tresaker av alm, vet jeg ikke. I nyere tid er alm blitt hugget til trevirke for møbelindustrien flere steder i Norge, ja allerede i 1786 skriver H. J. WILLE at alm bl. a. brukes til sledemeier, så tabuen har ikke vært absolutt.

Det er ett punkt med hensyn til almens bruk i Norden som ennå er noe usikkert: i hvilken utstrekning har dens bast vært preparert og brukt til tau og reip? Hittil har mine undersøkelser på dette punkt falt negativt ut (bortsett fra tvilsomme opplysninger, beroende på sammenblanding av alm og lind). Det eneste jeg vet, er at strimler av frisk almebark har vært brukt ute i marken som bæretau f. eks. i Romsdal. RETZIUS (1806), som vier linden og lindebastfremstillingen i Sverige et langt kapitel, har intet å fortelle om almebast som tekstilmateriale. Imidlertid har Norsk Folkemuseum nylig sendt ut et spørreskjema i samband med gammel norsk bastindustri, og dette vil trolig bringe klarhet i saken. F. C. SCHÜBELERS passus om almebast (1886 p. 533) kan ikke godtas, noe allerede HANSSEN og LUNDESTAD har klarlagt (1932). På den annen side fremgår det av botanisk litteratur (jfr. HEGIS Flora Bd. III) at almebast har vært brukt som et, rigtignok mindreverdig, tekstilmateriale i Tyskland, trolig mest til oppbinding (jfr. omtalen av navnene *Wieke*, *Bastwieke* etc. side 300 nedenfor).

I. REICHBORN-KJENNERUD uttaler (1922 p. 47): »Det ser ut til at almebasten hos oss har vært det første forbindingsmateriale for sår og andre ytre skader. På Voss har de ordtaket: »Bitt um bast, i morgo vert det godt att trast« (ɔ: bind om bast, imorgen blir det godt igjen straks) som en levning fra denne tid, og her gjelder det bestemt almebast; men det er sannsynlig at også lindebasten har spilt en lignende rolle (HÖFLER, Oberbayern, 1888 p. 156). At basten ved sårbehandlingen ikke bare har vært ment som forbinding, men også som et vern mot trollskap, viser et annet ordtak, fra Hardanger: »Bast um bein lokkar alle trolli heim.«

Alt i alt torde Norge være det land i Europa der almen like til moderne tid har funnet den mest allsidige bruk under naturalhusholdning. — I Schweiz regnes *Ulmus* for et av de viktigste »Laubfutterbäume«, og i enkelte kantoner plantes alm fremdeles i stor utstrekning ved veier, i enger og nær landsbyer (BROCKMANN-JEROSCH op. cit. p. 145—146). Almeartenes anvendelse i det romerske landbruk vil bli omtalt nedenfor.

VI. Avspeiler pollenkurvene fra forhistorisk tid menneskets utnyttelse av almen?

Ovenfor har jeg så konkret som mulig forsøkt å vise hvilket enestående viktig ernæringsmiddel almebark, almeløv og almekvist har vært for folk og fe i Norge helt fram til våre besteforeldres tid. Av KEYLANDS og RETZIUS bøker fremgår det at almen også i Sverige har vært høyt skattet.

Allting tyder på at bruken av alm til menneskeføde og kreaturfôr går tilbake til forhistorisk tid. Imidlertid har en sterk utnyttelse av almens grensystem (krone) ganske bestemte biologiske følger for almen selv: hvis skuddene høstes med f. eks. bare 2—5 års mellomrom, kommer et almetre overhodet ikke i blomst. Ifølge undersøkelser av SØREN VE (1930 p. 81) trenger almeskuddene 7—8 år for å bli blomstringsdyktige. I Indre Sogn, hvor almen fremdeles brukes i stor udstrekning til kreaturfôr (lauving og rising), finnes almetrær som praktisk talt aldri blomstrer fordi de høstes for ofte, uttaler Ve (jfr. hans bilde fig. 35).

Dette er ensbetydende med følgende: hvis befolkningen i en bygd systematisk tar almen i sin tjeneste på de nevnte måter, vil almens pollen-produksjon automatisk gå tilbake i vedkommende bygd. I 1939, den gang nåværende professor KNUT FÆGRI hadde ferdig sine pollenanalytiske kurver fra Jæren i forhistorisk tid, diskuterte han med meg visse eiendommeligheter ved de edle løvtrærs og særlig almens pollenkurve. Denne viste fluktuasjoner som f. eks. ikke ble fulgt av lindens, som dog er et mer varmekjært treslag (dette ses tydelig av forholdet mellom de to treslags nordgrense og høydegrense i Norge). Jeg gjorde da Fægri oppmerksom på Søren Ve's resultater med hensyn til almens blomstring eller manglende blomstring i Indre Sogn under menneskets innflytelse. Og jeg fremholdt at man under diskusjoner som angår almekurvens forløp, må være oppmerksom på at både lauving og rising av alm til kreaturfôr (noe som sikkert er eldre enn høyslått og høyberging) og barkflekking til menneskeføde automatisk vil fremkalle en nedgang i almepollenkurven. FÆGRI har (1940 p. 122) latt denne tanke komme til uttrykk i sin avhandling. Senere er den for Danmarks vedkommende tatt opp av afdelingsgeolog J. TROELS-SMITH, som for tiden ved et intenst analysearbeid søker å klarlegge almekurvens eventuelle relasjoner til de prehistoriske landnåmsfaser som på annen måte manifesterer seg i danske og mellomeuropeiske pollenspektra. Mer om den ting skal jeg ikke si ved denne anledning, da saken jo er i de beste hender. Dette gjelder også oppsporing av forhistoriske redskaper beregnet på barkflekking.

Jeg anser det ikke for utelukket at den voldsomme pågang på furuskogen som skyldes barkflekking i nødsår, avspeiler seg i furupollenkurvens forløp. Men da der på Den skandinaviske halvøy er — og sikkert alltid har vært — forholdsmessig langt mer furu enn alm, og folk dessuten ikke har nyttet eldre furutrær, vil menneskets innflytelse på furupollenkurven neppe kunne manifestere seg i samme grad som for almens vedkommende. Saken burde etterprøves i torvavleiringer som ligger i nærheten av navngitte steder hvor man av kildene kan se at store mengder av furutrær er blitt felt i én bestemt tidsperiode eller i visse intervaller i løpet av de siste 350—400 år.

VII. Hva betyr trenavnet alm, ëlm, ulmus? Noen iakttagelser over Ulmus carpinifolia i Spania.

Til sist noen ord om trenavnet *alm*, gammelnorsk *almr*. Ifølge Alf Torp (1919) går dette tilbake på et urnordisk **almaʀ*. I svensk heter treet også *alm*, i dansk offisielt *ælm*, men i østdanske dialekter *alm*. Noen mener at dansk *ælm* har fått sin vokal fra et gammelt kollektiv *elmi* n. »almeholt«, som også fantes i g. norsk, og som ennå eksisterer i svenske dialekter som *älme*.

Går vi til vestgermanske språk, finner vi i gammel-høytysk, mellomhøytysk og angelsaksisk *ëlm*, som står i avlydsforhold til g.norsk *almr*. Angelsaksisk hadde dessuten *ulm-tréow*, og mellom-høytysk *ulmboum* (tysk *Ulme*). Enkelte forskere har antatt at disse vestgermanske former med vokalen *u* er influert av latin *ulmus*; men i nyere etymologiske ordbøker betraktes vestgermansk *ulm(e)* som genuint. I germansk finnes altså tre vokaltrin.

Romernes navn på almetrærne var *ulmus*. Fra keltiske språk er kjent det mellom-irske *lem*. (I slaviske språk finner man *ilma, ilm* o. fl. former, men dette er lånord fra tysk, hvor treet i visse dialekter heter *Ilme, Ilmbaum*).

Ifølge Falk og Torp (1910), og Walde-Pokorny's håndbok (1926) hører de nevnte germanske, italiske og keltiske ord for alm nøye sammen:

1) Latin *ulmus* føres tilbake til et indoeuropeisk **l̥-mos*. Samme avlydstrinn (nulltrinnet, svakstadiet) foreligger i mellomirsk *lem*. Sammen med dette stiller Walde-Pokorny gallisk *Lemo-, Limo-* i franske stedsnavn;
2) g.høytysk *ëlmboum*, angelsaksisk *ëlm* (engelsk *elm*) antas å innebære avlydstrinnet **el-*, altså **ĕl-mos*;
3) g.norsk *almr* < **almaʀ* antas å gå tilbake på indoeuropeisk **ol-mos*, det vil si avlydstrinnet **ol-*;
4) m.høytysk *ulmboum* og angelsaksisk *ulm-tréow* antas å innebære avlydstrinnet germansk **ul-* (indoeurop. **l̥-*; se under punkt 1 ovenfor).

Ifølge Walde-Pokorny er alm-navnene bygd over en rot indoeur. *ĕl-*: *ol-*: *l̥-*, som i germansk ga *el-*: *al-*: *ul-*.

Bortsett fra at enkelte forskere antar at navnekretsen kanskje er beslektet med den som utmerker treslaget *or* eller *older*, dansk *el*, svensk *al*, latin *alnus*, noe som er høyst tvilsomt, har jeg ikke kunnet finne noe forsøk til en tydning av *alm*, *ëlm*, *ulmus*, *lem*. Hva sikter navnekretsen til?

Som kjent er betydningen av en rekke av våre vanligste trenavn ukjent. Dette gjelder f. eks. *ask*, *asp*, *lønn*, *eik*, *furu*, *hassel* o. fl. At de en gang, langt tilbake i tiden, må ha hatt en lettfattelig og for samtiden selvinnlysende mening, kan ikke være tvilsomt. Men disse navnene er eldgamle »arveord« i språkene, og det er idag uhyre vanskelig å avsløre hva vi kaller motivet i et slikt arkaisk trenavn. På den annen side er meningen med navnet *bjørk*, *birk*, som har tilsvar i slavo-baltiske språk og i sanskrit, oppklaret: det betyr »det lyse eller skinnende tre« og sikter til noe helt essensielt, nemlig den hvite bjørkeneveren.

Sannsynligheten taler for at grunnmeningen i henholdsvis *ask*, *asp*, *lønn*, *eik*, *furu*, *hassel* og *alm* også har vært ganske enkel, og trolig konkret.

I Europa finnes tre forskjellige arter av alm; av disse har de to (*U. carpinifolia* og *U. laevis*) ikke nådd fram til Norge, men de finnes så vidt i våre granneland. Alle tre arter ligner hverandre i arkitektur, bladform, blomstring (på bar kvist) og fruktform. Over hele Europa betraktes almeartene som verdifulle treslag. Men deres trevirke kan ikke sies å være originalt; eik og ask har likså god og motstandsdyktig ved. Bladene minner om andre løvtrærs. De tørre, skillingaktige almefruktene er eiendommelige, og har atskillige navn rundt omkring i språkene, særlig i barnespråket; men de har så vidt jeg kan forstå ikke vært brukt til menneskemat eller dyrefôr i Europa — selve frøet er lite, og omgitt av en bred, tørr vinge, som fullstendig dominerer.

Det virkelig originale og oppsiktsvekkende ved slekten alm og dens arter, både i Den gamle og Den nye verden, er barken og dens anvendelse. Jeg vil her nevne at i legekunsten har den slimrike og adstringerende almebarken helt fra oldtiden av vært brukt til å legge på sår og byller. I Europa er det *Ulmus carpinifolia* som leverer slimdrogen *cortex ulmi interior* (jfr. Ramstad 1940). Allerede Dioscorides anbefaler almebast på sår, og Plinius Major har i Naturalis Historia, 24. bok, kapitel 33, viet *ulmus* en inngående omtale. At han her mener *Ulmus carpinifolia* er helt opplagt. Denne ble av romerne brukt som espalier eller underlag for vinstokken, og derfor plantet i store mengder. Særlig Columella gir fra tiden omkring vår tidsregnings begynnelse detaljerte anvisninger med hensyn til såning av almefrukter, formering ved stiklinger og drift av planteskoler for pleie av alm. Skuddene og bladene anbefales til kreaturfôr; dette gjelder både romersk alm (utvilsomt *U. carpinifolia*) og den galliske alm, som Columella spesielt roser for dens store næringsverdi, og med et gallisk (keltisk) ord kaller *atinia*. Trolig har dette vært *U. glabra* (= *U. scabra*), vår nordiske alm, som i Syd-Europa holder seg til fjelltrakter. Den er vanlig i Frankrike (Gallia).

Plinius må antas å ha hatt kjennskap til slimbarken; han taler nemlig om »den tåreaktige substans som kommer fra treet« og om »den fuktighet som flyter ut av margen på et beskåret tre«. Han nevner barkens bastlag og dens adstringerende (sår-sammentrekkende) evne. Som jeg før har nevnt inneholder almeslimet en del garvesyre. Den tyske forsker FLÜCKIGER uttaler i sin bok: Pharmakognosie des Pflanzenreiches (1891) at hos den mellom- og sydeuropeiske *Ulmus carpinifolia* (= *U. campestris*) er barkens rikdom på slim så stor at treet om sommeren ikke sjelden svetter ut slim, som litt etter litt omdanner seg til en brun, uoppløselig, klebrig masse. I enkelte bøker står det om denne arten at stammer som sages over eller skades, kan skille ut slim i klumper. HEMPEL og WILHELM omtaler (1889, III p. 5) »brauner Schleimfluss« hos denne almeart, og betegner fenomenet som »eine hinsichtlich ihrer Ursache noch nicht erkannte Krankheit«.

Under den 10. internasjonale plantegeografiske ekskursjon (I. P. E.) i Spania sommeren 1953 hadde jeg utmerket anledning til å studere *Ulmus carpinifolia* og dens oppførsel på sydligere breddegrader. Den plantes nesten over hele Spania ved autostradaer og mindre veier, både for å skape skygge og for å skaffe kreaturfôr. Jeg så ikke en *Ulmus* på hele reisen som ikke var beskåret, ofte meget sterkt. Langs de spanske hovedveier blir trestammene overstrøket med kritt oppslemmet i vann fra marken og opp til ca. 1,5 m.s høyde av hensyn til biltrafikken i mørke. Jeg oppdaget meget snart at der på almestammene (men ikke på *Robinia*, *Juglans*, *Celtis*, *Populus* osv.) fantes »brune« vertikale striper i den krittede zone. Ved nærmere undersøkelse viste dette seg å være størknet, forurenset slim, som var rent ned fra grenhull eller andre sår høyere oppe på stammen. Overordentlig interessante var noen mektige eksemplarer av *U. carpinifolia* i en park i byen Soria ved elven Duero. Etter et regnskyll var det fra store grenhull flytt ut en brun, geléaktig, grøtet masse i lange, brede striper, og stammene var her helt klissete å føle på. Hvor vidt denne utflod skyldes en sykdom, slik som antydet av HEMPEL og WILHELM, våger jeg ikke å uttale meg om; men vedkommende trær så, trass i sin høye alder, helt friske ut. Hovedsaken her er at fenomenet var vanlig over hele Spania og opptrådte på ellers normalt utseende almetrær (eksempler på »almesyke« så jeg ikke under denne reise). — I Granada, hvor en mengde almetræer er plantet langs hovedoppkjørselen til selveste Alhambra, fant jeg dessuten bekreftelse på påstanden om at *Ulmus carpinifolia* i sommervarmen svetter ut slim, som omdanner seg til en brun uoppløselig masse: på flere stammer, hvor man for noen år siden hadde avsaget større basalgrener, fant jeg (22. juli) tett i tett med mørke brune »perler« eller »dobber« langs sårflatens rand. Først trodde jeg at dette var tjære; men substansen var helt luktløs. Fenomenet ble også iakttatt av mine kolleger professor PAUL RICHARDS og docent JAKKO JALAS.

