NORSK POLARINSTITUTT
SKRIFTER NR. 125

SVEIN MANUM

STUDIES IN THE TERTIARY FLORA OF SPITSBERGEN, WITH NOTES ON TERTIARY FLORAS OF ELLESMERE ISLAND, GREENLAND, AND ICELAND

A PALYNOLOGICAL INVESTIGATION

WITH 26 FIGURES IN THE TEXT AND 21 PLATES

NORSK POLARINSTITUTT
OSLO 1962

DET KONGELIGE DEPARTEMENT FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT
Observatoriegt. 1, Oslo, Norway

Short account of the publications of Norsk Polarinstitutt

The two series, Norsk Polarinstitutt — SKRIFTER and Norsk Polarinstitutt — MEDDELELSER, were taken over from the institution Norges Svalbard- og Ishavsundersøkelser (NSIU), which was incorporated in Norsk Polarinstitutt when this was founded in 1948. A third series, Norsk Polarinstitutt — ÅRBOK, is published with one volume per year.

SKRIFTER includes scientific papers, published in English, French or German. MEDDELELSER comprises shorter papers, often being reprints from other publications. They generally have a more popular form and are mostly published in Norwegian.

SKRIFTER has previously been published under various titles:

Nos. 1—11. Resultater av De norske statsunderstøttede Spitsbergen-ekspeditioner.
No. 12. Skrifter om Svalbard og Nordishavet.
Nos. 13—81. Skrifter om Svalbard og Ishavet.
» 82—89. Norges Svalbard- og Ishavs-undersøkelser. Skrifter.
» 90— . Norsk Polarinstitutt Skrifter.

In addition a special series is published: NORWEGIAN—BRITISH—SWEDISH ANTARCTIC EXPEDITION, 1949—52. SCIENTIFIC RESULTS. This series will comprise 6 volumes. Hitherto 20 papers have been published, and the series will probably be completed in 1963.

Topographic and hydrographic surveys make an important part of the work done by Norsk Polarinstitutt. A list of the published maps and charts is found on the back of SKRIFTER.

A complete list of publications (including maps and charts) is enclosed in SKRIFTER NR. 123.

ÅRBØKER

Årbok 1960. 1962. Kr. 15.00.

LANDSCAPE IN VESTSPITSBERGEN

Photograph taken in Adventdalen, at an altitude of about 100 metres, in mid-July. Patches of *Dryas octopetala* L. flowering in the foreground. (Photo: S. MANUM.)

NORSK POLARINSTITUTT
SKRIFTER NR. 125

SVEIN MANUM

STUDIES IN THE TERTIARY FLORA OF SPITSBERGEN, WITH NOTES ON TERTIARY FLORAS OF ELLESMERE ISLAND, GREENLAND, AND ICELAND

A PALYNOLOGICAL INVESTIGATION

WITH 26 FIGURES IN THE TEXT AND 21 PLATES

NORSK POLARINSTITUTT
OSLO 1962

PUBLISHED BY NORSK POLARINSTITUTT
DISTRIBUTED BY OSLO UNIVERSITY PRESS
OSLO 1962

Preface

The present work was commenced on the suggestion of Mr. H. MAJOR, Geologist at Norsk Polarinstitutt, who at the time was investigating the Tertiary coals of Vestspitsbergen. It was hoped that the pollen and spores contained in the coals would provide a means of correlating the individual seams in the area. However, the material did not appear promising for a solution of the stratigraphical problems, and since it was placed in the hands of a botanist the mere botanical aspect attracted the greater interest. Comparisons with some other floras of similar age and latitudes formed a natural extension of the work.

I acknowledge my indebtedness to Mr. H. MAJOR not only for his readiness to help with geological information and for valuable discussions, but also for the material, which had been collected during several Spitsbergen expeditions, and which he placed at my disposal. My thanks for additional material are due to Mr. F. F. BARNES, Coal Geologist at the Alaskan Geology Branch of the U. S. Geological Survey (Alaska material), Mr. B. E. KOCH, Geologist at Grønlands Geologiske Undersøgelse (Greenland material), Mr. R. W. FEYLING-HANSSEN, Geologist at Norges Geologiske Undersøkelse (material from Sarsbukta), and to Mr. P. SUNDING (material from the upper plant-bearing series, Spitsbergen). The samples from Iceland were generously supplied by the late Mr. J. ÁSKELSSON, Reykjavík.

Professor O. A. HØEG of the University of Oslo, in whose department most of the investigations were made, has promoted the work in every respect. Thus I wish to express my deep gratitude for his never-failing willingness to place his experience at my disposal, and for his efforts to provide the best possible working facilities.

I am also indebted to Professor G. ERDTMAN, Palynologiska Laboratoriet, Stockholm, and Professor R. POTONIÉ, Amt für Bodenforschung, Krefeld, for the opportunities to visit their institutions and for help whilst there. To Dr. I. C. COOKSON, Melbourne, I wish to express my appreciation for valuable discussions and helpfull criticism of my English during her visits in Oslo.

The financial support from Norges Almenvitenskapelige Forskningsråd is gratefully acknowledged.

Contents

Notes on the Lower Tertiary floras of some northern localities outside Spitsbergen

Introduction

Geology

The Tertiary sequence in Spitsbergen was briefly treated by ORVIN (1940) and described in more detail by NATHORST (1910). The distribution of the Tertiary system is shown in the map (text-fig. 1). The Tertiary is represented in Vestspitsbergen, which is the largest island in the Spitsbergen archipelago, and in Prins Karls Forland.

In Vestspitsbergen the Tertiary beds are preserved mainly in a syncline south of Isfjorden where the thickness of the formation in some places is nearly 2000 metres. Continental as well as marine beds are represented. NATHORST (1910) divided the formation into six series, the lower- and uppermost of which are of interest to the present investigation as they contain coal seams and other plant-bearing horizons.

The lowermost series (NATHORST's "Lower light sandstone series") is 110–130 metres thick, and the basal 50–60 metres contain several coal-seams from which most of the material examined has been collected. The following descriptions of the seams are based on personal communications with Mr. H. MAJOR. MAJOR has distinguished and named five main seams which, however, have developed differently in the various parts of the area. The "Svea-seam" is situated less than 10 metres above the base of the Tertiary sequence; the thickness is 3.5–4.5 metres in the Sveagruva–Reindalen district where the seam was formerly worked by the Sveagruva mines; in the Longyearbyen district the seam is very weakly developed. Next in the sequence is the "Todal-seam", which has also been worked by Sveagruva, where it occurs in thicknesses of up to 1 metre. This seam is also weakly developed around Longyearbyen. The "Longyear-seam" is the most developed one around Adventdalen where the thickness is 0.7–2.0 metres; it is at the present worked by the Longyearbyen mines. The "Svarteper-seam" and the "Askeladd-seam" are both rich in ashes and are more or less frequently interrupted by bands of carbonaceous rock. The "Askeladd-seam" terminates the succession of coal seams in the bottom series.

In some localities in the lowermost part of the coal-bearing sequence there is a shale particularly rich in plant fossils (the "Taxodium-shale"[1], NATHORST 1910, p. 384). Several marine horizons in the coal-bearing sequence indicate that the sedimentary basin was a low area close to the sea.

The uppermost series (NATHORST's "Upper plant-bearing sandstone series") is separated from the lowermost one by several hundred metres of sandstone and

---

[1] See p. 85, footnote.

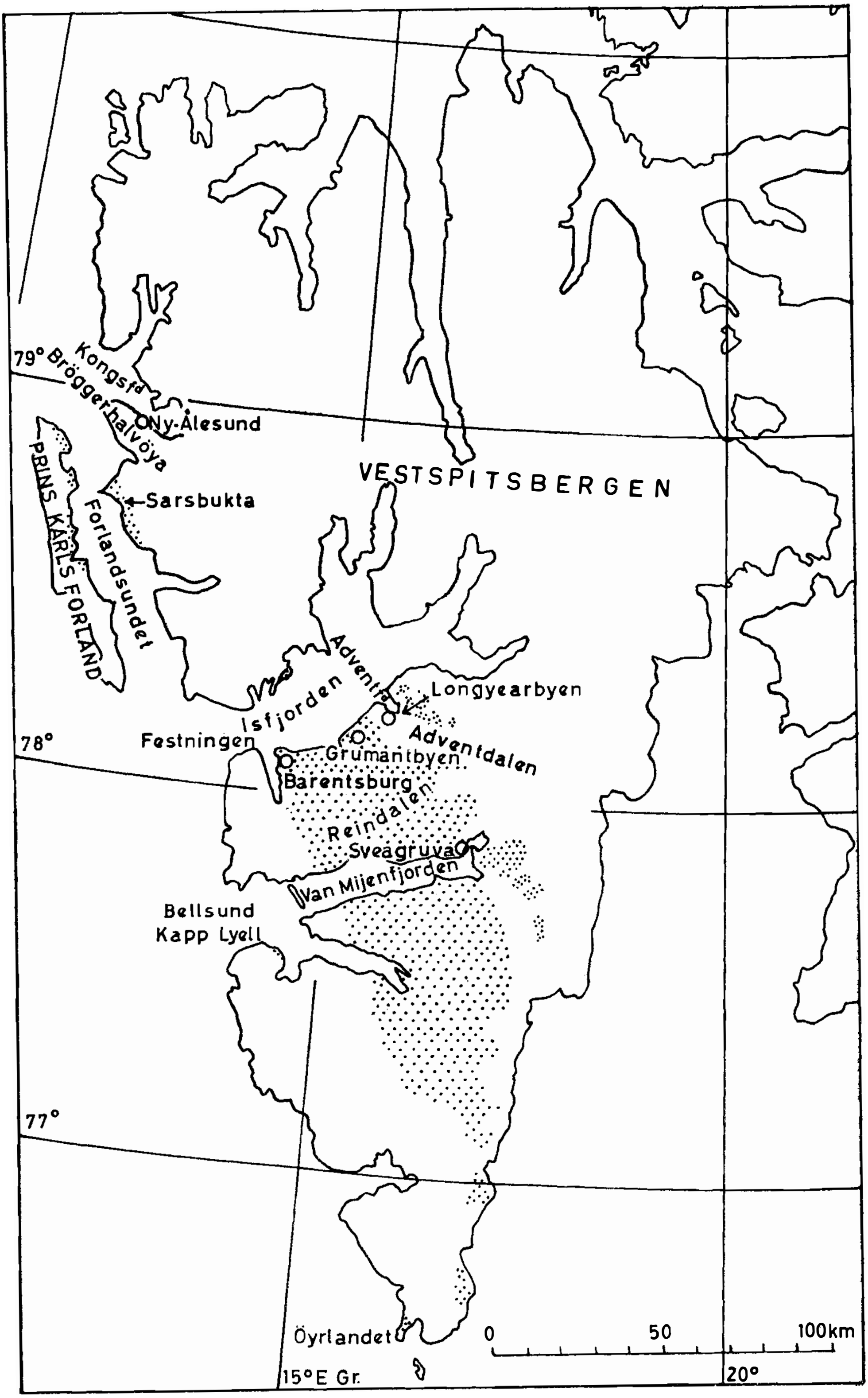


Fig. 1. The Tertiary system in Spitsbergen (dotted areas). Scale 1 : 2 000 000

shales. This series contains many thin coal-seams and horizons particularly rich in plant impressions. No marine fossils are known from this series.

Tertiary beds with several coal-seams occur in a small area around Ny-Ålesund on the eastern part of Brøggerhalvøya. These beds are held to be contemporaneous with the lower series of the main Tertiary basin (ORVIN 1934). Some of these seams are being mined at Ny-Ålesund.

Isolated Tertiary areas of interest are found also at Kapp Lyell and on both sides of Forlandsundet. These beds have not yet been accurately correlated with the main Tertiary basin, but on lithological and paleontological grounds they are considered contemporaneous with, or younger than, the uppermost series of the main basin.

HEER, in his "Flora fossilis arctica", claimed the Spitsbergen Tertiary to be of Miocene age. To some extent this dating was supported by FUCHS (1883) who found that the composition of the marine faunas might indicate a Miocene age. FUCHS' material, however, was very unsatisfactory, and none of his fossils could be specifically identified. Later, RAVN (1922) had the opportunity to study more adequate collections of Mollusca from several expeditions. His conclusion (l. c. p. 12) was that "it is very probable, if not absolutely certain, that at all events the older part of the Tertiary of Spitsbergen (including NATHORST's third series) was deposited towards the end of the Paleocene epoch, and – – it may be supposed that the other part of the whole series is but little younger". It is now generally accepted that the Spitsbergen Tertiary is of Paleocene-Eocene age, although a more definite dating remains to be settled.

Material

The Spitsbergen localities from which samples have been studied belong – except for the Sarsbukta and Ny-Ålesund ones – to the main Tertiary basin. Their positions are shown on the maps (text-figs. 1 and 2), and details are given in table I (p. 10). The samples have been collected during various expeditions organized by Norsk Polarinstitutt.

The samples from the main basin are all non-marine and belong either to the lowermost or the uppermost of NATHORST's divisions. The majority of samples are from coal beds of the lowermost series as these are of greater interest and have yielded more successful macerations.

Many of the samples investigated were taken from larger samples of coal crushed for quality tests. These test samples had been made so as to represent the average of a column through the whole, or part, of the seam. A small amount taken from such a sample naturally cannot be considered an adequate average of the original material. Such samples should be advantageous for obtaining representative microfossil assemblages from the coals but not for stratigraphical purposes within such a limited sequence as the coal-bearing part of the Spitsbergen Tertiary.

The preservation of the microfossils in the coal samples varies considerably. Thus, a series of samples from Svea Vestgruva contained practically nothing identifiable as pollen or spores but abundant microscopic resinoid bodies of

Table I

List of the Spitsbergen localities

Nathorst's divisions		Locality	Type of material	Map references (text-fig. 2, unless otherwise stated)
?		Sarsbukta	Soft marine claystones	Sarsbukta (text-fig. 1)
Upper plant-bearing sandstone series		Nordenskiöldfjellet, top plateau	Coal	U 1
		Do.	Light fine-grained sandstone with plant impressions	(Preparations inadequate)
		Nordenskiöldfjellet, loose material from east slope, 870 m a.s.l.	Do.	(Do.)
		Lars Hierthafjellet, loose material from north ridge, 800 m a.s.l.	Dark fine-grained sandstone with plant impressions	(Do.)
		Do. 805 m a.s.l.	Coal	U 2
		Do. 850 m a.s.l.	Coal	U 3
		Do. 870 m a.s.l.	Coal	(Preparations inadequate)
		Lars Hierthafjellet, east ridge, 810 m a.s.l.	Light fine-grained sandstone with plant impressions	(Do.) U 4
		Ishøgda, south-east ridge, 720 m a.s.l.	Coal	U 5
Flaggy sandstone series		No samples investigated		
Upper black shale series				
Green sandstone series				
Lower dark shale series				
Lower light sandstone series	"Askeladd-seam"	Endalen, west side, 290 m a.s.l., between 10 and 20 cm below roof of seam	Coal, rich in ashes	A
		Do., 20–30 cm below roof of seam Do., 30–40 cm » » » »	Carbonaceous silt rock with some coal	(Preparations inadequate)
	"Longyear-seam"	Longyearbyen, Mine I, from sample representing average of seam	Coal	L 1
		Do., roof of seam	Dark fine-grained sandstone with thin coal-stripes	(Preparations inadequate)
		Do., 50–55 cm below roof of seam Do., 100–110 » » » » » Do., 185–188 » » » » »	Carbonaceous silt rock	
		Longyearbyen, Mine II, from sample representing average of seam	Coal	L 2
		Longyearbyen, Mine II, 0– 4 cm below roof of seam Do., 10–15.5 » » » » » Do., 19–26 » » » » » Do., bottom of seam	Coal Coal Coal Carbonaceous silt rock	
		Longyearbyen, Mine II, 7–11 cm below roof of seam Do., 24–28 » » » » » Do., bottom of seam	Coal Coal Carbonaceous silt rock	

Table I (cont.)

Nathorst's divisions	Locality		Type of material	Map references (text-fig. 2, unless otherwise stated)
Lower ligth sandstone series	"Longyear-seam"	Longyearbyen, Mine II, roof of seam	Coal-stripes in the fine-grained sandstone	L 2
		Do., 14–18 cm below roof	Coal	
		Do., bottom of seam	Carbonaceous silt rock with several coal-stripes	
		Mountain-side west of Höganäsbreen, 36 m above base of Tertiary	Coal scrap	L 3
	"Todal-seam"	Do., 25 m above base of Tertiary	Coal	L 3
		Svea, Vestgruva, several selected samples from a section of the seam	Coal	(Preparations inadequate)
	"Svea-seam"	Svea, Østgruva, from sample representing average of upper 100 cm of seam	Coal	S 1
		Svea, *c.* 800 m north-east of Østgruva, from sample representing average of seam	Coal	S 2
		Röysklumpen, west ridge, 570 m a.s.l., random sample of seam	Coal	S 3
		Bassen, south-east ridge, *c.* 600 m a.s.l., random sample from upper 100 cm of seam	Coal	S 4
		Do., random sample from lower 34 cm of seam	Coal	
	Exact position in relation to coal seams uncertain	Festningen, Metasequoia-shale	Black, bituminous shale with plant fossils	Festningen (text-fig. 1)
(Probably same series)		Ny-Ålesund, plain between the rivers from E. and W. Brøggerbre respectively	Light fine-grained sandstone with plant impressions (*Equisetum* sp.)	Ny-Ålesund (text-fig. 1) (Preparations inadequate)
		Ny-Ålesund, Ester-seam, from samples representing average of seam	Coal	
		Do., Sofie-seam, do.		

unknown nature. In some other samples the preservation was very poor, e. g. in those from the Ny-Ålesund coal field.

Non-coaly as well as carbonaceous rocks which appeared promising for microfossil study have also been examined, but where fossils were present, the preservation was usually too poor to make detailed examinations worth while. The Sarsbukta marine samples form the most important exception, as the preservation of their fossil contents is considerably better than in any of the other samples.

When selecting samples for closer study, more weight has been attached to the state of preservation of the fossils than to the possible stratigraphical interest of the material. Further, material from some interesting localities, such as Kapp

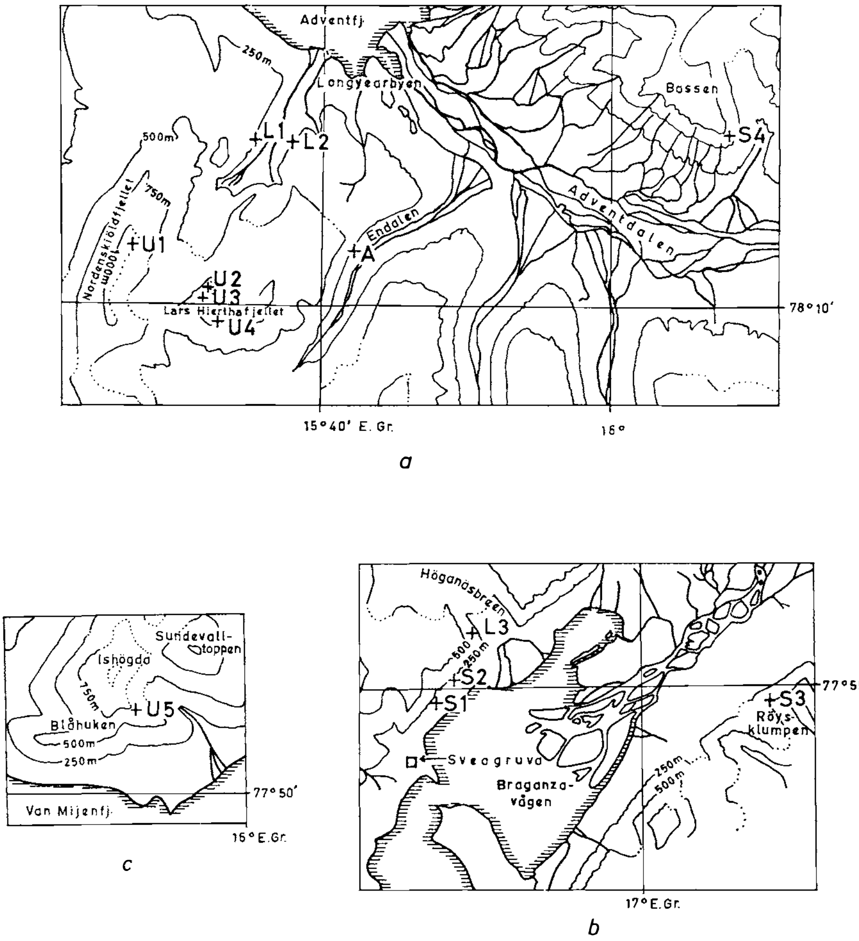


Fig. 2. The positions of the localities around Longyearbyen (a), Sveagruva (b), and on Ishøgda (c). Scale 1 : 200 000.

Lyell and Prins Karls Forland, has not been available; and suitable samples from the area around Sarsbukta have been scarce. Also suitable material from the upper plant-bearing sandstone series of the main basin has been scarce, and the preparations are of poor quality. The Ny-Ålesund locality is poorly represented, and the few samples studied proved most unpromising. Therefore, the present material has offered very little to clarify the stratigraphical correlation of the isolated localities to the west and north-west with the main Tertiary basin.

Preparation of material

SCHULZE's macerating solution was used for the oxidization of coal samples (MANUM 1956); concentrated nitric acid (sp. gr. 1.40) was added to a mixture of approximately equal parts of potassium chloride and ground coal. The required duration of the treatment was from under one hour to nearly four days. Coals from the upper plant-bearing sandstone series need the shortest treatment time, corresponding to their lower rank (streak brownish to brown). For maceration of such easily oxidizable samples cooling was usually necessary to prevent too violent an effect. Hydrogen peroxide was tried as an oxidizing agent, but it proved less successful and convenient than SCHULZE's solution.

After oxidization the samples were rinsed with water and then treated for a few minutes with hot two per cent potassium hydroxide solution. The samples were then rinsed repeatedly with water and centrifuged.

Dilute ammonia may be used instead of potassium hydroxide, but it does not improve the results and is less pleasant to use. For several samples ERDTMAN's acetolysis method was tried after oxidization, but with satisfactory results only for some low-rank coals. It offered no apparent advantage over the traditional alkali treatment. Chlorination and subsequent acetolysis (after ERDTMAN), which may give excellent results with brown coals, did not work for even the most easily oxidizable Spitsbergen coals.

Carbonaceous shales and coals rich in ashes were treated in the same way as the pure coals, except that a treatment with hydrofluoric acid was usually necessary to remove the mineral particles which otherwise hampered the microscopic examination.

For non-coaly samples the traditional hydrofluoric acid treatment was used, and subsequent oxidization and alkali treatment of the organic residue were usually necessary. In some cases the chlorination-acetolysis method gave good results. On the whole, an attempt was made to treat the samples according to their varying requirements, which may differ considerably.

Maceration residues are kept in glycerin suspension in glass tubes. The microfossils are of a brownish to yellow colour, which makes staining generally unnecessary, but when required, fuchsine was used.

The preparations were mounted in glycerin jelly and were sealed with paraffin wax placed upon the warm slide and allowed to enter under the cover slip before the jelly reached its edges.

When microfossils are to be stored for future reference, single grain preparations are preferable. To single out adequate specimens for such preparations, however, when scarce in the material, is time-consuming. About three hundred single grain preparations were made, but a great number of the described specimens had to be preserved in ordinary preparations. From these the specimens are recovered with the aid of the mechanical stage coordinates of the microscope.

Nomenclature

A binominal designation, as applied to macroscopic plant fossils, has for a long time also been used for fossil spores in the broad sense. The taxa here concerned are species of organ genera or form genera as these are defined in Article PB. 1 of the International Code of Botanical Nomenclature[1] (in the following referred

---

[1] These nomenclatural considerations were based on the Paris Code. The Montreal Code was published when this work was already in press. The special appendix concerning fossil plants has been omitted from the Montreal Code, where the rules for fossil plants are incorporated in the main body of the code. Other changes cannot be recognized in the new code which are significant for the nomenclatural considerations in this work.

to as the "Code"). A clear distinction between form genera and organ genera in this connection is not always possible, as pointed out by POTONIÉ (1956 a, p. 72). This is not essential, however, as long as the creation of taxa above the rank of genera is avoided, and an artificial ("morphographic") key system is used for the arrangement of the genera.

Fossil pollen and spores are not specially provided for in the Code. Some authors (inter al. VAN DER HAMMEN 1956) consider special rules necessary in order to handle the nomenclature problems of these fossils, whereas others find the existing rules to be satisfactory (FÆGRI 1956, POTONIÉ 1956 a and 1958, TRAVERSE 1957, and others). It is evident, however, that if spore descriptions are published under binominal names for which priority is claimed, these must accord with the rules of nomenclature as laid down in the Code.

A brief study of the literature on fossil spores will show a confusion in their nomenclature. POTONIÉ's "Synopsis der Gattungen der Sporae dispersae" (1956 b, 1958, 1960) represents an important contribution to the clarification of the situation but hardly solves the problem in every case. Therefore a brief discussion of the nomenclatural problems encountered in the present work may be useful. First, some of the main reasons for the prevailing confusion will be pointed out:

1. Insufficient knowledge of botany and the rules of botanical nomenclature on the part of the authors in some cases.

2. The enormous increase during the last three decades in the number of names of pollen and spores described. For a general survey of the very numerous forms, suitable keys or "morphographic" systems have been provided for their logical classification. Many such keys have been proposed, and the various categories have been named on a descriptive basis (e. g. THOMSON & PFLUG 1953, VAN DER HAMMEN 1956). The designations used, however, have sometimes been treated as generic names with a legal status under the Code when the conditions necessary for this have not been fulfilled. Very often designations of this kind are synonymous with earlier ones.

3. When naming fossils which to some extent may be related to extant taxa, the supposed relationships have often been indicated in the designations adopted. Many such names, however, which were originally intended to call attention to supposed natural relationships and with no nomenclatural status, have later been uncritically adopted by some authors (e. g. the names in POTONIÉ, THOMSON & THIERGART 1950).

One way of bringing order into the nomenclatural confusion would be the adoption of a complete new set of rules for these fossils and the introduction of a system based on morphological terms. This system might also serve as a key to the genera. It would imply rejection of the priority of all earlier names which were out of harmony with the new nomenclature. VAN DER HAMMEN (1956) proposed this solution and described and established new genera for the more important forms. Such a systematic nomenclature would no doubt facilitate a survey of the great variety of pollen and spore forms and simplify the identification and classification of any new material. It would, however, be incompatible with the present nomenclatural rules. Such a system can therefore only serve as a key to the forms, but with no claim on priority for the names or terms adopted.

A systematic nomenclature based on principles similar to those of VAN DER HAMMEN was used by THOMSON & PFLUG (1953), but these authors claimed priority for the names they introduced. They rejected most of the earlier generic names because descriptions were lacking. It will be seen from the following that many of the names introduced by THOMSON & PFLUG are synonymous with those previously applied.

On the whole, it must be concluded that a logical morphographical nomenclature that is also legitimate, is at the present impracticable because of the great number of existing generic names of non-morphographic type which have a status under the Code.

Many authors have included fossil pollen and spores, particularly Cenozoic ones, in the taxa of modern plants when the natural affinities of the fossils have seemed probable. For the naming of the fossils mainly two different systems have been adopted. In one (used inter al. by RUDOLPH 1935, THIERGART 1940, ZAKLINSKAJA 1953) the fossils are referred to modern genera, and – if possible – to species, without coining new names (e. g. "*Alnus* sp.", "*Alnus* aff. *incana*"). This practice seems unobjectionable. In the other (used inter al. by WODEHOUSE 1933, BOLCHOVITINA 1953, COUPER 1953, TRAVERSE 1955) new species (organ species) are established for the fossils, which are then ranked among the natural species of modern genera, and – where affinity to a modern genus is less certain – new genera (organ genera) are also set up and ranked among the modern genera in the natural plant families.

TRAVERSE (1957) has strongly advocated the inclusion of organ species, based on fossil pollen and spore forms, into the natural genera of living plants. He stated that the main purpose of his paper (l. c. pp. 257–258) was "to back strongly the idea that fossil species of extant genera are organ species and that the recognition of this fact helps one greatly in handling nomenclatural problems. That all fossil species of extant genera are organ species, not natural species, is evident." The last sentence of that statement contains the reason for my rejection of TRAVERSE's practice. A natural genus is intended to unite as closely as possible genetically related natural species. The difference between the concepts of organ species and natural species is so wide that a co-ordination of the two under one generic name causes serious confusion. It is true that such co-ordination is not expressly prohibited in the Code; but like POTONIÉ (1956 a and b), KREMP, AMES & FREDERIKSEN (1959), and others, I hold that organ species belong under organ genera only, and should not be co-ordinated with the natural species of ordinary genera. TRAVERSE's examples 1) and 2) (l. c. p. 258), which demonstrate how "the common objections to creating fossil species of extant genera are eliminated by regarding these species as organ species", provide good arguments, indeed, against such co-ordination because of the resultant confusion.

In the present work the introduction of new generic names has been avoided. In cases when existing generic names have proved synonymous, the one which was found correct according to the Code has been maintained. For a logical arrangement of the pollen form genera the morphographic key introduced by IVERSEN & TROELS-SMITH (1950) is used.

Unfortunately, the application of some of the Code rules raises a few problems on which opinions diverge. One point debated has been whether or not the designations used in the early works of POTONIÉ and collaborators should be regarded as valid generic names (e. g. *Alni-pollenites*, *Piceae-pollenites*). These authors did not indicate whether their designations were meant as generic names with a status under the rules of nomenclature (e. g. by addition of "n.gen."), nor did they describe them. Their use of the names suggests that they were originally intended as alterable references to the natural affinity of the fossils (e. g. *Piceae-pollenites*, cp. MANUM 1960 a, p. 12). PFLUG (in THOMSON & PFLUG 1953, pp. 12–16) strongly criticized such names and considered them invalid owing to lack of description and other defects. In contrast to PFLUG, POTONIÉ (1956 a, pp. 75–76) claimed all the early generic names to be valid, even without a description. He held that before 1 Jan. 1953 a description was not conditional for a valid publication of a taxon of fossil plants, referring to Article PB. 3 of the Code, where from that date a description is required. As for Article 36, which demands that after 1 Jan. 1912 "an illustration or figure showing the essential characters, in addition to the description" should be given for a new taxon of fossil plants, POTONIÉ stated that "description" here is only incidental ("nur nebenbei erwähnt") and therefore not conditional before 1 Jan. 1953 (Article Pb. 3). It is difficult, however, to see how the conclusion can be avoided that Article 36 in both the English and German versions of the Code requires a description as well as an illustration. The acceptance of any undescribed, and therefore undefined, designation once published in a binary combination, seems a serious step towards more nomenclatural confusion.

POTONIÉ, in some early publications (1931 a, b, c, and d), employed a few symbols only for the characterization of the species. These symbols are, in my opinion, illustrations rather than descriptions. In later works (POTONIÉ 1934, POTONIÉ & VENITZ 1934, WOLFF 1934) the same species were described in detail, therefore the date of their valid publication is regarded as that of these works.

Some of the genera, however, for which a description is lacking, may nevertheless have been validly published, namely when the genus is monotypic and based on a new species. Then the description of the species also serves for the genus (Article 41). Such combined generic and specific descriptions of fossil plants are not valid after 1 Jan. 1953 (Article PB. 6). Examples: *Sequoia-pollenites* THIERGART (1938, p. 301) appeared as an undescribed new generic name to which a single new species (*S. polyformosus*) was assigned. The description of that species is at the same time a description of the genus, which therefore was validly published according to Article 41. *Juglans-pollenites* RAATZ (1937, p. 18) represents an analogous example. *Sciadopitys-pollenites* RAATZ (l. c. p. 13), however, was not validated by the combined generic and specific description, because the single species assigned to it was not a new one, but had been described earlier by POTONIÉ & VENITZ (1934, p. 15).

In many generic names – acceptable according to Article 41 – the names of genera of extant plants are used. In an objection to such names it has been claimed that originally they expressed merely the author's opinion regarding the natural relationships of the fossils and were not meant as generic names with a defined circumscription and a status under the nomenclatural rules. However, it is evident from Article 62 that a name which is otherwise in accordance with the rules cannot be rejected because a meaning had been implied that is not accepted later. In the work of POTONIÉ, THOMSON & THIERGART (1950) a number of names were published in which the names of extant genera were used. From the considerations of these authors l. c. pp. 39—40) it is obvious that these names were meant as proposals open to discussion and therefore must be regarded as provisional (Art. 33). Furthermore, none of the names were described and they were only used in combination with previously published species. Thus they have no legal status as generic names as was claimed for them by POTONIÉ (1958, p. 76), for example for *Laricoidites*.

When names of extant plants are used in generic names of pollen and spores, they will evidently arouse associations of natural affinities. However, the components of a form genus are not determined by such ideas of natural affinity, but by the diagnostic characters derived from the type species. POTONIÉ (1956 a) clearly observed this principle.

It seems logical that the above principle should also be applied where the geological age of pollen and spores is concerned. Evidently age alone cannot suffice as a "diagnostic character" by which organ genera or form genera may be distinguished. Therefore, the maintenance of two morphologically indistinguishable genera, one for Paleozoic and another for Tertiary spores, as in the cases of *Laevigatosporites* and *Polypodiaceaesporites* (POTONIÉ 1956 b, pp. 75–76) cannot be accepted.

Typification is a fundamental principle in botanical nomenclature (Code, Principle II) which applies also to genera and species of plant microfossils (Article 7, Note 5). Opinions differ, however, as to what constitute the types of fossil pollen and spore species. PFLUG (in THOMSON & PFLUG 1953) considered preservation of type specimens to be unnecessary, and held that a photograph of a specimen sufficed for a type. In the Code (Article 7) a nomenclatural type is defined as "that constituent element of a taxon to which the name of the taxon is permanently attached". Because a figure or a description does not represent a "constituent element" of a species, the type must be a specimen. Also Article PB. 4 demands a specimen as the type of a fossil plant species. In agreement herewith POTONIÉ (1956 a) declared a type specimen to be required by the Code. On the basis of Article 7, Note 3, however, he found an explicit indication of the type specimen by the author to be unnecessary; it suffices that specimens are quoted from which a type may later be selected. It seems desirable, however, that type specimens should be preserved and indicated for new species of fossil pollen and spores. On the other hand, earlier species and genera should not be rejected merely because indication of a type has been neglected.

Descriptions of pollen and spores from the Spitsbergen Tertiary

List of descriptions

Cedripites Wodeh.

Pityosporites Sew. emend. Man.

Disaccates ?
Abietipites Wodeh.

Inaperturates

Sciadopityspollenites Raatz emend. Pot.

Inaperturates incertae sedis

Monocolpates

Tricolpates

Tricolporates
Trudopollis Pf.

Stephanocolporates
Tetrapollis Pf.

(Triporates continued)

The slides are kept in the collections of Universitetets Paleontologiske Museum, Oslo, under the common number PAP 3. One series of slides marked by an S. before the slide number comprises single grain preparations. For specimens preserved in ordinary preparations mechanical stage coordinates are given, referring to microscope No. 328883 by Carl Zeiss, Jena, stage No. 77461, which belongs to Universitetet i Oslo, Farmasøytisk Institutt.

Descriptions

SPORITES

MONOLETES

Genus **Laevigatosporites** IBR. emend. POT. & KR.

1933. *Laevigato-sporites* IBRAHIM, p. 39.
1956. *Laevigatosporites* IBR. emend. POTONIÉ & KREMP, p. 137.
1956 b. *Polypodiaceaesporites* THIERG. ex POTONIÉ, p. 76.

Remark. The genotype of *Laevigatosporites* is a form species containing Carboniferous spores, therefore the genus was reserved for Paleozoic spores by POTONIÉ & KREMP (1956), and also by POTONIÉ (1956 b). For similar spores from younger deposits POTONIÉ (l. c.) described and validated *Polypodiaceaesporites* THIERG. (1938). However, geological age cannot be used as a "diagnostic character" for separating individual form genera. Since there is no morphological character by which *Polypodiaceaesporites* and *Laevigatosporites* can be distinguished, they must be regarded as synonyms (cp. p. 17), as also did THOMSON & PFLUG (1953, p. 59). *Laevigatosporites* must be used according to priority.

Laevigatosporites haardti (POT. & VEN.) TH. & PF.

Pl. I, fig. 1.

1934. *Sporites haardti* POTONIÉ & VENITZ, p. 13.
1953. *Laevigatosporites haardti* (POT. & VEN.) THOMSON & PFLUG, p. 59.

Description. Bilateral spores, exine *c.* 1.0 μ thick, entirely smooth, sometimes with a faint, minutely punctate pattern. Length 30–55 μ, commonly 50–55 μ. Shape varies, depending on the position of the spore at the time of flattening, usually nonsymmetrically oval with one side straighter than the other or even slightly concave in lateral aspect. Monolete scar prominent, about 2/3 the length of the spore.

Specimens: S. 75 (pl. I, fig. 1), S. 74, S. 76.

Affinities and remarks. The size and overall appearance of these spores vary a great deal, but in the absence of more distinctive characters a further classification is impracticable. They are typical polypodiaceous spores. The occurrence is sparse throughout the sequence.

Genus **Polypodiisporites** POT.

1933. *Polypodii-sporites* POT. in POTONIÉ & GELLETICH, p. 524.
1956 b. *Polypodiisporites* POTONIÉ, p. 78.

Remark. This generic name was validated by the description of the single species *P. favus* by POTONIÉ & GELLETICH (1933). The name of that species appeared already in POTONIÉ (1931 d), but without a validating description; its validation as a new species was therefore attained in the publication by POTONIÉ & GELLETICH which also fulfilled the requirements of a combined generic and specific description (Code, Art. 41). POTONIÉ (1956 b) subsequently provided the generic definition.

KRUTZSCH (1959, pp. 213–14), however, refused to accept the 1933 publication as valid because the name had not been explicitly intended as that of a form genus, and he regarded it as not being valid until the publication by POTONIÉ in 1956.

Polypodiisporites cf. **favus** POT.

Pl. I, figs. 2–7.

1933. *Polypodii-sporites favus* POT. in POTONIÉ & GELLETICH, p. 524.

Description. Bilateral spores with varying shape as in *Laevigatosporites haardti*. Monolete scar ½–⅔ the length of the spore. Sculpturing coarse, produced by pits connected by shallow grooves, thus forming irregular wart-like ridges and peaks. Two types represented:

Type A (pl. I, figs. 2–4). The longer diameter *c.* 41 μ, the shorter diameter 25–30 μ. Exine 1.5–2.5 μ thick. Pits prominent with diameters 1.0–2.5 μ. The area of the raised parts of the exine surface is approximately equal to, or slightly smaller than, that of the depressed parts.

Specimens: 32: 3.9–84.4 (pl. I, figs. 2, 3), 20: 11.6–88.9 (pl. I, fig. 4).

Type B (pl. I, figs. 5–7). The longer diameter 55–60 μ, the shorter diameter 35–40 μ. Exine *c.* 2.5 μ thick. Grooves, between 0.8 and 1.5 μ wide, more conspicuous than the pits. The area of the raised parts of the exine surface is considerably larger than that of the depressed parts.

Specimens: 59: 9.7–79.3 (pl. I, figs. 5, 6), 28: 11.7–87.8 (pl. I, fig. 7).

Affinities and remarks. The sculpturing resembles that of *P. favus* but is produced by pits and grooves rather than by warts. For this reason a definite identification with *P. favus* has not been made.

These spores must be referred to the Polypodiaceae. They occur sparsely in the lower series, Type B is rather rare.

TRILETES

Genus **Baculatisporites** TH. & PF.

1953. *Baculatisporites* THOMSON & PFLUG, p. 56.

Baculatisporites cf. **gemmatus** KRUTZSCH

Pl. I, figs. 8, 9.

1959. *Baculatisporites gemmatus* KRUTZSCH, p. 142.

Description. Equatorial outline subcircular, usually more or less distorted through folding; diameter 70–75 μ. Exine 0.5–0.8 μ thick, sculptured with rods of varying sizes spaced at intervals approximately equal to their diameters as seen in surface view. Rods 1.0–2.5 μ high and 0.5–2.0 μ in diameter, some so short and broad that they appear as warts rather than rods. Triradiate scar inconspicuous, rays about ⅔ the radius of the spore.

Specimens: S. 41 (pl. I, fig. 8), 16: 12.0–86.4 (pl. I, fig. 9).

Affinities and remarks. These spores seem to come very close to *B. gemmatus*, to which species KRUTZSCH in fact referred the specimen illustrated by MANUM in 1954 (fig. 8) and herein in pl. I, fig. 8. In the spores described by KRUTZSCH there seem to be similar variations in the sculpturing elements, however, they differ in having triradiate rays practically reaching the equator.

Two slightly different types seem to be present in the material: the more common type has large rods of wide size variation, and in the other type the rods are smaller and more uniform. The spores occur rarely in both of the plant-bearing series of the main Tertiary basin.

The size, sculpturing, and the inconspicuous triradiate scar suggest an affinity with the Osmundaceae rather than the Polypodiaceae.

Genus **Cicatricosisporites** POT. & GELL. emend. POT.

1933. *Cicatricosi-sporites* POTONIÉ & GELLETICH, p. 522.
1956 b. *Cicatricosisporites* POT. & GELL. emend. POTONIÉ, p. 47.

Cicatricosisporites cf. **cicatricosoides** KRUTZSCH

Pl. I, figs. 10, 11. Text-fig. 3.

1959. *Cicatricosisporites cicatricosoides* KRUTZSCH, p. 171.

Description. Equatorial outline subcircular, diameter 50–60 μ. Exine with more or less meridional ridges, 3–4 μ broad, anastomizing on the distal face and

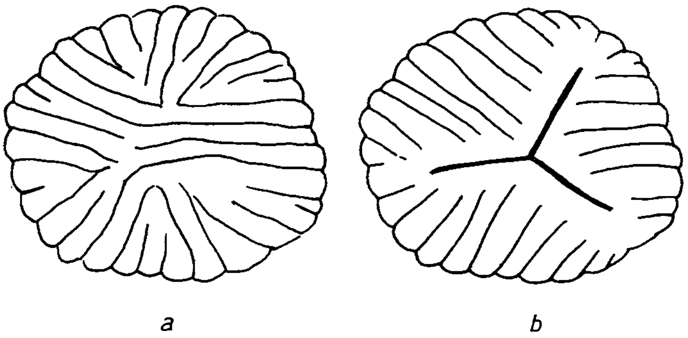


Fig. 3. *Cicatricosisporites* cf. *cicatricosoides*. Distal (a) and proximal (b) face of same specimen as in pl. I, figs. 10, 11. ×750.

separated by V-shaped grooves *c.* 2.5 μ deep. Exine *c.* 4.0 μ thick, ridges included. Ridges less prominent on the proximal face. Triradiate rays about ⅔ the radius.

Specimens: 18: 7.0–77.0 (pl. I, figs. 10, 11), 7: 13.1–83.1.

Affinities and remarks. Only a few spores of this distinctive type have been recovered, all from various points of the "Longyear-seam". In the absence of better material they are provisionally compared with *C. cicatricosoides*, which species they resemble more than any other of the genus owing to their very prominent ridges. Krutzsch (1959, p. 168) referred to the specimen illustrated by Manum in 1954 (fig. 9), and herein in pl. I, figs. 10 and 11, as *Cicatricosisporites* fsp. C, and stated that somewhat similar spores occur in certain German Eocene deposits.

It is a common feature in *Cicatricosisporites* that the ridges of the proximal and distal faces have the appearance of crossing one another when the spores are flattened. In the Spitsbergen spores, however, no prominent criss-cross pattern appears because the ridges are more meridional. They differ in this respect from *C. cicatricosoides* in which the ridges are more oblique. Furthermore, the ridges of *C. cicatricosoides* generally have undulate margins.

Krutzsch (1957, 1959) gives the range of the known species of *Cicatricosisporites* in Central European sediments as from Cretaceous to Oligocene.

Pflug (1956, pl. 17, figs. 1, 4) mentioned *C. dorogensis* from Tröllatunga, Iceland. His illustrated spores are different from the Spitsbergen ones.

Similarly sculptured spores are found in schizaeaceous genera (*Anemia*, *Mohria*), but generally the ridges are less meridional than in those described here. However, there seem to be no further modern forms with which they can be better compared.

Genus **Leiotriletes** Naum. emend. Pot. & Kr.

1939. *Leiotriletes* Naumova, p. 355.
1954. *Leiotriletes* Naum. emend. Potonié & Kremp, p. 120.

Leiotriletes cf. **adriennis** (Pot. & Gell.) Krutzsch

Pl. II, figs. 1, 2.

1933. *Punctati-sporites adriennis* Potonié & Gelletich, p. 521.
1959. *Leiotriletes adriennis* (Pot. & Gell.) Krutzsch, p. 57.

Description. Equator subtriangular with greatly rounded corners; diameter 45–50 μ. Exine entirely smooth and pellucid, thickness 1 μ or slightly less.

Triradiate scar with inconspicuous margins, *c.* 1 μ wide; rays about ⅔ the radius of the spore.

Specimens: 17: 5.3–87.1 (pl. II, fig. 1), S. 30 (pl. II, fig. 2).

Affinities and remarks. The transparency of these spores makes them easily recognizable, and they form a homogeneous unit. They are always more or less folded. They differ from the type of the species (according to the redescription by KRUTZSCH 1954, pp. 294–295) in their smaller size, the longer triradiate rays, and the thinner exine. However, the characters of one of the varieties described by KRUTZSCH (*L. adriennis* fvar. *pseudotorus*, 1959, p. 61) correspond to a great extent to those of the Spitsbergen spores, except that the Spitsbergen spores have no distinct stratification in the exine. The comparison with *L. adriennis* is therefore maintained.

The natural affinity is uncertain, both Polypodiaceae in a wide sense (*Adiantum* ?) and Schizaeaceae (*Lygodium* ?) are possibilities. The spores occur rarely in both of the plant-bearing series of the main Tertiary basin.

Leiotriletes sp.

Description. Included here are smooth, triradiate spores not belonging to *L.* cf. *adriennis* and whose indistinctness makes further classification impossible. Usually they are small, 20–35 μ. Equator subtriangular with greatly rounded corners. Triradiate rays from approximately ½ to over ⅔ the radius of the spore. Exine non-sculptured but sometimes faintly punctate; thickness 1 μ or less.

Specimens: 14: 12.3–76.1, 14: 7.2–77.0, 15: 6.8–80.8, 15: 6.5–76.6.

Affinities and remarks. Both pteridophytic and bryophytic spores may be represented. The spores are common and at certain points abundant in the "Longyear-seam".

Genus **Reticulatisporites** IBR. emend. POT. & KR.

1933. *Reticulati-sporites* IBRAHIM, p. 33.
1955. *Reticulatisporites* IBR. emend. POTONIÉ & KREMP, p. 111.

Reticulatisporites incomptus n.sp.

Pl. II, figs. 4–7.

Diagnosis. Equatorial outline rounded to subtriangular. Diameter 40–45 μ, excluding sculpturing. Triradiate rays approximately ⅔ the radius, with delicate and slightly undulate lamellae. Exine slightly less than 1.5 μ thick, with a conspicuous reticulum which disappears close to the proximal pole. Reticulum meshes angular, 5–10 μ in diameter; muri 2.5 μ high, delicate and usually slightly undulate.

Holotype: 33: 11.8–89.7 (pl. II, figs. 4–6).

Paratype: 47: 13.5–75.7 (pl. II, fig. 7).

Description. The muri produce a more or less uneven bordering of the spores. The muri are rather straight at their bases, but the upper parts are more or less undulate. The lamellae projecting from the triradiate scar are of a similar delicate nature as the muri. The polar axes of the spores were probably only slightly shorter than the equatorial diameters, as many specimens are flattened obliquely or laterally.

Affinities and remarks. These spores are referred to *Reticulatisporites* because of their large reticulum meshes. *Microreticulatisporites* KNOX emend. POTONIÉ & KREMP (1955, p. 96) is used for spores with meshes smaller than 6 μ (cp. also KRUTZSCH 1959, pp. 158–61). *Lycopodiumsporites* THIERG. ex DELCOURT & SPRUMONT (1955, p. 31) has more regular, and nearly circular, meshes and broad muri, attaining a nearly pitted pattern (cp. the description of the type species = *Foveasporis agathoecus*[1] by KRUTZSCH 1959, pp. 164–65).

The spores described here appear to be referable to *Lycopodium*. They resemble, in particular, the spores of *L. alpinum* (description by KNOX 1950, p. 230). Spores of similar appearance are characteristic of a number of species of *Lycopodium*.

These spores have a rare occurrence in the lowermost series. One specimen which could not be definitely identified with this species was observed in material from Sarsbukta.

Reticulatisporites sp.

Pl. II, figs. 8, 9.

Description. Equatorial outline rounded to subtriangular. Diameter 45 μ, excluding sculpturing. Triradiate rays more than ⅔ the radius, with slightly undulate lamellae. Exine thickness 1.5 μ or slightly greater. Sculpturing distinctly reticulate but disappears towards the angles of the triradiate scar. Reticulum meshes rounded to subangular, diameters 5–10 μ. Muri *c.* 2 μ high, 0.8–1.0 μ broad at the top. The broadened top forms a "roof", and the muri are Y- to T-shaped in transverse section. This "roof" rounds off the angles of the meshes as seen in surface view.

Specimen: S. 136 (pl. II, figs. 8, 9).

Affinities and remarks. Only one specimen has been found. It is well preserved and very distinctive. I know of no previous description of this particular type of a spore, but owing to the insufficient material a new form species has not been established. The spore is referred to *Reticulatisporites* although in surface view the meshes appear rounded. The characters of the muri, however, make the reticulum markedly different from the more pitted pattern characteristic of *Lycopodiumsporites*.

This type is probably also related to *Lycopodium*.

Genus **Rugulatisporites** TH. & PF.

1953. *Rugulatisporites* THOMSON & PFLUG, p. 56.

Remark. KRUTZSCH (1959, p. 143) regarded *Rugulatisporites* as a synonym of *Verrucosisporites*. However, the two genera seem well distinguished by their

---

[1] The transference of that species to *Foveasporis* by KRUTZSCH, and his considerations in the footnote p. 159 regarding *Lycopodiumsporites* cannot be agreed with. *Lycopodiumsporites* must be regarded as validly published by DELCOURT & SPRUMONT. The first invalid publication of the name by THIERGART (1938) provides no legal base for a rejection of DELCOURT & SPRUMONT's validation of it.

different types of sculpturing, which was clearly expressed in POTONIÉ's Synopsis (1956 b, pp. 28, 38).

Rugulatisporites cf. **quintus** TH. & PF.

Pl. II, figs. 10, 11.

1953. *Rugulatisporites quintus* THOMSON & PFLUG, p. 56.

Description. Equatorial outline circular, diameter *c.* 50 μ. Triradiate rays *c.* ⅔ the radius. Exine thickness slightly more than 1.5 μ, including sculpturing. Sculpturing appears in profile as very closely spaced warts of uniform height but varying width. In surface view, however, sculpturing appears as bands and patches of variable shapes and sizes, frequently branching or anastomizing. Interstitial spaces form serpentine grooves generally 0.5 μ wide but in places exceeding 1 μ.

Specimens: 22: 11.6–86.5 (pl. II, fig. 10), 22: 9.3–84.5 (pl. II, fig. 11).

Affinities and remarks. These spores resemble *R. quintus* in which, however, the sculpturing elements appear as more pronounced muri. Identification is therefore avoided. In Germany the species ranges throughout the Tertiary (THOMSON & PFLUG).

These spores are of an osmundaceous type and probably represent *Osmunda*. At low magnification they resemble *Verrucosisporites septentrionalis* (cp. p. 28), but on close examination the sculpturing is seen to be different. In *V. septentrionalis* individual warts can be easily distinguished and their interstices are wider. The spores have a rare occurrence in the sample from locality U 5.

Genus **Stereisporites** PF.

1953. *Stereisporites* PF. in THOMSON & PFLUG, p. 53.

1956 b. *Sphagnumsporites* RAATZ ex POTONIÉ, p. 17.

Remark. POTONIÉ (1956 b, p. 17) provided a description for the genus *Sphagnumsporites* RAATZ (1937, p. 9) and regarded *Stereisporites* PF. as a later synonym. However, since RAATZ did not describe his *Sphagnumsporites*, the date of its valid publication is that of POTONIÉ's description (cp. p. 16). Thus *Stereisporites* has priority and *Sphagnumsporites* must be treated as a later synonym.

Stereisporites psilatus (ROSS) PF.

Pl. II, fig. 3.

1949. *Trilites psilatus* ROSS, p. 32.

1953. *Stereisporites psilatus* (ROSS) PF. in THOMSON & PFLUG, p. 53.

Description. Equator subtriangular with rounded corners, diameter 30–40 μ. Exine smooth, *c.* 2 μ thick, with slight thickenings at the angles of the equator. Triradiate rays ½ the radius of the spore, or less.

Specimen: 1: 7.0–78.2 (pl. II, fig. 3).

Affinities and remarks. As mentioned by ROSS and THOMSON & PFLUG there are resemblances to *Sphagnum* spores, but these spores are too indistinct for a definite statement as to their natural affinities. THOMSON & PFLUG found the stratigraphical range of the species to be the Tertiary.

These spores are found rarely in samples from the "Longyear-seam".

Similar spores with exines usually thinner than 1 μ and without thickenings at the angles of the equator are referred to as *Leiotriletes* sp.

Genus **Verrucosisporites** IBR. emend. POT. & KR.

1933. *Verrucosi-sporites* IBRAHIM, p. 24.
1954. *Verrucosisporites* IBR. emend. POTONIÉ & KREMP, p. 137.

Verrucosisporites opimus n. sp.

Pl. III, figs. 1–4.

Diagnosis. Equatorial outline subcircular, diameter 40–55 μ. Sculpturing of closely spaced warts varying greatly in shape; sometimes they can be rod-like or their bases are constricted. Warts in surface view more or less irregularly rounded or somewhat elongate in outline. Height of warts 1.0–2.5 μ, diameters from slightly less than 1 μ to 3 μ, occasionally greater. Unsculptured exine *c.* 1.5 μ thick. Triradiate rays fairly distinct, longer than ⅔ the radius, usually with margins of merging warts.

Holotype: 22: 19.3–74.9 (pl. III, figs. 1, 2).

Paratypes: S. 38 (pl. III, fig. 3), 16: 5.1–88.5 (pl. III, fig. 4.).

Description. Usually the edge of the flattened spore is folded so as to give the appearance of a belt encircling part of the spore, or in some cases the entire spore. The margins of the triradiate scar are indistinct in some specimens.

Affinities and remarks. The characters suggest affinity to Polypodiaceae, but also to *Selaginella*, particularly the "group of *S. vaginata*" (KNOX 1950, p. 266). The spores are rare and have been recovered from the localities U 5 and Sarsbukta.

Verrucosisporites pulvinulatus n.sp.

Pl. III, figs. 7–10.

Diagnosis. Equatorial outline subtriangular with greatly rounded corners. Diameter 24–33 μ. Proximal face smooth. Distal face with low and closely spaced elevations appearing, in surface view of the exine, as rounded to subangular patches 2–3 μ in diameter, and, in profile, as gentle undulations *c.* 0.5 μ high. Exine *c.* 1.2 μ thick at the equator, where no elevations occur. Triradiate rays ½ the radius of the spore with margins 2–3 μ broad.

Holotype: 14: 6.7–80.1 (pl. III, figs. 7, 8).

Paratypes: 14: 8.4–81.1 (pl. III, figs. 9, 10), 14: 11.7–80.9, 15: 15.3–84.6.

Description. Most specimens are flattened so that the outline coincides with the equator, which is smooth. A slightly darkened belt indicates that the exine is somewhat thickened equatorially. Occasionally there are indications of further thickenings at the angles of the equator. In no specimen has a measurement of the exine thickness outside the equatorial region been possible. The elevations are not typical warts, but rather minute cushions, which are restricted to the distal face of the spore.

Affinities and remarks. These spores are referred to *Verrucosisporites* with some hesitation because their sculpturing is not typically warty. It was felt, however, that it was better to refer them to that genus than to create a new one on the basis of the present knowledge.

The spores recall somewhat those of *Botrychium* (e. g. *B. lunaria*), but in them the proximal faces are also sculptured. Their origin may have been bryophytic as well as pteridophytic. They are common, sometimes abundant, in samples from the lowermost series.

Verrucosisporites pulvinulatoides n. sp.

Pl. III, figs. 5, 6.

Diagnosis. In general resembles *V. pulvinulatus* but differs in the following characters: Equatorial diameter 35–40 μ. Elevated patches less prominent and more faintly delineated, diameters 3–5 μ. Margins of the triradiate rays unnoticeable. Exine *c.* 1.5 μ thick at the equator, faintly granular in profile and composed of two layers of equal thickness. Exine in surface view shows close dots, *c.* 0.5 μ in diameter.

Holotype: 65: 15.6–91.7 (pl. III, fig. 5).

Paratypes: 65: 16.5–89.3 (pl. III, fig. 6), S. 35.

Description. The stratification of the exine is not prominent. The outer layer consists of closely spaced granules barely distinguishable in profile. Occasionally an increase in the exine thickness is noted at the angles of the equator.

Affinities and remarks. This form has been recovered rarely from both of the plant-bearing series of the main basin. For further remarks compare under *V. pulvinulatus*.

Verrucosisporites septentrionalis n. sp.

Pl. III, figs. 11–13.

Diagnosis. Equatorial outline subcircular, diameter 60–80 μ. Triradiate rays ½–⅔ the radius. Exine thickness slightly greater than 0.5 μ. Fairly closely spaced warts, 1.0–1.5 μ high and in surface view irregularly rounded to elongate in outline. Their diameters vary from less than 1 to over 3 μ.

Holotype: 22: 19.5–81.1 (pl. III, figs. 11, 12).

Paratypes: S. 176 (pl. III, fig. 13), S. 273, 15: 12.7–86.9.

Description. The originally circular outline of the spores is usually distorted and the triradiate scar often partly hidden by folds. The shapes of the warts vary less than in *V. opimus*.

Affinities and remarks. These spores strongly resemble spores of *Osmunda*, and the affinity is considered to be osmundaceous, probably with *Osmunda*. They occur in samples from both of the plant-bearing series of the main basin and from Sarsbukta, but they are rare.

Corrugati-spor. sextarius PFLUG (1959, p. 146) from Iceland bears some resemblance to this species, but the warts of the former merge into muri of varying heights.

POLLENITES

TETRADES

Genus **Ericipites** WODEH.

1933. *Ericipites* WODEHOUSE, p. 516.
1953. *Tetradopollenites* THOMSON & PFLUG, p. 112, pro parte.
1960. *Ericaceoipollenites* POTONIÉ, p. 138.

Remark. The synonymy of *Ericipites* and *Tetradopollenites* was settled by POTONIÉ (1960, pp. 137–138). At the same time POTONIÉ validated *Ericaceoipollenites* which he first published in 1951 (p. 147) without a description. However, it is difficult to see how *Ericaceoipollenites* can be distinguished from *Ericipites*. Therefore they are regarded here as synonyms.

Ericipites sp.

Pl. IV.

Remark. Specimens belonging to *Ericipites* are difficult to distinguish when flattened. In the present material the aperture details are indistinct. A few types distinguishable by their sizes and exine patterns are described below. A close comparison with earlier species and the establishment of new ones have been precluded by the state of preservation, and the types have been provisionally designated by letters (A to E).

Descriptions. Type A (pl. IV, figs. 1–4). – Diameter of tetrad 38 to 40 μ, of individual grains *c.* 25 μ. Thickness of exine *c.* 1.0 μ. Generally two layers distinguishable, the inner one slightly thinner than the outer. Outer layer composed of closely arranged granules. In surface view the granules are seen as dots with diameters somewhat less than 0.5 μ.

Specimens: S. 84 (pl. IV, fig. 1), S. 196 (pl. IV, fig. 4), 25: 14.7–73.2 (pl. IV, fig. 2), 15: 13.5–77.6 (pl. IV, fig. 3).

Type B (pl. IV, figs. 5, 6). – Slightly larger than type A, tetrad *c.* 45 μ. Exine thickness *c.* 1.0 μ, with two layers of approximately equal thickness. The granules are larger than in type A and make the exine appear undulate in profile, with wavelengths *c.* 1.0 μ.

Specimens: 25: 18.0–80.7 (pl. IV, fig. 6), 25: 7.1–75.4 (pl. IV, fig. 5).

Type C (pl. IV, figs. 7–10). – Tetrad 25 to 30 μ, individual grains *c.* 17 μ. Exine thickness 1.0 μ or slightly less. Exine in profile smooth or slightly undulate. In surface view the exine shows a faintly dotted pattern; the dots, *c.* 0.5 μ in diameter, represent the exine elements which are very obscure in optical section. The elements occupy about ⅔ the exine thickness, but the stratification is not clear.

Specimens: S. 82 (pl. IV, figs. 9, 10), 14: 15.2–77.4 (pl. IV, fig. 8), S. 86.

Some specimens seem quite smooth and lack distinguishable exine elements: 25: 14.0–85.9 (pl. IV, fig. 7).

Many specimens are rather opaque and the individual grains of the tetrad seem more firmly united. Exine details obscure: 25: 13.8–85.4, 25: 14.5–84.6.

Type D (pl. IV, fig. 11). – Tetrad 45 to 50 μ, individual grains *c.* 28 μ. Exine thickness *c.* 1.0 μ, surface faintly and minutely dotted, profile smooth to slightly rough, but further details of the exine composition indistinguishable.

Specimen: 25: 8.9–76.5 (pl. IV, fig. 11).

Type E (pl. IV, figs. 12–14). – Tetrad slightly larger than type D; individual grains 30 to 35 μ. Exine *c.* 0.6 μ thick, two layers of approximately equal thickness distinguishable. The outer layer composed of dense granules quite conspicuous in surface view as dark dots with diameters 0.3 to 0.4 μ.

Specimen: 32: 8.5–84.5 (pl. IV, fig. 12–14).

Affinities and remarks. These tetrads must be considered as ericalean in origin; most probably they derived from species of Empetraceae and/or Ericaceae. The tetrads occur in appreciable numbers in several samples from the lowermost series, up to 7 per cent of the total exine contents having been recorded with the types A, B, and C as the most common ones. This fact indicates that in certain places in the original swamp empetraceous and/or ericaceous species played a notable role in the vegetation.

Genus **Droseridites** Cooks. emend. Pot.

1947. *Tetradites* (*Droseridites*) Cookson, p. 137.
1960. *Droseridites* Cooks. emend. Potonié, p. 139.

Droseridites spinulosus n. sp.

Pl. V, figs. 1–5, text-fig. 4.

Diagnosis. Diameter of tetrad *c.* 65 μ, individual grains *c.* 50 μ. Distal face of grains with scattered spines 4–5 μ high, exine *c.* 5 μ thick, in optical section faintly striated, surface granular. No apertures apparent.

Holotype: 64: 12.6–86.1 (pl. V, fig. 1).

Paratypes: 58: 15.1–81.1 (pl. V, fig. 2), 57: 5.9–81.3 (pl. V, fig. 3), 57: 6.8–84.3 (pl. V, figs. 4, 5), S. 138.

Description. The individual members of the tetrad seem somewhat loosely connected, and during slide preparation tetrads have been observed to break. Incomplete tetrads and single grains have been observed more often than complete units. The conspicuous spines of the distal face are isometrically spaced at intervals of 6–10 μ. The spines have slender ends and their base diameters range from 1.5 to 2.0 μ. There is no discernible structure within the spines. The exine of the distal face is 4–6 μ thick, and the surface has a minutely granular appearance. The exine appears striated in optical section, but the structure is obscure. The apparently structureless spines seem to project from low cushions. The exine of the contact face is thinner and the details are not clear, although it has an irregularly

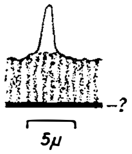


Fig. 4.

Fig. 4. *Droseridites spinulosus* n. sp. Exine of distal face in optical section.

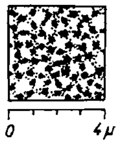


Fig. 5.

Fig. 5. Tetrad of monoporate(?) reticulate grains. Exine in surface view.

fringed and folded appearance. Sometimes the fringes form a pattern suggestive of a triradiate mark. No apertures are apparent.

Affinities and remarks. This pollen shows more exine details and has longer spines than has the type of the genus, *D. spinosa* Cooks. Although not known in every detail the form is so distinctive that the establishment of a new species appears justified.

Regarding natural affinity a reference to the Droseraceae is strongly suggested by the observed characters, for example the tetrahedrally but somewhat loosely connected grains and their spinuliferous ornamentation. In Droseraceae tetrads the individual grains are connected by peculiar fringes of the central parts of the proximal faces, and closer to the equator there are perforations which serve as apertures. Such features have not been positively recognized in the Spitsbergen grains, but there are indications of the fringes.

The grains have a rare occurrence in samples from the "Longyear-seam".

Tetrades incertae sedis

Tetrad of monoporate(?) reticulate grains.

Pl. V, figs. 6–8, text-fig. 5.

Description. Grains originally united in tetrads. Apparently the tetradic arrangement follows no definite pattern. Flattened tetrads 3- to 4-lobed in outline; diameter of individual grains approximately 28 μ. Complete tetrads are rare; more often incomplete examples are found and frequently single grains which are usually more or less torn, indicating the loss of tetrad members. Sculpturing reticulate with beaded muri, but sometimes grading into a dotted pattern with indication of the reticulum only. Measurement across meshes *c.* 1 μ, muri included. Exine thickness *c.* 0.8 μ.

An inconspicuous, rounded hole, *c.* 2.5 μ in diameter, is observed in many specimens. It is probably a pore which due to preservation is not observable in all specimens.

Specimens: 49: 14.1–84.3 (pl. V, figs. 6, 7), 49: 6.4–77.9 (pl. V, fig. 8).

Affinities and remarks. Monoporate grains of this type are characteristic of *Sparganium* and *Typha*. The tetradic arrangement makes an affinity with *Typha* probable. The grains occur sparsely in one sample from the bottom of the "Longyear-seam".

DISACCATES

Remark. Two-winged pinaceous grains usually comprise 10–20 per cent of the total spore and pollen contents of the samples, and the number of forms present is fairly large. However, their distinction is difficult because their overall shape and some finer characters are greatly influenced by the flattening and other fossilization effects. Usually the more resistant part of the grain has been the dorsal wall of the pollen body, here called the "cap", which may possess characters of diagnostic value, namely sculpturing, composition, and thickness of the exine. Commonly the size of the pollen body itself is a useful character, whereas the bladders have been more subject to deformation.

An important character used for the distinction of the form genera is the overall shape of the grain. However, as the shape varies greatly in the present material, the reference to a certain form genus frequently becomes difficult. Difficulties particularly are encountered in the form genera *Pityosporites* and *Abietineaepollenites* to which the bulk of the specimens must be referred. For the distinction of these genera the form of the bladders is important (cp. POTONIÉ 1958). In the following account the specimens are referred to *Pityosporites* when in lateral view the bladders are clearly more than semicircular or semioval in outline, and when in dorsoventral view the bladders appear distinctly set off from the outline of the body as more or less elliptical appendages at both its ends, and the sizes of the bladders in both aspects are similar to that of the body (cp. text-fig. 7). When such grains possess a heavily sculptured cap, a reservation is made concerning the reference to *Pityosporites* ("cf. *Pityosporites*").

The specimens are referred to *Abietineaepollenites* when the outlines of the bladders are not markedly more than a semicircle (or semioval) in lateral view, and in dorsoventral view their outlines do not markedly deviate from the oval outline of the entire grain. The thickness of the cap should be moderate; generally the limit is set at *c.* 2 μ, but the marginal thickness of the cap may be as great as 4 μ. Specimens with a stronger cap are referable to *Piceaepollenites*.

Differentiation within the form genera is naturally even more difficult, and the categories of two-winged grains described in the following are to varying degrees heterogeneous.

Genus **Abiespollenites** THIERG. emend. POT.

1937. *Abies-pollenites* THIERGART in RAATZ, p. 16.
1958. *Abiespollenites* THIERG. emend. POTONIÉ, p. 63.

Remark. *Abiespollenites* was first used in RAATZ (1937) for an apparently new species (*A. absolutus*) which was illustrated but poorly described. The genus itself was not described. *Abiespollenites* was subsequently defined by POTONIÉ (1958) so that it can now be distinguished from other genera.

Abiespollenites sp.

Pl. VI, figs. 1, 2.

Description. Length of pollen body 110–130 μ, width in dorsoventral view *c.* 90 μ. Bladders distinctly set off from the body and more than semicircular in outline. Cap *c.* 5 μ thick with a fine granular texture suggestive of a reticulum. Reticulum of bladders obscure.

Specimens: 63: 18.1–77.9 (pl. VI, fig. 1), 34: 9.4–91.8 (pl. VI, fig. 2), 34: 14.1–92.4.

Affinities and remarks. The specimens all seem to be of the same origin. The finer characters are poorly preserved, but overall features strongly suggest an affinity with *Abies*. Only a few specimens have been recovered from the locality S 4 (upper 100 cm).

The grains described as *A. absolutus* THIERG. in RAATZ (1937, p. 16) seem to have a thicker cap.

Genus **Abietineaepollenites** POT.

1958. *Abietineaepollenites* POTONIÉ, p. 61.

Remark. The generic name was first used in POTONIÉ (1951) in several combinations, but it was neither described nor defined. It was validly published in POTONIÉ (1958), in which the date of its valid publication, however, is erroneously indicated as 1951.

Abietineaepollenites sp., Type A.

Pl. VII, figs. 1–5, text-fig. 6.

Description. In dorsoventral view the bladders do not extend markedly beyond the overall elliptical grain outline. In side view the bladders appear approximately semicircular in outline, and the angle formed with the outline of the cap is obtuse. Length of body 60–80 μ, entire grain as much as 90 μ in length but varying greatly. Cap slightly roughened in outline, sometimes prominently; in optical section faintly striated radially, 1.5–2.0 μ thick; in surface view more or less distinctly dotted. In some specimens the cap is 2.0–2.5 μ thick, increasing to 3–4 μ towards the bladders. In specimens from the Sarsbukta locality (pl. VII, figs. 1, 2) the cap is 1.5–2.0 μ thick and distinctly striated radially in optical section. In surface view dots merge into a reticuloid pattern. The reticulum of the bladders has meshes up to 4 μ in diameter.

Specimens: 90: 10.0–76.5 (pl. VII, figs. 1, 2), 33: 15.4–85.4 (pl. VII, fig. 3), 59: 6.1–85.9 (pl. VII, fig. 4), S. 151 (pl. VII, fig. 5), S. 186.

Affinities and remarks. These grains do not form a homogeneous unit. Specimens from the main Tertiary basin, where they are fairly common in samples from the lowermost series, are not sufficiently well preserved for further distinction of forms. A few specimens from the Sarsbukta locality, showing more clearly the finer characters, have the same overall appearance, but their identity with specimens from the main basin is not absolutely certain. The specimen S. 186 from Sarsbukta differs somewhat in being smaller and possessing a slightly finer surface pattern of the cap.

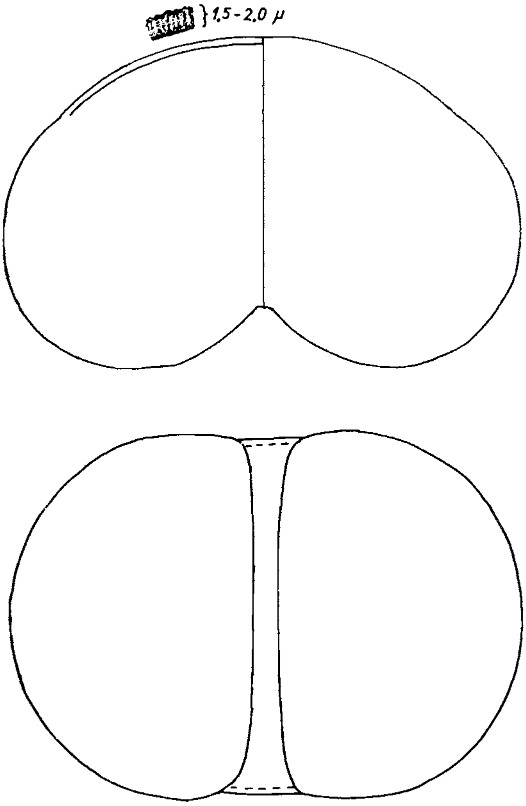


Fig. 6. *Abietineaepollenites* sp., Type A. Diagram of lateral and ventral aspects. ×750.

In general appearance the grains resemble ***Abietineaepollenites microalatus*** f. ***major*** Potonié (1951, p. 145). It appears that more than one natural species is represented. The natural affinity is perhaps with ***Picea*** in some cases, but generally the relative size of the bladders and roughness of the cap rather suggest affinity with ***Pinus***. The Sarsbukta specimens seem to belong to ***Pinus***.

Abietineaepollenites sp., Type B.

Pl. VIII, figs. 1–3.

Description. Grain 120–130 μ in length, 80–90 μ broad, with bladders that are very poorly set off from the body. Body has fine reticuloid surface pattern with more or less faintly beaded muri; "meshes" up to 1.0 μ across, merging gradually with the reticulum of the bladders which have meshes usually less than 4 μ in diameter. Cap 2–4 μ thick, practically smooth, radially striated in optical section.

Specimens: 42: 8.2–81.5 (pl. VIII, fig. 1), 33: 8.7–84.9 (pl. VIII, fig. 2), S. 188 (pl. VIII, fig. 3), 92: 15.9–82.1.

Affinities and remarks. In specimens from the lowermost series of the main Tertiary basin the finer characters are less clear but not essentially different from those of the specimens from the Sarsbukta locality. Their size and general appearance strongly suggest an affinity with *Picea*. The grains are rare in the lowermost series, less so in the Sarsbukta material.

Apparently very similar grains have been described by THOMSON & PFLUG (1953, p. 68) as *Pityosporites alatus* (POT.) TH. & PF. However, their description differs considerably regarding the size of the grains and the thickness of the cap from the original one in POTONIÉ & VENITZ (1934, p. 18) of the same species. For the present material, use of the name is therefore avoided. In his "Synopsis" POTONIÉ (1958, p. 64) designated the species *P. alatus* in its original sense as the type of *Piceaepollenites*, when that genus was described and thus validated (cp. MANUM 1960, p. 12). The form described here does not belong to *Piceaepollenites* because it lacks the prominent "crest" shown in the optical section of the cap which is characteristic of that genus.

PFLUG (1956, p. 418) reported grains from the Lower Tertiary of Iceland (Tröllatunga) which he compared with *P. alatus* (in the sense of THOMSON & PFLUG), but they were neither illustrated nor described. In a sample from Tröllatunga I observed large numbers of grains which appear indistinguishable from specimens from Sarsbukta (cp. pl. XIX, figs. 1–3). It is evidently the same type that was described by ÁSKELSSON (1947, p. 49) as *Picea* sp.

Genus **Cedripites** WODEH.

1933. *Cedripites* WODEHOUSE, p. 490.

cf. **Cedripites**

Pl. VII, figs. 6, 7.

Description. Length of the body 55 μ and 70 μ in the two specimens recovered. Margin of cap irregularly undulate, its thickness 4–7 μ towards the roots of the bladders. Cap finely striated in optical section, in surface view showing fine, inconspicuous, and irregular dots. The bladders appear not to have been markedly constricted towards their roots; their reticulum appears to be fine.

Specimens: 59: 16.1–81.0 (pl. VII, fig. 6), S. 154 (pl. VII, fig. 7).

Affinities and remarks. These grains are distinguished by the undulate margin and thickness of the cap. It is not certain whether the bladders are of the *Cedrus*-type (cp. WODEHOUSE l. c.), therefore the reference to *Cedripites* is not definite. The natural affinity appears to be with *Cedrus* or *Pinus*.

Genus **Pityosporites** SEW. emend. MAN.

1914. *Pityosporites* SEWARD, p. 23, pro parte.
1954. *Pityosporites* SEW. emend. POTONIÉ & KLAUS, p. 534, mut. char.
1958. *Pinuspollenites* RAATZ ex POTONIÉ, p. 62.
1960 a. *Pityosporites* SEW. emend. MANUM, p. 14.

Pityosporites cf. **labdacus** (POT.) TH. & PF.

Pl. IX, figs. 1–8, text-fig. 7.

1934. *Pollenites labdacus* POTONIÉ, p. 49.
1951. *Abietineae-pollenites labdacus* POTONIÉ, p. 144.
1953. *Pityosporites labdacus* (POT.) THOMSON & PFLUG, p. 68.
1958. *Pinuspollenites labdacus* POTONIÉ, p. 62.

Description. Dorsoventrally flattened grains, which are in majority, measure *c.* 50 × 70 μ; length of body *c.* 50 μ, usually somewhat longer in laterally flattened grains. The bladders narrow distinctly towards their roots. Outline of the cap in dorsal view finely undulate; in lateral view it appears to have an inconspicuous marginal crest. Cap radially striated in optical section and slightly less than 2 μ thick, in surface view distinctly dotted in a reticuloid pattern.

Specimens: S. 156 (pl. IX, fig. 4), S. 157 (pl. IX, fig. 5), S. 163 (pl. IX, fig. 3), S. 165 (pl. IX, figs. 1, 2), S. 189 (pl. IX, figs. 7, 8), 33: 16.7–78.0 (pl. IX, fig. 6).

Affinities and remarks. The original description of the species gives the shape of the grains, while exine details are neglected. A wide range is therefore permitted, and the grains referred to the species are rather multiform. The description of *P. labdacus* would permit the inclusion of the Spitsbergen specimens, but since their identification cannot be based on finer characters they are only compared with the species.

This is the most common of the two-winged forms. The major part of the specimens form a quite homogeneous unit, but some specimens differ in having a thicker cap with a coarser texture (pl. IX, figs. 3, 6). Both forms are present in the lower beds of the main basin as well as in the samples from Sarsbukta.

As for the natural affinity, the characters definitely suggest that it is with *Pinus*.

cf. **Pityosporites**

Pl. VIII, figs. 4–6, text-fig. 8.

Description. Cap with prominent wart-like sculpturing, particularly towards the bladder roots. Bladders narrow towards their roots. – Grains with these characters are rare, yet they form a heterogeneous group, and two types can be distinguished:

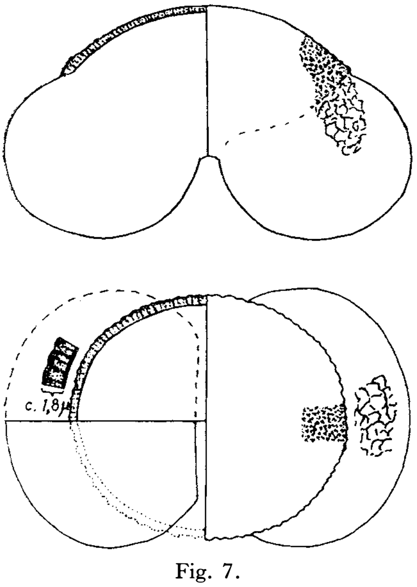


Fig. 7.

Fig. 7. *Pityosporites* cf. *labdacus*. Diagram of lateral and dorsoventral aspects. ×750.

Fig. 8. Cf. *Pityosporites*, Type A. Diagram of dorsoventral aspect. ×750.

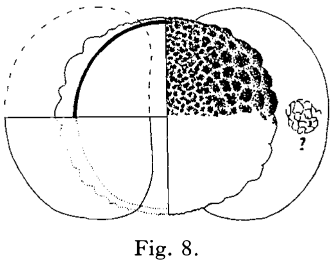


Fig. 8.

Type A (pl. VIII, figs. 5, 6, text–fig. 8). – Length of body 35 to 60 μ, cap *c.* 4 μ thick towards the bladder roots with wart-like projections up to 4 μ in diameter in surface view, or sometimes with radial ridges. Wall thinner and warts finer (*c.* 1 μ) in the polar area of the cap and in the marginal parts between the bladders.
Specimens: 33: 5.7–85.3 (pl. VIII, fig. 5), 33: 19.9–78.8 (pl. VIII, fig. 6).

Type B (pl. VIII, fig. 4). – Length of body over 70 μ; cap up to 9 μ thick, with heavy wart-like sculpturing all over.
Specimen: 57: 14.4-79.4 (pl. VIII, fig. 4).

Affinities and remarks. The general shape of the grains suggests a reference to *Pityosporites*, but they cannot be referred to that genus without reservation because of the prominently sculptured cap.

Various species of *Pinus* have a similar, more or less coarse sculpturing of the cap. This, together with the overall appearance of the grains suggests an affinity with *Pinus*.

DISACCATES?

Genus **Abietipites** WODEH.

1933. *Abietipites* WODEHOUSE, p. 491.

Abietipites arcticus n. sp.

Pl. IX, figs. 9, 10, pl. X, fig. 5, text-fig. 9.

Diagnosis. Shape oval in polar as well as lateral view. Length of grain *c.* 70 μ, width in polar view *c.* 55 μ, in lateral view *c.* 50 μ. The ventral side has a transverse furrow, 8–12 μ wide with rounded ends, reaching almost across dorsoventrally flattened grains. Wall rugose, except for the furrow, 5–8 μ thick and composed of wrinkled protrusions of wart-like appearance in the dorsal part. Towards the ventral side, 10–12 μ thick and possessing "puffy" corrugations. Wall in the furrow thin and of granular appearance. Greatest thickness of the wall is ventrally, a short distance from the furrow.
Holotype: S. 145 (pl. IX, fig. 10).
Paratypes: S. 143 (pl. X, fig. 5), 57: 8.4–82.2 (pl. IX, fig. 9), S. 142.

Description. The majority of specimens have been flattened dorsoventrally. In text-figure 9 an attempt has been made to convey an idea of the original shape and general appearance of the new species. The peculiar rugose sculpturing with its greatest thickness on the ventral side suggests a pair of rudimentary bladders. In ventral view the furrow often seems constricted in the middle, which is not seen in laterally flattened specimens. The constriction is probably due to overlapping of the furrow by the surrounding thick wall.

Affinities and remarks. Judging from the description of the type species, *A. antiquus* WODEHOUSE (1933), *A. arcticus* differs in having a coarser dorsal sculpturing. In it there is a regular increase in the thickness of the wall towards the equator and the ventral side, whereas in *A. antiquus* there is a more prominent equatorial fringe. *A. arcticus* does not correspond to any known modern pollen,

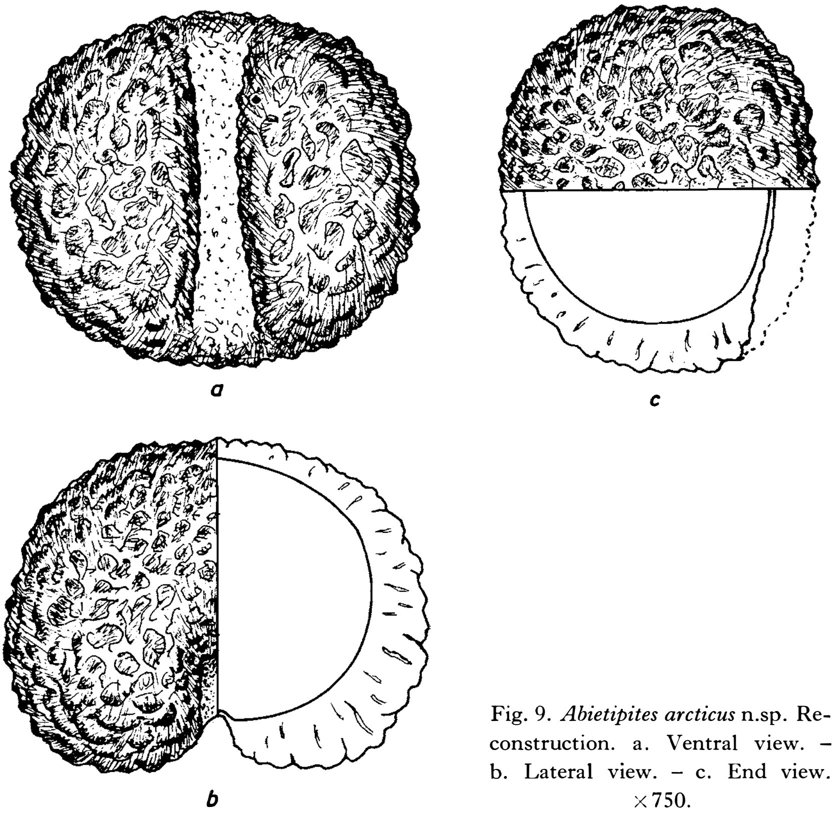


Fig. 9. *Abietipites arcticus* n.sp. Reconstruction. a. Ventral view. – b. Lateral view. – c. End view. ×750.

but the resemblance to winged pollen of the Pinaceae (including *Tsuga*) is obvious. The resemblance to the *Tsuga* type is stronger than to any of the two-winged types, but in *Tsuga* the thickest part of the wall forms an equatorial fringe and there is no prominent furrow. That the grains originated from some member of the Pinaceae appears most probable.

KIRCHHEIMER (1934, p. 175) included *A. antiquus* in his treatise on Tertiary *Tsuga* pollen and thought that the furrow and the peculiar wall structure represent a mode of preservation of a *Tsuga* type. In his own material he had observed *Tsuga* grains in a state of preservation that would support this view. In *A. arcticus*, however, the furrow represents a true character of the grains. The true nature of the sculpturing is less clear, for the flattening has obviously had some obscuring effect on such loose and "puffy" structures as are met with here.

These grains have been recovered rarely from two samples of the "Longyear-seam".

INAPERTURATES

Genus **Inaperturopollenites** TH. & PF.

1953. *Inaperturopollenites* THOMSON & PFLUG, p. 64, pro parte.

Remark. THOMSON & PFLUG established the genus for more or less spherical grains either without or with an inconspicuous aperture and with smooth or finely sculptured exines. In the genus they also included grains with an exitus papilla, namely *I. polyformosus* (THIERG.) TH. & PF. This species was first described by THIERGART (1938, p. 301) as a new species of the monotypic new genus *Sequoiapollenites*, and this genus then became validly published. Being thus the genotype of *Sequoiapollenites*, the species *polyformosus* was incorrectly transferred to the subsequently published genus *Inaperturopollenites*. Moreover, the exitus papilla is so diagnostic that grains possessing it merit a separate genus.

Later, *Inaperturopollenites* was altered by POTONIÉ (1958, p. 77) who transferred some of its species to the genera *Laricoidites* POT., TH. & THIERG., *Taxodiaceaepollenites* KR., and *Sequoiapollenites*, because these genera were regarded by him to have the priority over *Inaperturopollenites*. As stated above, *Sequoiapollenites* has priority; *Laricoidites* and *Taxodiaceaepollenites*, however, were not validly published until 1958 by POTONIÉ because descriptions were lacking in the original publications. The last two genera therefore offer no reason for the transference of species from *Inaperturopollenites*. Furthermore, the two genera, as defined by POTONIÉ, are only poorly distinguished from *Inaperturopollenites*. (Cp. also the nomenclatural note under *I.* cf. *magnus*.)

In this work the original meaning of *Inaperturopollenites* has been retained, except that grains with an exitus papilla (*Sequoiapollenites*) are excluded from it.

Inaperturopollenites insignis n. sp.

Pl. VI, figs. 3, 4.

Diagnosis. Outline approximately circular, diameter 65–100 μ. No aperture apparent. Exine *c.* 1.4 μ thick, in profile indistinctly striated, as if composed of rod-like elements producing a fine but conspicuously rough surface. Elements in surface view conspicuous, with diameters *c.* 0.5 μ.

Holotype: 42: 16.3–92.4 (pl. VI, fig. 4).

Paratypes: 34: 9.5–91.5 (pl. VI, fig. 3), S. 63.

Description. Owing to accidental folds the shape and size vary greatly. The original shape appears to have been spheroidal. The apparently granular surface seems to be produced by rod-like elements barely noticeable in optical section of the exine.

Affinities and remarks. The grains do not resemble closely any known modern form, but their characteristics indicate a pinaceous origin. Grains of similar size and shape but with a finer texture are found in *Larix* and *Pseudotsuga*. The composition of the exine resembles more that of the central bodies of many winged pinaceous grains.

The grains have been recovered rarely from the lowermost series.