Det er innlysende at de indoeuropeisk talende folk, liksom andre folk i de strøk av jorden hvor slekten *Ulmus* er representert, fra de eldste tider må ha lagt merke til almebarkens merkelige slimrikdom. Feller man et almetre til trevirke og avbarker stammen, og der så inntreffer regnvær, vil slimet meget snart gjøre barken sleip. Dessuten må sikkert folk fra de eldste tider ha gjort de samme iakttagelser som jeg selv gjorde i Spania i 1953. Da allerede romerne brukte almeblad og almekvister til kreaturfôr, og man i Vest-Norge har fortalt meg at f. eks. kveg hvis det fôres med almebark eller almeløv, får store slimklumper i munnvikene, så kan heller ikke dette forhold ha unngått folks oppmerksomhet i forhistorisk tid.

Professor CARL J. S. MARSTRANDER skrev en gang til meg, etter at jeg hadde fortalt ham om almens anvendelse under naturalhusholdning ned gjennom tidene, at det i og for seg var fristende å stille trenavnet sammen med latin *Alma*, et kvinnenavn, som igjen oppfattes som en avledning til det latinske adjektiv *almus* »huld, nærende«, til verbet *alere* »nære, fostre, oppale«. Dette verbet gjenfinnes i nordiske språk som *ala*, *ale*, *oppale*. Men, skriver Marstrander, »vanskeligheten består deri at *ale* har førgermansk *a*, noe som latin *alere* og irsk *alid* viser. Og et førgermansk *a* skifter bare rent unntaksvis med *o*. Hadde latin hatt *olere* ved siden av *alere*, ville vel saken ha vært klar. I virkeligheten nevner gamle latinske grammatikere et latinsk verbum *olescere* = *alescere*; men dette er vel abstrahert av sammensetninger som *adolescere*, hvor *o* rimeligvis er utviklet av *a* foran *l*.« — Alt i alt, uttaler Marstrander, må det anses »for lite sannsynlig at *alm*, *ëlm*, *ulmus*, *lem* har noe med *al-* i *alere* og *ale* å gjøre.«

Det er altså eksistensen av de tre avlydstrinn innenfor navnekretsen som står i veien for en tydning i tilslutning til *Alma* og *almus*. Som botaniker må jeg her tilføye at det jo er et overveldende stort antall planter, også busker og trær, som leverer menneskeføde av forskjellig slag, og som derfor kunne fortjene navnet »den nærende« vel så godt som alm.

Imidlertid gis der i dette tilfelle et tydningsalternativ som meg bekjent aldri har vært tatt opp til overveielse: Man har i indoeuropeiske språk faktisk en språkrot eller et tema *el-* med avlydstrinnene *ol-* og *l̥-* som finnes i en lang rekke orddannelser — både substantiver, adjektiver og verb — som angår slimete, sleipe, stundom uappetittlige ting. Jeg skal her nevne en del eksempler:

A. Substantivet *ulka* f. i norske dialekter »vedhengende slim, slam etter flom, ekkel bløt masse, myggel«. Adjektivet *ulken* »kvalm, motbydelig«. Dyrenavnet *ulk* m. og *ulka* f. = fisken »marulk«; videre det telemarkske *ulka* f. »padde« og visse svenske og danske navn på fisk. Alle disse dyrene har en sleip, slimet hud. Ifølge Hellquist hører ordene til germansk **ulk* »fuktig«. Plattysk har *Ulk* »frosk« (se også TORP 1919 under *ul*, *ulma* og *alka*).

B. Det norske verb *alka* »søle, grise«; substantivet *alka* f. »svinsk person« (Sørlandet). Adjektivet *alken* »svinsk«; jysk *alke* »elte med besvær i noe«. Plattysk har verbet *alken* »tråkke i søle, rote i urene saker«. Frisisk har *alsk*, *älsk* »uren, utskjemt«.

C. Det norske verb *elgja*, *elja* »føle kvalme«, nyislandsk *elgja hálsinn* »ville brekke seg«.

D. Verbet *ulma* i norske dialekter »bli utskjemt, om matvarer«. Jysk har *olm* »myglet«; middel-nedertysk har *ulmich* »morken«, østfrisisk har *olm*, *ulm* »morkenhet« og verbet *ulmen* »råtne, oppløses«.

Alle disse ord refereres av WALDE-POKORNY og ALF TORP til den før nevnte indoeuropeiske rot *el-* med tilhørende avlydstrinn. De tar også med latin *ulva* »en slags sjøgras«, det vil si en grønn alge, og latin *alga* »tang, alger, havplanter«. Alger er sleipe. TORP (1919 p. 836 under *ulma*) tar også med litauisk *élmės*, *almens* »veske som flyter ut av lik«.

På en forespørsel fra meg om trenavnene *ëlm*, *alm*, *ulmus* kan forbindes med roten *el-*: *ol-*: *ḷ-* i de nettopp nevnte orddannelser, uttaler MARSTRANDER at dette er mulig. Det er språklig sett intet i veien for å jevnføre det norrøne *almr* med f. eks. det norske verb *ulma*. Med andre ord: formelt språklig er det intet i veien for å tyde trenavnet *alm* henholdsvis *ëlm*, *ulmus* og *lem* som »det slimavgivende« eller »sleipe tre«, siktende til barkens eiendommeligheter.

Man kan her føre fram den innvending at den ordkretsen som trenavnet ad denne vei havner i, for det meste omfatter nedsettende betegnelser, og at dette harmonerer dårlig med almeartenes høye stilling i folks bevissthet. Men ved nærmere undersøkelse av plantenavn finner vi at våre forfedre ikke var sentimentale, men snakket rent ut av posen. Jeg har ved en tidligere anledning behandlet nordiske og i det hele tatt germanske navn på *Rubus chamaemorus*, et i Norden uhyre populært bærslag; men ikke et eneste av dets folkelige navn er rosende. Det norske *molta* hører således til partisippet *molten* »skjørnet, bløt, oppløst«, jysk *multen* »råtten, trøsket« og nyislandsk *moltinn* »nær ved å råtne«. En rekke navn på molter i svensk er humoristisk-ringeaktende og sikter til det klissete, modne bæret f. eks. *snotterbär*, *snytterbär*, *snottron* (utvilsomt til *snot* »neseslim«; jfr. norsk *snørbœr* om skinntryter og engelsk *snottergall*, *snottleberries* etc. om de slimete, røde bærene [arillus] av barlind, *Taxus baccata*).

Jeg vil også minne om det viktige fôrmiddel som lages av almebark oppbløtt i vann, og som i norske dialekter kalles *almekvamp* og *almekorg*. Her er substantivet *kvamp*, hvordan man enn vil etymologisere det, i realiteten symbol på noe uappetittlig (se TORP 1919). Det samme gjelder *korg*, som betyr »grums, berme« (TORP 1919). Men likevel har *almekvamp*, *almekorg* vært betraktet som en stor herlighet av bonden.

Det er meget mulig at grunnmeningen i roten *el-*: *ol-*: *l̥-* har vært »fuktig, klebrig, oppløst, sleip«, altså nøkternt beskrivende, og ikke foraktelig.

Til sist vil jeg bare nevne at særlig *Ulmus carpinifolia* i vestgermanske språk har flere andre navn, som ikke har noe med *alm*, *ëlm*, *ulme* å gjøre, men som utvilsomt sikter til de seige basttrevlene i almebarken og dennes anvendelse som et primitivt tekstilmateriale. Dette gjelder *Wieke*, *Bastwieke*, *Witsch(e)* i nordvesttyske dialekter, og angelsaksisk *wice* (i moderne engelsk: *wych elm*). Navnet refereres av linguistene til perfektum partisipp av et verb *wīcan* »bøye«. Også i slaviske språk finnes en navnekrets om alm som synes å bety det samme, ja som kanskje rent språklig sett er urbeslektet med den vestgermanske. Det er helt tydelig at en del av de europeiske navn på dette treslaget sikter til en bestemt egenskap ved barken og basten, nemlig dens seighet og anvendelighet til flettverk. Det er da ikke usannsynlig at den vestindoeuropeiske navnekrets som jeg her har oppholdt meg ved, også sikter til barken, men til dens slimrikdom.

I samband med denne undersøkelse har en rekke av mine kolleger ved Universitetet i Oslo stilt sin fagkunnskap og sin tid til min disposisjon. Professor dr. Leiv Amundsen har til mitt bruk oversatt fra latin enkelte kapitler av Plinius: Naturalis historia og Columella: De re rustica og De arboribus. Professor dr. Emil Smith har oversatt avsnitt fra Herodot, Polybios og Plutarchos. Professor dr. Nils Lid har skaffet meg finsk litteratur om barkebrød, og professor dr. Carl J. S. Marstrander har gitt meg språklig rettledning i samband med trenavnene alm, ëlm, lem og ulmus. Av professor dr. Chr. Stang har jeg fått en orientering om almetrærnes navn i slaviske språk, og av professor dr. Georg Morgenstierne og professor dr. Hans Vogt opplysninger om alm, dens navn og anvendelse hos indo-iransk og kaukasisk talende folkeslag.

Lektor cand. real. Alv Aksnes har skaffet meg viktige opplysninger om bruk av alm til husdyrfôr i Hardanger. Amanuensis cand. real. Finn-Egil Eckblad har utført mikroskopiske undersøkelser av barkemel og renset bark i professor F. C. Schübelers etterlatte samlinger, og gitt meg tillatelse til å referere de resultater han er kommet til. Cand. pharm. fru Dagrun Øiseth, som har foretatt en kjemisk analyse av almebark-slim (*Ulmus glabra*), har godhetsfullt laget et resymé av sine upubliserte undersøkelser til bruk for denne avhandling, og amanuensis cand. pharm. A. Bærheim Svendsen har overlatt meg prøver av den pulveriserte innerbark av *Ulmus fulva* til sammenligning med norsk almebarkmel. De på fig. 2 avbildete redskaper har jeg fått utlånt fra Norsk Folkemuseum ved imøtekommenhet fra konservator H. Stigum. — Til alle dem som har hjulpet meg, vil jeg også her rette en hjertelig takk!

Til sist vil jeg uttrykke min glede over å ha fått anledning til, med dette bidrag, å være med på å hylde professor KNUD JESSEN på hans 70 års dag. Ingen annen nålevende botaniker har som han klart å kaste lys over kornavlens historie i Nord- og Vest-Europa fra de eldste tider. Barkebrødets saga er reversen av denne historie.

Summary in English.

Ethnobotanical studies on barkbread and the employment of wych-elm under natural husbandry.

Chapter I–III.

In Norway, Sweden, and Finland the dried and crushed inner bark of certain trees has been used as a substitute for bread-meal since time out of mind. In Sweden a small cake made of a mixture of pine-meal (*Pinus silvestris*) and pease-meal (*Pisum arvense*) was found in 1911 near Söderköping in Östergötland in a man's grave dating from the viking age (circ. 800 – circ. 1050 A. D.). Especially in Lapland, Northern Russia, and Siberia the inner bark of pine has played a very great role as an alimentary substance until the beginning of our century (cp. MANNINEN 1931; concerning Sweden cp. the excellent treatise by KEYLAND 1919 p. 111–133).

In Scandinavia and Finland pine-bark was probably used only during famines, and thanks to many reliable written sources of information we know pretty well how the bark was peeled, purified, threshed, and watered down (because of the resin). Intelligent people always peeled young pine-stems or only the top of older stems, and the peeling was performed between the spring business and the hay-harvest. During this interval the bark is at its best and easy to slit. The scraper- and chisellike implements which were used, are very interesting from an archaeological point of view. They were made of wood (fig. 2), very often with an iron edge and grip, or of elk- or reindeerhorn.

An analysis of a sample of Norwegian pine-meal, dating from the middle of the 19th century and now in the collection of the Botanical Museum, Oslo, shows that the flour was made solely of the innermost layers of the secondary bark, the bulk of the fragments being parenchymatous cells, mostly from the medullary rays, with lots of starch grains, and pieces of sieve-tubes. As no traces of periderm were observed, the raw material of this sample must have been very carefully scraped. Fig. 3 shows pieces of the purified inner bark of pine, collected during a famine in Eastern Norway in the 19th century. These plates, which now are about 1 mm thick, have some patches of periderm. Originally they must have been pliable as some of them are doubled up. They were pounded, threshed, sieved, and ground on hand- or water-mills.

The pine-meal was used for bread, porridge, and skilly. It has a rather homogenous light brown or reddish colour. If a family still had some grain-flour left, the pine-meal was never used alone as it is destitute of agglutinants, and if mixed with water consequently gives a dough unfit for rolling. The

Scandinavian pine-bread was always made as "flat-bread" or frame food-bread, never as a fermented bread.

If the meal was conscientiously prepared, the bread seems to have been usable in spite of a very bad taste. But during famines people were so exhausted that they probably manufactured the bark-plates without sufficient preparation, and consequently both periderm-cells (cp. fig. 3) and resin-cells became accumulated in the meal. The descriptions given by the Swedish authors RETZIUS, ZETTERSTEDT, and M. AXELSON, the Finnish author MANNINEN, and the Norwegians A. C. SMITH, DE SEUE and others from the 19th and 20th century of the influence of pine-bread upon the digestion and the general health of famine-stricken people are shocking.

The oldest reports of tree bark used for food in Europe can be traced back to Plutarch, Polybios, and Herodotos. Whereas the written sources from Eastern-Europe about this matter are very copious (cp. A. MAURIZIO 1927; MANNINEN 1931), the author has until now not succeeded in tracing the history of bark-breads in Middle-Europe. A French book, however, published in 1874 by M. DU CAMPS, contains a short passage about a famine in Dauphiné in 1675 and the use of herbs and tree-bark (l'ecorce des arbres) for food among the field-labourers. In Eugène Rolland: Flore Populaire (Tome X, 1913) one finds a very interesting vernacular name of the elm, namely *arbre au pauvre homme*, which says a great deal (cp. below).

In the highlands and northern parts of Scandinavia and Finland *Pinus silvestris* was the most important bread-tree; but occasionally the inner bark of *Betula*-species, *Populus tremula*, and other deciduous trees was used as well. Several sources mention *Picea abies*, but its bark seems to have been atrocious and only peeled in extremity. In the low-lands of Sweden and Norway, however, the wych elm (*Ulmus glabra*) was the favourite bread-tree.

Chapter IV–V.

These deal with the merits of the inner bark of wych elm compared with that of the pine: (1.) it contains no resin and not very much tannic acid; consequently one does not need to water down the scraped rind; (2.) it is rather rich in slime-cells, a fact which is extremely interesting and important in connection with bread-baking. As mentioned above the pine-meal contains no agglutinants, and the making of bread or cakes of pure pine-meal seems to have been very difficult indeed. The inner bark of *Ulmus glabra* contains both starch, proteins, fat oil, and slime. The chemical constitution of the latter has recently been deciphered by Mrs. DAGRUN ØISETH, The Pharmaceutical Institute of the University of Oslo (unpublished). The slime seems to be composed of certain sugars and methylated sugars, mostly identical with the carbohydrates which recently have been isolated by British chemists from the bark of the American species *Ulmus fulva* (cp. GILL, HIRST, JONES, and HOUGH 1939–1951), the so-called slippery elm. It is told that this bark has been used by Indians as food, and without preparation.

According to MAURIZIO (1927) the inner bark of elms (probably of all the three species which are spontaneous in Eastern Europe) seems to have been the most coveted substitute for cereals in Russia. At any rate it is mentioned again and again in the reports published by the department governors and the investigation committees from nearly all parts of Russia and Russian Poland in the 19th and even the 20th century.