Inaperturopollenites cf. **magnus** (POT.) TH. & PF.

Pl. X, fig. 6.

1934. *Pollenites magnus* POTONIÉ, p. 48.
1937. *Larix-pollenites magnus* (POT.) RAATZ, p. 15.
1950. *Laricoidites magnus* (POT.) POTONIÉ, THOMSON & THIERGART, p. 48.
1951. *Laricoipollenites magnus* POTONIÉ, p. 149.
1953. *Inaperturopollenites magnus* (POT.) THOMSON & PFLUG, p. 64.
1955. *Laevigatasporites magnus* (POT.) DELCOURT & SPRUMONT, p. 49.

Nomenclatural note. Of the various combinations in which this specific name has appeared, POTONIÉ (1958, p. 76) adopted *Laricoidites magnus* as the correct one, because he considered that *Laricoidites* was validly published in POTONIÉ, THOMSON & THIERGART (1950) with *L. magnus* as the type species. However, as stated elsewhere (p. 17) the 1950 publication of *Laricoidites* must be considered as invalid; the genus was first validly published in POTONIÉ (1958). The synonymous genus *Laevigatasporites* POT. & GELL. ex DELCOURT & SPRUMONT (1955), having the same type species as *Laricoidites*, therefore has priority. However, the combination *I. magnus*, which is also legitimate, has been preferred here because *Laevigatasporites* does not seem well enough distinguished from *Inaperturopollenites* to justify the transference.

Description. Original shape apparently spheroidal and the diameter 60–80 μ. No apparent aperture. Exine *c.* 0.5 μ thick, entirely smooth and with several accidental folds, no stratification apparent. Shape and size vary greatly owing to the folds. A faint pattern of minute, light spots observable in surface view, resembling the meshes of a very delicate reticulum.

Specimens: 34: 10.9–83.5 (pl. X, fig. 6), 34: 16.9–79.6.

Affinities and remarks. Living equivalents are found among the pollen of *Larix* and *Pseudotsuga*; grains of *Larix* have an exceedingly fine reticuloid pattern. In all probability these grains originated from a representative of the Pinaceae, and an affinity to *Larix* is suggested. The grains occur in several samples of the lowermost series but are rare.

The descriptions of the German material vary, and it is not clear whether the delicate surface pattern of the grains described here corresponds to the very faintly spotted surface ("kaum punktiert") of the German forms. Therefore a definite identification of the Spitsbergen grains with *I. magnus* is avoided.

Inaperturopollenites sp.

Pl. XI, figs. 10–16, pl. XII, figs. 1–4, text-fig. 10.

Description. Thin-walled grains with diameters up to 55 μ, an exine with a more or less pronounced granular pattern, and with no apparent aperture or exitus, have been classified here under *Inaperturopollenites* sp. The poor diagnostic characters make further differentiation difficult. The size of the grains has been much affected by folding, and the details of the exines are so delicate that it is difficult to distinguish their true nature even in fairly well preserved specimens. However, the grains may be roughly divided according to their size into two groups, described in the following, and provisionally designated by the letters A and B. One form of the latter group is described separately because of its markedly different exine granulation.

Type A (pl. XI, figs. 10–16, text-fig. 10, a–c). – Usually much folded and often ruptured. Diameter 35–55 μ. Exine 0.5–0.8 μ thick. Surface densely flecked; flecks up to 0.8 μ in diameter, in profile appearing as granules or rods. A few specimens are ruptured into two nearly equal parts which may have conspicuous longitudinal folds (pl. XI, figs. 12, 13).

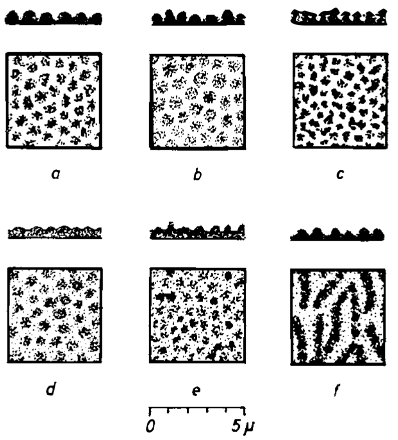


Fig. 10. *Inaperturopollenites* sp. Diagrams of surface views and optical sections of some specimens. – a, b, c. Type A. – d, e. Type B. – f. Type B_1.

Specimens: 52: 19.8–78.1 (pl. XI, fig. 10, text-fig. 10, b), 52: 13.8–74.5 (pl. XI, fig. 11), 34: 11.4–81.3 (pl. XI, fig. 12), 32: 13.7–81.4 (pl. XI, fig. 13, text-fig. 10, c), 14: 18.1–81.1 (pl. XI, fig. 14), 34: 19.7–81.4 (pl. XI, fig. 15), 15: 16.8–84.3 (pl. XI, fig. 16), 14: 8.1–76.3 (text-fig. 10, a).

Type B (pl. XII, figs. 1–4, text-fig. 10, d–f). – Diameter 20–30 μ. Exine as in Type A but usually less folded and with less conspicuous flecks.

Specimens: 5: 17.0–84.9 (pl. XII, figs. 1, 2, text-fig. 10, d), 5: 14.0–85.2 (pl. XII, fig. 3, text-fig. 10, e).

Within this type a separate form (Type B_1) can be distinguished which has a rugate sculpturing consisting of short, delicate ridges that in surface view are very faintly spotted indicating a granular composition (text-fig. 10, f). Exine appears granular in profile; thickness slightly greater than 0.5 μ.

Specimen: 51: 18.1–80.7 (pl. XII, fig. 4, text-fig. 10, f).

Affinities and remarks. The characters indicate a natural affinity to conifers having wing-less pollen that lack a conspicuous exitus papilla, namely members of Cupressaceae, Taxaceae and Taxodiaceae. It is hardly possible to specify the affinity exactly since the pollen of the various genera in question is difficult to distinguish. The possibility cannot be neglected that some non-coniferous pollen also is included here, for instance poorly preserved monocotyledonous grains. It seems, however, that by far the greater number of the grains are referable to conifers. The grains occur in large numbers in most samples, usually comprising more than 20 per cent, and in a few samples even more than 50 per cent, of the total exine numbers.

Although it is difficult to make a further division of the group, differences are noticed, particularly in the type and the coarseness of the granulation, which indicate that there are considerably more forms present than the three described.

POTONIÉ & VENITZ (1934, p. 17) described similar grains as *Pollenites magnus dubius* (= *I. dubius* in THOMSON & PFLUG 1953). From the descriptions it appears to be a heterogeneous species containing grains with sizes varying from 20 to 50 μ and the exines being from smooth to granular. Such grains occur throughout the

Tertiary of Central Europe and are particularly abundant in the younger beds (Krutzsch 1957). Pflug (1956) reported *I. dubius* from the Icelandic Tertiary.

The specimens that are ruptured into two nearly equal parts resemble *Glyptostrobus vacuipites* Wodehouse (1933, p. 494) but are not identical with that species since it has more irregularly spaced flecks on the surface. The characteristically ruptured specimens are rare, and the diagnostic value of this particular feature is uncertain.

Genus **Sciadopityspollenites** Raatz emend. Pot.

1937. *Sciadopitys-pollenites* Raatz, p. 13.
1958. *Sciadopityspollenites* Raatz emend. Potonié, p. 81.

Sciadopityspollenites serratus (Pot. & Ven.) Raatz

Pl. XI, figs. 1–9.

1934. *Sporites serratus* Potonié & Venitz, p. 15.
1937. *Sciadopitys-pollenites serratus* (Pot. & Ven.) Raatz, p. 13.
1953. *Monocolpopollenites serratus* (Pot. & Ven.) Thomson & Pflug, p. 64.

Description. Outline circular to oval or spindle-shaped, diameter between 35 and 60 μ. Surface densely sculptured with irregular and somewhat "puffy" warts up to 2.5 μ high, with diameters of 1–3 μ; the wall supporting the warts is *c.* 0.5 μ thick. No distinct aperture apparent, but sometimes an elongate, essentially wartless area indicates the presence of an apertural region.

The nature of the warts is peculiar. In surface view bright spots appear in their central parts suggesting that they are pitted, or they can be broken up into faint, irregular dark spots. Other warts appear more homogeneous in structure.

Specimens: S. 172 (pl. XI, fig. 7), S. 266 (pl. XI, figs. 2, 3), 33: 17.9–87.8 (pl. XI, fig. 1), 62: 15.3–85.0 (pl. XI, figs. 8, 9), 42: 14.3–84.3 (pl. XI, fig. 4), 33: 14.9–78.7 (pl. XI, figs. 5, 6).

Affinities and remarks. The grains vary greatly in size, but usually their diameters lie between 36 and 40 μ. Some specimens are, on the average, 10 μ larger, their warts more scattered, and the interstices occupied by much smaller warts and granules. There are also transitional forms so that a differentiation is impracticable.

By comparing Spitsbergen specimens with *S. serratus*, for example, from German Miocene lignites, no essential differences could be recognized (cp. Potonié, Thomson & Thiergart, pl. A, figs. 16 and 17, pl. C, fig. 7 a). The Spitsbergen forms are therefore referred to the same species.

Grains referred to this species occur more or less regularly in Germany from Middle Eocene, and commonly from Oligocene onwards, with striking abundance in some Oligocene and Miocene levels (Kirchheimer 1950, Krutzsch 1957, Thiergart 1949). Various modifications occur, but they are not distinct enough to be separated from the original species. Ingwersen (1954) reported corresponding grains from Danish Miocene lignites and also pointed out the variations occurring. Furthermore, Pflug (1956) reported *S. serratus* from Icelandic Lower

Tertiary (Tröllatunga). As stated later in this work (p. 111) it is now recorded also from the Lower Tertiary of Greenland and Ellesmere Island.

On the basis of the very close similarity of these grains to the pollen of *Sciadopitys verticillata* SIEB. & ZUCC. they are held to be representatives of *Sciadopitys*. THIERGART (1949) inferred from the available evidence of *Sciadopitys* in the Tertiary, that only a single species existed, which was identical with the living one (fossil leaves, *Sciadopitys tertiaria* MENZEL, and wood, *Sciadopityoxylon wettsteini* JURASSKY, agreeing closely with *S. verticillata*). What the fossil record really shows is that in the Central European Tertiary at least one species of *Sciadopitys* was represented which was apparently closely related to the living species, but the identity has so far not been demonstrated (cp. KIRCHHEIMER 1950, p. 61).

There is no macrofossil record of *Sciadopitys* from the Spitsbergen Tertiary, but the pollen occurs in most samples, frequently with percentages between 3 and 6, indicating that the parent plants lived in the area. The grains have not been recovered from samples of the upper plant-bearing series. Whether more than one species was represented cannot be said for certain. It is noteworthy in this connection that pollen of the living species varies with regard to the sculpturing (cp. also INGWERSEN 1950, p. 44).

Genus **Sequoiapollenites** THIERG.

1938. *Sqeuoia-pollenites* THIERGART, p. 301.

Remark. *Sequoiapollenites* was published as a monotypic new genus by THIERGART (1938) and was validated by the combined generic and specific description of *S. polyformosus* THIERG.

POTONIÉ (1958, pp. 79–80) gave a generic definition of *Sequoiapollenites* and in addition described another genus, *Cryptomeriapollenites*, also with an exitus papilla. However, it is not clear how the two genera can be distinguished in practice. Even the species selected as the genotype of *Cryptomeriapollenites* (*Poll. largus* KR.) is not clearly distinguishable from the genotype of *Sequoiapollenites*, which is seen from the description in KREMP (1949, p. 58). Therefore, in order to avoid confusion it is better to use *Sequoiapollenites* for all the fossil grains with a distinct exitus papilla. It is in this sense that the genus is used here. It will include representatives of *Cryptomeria*, *Glyptostrobus*, *Metasequoia*, and *Taxodium* as well as *Sequoia*. This heterogeneity of the genus was also observed by THIERGART.

According to POTONIÉ (1958) *Cryptomeriapollenites* had been invalidly published by KREMP (1949) and was subsequently validated by POTONIÉ. However, *Cryptomeriapollenites* does not appear as a generic name in KREMP (l. c. p. 58) because in the place in question he wrote "cf. *Cryptomeria* – *Poll. largus* n.sp.". Here the name *Cryptomeria* was used to indicate the natural affinity of the species *Pollenites largus* and is not a part of the generic name itself. This is clear from an analogous example (l. c. p. 65), namely "cf. *Carpinus americana* – *Poll. bituitus* R. POT."; obviously *Carpinus americana* – *Pollenites* is not a new generic name.

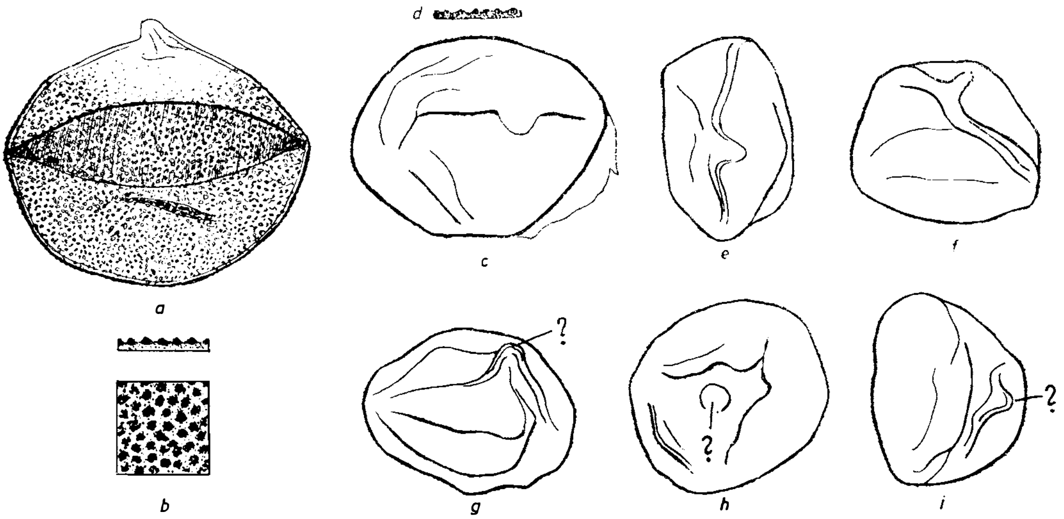


Fig. 11. *Sequoiapollenites* sp. × 1250; detail figures of surface view and optical sections of exine (b and d) × 2500. References to specimens in the text.

Sequoiapollenites sp.

Pl. XII, figs. 5–9, text-fig. 11.

Description. More or less irregularly folded, diameter 20–35 μ. Papilla more or less conical, length less than 4 μ and base diameter slightly less than the length. Exine 0.5–1.0 μ thick, with dense and more or less conspicuous flecks up to 0.8 μ in diameter. In optical section, rough or delicately undulate; the papilla and sometimes a part of the surrounding exine are smooth.

Specimens: 34: 10.1–93.8 (pl. XII, fig. 6, text-fig. 11, a, b), 66: 15.0–86.0 (pl. XII, fig. 5, text-fig. 11, c, d), 4: 15.9–79.6 (pl. XII, fig. 9, text-fig. 11, e), 4: 13.9–78.4 (pl. XII, fig. 8, text-fig. 11, f), 4: 12.5–82.1 (pl. XII, fig. 7, text-fig. 11, h), 5: 15.0–76.1 (text-fig. 11, g), 3: 12.0–86.2 (text-fig. 11, i).

Affinities and remarks. It is possible that a small papilla may be overlooked unless the grain is flattened so as to make the papilla protrude clearly from the outline. Considering this possibility, a large number of grains have been closely examined, and the only possible conclusion reached is that grains originally possessing well-marked papillae are very rare. The illustrated specimens, in fact, represent the total number recovered, in addition to some more doubtful examples.

The specimens do not form a homogeneous unit, but the characters are not sufficiently distinctive for a further division. The two specimens quoted first (text-figs. 11, a, c) appear to be identical and somewhat larger than the others, indicating that at least two natural species are represented.

Papillate grains of this type can be referred to the Taxodiaceae, but a more exact indication of their natural affinity is not justifiable. The size and form of the papilla, particularly in the two specimens indicated above, are comparable with that of *Taxodium*. It is noteworthy that none of the observed specimens possesses a prominent and more or less bent papilla like that of *Sequoia* or *Cryptomeria*.

Genus **Tsugaepollenites** Pot. & Ven. emend. Pot.

1934. *Tsugae-pollenites* Potonié & Venitz, p. 17.
1937. *Tsuga-pollenites* Raatz, p. 15.
1953. *Zonalapollenites* Pf. in Thomson & Pflug, p. 66.
1958. *Tsugaepollenites* Pot. & Ven. emend. Potonié, p. 48.

Remark. The description in Potonié (1958) does not clearly distinguish this genus from morphologically related ones (as for instance *Enzonalasporites* Leschik, see Potonié 1958, p. 47). The characters have been given as corresponding to those of *Tsuga* pollen and more particularly the pollen of *T. diversifolia* Maxim. Thus at least two characters of *Tsugaepollenites* which would distinguish it more clearly from other genera were not mentioned in the description. 1. The corrugated protrusions forming the conspicuous sculpturing are hollow. This may easily be observed both in surface view and in optical section of the exine. (Cp. also Erdtman 1957, fig. 73). 2. The grains are heteropolar (Thomson & Pflug's statement in their diagnosis of *Zonalapollenites* that the equatorial plane forms a plane of symmetry, is erroneous). The ventral side has a central area which has a less "puffy" and corrugated sculpturing than the dorsal side, and it is usually depressed. Protrusions of a more puffed-out nature than those of the dorsal side surround the area and are present in the equatorial region where they produce a more or less prominent equatorial fringe, noticeable in polar aspect of the grains.

German examples of *Tsugaepollenites* which I have seen possess these characters.

Tsugaepollenites viridifluminipites (Wodeh.) Pot.

Pl. X, figs. 1–4.

1933. *Tsuga viridi-fluminipites* Wodehouse, p. 491.
1934. *Sporites macroserratus* Wolff, p. 67.
1935. *Tsuga* (*Canadensis*-Typ), Rudolph, p. 326.
1938. *Tsuga-pollenites macroserratus* (Wolff) Thiergart, p. 304.
1953. *Zonalapollenites viridifluminipites* (Wodeh.) Thomson & Pflug, p. 67.
1958. *Tsugaepollenites viridifluminipites* (Wodeh.) Potonié, p. 48.

Description. Usually flattened dorsoventrally and often folded, outline subcircular to spindle-shaped; longer diameter 70–100 μ. Entire surface densely covered with corrugated protrusions, usually 2–3 μ high and of "puffy" nature, thickness of their membranes *c.* 0.7 μ. Central part of the ventral side apparently depressed and has smaller and more wart-like protrusions, surrounded by a subequatorial belt with protrusions somewhat larger and more "puffy" than those of the dorsal side.

Specimens: S. 184 (pl. X, figs. 1, 2), S. 177 (pl. X, fig. 4), S. 183 (pl. X, fig. 3), S. 171, S. 174.

Affinities and remarks. Thiergart (1938) regarded *S. macroserratus* Wolff as synonymous with *T. viridi-fluminipites* Wodeh. but retained the specific name *macroserratus*, whereas Thomson & Pflug recognized the priority of Wodehouse's epithet.

In the German works the grains referred to this form species evidently form a heterogeneous assemblage. The figures show that specimens, both with and without prominent spines, have been included (for instance POTONIÉ 1951, pl. 20, fig. 24, and KRUTZSCH 1957, pl. 4, fig. 32). The spines have not been mentioned in earlier descriptions, but there is no reason why they should not be used as a diagnostic character. WODEHOUSE did not mention this character and evidently spines are lacking in his type specimen. This can be seen from his illustration as well as inferred from his statement about the correspondence to the pollen of *Tsuga canadensis* CARR., which entirely lacks spines. Therefore, the application of this form species should be restricted to grains without spines.

Allowing for the preservation, there is no character by which the Spitsbergen specimens could be distinguished from the pollen of *Tsuga canadensis.* Since WODEHOUSE stated about his species that "the size of the grain and the character of its convolutions correspond exactly with the grains of *Tsuga canadensis*", the Spitsbergen specimens can safely be referred to the same form species. The grains undoubtedly represent *Tsuga.* They have only been recovered from the Sarsbukta samples where they comprise 5 per cent of the exine contents, indicating that a species of *Tsuga* lived somewhere in the Spitsbergen area during the time when the Sarsbukta deposits were laid down.

Inaperturates incertae sedis

Non-aperturate reticulate grains.

Pl. XII, fig. 10, text-fig. 12.

Description. Outline circular to oval but with tendency towards an irregular polygonal shape. Longest diameter 20–30 μ. Original shape apparently spheroidal. Exine conspicuously reticulate, diameter of meshes 0.5–1.0 μ, occasionally up to 2.0 μ. In some specimens there is a marked difference in the mean size of the meshes in different parts of the exine. The muri are *c.* 0.5 μ high, and beaded in surface view. No aperture apparent.

Specimens: S. 137 (pl. XII, fig. 10), 65: 17.5–87.3, 15: 13.3–84.6, 14: 11.9–88.5.

Affinities and remarks. The grains have always been found singly, but many specimens are ruptured or incomplete in a way which suggests that they may have belonged to tetrads. Complete specimens have no visible apertures, and their characters strongly indicate a relationship with *Potamogeton.* Ruptured and incomplete specimens which have possibly been dispersed as tetrads and whose lack of apertures is uncertain may be referable to *Sparganium* or *Typha.*

The grains have been found sparsely in the lowermost series.

Potamogeton hollickipites WODEH. (1933, p. 496) from the Green River formation (Eocene, U.S.A.) includes grains resembling those considered here but possessing a coarser reticulum. THIERGART (1938, p. 308) found grains which he compared with *Potamogeton* in the lignites of Niederlausitz (U. Oligocene – Miocene).

MONOCOLPATES

Genus **Monocolpopollenites** Th. & Pf.

1953. *Monocolpopollenites* Thomson & Pflug, p. 62.
1958. *Palmaepollenites* Potonié, p. 97.

Remark. Potonié (1958, pp. 97–98) rejected this genus because it has the same genotype as *Palmaepollenites* Pot. (1951). However, it is difficult to see how the mere publication of the combination "*Palmaepoll. tranquillus* R. Pot. (1934)" in Potonié (1951, explanation to pl. XX, fig. 31) validates *Palmaepollenites* as a generic name. The first valid publication of *Palmaepollenites* was in Potonié (1958), while *Monocolpopollenites* was validly published by Thomson & Pflug in 1953 and therefore has priority.

Monocolpopollenites sp.

Pl. XII, figs. 11, 12.

Description. Outline subelliptical to boat-shaped, length *c*. 34 μ, width *c*. 20 μ. One prominent furrow in the full length of the grain and evidently deeply introverted. Exine *c*. 1.0 μ thick, smooth or very finely undulate; faint surface pattern of minute light dots.

Specimens: S. 267 (pl. XII, fig. 11), S. 264 (pl. XII, fig. 12).

Affinities and remarks. Only two rather poorly preserved grains have been found. They apparently resemble *M. tranquillus* (Pot.) Thomson & Pflug (1953, p. 62), but the material is not suitable for a closer identification and an indication of the natural affinity.

TRICOLPATES

Genus **Tricolpopollenites** Th. & Pf.

1953. *Tricolpopollenites* Thomson & Pflug, p. 95.
1960. *Cornaceoipollenites* Potonié, p. 93.

Remark. This is a nomenclatural case entirely analogous to that of *Monocolpopollenites.*

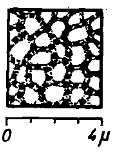


Fig. 12. Non-aperturate reticulate grains. Exine in surface view.

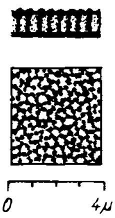


Fig. 13. *Tricolpopollenites haraldii* n. sp. Exine in surface view and optical section.

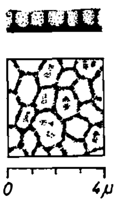


Fig. 14. *Tricolpopollenites* sp., Type A. Exine in surface view and optical section.

Tricolpopollenites haraldii n. sp.

Pl. XII, figs. 13–19, text-fig. 13.

Diagnosis. Meridional outline elliptical, polar axis 23–28 μ, equatorial diameter approximately ⅔ the polar axis. Three simple meridional furrows with tapering ends, and length ¾ the meridian, or more. Exine thickness *c.* 1.2 μ; two distinct layers, an inner one *c.* 0.3 μ thick supporting an outer one that consists of distinct rods, the ends of which make the exine profile rough. Surface pattern delicately but distinctly reticulate; muri beaded (text-fig. 13).

Holotype: 59: 10.0–82.8 (pl. XII, figs. 13, 14).

Paratypes: S. 91 (pl. XII, figs. 15, 16), 25: 15.5–73.8 (pl. XII, figs. 18, 19), 14: 8.3–86.6 (pl. XII, fig. 17).

Description. Most specimens are flattened laterally, only a few are flattened obliquely or show a polar aspect, which indicates an originally prolate shape. Some specimens differ somewhat in having slightly wider reticulum meshes, particularly in the equatorial and subequatorial areas.

Affinities and remarks. An indication of the possible affinity of these grains is suggested by their close resemblance to a pollen type met with in Hamamelidaceae and Platanaceae. Pollen of the *Platanus* type has been reported from several German Tertiary lignites: *Pollenites gertrudae* POT. (1934, p. 91) is smaller than *T. haraldii*, furthermore, the exine elements are broader and appear more like granules; *T. retiformis* TH. & PF. (1953, p. 97) apparently resembles *T. haraldii* but its description and figure are inadequate for a close comparison.

The form is rather common in both of the plant-bearing series of the main Tertiary basin.

The specific name is in honour of Mr. HARALD MAJOR, geologist at Norsk Polarinstitutt, who on his numerous expeditions to Spitsbergen collected most of the samples for the present work.

Tricolpopollenites sp.

Pl. XII, figs. 20–23, text-fig. 14.

Remark. In the following treatment, some tricolpate forms are described which differ from *T. haraldii*, and which could not be definitely identified with previously described forms. Since the forms are of minor importance quantitatively and not very distinctive, new species have not been described, and the forms are referred to *Tricolpopollenites* sp. and designated by letters A to C.

Descriptions. Type A (pl. XII, fig. 20, text-fig. 14). – Polar axis *c.* 20 μ, equatorial diameter approximately ⅔ the polar axis. Three somewhat poorly defined furrows nearly reach the poles. Sculpturing reticulate, meshes more or less polygonal, 1.0–1.5 μ across, but smaller ones occur. Muri faintly beaded. Exine thickness *c.* 1.0 μ, muri included; in optical section slender projections correspond to the elements of the muri. In surface view darkish spots may be observed in the reticulum meshes.

Specimens: 15: 13.6–76.0 (pl. XII, fig. 20), 49: 6.5–78.2, 49: 16.6–81.8.

Type B (pl. XII, figs. 21, 22). – Resembles Type A but differs in the following characters. Polar axis 26–30 μ. Furrows more prominent. The reticulum appears more irregular because the muri are more or less sinuous, and the meshes vary from less than 1 μ to 2.5 μ across. Also there is a slight decrease in the overall size of the meshes towards the poles. A beading of the muri is just perceptible.

Specimens: 25: 18.0–75.9 (pl. XII, figs. 21, 22), 25: 18.2–79.9.

Type C (pl. XII, fig. 23). – Rather indistinct grains with the following characters. Polar axis 15–25 μ, equatorial diameter ⅔ the polar axis, or more. Furrows prominent, nearly reaching the poles. Exine from finely dotted to apparently unpatterned, in optical section with or without radial elements visible, surface granular to smooth; thickness 0.5–1.5 μ.

Specimens: 14: 4.8–81.4 (pl. XII, fig. 23), 14: 13.7–86.9, 1: 7.9–76.7.

Affinities and remarks. Types A and B probably represent *Salix*. Type C is a heterogeneous group, but no further division seems possible. The possible relationships are too diverse to be specified.

Grains resembling to some extent the types A and B have been described by POTONIÉ (1934, pp. 89–91, *Pollenites confinis*, *P. gertrudae*), THIERGART (1938, pp. 310 and 326) and WODEHOUSE (1933, p. 506, *Salix discoloripites*). The species described by WODEHOUSE appears to be the most similar, but the reticulum walls are thicker than in types A and B. Similar but not identical grains from the Icelandic Tertiary were reported by PFLUG (1959, p. 156, *T. retiformis*; cp. also below p. 107).

Grains of the types A and B occur rarely in samples from the lowermost series. Type C occurs also in samples from the uppermost series and from Sarsbukta.

TRICOLPORATES

Genus **Trudopollis** PF.

1953. *Trudopollis* PFLUG, p. 98.

Trudopollis barentsii n. sp.

Pl. XII, figs. 24–27, text-fig. 15.

Diagnosis. Equatorial outline triangular, with somewhat convex sides and broadly rounded angles of slightly protruding appearance. The furrows form notches in the outline at the angles. Equatorial diameter 33–35 μ. Exine profile markedly rough to slightly undulate, "lips" of the apertures smooth. Surface pattern irregularly spotted except near the apertures, the spots consisting of clusters of minute dots, 0.5–0.8 μ in diameter. Three exine layers distinguishable. An outer one of nearly uniform thickness (*c.* 0.8 μ) with indistinct radial striation corresponding to the dots of the surface pattern; a middle layer somewhat thinner but with considerable thickening (2.0–2.5 μ) at the apertures; an inner one, *c.* 0.5 μ thick, increasing to twice the thickness towards the apertures, and apparently separated from the middle layer by a narrow space. The inner layer has large, pore-like interruptions at each aperture.

Holotype: S. 115 (pl. XII, figs. 24, 25).

Paratypes: 57: 17.0–77.6 (pl. XII, fig. 26), 57: 16.4–84.4 (pl. XII, fig. 27).

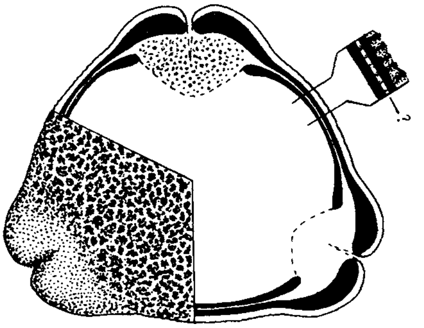


Fig. 15. *Trudopollis barentsii* n. sp. Diagram of grain in polar view. × 1250, detail section of exine × 2500.

Description. Judging from many obliquely and laterally flattened specimens, the polar axis was probably a little over ⅔ the equatorial diameter. The stratification of the exine is more or less obscure, but generally the innermost layer is quite prominent. The middle layer is distinguishable only in well-preserved specimens. There are indications of sparse elements connecting the innermost and middle layers. The ends of the rod-like elements of the outer layer make the exine surface appear granular; in surface view these elements form a more or less prominent pattern of irregular spots, except in the "lips" of the apertures, where they seem to be absent. An internal pattern of minute dots appears in each apertural region in the space between the furrow and the pore. This pattern can be quite conspicuous, but its nature is not clear.

Affinities and remarks. This new species resembles *Extratriporopollenites baculotrudens* PF. (in THOMSON & PFLUG, p. 74; transferred to *Trudopollis* in PFLUG 1953). The main differences are the more prominent radial striation of the exine ("deutlich intrabaculat und baculat") and the more pronounced thickenings of the outer exine layers at the apertures in PFLUG's species. Compared with the genotype (*T. pertrudens* PF.), *T. barentsii* has less protruding aperture regions and thinner inner exine layer. Furthermore, the genotype has no thickening of the inner layer at the apertures.

This species is common in the "Longyear-seam" and has also been recovered from Sarsbukta. The natural origin of this and similar forms is unknown. The group as a whole is particularly abundant in Central European lignites of the Upper Cretaceous and Paleocene but disappears during the Eocene.

The specific name is in honour of WILLEM BARENTS, the Dutch explorer who rediscovered the land now called Vestspitsbergen during his search for the Northeast Passage in 1596.

Trudopollis resistens n. sp.

Pl. XIII, figs. 1–5, text-fig. 16.

Diagnosis. Equatorial outline convex-triangular with broadly rounded angles where the furrows appear as notches. Equatorial diameter *c.* 45 μ. Aperture regions of very slightly protruding appearance. Exine profile uneven, with scattered pits, except near the furrows where the exine is smooth. Three exine layers distinguishable. An inner membrane of uniform thickness *c.* 0.7 μ, with large interruptions at the apertures; a second layer *c.* 0.5 μ thick, increasing to *c.* 2.0 μ

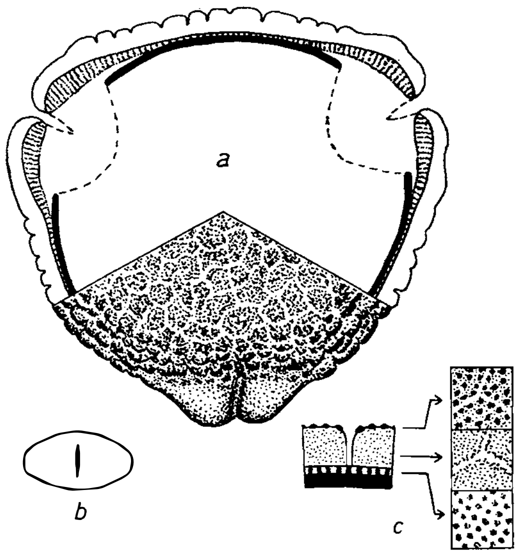


Fig. 16. *Trudopollis resistens* n. sp. – a. Diagram of grain in polar view, ×1250. b. Probable shape in meridional view. – c. Exine in optical section and in surface view at three successive foci, ×2500.

at the apertures, with more or less faint radial striation; an outer layer of nearly uniform thickness 1.8–2.0 μ, traversed by a network of narrow grooves. The grooves give rise to steep-sided, irregular warts, whose surfaces are minutely granular.

Holotype: 61: 15.0–80.6 (pl. XIII, figs. 1–4).

Paratypes: 25: 15.7–82.7 (pl. XIII, fig. 5), 69: 8.7–77.6.

Description. The original shape was evidently oblate. In surface view the sculpturing appears to be composed of close, irregular, and rather steep-sided warts. When focusing on the tops of the warts, small dark spots, which are minute granules, can be seen on their surfaces. These granules are perhaps the ends of rod-like exine elements, but in optical section no corresponding elements can be observed. The striation of the second layer is not very marked in optical section, but in surface view the elements can be distinguished when focusing on the proper layer. At the apertures the internal delineation of the second layer is not quite as clear as indicated in text-figure 16.

Affinities and remarks. Morphologically this species closely resembles *T. barentsii*, but the sculpturing is different. It has been sparsely recovered from the "Longyear-seam".

Trudopollis rotundus n. sp.

Pl. XII, figs. 28–31, text-fig. 17.

Diagnosis. Equatorial outline nearly circular, tending towards a triangular shape. The furrows form notches at the angles; the aperture regions are non-protruding. Equatorial diameter 28–32 μ. Exine rough, smooth near the apertures. Surface pattern minutely and distinctly dotted, dots slightly irregularly arranged, occasionally grouped to form spots or bands. Two main exine layers apparently separated by a narrow space. Outer layer with short furrows, in polar view slightly

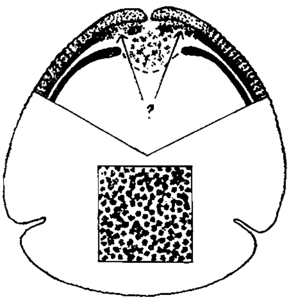


Fig. 17. *Trudopollis rotundus* n. sp. Diagram of grain in polar view. ×1250, detail of surface pattern ×2500.

shorter than ¼ the radius of the grain; inner layer with big pores opposing the furrows; width of pores in polar view *c.* 6 μ. Outer layer faintly striated, the ends of the elements roughen the surface and correspond to the dotted pattern in surface view; striation indistinguishable in the "lips" of the apertures. Striated part of uniform thickness and resting on a thinner part, which appears thickened at the apertures. Total thickness of the outer exine layer *c.* 1.6 μ, increasing to somewhat more than 2 μ at the apertures. Thickness of the inner layer *c.* 0.5 μ with a slight increase towards the pores.

Holotype: S. 123 (pl. XII, figs. 28, 29).

Paratype: 60: 6.2–83.1 (pl. XII, figs. 30, 31).

Description. The specimens are flattened so as to indicate an originally oblate shape. The stratification in the outer of the two main exine layers is not conspicuous; the composition is particularly unclear at the apertures. The outer part of this layer does not increase in thickness at the apertures, whereas the inner part appears to be thickened. There are faint indications of a vestibulum formed by the two parts of the outer layer. No connecting elements could be distinguished in the apparent interstice between the two main layers. An internal dotted pattern, whose true nature could not be discerned, appears in the apertural regions between the furrows and the pores. This pattern is coarser and less regular than that of the exine surface. The delineation of the pores of the inner layer is usually clear.

Affinities and remarks. This species, which is also common in the "Longyear-seam", somewhat resembles *T. barentsii*, but apart from being smaller it can be distinguished from that species by the much less triangular shape of the equator and the non-protruding apertures. Also the dotted surface pattern is finer, with less prominent spots. When compared with PFLUG's species, a resemblance to *T. parvotrudens* and *T. proparvus* is evident (PFLUG 1953, p. 100), but both comprise grains which are smooth or nearly smooth and only 15 μ in diameter.

Trudopollis sp., Type A.

Pl. XIII, fig. 6.

Description. Equatorial outline rounded with tendency towards a more or less triangular shape. Apertures not markedly protruding. The furrows produce U- to V-shaped notches at the angles of the equatorial outline. Equatorial diameter *c.* 40 μ. Except for the apertural regions the exine is markedly granular, apparently due to the ends of rod-like elements of the outer exine layer, which in surface view appear as distinct dots with diameter *c.* 0.5 μ. Two exine layers distinguishable, the inner one of which is very thin and apparently separated from the outer one by a narrow space. In this space there are faint indications of thinly spaced rods connecting the two layers. The total exine thickness is slightly greater than 1 μ, with a very slight increase in the thickness of the outer layer towards the apertures. At each aperture there are large pore-like interruptions in the inner layer.

Specimens: 57: 17.4–86.3 (pl. XIII, fig. 6), 67: 16.6–81.7, 67: 19.0–82.5.

Affinities and remarks. These grains do not differ much in general appearance from specimens referred to *T. barentsii*, except that the exine is thinner and more translucent. On close examination, however, the differences become apparent. The apertures are usually less protruding and practically without thickening of the exine; the granules of the surface are finer; the exine is thinner, and only two layers with an interstice can be distinguished.

This type seems different from the existing species, but it is not sufficiently known for the establishment of a new one. It has been rarely recovered from the "Longyear-seam".

Trudopollis sp., Type B.

Pl. XIII, figs. 7–12, text-fig. 18.

Description. Equatorial outline triangular with nearly straight sides, angles rounded, with furrows as notches in the outline. In polar view the furrows reach nearly ⅓ the distance to the pole. Equatorial diameter 42–47 μ. Exine smooth or very slightly rough, in surface view with spots of varying size but less than 0.8 μ in diameter. Thickness of exine *c.* 2 μ equatorially in the extra-apertural regions, two layers distinguishable. Innermost layer *c.* 0.5 μ thick with thickness increasing slightly towards the apertures. External and internal margins of the exine *c.* 5 μ apart in the apertural regions, this thickness apparently includes apertural interstices of vestibulum-type. Opposing the furrows of the outer layer there are large pore-like interruptions in the inner one. Other details of the apertures are unclear,

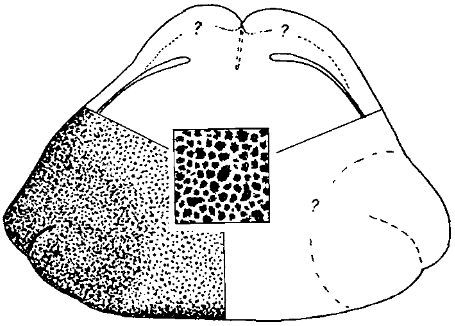


Fig. 18. *Trudopollis* sp., Type B. Diagram of grain in polar view. ×1250, detail of surface pattern ×3000.

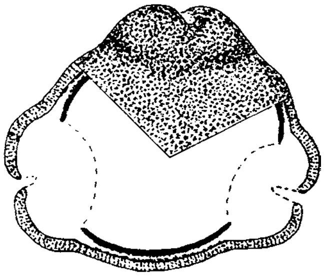


Fig. 19. *Trudopollis*(?) sp., Type C. Diagram of grain in polar view. ×1250.

because the specimens are particularly opaque in the apertural regions. In polar view the more opaque fields have a nearly semicircular delineation, but the outline is not distinct. The opaqueness is probably due to circum-apertural thickenings of the outer exine layer.

Specimens: 41: 15.3–69.6 (pl. XIII, figs. 7–9), 19: 13.3–76.8 (pl. XIII, figs. 10–12).

Affinities and remarks. These grains are distinguished from *T. barentsii* by their larger size and the more straight-sided triangular outline. Although the composition of the apertures is not quite clear in every detail, they are obviously of the *Trudopollis* type. The grains have been rarely recovered from the "Longyear-seam" and the "Askeladd-seam".

Trudopollis (?) sp., Type C

Pl. XIII, figs. 13–16, text-fig. 19.

Description. Equatorial diameter *c.* 30 μ, equatorial outline rounded with broad and prominently protruding apertural regions. Exine delicately dotted; surface rough but smoother in the protruding parts. Two exine layers of uniform thickness distinguishable, the outer one *c.* 0.8 μ thick, the inner one *c.* 0.5 μ thick. The layers are apparently separated by a space, but adjacent parts are rough and show indications of connecting elements. The outer layer has a faint radial striation. The apertures appear as short meridional furrows in the outer layer. In polar view of the grains the optical section of the inner layer appears as three arcs of a subcircle (cp. text-fig. 19), with the wide interruptions opposing the furrows of the outer layer.

Specimens: S. 123 (pl. XIII, figs. 13, 14), 57: 12.5–79.2 (pl. XIII, figs. 15, 16).

Affinities and remarks. Only two specimens of this very distinct form have been found. They are referred to *Trudopollis* with reservation because the apertures are not of the typical *Trudopollis* type. The form is not sufficiently known to be determined more exactly.

STEPHANOCOLPORATES

Genus **Tetrapollis** Pf.

1953. *Tetrapollis* Pflug, p. 112.

Tetrapollis conspectus n. sp.

Pl. XIV, figs. 1–8, text-fig. 20.

Diagnosis. Equatorial outline rounded to quadrangular with the furrows at the angles; diameter *c.* 35 μ. Meridional outline oval but tends towards a rectagonal form with rounded corners. Four furrows *c.* 6 μ long, at right angles to the equator. Exine consists of two distinct layers apparently separated by a narrow space; outer layer *c.* 0.6 μ thick, inner layer 1.0–1.5 μ thick; both are slightly thickened at the apertures. Exine surface non-sculptured. On focusing slightly

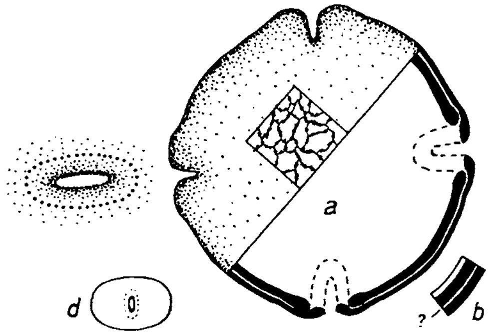


Fig. 20. *Tetrapollis conspectus* n. sp. – a. Diagram of grain in polar view, ×1250. Central square shows the internal reticulum. – b. Exine in optical section, ×2500. – c. Meridional view of an aperture, ×1250. – d. Probable shape of grain in meridional view.

below the surface, a faint reticulate pattern appears with thin, beaded muri and irregular meshes, diameters between 1 and 3 μ. The inner layer has elliptical pores, *c.* 6 × 12 μ, with their long axes parallel to those of the furrows.

Holotype: 54: 10.0–90.6 (pl. XIV, fig. 1).

Paratypes: 57: 15.3–84.7 (pl. XIV, figs. 2–4), 57: 10.9–88.2 (pl. XIV, fig. 5), 57: 18.3–77.3 (pl. XIV, fig. 6), 57: 11.9–74.8 (pl. XIV, fig. 7), 57: 18.7–85.9 (pl. XIV, fig. 8).