Bread made solely or partially of crushed elm-bark is mentioned in written

Norwegian sources from 1596 and down to 1895, and there are still old people living who remember having seen and eaten such bread. The Botanical Museum in Oslo has some pieces of flat-bread baked for fun in 1935 in the Romsdal-district by an old man who is still going strong. He remembers the whole process of flour- and bread-making from elm-bark. The colour of this bread is French Beige-Oakbuff, and the taste is not at all unpleasant, but it contains 50 % barley.

During famines the elm-bark was used all over the Norwegian districts where this tree occurs or has existed. The bark was peeled only from young branches or shoots not more than 2 or 3 years old. Afterwards the primary bark (cortex) was removed with a knife, and only the secondary bark, after having been cut, dried and ground, was used for making bread and porridge. A meal-sample from Hardanger collected by the late professor F. C. Schübeler about the middle of the 19th century consists of bast-fibres, sieve-parenchyma, fragments of the medullary rays and sieve-tubes, and big, slime-containing cells. The slime-cells, however, are only present in the primary bark and the first layers of the secondary bark (RAMSTAD 1940), and consequently the older shoots and the chief stems were not peeled.

The elm-meal was as a rule mixed with ground hinderends, tailings, pieces of straw and chaff, and very often with pine-meal, but also used alone.—During years when barley and oats are injured by frosts and the flour consequently becomes inferior to the normal especially concerning agglutinants, the women on the farms in the fiord-districts of Western Norway have up to recent years been in the habit of kneading the corn-flour or the dough in water containing elm-slime prepared from slips of the bark which have been soaked from 12 to 48 hours in lukewarm water. The same method is mentioned from Sweden by Retzius in 1806.—In Norway the peeling of elm-trees during years of famine has been so excessive, at any rate in certain districts as well in Eastern as in Western and Northern Norway, that the geographic distribution of *Ulmus glabra* has declined.

In Scandinavia the wych elm has since time out of mind also been used as food stuff for cattle, the leaves, fresh or dried, the twigs, and the bark of the younger shoots having been gathered in great quantity. The rind-slips have practically all over the lowlands of Norway been put in water, and the sweetish slime given as a nutrition to calves. This substance was mentioned in a Norwegian book as early as 1646, and it has many vernacular names. As in Switzerland the fresh green elm-leaves, stripped from vigorous shoots, are used as swine-fodder.

In Norway the wych elm in fact seems to have been treated by man as a sort of cultural tree, and often been planted near the houses. In certain parts a kind of taboo has been conferred upon the elm-trees: it is believed that a person who cuts down an elm-tree and makes a pair of skis of it, gets the devil behind him when using them; and if a man comes to an accident with elm-skis on his feet, he runs directly into hell. The same taboo is in other Norwegian precincts applied to the roan-tree (*Sorbus aucuparia*), but also this was—and still is —an important alimentary tree for live stock, besides having been used in sorcery from the bronce age up to recent times. In Norway the elm seems to have been looked upon as a bread reserve, and accordingly treated with great veneration.

The author has not succeeded in obtaining pieces of information about bark-bread from Great Britain. It is neither mentioned by G. E. FUSSELL (1949) nor by W. Ashley (1928). But one thing is significant: especially in Western Norway the inner bark of elm is still very popular among country lads, who take pieces of it during the sap time and use it as a sort of treat, chewing it deliberately to the end that the sweetish slime may disengage itself from the bast. According to Britten & Holland (1878 p. 101) "the inner bark of the elm, for a certain pleasant clamminess, is chewed by children, and hence the tree is called *Chewbark*" (from G. Johnston 1853 "The Botany of the Eastern Borders", comprehending the whole of Berwickshire, the Liberties of Berwick, N. Durham and the immediately adjacent parts of Northumberland and Roxburghshire). Most probably this chewing is a very old custom, having been introduced into Great Britain by Norwegian vikings, or perhaps by the Anglo-Saxons themselves. As famines are not unknown in the annals of Great Britain and Ireland, one ought to be able to elucidate the bread- or meal-surrogates of both the Anglo-Saxons and the Celts. According to Ashley (1928 p. 171) "after-logginges of wheate"—straw from wheat—were ground for "servants pyes" in Yorkshire 1641.

There is every reason to suppose that the utilization of elm-bark as a substitute for cereals has belonged to the cultural joint ownership not only of the Teutonic and Slavic speaking peoples, but of all the races of Europe.

According to the Norwegian ethnologist I. Reichborn-Kjennerud (1922) the astringent elm-bast was the first dressing applied by the Scandinavian peoples to wounds and bruises (cp. the Norwegian phrases quoted on p. 293). Whether this bast has been used in Scandinavia as a textile as well, i. g. for making ropes and lines, or not, is rather uncertain. At any rate the bast of the lime-tree (*Tilia cordata*) has both in Norway and Sweden been given preferance to that of the elm (cp. Retzius 1806; Hanssen & Lundestad 1932). From Germany the use of elm-bast as a second-rate textile is mentioned in several books.

Chapter VI.

The author, with reference to a treatise printed by S. Ve in 1930, states that if the branches and shoots of an elm are harvested only with 2–5 years interval, the tree in question will not flower. According to Ve the shoots require 7–8 years of undisturbed growth in order to be able to bloom, but in the inner parts of the Sognefiord district the elm is still harvested so intensely as a feed stuff for cattle that many trees never produce flowers. This means that if the inhabitants of a certain district systematically use the elm-trees in the ways described above, the pollen-production of the elm automatically must decline. As early as 1939, when the now Professor Knut Fægri discussed his interesting pollen-curves from Southwestern Norway with the author, the latter advanced the opinion that certain declines in the elm-curve which made the impression of being quite independant of the fluctuations of the lime-curve, probably might be due to prehistoric human influence (cp. Fægri 1940 p. 122). Later on the Danish geologist J. Troels-Smith has worked with this problem both in Denmark and Switzerland, but not yet published his results.

According to the author's opinion the intense utilisation of pine-bark in years of famine in the continental and northern districts of Scandinavia and Finland might very well have put its traces on the local pollen-curves of *Pinus silvestris*. But as old pine-trees never were used for peeling, and there always has been much more pine than elm—if any at all—in the said parts, the influence of man upon the pine-curve probably has not been able to manifest itself to the same degree as in the case of the elm.

Chapter VII.

Here the author enters into a discussion of the etymology of the tree-name *ëlm* with its substitutes Norwegian and Swedish *alm* (ON. *almr*), Middle-Low German *ulmboum*, OE. *ulm-tréow*, Latin *ulmus*, and Middle-Irish *lem*. According to the unanimous opinion of European linguists these words must belong together, forming an ablaut series (*el-mos, ol-mos, l̥-mos*) and containing one and the same theme (**ĕl-, ol-, l̥-*, giving Teutonic *el-, al-, ul-*).

But up to the present nobody has been able to give a satisfactory etymological-semantic interpretation of the said tree-name(s). The author has tried to work out the problem by taking into consideration the most prominent qualities of the two species *Ulmus glabra* and *Ulmus carpinifolia*, which have the widest geographical distribution of the European elms. The importance of these two species as alimentary trees for cattle during antiquity can be read out of the Naturalis Historia by PLINY and the books De arboribus and De re rustica by COLUMELLA. By *ulmus* the latter without doubt means *U. carpinifolia*, whereas his *atinia*, the gaulish elm, probably refers to *U. glabra*.

A priori an interpretation of the words *ëlm, alm, ulmus* as relatives of latin *Alma*, a woman's name, meaning "The nourishing" (cp. the adjective *almus* and the verb *alere*), is very tempting. But according to Professor CARL J. S. MARSTRANDER, Oslo, the verb *alere*, Irish *alid*, ON. *ala*, has a preteutonic *a*, and such an *a* very rarely alternates with *o*. Consequently the ablaut series *ĕl-, ol-, l̥-* in the elm-names does not speak in favour of such an etymology.

One of the most striking qualities of the said elms, and especially of *U. carpinifolia* (the Roman *ulmus*), is the richness of the bark in slime or gluten. This property, which in *U. carpinifolia* is still more prominent than in *U. glabra*, must have been well known in antiquity as already PLINY writes about the "tear-like substance emerging from the tree" and "the moisture coming out of the pith of a pruned elm-tree". He also describes the bark as an astringent remedy for wounds. It is well known that the inner bark of *Ulmus carpinifolia* has been used in Europe as a slime drug or simple (*cortex ulmi interior*) up to the last century, before the American slippery elm (*Ulmus fulva*) came upon the market.

During the 10th I.P.E. throughout Spain in July 1953 the author had excellent facilities for studying *Ulmus carpinifolia* in the open as it is grown along nearly all Spanish road-sides, the shoots being used as fodder for live stock as in Roman times. On nearly all the stems observed by the author there had been outflow of slime from wounds (chopped branches and shoots), and in moist weather these streaks were quite sticky. FLÜCKIGER (1891) states that the bark of this elm-species is so rich in slime that it is often sweating out clumps of gluten during the summer-months. HEMPEL & WILHELM (1889) speak about a brown blenorrhea ("brauner Schleimfluss") in connection with *U. carpinifolia*, saying that its cause is unknown.

Having considered different etymological possibilities the author comes to the conclusion that the tree-names *ëlm, alm, ulmus* probably belong to a certain well-known indoeuropean root *el-, ol-, l̥-* which in the course of time has produced a lot of nouns and verbs in different languages alluding to slimy, sticky, slippery things or to decomposition (cp. the many Teutonic words mentioned above p. 298–299, for instance East-Frisian *olm, ulm* "decay" and *ulmen* "to decay"; Norwegian *ulma* "to be spoiled" (about food); Norwegian, Swedish, Danish and German *ulk, ulka* "certain kinds of fish with a slimy skin" or "toad"; Norwegian and Low-German *alka, alken* "to soil, to muzzle in unclean things" etc. etc.—In Walde-Pokorny (1926) the latin plant-names *ulva* and *alga* are referred to the same root, and these plants are slimy.

According to Professor MARSTRANDER the reference of the tree-names *ëlm, alm, ulmus* to this group of words is fully justified from a formal-linguistic point of view. One might perhaps make the objection to this etymology that it places the tree-name in a group of words symbolising rather unpleasant things. But a close study of old vernacular plant-names clearly shows that our ancestors were not sentimental, but called a spade a spade when not hampered by superstitions. The author has previously (1947) tried to show that none of the Norwegian, Swedish or Danish names of the fruits of *Rubus chamaemorus,* which are extremely popular all over Scandinavia, in fact reckoned the best of all wild berries, are laudatory but rather pejorative, alluding to the soft, decomposed, sleepy consistence of the ripe fruit (cp. the Norwegian name *molta* and the Swedish names *snotterbär* and *snottron*; here the first part without doubt is *snot,* the same as in the English names *snottergall, snottle-berries* etc., which according to BRITTEN & HOLLAND refer to the seed of *Taxus baccata* with its sticky arillus).

The author thus arrives at the conclusion that *ëlm, alm, ulmus* in all probability means "the slippery (tree)", alluding to a special property of the bark which has made the elm one of the most important European trees under natural husbandry, and its bast a valuable drug.

In European languages the elms also have other names i. g. German *Wieke, Bastwieke, Witsch(e),* corresponding with OE. *wice,* modern English *wych* or *witch.* The meaning of this name has been elucidated long ago: it belongs to the past participle of the verb *wīcan* "to bend", alluding to the flexible twigs or—according to the authors opinion—to the bark or bast which as mentioned above has been used in Germany for making ropes, keeping framework together etc. etc. Accordingly the name *wych* gives us a convincing example of how important this tree has appeared to the mind of the Teutonic speaking peoples, and as *wych* concerns the bark or bast, it indirectly supports the etymology of *ëlm* etc. advanced above.

The author's obligations are numerous. The names of his helpers are mentioned at the end of the Norwegian text.

Litteraturliste.

ASHLEY, W.: The Bread of our Forefathers. An Inquiry in Economic History. Oxford 1928.

AXELSON, MAXIMILIAN: Vandring i Wermlands Elfdal och Finnskogar. Stockholm 1852.

BRITTEN, J. and HOLLAND, R.: A Dictionary of British Plant-Names. London 1876–1886.

BROCKMANN-JEROSCH, H.: Das Lauben und sein Einfluss auf die Vegetation der Schweiz. Mitt. d. geogr.-ethnogr. Gesellsch. Zürich 1917–1918. Band XVIII. Zürich 1918.

DAA, LUDV. KR.: Skisser fra Lapland, Karelstranden og Finland. Kristiania 1870.

FALK, HJ. og TORP, A.: Etymologisk ordbog over det norske og det danske sprog. Kristiania 1903–1906.

— Norwegisch-Dänisches etymologisches Wörterbuch. Heidelberg 1910–1911.

FLÜCKIGER, F. A.: Pharmakognosie des Pflanzenreiches. III. Auflage. Mit einem geschichtlichen Anhange. Berlin 1891.

FRIIS, J. A.: En sommer i Finmarken, russisk Lapland og Nordkarelen. Kristiania 1871.

FRIIS, PEDER CLAUSSØN: Samlede Skrifter. Utg. av Gustav Storm. Kristiania 1881.

FUSSELL, G. E.: The English Rural Labourer. London 1949.

FÆGRI, KNUT: Quartärgeologische Untersuchungen im westlichen Norwegen. II. Zur spätquartären Geschichte Jærens. Bergens Museums Årbok 1939–40. Naturv. rekke nr. 7. Bergen 1940.

GILL, HIRST & JONES: Journal Chem. Society 1939; 1946.

GRØN, F.: Om kostholdet i Norge indtil aar 1500. Skrifter utg. av Det norske Videnskapsakademi i Oslo, 1926, Kl. II nr. 5. Oslo 1927.

— Om kostholdet i Norge fra omkring 1500-tallet og opp til vår tid. Ibidem, 1941, Kl. II nr. 4. Oslo 1942.

GUNNERUS, J. E.: Flora Norvegica. Nidrosiae 1766.

HANSSEN, O. og LUNDESTAD, JON: Lindebast og bastetog. Nytt Mag. f. Naturv. Bd. 71. Oslo 1932.

HAUKENÆS, TH. S.: Natur, Folkeliv og Folketro i Hardanger. 1885.

HEMPEL, G. und WILHELM, K.: Die Bäume und Sträucher des Waldes. Berlin und Olmütz 1889.

HIRST, HOUGH & JONES: Journal Chem. Society 1951.

JENSØN, CHRISTEN: Den norske Dictionarium eller Glosebog. Kiøbenhaffn 1646. Facsimileutgave utgitt av a/s J. W. Eides Forlag. Bergen 1946.

KEYLAND, NILS: Svensk Allmogekost I. Nordiska Museet. A.-B. Svenska Teknologföreningens Förlag. Stockholm 1919.

LID, NILS: Den serlege folkelege tidsrekningi i Noreg. Nordisk Kultur bd. XXI. Stockholm 1934.

LINNÉ, CARL VON: Iter Dalecarlicum 1734. — C. von Linné's Ungdomsskrifter. Utgifna af E. Ährling. Ser. 2. Stockholm 1889.

MANNINEN, I.: Überreste der Sammlerstufe und die Notnahrung aus dem Pflanzenreich bei den nordeurasischen, vorzugsweise den finnischen Völkern. Eurasia septentrionalis antiqua VI. 1931.

MAURIZIO, A.: Die Geschichte unserer Pflanzennahrung von den Urzeiten bis zur Gegenwart. Verlag Paul Parey. Berlin 1927.

MENANDER, C. FR.: Stampe-, Bark- och Misse-Bröd. Svenska Vetenskapsakademiens Handl. 1742 (citert etter Manninen).

NORDHAGEN, ROLF: Hjortron og hjortinger. Komparative studier over nordiske dialektnavn på *Rubus chamaemorus*. Nysvenska studier. 1947.

OLSEN, MAGNUS: Skaldevers om nøds-år nordenfjells. Studia septentrionalia II, 1945. Trykt også i forfatterens »Fra norrøn filologi«, Oslo 1949.

PERSSON, STRAND GUSTAF: Om nødbröd i Lima och Transtrand under forna tider. Dalarnas Hembygdsbok 1932.

RAMSTAD, E.: Kan almebark til medisinsk bruk samles av viltvoksende alm i Norge? Norges Apotekerforenings Tidsskrift, Årgang 48. Oslo 1940.

REICHBORN-KJENNERUD, I.: Våre folkemedisinske lægeurter. Den norske lægeforenings forlag. Kristiania 1922.

RETZIUS, A. J.: Flora Oeconomica Sveciæ. Lund 1806.

ROLLAND, E.: Flore populaire ou Histoire naturelle des plantes dans leurs rapports avec la linguistic et le folklore. Tome X. Paris 1913.

SCHNABEL, MARCUS: Udkast til Beskrivelse over Hardanger. Kjøbenhavn 1781.

SCHÜBELER, F. C.: Viridarium Norvegicum I–III. Christiania 1886–1889.

SIRELIUS, U. T.: Suomen kansanomaista kulttuuria I. 1919 (Finlands folkliga kultur. Svensk oversettelse, stensilert av Nordiska Museet, Stockholm).

STOLTENBERG, E.: Utrast. Viking, bind XI, Oslo 1947.

TORP, ALF: Nynorsk etymologisk ordbok. Kristiania 1919.

VE, SØREN: Skogtrærnes forekomst og høidegrenser i Årdal. Plantegeografiske og bygdehistoriske studier. Meddel. fra Vestlandets forstl. forsøksstasjon. Bd. LV. Medd. nr. 13. Bergen 1930.

— Skog og treslag i Indre Sogn frå Lærdal til Fillefjell. Med ei utgreiding um gran i Sogn. Ibidem. Medd. nr. 23. Bergen 1940.

VISTED, K. og STIGUM, H.: Vår gamle bondekultur. III. utgave. Oslo 1951–52.

WALDE, A.: Vergleichendes Wörterbuch der indogermanischen Sprachen, herausgegeben und bearbeitet von J. POKORNY. 3 Bde. Berlin 1927, 1930, 1932.

WALLENIUS, J. F.: Afhandling om finska allmogens nödbröd. Åbo 1782 (citert etter Manninen).

WILLE, H. J.: Beskrivelse over Sillegjord Præstegjeld i Thelemarken. Kjøbenhavn 1786.

WORM-MÜLLER, JACOB: Norge gjennem nødsårene. 1918.

AASEN, IVAR: Norsk Ordbog. Christiania 1873.

Plate X. Böllingsö.

Fig. 1. Composite pollen diagram. The basis of calculation for the pollen curves is the total pollen of all land plants, also including herbaceous plants. The left part of the diagram shows the ratio of pollen of trees and shrubs (blank area) to herb pollen (hatched area) and to Ericales, chiefly *Empetrum*, (dotted area); these categories represent wood and shrub, grassland, and the oligotrophic heath respectively. The curves for *Betula* (including *B. nana*), *Pinus* and *Salix* are inserted on the left. Next are given the curves for the most important anemophilous herbs, and histograms for *Hippophaë* etc.

Pollen total, pr. analysis, from 190 cm.–380 cm.: 406, 289, 245, 426, 357, 287, 328, 350, 300, 287, 235, 538, 470, 388, 429, 387, 210, 137, 212, 252, 196, 150, 180, 132, 169, 108, 164.

To the right is found the percentages of rebedded, mainly Tertiary, pollen (oblique shadowing). Here the basis for calculation is the pollen sum total, rebedded pollen in this case being—exceptionally—included. As to the method of calculation of the rebedded pollen see IVERSEN (1936).

Sediments (left): –189 cm. detritus-gyttja; 189–254 cm. diatom-gyttja, ± sandy; 254–290 cm. detritus-gyttja; 290–317 cm. diatom-gyttja; 317–333 cm. silt; 333–363 cm. diatom-gyttja with sand and silt; 363 cm.– clay.

On the extreme left is the zonal division (see text).

Fig. 2. These diagrams correspond with the pollen diagram fig. 1, usually analysis to analysis. The diagram on the left shows the varying quantity of the components of the sediment throughout the series. Microorganisms are given against detritus and inorganic matter. These components were measured microscopically: by means of an ordinary eye-piece micrometer it was noted how many of the index lines touched the various components. When this had been completed for a large number of fields of vision, the percentages were calculated. On the right a microfossil diagram. The quantities of diatoms, chlorophyceae, cyanophyceae, and chrysomonades were measured and calculated in the same way as before.

It will be noticed that there is a very fine correlation between all these diagrams. Maximum of herb pollen is correlated with maximum of derived pollen and of inorganic matter. The warmest parts of the Alleröd period—just as the postglacial period—is characterized by Chlorophyceae and a maximum of detritus, but a minimum of inorganic matter.

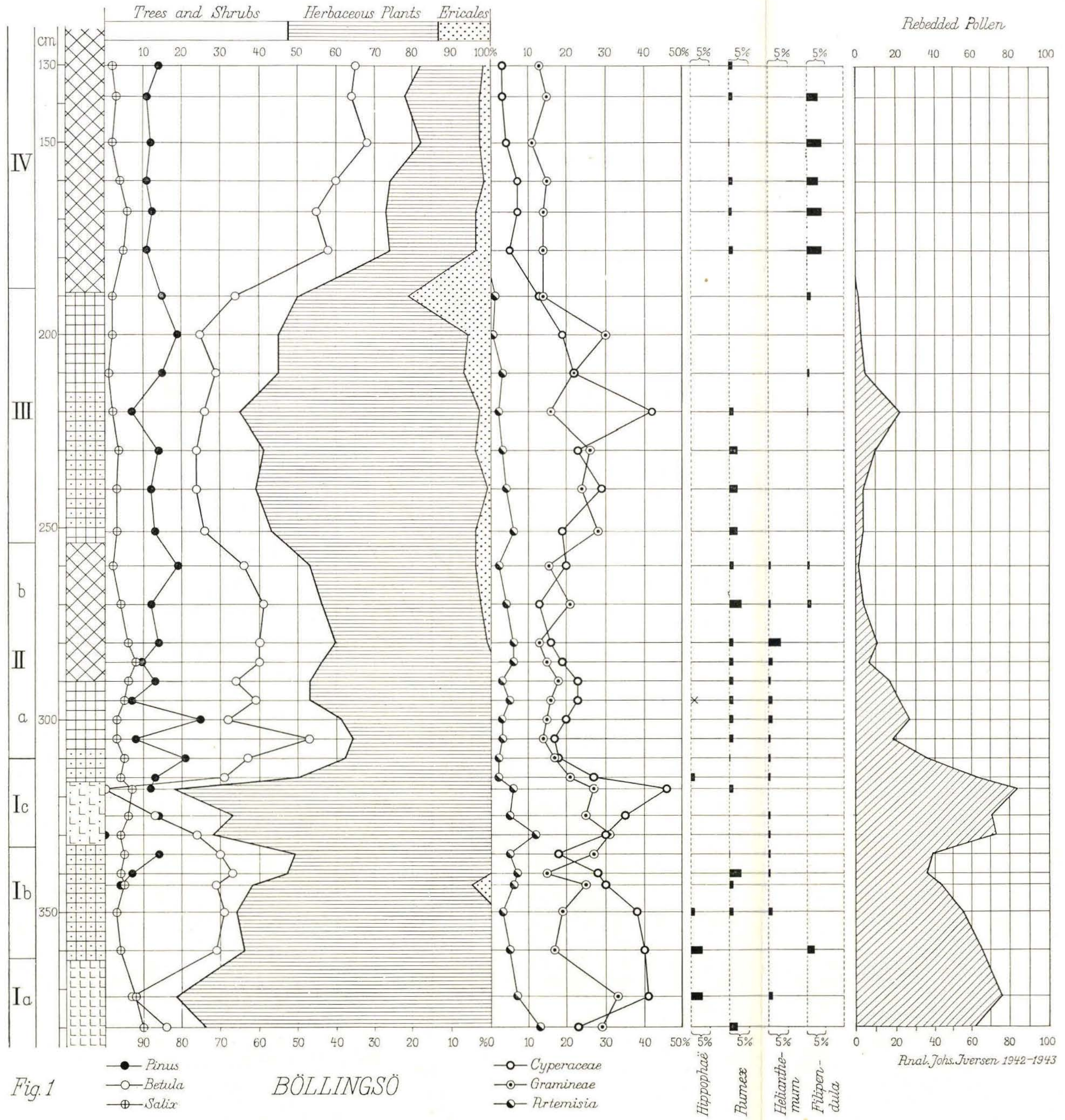


Fig. 1

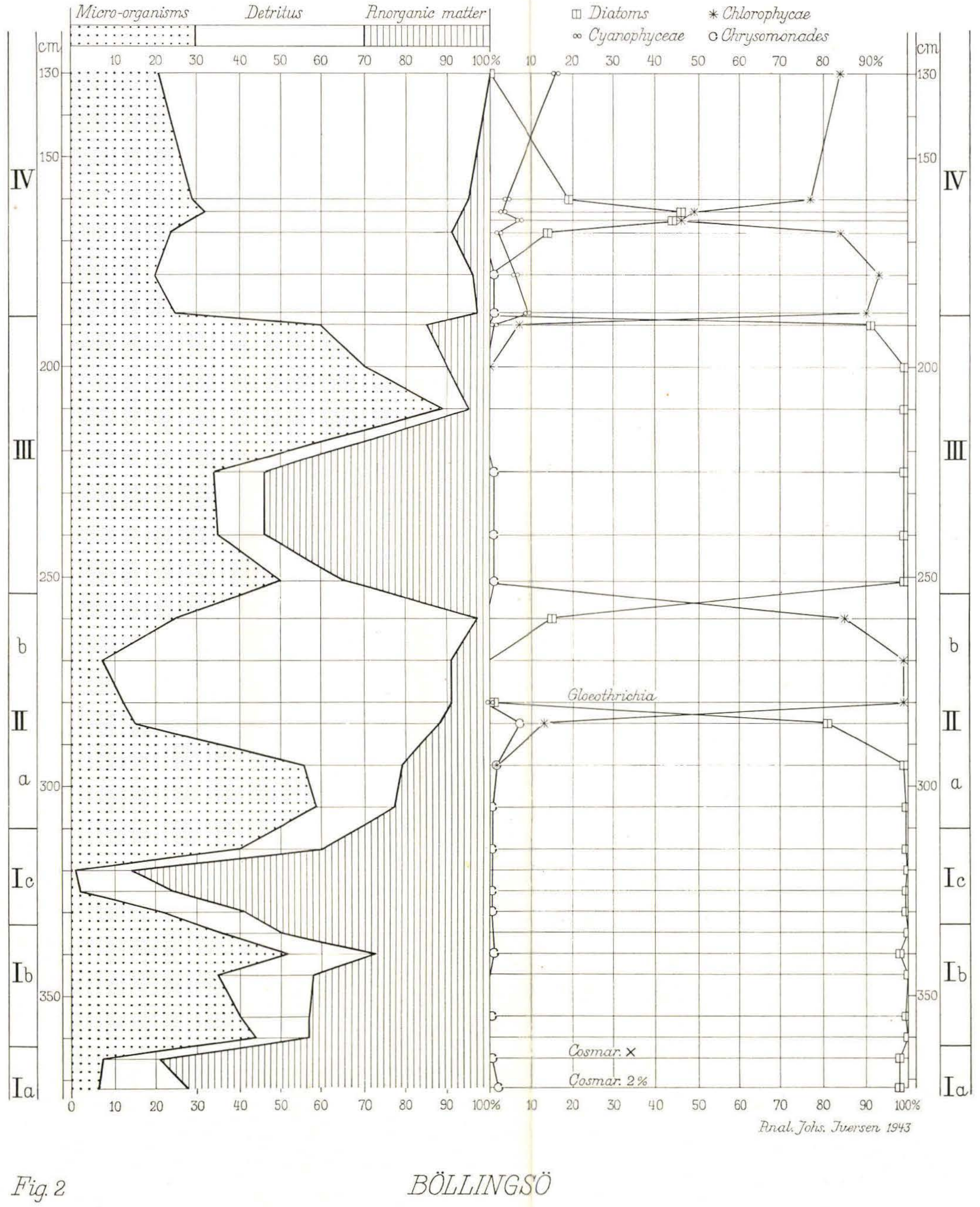


Fig. 2

Plate XI. Vallensgaard Mose, Bornholm.

Explanation see plate X. *Juniperus* and *Populus* have, however, been counted and are included in the category of trees and shrubs. In the histograms pollen types occurring in small frequencies are also given on an increased scale (dotted).

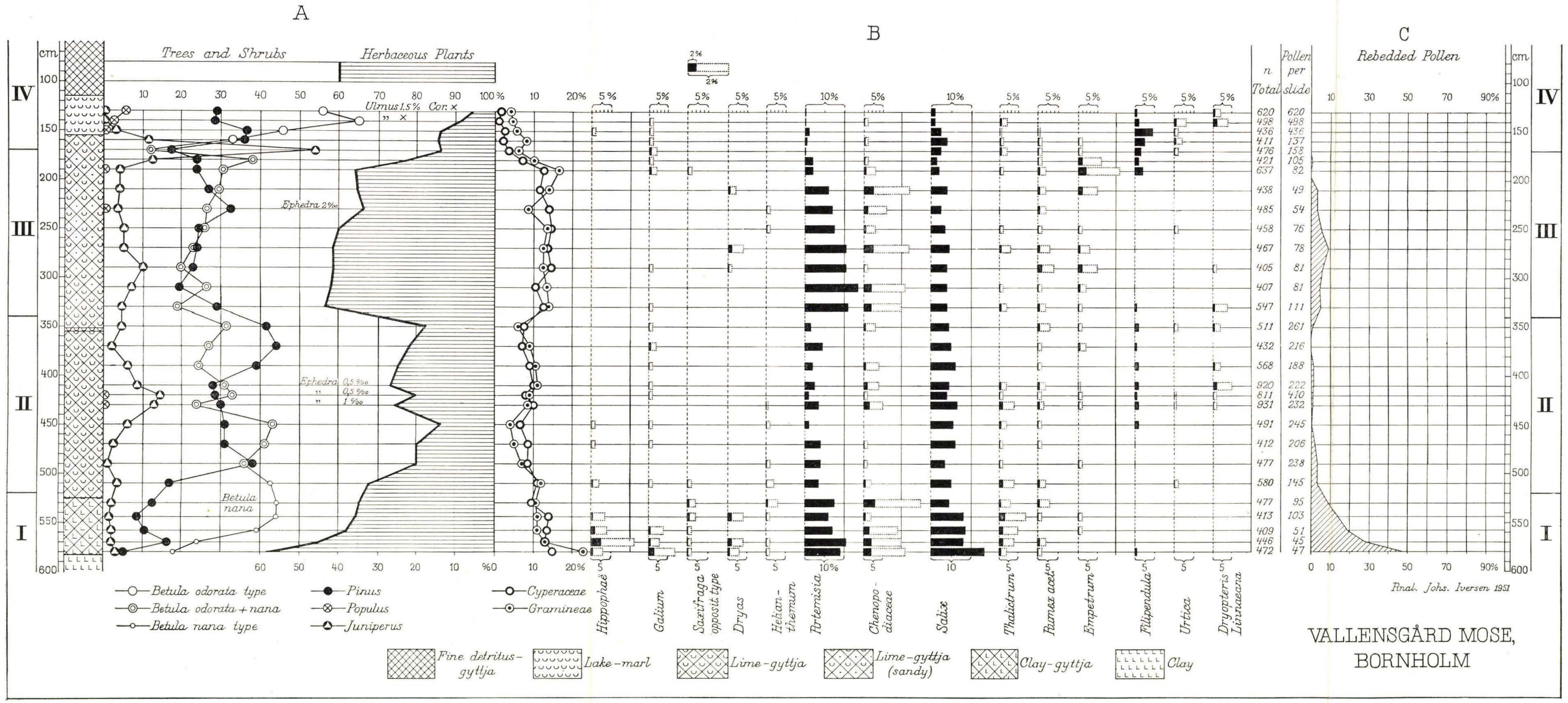


Plate XII. Ruds Vedby Brickwork's clay pit.