Description. The exine is unfolded and appears rather resistant. Most specimens show the polar aspect, but a few are flattened obliquely or show a meridional aspect, thus indicating the originally oblate shape. The exine surface is smooth and without surface pattern, but in optical section both the internal and external exine outline can have inconspicuous and gentle, irregular undulations.

On focusing slightly below the surface a reticulate pattern appears, showing muri that are faintly beaded. The meshes are of varying shapes and sizes. Possibly the pattern belongs to the apparent space between the main exine layers, but in optical section no corresponding elements have been distinguished. Both layers of the exine thicken slightly at the apertures, and the apertural regions protrude somewhat. The apertures of the outer layer are quite short furrows, whereas in the inner layer they are oval and pore-shaped, having lengths not exceeding twice their widths. In some specimens one can distinguish in this inner part of the exine two layers, of which the inner one appears to be of uniform thickness throughout.

Affinities and remarks. In *Tetrapollis* the apertures are esentially as in *Trudopollis*, but in the present species they are not typically as in that genus. With some hesitation, therefore, this species is referred to *Tetrapollis*, which appears to be the genus to which it most closely corresponds. The establishment of a new genus is undesirable before the form is better known.

The species is very homogeneous and probably represents one natural species. It has been rarely recovered from certain samples of the "Longyear-seam". As for the natural affinity the overall appearance suggests Ulmaceae. It lacks the sculpturing characteristic of the pollen of *Ulmus* and some related genera.

Tetrapollis quadratus n. sp.

Pl. XIV, figs. 9–12, text-fig. 21.

Diagnosis. Equatorial outline approximately quadrangular with sides somewhat convex, diameter *c.* 40 μ. Meridional furrows, *c.* 6 μ long, situated at the angles; apertural regions protrude slightly. Exine conspicuously granular, undulate in profile, but apertural regions practically smooth. Exine, *c.* 1.5 μ thick, consists of at least two layers apparently separated by a narrow space. The inner layer is a thin membrane less than 0.4 μ thick with large, rounded pores opposing the furrows; the outer layer is *c.* 0.8 μ thick in the extra-apertural part and is composed of closely spaced rods, *c.* 0.5 μ in diameter, which make the surface granular.

In the apertural regions the outer layer is twice as thick, but this is not due to an increase in the length of the rods.

Holotype: S. 130 (pl. XIV, figs. 9, 10).

Paratypes: S. 131 (pl. XIV, figs. 11, 12), 69: 9.6–83.3.

Description. The manner in which specimens are flattened indicates that the grains originally had flat oblate forms. The furrows apparently cross the equator at right angles. The granulation is conspicuous, but the corresponding rods are sometimes obscure in optical section of the wall, and in the apertural regions the individual rods cannot be distinguished. However, the particular layer can be distinguished also in the apertural regions, and it can be seen that the thickening is due to a part underlying the rod-like elements but which is for some reason indistinguishable in the extra-apertural part of the wall. No elements can be seen connecting the two main layers of the exine.

Affinities and remarks. *T. quadratus* has less pronounced apertural thickenings than the species referred to *Tetrapollis* in Pflug (1953). The apertures, however, appear to be of essentially the same type as in *Tetrapollis*.

The apertures correspond morphologically to those of *Trudopollis*, and apart from the number of apertures the species has much in common with *Trudopollis* sp., Type A. *Tetrapollis quadratus* and *Trudopollis* sp., Type A, are not regularly associated in the samples, therefore they cannot be merely representatives of the same natural species having pollen with a varying number of apertures. However, the morphological resemblance possibly indicates a natural relationship between the parent plants of these grains and those of the *Trudopollis* category.

This species has only been recovered very rarely from the roof of the "Long-year-seam".

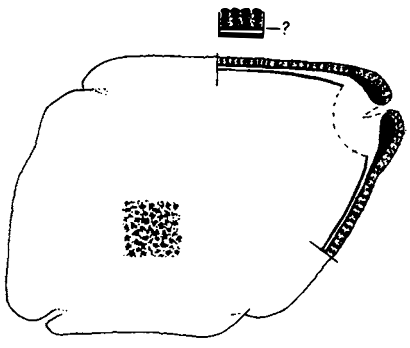


Fig. 21. *Tetrapollis quadratus* n. sp. Diagram of grain in polar view. ×1250, detail section of exine ×2500.

Tetrapollis sp. (cf. **Trudopollis resistens**)

Pl. XIV, fig. 13.

Description. Corresponds in every detail to *Trudopollis resistens*, except that there are four apertures.

Specimen: 69: 17.0–81.5 (pl. XIV, fig. 13).

Affinities and remarks. One specimen was found. Morphologically it belongs to the form genus *Tetrapollis*, but the conformity with *Trudopollis resistens* indicates that it is merely a four-aperturate variety of the grains included in that species.

TRIPORATES

Remark. Triporate grains abound in the material. However, the details of their apertures, which are of particular diagnostic value, are generally too obscure to make close identifications with existing form species possible. Even a reference to form genera[1] has to be in most cases tentative, since they are also distinguished by the pore details. Therefore, except in two cases, the forms which have been distinguished here have been designated provisionally as Triporates, types A to F. However, for large numbers of triporate specimens a reference even to these types is either difficult or impossible because the diagnostic characters are obscure. The number of distinct types present is probably less than fifteen.

Genus **Myricipites** WODEH.

1933. *Myricipites* WODEHOUSE, p. 505.

Remarks. This generally overlooked genus was validly published, and it is the proper name for species which have been published later under different generic names, such as, for instance, *Triatriopollenites* PF. (in THOMSON & PFLUG 1953, p. 76).

Myricipites speciosus n. sp.

Pl. XIV, figs. 14–20, text-fig. 22, a.

Diagnosis. Equatorial outline circular to somewhat triangular, diameter 30–35 μ. Three equatorial pores. Pore regions moderately protruding. Exine smooth, with a dotted surface pattern. By focusing on a level just below the surface, another more distinct pattern of dots can be observed. Pore regions dark and slightly thickened, and where not too dark, a conspicuously dotted pattern resulting from internal structures can be seen. Exine is *c.* 1.4 μ thick, consisting of three layers. Relative thickness and details of the exine layers are given in text-figure 22, a. A thickening in the pore regions seems to be caused by the middle layer, the other two being of uniform thickness. In optical section of the pore

---

[1] POTONIÉ's treatment of the genera of triporate grains in "Synopsis" (1960) cannot be agreed with. A large number of the generic designations that were regarded valid by POTONIÉ were actually validated through "Synopsis" (e. g. *Betulaceoipollenites*, *Ostryoipollenites*, *Engelhardtioipollenites*, *Engelhardtioidites*, *Myricaceoipollenites*).

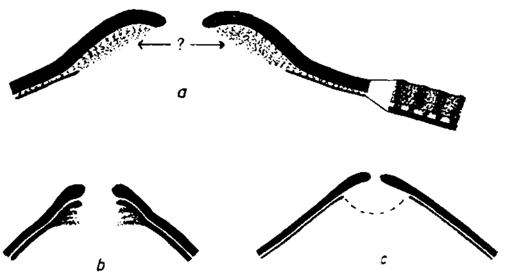


Fig. 22. Triporates, pore details in optical equatorial sections. ×1500, detail section in a ×3000. – a. *Myricipites speciosus* n. sp. – b. Triporates, Type A. – c. Type B.

regions the innermost layer is seen to stop shortly after the rise of the outermost layer.

Holotype: 59: 17.4–83.1 (pl. XIV, figs. 15, 16).

Paratypes: 59: 17.4–82.9 (pl. XIV, fig. 14), 57: 18.6–80.5 (pl. XIV, figs. 17, 18), 57: 17.2–86.3 (pl. XIV, fig. 19), 57: 17.6–86.0 (pl. XIV, fig. 20).

Description. From the manner of flattening of the specimens it appears that the original shape of the grains was oblate and the polar axis not very much shorter than the equatorial diameter. A dotted exine pattern is always prominent, but it is not always evident that there are two different patterns at slightly different focusing levels. In optical section the middle exine layer usually appears as a narrow space between the two others, but in some specimens rod-like elements are quite conspicuous. The elements of the outer layer, however, are never very distinct.

In the pore regions the dotted pattern becomes somewhat different. When the exine is not too opaque, the pattern is emphasized, and appears to be produced by some internal structures; when viewed in oblique position the pattern elements appear elongate. The thickening in the pore regions seems to be caused by an increase in the length of the elements of the middle layer; but the details are not clear, and the inward delineation of this layer is diffuse.

Affinities and remarks. Though the composition of the pores is not completely clear, it is obvious that their structure as seen in optical section is of the type termed "tarsus pattern" by WODEHOUSE (1933, p. 505) and which is one of the distinctions of *Myricipites*. Characteristic of this pattern is the wide broadening of the pore inwards and the blurred delineation of the lower exine layers towards the pore. As far as the pore characters of the Spitsbergen grains can be distinguished, they appear comparable to those of *Myrica*. However, an affinity with the Betulaceae (*Corylus* ?) cannot be excluded. The grains form a fairly homogeneous unit. They are fairly common in various samples from the "Longyear-seam".

Triatriopollenites rurensis THOMSON & PFLUG (1953, p. 79) appears similar, but details are insufficiently known for a closer comparison.

Myricipites sp.

Pl. XV, figs. 1, 2.

Description. Differs from *M. speciosus* in having an equatorial diameter of 25 μ and practically non-protruding pores.

Specimens: S. 197 (pl. XV, fig. 1), S. 199 (pl. XV, fig. 2).

Affinities and remarks. Only two grains of this type were available. The pore structures suggest similar affinities as those indicated for *M. speciosus*.

Triporates incertae sedis

Triporates, Type A

Pl. XV, figs. 3–9, text-fig. 22, b.

Description. Equatorial outline subtriangular with prominently arched sides and somewhat abruptly protruding pore regions that are 7–8 μ broad. Equatorial diameter *c.* 26 μ. Exine *c.* 1.2 μ thick, composed of at least two layers of nearly equal thickness. The outer layer forms somewhat thickened "lips" at the pores while the inner one appears to split into several lamellae to form a vestibulum (text-fig. 22, b). The exine is finely and usually distinctly dotted in surface view, in optical section it is smooth.

Specimens: S. 175 (pl. XV, figs. 3, 4), S. 262 (pl. XV, fig. 5).

To this type are also referred grains of the same overall appearance but with barely visible exine stratification and pore details; the pore regions are usually remarkably opaque, indicating that they have exine thickenings of the vestibulum type. Equatorial diameter generally between 25 and 35 μ, but occasionally greater.

Specimens: S. 1 (pl. XV, fig. 6), 14: 18.3–83.2 (pl. XV, figs. 7, 8), 25: 17.3–77.0 (pl. XV, fig. 9).

Affinities and remarks. The details are not sufficiently distinct for further differentiation, but the heterogeneity of the grains indicates diverse origins. The characters are distinctly betuloid, and probably two or three species of *Betula* are represented.

The best specimens come from the Sarsbukta samples where they are rather uniform; grains which are probably identical are found in the coal samples, but their details are less clear.

Triporates, Type B

Pl. XV, figs. 10–12, text-fig. 22, c.

Description. Equatorial outline of triangular appearance, with markedly convex sides; diameter 30–35 μ. Pores essentially as in text-figure 22, c, sometimes they protrude more but always more gently than in Type A. The pores also lack the conspicuous thickenings of that type. Exine *c.* 1.0 μ thick, sometimes with an indication of stratification, particularly at the pores where an innermost layer can be seen to terminate a short distance from the pore. Surface pattern minutely dotted, usually inconspicuous.

Specimens: 69: 13.7–77.2 (pl. XV, fig. 10), 52: 19.6–77.1 (pl. XV, fig. 11), 47: 7.0–79.1 (pl. XV, fig. 12).

Affinities and remarks. There is some variation in the appearance of the pores, but they are essentially as shown in text-figure 22, c. The pore characters suggest an affinity with *Corylus*, but a myricaceous affinity also seems possible. Usually the details are too obscure to allow a definite determination. The type is common in the lowermost series.

Triporates, Type C

Pl. XV, figs. 13–16.

Description. Equatorial outline nearly circular, diameter 25–32 μ. The pores are non-protruding, and appear as notches in the equatorial outline. The grains are frequently flattened in an oblique position, indicating an originally almost globular shape. The exine is not thickened at the pores, and there are no dark fields around the pores. The pores seem to be of rather simple composition. Exine thickness varies (0.5–1.0 μ). The sculpturing seems to indicate the presence of at least two varieties: one that is minutely granular, with slightly rough exine profile, and one that is more coarsely granular and with a delicately undulate profile. The latter usually has a thinner exine.

Specimens: S. 96 (pl. XV, fig. 16), 14: 10.3–84.5 (pl. XV, figs. 13–15).

Affinities and remarks. The indistinct characters make an indication of the natural affinity difficult, but an origin from within the Amentiflorae seems likely. The type occurs sparsely in the lowermost series.

Triporates, Type D

Pl. XV, fig. 26.

Description. Equatorial outline approximately hexagonal, due to the broad pore regions. Diameter 29 μ. Exine *c.* 0.7 μ thick, finely granular, profile very slightly rough. Pores simple, with no conspicuous exine thickenings, surrounded by slightly darker fields which are not sharply delineated.

Specimen: 57: 10.9–88.0 (pl. XV, fig. 26).

Affinities and remarks. The statements made for Type C apply here also. The type is very rare.

Triporates, Type E

Pl. XV, figs. 18–21.

Description. Equatorial outline of triangular appearance, with markedly convex sides; the pores protrude prominently. Equatorial diameter 25–30 μ. Exine *c.* 1.0 μ thick and two layers of approximately equal thickness can be distinguished. Surface pattern minutely and indistinctly dotted, exine profile is smooth. Details of the pore regions are obscure. At the pore regions the exine is approximately twice as thick and both layers appear to be thickened; they seem to form a vestibulum. More or less distinct bands of thickened exine (arcus) connect the pores, or folds of the exine indicate such bands. In polar view the bands extend into the "lips" of the pores.

Specimens: 20: 19.7-88.9 (pl. XV, figs. 18, 19), 20: 13.2–87.7 (pl. XV, figs. 20, 21), 25: 7.4–78.8.

Affinities and remarks. Apparently the exine is apt to fold along the arcus, which therefore appear more prominent than they probably would in an unflattened grain. The apertures match well with the *Betula* type as far as the details can be distinguished. The arcus compare with those which are sometimes seen in *Betula* pollen and which are characteristic in *Alnus* pollen. Together with the number of apertures this strongly suggests an affinity with *Betula*. The grains are not merely three-pored varieties of one of the forms referred to *Alnipollenites*. They occur rarely in the lowermost series.

Very similar grains from the Icelandic Tertiary were described by PFLUG (1959, p. 158, *Trudopollis probetuloides*), who offered, however, an improbable interpretation of features produced during fossilization ("Y-Doppelmarke"; for further discussion cp. p. 104). Grains of similar appearance, but smaller and more triangular in shape, were described by PFLUG (1953, p. 97, *Plicapollis serta*, from Upper Cretaceous, Aachen) and POTONIÉ (1934, p. 58, *Betulae-pollenites microexcelsus*, from Eocene, Geiseltal, and Miocene, Ville).

Triporates, Type F

Pl. XV, fig. 17.

Description. Equatorial outline nearly circular; the pores protrude very slightly. Diameter 20–23 μ. Exine very finely but distinctly granular. The pores appear as simple holes, *c.* 1.0 μ in diameter. Faint indication of an exine stratification: an outer layer, *c.* 0.8 μ thick, which is finely but distinctly granular, and an inner, very thin layer which appears loosely connected with the outer. Indications of a pore pattern similar to Type B (text-fig. 22, c). The specimens are usually somewhat folded.

Specimens: 65: 18.4–83.7 (pl. XV, fig. 17), 65: 14.5–85.2.

Affinities and remarks. The characters are not very conclusive, but a betulaceous or myricaceous relationship is suggested. The grains have been recovered rarely from one sample of the "Longyear-seam" only.

Triporates? type

Pl. XV, figs. 22–25.

Description. Equatorial outline more or less triangular to circular; diameter varying from 25 to 40 μ. Three conspicuous apertures, which seem to be pores, are meridionally slightly elongate. They are surrounded by a prominent ring-shaped swelling, but a satisfactory interpretation of the true nature of the apertures cannot be given. The sculpturing consists of large, prominent warts that are quite close and vary in shape; their diameters are rarely less than 4 μ. A pattern of small dark dots, not always conspicuous, is seen on the surface of the warts. In optical section corresponding dots can be observed in some places, and there is also a vague indication of a radial striation, possibly indicating that the dots are the tops of rod-like exine elements. The warts are smooth in profile.

Specimens: S. 27 (pl. XV, fig. 23), 54: 9.9–86.8 (pl. XV, figs. 24, 25), 14: 9.4–78.6 (pl. XV, fig. 22).

Affinities and remarks. I know no living or fossil equivalents to these grains. They have been very rarely recovered from the "Longyear-seam".

STEPHANOPORATES

Genus **Alnipollenites** Pot.

1934. *Alni-pollenites* Potonié, p. 58.
1953. *Polyvestibulopollenites* Pf. in Thomson & Pflug, p. 90.
1960. *Alnipollenites* Potonié, p. 129.

Remark. Potonié (1960) provided a description of this genus, which was validly published by the combined generic and specific description of *A. verus* in Potonié (1934).

Alnipollenites sp.

Pl. XVI, figs. 1–10.

Remark. Grains referable to *Alnipollenites* are abundant in some samples. They vary greatly in appearance, but it has been difficult to classify them satisfactorily. The considerations concerning the details of the exine and the apertures given for the triporate grains apply also to the representatives of *Alnipollenites*. The grains are therefore referred neither to previous species nor to new ones, but are classified provisionally into three major types designated by letters (A, B, C).

The outline of the flattened specimens usually coincides with the equator, indicating an originally oblate shape. Some specimens show a more or less oblique aspect, and in such cases it is seen that the pores are elongate meridionally.

Descriptions. Type A (pl. XVI, figs. 1–4). – Equatorial diameter usually 30–40 μ, but some crumpled up specimens can be smaller. Pores 5–7, protrude only very slightly. Exine slightly rough, in surface view very finely dotted, noticeably dark in the pore regions where the thickness is 2.0–2.5 μ. In the extra-apertural parts the exine is less than 1 μ thick. Arcus conspicuous.

Specimens: 14: 12.6–76.0 (pl. XVI, fig. 1), S. 133 (pl. XVI, fig. 2), 25: 6.6–82.1 (pl. XVI, fig. 3), 25: 9.4–84.5 (pl. XVI, fig. 4).

Type B (pl. XVI, figs. 5–9). – Equatorial diameter 20–25 μ. Pores usually 5, protrude somewhat. Exine smooth, in surface view minutely dotted, thickness in the extra-apertural parts *c.* 1.0 μ, in the pore regions *c.* 2.5 μ. Two layers distinguishable, the inner one is of uniform thickness *c.* 0.5 μ, the outer one forms the protruding and somewhat thickened "lips" of the apertures. Arcus can be inconspicuous.

Specimens: S. 265 (pl. XVI, figs. 7, 8), S. 252 (pl. XVI, fig. 9), S. 253 (with 4 pores).

The above specimens come from the Sarsbukta locality. In coal samples from the lowermost series of the main basin similar grains with 5 or 6 pores occur, but their finer details are obscure.

Specimens: 15: 11.9–86.8 (pl. XVI, fig. 5), 14: 11.4–73.7 (pl. XVI, fig. 6), 14: 18.0–80.6 (with 6 pores).

Type C (pl. XVI, fig. 10). – Equatorial diameter *c.* 30 μ. Pores 7. Exine surface minutely dotted, profile smooth. Exine thickness *c.* 1.5 μ, increasing to 2.0–2.5 μ in the pore regions. In the extra-apertural parts two layers of approximately equal thickness can be distinguished. The pores have indications of vestibuli.

Pore regions protrude slightly, and the pores are smaller than in type A; their surrounding exine thickenings and the arcus are prominent.

Specimen: 14: 9.3–87.0 (pl. XVI, fig. 10).

Affinities and remarks. These very distinctive grains possess the characteristics of *Alnus* pollen and there can be no doubt that they represent that genus. They occur sparsely in samples from the main Tertiary basin, Type C is very rare. From Sarsbukta material Type A and cf. Type B have been recovered.

Although a great variety of types have been included in *A. verus* (the type species of the genus), particularly by THOMSON & PFLUG, identification of any of the present types with it is avoided. Type B seems to correspond closely to the original description of *A. verus* (POTONIÉ 1934, p. 58).

PFLUG (1959) identified various Icelandic grains with *A. verus*. His *Polyvestibulopollenites verus* Form S seems to resemble the present Type B, and his Form H resembles the present Type A. Type A also resembles *Alnus speciipites* WODEHOUSE (1933, p. 508).

Genus **Polyatriopollenites** PF.

1953. *Polyatrio-pollenites* PFLUG, p. 115.
1960. *Pterocaryapollenites* THIERG. emend. POTONIÉ, p. 132.

Remark. The first valid publication of *Pterocaryapollenites* was that in POTONIÉ (1960) so that *Polyatriopollenites* has priority. Moreover, RAATZ (1937, p. 18) used the designation *Pterocarya-pollenites* prior to THIERGART and in the same combination.

Polyatriopollenites cf. **stellatus** (POT.) PF.

Pl. XVI, figs. 11–12.

1934. *Pollenites stellatus* POT. in POTONIÉ & VENITZ, p. 20.
1937. *Pterocarya-pollenites stellatus* (POT.) RAATZ, p. 18.
1938. *Pterocarya-pollenites stellatus* (POT.) THIERGART, p. 311.
1953. *Polyporopollenites stellatus* (POT.) THOMSON & PFLUG, p. 91.
1953. *Polyatriopollenites stellatus* (POT.) PFLUG, p. 115.
1960. *Pterocaryapollenites stellatus* (POT.) THIERG. in POTONIÉ, p. 132.

Description. Equatorial outline of somewhat angular shape, size 34 × 40 μ. 6 pores of which some appear slightly subequatorial; they are slightly elongate meridionally, about 2.5 × 3.5 μ in size. Exine apparently two-layered, *c.* 1.0 μ thick, in the pore regions it is slightly thicker but does not protrude. Pore pattern essentially as in *Juglanspollenites* sp. (cp. text-fig. 23). Exine in surface view minutely dotted.

Specimens: 90: 12.3–84.1 (pl. XIV, figs. 11, 12), 19: 16.1–70.0.

Affinities and remarks. The first of the specimens listed was recovered from Sarsbukta material. It is slightly folded but otherwise well preserved. Probably it could have been included in *P. stellatus* which evidently comprises a heterogeneous assemblage. The characters strongly suggest a relationship with *Pterocarya*.

The second specimen (from L 3, upper point) has the same general characters, but it is less well preserved so that its identity with the first one cannot be confirmed.

PERIPORATES

Genus **Juglanspollenites** RAATZ

1937. *Juglans-pollenites* RAATZ, p. 18.
1953. *Multiporopollenites* PF. in THOMSON & PFLUG, p. 94.

Remark. As a monotypic genus *Juglanspollenites* was validated by the description of *J. verus* RAATZ (1937, p. 18). From the description of *Multiporopollenites* PF. it is clear that it duplicates *Juglanspollenites* and therefore has to be treated as a later synonym. The distinction made between *Juglanspollenites* and *Multiporopollenites* by POTONIÉ (1960, pp. 135, 136) is hardly tenable.

Juglanspollenites sp.

Pl. XVI, figs. 13, 14, text-fig. 23.

Description. Outline subcircular to slightly angular, size 33 × 37 μ. Pores sixteen in number, distributed mostly over one hemisphere but a few are in the subequatorial region of the other hemisphere. Pores circular to slightly elongate, non-protruding, diameter approximately 2 μ. Exine *c.* 1.0 μ thick, not appreciably thickened at the pores; apparently two-layered with a very thin inner layer. Exine in surface view faintly dotted, in optical section smooth. Pore-pattern and distribution of pores are shown in text-figure 23.

Specimen: S. 166 (pl. XVI, figs. 13, 14, text-fig. 23).

Affinities and remarks. The single well preserved specimen (from Sarsbukta) must be related to *Juglans*. It is not referable to *Juglanspollenites verus* RAATZ. A poorly preserved specimen (from the lowermost series) with few distinguishable details but the same overall appearance and arrangement of the pores is preserved as S. 14.

Genus **Periporopollenites** TH. & PF.

1953. *Periporopollenites* THOMSON & PFLUG, p. 111.
1960. *Liquidambarpollenites* RAATZ emend. POTONIÉ, p. 134.

Remark. *Liquidambarpollenites* has the same type as *Periporopollenites* and was first validly published by POTONIÉ (1960) so that it is a later synonym.

Periporopollenites sp.

Pl. XVI, figs. 15, 16.

Description. Outline subcircular, diameter 18–25 μ. About eight poorly defined apertures regularly distributed throughout the surface; they appear as gentle depressions *c.* 4 μ wide. Exine *c.* 1.0 μ thick, composition and stratification obscure, in surface view finely dotted, as is the aperture membrane; surface finely granular.

Specimens: 28: 17.6–81.4 (pl. XVI, fig. 15), 21: 3.3–80.2 (pl. XVI, fig. 16).

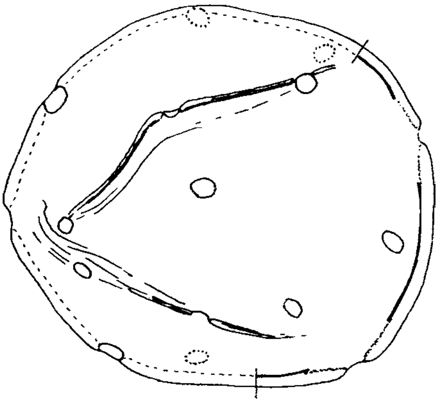


Fig. 23. *Juglanspollenites* sp.
Same specimen as in pl. XVI figs. 13, 14. × 1500.

Affinities and remarks. These distinctive grains are extremely rare and the specimens yield only few details. Their general appearance and the poorly defined apertures suggest an affinity with the Alismataceae.

INCERTAE SEDIS

Incertae sedis, Type A (cf. **Oculopollis)**

Pl. XVI, fig. 22, text-fig. 24.

Description. Pollen body rounded with diameter 42 μ and four beak-like apertural regions *c.* 20 μ broad, which protrude *c.* 10 μ above the rounded body. Exine with two layers apparently separated by a narrow space. Outer layer *c.* 1.7 μ thick with quite conspicuous rod-like elements, except in the apertural regions where they are faint and apparently finer. Inner layer *c.* 0.8 μ thick with no visible details. Exine surface rough with a pattern of irregular spots; apertural regions smooth. The outer exine layer produces the protruding apertural regions, whereas the inner layer maintains the approximately circular outline of the pollen body also in the apertural regions. The outer layer has short furrows at the ends of the protruding regions, the inner layer has rounded pores with diameters *c.* 5 μ opposing the furrows.

Specimen: 68: 8.9–86.8 (pl. XVI, fig. 22).

Affinities and remarks. The apertures may be compared with those of *Oculopollis* PFLUG (1953, p. 110), but this genus has three apertures. The single specimen appears to have much in common with *O. bulbosus* WEYLAND & KRIEGER (1953, p. 19).

Incertae sedis, Type B

Pl. XVI, figs. 17–19, text-fig. 25.

Description. Meridional outline nearly circular, diameter 30 μ. Sculpturing of faintly beaded ridges, *c.* 0.5 μ broad, which in surface view form a fingerprint-like pattern with no particular direction of the ridges dominating. Exine just under 1 μ thick. In optical section the ridges appear as rods, otherwise the stratification is obscure.

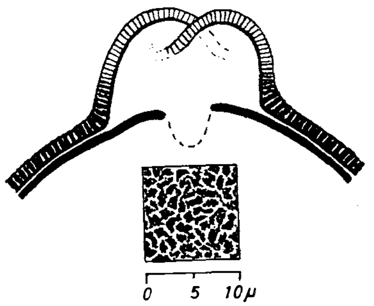


Fig. 24. Incertae sedis, Type A. Optical section of aperture as seen in polar view of the grain, and surface pattern of exine.

Fig. 25. Incertae sedis, Type B. Exine pattern in surface view.

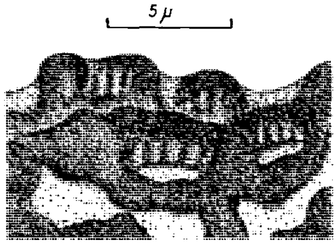


Fig. 26. Incertae sedis, Type C. View of exine near the outline of the grain.

The first specimen listed below has five, the second has four simple furrows extending close to the poles.

Specimens: S. 61 (pl. XVI, figs. 18, 19), 26: 11.8–70.6 (pl. XVI, fig. 17).

Affinities and remarks. There seems to be no existing form taxon applicable to this type. The two specimens found show insufficient details for the establishment of a new taxon, therefore they are referred to incertae sedis. Besides having different numbers of furrows, the specimens differ somewhat with regard to exine patterns. The surface pattern shown in text-figure 25 is that of the specimen in slide no. 26, whose ridges are less than 0.5 μ broad and with a fairly clear beading, while in the other specimen the ridges are over 0.5 μ broad and are faintly beaded.

The characters suggest an affinity with *Acer*.

Incertae sedis, Type C

Pl. XVI, figs. 20, 21, text-fig. 26.

Description. Outline subcircular, diameter 25–35μ. Sculpturing of very prominent ridges or communicating wart-like projections which form no regular pattern; interstices vary from narrow grooves to hollows wider than the ridges, so that a coarse, net-like pattern appears. The ridges are 1.0–1.5 μ broad, and *c.* 2.0 μ high. Their structure is obscure. In optical section the lower parts seem to consist of pillar-like elements carrying a solid "roof" (cp. text-fig. 26). In surface view the corresponding traces of these elements are faint, presumably because of the solid nature of the "roof". No aperture or dehiscence mark could be distinguished.

Specimens: 25: 10.5–71.8 (pl. XVI, fig. 20), 25: 16.8–74.5 (pl. XVI, fig. 21), 4: 13.5–82.1.

Affinities and remarks. I know no equivalent to this type of grains. Since apertures and dehiscence marks have not been seen, the sculpturing is their only distinctive feature. They appear to be spores rather than pollen grains. They have been rarely recovered from the "Longyear-seam".

Some quantitative analyses

Quantitative analyses of the material have been considerably hampered by the unfavourable state of preservation of the pollen and spores. In several samples the numbers of uncertain identifications were too high for worth-while counting, and even in those samples where the preservation was better, reference to readily recognizable major categories such as Monoletes, Triletes, *Ericipites*, etc. was usually necessary. The percentages of such major categories in certain samples are shown in the diagrams in plate XXI. The percentages were calculated on the basis of the total number of determinable plus indeterminable exines counted. Within some of the major categories the proportions of the more frequently occurring pollen or spore types have also been included in the diagrams. It will be observed from the diagrams that the percentages of exines referable to definite types within a category are sometimes less than the percentage given for the entire category. The discrepancy results from the specimens of which only the major category can be determined. Proportions less than two per cent are indicated by + in the diagrams.

Examinations were carried out with the help of an oil immersion lens (× 60). The counting of a minimum of 150 exines per sample was aimed at, but diagrams were also made for a few samples where fewer exines had been counted. The resulting diagrams give an idea of the frequencies of the major pollen and spore categories.

The stratigraphical implications of the quantitative analyses are rather uncertain. For example, significant differences between the microfossil contents of the individual coal seams in the lowermost series have not been demonstrated. The possibility of distinguishing the uppermost series and the deposits at Sarsbukta has been discussed elsewhere (p. 93).

The more botanical implications of the analyses have been discussed in the systematic survey of the flora (p. 83). In the following, only a few comments on some of the diagrams will be given.

Diagrams 4–13 represent samples taken from various points in the "Longyear-seam" (Mine II). Three of these diagrams (6, 10, and 13), which represent bottom samples of the seam at different points, possess some distinctive features in common, viz. the dominance of *Inaperturopollenites*, and the rather small proportions or absence of Disaccates, Triporates, and *Trudopollis*. These features can be regarded as reliable despite the large numbers of indeterminable exines in the samples, because among these indeterminable ones there are scarcely any disaccate grains, but almost certainly a fair number of inaperturate grains. Furthermore, members of Triporates and *Trudopollis* are usually better preserved and more readily determined than those of *Inaperturopollenites*, and also *Tricolpopollenites*. The real proportions of *Tricolpopollenites* in these samples are therefore probably fairly high. In the other samples of the "Longyear-seam", including the one from the roof of the seam (diagr. 4), the proportions of Disaccates and *Inaperturopollenites* are more similar, and they are approximately equalled by those of Triporates, as well as, in some samples, those of *Trudopollis* and Triletes; occasionally the proportions of the last two can be rather large. The results from the bottom samples indicate that during the early stages of the formation of the original swamp the wet plains supported forests dominated by taxodiaceous/cupressaceous species. The results from the "Svea-seam" sample (diagr. 14) indicate that similar conditions existed during the life of the swamp.

Diagrams 1–3 represent average samples (intended for quality tests of the coals) through the "Longyear-seam" from three different places. They correspond fairly closely to one another, although the small quantities of these samples used for the macerations cannot be expected to represent equivalent averages for the seams. There also are resemblances in these diagrams to those of other samples from the "Longyear-seam".

The Tertiary flora of Spitsbergen

Earlier works

Tertiary plants from Vestspitsbergen make up an important part of HEER's "Flora fossilis arctica" (1868, 1870, 1876). In this work he described 178 species from Spitsbergen, 117 of which were new. HEER's determinations, however, were to a great extent based on specimens of doubtful value and in many cases he gave a free rein to his imagination, for instance in the reconstruction of leaves of *Magnolia regalis* HEER (1876, pl. 20), of *Tilia malmgreni* HEER (1868, pl. 33), and in his description of a fossil strawberry, *Fragaria antiqua* HEER (1876, p. 91). Another reason for the high number of species is that HEER distinguished many of them on the basis of slight variations in general leaf forms, for example the several *Populus* species which have later been referred to *Cercidiphyllum arcticum* by BROWN (1939). The tenable number of species is therefore considerably lower than the 178 described by Heer. Some revision has been carried out (FLORIN 1936, BROWN 1939, CHANEY 1951, SCHLOEMER-JÄGER 1958), but the true number will only be known after a complete study of his material.

Here it should be emphasized that, although HEER's work has its weak points, his general conclusions regarding the temperate character of the Tertiary flora of Spitsbergen are valid. His work represents a major contribution to our knowledge of the Tertiary floras in Arctic regions.

The most important of recent works on the Tertiary flora of Spitsbergen is that by SCHLOEMER-JÄGER (1958) based on a collection from the coal seams of the Ny-Ålesund area. Of particular value is her treatment of the genera *Metasequoia*, *Sequoia*, *Taxodium*, and *Cercidiphyllum*.

In his work on the geology of the Svalbard archipelago, NATHORST (1910) gave a survey of the flora from the various Tertiary beds and presented a plant list compiled from HEER's works, with additions based on his own observations. He was himself preparing a comprehensive paper on the Tertiary flora of Spitsbergen, but at the time of his death (1921) only the plates had been finished.

HORN (1928) studied the coals of the Spitsbergen Tertiary from a petrographical point of view. In this connection he macerated a few samples and reported the occurrence of cuticles and pollen grains in the residues.

The macrofossil record

The Tertiary plant macrofossils hitherto described from Spitsbergen are recorded in a list (p. 72) in order to survey the evidence they provide of the former flora and to facilitate the comparison with the microfossils described in the present work. Most of the species derive from the works of HEER. Because so many of his determinations are obviously doubtful, it was necessary to consider them all critically and to supply the list with remarks on the reliability of the species. These remarks were based on HEER's descriptions and illustrations, not on direct examination of the specimens themselves, which admittedly would have been a more desirable procedure, but outside the scope of the present work. In the list a query is put before the name when the determination of a species has been considered questionable. Information regarding subsequent revisions have been included in the remarks. The symbols to the left of the names in the list indicate from which part of the formation the fossils have been recorded.

The conception of the natural affinities of some of the macrofossils has changed considerably since the time of NATHORST's survey (1910) of the flora. A large number of species originally referred to *Grewia*, *Hedera*, *Nyssa*, and *Populus* have been recognized as belonging to *Cercidiphyllum* as a result of BROWN's investigations (1939) into the fossil record of *Cercidiphyllum*. The great majority of the fossils concerned were referred to *C. arcticum* (HEER) BROWN, which thus turned out to be an important component of the flora.

Another important revision was CHANEY's (1951) recognition that in North America a major part of Tertiary plant remains originally referred to *Sequoia* and *Taxodium* belongs to a single species of *Metasequoia*, namely *M. occidentalis* (NEWB.) CHANEY. Most of the abundant taxodiaceous remains in Spitsbergen have also been included in that species.

CHANEY's revision of the Taxodiaceae present in the flora has an implication that deserves special attention. NATHORST (1910, pp. 383–384) found, from HEER's determinations as well as from his own observations, that the plant-bearing series at the top and at the bottom of the Tertiary sequence differed regarding their contents of taxodiaceous remains. He noted that *Sequoia langsdorfii* was absent or extremely rare in the bottom series and abundant in the top series. NATHORST maintained his view, although he was aware that it was difficult to distinguish *S. langsdorfii* from *Taxodium distichum miocenum*, which was abundant in both series. CHANEY, however, found that all the described specimens of these two species in the top series, and nearly all specimens of *T. distichum miocenum* from the bottom series belong to *Metasequoia occidentalis*. Thus the difference between the two series, pointed out by NATHORST, does not exist. *S. nordenskiöldi*, believed by HEER and NATHORST to represent *Sequoia* in the bottom series, was found by CHANEY (1951, p. 190) to be more like *Glyptostrobus*.

The microfossil record

With a few exceptions the microfossils have been obtained from coal samples because the macrofossil-bearing sediments have yielded only a few or badly preserved pollen and spores. Thus the sources of the microfossil and macrofossil records are not identical. Still they can be regarded as offering complemental evidences of the flora, as both kinds of sediments are integral parts of the plant-bearing series in question.

Although the two records naturally reflect the flora differently, they must be expected to have representatives of several species in common. Thus it seems highly probable that the microfossil record from the coals includes pollen of most of the wind-pollinated species, at least the arboraceous ones, found in the macrofossil record. If these species did not inhabit the coal-forming swamp itself, they must have been growing somewhere in the surrounding land from where their pollen could have been carried into the swamp. In the microfossil record we should also expect to find some of those plants represented which are not present in the macrofossil record because they grew in dry habitats away from the sedimentary basins.

In the descriptive section of the present work the pollen and spores have been classified artificially. However, in the list below the pollen and spore types have been entered according to their presumed natural affinities in order to compare the evidence they provide about the flora with that provided by the macrofossil record. Cases of more tentative attributions to natural taxa have been indicated by means of queries; attributions which appear probable are indicated by queries in brackets. For further information about the natural affinities the descriptive section should be consulted.

Annotated list of Spitsbergen Tertiary plant fossils

The left hand column contains the recorded macrofossils, the right hand column the microfossils described herein; both are arranged according to their natural affinities. Their positions in the Tertiary sequence are indicated by symbols placed in front of the names: ↓ = the lowermost series, including the beds in the Ny-Ålesund area, ↑ = the uppermost series, ↓↑ = both lowermost and uppermost series, * = the isolated areas either at Kapp Lyell (macrofossils) or at Forlandsundet (microfossils).

BRYOPHYTA

? *Muscites berggreni* HEER (1870)
Based on one questionable specimen.

↓ *Stereisporites psilatus* (ROSS) PF.

PTERIDOPHYTA

LYCOPODIINAE

Lycopodium
↓(*) *Reticulatisporites incomptus* **n.sp.**
↓ (?)*Reticulatisporites* sp.

EQUISETINAE

↓* *Equisetum arcticum* HEER (1868, 1870, 1876)
↓ *Equisetum grimaldii* REN.
RENAULT (1900); recorded also by SCHLOEMER-JÄGER.
(↑) [*Equisetites nordenskiöldi* NATHORST (1910, nom.nud.)]
Undescribed sp., "magnificent, its dimensions quite striking" (l. c. p. 382). Identical with *E. grimaldii*?

FILICINAE

Osmundaceae

(↓) [*Osmunda spetsbergensis* NATHORST (1910, nom.nud.)]
Undescribed sp., "very close affinity to the recent *O. regalis*" (l. c. p. 382).

Osmunda(?)
↑ *Rugulatisporites* cf. *quintus* TH. & PF.
↑* *Verrucosisporites septentrionalis* n.sp.

Schizaeaceae

↓ ? *Cicatricosisporites* cf. *cicatricosoides* KRUTZSCH

Dennstaedtiaceae

↓ ? *Sphenopteris blomstrandi* HEER (1868) = *Dennstaedtia blomstrandi* (HEER) HOLLICK. Sterile frond fragments.

Polypodiaceae (in the wide sense)

* ? *Adiantum dicksoni* HEER (1870)
Based on a single pinnule, affinity uncertain.

* ? *Lastraea stiriaca* UNG. sp. (HEER 1876)
Sterile frond of uncertain affinity.
(LA MOTTE transferred the species to *Dryopteris*)

↓* *Laevigatosporites haardti* (POT. & VEN.) TH. & PF.
↓ *Polypodiisporites* cf. *favus* POT., Type A
↓ *Polypodiisporites* cf. *favus* POT., Type B
↓* ? *Verrucosisporites opimus* n.sp.

FILICINAE INCERTAE SEDIS

? *Filicites deperditus* HEER (1868)
Entirely indeterminable "stem".

↑ *Baculatisporites* cf. *gemmatus* KRUTZSCH (Osmundaceae ?, Polypodiaceae ?)

↓↑ *Leiotriletes* cf. *adriennis* (POT. & GELL.) KRUTZSCH (Polypodiaceae ?, Schizaeaceae ?)

BRYOPHYTA OR PTERIDOPHYTA

↓ *Leiotriletes* sp.
↓ *Verrucosisporites pulvinulatus* n. sp.
↓↑ *Verrucosisporites pulvinulatoides* n.sp.
↓ ? Incertae sedis, Type C

GYMNOSPERMAE

GINKGOINAE

Ginkgoaceae

↓ *Ginkgo adiantoides* (UNG.) HEER
Leaves described by NATHORST (1919).
↓ *Ginkgoites* sp. indet. a, SCHLOEMER-JÄGER
↓ *Ginkgoites* sp. indet. b, SCHLOEMER-JÄGER

GINKGOINAE INCERTAE SEDIS

↓ *Torellia rigida* HEER (1870)
Redescribed by FLORIN (1936), who regarded it as most probably a ginkgophyte.

↓ ? *T. bifida* HEER (1870)
Based on questionable material; see also FLORIN (1936).

CONIFERAE

Pinaceae

↓ *Abies, Picea, Pinus, Tsuga*
HEER (1870) distinguished 12 species which he referred to *Pinus* in the wide sense (including inter al. *Abies, Picea* and *Tsuga*). Five of these species were related to *Pinus* in the narrow sense, one to *Abies*, three to *Picea*, two to *Tsuga*, and for one sp. the affinity was not indicated. HEER's material obviously contains pinaceous remains (seeds and leaves, usually fragmentary), but they do not appear sufficiently distinctive to justify his generic determinations nor his identifications with living sp. as was done in two cases.

The following sp. were distinguished by HEER:
Referred to *Abies* (in HEER to *Pinus* "sect. *Picea* DON. Tannen"):
Pinus impressa HEER, based on an incomplete seed; leaf fragments were included which later have been referred to *Pseudolarix* by SCHLOEMER-JÄGER.

Abies (?)
↓ * *Abiespollenites* sp.

(Pinaceae continued)

Referred to *Picea* (in HEER to *Pinus* "Sect. *Abies* DON. Fichten"):
Pinus abies L. (= *Picea abies* KARST.), seeds and leaves by HEER presumed to be more or less similar to the living sp., see also *Pseudolarix septentrionalis* SCHL.-JÄG.
Pinus loveni HEER, based on incomplete cone-scale and isolated seed believed to fit into the scale.
Pinus ungeri (ENDL.) HEER, seed and cone-scale isolated, cone-scale later referred to *Pseudolarix septentrionalis* SCHL.-JÄG.