The diagram is divided into three parts, each one corresponding analysis by analysis. All pollen grains and spores from terrestrial plants are included in the total, on which the percentage calculation for all pollen and spore curves in the diagram is based.

A. Main diagram, showing the proportions between the pollen originating from trees (white area), shrubs and dwarf bushes (dotted area) and herbaceous plants (hatched area). The trees include *Populus*, *Pinus* and *Betula*, the curves for which are recorded within the area of the tree group.

B. Curves and silhouettes for the more important plants included in the total curves for "shrubs" and "herbs" in A. The silhouettes for shrubs and dwarf shrubs are, in so far as space permits, given with the same dotting as the total curve. All curves are drawn to the same scale; some of the silhouettes are, in addition, drawn to a scale of 5:1.

C. The percentage of rebedded pollen. In this case the rebedded pollen is included in the total forming the basis of the calculation.

n Pollen total (rebedded pollen subtracted).

The zonal division, according to Knud Jessen's system (1935), is given at both sides of the diagram. I Older Dryas, II Alleröd, III Younger Dryas

The results of the C^{14} datings appear on the extreme left.

RUDS VEDBY

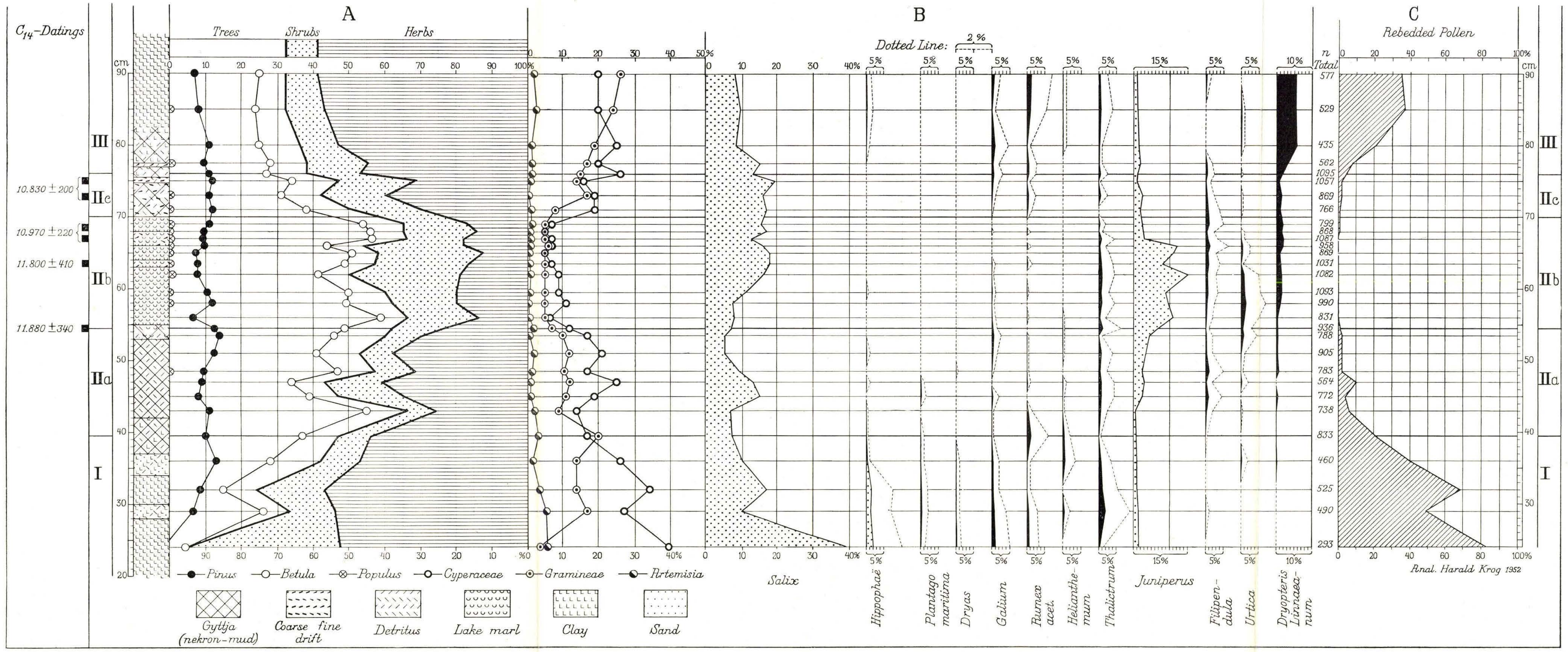
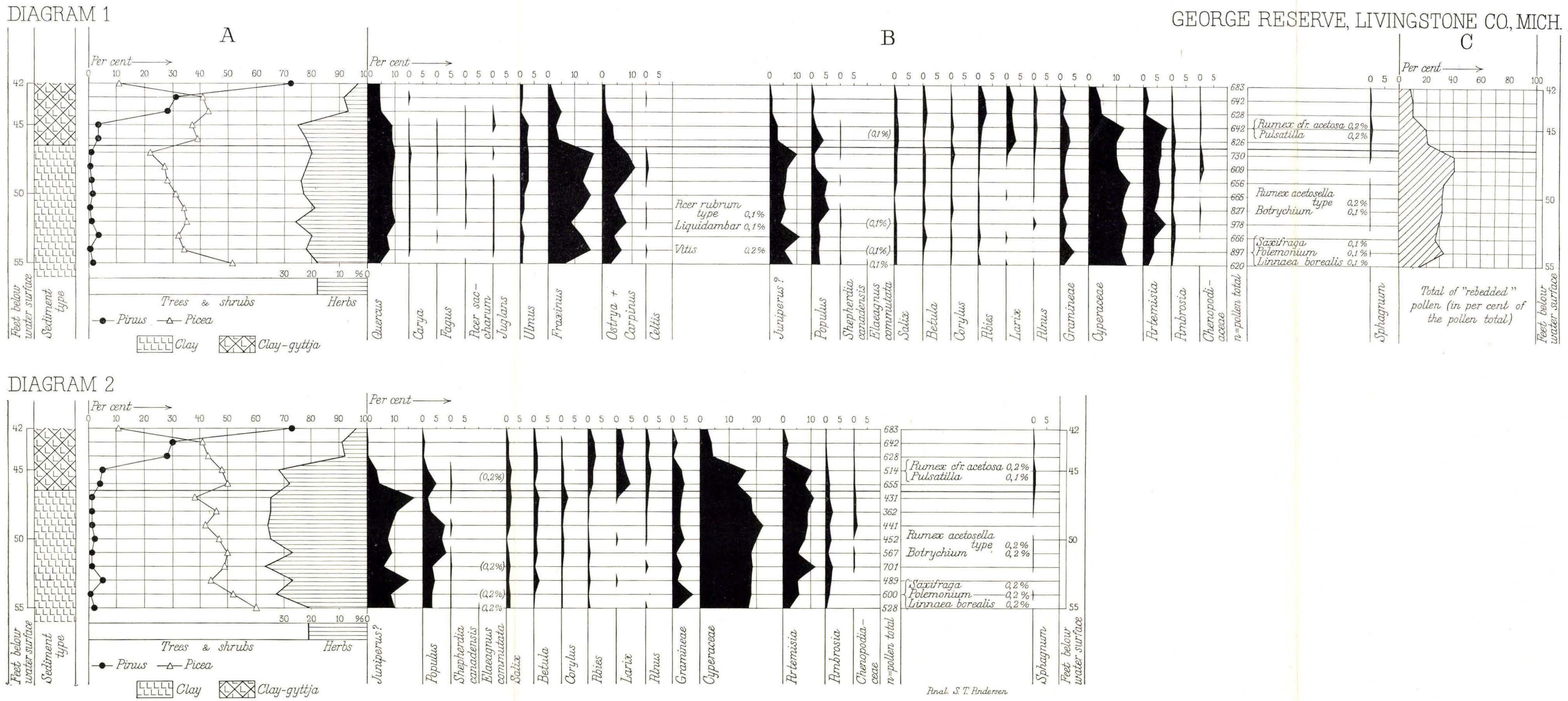


Plate XIII. George Reserve, Livingstone Co, Michigan.

In diagram 1 the pollen total includes trees, shrubs, and anemophilous herbs. Part A shows the total of trees and shrubs (white area) against that of herbs (hatched area), and curves for *Pinus* and *Picea*. Part B shows the individual curves for other trees, shrubs, and herbs. Part C shows a curve for the total of "rebedded" pollen (cp. text, p. 148). In diagram 2 "rebedded" pollen is excluded from the pollen total (cp. text p. 149), otherwise it is constructed as diagram 1.



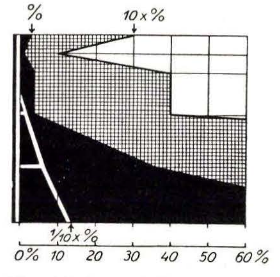


Plate XIV. Verup Mose, Flint pick.
Text see page 160.

Fig. 1. Main Diagram; explanation see page 163.

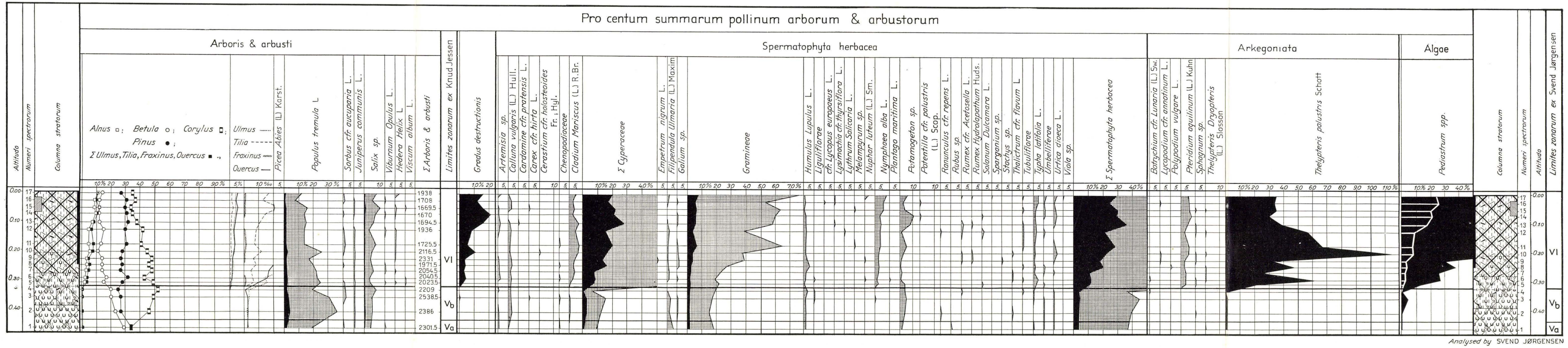
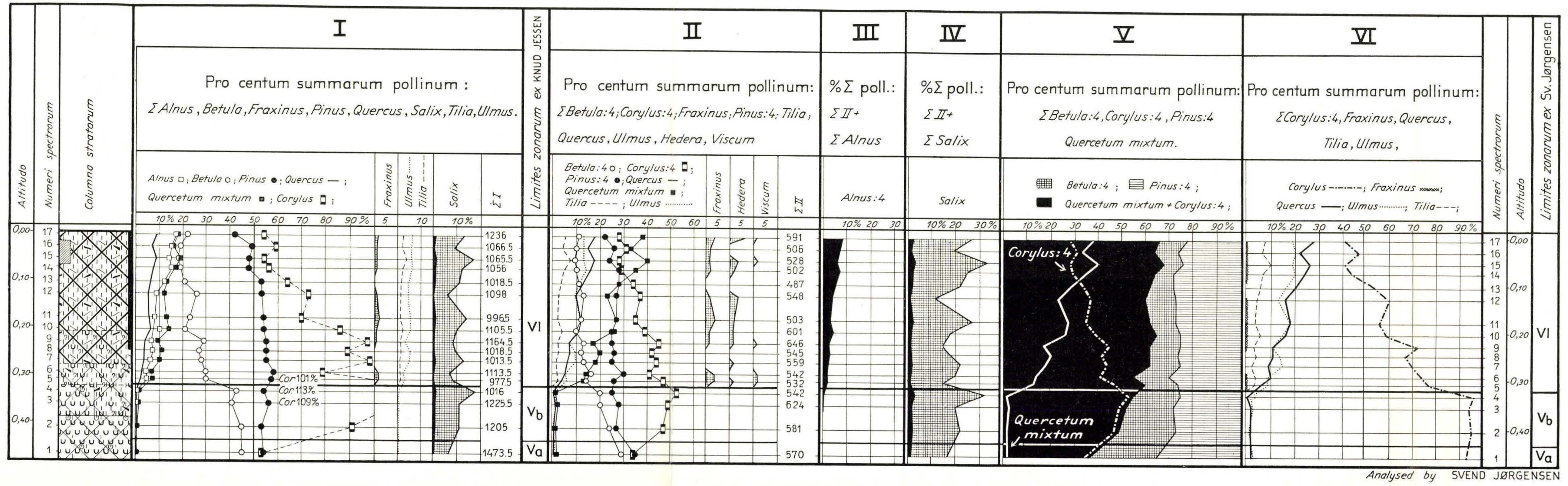


Fig. 2. Survey Diagram; explanation see page 164.



Verup Komplexet, Verup I.

Niløse S. Merløse H. Holbæk A.

Plate XV. Verup Mose, Verup I.

Text see page 166.

Fig. 3. Main Diagram. Explanation see page 163.

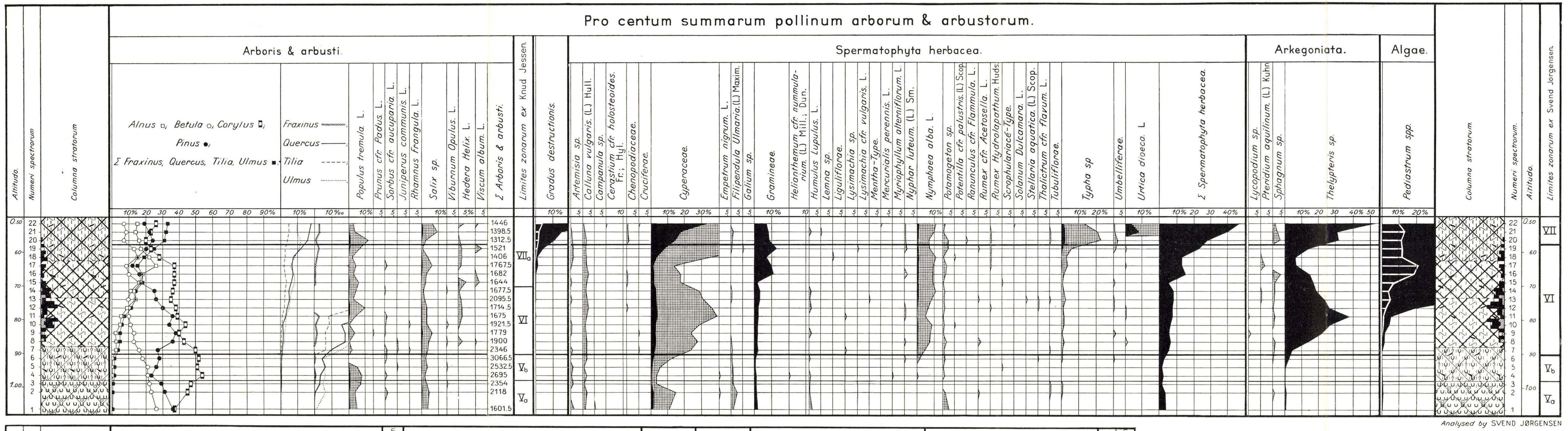


Fig. 4. Survey Diagram. Explanation see page 164.