Picea
↓ * *Abietineaepollenites* sp., Type B
? *Abietineaepollenites* sp., Type A, pars

Referred to *Pinus*, in the narrow sense (in HEER to "Sect. *Eupitys* SPACH. Föhren", "Sect. *Taeda* ENDL.", and "Sect. *Strobus*"):
Pinus cycloptera SAP., seeds of doubtful value, hardly suitable for identification with SAPORTA's sp.
Pinus macrosperma HEER, based on two incomplete seeds, one leaf also included.
Pinus montana MILL. (= *P. mugo* TURRA), leaf fragment and seed.
Pinus polaris HEER, leaf fragments and seeds.
Pinus stenoptera HEER, based on two seeds, leaves of doubtful value included.

Pinus
↓ * *Pityosporites* cf. *labdacus* (POT.) TH. & PF.
↓ (?)cf. *Pityosporites*, Type A
↓ (?)cf. *Pityosporites*, Type B
↓ * (?)*Abietineaepollenites* sp., Type A, pars

Referred to *Tsuga* (by HEER to *Pinus* "Sect. *Tsuga*"):
Pinus dicksoniana HEER, based on one rather indistinct seed, some leaves of doubtful value were included.
Pinus malmgreni HEER, based on poor seeds, two leaves of doubtful value were included.

No definite generic reference:
Pinus hyperborea HEER, hardly identifiable leaf fragments.

Tsuga
Tsugaepollenites viridifluminipites (WODEH.) POT.

Larix ?
↓ *Inaperturopollenites* cf. *magnus* (POT.) TH. & PF.

↓ *Pseudolarix*
P. septentrionalis SCHL.–JÄG. was based on seeds and cone-scales; two cone-scales referred by HEER to *Pinus abies* L. and *P. ungeri* (ENDL.) HEER, were included. – SCHLOEMER–JÄGER referred leaves from the same material to *Pseudolarix* sp. indet.; she also included specimens by HEER referred to *Ephedrites sotzkianus* UNG., *Pinus impressa* HEER, and *Taxites olriki* HEER.

Pinaceae incertae sedis

↓ *Abietipites arcticus* n.sp.
↓ cf. *Cedripites* (*Cedrus* ?, *Pinus* ?)
↓ ? *Inaperturopollenites insignis* n.sp.

Taxodiaceae

↓↑ * ? *Glyptostrobus ungeri* HEER (1876)
The specimens offer no satisfactory evidence for reference to *Glyptostrobus* (more related to *Sequoia* ?). – Also recorded by NATHORST (1910) from the upper plant-bearing series.

↓↑ * *Metasequoia occidentalis* (NEWB.) CHANEY
To this species are now referred most of the taxodiaceous specimens which were originally referred by HEER to various other sp. (see SCHLOEMER–JÄGER for references):

(Taxodiaceae continued)

Sequoia disticha Heer, *S. langsdorfii* Heer, *Taxodium distichum miocenum* Heer pars; the specimens referred to *S. brevifolia* Heer also seem to belong here.

Sciadopitys

↓ * *Sciadopityspollenites serratus* (Pot. & Ven.) Raatz

[*Sequoia brevifolia* Heer (1870) = *Metasequoia occidentalis* (Newb.) Chaney ?]

[*Sequoia disticha* Heer (1876) = *Metasequoia occidentalis* (Newb.) Chaney]

↓ *Sequoia langsdorfii* (Brogn.) Heer

Determined by Schloemer–Jäger from Brøggerhalvøya. The specimens referred to this sp. by Heer (1876) belong to *Metasequoia occidentalis* (Newb.) Chaney.

↓ ? *Sequoia nordenskiöldi* Heer (1870)

Probably referable to *Glyptostrobus* (Chaney 1951).

↓ *Taiwania schaeferi* Schl.–Jäg.

↓↑ * ? *Taxodium* sp.

T. distichum miocenum Heer (1870, 1876) pars; according to Schloemer–Jäger (p. 60) the specimens in Heer 1870 (pl. 3, figs. 3 and 3 b) may belong to *Taxodium.*

T. tinajorum Heer (1876), two hardly identifiable specimens. – Recorded also by Nathorst (1910) from the upper plant-bearing series.

T. sp. indet., Schloemer–Jäger, who herself questioned the determination.

Taxodium ?

↓ * *Sequoiapollenites* sp.

↑ *Cupressinoxylon*-type, Gothan (1910)

Probably taxodiaceous wood, according to Gothan.

↑ *Taxodioxylon* sp., Gothan (1910)

Taxodiaceous wood, according to Gothan.

Cupressaceae

? *Juniperus rigida* Heer (1870)

Based on a fragment of highly questionable value.

↓ ? *Libocedrus* sp.

L. sabiniani Heer (1870), cupressineous shoots which provide insufficient evidence for an affiliation to *Libocedrus.*

L. gracilis Heer (1870), based on fragments of questionable value.

↓ *Thuites ehrenswaerdi* Heer (1870)

Based on two cupressineous fragments of uncertain generic affinity.

Taxodiaceae, Cupressaceae (Taxaceae ?)

↓↑ * *Inaperturopollenites* sp. (several forms)

CONIFERAE INCERTAE SEDIS

↓* *Taxites olriki* Heer (1870, 1876)
No evidence for reference to Taxaceae; two of the specimens have been transferred to *Pseudolarix* sp. indet. by Schloemer–Jäger.

GNETINAE

? *Ephedrites sotzkianus* Ung. (Heer 1870)
From the depicted specimens the identification appears doubtful; there is no evidence of affiliation with gnetaceous plants. One specimen transferred to *Pseudolarix* sp. indet. by Schloemer–Jäger.

ANGIOSPERMAE

DICOTYLEDONEAE

Nymphaeaceae

↓ *Nymphaea arctica* Heer (1870)
Rather good rhizomes; leaves, and particularly fruits and a flower bud appear questionable.

↓ *Nymphaeites thulensis* Heer (1870)
Questionable fragments of rhizomes and a leaf.

Cercidiphyllaceae

↓* *Cercidiphyllum arcticum* (Heer) Brown
(↑ ?) Includes specimens by Heer referred to the following species: *Populus arctica*, *P. curvidens*, *P. hookeri*, *P. retusa*, *P. richardsoni*, *P. zaddachi*, *Hedera macclurii*, *Nyssa arctica*, *N. reticulata*, *Nyssidium crassum*, *N. ekmani*, *N. fusiformae*, *N. lanceolatum*, *N. oblongum* (see Schloemer–Jäger for further references). [*Populus* mentioned by Nathorst (1910) from the upper plant-bearing series probably belongs here; Nathorst also mentioned *Cercidiphyllum*.]

↓⇡ *C. crenatum* (Ung.) Brown
Includes specimens by Heer referred to the following species: *Grewia crenata*, *G. crenulata*, *G. obovata* (for further references see Schloemer–Jäger).

Ranunculaceae

↓ ? *Helleborites inaequalis* and *H. marginatus* Heer (1870)
Seeds and fruits of questionable affinity.

Magnoliaceae

↑* ? *Magnolia* sp.
Two sp. recognized by Heer (1876) (*M. nordenskiöldi* Heer and *M. regalis* Heer) from fragmentary leaves of rather questionary affinity; Heer's reconstruction of a leaf of *M. regalis* (pl. 20) is insufficiently founded.

Rosaceae

(including Amygdalaceae and Pomaceae)

? *Crataegus* sp.
Four sp. recognized by Heer (1870, 1876) (*C. antiqua* Heer, *C. carneggiana* Heer, *C. glacialis* Heer, *C. oxyacanthoides* Goepp.), all of questionable value.

(Rosaceae continued)

? *Fragaria antiqua* HEER (1876)
A fossil "strawberry" (sic).

? *Prunus staratschini* HEER (1870)
"Fruit" highly questionable.

? *Rubus ? scabriusculus* HEER (1870)
Fragmentary leaf, affinity questioned by HEER.

? *Sorbus grandifolia* HEER (1870)
Questionable leaf fragment.

Hamamelidaceae

↓ *Hamamelis clarus* HOLL.
One leaf determined by SCHLOEMER–JÄGER.

(↑) [*Hamamelis* mentioned by NATHORST (1910) from the upper plant-bearing series.]

? *Parrotia pristina* ETT. (HEER 1876)
Leaf fragment of no value.

Platanaceae

? *Platanus aceroides* GOEPP. (HEER 1868, 1870, 1876)
Leaf fragments of doubtful value.

Hamamelidaceae? Platanaceae?

↓↑ *Tricolpopollenites haraldii* n. sp.

Papilionaceae

? *Leguminosites* sp.
One valueless "seed" referred to *L. vicioides* HEER (1870) and four valueless leaves referred to *L. thulensis* HEER (1876).

Elaeagnaceae

? *Elaeagnites campanulatus* HEER (1870)
"Calyx", no botanical value.

Droseraceae

↓ *Droseridites spinulosus* n. sp.

Tiliaceae

[*Grewia crenata*, *G. crenulata*, and *G. obovata* HEER (1876) = *Cercidiphyllum crenatum* (UNG.) BROWN.]

↓ * ? *Tilia malmgreni* HEER (1868, 1876)
Poor leaf fragment, hardly suitable as evidence of *Tilia*.

(↑) [*Tilia* mentioned by NATHORST (1910) from the upper plant-bearing series.]

↓ * ? *Nordenskiöldia borealis* HEER (1870)
These fossils, in some localities quite abundant, are of uncertain affinity. The tiliaceous origin as assumed by HEER, is weakly founded.

Aceraceae

↓ * *Acer arcticum* HEER (1876)
Based on leaves, distinct *Acer*-fruits included, but their connection with the leaves is not proved.

Acer?
↓ Incertae sedis, Type B

↓ *Acer spitsbergense* SCHL.–JÄG.
Leaves.

(Aceraceae continued)

↓ * *Acer* sp.

A. sp. indet., SCHLOEMER–JÄGER, one fruit.

? *A. inaequale* HEER (1876), hardly determinable leaf fragments.

? *A. thulense* HEER (1876), based on one leaf hardly distinguishable from *A. arcticum.*

Sapindaceae

? *Koelreuteria borealis* HEER (1876)

Two leaf fragments of doubtful value.

Hippocastanaceae

↓ *Aesculus longipedunculus* SCHL.–JÄG.

Leaves.

Celastraceae

? *Celastrus* sp.

Two leaf fragments of no botanical value referred to *C. cassinefolius* Ung. and *C. greithianus* HEER respectively (HEER 1876).

Rhamnaceae

? *Rhamnus eridani* UNG. (HEER 1870, 1876)

Two fragmentary leaves and two fruits, all of highly questionable value.

? *Paliurus colombi* HEER (1870, 1876)

Two poor leaves, hardly determinable. (BROWN transferred the Greenland type of this sp. to *Cercidiphyllum arcticum.*)

Vitaceae

↓ cf. *Vitis olriki* HEER

Recorded by SCHLOEMER–JÄGER.

Nyssaceae

? *Nyssa europaea* UNG. (HEER 1870)

One fruit with very indistinct characters, hardly determinable.

[*Nyssa arctica* and *N. reticulata* HEER (1876), and the five sp. of *Nyssidium* in HEER (1870) = *Cercidiphyllum arcticum* (HEER) BROWN.]

Cornaceae

? *Cornus* sp.

HEER (1870, 1876) recognized five sp. (*C. hyperborea* HEER, *C. macrophylla* HEER, *C. orbifera* HEER, *C. ramosa* HEER, *C. rhamnifolia* WEBER), all from fragments of questionable value.

Araliaceae

[*Hedera macclurii* HEER (1870, 1876) = *Cercidiphyllum arcticum* (HEER) BROWN]

Betulaceae

↓ * *Alnus kefersteinii* (GOEPP.) UNG. (HEER 1868, 1876)

Leaves.

cf. *A. kefersteinii.* Fragmentary leaves determined by SCHLOEMER–JÄGER.

(↑) [*Alnus* mentioned by NATHORST (1910) from the upper plant-bearing series.]

Alnus

↓ * *Alnipollenites* sp., Type A

↓ * *Alnipollenites* sp., Type B

↓ *Alnipollenites* sp., Type C

(Betulaceae continued)

↓ * *Betula macrophylla* GOEPP. sp. (HEER 1870, 1876)
Fruit, fragmentary leaves.

↓ *Betula prisca* ETTINGSH. (HEER 1870, 1876)
Fruits, leaves, bark(?).

? *Carpinus grandis* UNG. (HEER 1876)
Fragmentary leaf of doubtful value.

↓ * *Corylus macquarrii* FORB. sp. (HEER 1868, 1870, 1876)
Fragmentary leaves and a nutshell(?).

? *Corylus scotti* HEER (1876)
Based on one fragmentary leaf of doubtful value.

(↑) [*Corylus* mentioned by NATHORST (1910) from the upper plant-bearing series.]

Betula

↓ * Triporates, Type A (2 or 3 sp.?)

↓ Triporates, Type E

Fagaceae

? *Fagus deucalionis* UNG. (HEER 1868, 1870, 1876)
Hardly determinable fragments.

? *Quercus* sp.
HEER (1870, 1876) recognized five sp. (*Q. elaena* UNG., *Q. groenlandica* HEER, *Q. lyelli* HEER, *Q. platania* HEER, *Q. spinulifera* HEER), containing only leaf fragments whose affinities seem hardly determinable. *Q. platania* has later been changed to *Phyllites platania* (see SCHLOEMER–JÄGER).

Betulaceae or Myricaceae

Corylus?
↓ Triporates, Type B
Myrica ?
↓ * *Myricipites speciosus* n.sp.
* *Myricipites* sp.

Betulaceae? Myricaceae?

↓ Triporates, Type F

Juglandaceae

? *Juglans* (*Carya*) *albula* HEER (1870)
One incomplete "nut" from unknown locality and formation; NAGEL (1915) considered it an inorganic concretion.

(↑) [*Juglans* mentioned by NATHORST (1910) from the upper plant-bearing series.]

Juglans
*(↓) *Juglanspollenites* sp.

Pterocarya (?)
*(↓) *Polyatriopollenites* cf. *stellatus* (POT.) PF.

Salicaceae

? *Populus* sp.
HEER (1868, 1870, 1876) recognized seven sp.; the determinable contents of six of them have later been transferred to *Cercidiphyllum arcticum* (HEER) BROWN; the seventh sp. (*P. balsamoides* GOEPP.) contains one hardly determinable leaf fragment.

? *Salix* sp.
HEER (1868, 1870, 1876) recognized three sp. (*S. macrophylla* HEER, *S. raenana* HEER, *S. varians* GOEPP.), each containing only one fragmentary leaf of rather doubtful value; the affinity of the leaf referred to *S. macrophylla* was questioned by HEER himself.

Salix (?)
↓ *Tricolpopollenites* sp., Type A
↓ *Tricolpopollenites* sp., Type B

Ulmaceae

↓ *Planera ulmifolia* SCHL.–JÄG.
Ulmaceous leaves, but generic affinity not certain.

(↑) [*Ulmus asperrima* NATHORST (1910, nom.nud.)]
Undescribed sp.

* *U. braunii* HEER (1876)
Leaves and fruits.

↓ ? *Tetrapollis conspectus* n. sp.

Polygonaceae

? *Polygonum ottersianum* HEER (1870)
Remains of doubtful affinity.

Chenopodiaceae

? *Salsola arctica* HEER (1870)
Questionable "flower".

Empetraceae, Ericaceae

↓ (?) *Andromeda protogaea* UNG. (HEER 1870)
A single, good leaf, possibly of ericaceous affinity.

↓ * *Ericipites* sp., Type A
↓ *Ericipites* sp., Type B
↓ *Ericipites* sp., Type C
↓ *Ericipites* sp., Type D
↓ *Ericipites* sp., Type E

Oleaceae

? *Fraxinus* (?) *microptera* HEER (1870)
Very doubtful fructification fragments; HEER himself questioned the affinity.

Caprifoliaceae

↓ (?) *Viburnum* sp.
(↑) HEER (1870, 1876) distinguished three sp., two from some doubtful leaf fragments (*V. nordenskiöldi* HEER, *V. whymperi* HEER), the second of which also included a large number of seeds (stone cases), the third sp. (*V. macrospermum* HEER) was based on seeds only. Whereas the value of the leaves appears doubtful, the seeds may serve to demonstrate the presence of *Viburnum*. – [*Viburnum* mentioned by NATHORST (1910) from the upper plant-bearing series.]

MONOCOTYLEDONEAE

Alismataceae

* (?) *Alisma macrophyllum* HEER (1876)
Most probably alismataceous remains, but the generic affinity appears uncertain.

? *Sagittaria* sp.
HEER (1870) described two species (*S. difficilis* and *S. hyperborea*) based on some questionable fruits; he himself questioned their affinity to *Sagittaria*.

↓ ? *Periporopollenites* sp.

Potamogetonaceae

↓ * ? *Potamogeton nordenskiöldi* HEER (1868, 1870, 1876)
Heer based the sp. on very fragmentary leaves which appear too indistinct for an identification with *Potamogeton*. A few fruits were included, the determination of which seems less doubtful, but can hardly be regarded as conclusive evidence of *Potamogeton*.

Potamogeton ?
↓ Non-aperturate reticulate grains

Najadaceae

? *Najas stricta* Heer (1870)
One fruit and some stem fragments of doubtful value.

Liliaceae

? *Majanthemophyllum boreale* Heer (1876)
Fragmentary leaf of doubtful value.

Iridaceae

↓ *Iris latifolia* Heer (1870)
Leaf fragments and rhizomes.

↓ ? *Iridium groenlandicum* Heer (1870)
Very fragmentary monocotyledonous leaves, but a closer determination appears impossible.

Juncaceae

? *Juncus antiquus* Heer (1870)
Leaf fragment and "rhizome" of very doubtful value.

Cyperaceae

? *Carex* sp.
Heer (1870, 1876) recognized seven sp. which are hardly tenable since they are based on a few fruits and leaf fragments of rather indistinct characters.

↓* ? *Cyperus arcticus* Heer (1870, 1876)
Some of the fragments included may be monocotyledonous, but a closer determination appears impossible.

↓ ? *Cyperacites* (*Cyperites*) sp.
Heer (1870, 1876) recognized four sp. from a few poor leaf fragments whose origin may be monocotyledonous, but otherwise they appear indeterminable.

Gramineae

? *Phragmites oeningensis* A. Braun (Heer 1870)
Remains of very doubtful value.

↓* *Poacites* sp.
Heer (1868, 1870, 1876) recognized 13 sp. from various remains most of which appear very doubtful and unworthy of description and specific naming. A few of the fossils may be gramineous.

Araceae

↓ *Acorus brachystachys* Heer (1870)
Part of stem with spadix and spathe. Schloemer–Jäger also recorded this species.

Sparganiaceae

↓ ? *Sparganium crassum* Heer (1870)
Part of stem and inflorescence, but too incomplete to be convincing.

Sparganiaceae ? Typhaceae ?

Typha (?)
↓ Tetrad of monoporate (?) reticulate grains

Sparganium ? *Typha* ?
↓ Non-aperturate reticulate grains

INCERTAE SEDIS

Carpolithes sp.

HEER (1870, 1876) distinguished 22 sp., generally from single fruits or seeds of doubtful value.

Cypselites sp.

HEER (1870) described two sp. of fruits which he related to the Compositae; but the affinity appears doubtful.

Macclintockia ? tenera HEER (1876)

A fossil of no value. HEER himself questioned the determination.

Phyllites sp.

P. hyperboreus HEER (1870), leaf fragments of doubtful value.

P. platania (HEER) SEW. & HOLTT., recorded by SCHLOEMER–JÄGER. Here leaves were included which by HEER had been referred to *Quercus platania.*

P. sp. indet., SCHLOEMER–JÄGER.

Pterospermites spectabilis HEER

Recorded by SCHLOEMER–JÄGER.

Dicotyledonous:

⇣ *Tetrapollis quadratus* n.sp.
⇣ *Tricolpopollenites* sp., Type C
⇣ * *Trudopollis barentsii* n.sp.
⇣ *Trudopollis resistens* n.sp.
↓ (*) *Trudopollis rotundus* n.sp.
↓ *Trudopollis* sp., Type A
↓ *Trudopollis* sp., Type B
⇣ *Trudopollis* (?) sp., Type C
⇣ Triporates, Type C (Amentiflorae ?)
Triporates, Type D (Amentiflorae ?)
⇣ Triporates ?type
⇣ Incertae sedis, Type A

Monocotyledonous:

* *Monocolpopollenites* sp.

Systematic survey of the flora with a comparison of the fossil records

Bryophyta

Mosses were undoubtedly represented in the flora, but there is no conclusive macrofossil record of them. *Muscites berggreni* described by HEER appears to be too indistinct for a definite statement of affinity. Four spore types have possible affinity with mosses but the attribution is not definitive. Of these spores those referred to as *Verrucosisporites pulvinulatus* and *Leiotriletes* sp. occur in large numbers, as is seen from the percentage diagrams shown in plate XXI, where the high percentages of Triletes are largly due to them. It may be noted that when richly represented the two types mentioned seem to occur in approximately equal numbers.

Pteridophyta

Pteridophytes are poorly represented in the macrofossil record, except for the Equisetinae of which two distinct species are abundant in certain beds in the Ny-Ålesund area (*Equisetum arcticum, E. grimaldii*). NATHORST (1910) named, but did not describe, a third species which is suspected to be identical to *E. grimaldii.* Equisetaceous spores have not been recognized.

HEER described four species which he related to the Filicinae, but the specimens were few and too indistinct for references on the family level. NATHORST (1910) evidently found remains sufficiently distinctive for a definite reference to *Osmunda*, but unfortunately they were not described. Filicalean spores tell more about the class, and ten types in all can be related to it. However, they make no great contribution to the microfossil contents of the samples. Three, possibly four types can be referred to the Polypodiaceae, and two types to the Osmundaceae, most probably to *Osmunda*. The osmundaceous spores are best represented in the upper plant-bearing series from which NATHORST also reported his find of *Osmunda*; one of the types is known only from that series. One spore type (*Cicatricosisporites* cf. *cicatricosoides*) suggests the presence of a member of the Schizaeaceae. Only a few specimens have been found, indicating that the parent plants were sparse, at least near the sites of deposition. It does not seem impossible that a schizaeaceous species with temperate climatic requirements could have occupied favourable positions in Spitsbergen in the Lower Tertiary. However, the presence of members of this family needs to be verified by more conclusive finds.

Lycopods have not been recorded among the macrofossils, but spores clearly indicate their presence.

Gymnospermae

Ginkgoinae. – The macrofossils indicate the presence of several species, but only one in any quantity (*Torellia rigida*). However, no pollen of the *Ginkgo* type has been found. Such grains would surely have been recognized, at least if present in reasonable numbers. Therefore, the apparent absence of the pollen probably indicates local or scanty representation of the class. Examination for microfossils in samples containing ginkgophytic macrofossils has to be carried out.

Coniferae. – Coniferous remains are among the most common macrofossils, and the great majority of them were referred by HEER to the Taxodiaceae, namely to *Sequoia*, *Taxodium*, and a few to *Glyptostrobus*. The discovery of *Metasequoia* proved that the main part of the taxodiaceous remains in Spitsbergen, as in several other Tertiary localities of northern latitudes, belongs to a single species of that genus, *M. occidentalis*. It was concluded "that *Metasequoia* rather than *Sequoia* was the dominant conifer of the Arcto-Tertiary Flora" (CHANEY 1948, p. 509).

CHANEY's revision (1951) seemed to indicate that the Spitsbergen material contained no certain remains of *Sequoia*, but recently SCHLOEMER-JÄGER (1958) reported the find of true *S. langsdorfii* in material from Ny-Ålesund. SCHLOEMER-JÄGER also reported a new taxodiaceous species which she referred to *Taiwania*, a genus previously unknown from Spitsbergen. So far the macrofossils have yielded no conclusive evidence as to the presence of *Glyptostrobus* and *Taxodium*. It may be assumed that these genera, if present in the flora, would have been evident since they are deciduous (or semi-evergreen) and occupy wet habitats which offer favourable conditions for preservation in sediments.

Macrofossil remains of pinaceous affinity are scarce. Nevertheless HEER described a total of twelve species of Pinaceae (*Abies* 1, *Picea* 3, *Pinus* 5, *Tsuga* 2, genus indet. 1). These identifications are unreliable, however, because most of HEER's material was obviously inadequate for definite determinations. SCHLOEMER-JÄGER (1958) reported *Pseudolarix* and established a new species (*P. septentrionalis*). She also transferred to *Pseudolarix* some specimens which had been referred by HEER to other pinaceous genera and to *Ephedrites* and *Taxites*.

Macrofossils referable to the Cupressaceae are even more scarce, and only a few specimens of uncertain generic affinity have been recorded. Of the Taxaceae there is no macrofossil evidence.

Turning to the microfossils, we find that they indicate the important role played by the conifers to no less a degree than do the macrofossils. A great variety of pollen forms occur. The coniferous pollen exceeds 40 per cent of the total number of exines in over half of those samples of which the microfossils have been counted. Only rarely is the percentage less than 20.

While the coniferous pollen is fairly easily recognized as such, there are considerable difficulties in identifying the natural genera, or even families, involved. The grains referred to as *Inaperturopollenites* sp. are the most difficult to classify. They make up an important part and outnumber the rest of the coniferous grains in most samples. From the descriptive section it can be seen that these grains occur in various forms which indicate several parent species. However, on a pollenmorphological basis it does not seem possible to specify the affinities of their parent plants more exactly than to say that they may be representatives of the Taxodiaceae, Cupressaceae, and the Taxaceae. It is necessary, therefore to consider the indications given by the macrofossils of the affinities of at least some of these grains.

As stated already, the Taxodiaceae is the only one of the three mentioned families for which generically determinable macrofossils have been recorded. When this fact is compared with the microfossil record, a difficulty arises. Living representatives of the taxodiaceous genera of which there are more or less reliable macrofossil records have pollen with a papilla of varying prominence, from a low, inconspicuous protruberance (*Taiwania*), to a marked, finger-like projection (*Sequoia*). Provided the pollen of *Metasequoia occidentalis* had an equally prominent papilla as has the only living species, *M. glyptostroboides* HU & CHENG, it would seem reasonable that this pollen would be recognizable by the papilla in the fossil state, if not in all, then at least in a large number of the specimens. But grains referable to *Metasequoia* by this feature are, at best, very scarce. On the whole, grains with a clear papilla (*Sequoiapollenites* sp.) are extremely rare.

This absence of typical *Metasequoia* pollen is characteristic not only of the coals, but also of the Metasequoia-shale which is known particularly for its abundant remains of *M. occidentalis* (formerly *Taxodium distichum miocenum*)[1]. In the bituminous shales from Atanikerdluk, Greenland (cp. p. 100), as well as in the samples from Stenkulfjorden, Ellesmere Island (cp. p. 95), both localities in which *M. occidentalis* is abundant, the same scarcity of typical *Metasequoia* pollen is found.

Now it seems most unlikely that these sediments would not have received noticeable amounts of pollen of *M. occidentalis*, which, as is inferred from the macrofossils, was a common and widely distributed species in far northern latitudes in early Tertiary times. The abundance of its remains also indicates that it was quite common in the vegetation near the sedimentary basins. Thus, if the species produced papillate pollen resembling that of *M. glyptostroboides*, the fact that such grains are not found in noticeable amounts requires an explanation. Selective destruction seems unlikely, because: 1. There is no indication that the pollen of the living species is of a particularly fragile nature. 2. Considerable numbers of grains of the inaperturate type have been preserved in most samples, also in those where the preservation on the whole appears poor. 3. Several workers in other areas have reported fossil *Metasequoia* pollen which resembles the extant type (inter al. SIMPSON 1949, YAMAZAKI & TAKEOKA 1956, SOHMA 1958, KUPRIANOVA 1959; such pollen has also been referred to as "*Sequoia*-type, *Sequoia* or *Metasequoia*"). The most probable explanation seems to be that the papilla was not prominent and had become indiscernible among the folds produced by the collapse and subsequent complete flattening of the grains. A certain delicacy of the papilla itself and the contiguous exine may have contributed to this result. An investigation of favourable male inflorescences of *M. occidentalis* should help to settle the question.

---

[1] This shale was discovered by G. NORDENSKIÖLD who named it Taxodium-shale in HEER (1870, p. 21); cp. also NATHORST (1910, p. 384). According to present knowledge its correct name is Metasequoia-shale.

The *Sequoia* macrofossils present a corresponding problem. Pollen of *Sequoia* should be more easily identified because of its more prominent papilla. If present in some amount, at least some of the grains should be recognizable. However, although carefully sought for, no certain *Sequoia* grains have been found. The possibility remains that *Sequoia* really was poorly represented in the flora, as indicated by the apparent scarcity of macrofossils. In this connection it should be recalled, however, that *Sequoia* was evergreen in contrast to the deciduous habit of *Metasequoia*, as inferred from their living representatives. The bearing of this fact on the relative abundance of their macrofossils is obvious.

Thus, instead of providing positive clues to more exact affinities of the pollen forms included in *Inaperturopollenites* sp., the macrofossils confront us with the problem of the absence of papillate grains. From the above it seems reasonable to presume that the *Metasequoia* grains have been included in *Inaperturopollenites* sp. owing to failure to recognize their particular characters. For the *Sequoia* grains a similar assumption seems less acceptable. However, it is obviously not possible to attribute to *Metasequoia* (and *Sequoia* ?) the whole variety of grains included in *Inaperturopollenites* sp. It appears that, in addition to the species of *Taiwania* known from the macrofossils, further representatives of the Taxodiaceae and Cupressaceae must have been represented in the flora. The large numbers of inaperturate grains in many samples might suggest representatives adapted to the wet habitats of the sedimentary basins. However, the absence of macrofossil remains of such representatives, although their chances of preservation in the sediments would seem the best, speaks against this suggestion. Probably the dry ground forests away from the sedimentary basins contained a considerable taxodiaceous/cupressaceous element.

Two-winged pollen grains of the Pinaceae constitute a conspicuous element which frequently makes up between 10 and 15 per cent of the total exine contents; only rarely is the percentage higher. The fact that pinaceous grains occur in relatively moderate numbers, when taken together with the meagre macrofossil record of the family, indicates the presence of dry-ground pinaceous forests more or less away from the coal-forming swamps or sedimentary basins. Some of the pinaceous pollen forms are so sparse that rather distant localities must be assumed for the parent plants.

Pinus is the best represented genus with regard to the total number of pollen grains as well as the variety of forms. The most common form is *Pityosporites* cf. *labdacus*. Less common, although sometimes outnumbering this form, are grains referred to as *Abietineaepollenites* sp., Type A, which probably for the greater part belong to *Pinus*. These forms indicate the presence of at least two species of *Pinus* in the land around the sedimentary basins. As mentioned already, HEER's record includes five questionable species of *Pinus*. The grains referred to as cf. *Pityosporites* types A and B, which are also probable representatives of *Pinus*, are so rare that either the species played a very minor role in the forests near the sedimentary basins, or the grains came from more distant localities.

Grains related to *Picea* occur sparsely in the beds of the main basin, however, in the Sarsbukta samples *Abietineaepollenites* sp., Type B, makes up notable proportions of the two-winged grains. This indicates the presence of a species of *Picea* in the Spitsbergen area in early Tertiary times. Whether the role of *Picea* was smaller at the time of deposition of the sediments of the main basin, or the trees grew more distant from the sedimentary basins cannot be stated. – HEER's record contains three species of *Picea.*

The grains referred to *Abiespollenites* sp. probably represent *Abies*, but they are so few that a rather distant origin is suggested. – HEER recorded one species of *Abies.*

HEER named two species of *Tsuga*, both of which are inconclusive. The main Tertiary basin has yielded no microfossil evidence of *Tsuga.* However, *Tsugaepollenites viridifluminipites* represents the genus in the Sarsbukta samples where the pollen makes up 5 per cent of the exine contents. This is taken as evidence of the presence of a species of *Tsuga* at the time of the deposition of the sediments of the Sarsbukta locality.

A pollen form, morphologically intermediate between two-winged grains and *Tsugaepollenites*, namely *Abietipites arcticus*, has been found as a rarity in two samples of the "Longyear-seam" (L 2). All the characters available suggest an affinity with the Pinaceae.

Two forms possibly of pinaceous origin are the *Inaperturopollenites* cf. *magnus* (*Larix*?) and *I. insignis.* As for *Pseudolarix*, which was recorded by SCHLOEMER-JÄGER, none of the pollen forms seem referable to that genus. The numerous unidentified two-winged grains, however, may well represent still unrecognized genera.

Pollen referable to *Sciadopitys*, a genus previously unrecorded in the Spitsbergen Tertiary, is found in most samples, quite often in proportions of 2 or 3 per cent but never exceeding 6 per cent. Its rather constant occurrence in such relatively small quantities suggests that *Sciadopitys* was a constituent of dry-ground forests situated at some distance from the sedimentary basins.

In reviewing the coniferous element of the flora it can be stated that the abundance of macrofossil remains of *Metasequoia*, together with the scanty or doubtful evidence of other conifers, supports the opinion expressed by CHANEY (1948, p. 509) that *Metasequoia* was the dominant conifer. CHANEY considered it a point of primary significance "that it was not an evergreen but a deciduous conifer which ranged northward to latitude 82° in Grinell Land during the Eocene. The deciduous habit of *Metasequoia* was wholly consistent with that of the majority of its angiosperm associates in the older Tertiary floras from high northern latitudes". The microfossil record, in contrast, provides substantial evidence that other conifers were also well represented in the flora. It is shown that members of *Picea*, *Pinus*, *Tsuga*, and *Sciadopitys*, which we must assume to have been evergreen, inhabited the Spitsbergen area during early Tertiary times. Therefore, the idea that the Arcto-Tertiary forests were prevailingly deciduous needs modification. This is supported by the results obtained from the Ellesmere Island samples which, in this respect, conform with the Spitsbergen ones. If we assume that these evergreens have occupied dry-ground habitats somewhat removed from the sedimentary basins and their systems of supply, this would explain the scarcity or even absence of their macrofossil remains. It is regrettable that such a number of microfossils, presumedly of taxodiaceous and cupressaceous affinities, have defied definite identifications.

Angiospermae

It can be seen from the annotated list of macrofossils that HEER's rich angiosperm record contains a large number of doubtful identifications. Very probably many of these doubtfully identified plants were actually present in the flora, but this survey will be restricted mainly to those whose presence appears to be well established.

Dicotyledoneae. – The presence of nymphaeaceous plants is based on HEER's identification of rhizomes of *Nymphaea*. Their pollen, however, has not been recovered.

Cercidiphyllum was recognized by BROWN (1939) who found that the very common leaf impressions and some fruits previously assigned by HEER and others to *Populus*, *Nyssa*, *Hedera*, and *Grewia* could be referred to two nominal species of *Cercidiphyllum*, named *C. arcticum* and *C. crenatum*. The abundance of the leaves referable particularly to *C. arcticum* shows that this species constituted one of the principal hardwood elements of the Spitsbergen Tertiary flora, at any rate close to the regions of sedimentation. It is natural to expect that these plants would have contributed pollen to the sediments, but none has been recorded, which, as judged by the characters of the extant species (*C. japonicum* SIEB. & ZUCC.), can be referred to *Cercidiphyllum*. The following are some possible explanations of this apparent discrepancy: 1. The modern *Cercidiphyllum* pollen has no conspicuous features which would make the form readily distinguishable in a poorly preserved material. Therefore such grains have possibly been neglected by inclusion in the bulk of indeterminable ones. If present, however, in amounts proportionate to the abundant macrofossil remains, it appears improbable that a single specimen would not be recognized. 2. The grains, although possibly abundantly contributed to the sediments, may have been completely destroyed. The lack, as far as is known, of any fossil record of *Cercidiphyllum* pollen tends to support this assumption. 3. The pollen of the fossil *Cercidiphyllum* may have been different from that of *C. japonicum*. However, no sound suggestion can be offered as to which grains should be attributed to these plants.

The presence of the Magnoliaceae has not been corroborated, in spite of HEER's (1876, pl. 20) impressive reconstruction of the leaf of *Magnolia regalis*. His statement about the material makes it clear that the reconstruction may well be characterized as highly imaginative. The microfossils have yielded no evidence of the family.

All the records of Rosaceae in a wide sense are questionable. The evidence for Hamamelidaceae and Platanaceae is hardly conclusive. In addition to the very poor remains recorded by HEER, there are the single leaf impression referred to *Hamamelis* by SCHLOEMER-JÄGER, and one fairly common form of tricolpate pollen (*Tricolpopollenites haraldii*) which possibly may be included in the relationship.

The distinctive grains named *Droseridites spinulosus* are regarded as evidence of the Droseraceae.

A *Tilia* species was reported by HEER, but the remains appear unsuited for the identification. The apparent absence of *Tilia* pollen strengthens the supposition that the genus was not represented. The tiliaceous affinity of *Nordenskiöldia borealis* has not been settled.

Identification of two species of *Acer* (*A. arcticum* and *A. spitsbergense*) based on leaf impressions appears well founded; the recorded fruits give additional evidence of the genus. A few pollen grains show characters suggestive of affinity to *Acer*.

The presence of *Aesculus* is probably evidenced by *A. longipedunculus*.

Many macrofossil representatives of the orders Celastrales, Rhamnales, and Umbelliflorae have been recorded, but none of them are conclusive. For *Nyssa* particularly, it may be assumed that if members of this mainly swamp-inhabiting genus played any role in the vegetation, their distinctive pollen would have been recognized.

Betulaceae is the angiosperm family which has the most varied representation in the fossil record. Three pollen forms referable to *Alnus* give a better idea of the occurrence of this genus than was indicated by the single macrofossil species. Triporate pollen of betulaceous affinity is rather abundant, but further distinction is often difficult. It indicates, however, that *Betula* was represented by more than the two species indicated by the macrofossils. The macro- and microfossil record of *Corylus* is poorer and less reliable, although there is reason to believe that the genus was represented in the flora. HEER's record of *Carpinus* is highly questionable.

The relative scarcity of *Alnus* pollen (2.5 per cent is the highest recorded) compared with the generally fairly numerous triporate grains indicates that *Alnus* was relatively less important in the vegetation in, and around, the former swamp than the representatives of Betulaceae and probably Myricaceae which contributed the triporate grains.

Positive evidence of the Fagaceae is lacking. It may be assumed that if members of the family played a role of some importance, they would have contributed noticeable amounts of pollen to the sediments. It is therefore noteworthy that, except for *Trudopollis*, tricolporate grains are almost lacking, and the rare specimens found have been too indistinct or ill-preserved to be of any value. Thus the lack of definite fagaceous macrofossil remains is parallelled by the pollen record.

A myricaceous affinity appears possible for some triporate pollen forms, particularly for *Myricipites speciosus*, which is fairly common.

Evidence of the occurrence of the Juglandaceae is negative rather than positive. The "nut" recorded by Heer ("*Juglans albula*") must be disregarded. The poor microfossil record (four specimens in all) indicates that members of the family did not constitute a notable element of the flora. The few grains observed probably originated from rather distant localities.

No convincing macrofossil of the Salicaceae has been found. The microfossil record is not quite conclusive, although two tricolpate pollen forms rather similar to those of *Salix* have been found.

The presence of the Ulmaceae is demonstrated by leaves referred to as *Planera ulmifolia* by SCHLOEMER-JÄGER, and leaves and fruits assigned to *Ulmus braunii* by HEER. However, no pollen reliably referable to this family has been seen.

Five types of pollen tetrads show that various species of ericalean affinity occurred in the flora. The tetrads vary in frequency from almost nought to 7 per cent, which shows that in some places these plants were relatively common. Only a single leaf of possible ericaceous affinity has been reported.

Some dicotyledonous pollen forms whose natural affinities, however, cannot be more closely indicated, deserve particular attention, namely the various forms referred to the genus *Trudopollis*. Among the grains of angiospermous affinity these generally come next to the triporate ones in abundance, and in some samples even form the largest category. Occasionally they make up more than 40 per cent of the pollen and spore contents, often more than 10 per cent, but there are also samples from which they are apparently absent. Representatives of this category are usually readily recognized, although finer distinction can be difficult. The most common form is *T. barentsii*, with *T. rotundus* as the next in rank. These grains belong to a category which in Central European Upper Cretaceous sediments occurs in a great varity of forms, with fewer forms in the Paleocene. During the Eocene period they disappear (cp. KRUTZSCH 1957; POTONIÉ 1951, "Myrtaceoide Formen"). It is not possible at present to indicate the plants in the Spitsbergen Tertiary to which the *Trudopollis* forms belonged. A possible relation may be suggested to the very common macrofossils referred to *Cercidiphyllum* to which no microfossils have so far been successfully related. This idea, however, can be rejected on the basis of the inconsistency arising between the macrofossil and the microfossil records, namely the lack of *Trudopollis* in the Metasequoia-shale from which *Cercidiphyllum* has been recorded. The same is observed in the samples from Atanikerdluk. The natural affinities of the Central European forms are also unknown. From the large numbers found in some Spitsbergen samples it may be concluded that their parent plants played an important role in certain localities, but their absence in other samples indicates that the distribution was not general. In this respect they differ from the triporate forms for which the variation in frequency is less marked.

Some other dicotyledonous forms of obscure affinities, entered in the list under incertae sedis, are less important since only a few specimens have been recovered. *Tetrapollis quadratus* and Incertae sedis, Type A, are forms which are morphologically similar to *Trudopollis.*

Monocotyledoneae. – The fossil record of this class is poor. HEER named 36 species but only a very few of these are convincing. Monocotyledonous pollen forms are also few in number, and their affinities are usually doubtful.

Alismataceae is probably represented by the remains referred to as *Alisma macrophyllum* by HEER. One pollen type, *Periporopollenites* sp., insufficiently known from only a few specimens, is possibly of the same relationship.

Pollen grains (non-aperturate reticulate), probably referable to *Potamogeton*, tend to support the somewhat inconclusive macrofossil evidence of the presence of this genus.

HEER's records of *Iris* and *Acorus* appear to be well founded. Additional evidence of the latter was provided by SCHLOEMER-JÄGER.

HEER recorded a great number of gramineous and cyperaceous species. Some of the fossils described may be of monocotyledonous origin, but they are too indistinct for accurate determination. No pollen has been referable to these families. The possibility cannot be excluded, however, that some grains of such affinities have been included in the large number of inaperturate ones.

One pollen form, tetrad of monoporate(?) reticulate grains, strongly suggests a typhaceous affinity, another form a sparganiaceous or typhaceous affinity. These grains together with those related to *Potamogeton* are never numerous, not more than 3 per cent having been recorded, but they occur in the majority of samples, and in pure coals as well as in black shales.

No pollen referable to the Palmae has been found. Grains compared by MANUM (1954, figs. 32, 33) with those of certain palms have since proved to be different modes of preservation of tricolpate grains.

The climatic character of the flora

From his identifications, particularly of *Fagus*, *Platanus*, and *Tilia*, HEER (1868, pp. 61–64) considered the climate to be like that of southern Sweden, with a mean annual temperature of 5.5° to 6.0° centigrade. In his next work (1870, pp. 16–17) HEER thought that this estimate was too low and equated the climate to that of northern Germany on the basis of "das Vorkommen der Sequoien, des Cyperus, der grossblättrigen Eichen, der Nyssa und des Paliurus". HEER's estimate of a temperate climate has not been changed in spite of our present knowledge that his identifications, which formed the main basis for his conclusions, were either erroneous or questionable.

From more recent knowledge of the flora, particularly the recorded remains of *Sequoia* and *Metasequoia*, SCHLOEMER-JÄGER (1958, pp. 89–91) estimated the climate to be a warm temperate, the winter temperatures rarely falling below the freezing point.

A more accurate estimate of the character of the climate cannot be given on the basis of the microfossil evidence, but some points should be mentioned. The rich and varied coniferous record and the not unimportant betulaceous and ericalean records corroborate the idea of a temperate climate. It should be noticed that definite microfossil evidence of a warm temperate climate is lacking. The apparent absence of members of the Fagaceae, Juglandaceae, and of *Tilia*, as already mentioned, supports the suggestion that the climate was not more than moderately temperate.