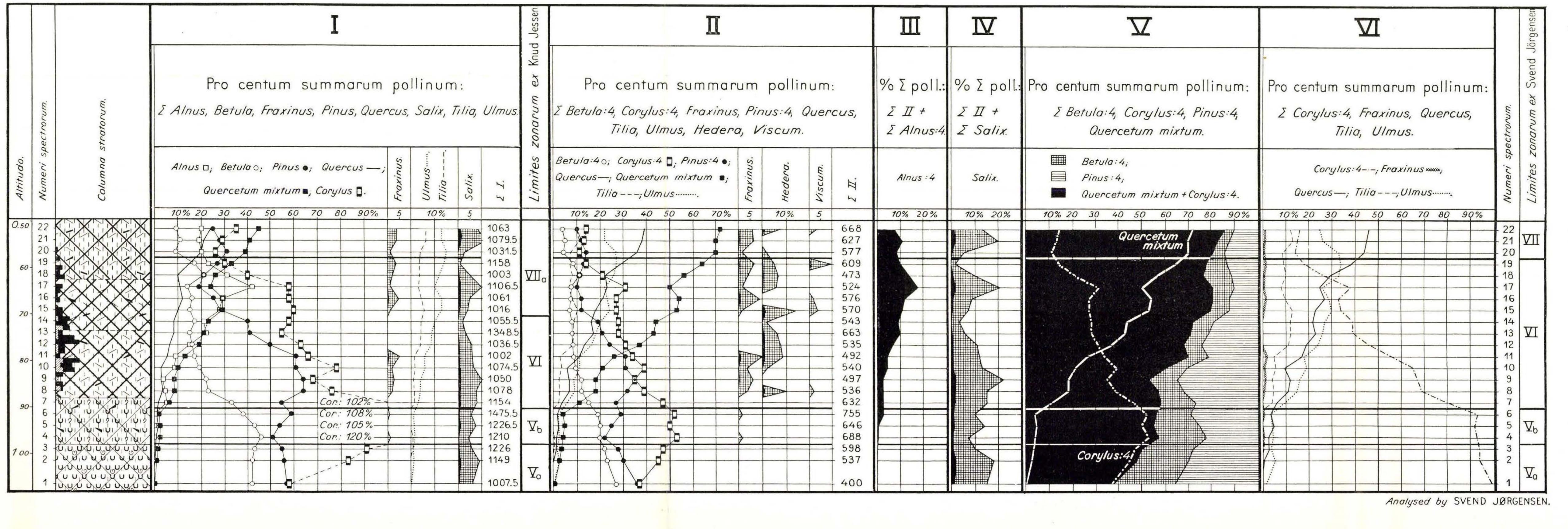


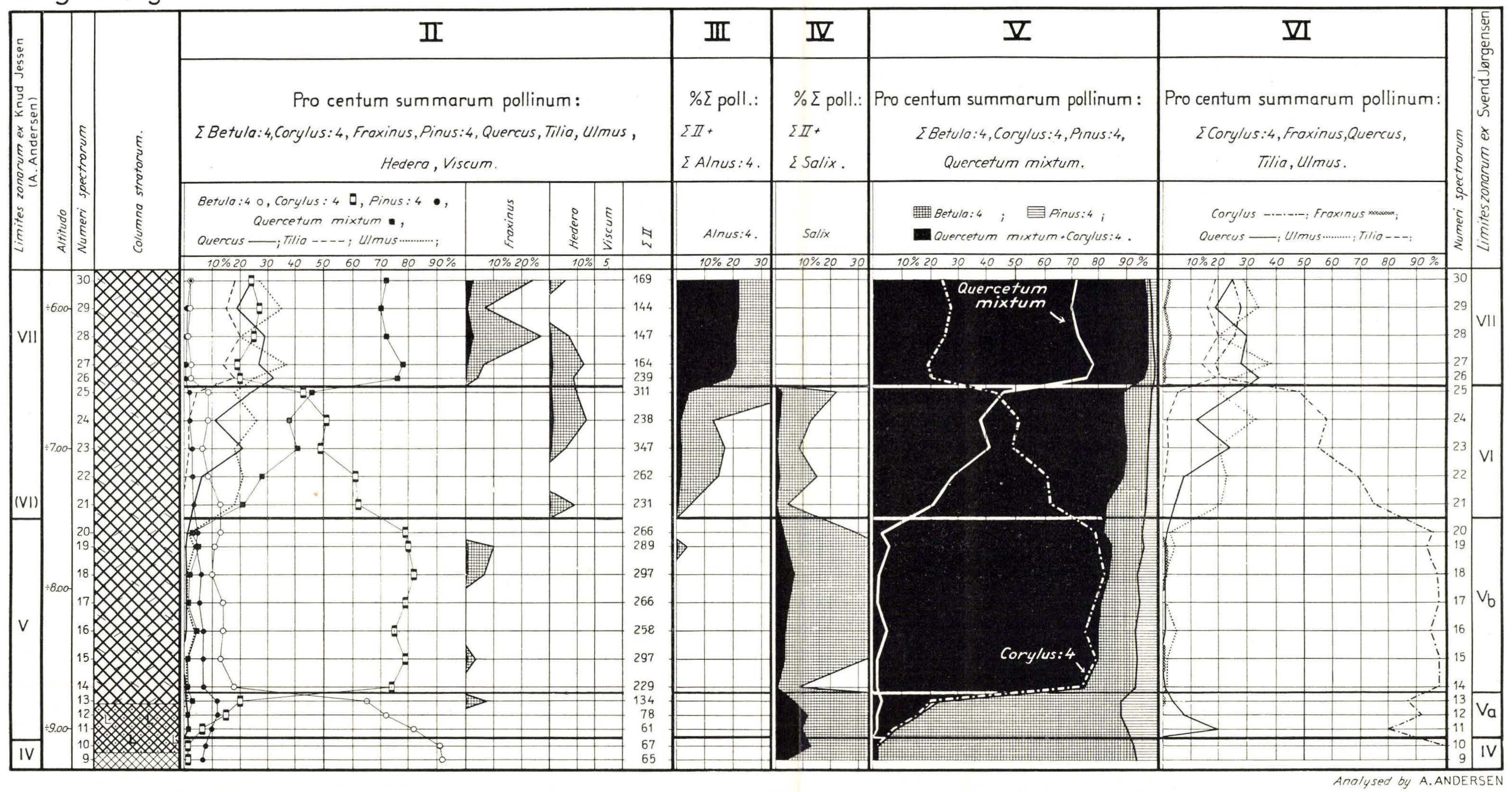
Plate XVI.

Explanation see page 164.

Fig. 5. Langesö. (Alfred Andersen, 1946). Text see page 172.

Fig. 6. Lake Even. (V. Mikkelsen, 1949). Text see page 173.

Langesø, Fyn. (Andersen, 1946)



Even (Mikkelsen 1949 Tavle VIII).

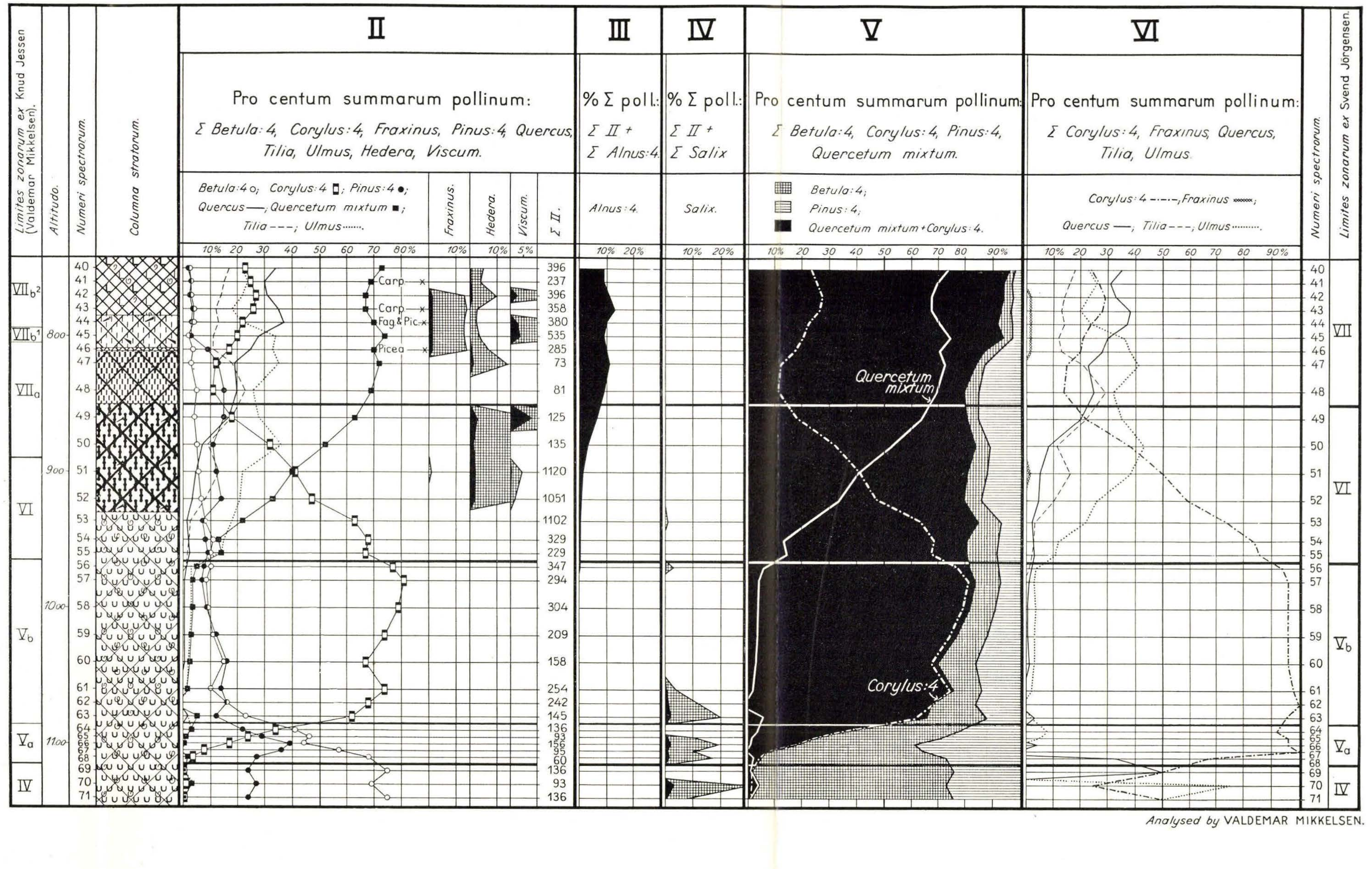


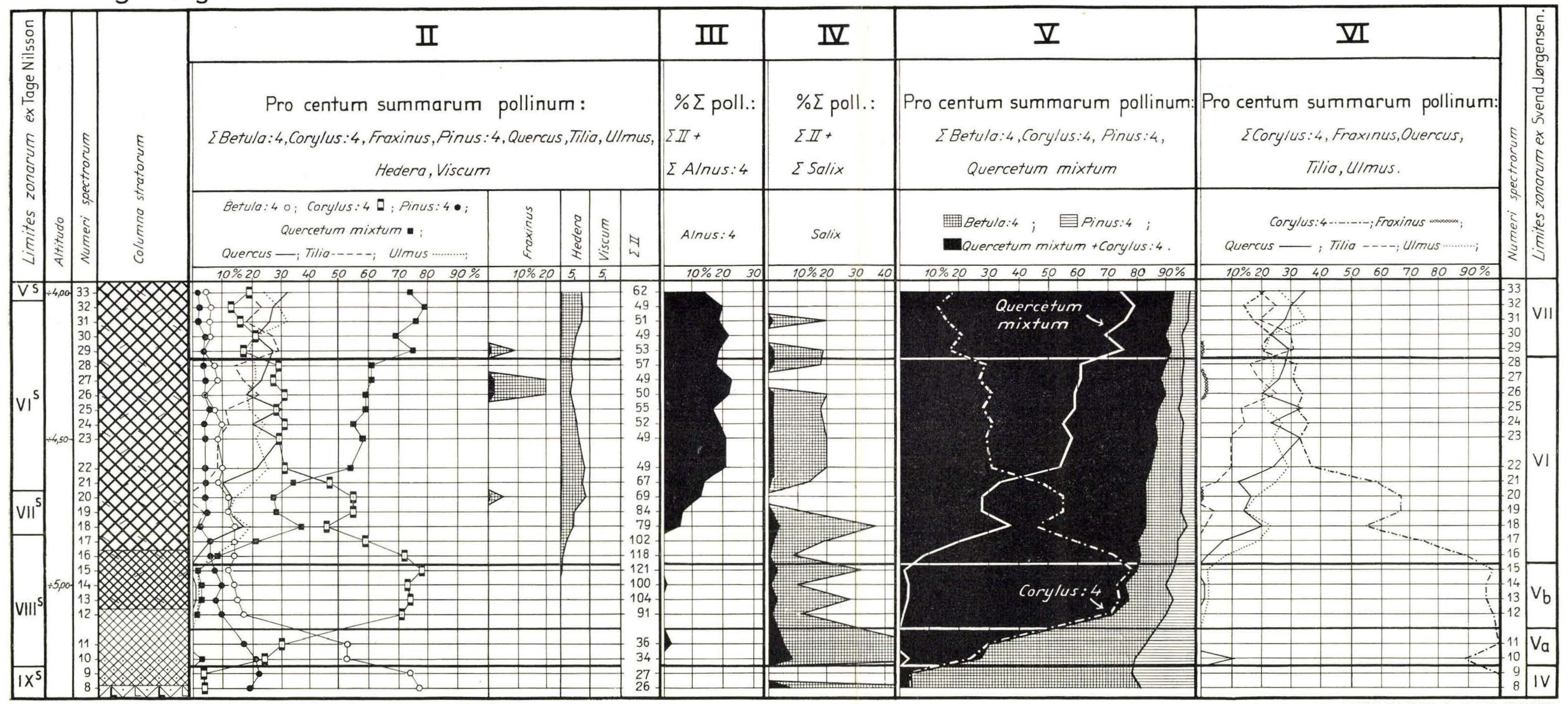
Plate XVII.

Explanation see page 164.

Fig. 7. Steveningen. (TAGE NILSSON, 1948). Text see page 174.