The age of the flora with a comparison of the plant-bearing sequences

The present investigation can offer no basis for a more definite age determination of the flora than that obtained from RAVN's dating of the Mollusca contained in the lower parts of the Tertiary sequence. The plant-bearing horizons in the basal part (NATHORST's first series) are situated immediately below marine beds regarded as late Paleocene by RAVN. There seems to be no reason to believe that the plant-bearing horizons in the basal part are much older.

The microfossils described herein include no forms which – from present knowledge of their distribution – give conclusive stratigraphical information. However, there are forms which furnish some evidence consistent with the paleozoological dating, namely the pollen forms referred to *Trudopollis*, and possibly the spore form referred to *Cicatricosisporites*. None of the results obtained appear to contradict RAVN's dating.

As stated earlier, the *Trudopollis* grains are found in most samples from the first series, sometimes in considerable numbers. Morphologically related forms in Central European beds are of considerable stratigraphical importance, their range being from Upper Cretaceous to Middle Eocene (cp. PFLUG 1956, pp. 415–416, KRUTZSCH 1957). ZAKLINSKAJA (1960) found a similar range in beds from the southern parts of W. Siberia. At present very little is known about the occurrence of this category and its range in the more northern latitudes. The only Arctic localities from which they have been reported in some variety and amount so far appear to be the ones in Spitsbergen. Their natural affinities are not known. However, from morphological similarities it may be assumed that there is some natural relationship between the Arctic forms and those of more southern latitudes. Further, it may be assumed that the extinction of the natural categories to which the *Trudopollis* belonged did not take place later in the north than it did in regions further south. In other words, the presence of such forms in Arctic sediments may indicate that their age is not younger than Eocene. It remains to be seen whether further information on these forms in Arctic sediments will verify their value as stratigraphical key forms in that region. It may be mentioned here that, except for a meagre Greenland record, *Trudopollis* and related forms were not seen in the material from Arctic localities outside Spitsbergen which was examined for the present work.

A Lower Tertiary age is perhaps indicated by the spores referred to *Cicatricosisporites* cf. *cicatricosoides*, as was proposed by PFLUG (1956, pp. 414–415) for Icelandic spores referred to *C. dorogensis*. Similar spores disappear from Central European sediments in Middle Oligocene, when unfavourable climatic conditions are believed to have caused the extinction of their parent plants, which presumedly were of schizaeaceous affinity. If the Icelandic and Spitsbergen forms also belong to that family, it is reasonable to assume that they disappeared from the area earlier in the Tertiary than did related forms in more southern latitudes.

The differences noted between the microfossil assemblage of the Greenland material and that of Spitsbergen may possibly be due in part to a difference in age (cp. p. 114).

RAVN's dating concerns mainly the first and third of NATHORST's series, while the evidence offered by fossils from the fifth series was less conclusive but indicated a Paleocene to Eocene age. The sixth (uppermost) series, which contains horizons rich in plant impressions and some thin coal seams, has yielded no animal fossils which could be used for age determination. Geological evidence, however, indicates a close connection with the fifth series.

There appear to be no essential differences in the macrofossil floras of the first and sixth series. The marked differences in the taxodiaceous remains (*Sequoia* versus *Taxodium*) indicated by NATHORST (1910) have been eliminated through the unification of these remains in *Metasequoia* (cp. p. 70).

Only a small amount of material from the sixth series has been studied, and the determination of the microfossils was to some extent hindered by their preservation. The results discussed in the following were obtained from the coal samples, which yielded the best preparations. The microfossil contents are dominated by two-winged, inaperturate, and triporate grains in varying relative proportions, comparable to the conditions in the first series. Representatives of *Trudopollis* and of *Sciadopityspollenites* have not been identified, although specifically sought for. The number of pollen forms appears to be somewhat smaller than in coal samples from the first series, but this observation may be due to the unsatisfactory state of preservation. In conclusion, it may be stated that there are no differences in the microfossil contents which indicate a great difference in age between the first and the sixth series. It is possible that *Sciadopitys* and the parent plants of *Trudopollis* are not present in the sixth series, but in view of the small material available and the state of preservation, the evidence cannot be regarded as conclusive.

The Tertiary deposits at Kapp Lyell and on both sides of Forlandsundet have not been exactly correlated with those of the main Tertiary basin. NATHORST (1910) found that the plants from Kapp Lyell described by HEER (1876) indicated a connection with the plant-bearing beds of the sixth series. Again, the taxodiaceous remains formed an important part of NATHORST's argument, but as mentioned previously this was rendered invalid by later revision. Various geological features make it probable that the deposits concerned are contemporaneous with the sixth series or are even younger (ORVIN 1940). The present investigation only includes material from one of these deposits outside the main basin, namely the marine clay-stones from Sarsbukta. The pollen and spore assemblage from that locality is remarkable for the dominating proportion of two-winged grains, these contributing as much as 70 per cent of the total. This may probably be explained as a marine over-representation.Grains referable to *Picea* are relatively somewhat more common than usual. The angiospermous constituent, the composition of which is rather varied, is numerically small, but when viewed in relation to the total contents of spores and non-winged grains, its proportion is found to be approximately one fifth, which is not remarkable. The following spore and pollen forms known from the main basin have been identified: *Laevigatosporites haardti*, *Verrucosisporites opimus*, *V. septentrionalis*, *Ericipites* sp., Type A, *Abietineaepollenites* sp., Type B, *Pitysporites* cf. *labdacus*, *Inaperturopollenites* sp., *Sciadopityspollenites serratus* (contributing approximately 3 per cent), *Trudopollis barentsii*, *Myricipites speciosus*, Triporates, Type A(?), *Alnipollenites* sp. ,Type A and Type B(?). One feature which clearly distinguishes this assemblage from those of the main basin is the presence of *Tsuga* pollen, which contributes approximately 5 per cent to the total. In none of the many preparations investigated from the main basin have similar grains been observed. This fact tends to confirm the geological evidence indicating that the Tertiary deposits at Forlandsundet are not contemporaneous with the plant-bearing series at the base of the main basin (first series). It also indicates that there is no correlation with the plant-bearing beds of the sixth series, but this indication is less conclusive in view of the inadequate material from the sixth series. What the presence of *Tsuga* may further signify is unknown, since there seems to be no other record of the genus in the Arctic Tertiary.

It can be concluded that the deposit from Sarsbukta was probably not contemporaneous with either of the plant-bearing series of the main Tertiary basin. On the other hand, the differences in age between the Sarsbukta deposit and the other two are unlikely to be very great. The small microplanktonic assemblage present in the Sarsbukta samples indicates that the age is not greater than Upper Paleocene (MANUM 1960 b). The pollen and spores, however, form no satisfactory basis for a correlation of the Sarsbukta deposit with the series of the main Tertiary basin. It is possible that the Sarsbukta deposit is somewhat younger than the uppermost (sixth) series of the main basin, as has been suggested by ORVIN (1940, p. 36).

Notes on the Lower Tertiary floras of some northern localities outside Spitsbergen

Ellesmere Island

Material

On the second Norwegian "Fram" Arctic expedition (1898–1902) Dr. H. G. SIMMONS collected coal samples and plant fossils in Stenkulfjorden in the southern part of Ellesmere Island (approx. 77° 25′ N. – 84° W. Gr.). NATHORST described the plant fossils (1915) and also quoted SIMMONS' observations on the locality. Some of the coal samples are now in the collections of Universitetets Paleontologiske Museum, Oslo. The actual localities from which the specimens were derived are not specified, but the labels together with NATHORST's quotations from SIMMONS clearly indicate the site in Stenkulfjorden, given by NATHORST (l. c. pp. 3–6). It is not known precisely from which of the several seams the coals were collected, but they came mainly from the lower part of the sequence (l. c. p. 5). The coal-bearing part of this sequence is 97 metres thick.

The coals studied are rather hard lignites with a brownish black streak. They required less than half an hour's treatment with SCHULZE's solution, and it was necessary to cool the mixture during the first minutes of the maceration process. The chlorination-acetolysis method was tried, with satisfactory results, for one of the samples. The pollen and spores are better preserved than in the Spitsbergen material.

Without discussing their stratigraphic relationship, NATHORST referred the beds to the Tertiary. According to TROELSEN (1950, pp. 78–79) the beds concerned belong to the "Eureka Sound group", which he presumed to be of Cretaceous or Cenozoic age. Further data on the Eureka Sound group were given by THORSTEINSSON & TOZER (1957, p. 17), who stated that recently collected plant fossils indicate an early Tertiary (Paleocene or Eocene) age.

Systematic survey

SPORITES

MONOLETES

Laevigatosporites haardti (p. 21)

Indistinguishable from the Spitsbergen specimens and fairly abundant (up to 9 per cent in one sample).

TRILETES

Verrucosisporites pulvinulatus (p. 27)

Indistinguishable from Spitsbergen specimens. Rare.

Triletes?

Pl. XX, figs. 1, 2.

Two specimens have very distinctive appearance due to nearly spherical warts of greatly varying sizes (diameters from less than 1 μ to 5 μ), and with constricted bases. One specimen has features suggestive of a triradiate scar. Possibly there is a morphological relationship to *Bullasporis* KRUTZSCH (1959, p. 126).

Specimens: 116: 9.1-84.9 (pl. XX, fig. 1), 116: 18.2–75.7 (pl. XX, fig. 2).

POLLENITES

TETRADES

Ericipites sp.

Two types were found, one indistinguishable from the Spitsbergen Type C (p. 29), the other resembles the Spitsbergen Type A (p. 29), but possesses finer granules. Both types are rare.

DISACCATES

Abietineaepollenites sp., Ellesm. Type A

Pl. XVII, figs. 1–3.

In dorsoventral view *c.* 95 μ long, *c.* 70 μ broad. Cap *c.* 1.5 μ thick; in optical section, fine radial elements are seen the upper ends of which appear to be joined by delicate arches, which make the exine surface slightly rough. In some aspects the cap appears to be thickened slightly and to have an irregularly undulating surface close to the roots of the bladders. Surface pattern finely reticulate, the meshes *c.* 0.7 μ in diameter, muri elements barely observable in surface view. (In the second specimen indicated below, pl. XVII, fig. 3, the bladders appear slightly more than semicircular in outline, and thus the specimen approaches a *Pityosporites* form). The natural affinity is probably with *Pinus*.

A comparison with Spitsbergen specimens from Sarsbukta referred to *A.* sp., Spitsb. Type A (pl. VII, figs. 1, 2) reveals many similarities. The only apparent difference is that the caps of the Spitsbergen specimens have a pattern which is not perfectly reticulate.

Specimens: 117: 14.4–85.1 (pl. XVII, figs. 1, 2), 115: 17.6–78.3 (pl. XVII, fig. 3).

Abietineaepollenites sp., Ellesm. Type B

Pl. XVIII, figs. 1, 2.

Smaller in size than Type A, longer diameter of body *c.* 50–55 μ. Bladders usually rather well marked and relatively large, thus approaching a *Pityosporites* form. The cap is smooth or softly undulate in outline; thickness 1.5–2.0 μ, but sometimes thicker at the margin. Surface pattern reticuloid, muri more or less prominently beaded.

The general appearance varies greatly and there are also variations in the cap texture suggesting that more than one natural species are present. The natural affinity appears to be with *Pinus*.

Specimens: 115: 11.5–82.6 (pl. XVIII, fig. 1), 112: 5.3–86.5 (pl. XVIII, fig. 2).

Abietineaepollenites sp., cf. Spitsb. Type B (p. 34)

Pl. XVII, figs. 4, 5.

Indistinguishable from specimens from the Sarsbukta locality, Spitsbergen (pl. VIII, fig. 3), and from the Tröllatunga and Brjánslækur localities, Iceland (pl. XIX, figs. 1–3). – Affinity most probably with *Picea*.

Specimens: 115: 8.2–75.5 (pl. XVII, fig. 4), 117: 15.4–75.9 (pl. XVII, fig. 5).

cf. **Pityosporites** sp., Ellesm. Type A

Pl. XVIII, figs. 3, 4.

Resembles the *Abietineaepollenites* sp., Ellesm. Type A, but differs in the following characters: Cap is more thickened towards the margin (up to *c.* 3.0 μ), and markedly undulate close to the bladder roots. The surface pattern is reticuloid, muri *c.* 0.5 μ apart. The bladders are greater than semicircular in outline and more distinctly set off from the body. – Affinity most probably with *Pinus*.

Specimens: 117: 13.2–77.0 (pl. XVIII, fig. 3), 117: 8.3–80.4 pl. XVIII, fig. 4).

cf. **Pityosporites** sp., Ellesm. Type B

Pl. XVIII, figs. 5, 6.

Differs from the Type A in that the cap surface is coarse and irregularly rough because of the joining of the radial elements by "arches", which give the wall a "puffy" appearance in optical section. The surface pattern is reticuloid with muri up to 1.0 μ apart. – Affinity most probably with *Pinus*.

Specimens: 117: 14.0–84.8 (pl. XVIII, fig. 5), 117: 15.4–76.5 (pl. XVIII, fig. 6).

cf. **Pityosporites** sp., Ellesm. Type C

Pl. XVIII, figs. 7, 8.

Smaller than types A and B. Greater diameter of body 45–60 μ. The irregular, warty appearance of the cap surface is to some extent similar to the dorsal part of some *Tsuga* pollen (e. g. *Tsuga heterophylla*). Outline of cap is coarse and irregularly undulate. A finely reticulate pattern can sometimes be observed, but is partly obscured by the unevenness of the surface. In surface view the "warts" are not distinctly outlined. Thickness of the cap is 2.0–4.0 μ, thickest towards the bladder roots. Radial elements are sometimes visible. The bladders are often more or less crumpled up, so that they are barely noticeable in some specimens. Such specimens may at first glance seem referable to *Tsugaepollenites*, but closer examination reveals a sculpturing different from *Tsuga*, and the bladders may usually be detected. – Affinity most probably with *Pinus*.

Specimens: 115: 6.4–82.3 (pl. XVIII, fig. 7), 117: 10.6–79.0 pl. XVIII, fig. 8).

INAPERTURATES

Inaperturopollenites sp., cf. Spitsbergen Type A (p. 40)

Pl. XX, figs. 6, 7.

Inaperturate grains comparable to the Spitsbergen Type A, but the assemblage is not as heterogeneous as the Spitsbergen one. The dominant form has a finely and densely granular exine similar to that shown in text-figure 10, c. (p. 41). Other forms are scarce.

Specimens: 115: 6.0–84.3 (pl. XX, fig. 7), 115: 14.9–75.4 (pl. XX, fig. 6), 115: 14.5–82.6.

Sciadopityspollenites serratus (Pot. & Ven.) Raatz

Pl. XX, figs. 3, 4.

Several specimens have been found which cannot be distinguished from Spitsbergen specimens (p. 42).

Specimens: 116: 12.8–77.9 (pl. XX, figs. 3, 4), 113: 7.0–84.1.

Sequoiapollenites sp.

A few specimens have an inconspicuous, conically elevated area which appears to be a papilla. They are similar to the specimens in text-figures 11, a and c (p. 44).

TRIPORATES

Triporate grains are rather common. By far the most are comparable to the Spitsbergen Type A (p. 59), e. g. pl. XX, figs. 21, 22. The assemblage appears less heterogeneous than that from Spitsbergen.

A few grains resemble the *Myricipites* sp. reported from Sarsbukta (p. 58).

PERIPORATES

One specimen with three subequatorial pores, strongly suggestive of an affinity with *Carya* (pl. XX, fig. 5).

Discussion

Among the macrofossils from the Stenkulfjorden locality, described by Nathorst (1915), *Sequoia langsdorfii* (= *Metasequoia occidentalis*) is the most important. Its small twigs are very abundant in the bituminous shale. Nathorst also recorded taxodiaceous remains as cf. *Glyptostrobus ungeri* Heer, and fossil coniferous wood, probably of the *Cupressinoxylon* type. He further mentioned two leaf fragments which probably belong to *Cercidiphyllum arcticum*.

The Eureka Sound group also includes the beds at Discovery Bay (81° 64′ N. – 64° 45′ W. Gr.) where the material for Heer's "Die miocene Flora des Grinnell-Landes" (1878) was collected. Besides the frequent occurrence of *Taxodium distichum miocenum* (= *Metasequoia occidentalis*), and the rare occurrence of *Populus arctica* and *P. zaddachi* (= *Cercidiphyllum arcticum*), Heer reported *Torellia* (*Feildenia*) *rigida* to be one of the most common fossils. Further, he described a few pinaceous leaves and seeds. Some leaves were referred to *Corylus*, and a number of other remains were named specifically, but the affinities of all of them appear to be questionable.

HEER pointed out the correspondence between the Tertiary floras of Ellesmere Island and Spitsbergen and also the great resemblance between the black shale of the Discovery Bay locality and the Metasequoia-shale of Spitsbergen. He also claimed that the Spitsbergen flora was by far the richer (178 versus 30 species) but admitted that this might be due to the more extensive collections available from Spitsbergen. This difference between the floras is also marked when the less well-founded species described by HEER, which are particularly numerous in his Spitsbergen work, are ignored.

The present microfossil record from Stenkulfjorden confirms the impression that the flora of the Eureka Sound group is less rich than that of the Spitsbergen Tertiary. The material investigated is admittedly not extensive; but considering the better state of preservation some weight may safely be placed upon the evidence of this microfossil record.

The microfossil record corroborates the macrofossil evidence regarding the importance of the coniferous element. Inaperturate coniferous grains, the greater part presumedly of taxodiaceous affinity, make up approximately half the exine contents; there is less variety of forms than in Spitsbergen. As in Spitsbergen there is a remarkable scarcity of grains with a distinct papilla.

Two-winged grains are also abundant, the three samples counted containing 6, 13, and 29 per cent respectively. The great variety of forms indicates the presence of several pinaceous species in the flora. Except for a rare type, probably a *Picea*, their generic affinity appears to be with *Pinus*.

Tsuga pollen has not been found. *Sciadopitys* grains are sparse; in none of the samples whose contents have been counted do they reach one per cent. The habitat of the trees was probably rather far from the sedimentary basin.

Grains which can be connected with the *Torellia* recorded by HEER have not been observed.

The angiospermous record is rather meagre. The most prominent are the triporate grains, which in one sample reach 15 per cent. Practically all the determinable ones are of a betuloid character and comparable to the Spitsbergen Type A. The heterogeneity of the type is less pronounced than in Spitsbergen, but variations in the pore characters indicate an origin from at least two species. The numbers of these grains indicate that in some places there was a considerable betulaceous element in the vegetation.

In one sample tricolpate grains constitute 4 per cent of the total, but they are too indistinct for a determination of their natural affinities. One specimen found appeared to be identical with *Tricolpopollenites haraldii* from Spitsbergen.

Ericalean tetrads occur sparsely, as do *Alnus* grains. One specimen could not be distinguished from the non-aperturate reticulate grains from Spitsbergen. No specimen of the *Trudopollis* category has been found.

Spores are relatively frequent, particularly a monolete *Polypodium* type (*Laevigatosporites haardti*). Trilete spores are less frequent than monolete ones; there are some specimens referable to *Leiotriletes* sp., and a few belonging to *Verrucosisporites pulvinulatus*.

Greenland

Material

The material investigated consisted of bituminous shales from Atanikerdluk, the classical West Greenland locality for Tertiary plant fossils (approx. 70° 4′ N. –52° 20′ W. Gr.). A description of the locality was given by KOCH (1955 and 1959). The material was generously provided by Grønlands Geologiske Undersøgelse, København (specimen G. G. U. No. 28265). It had been collected by Dr. ESKE KOCH, who has informed me that it was taken from the lowermost beds of the Tertiary sequence, the "Quikavsak member" (cp. KOCH 1959). According to KOCH (1959, pp. 85–86) the age of the beds is Lower Paleocene.

Preparations were made with the aid of SCHULZE's solution followed by treatment with hydrofluoric acid. They are fairly rich in microfossils which, however, are poorly preserved. A very large number of the grains and cuticular fragments have been severely damaged, apparently by microorganisms (e. g. pl. XVII, fig. 6). In the membranes, rounded holes are observed which are often occupied by spheroidal bodies, usually between 6 and 10 μ in diameter. The bodies appear to be composed of a large number of minute chambers about 0.8 μ in diameter. Such "chambered" bodies also frequently occur separately in the preparations.

Systematic survey

SPORITES

TRILETES

Rugulatisporites cf. **quintus** TH. & PF.

One spore observed which agrees with the Spitsbergen form (p. 26).

Verrucosisporites pulvinulatus (p. 27)

One spore which agrees with the Spitsbergen form.

Verrucosisporites septentrionalis (p. 28)

One specimen agrees with the Spitsbergen form. Two specimens may be referred to as cf. *V. septentrionalis*, being a smaller version of the species, with diameters 38–39 μ and slightly smaller warts.

Verrucosisporites sp. (cf. **V. opimus,** p. 27)

One specimen resembles *V. opimus* of Spitsbergen but is smaller (32 μ) and has smaller sculpturing elements.

POLLENITES

DISACCATES

Abietineaepollenites sp.

A few bad specimens whose overall appearance resembles *A. microalatus* (cp. POTONIÉ 1958, fig. 73), length of grains *c.* 60 μ.

Pityosporites cf. **labdacus** (POT.) TH. & PF.

Overall appearance as for the Spitsbergen form (p. 35), but the grains are usually somewhat larger, with length of body *c.* 65 μ. Among the determinable two-winged grains this is the most common form.

INAPERTURATES

Inaperturopollenites sp.

Inaperturate grains (with diameters less than 50 μ) form the dominant category of pollen and spores, but the material is not suitable for a detailed distinction of forms.

Sciadopityspollenites serratus (POT. & VEN.) RAATZ

Pl. XX, figs. 14, 15.

Four specimens have been found, two of which are fairly well preserved and appear identical with the smaller ones in Spitsbergen (p. 42).
Specimens: 111: 18.1–87.0 (pl. XX, figs. 14,15), 110: 12.8–79.5.

Sequoiapollenites sp.

A few specimens with inconspicuous papilla have been found, corresponding to the Spitsbergen form shown in text-figure 11, a (p. 44).

TRICOLPATES

Tricolpopollenites haraldii (p. 48)

Indistinguishable from Spitsbergen specimens. Rare.

Tricolpopollenites sp., cf. Spitsb. Type B (p. 48)

Differs from the Spitsbergen form in having a shorter polar axis, *c.* 24 μ, and a more pronounced decrease in the size of the reticulum meshes towards the poles. Rare.

TRICOLPORATES

Trudopollis sp.

Two badly preserved specimens belonging to the *Trudopollis* category have been found. In overall appearance they resemble *T. barentsii* (p. 49), but they are smaller (24 μ in diameter).

STEPHANOPORATES

Alnipollenites sp.

A few specimens occur, having six pores and diameter 30 μ or less. They can be compared with small specimens of the Spitsbergen type A (p. 62).

Discussion

The poor material and unsatisfactory preservation of the microfossils greatly limit the information that can be obtained. When making a quantitative analysis of the microfossil content, only the main categories could, as a rule, be distinguished; closer determinations were generally impossible.

The macrofossil flora of the beds concerned has been briefly reviewed by KOCH (1959). On the basis of geological evidence and the agreement between the plant fossils KOCH (pp. 96–97) considered the floras in various localities of the "Quikavsak member" and the basal part of "Naujât member", together with the flora of Agatdalen Valley (whose age had been determined by means of marine fossils) to belong to a Lower Paleocene association. It seems therefore permissible to view the fossils of these localities as a whole in order to obtain a better idea of the composition of the flora. The contained macrofossils are listed by KOCH (1959) who revised (pp. 88–89 and 95–96) the species in HEER's "Flora fossilis arctica", and assigned (p. 92) those species described by SEWARD & CONWAY (1935) to their proper horizons.

Little is known from the macrofossils about the pteridophytic element of the flora. The microfossils indicate the presence of five or more species. Monolete spores have not been found but a few trilete types representing a variety of forms occur. Two of the forms (*V. septentrionalis* and *R.* cf. *quintus*) indicate that *Osmunda* was probably present in the flora. There are a few spores of more or less gleichenioid appearance, and two, or probably three, forms appear to be represented (e. g. pl. XX, fig. 13). A closer determination has been impossible owing to their unsatisfactory state of preservation.

The coniferous macrofossils are rather varied, but their closer affinities are in many instances uncertain. *Metasequoia occidentalis* is abundant. According to SCHLOEMER-JÄGER (1958, p. 54) *Sequoia* is also represented, as she maintains that some specimens from Atanikerdluk ("Quikavsak member") referred to *S. langsdorfii* by HEER, and those from Kingitoq (basal part of "Naujât member") referred to *Sequoiites langsdorfii* by SEWARD & CONWAY (1935), belong to *Sequoia langsdorfii* and not to *Metasequoia*. SEWARD & CONWAY reported several pinaceous leaves and seeds.

A quantitative analysis of the exine content reveals that the coniferous element predominates. In this respect there is a close agreement with the microfossil assemblages of Ellesmere Island and Spitsbergen. Of the pollen and spores 33 per cent are referable to *Inaperturopollenites* sp., and another 26 per cent apparently also belong to this category, but their state of preservation makes the determination less certain. As in Spitsbergen and Ellesmere Island, grains referable to *Sequoiapollenites* are very rare. *Metasequoia* may account for part of the grains referred to *Inaperturopollenites*, but the macrofossils indicate the presence also of other taxodiaceous and cupressaceous species – whose closer affinities are uncertain – with which these grains may be combined. Two-winged pinaceous grains make up 7 per cent of the total, a proportion approaching that of several Spitsbergen samples and also of samples found on Ellesmere Island. The number of individual types is small, the two mentioned in the systematic survey may be related to *Pinus*. *Sciadopityspollenites* has a scattered occurrence similar to that on Ellesmere Island. Macrofossil *Sciadopitys* is not found in the Tertiary, but SEWARD & CONWAY (1935, p. 12) recorded *Sciadopitytes borealis* (HEER) in the Atane formation of Kingigtoq (Upper? Cretaceous, KOCH 1959, p. 46), upon which the Paleocene lies unconformably.

The microfossil record of the angiospermous element is not very informative. The most striking feature – in comparison with samples from the other areas studied – is the extremely scanty representation of triporate grains. For example, among 218 grains only a single triporate one was counted. One of the triporate types resembles the Spitsbergen Type A, another resembles Type D. Whether the scarcity of triporate grains is only accidental or indicates a generally weak representation in the flora of plants related to the Betulaceae (and Myricaceae) cannot be answered until more extensive material has been studied. Grains referable to *Alnipollenites* are also rare. It appears from KOCH (1959, p. 91), however, that betulaceous macrofossils are common in certain places.

Tricolpate grains make up 8 per cent of the total, but they are usually too indistinct and poorly preserved for closer determination. Two more distinct forms are mentioned in the systematic survey.

Another notable feature of the microfossil record is that prolate tricolporate grains, *c.* 15–17 μ long, make up 5 per cent of the total, whereas in the other areas studied such grains are absent or very rare. Their indistinct nature makes any indication as to their affinities impracticable. The occurrence of *Trudopollis* is of interest. – A few grains have been found which agree with the non-aperturate reticulate type from Spitsbergen, and one that agrees with the Incertae sedis, Type B.

Iceland

Material

Pollen and spores from Tertiary beds have been reported by ÁSKELSSON (1947, 1954, 1956), and extensively dealt with by PFLUG (1956, 1959) and SCHWARZBACH & PFLUG (1957). PFLUG found that the microfossil contents of certain beds were similar to those of the Spitsbergen Tertiary, as presented in the preliminary report by MANUM (1954). It therefore seemed desirable that further comparison of the microfossils themselves should be made in the light of the present investigation. The late Mr. JOHANNES ÁSKELSSON, Reykjavík, who had assisted SCHWARZBACH and PFLUG in obtaining part of their material, generously provided me with samples from two of the very same localities which had been studied by PFLUG, namely Brjánslækur and Tröllatunga (approx. 65° 30′ N. – 23° 10′ W. Gr. and 65° 40′ N. – 21° 40′ W. Gr. respectively). In a letter to me ÁSKELSSON stated that the Tröllatunga sample was of the same material as had been examined by PFLUG. For descriptions of the localities the works by ÁSKELSSON (1954, Brjánslækur) and PFLUG (1956, Tröllatunga) should be consulted.

The samples consisted of soft claystones with plant impressions. They were treated with hydrofluoric acid and SCHULZE's solution. By far the best microfossils were obtained from the Tröllatunga sample. Apparently they are considerably better than those obtained by PFLUG, judging from his illustrations. The comparison is therefore based mainly on that sample.

Modes of preservation of some previously described microfossils. – PFLUG (1956, p. 424; 1959, p. 152, pl. 14, fig. 2) reported several two-winged grains with pore- or furrow-like features which he suggested might have some reference to germinal apertures ("Keim-Austrittsstellen"). I have often observed similar holes in both two-winged and other pollen forms obtained from various samples, but rarely in coals. It seems more likely that the holes were caused by some agency, presumably of microbial nature, which was active after the deposition of the exines. In any case it is unreasonable to connect such holes in the air-bladders of two-winged grains with germinal apertures. The furrow-like features could also have been of secondary nature and due to folds formed when the grains became flattened. The same applies to the "Y-Doppelmarke" ("double Y-scar") in forms referred to *Sporopollis* (PFLUG 1956, p. 426, pl. 18, fig. 1; 1959, p. 157, pl. 15, fig. 1), *Trudopollis probetuloides* (PFLUG 1959, p. 158), and *Duplosporis* (PFLUG 1956, p. 416, pl. 17, figs. 9, 10, 12, 13). Secondary folds also explain the "deutliches Foramen äquatoriale an den Äquatorecken" of *Duplosporis*.

Further, a "particularly peculiar" spore type with "a circular, subequatorially running dehiscence furrow" (*Laevigato-spor.*, PFLUG 1959, pp. 150–151, pl. 13, fig. 6; 1956, pl. 17, fig. 6) is far from convincing. The "peculiarity" attributed to it is explained when it is considered how easily folds are apt to form on thin-walled spheroidal to ellipsoidal bodies when they become flattened.

In poorly preserved material, exines with equatorial pores may have shapes which make their recognition difficult. Obviously the outline of a flattened grain does not necessarily have to coincide with its equator. The pores therefore may be found in various positions and may look rather different in one and the same specimen. These facts should be considered when attempts are made to find out the true characters of such grains. One of the most obvious pitfalls is to give the position of the pores as subequatorial, e. g. the "subequatorial pores" reported in representatives of *Polyvestibulo-poll.* (= *Alnipollenites*) (PFLUG 1959, pp. 160–161). For several of the triporate forms reported by PFLUG (1956, 1959) the interpretations given are not convincing. A "common triporate type" with "apertures that are formed differently in one and the same exine" ("mit an der gleichen Exine verschiedenartig ausgebildeten Germinalien", 1956, p. 425, pl. 17, figs. 17, 18) can be recognized as a fairly common and not very severe distortion of a triporate grain. Two of the pores are seen in equatorial section since the outline partly coincides with the equator, the third pore is seen as a rounded opening a short distance within the outline. Folding has caused the protrusion of one of the pore regions interpreted as "Foramen mit Colpus".

The peculiar characters attributed to the grains in plate 17, figures 14–16 (1956) appear to be due to more severe folding. In addition there is no convincing evidence of subequatorial pores.

Systematic survey

SPORITES

MONOLETES

Laevigatosporites haardti (POT. & VEN.) TH. & PF. (cp. p. 21)

In the Tröllatunga sample these spores comprise 10 per cent of the total, which is far more than in any of the samples from Spitsbergen. On Ellesmere Island almost the same values were found.

TRILETES

Reticulatisporites sp.

Pl. XX, figs. 8–10.

Two forms have been found, both of which are rare. Neither is identical with the Spitsbergen forms.

Type A (pl. XX, figs. 9, 10). – Resembles *R. incomptus* from Spitsbergen (p. 24) but the reticulum meshes are generally somewhat smaller (5–8 μ), the muri slightly higher (3.0–4.5 μ), and the diameter of the spores 33–40 μ. It is probably similar to the form illustrated by PFLUG (1956, pl. 17, fig. 2).

Specimens: 105: 7.8–74.6 (pl. XX, figs. 9, 10), 107: 4.9–70.3.

Type B (pl. XX, fig. 8). – The main difference lies in the muri which appear more or less as edged ridges and not as lamellae. Exine thickness 1.5–2.0 μ, including the ridges; meshes 4–7 μ across. Spore diameter *c.* 31 μ.

Specimens: 107: 10.0–80.1 (pl. XX, fig. 8), 106: 5.8–70.9.

POLLENITES

TETRADES

Ericipites sp.

Two forms, one of which (A) cannot be distinguished from the Spitsbergen Type A (cp. p. 29). Both are rare. Neither form appears to correspond to the specimens illustrated by PFLUG (1959, pl. 16. figs. 9–11).

Type A – Similar to Spitsbergen Type A, but in some specimens the exine is slightly thinner.

Specimen: 105: 14.7–74.5.

Type B. – Tetrad 38 by 48 μ, individual grains 27–30 μ. Exine *c.* 1.0 μ thick, surface granular, in surface view showing irregular spots composed of minute dots. Only one specimen found.

Specimen: 107: 4.5–90.2.

DISACCATES

Abietineaepollenites sp., cf. Spitsb. Type B (p. 34)

Pl. XIX, figs. 1–3.

Grains which cannot be distinguished from Spitsbergen specimens (Sarsbukta locality, pl. VIII, fig. 3) are very abundant in both the Brjánslækur and Tröllatunga samples, and they make up nearly half the microfossil contents. They were also reported by Áskelsson (1947, p. 49, *Picea* sp.). It is probably the same form that was listed by Pflug as *Pityospor.* cf. *alatus* (1956, p. 418) with no further details, and as *P. microalatus* Form T (1959, p. 152). The affinity to *Picea* can hardly be questioned.

Specimens: 109: 12.9–74.7 (pl. XIX, figs. 1–2), 109: 16.9–91.7 (pl. XIX, fig. 3).

Pityosporites cf. **labdacus** (Pot.) Th. & Pf. (cp. p. 35).

Pl. XIX, figs. 4, 5.

Two varieties can be distinguished, mainly by their sizes. One, from Brjánslækur, was described and illustrated by Áskelsson (1947, p. 48, pl. II, fig. 3, *Pinus* sp.), but it is also present in the Tröllatunga sample. The second variety, a specimen of which is figured here, has a total length of *c.* 70 μ, and body length *c.* 40 μ. Both varieties resemble greatly specimens from Spitsbergen (Sarsbukta locality), which, however, are intermediate between the two in size.

Specimen: 106: 6.7–80.9 (pl. XIX, figs. 4, 5).

INAPERTURATES

Grains referable to *Inaperturopollenites* sp. (p. 40) are rare in the Tröllatunga sample, but less so in that from Brjánslækur. In the latter one specimen of *Sequoiapollenites* sp. was found. It is apparently identical with those described by Áskelsson (1947, pp. 49–50) and referred by him to *Cryptomeria.* This reference cannot be considered entirely conclusive, however. Pflug (1956, p. 423) also noted the lack of typical sequoioid pollen grains in contrast to the recording by Heer (1868) and Windisch (1886) of the macrofossils of *Sequoia sternbergi* (Goepp.) Heer.

One specimen comparable to *I. magnus* (Pot.) Th. & Pf. possesses distinct *Larix* features (pl. XIX, fig. 6). The outline is circular and has a diameter of 100 μ. The exine varies in thickness from an exceedingly thin membrane, somewhat folded, in one hemisphere, to slightly over 1 μ in the other. In the stronger part the exine appears to be composed of two layers of nearly equal thickness. The surface is smooth, and the surface pattern is faintly dotted. Somewhat below and parallel to the equator in the stronger hemisphere there is a distinctly thickened belt.

Sciadopityspollenites sp.

PFLUG (1956, p. 418) listed *Monocolpo-poll.* cf. *serratus* without giving further details. I have observed one specimen which is unfortunately folded in such a manner as to make closer study difficult. The characteristic sculpturing, however, is readily recognizable. The warts are slightly smaller than is usual in the specimens from Spitsbergen. Until more suitable specimens are found, the extent of agreement with the Spitsbergen specimens cannot be settled.

TRICOLPATES

Tricolpopollenites sp.

Pl. XX, figs. 16–18.

PFLUG (1959, p. 156) reported grains which he referred to *T. retiformis* TH. & PF. The specimens from Tröllatunga illustrated here can probably also be included in that species. Two forms can be distinguished.

Type A (pl. XX, fig. 18). – 16 by 23 μ. Reticulum meshes of fairly uniform size (1.5–2.0 μ across), and muri which have a somewhat sinuous course. The beading of the muri is very prominent and fairly open. The reticulum appears diffuse towards the furrow edges.

Specimen: 104: 21.4–80.8 (pl. XX, fig. 18).

Type B (pl. XX, figs. 16, 17). – Larger than Type A, with the longer axis *c.* 30 μ. The reticulum meshes are of two sizes, 1.5–2.0 μ, and less than 1.0 μ respectively. The muri are fairly straight and are more finely beaded. There appears to be no change in the reticulum towards the furrow edges.

Specimen: 104: 21.3–80.8 (pl. XX, figs. 16, 17).

Both forms are rare. Their natural affinity is possibly with *Salix.* Allied, but somewhat different grains occur in Spitsbergen (*Tricolpopollenites* sp., types A and B, cp. p. 48).

Tricolpopollenites striatus PF., "Form Tr."

Pl. XX, figs. 11–12.

This form, reported from Tröllatunga by PFLUG (1959, pp. 155–156), has a minutely undulate exine profile. In surface view there is a finely dotted striate pattern which is sometimes indistinct. Exine *c.* 0.8 μ thick.

The form is different from the Incertae sedis, Type B, from Spitsbergen (p. 65). The type of the species (PFLUG 1959, pl. 16, figs. 13, 14), however, appears to be more similar to the Spitsbergen form, but not identical with it.

Specimen: 107: 20.9–86.3 (pl. XX, figs. 11–12).

TRIPORATES

Pl. XX, figs. 19, 20.

Triporate grains rank next in abundance to the two-winged ones, making up 18 per cent in the Tröllatunga sample. All the better-preserved grains closely resemble the Spitsbergen Type A (p. 59). In fact, no distinct difference can be seen, except that the aperture details are not quite so clear as in specimens from the Sarsbukta locality.

PFLUG (1956) referred some triporate grains to his category Normapolles (cp. PFLUG 1953, p. 95). However, grains with aperture features that would place them in Normapolles have not been observed during the present investigation, neither has PFLUG (1956, 1959) illustrated convincing examples of such grains. The illustrations of Icelandic Normapolles representatives show protruding and thickened pore regions with more or less obscure details. The thickened regions often form fairly opaque fields around the pores. It appears that PFLUG based the reference to Normapolles on the interpretation of these darker fields as "oculi" (cp. THOMSON & PFLUG 1953, pp. 31, 32; PFLUG 1956, p. 416: "Der Oculus ist nur als Schatten über dem Germinal erkennbar"). The characters of these grains rather appear to be those of poorly preserved betuloid grains, comparable to the Spitsbergen Type A. Concerning other features observed by PFLUG ("Y-Doppelmarke", "Foramen") cp. above p. 104.

Specimens: 105: 4.6–76.2 (pl. XX, fig. 19), 103: 19.6–56.0 (pl. XX, fig. 20).

STEPHANOPORATES

Alnipollenites verus POT.

PFLUG (1956, 1959) reported several forms which he referred to this species (= *Polyvestibulo-poll. verus* in PFLUG). He illustrated one form from Tröllatunga (1956, pl. 18, figs. 10–12; same form?: 1959, pl. 15, figs. 20, 27) which resembles but does not appear to be identical with the Spitsbergen Type A (cp. p. 62). Apparently the same form was illustrated by ÁSKELSSON (1956, fig. 5 a) from Brjánslækur. In the Brjánslækur sample, grains, apparently belonging to PFLUG's Form S (1959, pl. 15, figs. 23, 24), have been observed. This form resembles the Spitsbergen Type B (cp. p. 62) but is not identical with it.

Concerning the subequatorial pores reported by PFLUG (1959, pp. 160–161) cp. above p. 105.

Discussion

A discussion of the microfossils in relation to the macrofossils was made by PFLUG (1956, pp. 421–423), and no essential additions can be made on the basis of the present very limited investigation. However, a few points may be mentioned. Both the Brjánslækur and the Tröllatunga samples clearly show the importance of pinaceous forests, at least in areas surrounding the sedimentary basins, as about half the microfossils are two-winged grains of pinaceous origin. It appears that by far the greatest number of these grains derived from a species of *Picea.*

Large proportions of *Picea* pollen were also noted by Áskelsson (1947, p. 49) who considered that a species of *Picea* played a major role in Icelandic forests during certain Tertiary times. The remainder of the two-winged grains (in Tröllatunga less than 5 per cent of them) came from possibly two species of *Pinus*. Inaperturate coniferous grains form an unimportant part of the two samples studied. Triporate grains make up a fairly large proportion of the total (Tröllatunga: 18 per cent) and are composed essentially of one distinctly betuloid form. A few grains, all apparently of the same type, are referable to *Alnus* (Tröllatunga: 2 per cent). No grains referable to the Juglandaceae have been observed. Such grains were mentioned very briefly by Áskelsson (1956, p. 48), who, however, gave no further details. Pflug mentioned and illustrated "juglandoide Formen" (1956, p. 425).

The geological age of the Tröllatunga microfossil assemblage was suggested by Pflug (1956, p. 417) as being within Upper Paleocene to Lower Oligocene limits. One of the main arguments used by Pflug was the occurrence of the Normapolles type of pollen with less ancient ("urtümliche") characters than the corresponding pollen from Spitsbergen. But it was stated above (p. 108, Triporates) that the particular characters of the Normapolles have not been convincingly demonstrated in any Icelandic specimens. However, the apparent absence of representatives of Normapolles does not preclude a Lower Tertiary age, since in the Spitsbergen material, where Normapolles representatives (*Trudopollis*) generally occur, sometimes abundantly, there are samples in which no such grains have been found.

Further arguments for Pflug's dating were the occurrence of spores resembling those of the Schizaeaceae (*Cicatricosisporites dorogensis*) and pollen doubtfully related to palms (*Sabal*). However, Pflug did not attach much importance to the latter. (Concerning Pflug's comparison with the "monocolpate" specimens in Manum 1954, see p. 91). Thus there remains only *Cicatricosisporites* which, inferring from Central European occurrences, may indicate a Lower Tertiary age (cp. Pflug 1956, pp. 414–415).

Heer regarded the Tertiary flora of Iceland as being of Miocene age, as he did for so many northern Tertiary floras which subsequently have proved to be of early Tertiary age. Schwarzbach (1956, p. 103) pointed to the uncertainty of the datings based on plant macrofossils, and simply indicated the age of certain localities, including Brjánslækur and Tröllatunga, as Lower Tertiary.

General comparison

The Tertiary floras of Ellesmere Island, Greenland, Iceland, Spitsbergen, and other localities in similar latitudes have been treated collectively by several authors (e. g. HEER 1868, BERRY 1922 and 1930, HOLLICK 1936, CHANEY 1940, SCHWARZBACH 1947). These floras became well known through HEER's renowned work on the Miocene floras of the Arctic. In later years they have been dated as fairly early Tertiary (e. g. Eocene by BERRY and HOLLICK), an age which is now accepted for most of them. In some cases the dating is supported by evidence of animal fossils (Spitsbergen, Greenland). It is also generally accepted that the climatic conditions of these Lower Tertiary floras were temperate.

In view of the present palynological study of the Spitsbergen Tertiary a comparison with other localities in similar latitudes is of interest. Results from the study of samples from Ellesmere Island, Greenland, and Iceland are presented earlier in this paper, where the relation of the microfossils to the earlier known macrofossils is also discussed. It now remains to compare the microfossil records of the various localities. The pollen and spore types which are common to two or more of these localities are listed in table II (p. 113).

In making these comparisons it is necessary to remember that the sediments from which the microfossil assemblages have been obtained are not all of the same kind. The Ellesmere Island and most of the Spitsbergen samples are coals, the Greenland sample is a bituminous shale, and the Icelandic samples are claystones. The sediments represent different environments that influenced the composition of the particular assemblages. The paucity of the material from Greenland and Iceland has also to be kept in mind.

The most conspicuous feature common to all the non-Spitsbergen samples, and the greater part of the Spitsbergen ones, is the preponderance of pollen of coniferous origin. Usually inaperturate forms are the most abundant. Probably representatives of the Cupressaceae and Taxodiaceae, adapted to swamp habitats, were predominant in the land around, and in certain places in, the sedimentary basins. Many representatives of these families at present occupy such habitats. In this connection the puzzling rarity of grains of the *Metasequoia/Sequoia* type, which is a general feature, should be noted (cp. p. 85).

Two-winged pinaceous grains are always present, but in greatly varying numbers, thus suggesting the existence of pinaceous forests in all the localities, but in situations more or less away from the sedimentary basins. *Pinus* appears to have been the dominant genus. *Picea* seems to have played a smaller role, since definite *Picea* pollen is usually rare. Exceptions are the Icelandic samples, with nearly 50 per cent *Picea* pollen.

Pollen of *Sciadopitys* has been recorded from all localities indicating that the genus had a wide Arctic and Subarctic distribution in early Tertiary times. In Spitsbergen some variation is noted in these grains, but there is no definite indication that more than one species was represented. It may be assumed that the grains from Ellesmere Island and Greenland were derived from that same natural species, although the similarity of the pollen is not sufficient proof of this. Similar grains have been obtained from Iceland, but a thorough comparison has been hindered by the lack of satisfactory specimens. The *Sciadopitys* pollen is present in most Spitsbergen samples, commonly making up between 2 and 3 per cent of the pollen and spore contents. In no samples, however, do these grains occur in quantities comparable to those found in certain Oligocene-Miocene levels in lignites of the Lower Rhine basin (THIERGART 1949, 20–30 per cent, in extreme cases, 60 per cent). These large numbers are found to be related to the drier facies of the former swamp (THOMSON 1950). High percentages of *Sciadopitys* pollen are also known from the Lower Tertiary of S. W. Siberia (ZAKLINSKAJA 1958). The low percentages in the Spitsbergen samples indicate that the trees concerned hardly contributed in any considerable degree to the vegetation at, or near, the sites of deposition, but that they were sufficiently represented on dry land at some distance from the sedimentary basins to contribute a fairly constant amount of pollen to the sediments. In the three other localities studied a similar origin for the few *Sciadopitys* grains may also be assumed. This assumption explains why macrofossils have not been found. The youngest occurrences of possible allies of *Sciadopitys* in the concerned regions are a Cretaceous species of *Sciadopitytes* from Greenland (cp. p. 103) and another from Padloping Island (BOSE 1955).

It is evident from the pollen record that evergreen conifers formed more important constituents of the floras than is suggested by the macrofossils, which are usually dominated by the deciduous *Metasequoia* (cp. also p. 87).

Triporate grains referable to *Betula* occur regularly. They usually occur in moderate numbers, and the Tröllatunga sample has the maximum amount – at least 15 per cent. Further triporate forms of betulaceous affinity usually occur, as do a few forms more suggestive of the Myricaceae. Grouped together, the triporate grains constitute a characteristic component, comparable in quantity to the two-winged grains. The Greenland sample, which is remarkably poor in triporate pollen, is an exception.

Alnus pollen has a scattered occurrence in most samples. It is noteworthy that nowhere is the contribution more than 3 per cent. Evidently *Alnus* took no great part in the vegetation of the former swamps.

The tricolpate form for which a hamamelidaceous or platanaceous affinity is suggested also has a wide distribution. On Ellesmere Island and in Greenland grains have been found which cannot be distinguished from the Spitsbergen form. Other tricolpate grains are very rare, and no form was distinctive enough for a determination. Only in the Greenland sample and in one of the samples from Ellesmere Island do such indeterminable tricolpate grains contribute notably to the microfossil contents (8 and 4 per cent respectively).

It is notable that prolate tricolporate grains are extremely rare. They have been too few in number and too indistinct to form a basis for determination or description. In the Greenland sample, however, such grains are less rare. Periporate and stephanoporate grains suggestive of juglandaceous affinity are also extremely rare, indicating that either their sources were remote or that the family was only of minor importance in the floras. The same appears to have been true for the Fagaceae.

Grains of the *Trudopollis* category are present in most Spitsbergen samples, and poorly represented in the Greenland sample, but have so far not been identified from Ellesmere Island and Iceland. For a further discussion of these grains cp. p. 92.

Scattered spores referable to the Osmundaceae are found in several samples indicating that the family was widely distributed. But the spores are usually so few that whether or not they are to be recovered may be accidental. Therefore nothing definite can be stated about their occurrence on Ellesmere Island where, so far, they have not been seen. The two osmundaceous forms in Spitsbergen and Greenland appear identical. Also monolete polypodiaceous spores have a sparse occurrence. It is probably only accidental that they have not been found in Greenland. PFLUG (1956) mentioned *Cicatricosisporites dorogensis* from Iceland (Tröllatunga). These spores are different from the Spitsbergen form referred to as *C.* cf. *cicatricosoides* (cp. also p. 92).

The richest material studied is that from Ellesmere Island. Since the material consists of coal, a comparison with the Spitsbergen material is more valid than for any of the other localities. Compared to Spitsbergen, Ellesmere Island has a richer and more varied representation of two-winged pinaceous grains, while the inaperturate record shows less variation. The only coniferous forms which appear identical with Spitsbergen ones are the two referable to *Picea* and *Sciadopitys*, and which are sparse. Ellesmere Island has a smaller number of angiospermous forms than has Spitsbergen, and the main role is played by those referable to the Betulaceae. Considering that the sediments are of the same type, it seems reasonable to regard the differences noted as evidence of a difference in the composition of the floras. The somewhat poorer Ellesmere Island flora, with the notable pinaceous and betulaceous components, probably suggests a slightly less favourable climate than that in Spitsbergen. Whether this may imply a younger age of the Ellesmere Island flora is left open.

The bituminous shale from Atanikerdluk is probably best compared with the samples from Spitsbergen of the Metasequoia-shale and the carbonaceous rock

Legend to Table II.

Degrees of correspondence with Spitsbergen forms are indicated thus:

= : fossils apparently identical but not necessarily originating from the same plant species.
≈ : fossils closely resembling, differing only in size of entire fossil and/or of finer characters.
— : fossil somewhat different, but morphologically agreeing to an extent which makes a natural affinity to the same family, or genus, probable.

General abundance of the fossils indicated thus:

· : less than 2 per cent of the total exine contents.
+ : between 2 and 10 per cent of the total exine contents.
++ : - 10 - 25 - - - - - - -
+++ : more than 25 - - - - - - -

Table II

A comparison of the microfossils which the studied assemblages have in common.

Spitsbergen		Ellesmere Island	Greenland	Iceland
PTERIDOPHYTA				
Lycopodiaceae				
Reticulatisp. incomptus	·			≈ ·
Osmundaceae				
Rugulatisp. cf. *quintus*	·		= ·	— ·
Verrucosisp. septentrionalis	·		= ·	— ·
Schizaeaceae ?				
Cicatricosisp. cf. *cicatricosoides*	·			*C.* cf. *dorogensis* accord. Pflug.
Polypodiaceae s.l.				
Laevigatosp. haardti	·	= +		= +
?*Verrucosisp. opimus*	·		— ·	
ARCHEGONIATAE INCERTAE				
Verrucosisp. pulvinulatus	+	= ·	= ·	
GYMNOSPERMAE				
Pinaceae				
Abietineaep. sp., Type A (*Pinus* ?)	+	— +	— ·	
Abietineaep. sp., Type B (*Picea*)	·	= ·		= +++ (*c.* 50%)
Pityosp. cf. *labdacus* (*Pinus*)	+	— + (3 types)	≈ +	≈ ·
Taxodiaceae, Cupressaceae, Taxaceae				
Inaperturop. sp.	++	— +++	— +++	— ·
Sciadopitysp. serratus (*Sciadopitys*)	+	= ·	= ·	— ·
Sequoiap. sp	·	— ·	— ·	— ·
ANGIOSPERMAE				
Hamamelidaceae ? Platanaceae ?				
Tricolpop. haraldii	+	= ·	= ·	
Aceraceae ?				
Incertae sedis, Type B	·		= ·	— ·
Betulaceae				
Alnip. sp. (*Alnus*)	·	— ·	— ·	— · (several types)
Triporates, Type A (*Betula*)	=	= +	— ·	= ? ++
Triporates, Type B (*Corylus* ?)	+	≈ ·		
Myricaceae ? (Betulaceae ?)				
Myricipites speciosus	=	— ·		
Salicaceae ?				
Tricolpop. sp.	·	— ? ·	≈ ·	— ·
Empetraceae, Ericaceae				
Ericipites sp., Type A		≈ ·		= ·
Ericipites sp., Type C	+	— ·		
Ericipites indet.		— ·		— ·
Potamogetonaceae ?				
Non-aperturate reticulate grains	·	= ·	= ·	
Familia incerta				
Trudopollis sp.	+(+)		— ·	
		Indistinct tricolpate grains: 4% in one sample	Gleichenioid spores. Exceedingly few triporate. Indistinct tricolpate 8%, do. tricolporate 5%	

from the bottom of the "Longyear-seam". Such a comparison shows no essential difference in the quantity and variety of the forms of coniferous origin. However, there is a notable difference in the angiospermous record. In the Atanikerdluk sample betulaceous grains are practically absent, and their place is taken by tricolpate and tricolporate grains whose affinities, however, cannot be indicated. The gleichenioid spores also deserve attention as a component unknown in samples from the other localities. In view of the poorer material and the frequent difficulties of close determinations of the grains it seems hazardous to venture an interpretation of the noted differences. It is tempting, however, to see these differences as a reflection of the presumedly higher age of the beds concerned (Lower Paleocene as compared to late Paleocene or Eocene of Spitsbergen, based on paleozoological evidence), and of a climatic change in the Paleocene period.

PFLUG (1956) compared the microfossil contents of the Icelandic plant-bearing claystones from the Tröllatunga locality with the Spitsbergen microfossil record presented in the preliminary report by MANUM (1954). PFLUG entered the microfossil assemblages in a table according to natural affinities, and found considerable similarities in the composition of the two floras. PFLUG believed that the Normapolles category was represented by less ancient forms in Iceland than in Spitsbergen and regarded this to be a difference of some importance. On this ground he considered the Tröllatunga assemblage to be somewhat younger than that of the Paleocene-Eocene beds of Spitsbergen.

After having seen the Icelandic assemblage studied by PFLUG, I agree that there is great correspondance between the Icelandic and Spitsbergen assemblages concerning the plant families and genera represented. However, when the microfossils themselves are compared, and not only the more or less wide natural categories they may represent, it is seen that Iceland has fewer forms that are common to Spitsbergen than has any of the other localities. Further, when the relative proportions of the various components are considered, it is seen that in Iceland the two-winged grains are by far the most important. It is particularly remarkable that the two-winged grains consist almost entirely of a *Picea* form. Apparently identical grains are found both on Ellesmere Island and in Spitsbergen, but in relatively small numbers. The Spitsbergen sediments that are not coals usually contain rather large proportions of inaperturate grains, while two-winged grains never attain proportions of the Icelandic order. In the Icelandic samples triporate betulaceous grains make up a considerable but rather uniform constituent. The Normapolles category reported by PFLUG has been dealt with earlier (p. 108).

It is felt that the particular composition of the Icelandic microfossil assemblage has not resulted merely from a particular facies of the sediments, but that it reflects a flora which as a whole differed from the others studied. The Icelandic flora appears to be poorer than that of Spitsbergen and to have one pinaceous and a few betulaceous species as the dominant components. Thus it seems to differ from the Spitsbergen flora in a manner similar to that suggested for the Ellesmere Island flora, but somewhat more markedly. Provided the relative positions of Spitsbergen and Iceland to the North Pole were essentially the same as at present, the noted difference in the floras suggests a younger age for the

Icelandic one. It must be emphasized, however, that the ideas presented here concerning the Tröllatunga microfossils need verification based on more comprehensive material.

The macrofossils indicate that the floras of Ellesmere Island, Greenland, and Spitsbergen dealt with had certain wide-spread species in common. The most important and reliable are *Metasequoia occidentalis* and *Cercidiphyllum arcticum*, which occur in all three localities, *Torellia rigida*, which has not been recorded from Greenland, and *Sequoia langsdorfii* and *Nordenskiöldia borealis*, which have not been recorded from Ellesmere Island. None of these species have been recorded from the Icelandic deposits included in the present study. Pollen forms definitely referable to any of these macrofossils have not been found.

As can be seen from table II (p. 113) there are some pollen and spore forms which are common to two or more of the regions studied, but none that occur in all four of them. In all regions, however, there is a higher number of forms that do not occur in any of the others. The most divergent assemblages are those from Iceland and Greenland. When a comparison between the four regions is made on the basis of the plant families and genera indicated by the microfossils, it appears that, although the floras were not identical, they were to a considerable degree composed of plants related on the family and genus level.

Further localities

Alaska

The Alaskan Geology Branch of the U. S. Geological Survey generously provided me with samples of some Alaskan Lower Tertiary coals. The pollen and spores obtained from them are not appreciably better preserved than those from the Spitsbergen coals. As yet they have not been thoroughly studied. A provisional study, however, has revealed marked differences from the other microfossil assemblages dealt with herein.

A sample from the northernmost of the localities represented in the Alaska collection may be taken as an example, namely Eocene lignites from Nenana Coal Field in Healy River Valley of the Yukon Region (approx. 64° 30′ N. – 149° W. Gr.). Coniferous grains make a less prominent contribution than is usual in samples from the other regions, and the inaperturate forms appear particularly unimportant. On the other hand, triporate betulaceous grains make up a conspicuous proportion, and grains of the *Alnus* type are abundant. Furthermore, there are fair numbers of grains referable to *Ilex*, *Tilia*, and *Ulmus*, and also several juglandaceous forms. The microfossils seem to reflect a flora which lived under climatic conditions markedly more favourable than those of the other localities studied.

U. S. S. R.

I have not seen any microfossil assemblages from the Arctic or Subarctic territories, nor do I know of published investigations with which a comparison could be made. From the literature it appears that the extensive Russian activity in Tertiary palynology is concerned mainly with localities on more southern latitudes, particularly S. W. Siberia and adjacent areas (cp. ZAKLINSKAJA 1957).

Summary

The pollen and spore contents of Tertiary beds in Vestspitsbergen have been studied. According to paleozoological dating the age of the beds is late Paleocene to Eocene. No means for a more precise age determination has resulted from the present investigation, but the results are consistent with the previous dating.

The preservation of the microfossils varies, but in general it is poor. Samples from the coals, which are bituminous, generally yielded better results than the non-coals. Altogether 70 individual pollen and spore types are described (15 Sporites, 54 Pollenites, 1 uncertain); of these, 15 are new species and 4 are referred to, and 9 compared with, previously described species. Furthermore, 42 types, which because of the inadequacy of the specimens could not be referred to known species or to new ones, have been provisionally designated and described. The natural affinities of the pollen and spores have been indicated as far as possible and the results compared with the macrofossil flora as described in the works of several authors.

Fifteen types of spores have been distinguished, although macrofossil remains of archegoniate plants are few. The families represented by spores are Polypodiaceae (3 or 4 types), Osmundaceae (2 types), and Lycopodiaceae (1 or 2 types). One type suggests the presence of a member of the Schizaeaceae. Usually the individual types occur in small numbers, only two of them, possibly referable to mosses, being more numerous.

None of the pollen grains seen could be related to the *Ginkgoinae*, despite the fact that macrofossils have been referred to this class.

Macro- and microfossils of coniferous origins are very abundant. Among the macrofossils *Metasequoia occidentalis* is particularly abundant, while other Taxodiaceae are either rare (*Sequoia*, *Taiwania*) or doubtful (*Glyptostrobus*). A few cupressaceous macrofossils are unsuitable for closer identification. Inaperturate pollen grains of a taxodiaceous-cupressaceous type are abundant and in some samples outnumber other coniferous grains. Papillate grains of *Metasequoia* type however, are extremely few, and the *Sequoia* type has not been seen. *Sciadopitys* pollen occurs in most samples, indicating the presence of a species of that genus in the flora. Macrofossil remains of *Sciadopitys* have not been recorded. Macrofossils of the Pinaceae are sparse and generally inadequate for generic reference. However, two-winged pinaceous pollen occurs regularly although usually in no very large numbers, indicating the presence of pinaceous forests somewhat away from the sedimentary basins. The pollen shows that the flora contained a more important element of evergreen conifers than what has been inferred from the macrofossils alone. The pollen indicates that *Pinus* was represented with at least two species in the forests around the sedimentary basins, and that one species of *Picea* was also present. Grains referable to *Abies* are so few that a rather distant origin is suggested for them. The pollen affords evidence of the presence of a species of *Tsuga* at the time when the deposits at Forlandsundet were laid down; *Tsuga* pollen has not been recovered from the beds of the main Tertiary basin.

Of the angiospermous macrofossils *Cercidiphyllum arcticum* is the most abundant and conspicuous. *C. crenatum* is less common. However, pollen referable to *Cercidiphyllum* has not been recovered. Triporate betulaceous pollen is abundant. *Betula* itself appears to be represented by at least three species against two among the macrofossils. *Alnus* pollen occurs in small amounts, three types being referable to the genus, whereas a single macrofossil species has been described. The occurrence of *Corylus* has not been positively demonstrated. *Myrica* is possibly represented by one common triporate pollen type. The relation between the numbers of *Alnus* grains and triporate ones in the samples indicates that members of *Alnus* were relatively less abundant in the vegetation in, and around, the former swamps than representatives of the Betulaceae and probably the Myricaceae. Five types of pollen tetrads indicate the presence of several ericalean species. Another distinct tetrad type is related to the Droseraceae. Six pollen types of unknown affinities are referred to *Trudopollis*. Some of these types occur in large numbers in certain samples, indicating that the parent plants were important constituents of the flora. There is no positive evidence of the presence of members of the Fagaceae and the Juglandaceae, nor of *Tilia*.

Fossil records of monocotyledons are poor, and most of the large number of described macrofossil species are doubtful. However, the somewhat inconclusive macrofossil record of *Potamogeton* is supported by pollen finds. Furthermore, two pollen types suggest typhaceous or sparganiaceous origins. Palms have not been found.

This investigation confirms the statement by HEER (1868) that the plant fossils indicate a temperate climate, and gives no reason to believe that it was more than moderately temperate.

A few Lower Tertiary samples from Ellesmere Island (Stenkulfjorden), Greenland (Atanikerdluk), and Iceland (Brjánslækur; Tröllatunga) have also been studied and the results compared with those obtained from the Spitsbergen material. The preponderance of coniferous pollen is recorded as a common feature for all these localities, and among such grains the inaperturate ones are usually the most abundant. As in the Spitsbergen material there is a remarkable scarcity of papillate grains of the *Metasequoia* or *Sequoia* type, despite the fact that macrofossil *Metasequoia* is abundant, except in Iceland from where it has not been recorded. The occurrence of two-winged pinaceous grains shows that evergreen conifers were more prominent members of these floras than is indicated by coniferous macrofossils alone, among which the deciduous *Metasequoia* is dominant and the Pinaceae sparsely represented. Of the Pinaceae *Pinus* is the best represented genus both quantitatively and with regard to the number of individual pollen types, only in Iceland does *Picea* pollen dominate, and there the inaperturate grains are few. *Sciadopitys* pollen has been recovered from all the regions, indicating that the genus was widely distributed over the Arctic and Subarctic in Lower Tertiary times, although macrofossil records of it are lacking. Whether more than one species was represented cannot be definitely stated.

Triporate grains form a characteristic component of the assemblages except in the one from Greenland in which they are remarkably poorly represented. Usually the number of triporate grains is comparable to that of two-winged ones. *Betula* pollen occurs regularly among them. The sparseness of *Alnus* pollen indicates that this genus, if present, played only a minor part in the vegetation of the original swamps.

A tricolpate form possibly representing a species of the Hamamelidaceae or Platanaceae is widely distributed. Grains referable to *Trudopollis* were not recovered from Iceland and Ellesmere Island, and only a few examples were found in the Greenland material. Furthermore, very few tricolporate grains occur, except in the Greenland material in which they are relatively common; their affinities are not known. Grains representing the Juglandaceae are extremely rare and probably came from rather distant sources. Spores of members of the Osmundaceae occur in all the assemblages.

Although the Lower Tertiary floras of Ellesmere Island, Greenland, Iceland, and Spitsbergen were not identical, they were to a considerable degree composed of the same families and genera.

Bibliography

(Abbreviations according to the World List of Scientific Periodicals.
Third edition. London 1952.)

ÅSKELSSON, J., 1947: Er hin smásæja Flóra surtarbrandslaganna vænleg til könnunar? – *Skýrs. Menntask. Reykjavík.* **1945–1946.** 45–57. 2 pls. Reykjavík.

— 1954: Myndir úr jardfrædi Íslands II. Fáeinar plöntur úr surtarbrandslögunum hjá Brjánslæk. – *Náttúrufrædingurinn.* **24.** 92–96. 4 pls. Reykjavík.

— 1956: Idem, IV. Fáeinar plöntur úr surtarbrandslögunum. – *Idem.* **26.** 44–48. 2 pls,

BERRY, E. W., 1922: A possible explanation of Upper Eocene climates. – *Proc. Amer. Phil. Soc.* **61.** 1–4. Philadelphia.

— 1930: The past climate of the North Polar region. – *Smithson. Misc. Coll.* **82** (7). 29 pp. Washington.

BOLCHOVITINA, N. A., 1953: Sporovo-pyl'cevaja charakteristika melovych otloženij central'nych oblastej SSSR. – *Trud. Inst. Geol. Nauk, Akad. Nauk SSSR.* **145.** 184 pp. 16 pls. Moskva.

BOSE, M. N., 1955: Sciadopitytes variabilis n. sp. from the Arctic of Canada. – *Norsk Geol. Tidsskr.* **35.** 53–68. 1 pl. Bergen.

BROWN, R. W., 1939: Fossil leaves, fruits, and seeds of Cercidiphyllum. – *J. Paleont.* **13.** 485–499. 6 pls. Tulsa.

CHANEY, R. W., 1940: Tertiary forests and continental history. – *Bull. Geol. Soc. Amer.* **51.** 469–488. 2 pls. New York.

— 1948: The bearing of the living Metasequoia on problems of Tertiary paleobotany. – *Proc. Nat. Acad. Sci.* **34.** 503–515. Washington.

— 1951: A revision of fossil Sequoia and Taxodium in Western North America based on the recent discovery of Metasequoia. – *Trans. Amer. Phil. Soc.* New Ser. **40.** 171–264. 12 pls. Philadelphia.

COOKSON, I. C., 1947: Plant microfossils from the lignites of Kerguelen Archipalego. – *B.A.N.Z. Antarctic Res. Exped. 1929–1931, Rep.* Ser. A. **2.** 127–142. 5 pls. Adelaide.

COUPER, R. A., 1953: Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand. – *Paleont. Bull. N. Z. Geol. Surv.* **22.** 77 pp. 9 pls. Wellington.

DELCOURT, A., & G. SPRUMONT, 1955: Les spores et grains de pollen du Wealdien du Hainaut. – *Mém. Soc. Belge Géol.* Nouv. Ser. 4°. **5.** 73 pp. 4 pls. Bruxelles.

ERDTMAN, G., 1957: Pollen and spore morphology/plant taxonomy. Gymnospermae, Pteridophyta, Bryophyta. – 151 pp. 5 pls. Stockholm.

FLORIN, R., 1936: Die fossilen Ginkgophyten von Franz-Joseph-Land nebst Erörterungen über vermeintliche Cordaitales mesozoischen Alters. I. Spezieller Teil. – *Palaeontographica.* **81 B.** 71–173. 32 pls. Stuttgart.

FUCHS, TH., 1883: Ueber die während der schwedischen geologischen Expedition nach Spitzbergen im Jahre 1882 gesammelten Tertiärconchylien. – *K. Svenska VetenskAkad. Handl. Bihang.* **8** (15). Stockholm.

FÆGRI, K., 1956: Recent trends in palynology. – *Bot. Rev.* **22.** 639–664. Lancaster, Pa.

GOTHAN, W., 1910: Die fossilen Holzreste von Spitzbergen. – *K. Svenska VetenskAkad. Handl.* **45** (8). 55 pp. 7 pls. Stockholm.

HAMMEN, T. VAN DER, 1956: A palynological systematic nomenclature. – *Bol. Geol.* **4.** 63–101. 12 pls. Bogotá.

Heer, O., 1868: Flora fossilis arctica I. Die fossile Flora der Polarländer enthaltend die in Nordgrönland, auf der Melville-Insel, im Banksland, am Mackenzie, in Island und in Spitzbergen entdeckten fossilen Pflanzen. – 192 pp. 50 pls. Zürich.

— 1870: Idem, II (3). Die miocene Flora und Fauna Spitzbergens. – *K. Svenska Vetensk-Akad. Handl.* **8** (7). 98 pp. 16 pls. Stockholm.

— 1876: Idem, IV (1). Beiträge zur fossilen Flora Spitzbergens. –*Idem.* **14** (5). 141 pp. 32 pls.

— 1878: Idem, V (1). Die miocene Flora des Grinell-Landes. – 38 pp. 9 pls. Zürich.

Hollick, A., 1936: The Tertiary floras of Alaska. – *Prof. Pap. U. S. Geol. Surv.* **182.** 185 pp. 122 pls. Washington.

Horn, G., 1928: Beiträge zur Kenntnis der Kohle von Svalbard (Spitzbergen und der Bäreninsel). – *Skr. Svalb. og Ishavet.* **17.** 60 pp. 5 pls. Oslo.

Ibrahim, A. C., 1933: Sporenformen des Aegirhorizonts des Ruhr–reviers. – *Diss. Tech. Hochschule Berl.* 48 pp. 8 pls. Berlin.

Ingwersen, P., 1954: Some microfossils from Danish Late-Tertiary lignites. – *Danm. Geol. Unders.* II Række. **80.** 31–64. 4 pls. København.

International code of botanical nomenclature adopted by the eighth international botanical congress, Paris, July 1954. – Utrecht 1956.

Iversen, J., & J. Troels-Smith, 1950: Pollenmorphologische Definitionen und Typen. – *Danm. Geol. Unders.* IV Række. **3** (8). 27–54. 16 pls. København.

Kirchheimer, F., 1934: Über Tsuga-pollen aus dem Tertiär. – *Planta.* **22.** 171–179. Berlin.

— 1950: Das Vorkommen von Sciadopitys im mitteleuropäischen Tertiär und die Bedeutung ihres Pollens für die Stratigraphie der Braunkohlenschichten. – *Neues Jb. Geol. Monatsh.* **1950.** 59–64. Stuttgart.

Knox, E. M., 1950: The spores of Lycopodium, Phylloglossum, Selaginella and Isoetes, and their value in the study of microfossils of Paleozoic age. – *Trans. Bot. Soc. Edinb.* **35.** 209–357. 12 pls. Edinburgh.

Koch, B. E., 1955: Geological observations on the Tertiary sequence of the area around Atanikerdluk, West Greenland. – *Medd. Grønland.* **135** (5). 50 pp. 1 pl. 1 map. København.

— 1959: Contribution to the stratigraphy of the non-marine Tertiary deposits on the South coast of the Nûgssuaq Peninsula Northwest Greenland. – *Idem.* **162** (1). 100 pp. 4 pls. 3 maps.

Kremp, G., 1949: Pollenanalytische Untersuchung des miozänen Braunkohlenlagers von Konin an der Warthe. – *Palaeontographica.* **90 B.** 53–93. 7 pls. Stuttgart.

— , H. T. Ames & N. O. Frederiksen, 1959: The organ-species concept and the International code of botanical nomenclature. – *Taxon.* **8.** 91–95. Utrecht.

Krutzsch, W., 1954: Bemerkungen zur Benennung und Klassifikation fossiler (insbesondere tertiärer) Pollen und Sporen. – *Z. Geol.* **3.** 258–311. Berlin.

— 1957: Sporen- und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung. – *Z. angew. Geol.* **1957.** 509–548. 16 pls. Berlin.

— 1959: Mikropaläontologische (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. I. Die Sporen und die sporenartigen sowie ehemals im Geiseltal zu Sporites gestellten Formeinheiten der Sporae dispersae der mitteleozänen Braunkohle des mittleren Geiseltales (Tagebau Neumark-West i. w. S.) unter Berücksichtigung und Revision weiterer Sporenformen aus der bisherigen Literatur. – *Z. Geol. Beih.* **21–22.** 425 pp. 49 pls. Berlin.

Kuprianova, L. A., 1959: O vidovych opredelenijach pyl'cy iz tretičnych otloženij. (On the determination of the species on pollen grains from Tertiary deposits. – Engl. summary). – *Problemy Botaniki* [publ. Akad. Nauk SSSR]. **4.** 129–140. 2 pls. Moskva.

LaMotte, R. S., 1952: Catalogue of the Cenozoic plants of North America through 1950. – *Mem. Geol. Soc. Amer.* **51.** 381 pp. Washington.

Manum, S., 1954: Pollen og sporer i tertiære kull fra Vestspitsbergen (Pollen and spores in Tertiary coal from West Spitsbergen. – Engl. summary). – *Medd. Norsk Polarinst.* **79** (repr. from *Blyttia.* **12.** 1–10). 2 pls. Oslo.

— 1956: Schulzes maserasjonsblanding. Et hundreårs-minne (Schulze's macerating solution. A centenary. – Engl. summary). – *Blyttia.* **14.** 126–130. Oslo.

MANUM, S., 1960 a: On the genus Pityosporites Seward 1914. With a new description of Pityosporites antarcticus Seward. - *Nytt. Mag. Bot.* **8.** 11–15. 1 pl. Oslo.

— 1960 b: Some dinoflagellates and hystrichosphaerids from the Lower Tertiary of Spitsbergen. - *Medd. Norsk Polarinst.* **85** (repr. from *Nytt Mag. Bot.* **8.** 17–26). 1 pl. Oslo.

NAGEL, K., 1915: Juglandaceae. - *Fossilium Catalogus II,* **6.** 87 pp. Berlin.

NATHORST, A. G., 1910: Beiträge zur Geologie der Bären-Insel, Spitzbergens und des König-Karl-Landes. - *Bull. Geol. Instn. Univ. Upsala.* **10.** 261–416. 2 maps. Uppsala.

— 1915: Tertiäre Pflanzenreste aus Ellesmere-Land. - *Rep. 2 Norw. Arctic Exped. "Fram" 1898–1902.* **35.** [publ. Vidensk. Selsk., Kristiania]. 16 pp. 2 pls. Kristiania.

— 1919: Ginkgo adiantoides (Unger) Heer im Tertiär Spitzbergens nebst einer kurzen Übersicht der übrigen fossilen Ginkgophyten desselben Landes. - *Geol. Fören. Stockh. Förh.* **41.** 234–248. Stockholm.

NAUMOVA, S. N., 1939: Spores and pollen of the coals of the U.S.S.R. - *Int. Geol. Congr., Rep. XVII Sess. U.S.S.R. 1937.* **1.** 353–364. 1 pl. Moskva.

ORVIN, A. K., 1934: Geology of the Kings Bay region, Spitsbergen. - *Skr. Svalb. og Ishavet.* **57.** 196 pp. 3 pls. 4 maps. Oslo.

— 1940: Outline of the geological history of Spitsbergen. - *Idem.* **78.** 58 pp. 3 pls. 1 map.

PFLUG, H. D., 1953: Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte. - *Palaeontographica.* **95 B.** 60–171. 11 pls. Stuttgart.

— 1956: Beiträge zur Klimageschichte Islands, II. Sporen und Pollen von Tröllatunga (Island) und ihre Stellung zu den pollenstratigraphischen Bildern Mitteleuropas. - *Neues Jb. Geol. Abh.* **102.** 409–430. 3 pls. Stuttgart.

— 1959: Idem. VIII. Sporenbilder aus Island und ihre stratigraphische Deutung. - *Idem.* **107.** 141–172. 5 pls.

POTONIÉ, R., 1931 a: Zur Mikroskopie der Braunkohlen. Tertiäre Blütenstaubformen. - *Braunkohle.* **1931.** 325–333. Halle (Saale).

— 1931 b: Pollenformen aus tertiären Braunkohlen. - *Jb. Preuss. Geol. Landesanst.* **52.** 1–7. Berlin.

— 1931 c: Pollenformen der miocänen Braunkohle. (2. Mitteilung). - *S. B. Ges. Naturf. Fr. Berl.* **1931.** 24–26. 2 pls. Berlin.

— 1931 d: Zur Mikroskopie der Braunkohle. Tertiäre Sporen- und Blütenstaubformen. (Vierte Mitteilung). - *Braunkohle.* **1931.** 554–556. Halle (Saale).

— 1934: Zur Mikrobotanik des eocänen Humodils des Geiseltals. - *Arb. Inst. Paläobot. Berl.* **4.** 25–125. 6 pls. Berlin.

— 1951: Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs. - *Palaeontographica.* **91 B.** 131–151. 2 pls. Stuttgart.

— 1956 a: Die Behandlung der Sporae dispersae und der fossilen Pflanzen überhaupt nach dem Internationalen Code der Botanischen Nomenklatur. - *Paläont. Z.* **30.** 69–87. Stuttgart.

— 1956 b: Synopsis der Gattungen der Sporae dispersae. I. Teil. - *Geol. Jb. Beih.* **23.** 103 pp. 11 pls. Hannover.

— 1958: Idem. II. Teil. - *Idem.* **31.** 114 pp. 11 pls.

— 1960: Idem. III. Teil. - *Idem.* **39.** 189 pp. 9 pls.

— , & J. GELLETICH, 1933: Ueber Pteridophyten-Sporen einer eocänen Braunkohle aus Dorog in Ungarn. - *S. B. Ges. Naturf. Fr. Berl.* **1933.** 517–528. 2 pls. Berlin.

— , & W. KLAUS, 1954: Einige Sporengattungen des alpinen Salzgebirges. - *Geol. Jb.* **68.** 517–546. 1 pl. Hannover/Celle.

— , & G. KREMP, 1954: Die Gattungen der paläozoischen Sporae dispersae und ihre Stratigraphie. - *Idem.* **69.** 111–194. 17 pls.

— , & — 1955: Die Sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte. Teil I. - *Palaeontographica.* **98 B.** 1–136. 16 pls. Stuttgart.

— , & — 1956: Idem. Teil II. - *Idem.* **99 B.** 85–191. 6 pls.

— , P. W. THOMSON & F. THIERGART, 1950: Zur Nomenklatur und Klassifikation der neogenen Sporomorphae (Pollen und Sporen). - *Geol. Jb.* **65.** 35–70. 3 pls. Hannover/Celle.

POTONIÉ, R., & H. VENITZ, 1934: Zur Mikrobotanik des miocänen Humodils der niederrheinischen Bucht. – *Arb. Inst. Paläobot. Berl.* **5.** 5–54. 4 pls. Berlin.

RAATZ, G. V., 1937: Mikrobotanisch-stratigraphische Untersuchung der Braunkohle des Muskauer Bogens. – *Abh. Preuss. Geol. Landesanst.* Neue Folge. **183.** 48 pp. 1 pl. Berlin.

RAVN, J. P. J., 1922: On the Mollusca of the Tertiary of Spitsbergen. – *Result. Norske Spitsbergeneksped.* **1** (2). 28 pp. 2 pls. Kristiania.

RENAULT, M. B., 1900: Plantes fossiles Miocènes d'Advent-Bay (Spitzberg). – *Bull. Mus. Hist. Nat., Paris.* **6.** 320–322. Paris.

ROSS, N.-E., 1949: On a Cretaceous pollen and spore bearing clay deposit of Scania. A preliminary report. – *Bull. Geol. Instn. Univ. Upsala,* **34.** 25–43. 3 pls. Uppsala.

RUDOLPH, K., 1935: Mikrofloristische Untersuchung tertiärer Ablagerungen im nördlichen Böhmen. – *Bot. Centralbl. Beih.* **54.** 244–328. 5 pls. Dresden.

SCHLOEMER-JÄGER, A., 1958: Alttertiäre Pflanzen aus Flözen der Brögger-Halbinsel Spitzbergens. – *Palaeontographica.* **104 B.** 39–103. 9 pls. Stuttgart.

SCHWARTZBACH, M., 1947: Klima und Klimagürtel im Alttertiär. – *Naturwissenschaften.* **33.** 353–361. Berlin/Göttingen.

— 1956: Beiträge zur Klimageschichte Islands. I. Allgemeiner Überblick der Klimageschichte Islands. – *Neues Jb. Geol. Monatsh.* **1955.** 97–130. Stuttgart.

— , & H. D. PFLUG, 1957: Idem. VI. Das Klima des jüngeren Tertiärs in Island. – *Idem. Abh.* **104.** 279–298. 1 pl.

SEWARD, A. C., 1914: Antarctic fossil plants. – *Brit. Antarctic (Terra Nova) exped. 1910. Nat. hist. rep. Geol.* **I.** 1–49. 8 pls. London.

— , & V. M. CONWAY, 1935: Fossil plants from Kingigtok and Kagdlunguak, West Greenland. – *Medd. Grønland.* **93** (5). 41 pp. 5 pls. København.

SIMPSON, J. B., 1949: Fossil pollen of Metasequoia type. – *Nature.* **163.** 771. London.

SOHMA, K., 1958: Palynological studies on a peaty lignite and a peat from the environs of Nagoya. – *Ecol. Rev.* **14.** 289–290.

THIERGART, F., 1938: Die Pollenflora der Niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Senftenberg. – *Jb. Preuss. Geol. Landesanst.* **58.** 282–351. 9 pls. Berlin.

— 1940: Die Mikropaläontologie als Pollenanalyse im Dienst der Braunkohlenforschung. – *Schr. Brennstoffgeol.* **13.** 82 pp. 14 pls. Stuttgart.

— 1949: Die Sciadopityszone und der Sciadopitys–Vorstoss in der niederrheinischen Braunkohle. – *Braunkohle, Wärme u. Energie.* **1949.** 153–156. Düsseldorf.

THOMSON, P. W., 1950: Grundsätzliches zur tertiären Pollen- und Sporenmikrostratigraphie auf Grund einer Untersuchung des Hauptflözes der rheinischen Braunkohle in Liblar, Neurath, Fortuna und Brühl. – *Geol. Jb.* **65.** 113–126. Hannover/Celle.

— , & H. PFLUG, 1953: Pollen und Sporen des mitteleuropäischen Tertiärs. – *Palaeontographica.* **94 B.** 1–138. 15 pls. Stuttgart.

THORSTEINSSON, R., & E. T. TOZER, 1957: Geological investigations in Ellesmere and Axel Heiberg Islands, 1956. – *Arctic.* **10.** 3–31. Montreal.

TRAVERSE, A., 1955: Pollen analysis of the Brandon lignite of Vermont. – *Rep. Invest. U.S. Bur. Min.* **5151.** 107 pp. 6 pls. Washington.

— 1957: The nomenclatural problem of plant microfossil species belonging to extant genera. – *Micropaleontology.* **3.** 255–258. New York.

TROELSEN, J. C., 1950: Contributions to the geology of Northwest Greenland, Ellesmere Island and Axel Heiberg Island. – *Medd. Grønland.* **149** (7). 86 pp. 1 map. København.

WEYLAND, H., & W. KRIEGER, 1953: Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung für die Charakterisierung des mittleren Senons. – *Palaeontographica.* **95 B.** 6–29. 5 pls. Stuttgart.

WINDISCH, P., 1886: Beiträge zur Kenntniss der Tertiärflora von Island. – *Z. Naturw.* **59.** 215–262. Leipzig.

WODEHOUSE, R. P., 1933: Tertiary Pollen – II. The oil shales of the Green River formation. – *Bull. Torrey Bot. Cl.* **60.** 479–524. New York.

WOLFF, H., 1934: Mikrofossilien des pliocänen Humodils der Grube Freigericht bei Dettingen a. M. und Vergleich mit älteren Schichten des Tertiärs sowie posttertiären Ablagerungen. – *Arb. Inst. Paläobot. Berl.* **5.** 55–86. 1 pl. Berlin.

YAMAZAKI, T., & M. TAKEOKA, 1956: On the identifications of the pollen of Taxodiaceae. – *Sci. Rep. Saikyo Univ. Agr.* **8.** 10–16. Saikyo.

ZAKLINSKAJA, E. D., 1953: Opisanie nekotorych vidov pyl'cy i spor, vydelennych iz tretičnych otloženij Pasekovskogo kar'era Voronežskoj oblasti. – *Trud. Inst. Geol. Nauk, Akad. Nauk SSSR.* **142.** 60–115. 6 pls. Moskva.

— 1957: Stratigrafičeskoe značenie sporovo-pyl'cevych spektrov kajnozojskich otloženij. – *Trud. Komissii po Izučeniju Četvertičnogo Perioda.* **13.** 124–130. Moskva.

— 1958: Tipy sporovo-pyl'cevych spektrov paleogenovych otloženij različnych fiziko-geografičeskich provincij. – *Materialy po Istorii Flory i Rastitel'nosti SSSR.* **3.** 42–61. Moskva.

— 1960: O značenii pyl'cy pokrytosemjannych rastenij dlja stratigrafii verchnego mela i paleogena. – *Dokl. Akad. Nauk SSSR.* **133.** 431–434. Moskva.

Index

The index includes entries in the text only, not in lists and tables. Names of systematic categories used in the adjective form in the text have not been entered in the index, but the concerned references are included under the respective names (e. g. betulaceous under Betulaceae). Names of new species are interspaced, synonyms are printed in *italics*.

PLATES

Explanation of plates

All photographs were made on 35 mm panchromatic film and subsequently enlarged to give a magnification of 1000 diameters. Plates with magnification of 750 diameters were reduced in reproduction. Oil immersion lenses have been used, with numerical apertures 1.30, and 1.0 for the largest objects.

The slides are kept in the collections of Universitetets Paleontologiske Museum, Oslo, under the common number PAP 3. One series of slides marked by an S. before the slide numbers comprises single grain preparations. For specimens in ordinary preparations mechanical stage coordinates are given, referring to microscope No. 328 883 by Carl Zeiss, Jena, stage No. 77 461. The microscope belongs to Universitetet i Oslo, Farmasøytisk Institutt.

Sample localities of the figured specimens from Spitsbergen are indicated according to the list pp. 10–11.

The photographs for the plates were taken by MANUM; the blocks were made by A/S Cliché, Oslo.

PLATE I

Spitsbergen. ×1000

Fig. 1. *Laevigatosporites haardti* (POT. & VEN.) TH. & PF. – S. 75 (U 5). – P. 21.

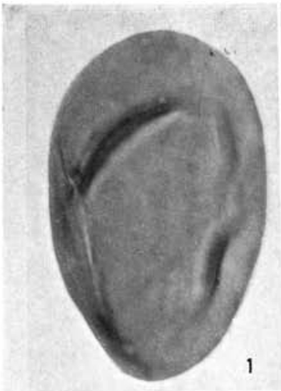
Figs. 2–4. *Polypodiisporites* cf. *favus* Pot., Type A. – Figs. 2, 3. 32: 3.9–84.4 (S 4, upper 100 cm), two different foci. – Fig. 4. 20: 11.6–88.9 (S 2). – P. 21.

Figs. 5–7. *Polypodiisporites* cf. *favus* Pot., Type B. – Figs. 5, 6. 59: 9.7–79.3 (L 2, roof), two different foci. – Fig. 7. 28: 11.7–87.8 (S 2). – P. 21.

Figs. 8, 9. *Baculatisporites* cf. *gemmatus* KRUTZSCH. – Fig. 8. S. 41 (L 3, 36 m). – Fig. 9. 16: 12.0–86.4 (U 5). – P. 22.

Figs. 10, 11. *Cicatricosisporites* cf. *cicatricosoides* KRUTZSCH. – 18: 7.0–77.0 (L 2, average), two different foci – P. 22.