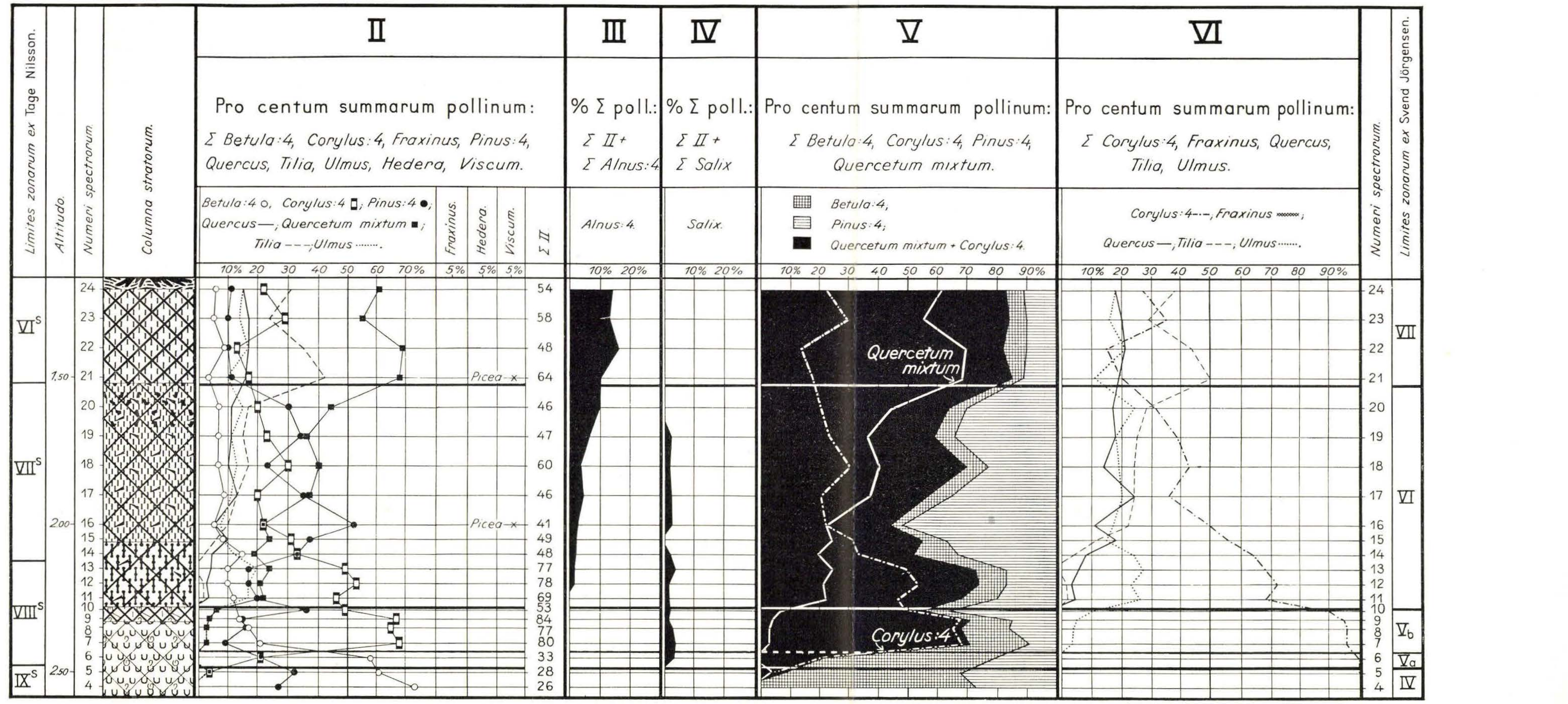
Fig. 8. Holmegaards Mose, (TAGE NILSSON, 1947). Text see page 175.

Stevningen, Fyn. (Nilsson 1948 Tavle I)



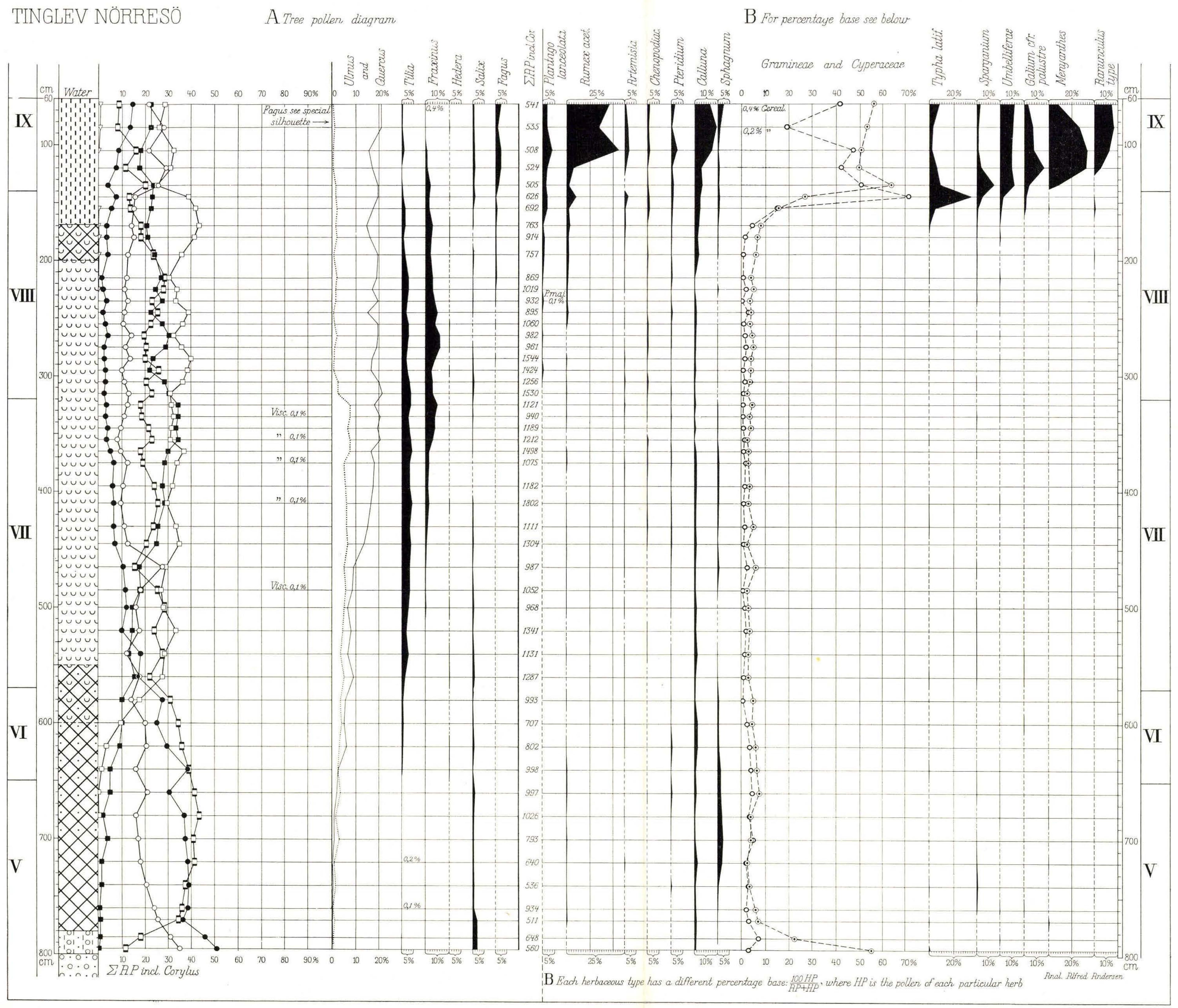
Analysed by TAGE NILSSON & MAJA PERSSON

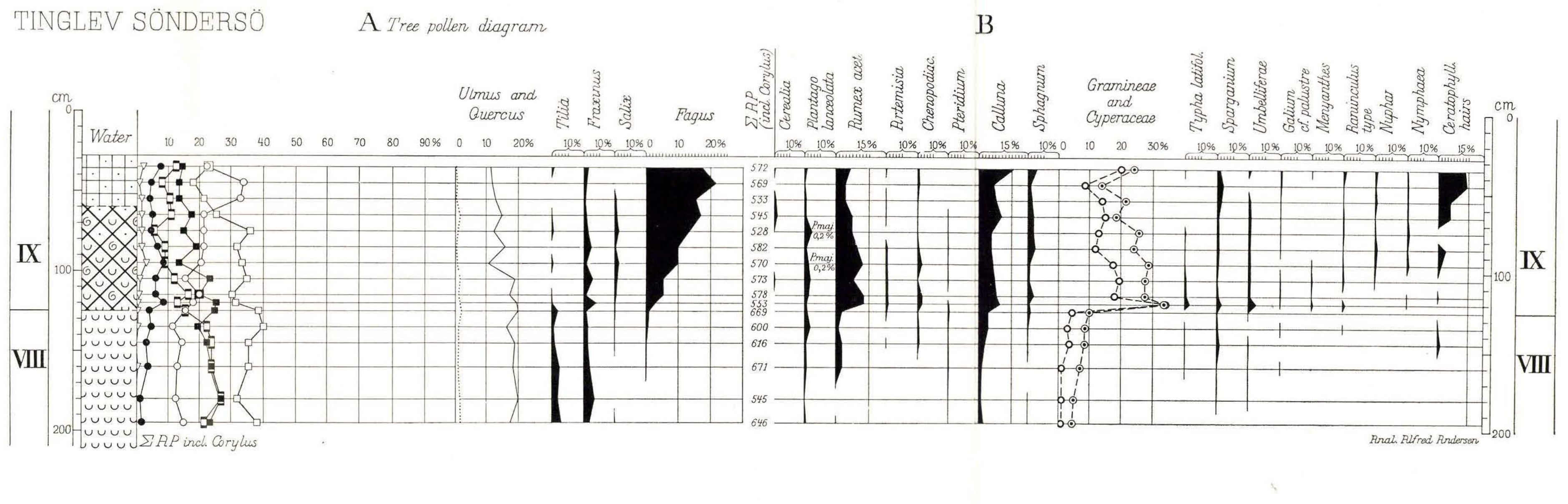
Holmegaards Mose. Western dwelling-place P_1. (Nilsson 1947).



Analysed by TAGE NILSSON & MAJA PERSSON.

Plate XVIII. Lake Tinglev.
(See page 190).





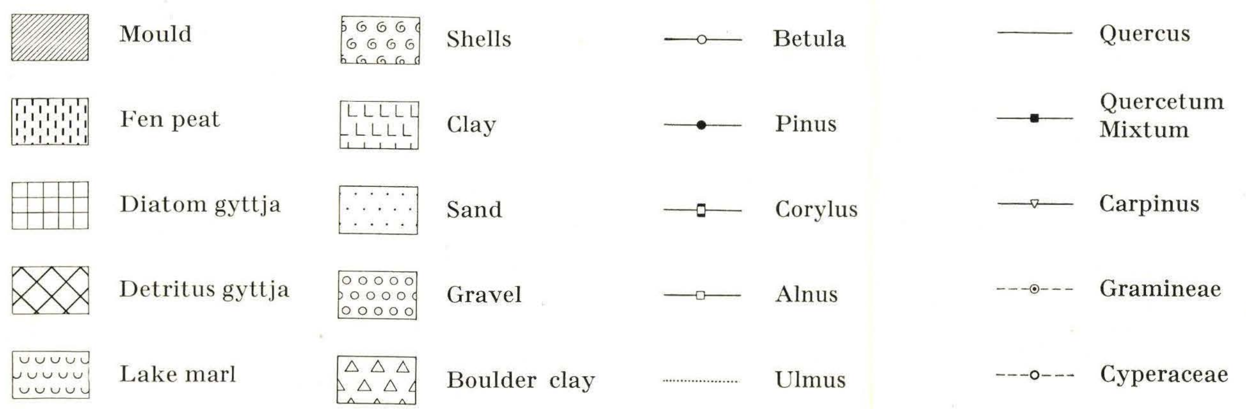
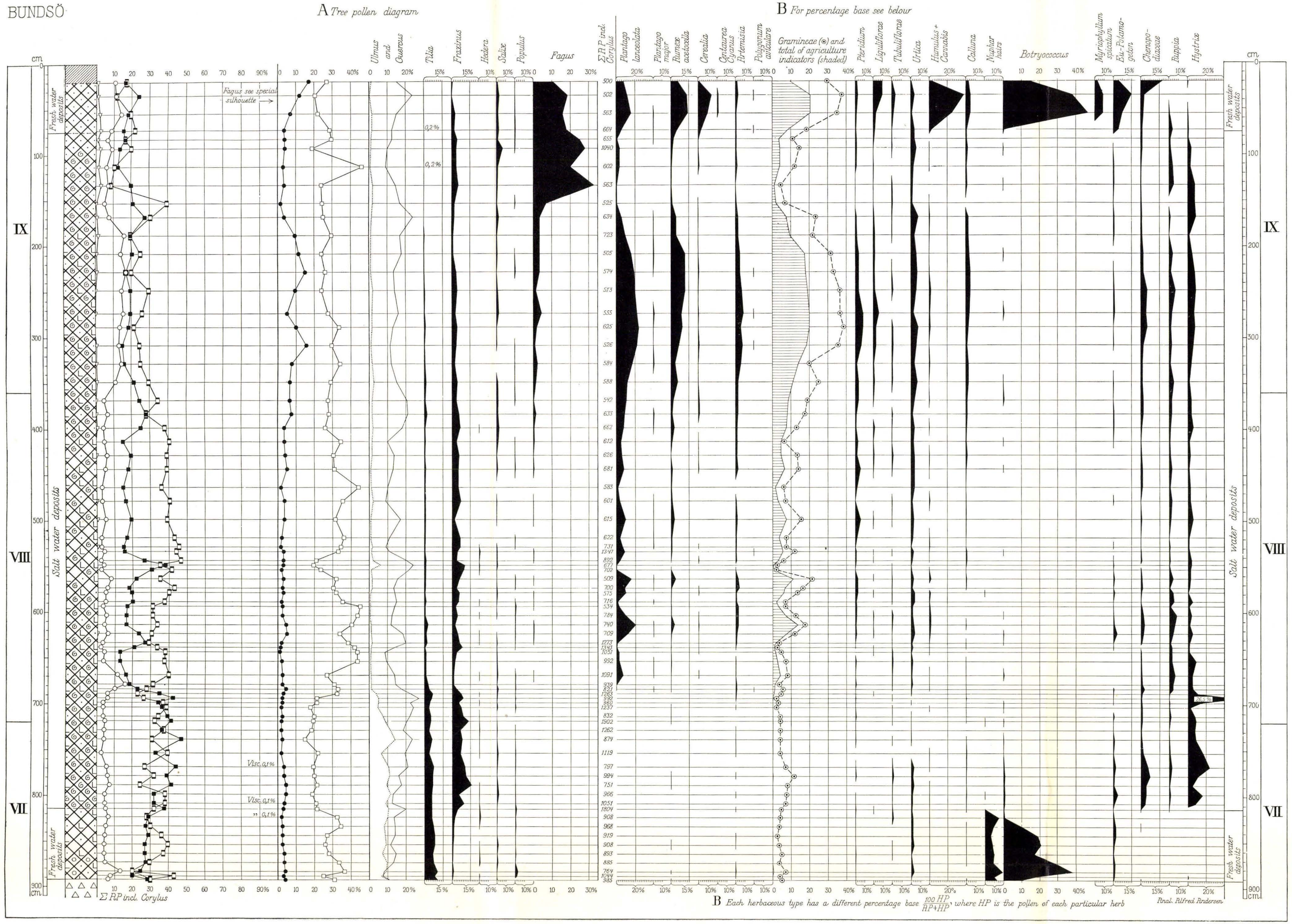


Plate XIX. Bundsö.
(See page 194).
Explanation see plate XVIII.



Figs. 1–2. Pollen diagrams from Græssöen (fig. 1) and the Ankermyr (fig. 2). A supplement to these diagrams is given in tables III–IV page 226–228. Depths are measured from the surface downward.

Cerelia: The first analysis containing pollengrains which can be determined to *Secale* is marked Sec.

Gram. sm.: *Gramineae* less *Cerealia* (i. e. wild grasses).

Cent. cyan.: *Centaurea cyanus* (cornflower).

Melamp.: *Melampyrum cf. pratense.*

Ericales: Mostly *Calluna.* In the lower analyses in fig. 1, however, *Empetrum.*

Typha lat.: *Typha latifolia.*

Menyanth.: *Menyanthes trifoliata.*

Myrioph. alt.: *Myriophyllum alterniflorum.*

The diagrams are divided in sections:

A comprises the trees, the pollentotal of which are given as Σ AP.

B_1 and B_2 comprise the shrubs and herbs. The percentages are calculated on a total of AP + the species in question.

B_1. The curves are shown to the same scale as in A.

B_2. The scale is halved compared with the other sections in the diagrams.

C_1. Reduced pollen diagram giving an approximate relation between the areas of 1. forest (black area), 2. more or less cultivated land (white area), and 3. heath (dotted area).

The total on which the percentages are calculated comprises:

1. Pollen from the trees of the forest, represented by the species of section A less *Juniperus* plus *Corylus.* The values for *Pinus, Betula, Alnus,* and *Corylus* are divided by 4 (cf. Iversen 1949, Mikkelsen 1949).
2. Pollen from plants of the fields and commons, represented by culturepollen and pollen of wild grasses.
3. Pollen from plants of the heath, represented by *Ericales* and *Juniperus.*

C_2 gives the values for fields and commons, which are difficult to read in C_1.

The dates given to the right of the diagrams are approximate.

Fig. 3.

a. Section across Græssöen.

The clay content of the wood peat was easily detectible in the field only at the eastern end of the basin and in the lower parts of the other borings. The dotted line shows the probable limit of the upper clayey layer in the whole section, as inferred after its discovery during microscopic study of P 3.

The *Sphagnum cuspidatum* peat contained much wood in places but the lamination caused by *S. cuspidatum* was unmistakeable.

In P3 the upper 30 cm. of the *Sphagnum* peat were somewhat more humified (H5–6) than the lower part of this peat (H2–3), but no distinction between various grades of humification is made in the section.

b. Key to the symbols.

1. *Sphagnum* peat.
2. Fen peat containing some mosses.
3. *Equisetum limosum* peat.
4. *Sphagnum cuspidatum* peat.
5. Wood peat without clay.
6. Clayey wood peat.
7. Mud (gyttja) with clay.
8. Nekron mud (gyttja). Not found in Græssöen but in the Ankermyr.

S. Sand

SC. Sandy clay.

Fig. 1.

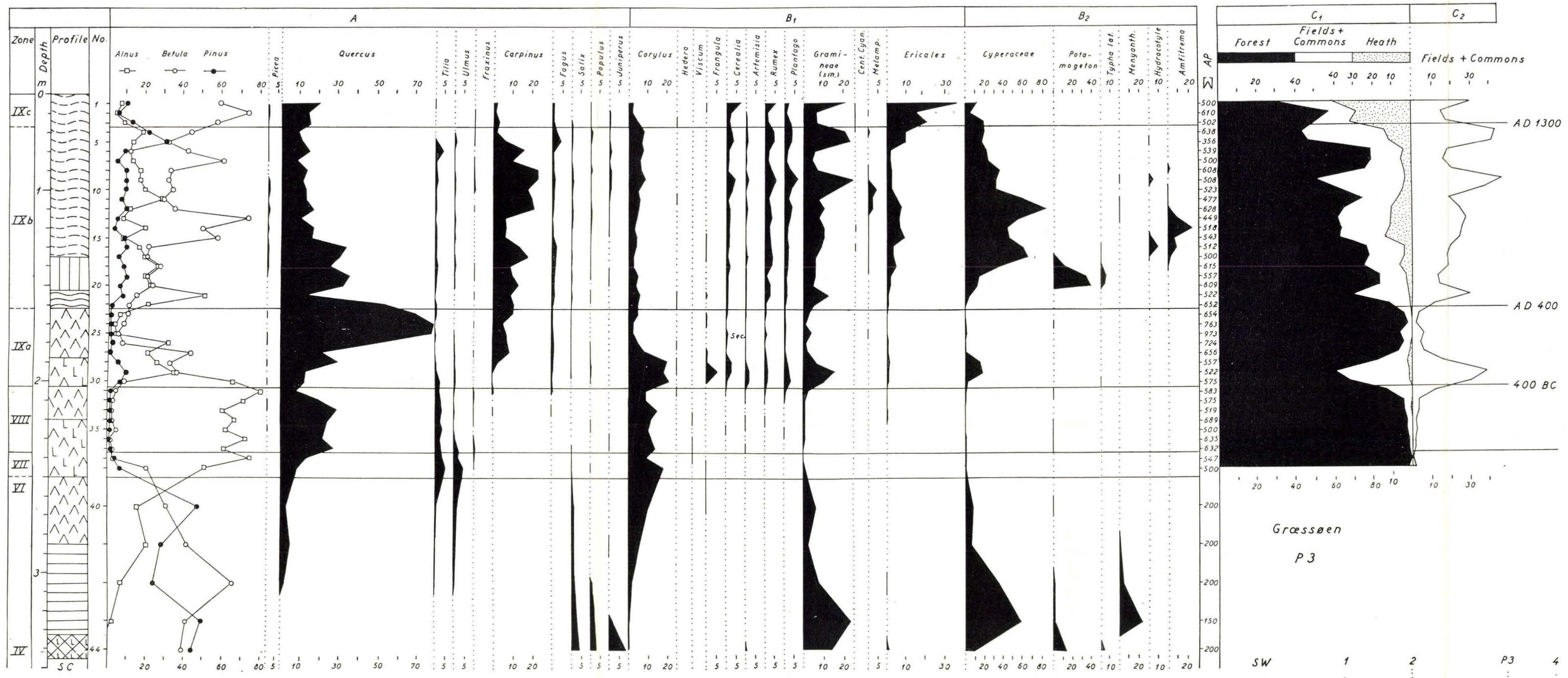


Fig. 2.

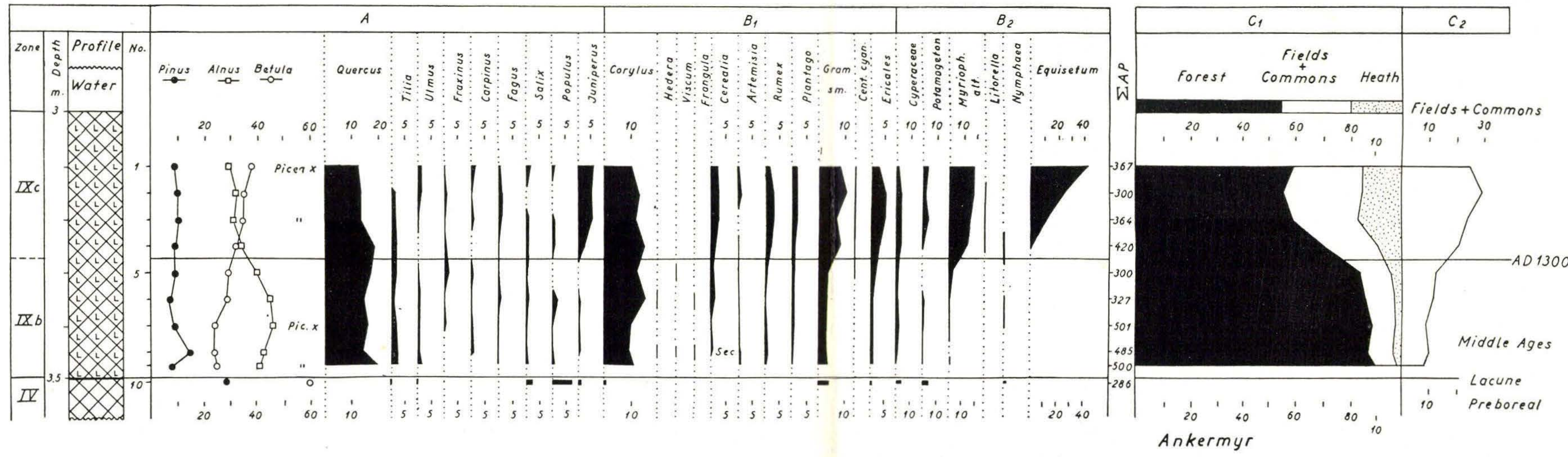


Fig. 3.

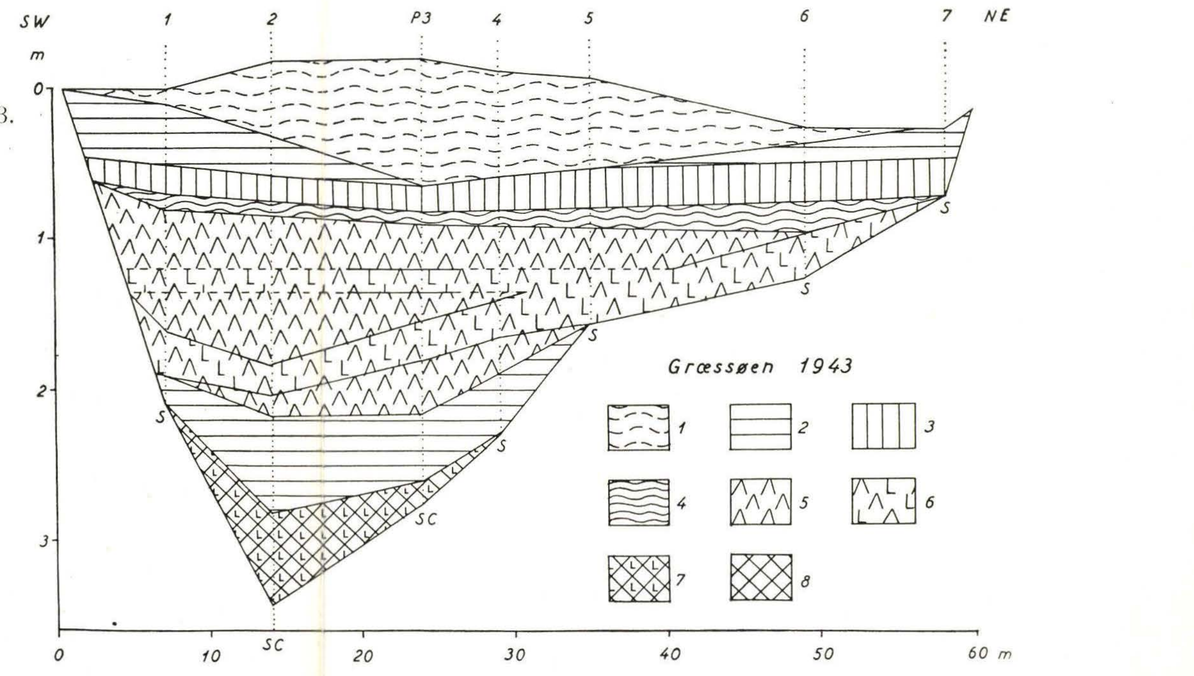
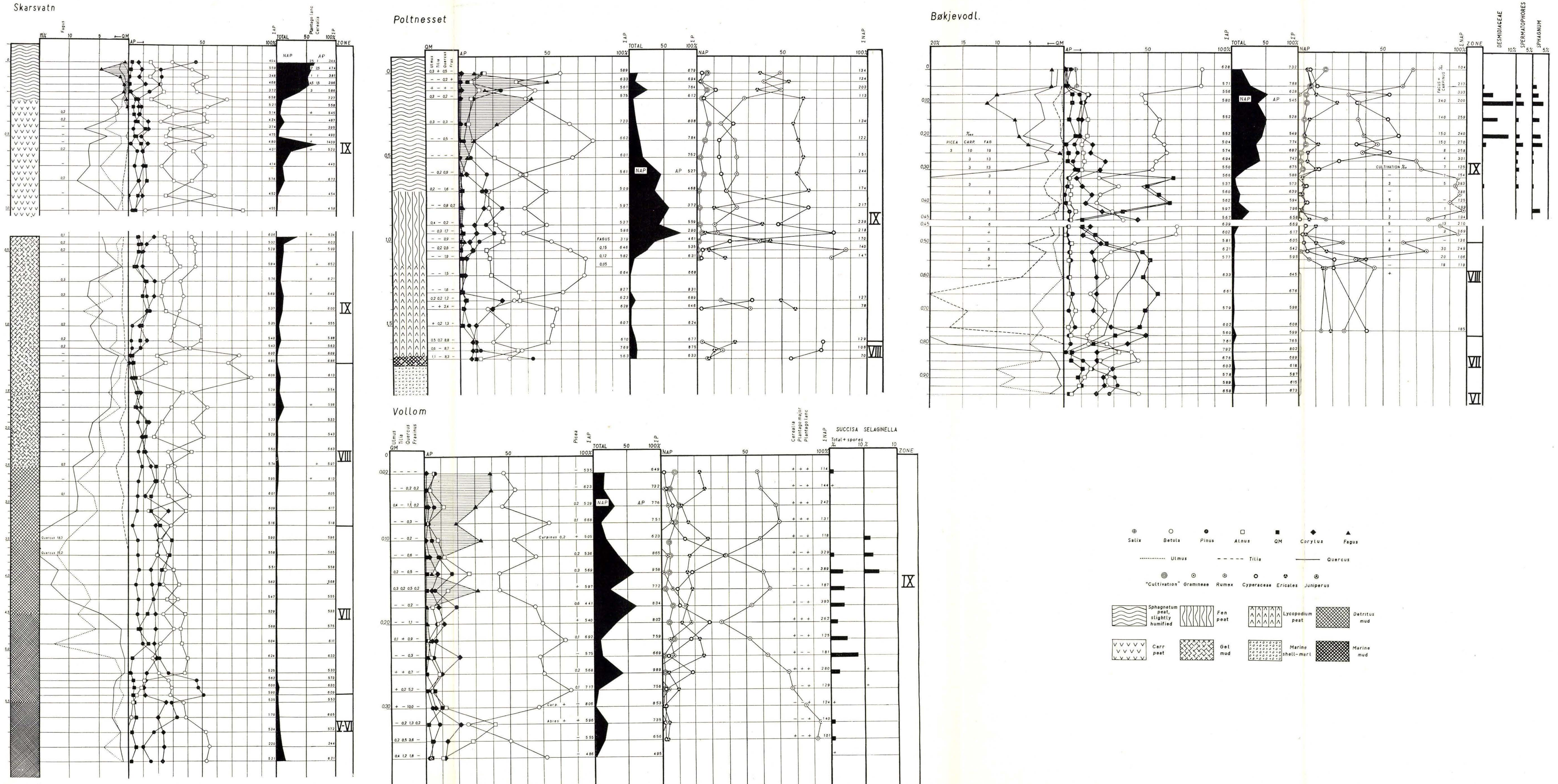


Plate XXI.


Skarsvatn
Poltnesset
Bøkjevodl.
Vollom
SUCCISA SELAGINELLA
Salix
Betula
Pinus
Alnus
QM
Corylus
Fagus
Ulmus
Tilia
Quercus
"Cultivation"
Gramineae
Rumex
Cyperaceae
Ericales
Juniperus
Sphagnetum peat, slightly humified
Fen peat
Lycopodium peat
Detritus mud
Carr peat
Gel mud
Marine shell-marl
Marine mud

FR. BAGGES KGL. HOFBOGTRYKKERI
KØBENHAVN