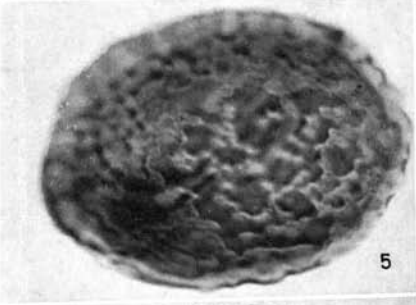
Plate I

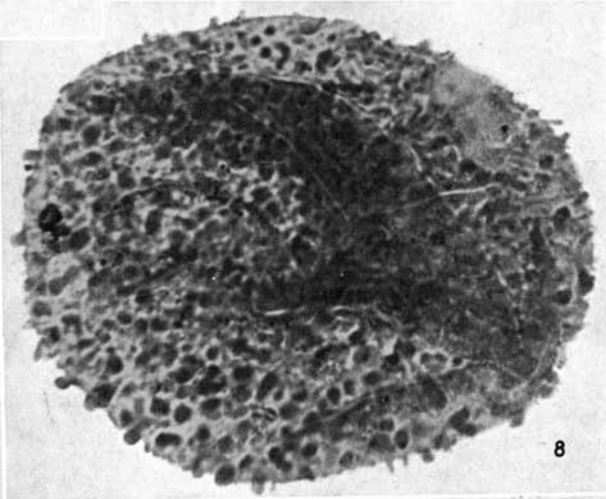

1

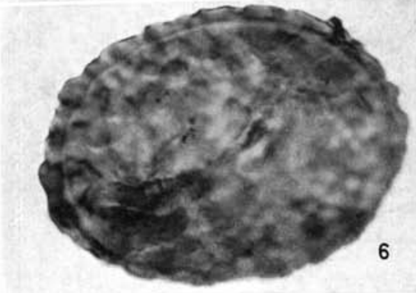

2

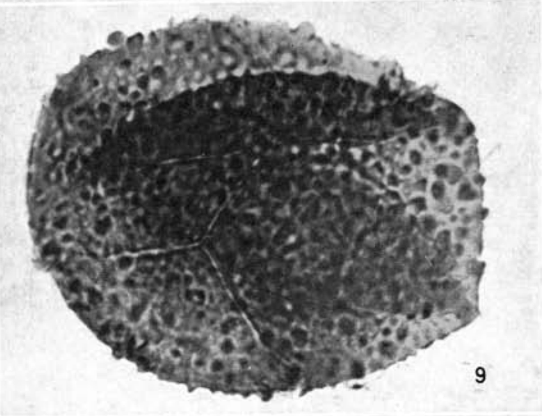

3


4

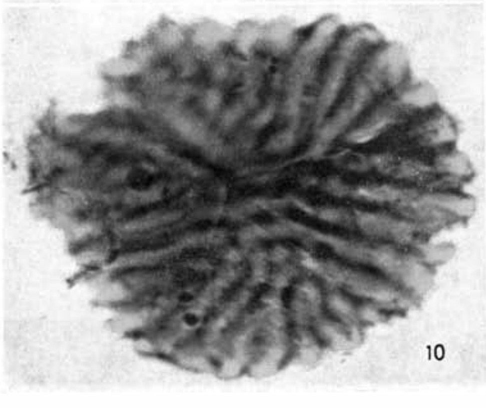

5


8


6


9


7


10

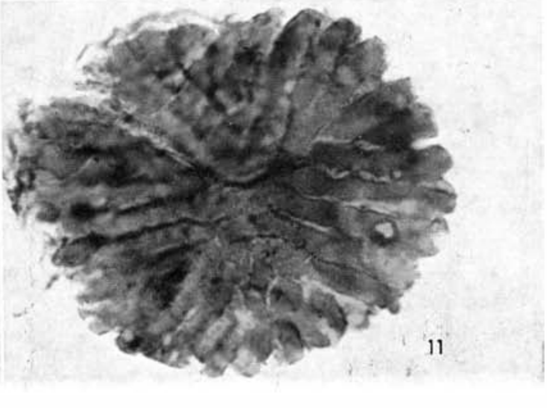

11

PLATE II

Spitsbergen. ×1000

Figs. 1, 2. *Leiotriletes* cf. *adriennis* (POT. & GELL.) KRUTZSCH. – Fig. 1. 17: 5.3–87.1 (U 5). – Fig. 2. S. 30 (L 3, 36 m). – P. 23.

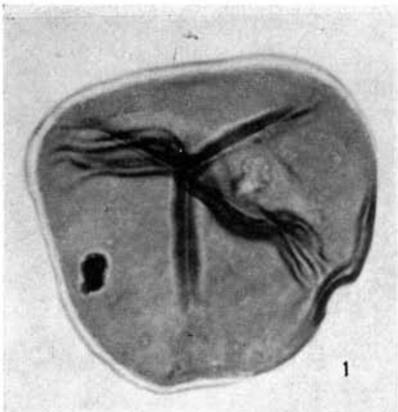
Fig. 3. *Stereisporites psilatus* (ROSS) PF. – 1: 7.0–78.2 (L 1). – P. 26.

Figs. 4–7. *Reticulatisporites incomptus* n. sp. – Figs. 4–6. Holotype, 33: 11.8–89.7 (S 4, upper 100 cm), three successive foci. – Fig. 7. 47: 13.5–75.7 (S 4, lower 34 cm). – P. 24.

Figs. 8, 9. *Reticulatisporites* sp. – S. 136 (L 2, 24–28 cm below roof), two different foci. – P. 25.

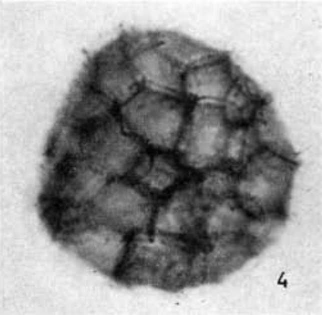
Figs. 10, 11. *Rugulatisporites* cf. *quintus* TH. & PF. – Fig. 10. 22: 11.6–86.5 (U 5). – Fig. 11. 22: 9.3–84.5 (do.). – P. 26.

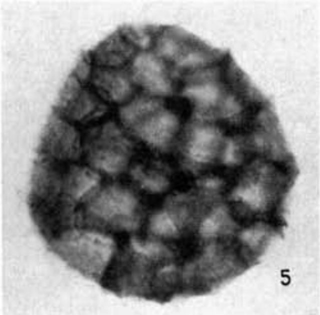
Plate II

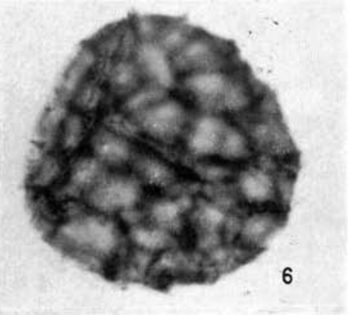

1

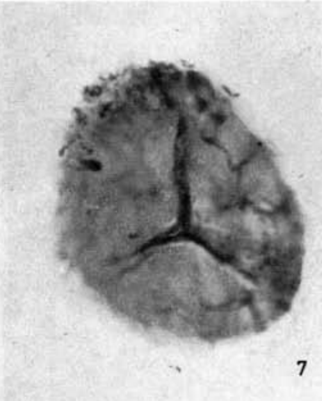

2

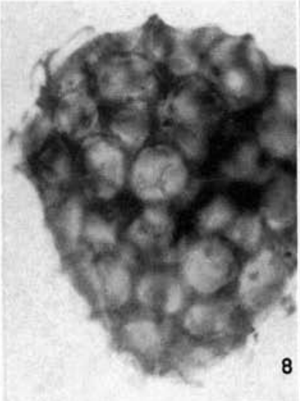

3

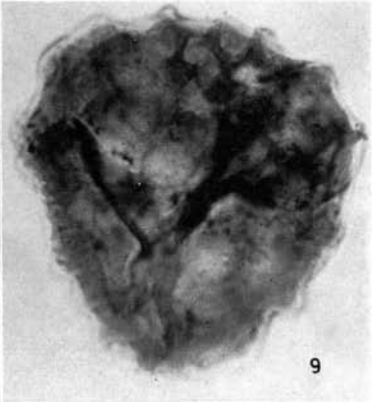

4

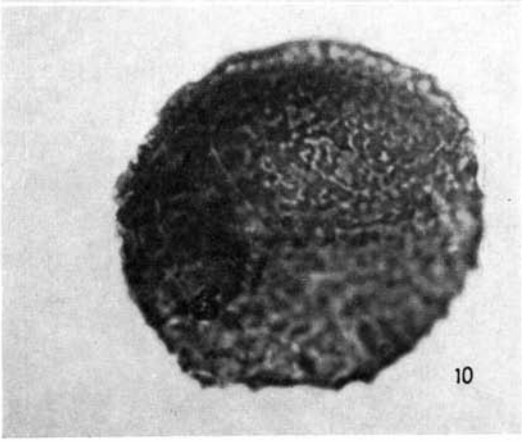

5


6


7


8


9


10

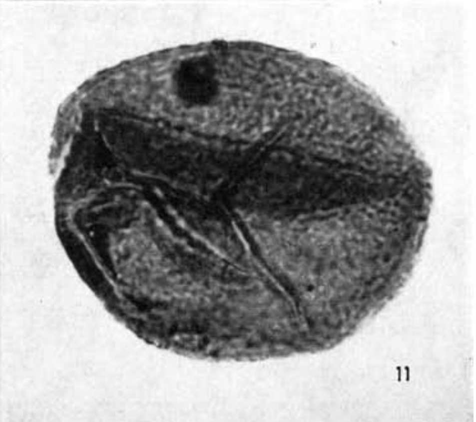

11

PLATE III

Spitsbergen. × 1000

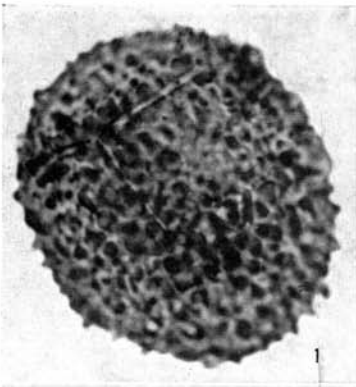
Figs. 1–4. *Verrucosisporites opimus* n. sp. – Figs. 1, 2. Holotype, 22: 19.3–74.9 (U 5), two different foci. – Fig. 3. S. 38 (U 5). – Fig. 4. 16: 5,1–88.5 (U 5). – P. 27.

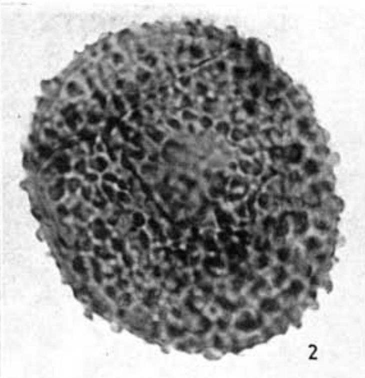
Figs. 5, 6. *Verrucosisporites pulvinulatoides* n. sp. – Fig. 5. Holotype, 65: 15.6–91.7 (L 2, 7–11 cm below roof). – Fig. 6. 65: 16.5–89.3 (do.) – P. 28.

Figs. 7–10. *Verrucosisporites pulvinulatus* n. sp. – Figs. 7, 8. Holotype, 14: 6.7–80.1 (L 2, average), two different foci. – Figs. 9, 10. 14: 8.4–81.1 (do.), do. – P. 27.

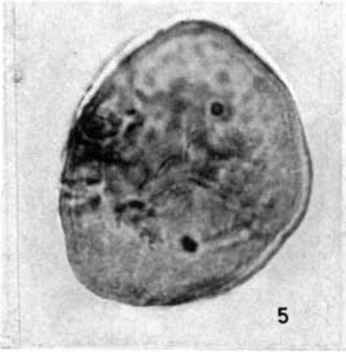
Figs. 11–13. *Verrucosisporites septentrionalis* n. sp. – Figs. 11, 12. Holotype, 22: 19.5–81.1 (U 5), two different foci. – Fig. 13. S. 176 (Sarsbukta). – P. 28.

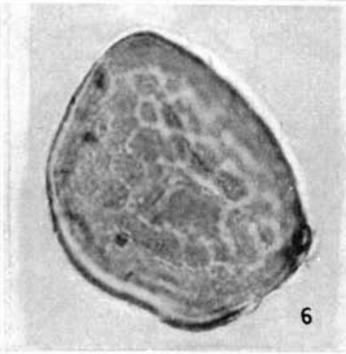
Plate III


1

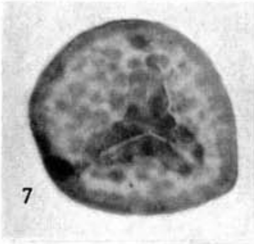

2

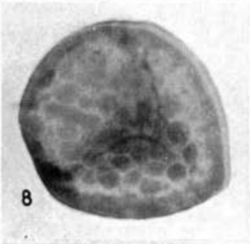

3

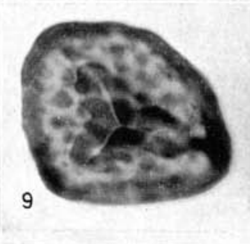

5

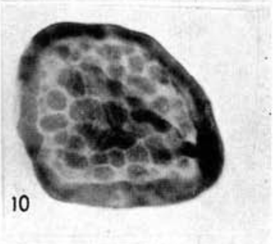

6


4


7


8


9


10


11


12

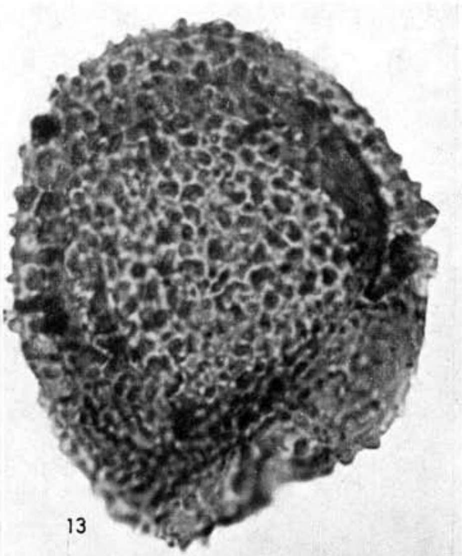

13

PLATE IV

Spitsbergen. ×1000

Figs. 1–4. *Ericipites* sp., Type A. – Fig. 1. S. 84 (L 2, average). – Fig. 2. 25: 14.7–73.2 (do.). – Fig. 3. 15: 13.5–77.6 (do.). – Fig. 4. S. 196 (Sarsbukta). – P. 29.

Figs. 5, 6. *Ericipites* sp., Type B. – Fig. 5. 25: 7.1–75.4 (L 2, average). – Fig. 6. 25: 18.0–80.7 (do.). – P. 29.

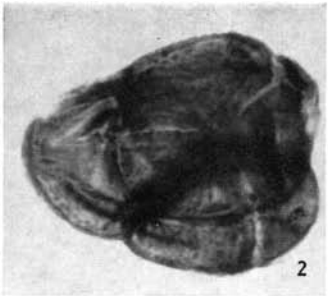
Figs. 7–10. *Ericipites* sp., Type C. – Fig. 7. 25: 14.0–85.9 (L 2, average). – Fig. 8. 14: 15.2–77.4 (do.). – Figs. 9, 10. S. 82 (do.), two different foci. – P. 29.

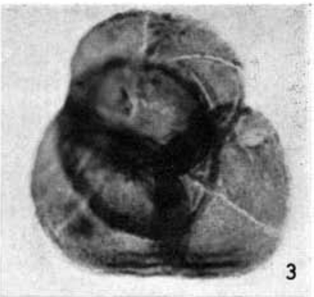
Fig. 11. *Ericipites* sp., Type D. – 25: 8.9–76.5 (L 2, average). – P. 30.

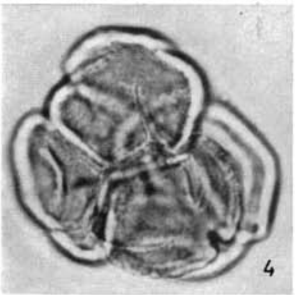
Figs. 12–14. *Ericipites* sp., Type E. – 32: 8.5–84.5 (S 4, upper 100 cm), three successive foci. – P. 30.

Plate IV

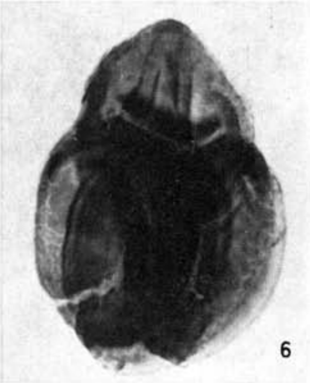

1

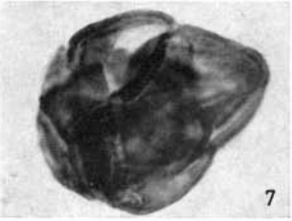

2

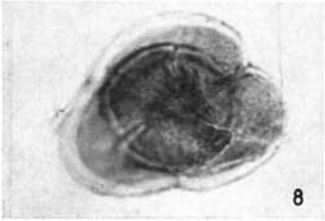

3

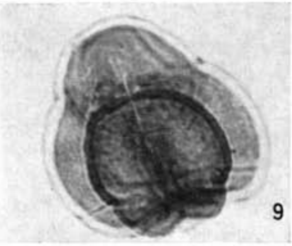

4

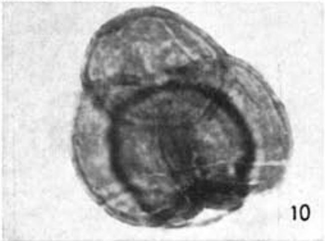

5


6

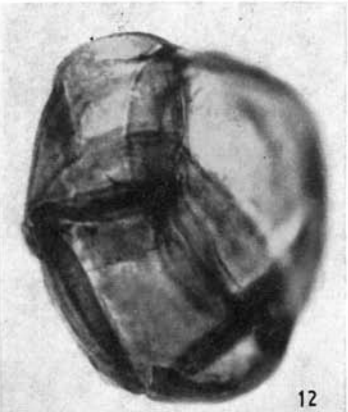

7

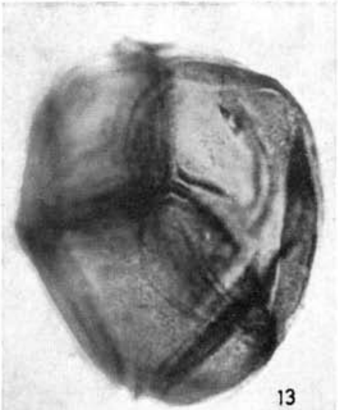

8


9


10


11


12


13


14

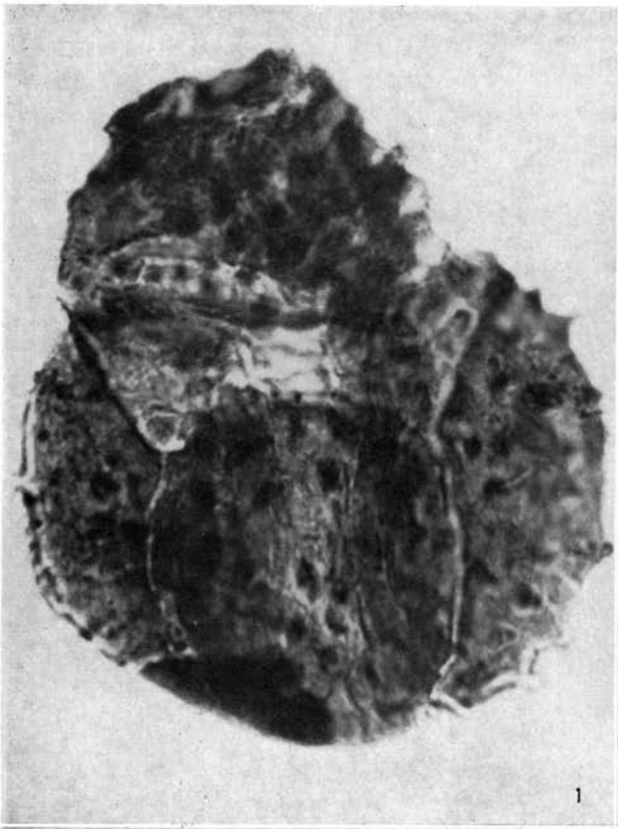
PLATE V

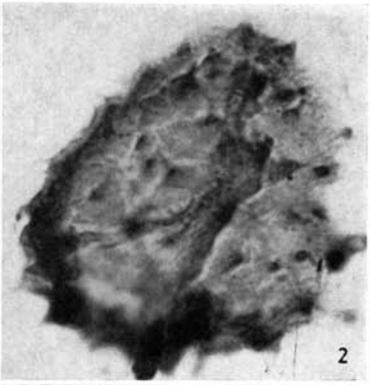
Spitsbergen. ×1000

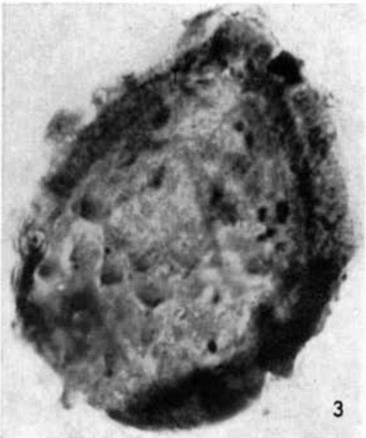
Figs. 1–5. *Droseridites spinulosus* n. sp. – Fig. 1. Complete tetrad. Figs. 2–5. Single grains. – Fig. 1. Holotype, 64: 12.6–86.1 (L 2, 7–11 cm below roof). – Fig. 2. 58: 15.1–81.1 (L 2, roof). – Fig. 3. 57: 5.9–81.3 (do.). – Figs. 4, 5. 57: 6.8–84.3 (do.), two different foci. – P. 30.

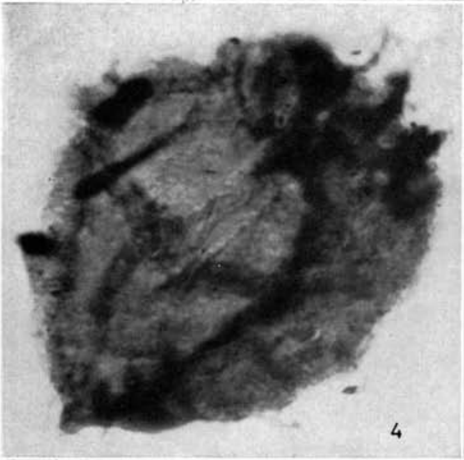
Figs. 6–8. Tetrad of monoporate (?) reticulate grains. – Figs. 6, 7. 49: 14.1–84.3 (L 2, bottom), two different foci. – Fig. 8. 49: 6.4–77.9 (do.). – P. 31.

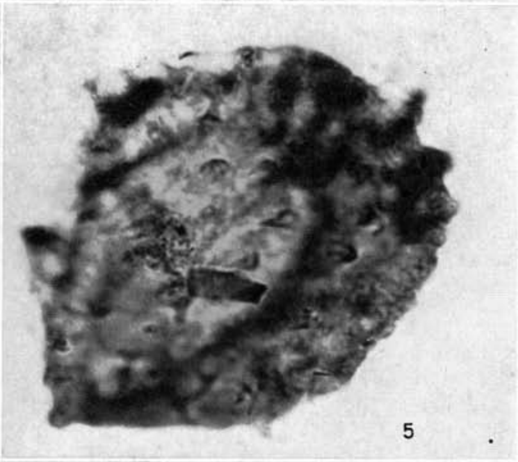
Plate V

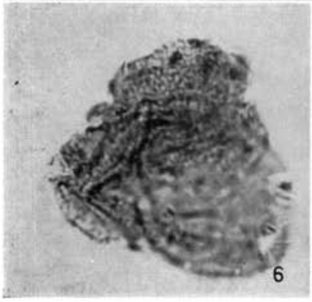

1

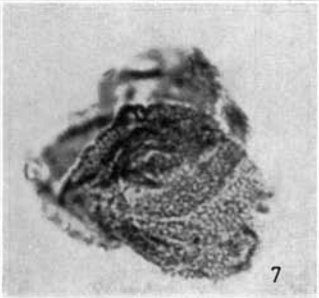

2


3


4


5


6


7

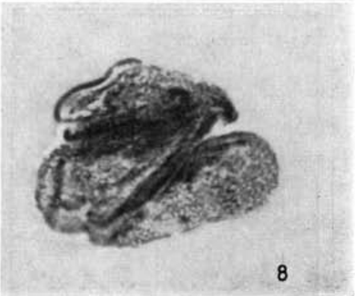

8

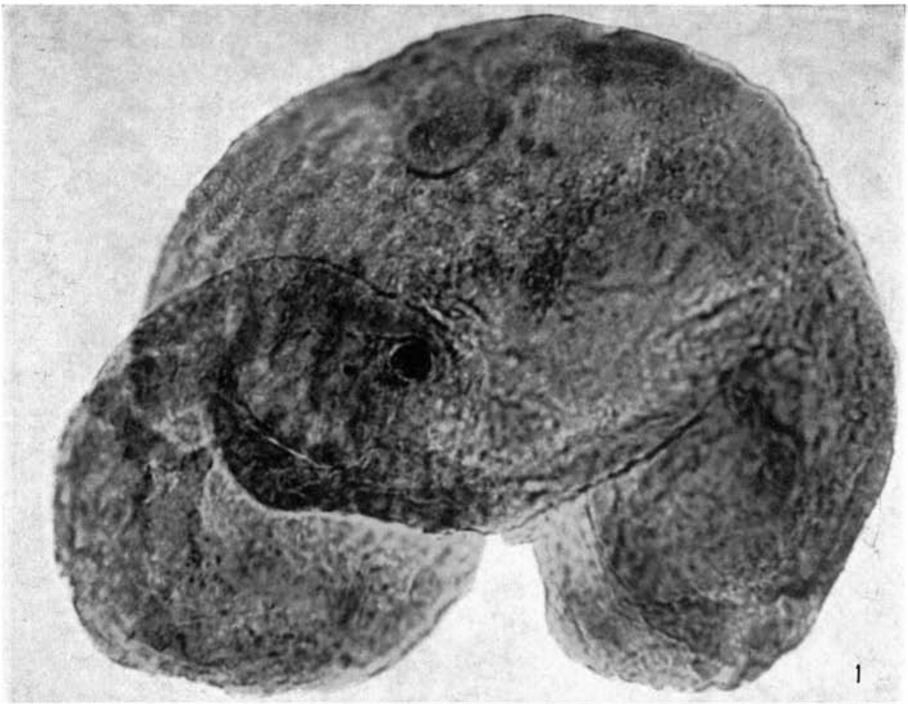
PLATE VI

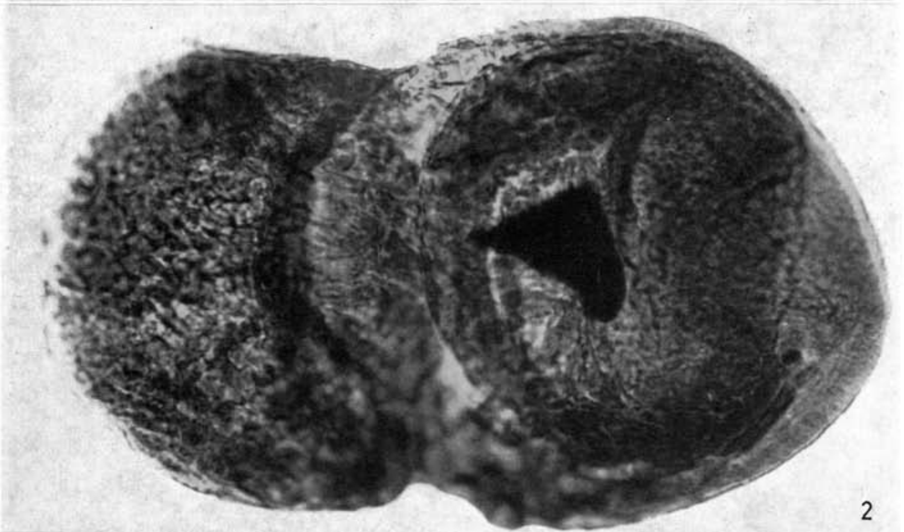
Spitsbergen. ×750

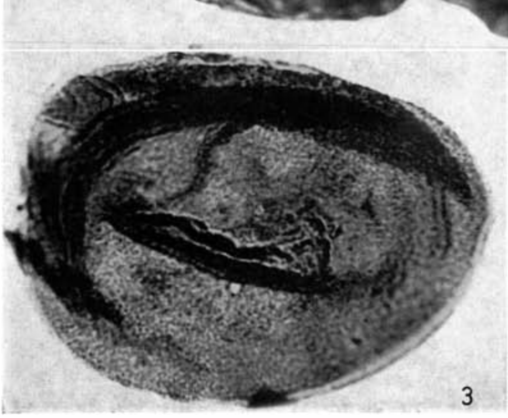
Figs. 1, 2. *Abiespollenites* sp. – Fig. 1, 63: 18.1–77.9 (S 4, upper 100 cm). – Fig. 2. 34: 9.4–91.8 (do.) – P. 33.

Figs. 3, 4. *Inaperturopollenites insignis* n.sp. – Fig. 4. Holotype, 42: 16.3–92.4 (S 4, upper 100 cm). – Fig. 3. 34: 9.5–91.5 (do.). – P. 39.

Plate VI


1


2


3

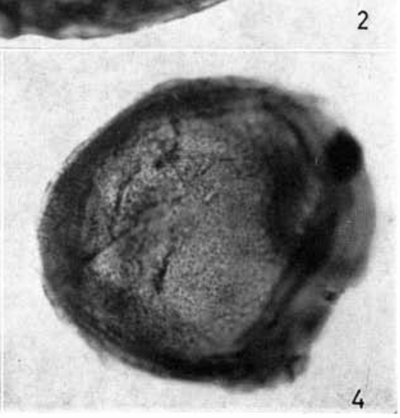

4

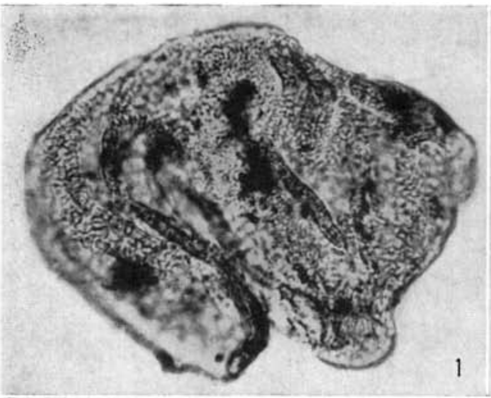
PLATE VII

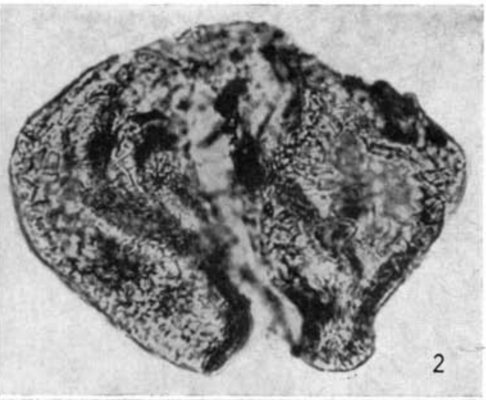
Spitsbergen. ×750

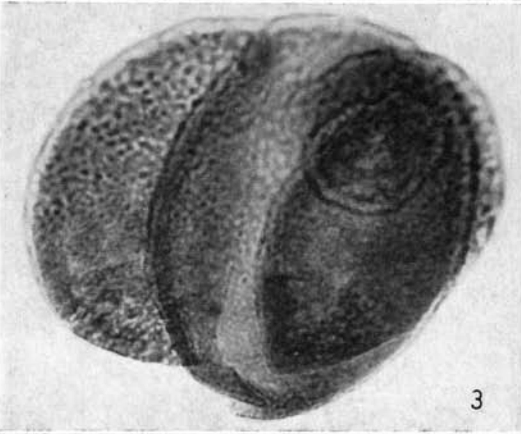
Figs. 1–5. *Abietineaepollenites* sp., Type A. – Figs. 1, 2. 90: 10.0–76.5 (Sarsbukta). – Fig. 3. 33: 15.4–85.4 (S 4, upper 100 cm). – Fig. 4. 59: 6.1–85.9 (L 2, roof). – Fig. 5. S. 151 (L 2, 24–28 cm below roof). – P. 33.

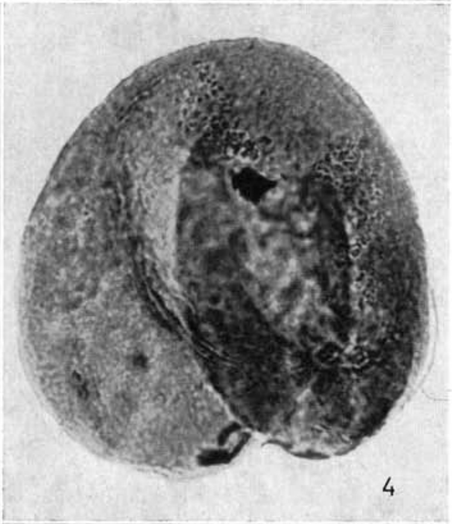
Figs. 6, 7. cf. *Cedripites*. – Fig. 6. 59: 16.1–81.0 (L 2, roof). – Fig. 7. S. 154 (do.). – P. 35.

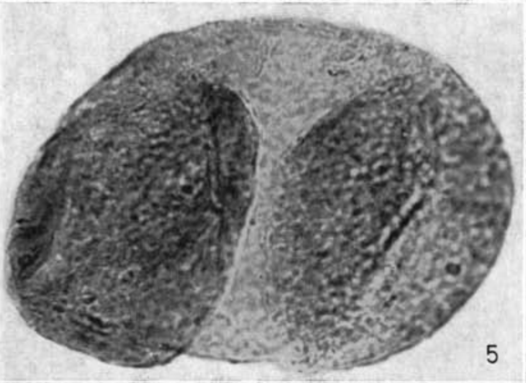
Plate VII

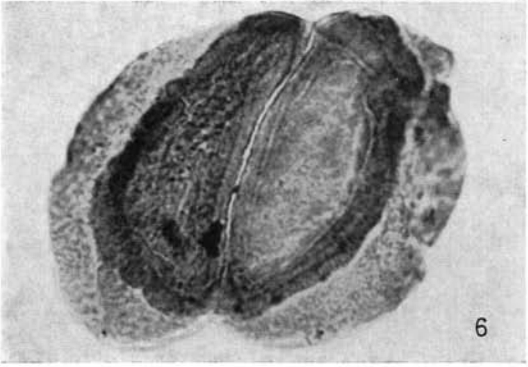

1


2


3


4


5


6

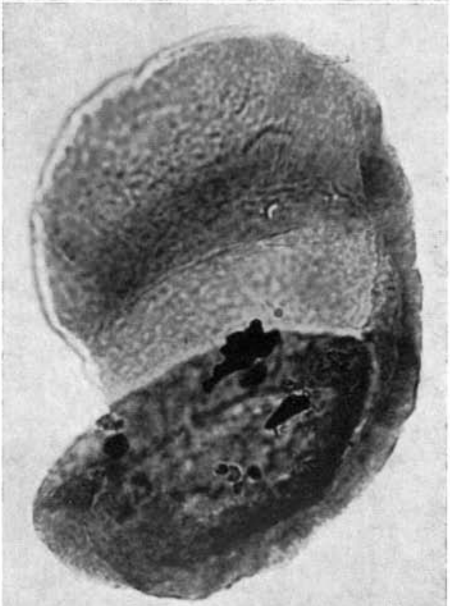

7

PLATE VIII

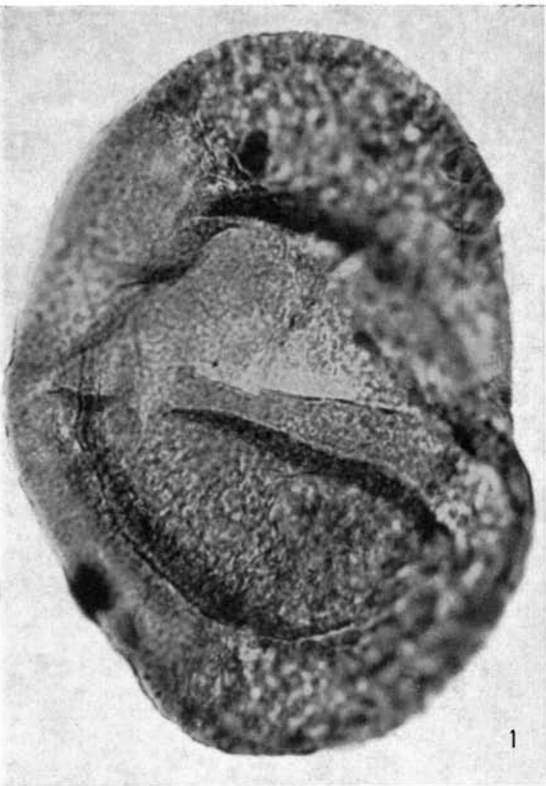
Spitsbergen. ×750

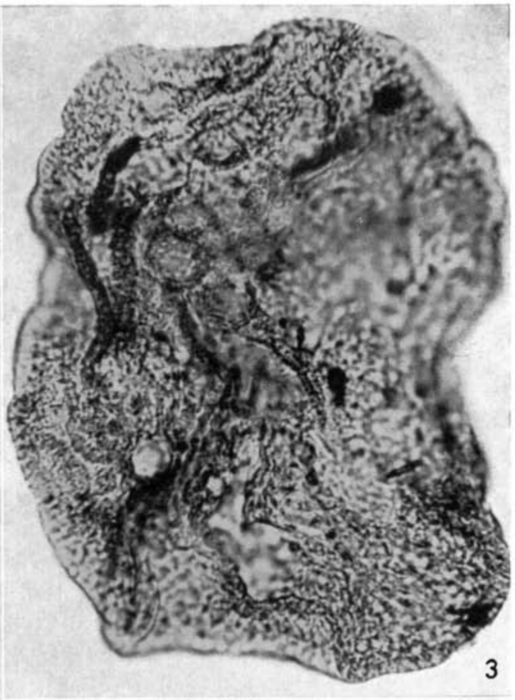
Figs. 1–3. *Abietineaepollenites* sp., Type B. – Fig. 1. 42: 8.2–81.5 (S 4, upper 100 cm). – Fig. **2.** 33: 8.7–84.9 (do.). – Fig. 3. S. 188 (Sarsbukta). – P. 34.

Fig. 4. cf. *Pityosporites*, Type B. – 57: 14.4–79.4 (L 2, roof), end view, slightly oblique. – P. 37.

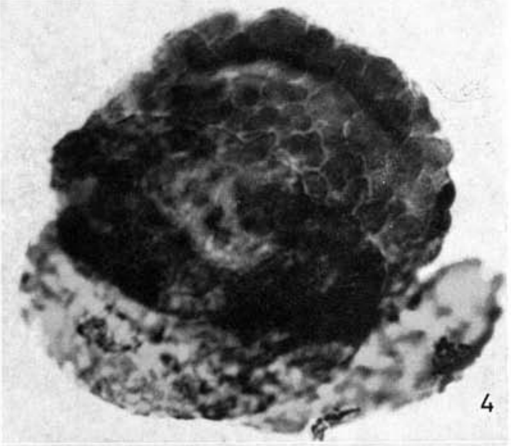
Figs. 5, 6. cf. *Pityosporites*, Type A. – Fig. 5. 33: 5.7–85.3 (S 4, upper 100 cm). – Fig. 6. 33: 19.9–78.8 (do.). – P. 37.

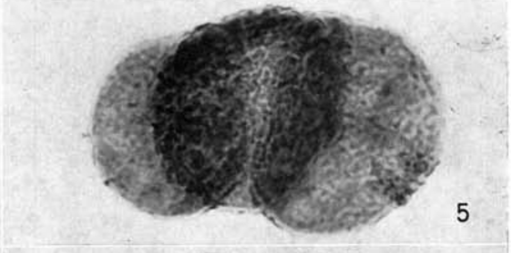
Plate VIII


1


3


2


4


5

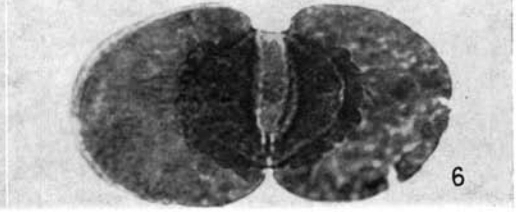

6

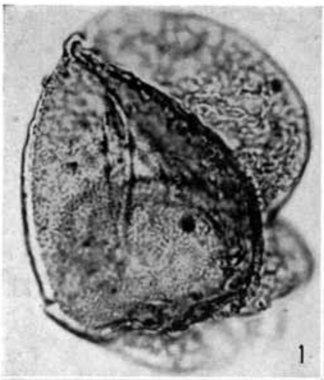
PLATE IX

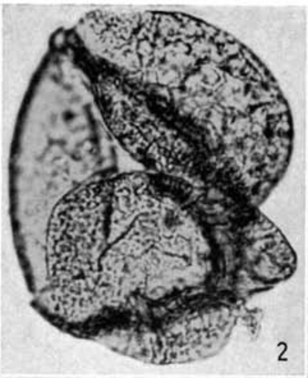
Spitsbergen. ×750

Figs. 1–8. *Pityosporites* cf. *labdacus* (Pot.) Th. & Pf. – Figs. 1, 2. S. 165 (Sarsbukta), two different foci. – Fig. 3. S. 163 (do.). – Fig. 4. S. 156 (L 2, 24–28 cm below roof). – Fig. 5. S. 157 (L 2, roof). – Fig. 6. 33: 16.7–78.0 (S 4, upper 100 cm). – Figs. 7, 8. S. 189 (Sarsbukta), two different foci. – P. 35.

Figs. 9, 10. *Abietipites arcticus* n. sp. – Fig. 9. 57: 8.4–82.2 (L 2, roof). – Fig. 10. Holotype, S. 145 (L 2, 24–28 cm below roof). – P. 37.

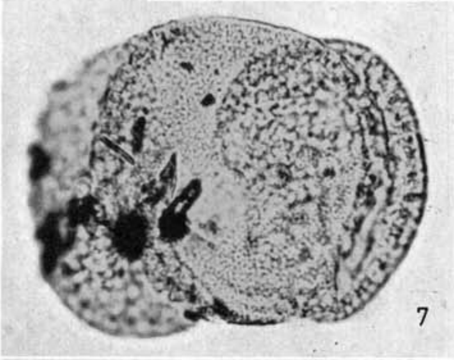
Plate IX

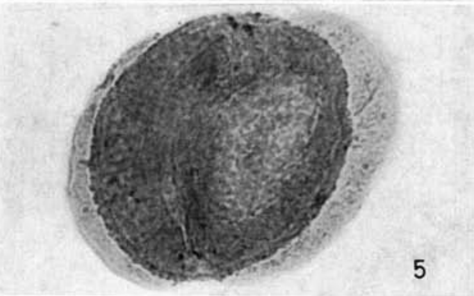

1

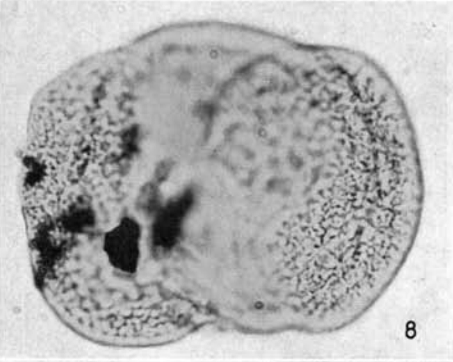

2

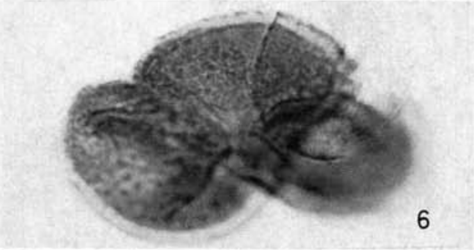

3

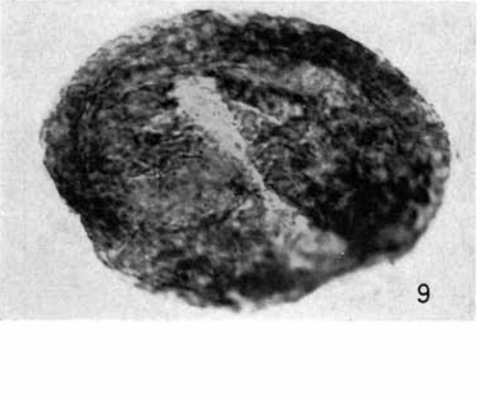

4


7


5


8


6


9

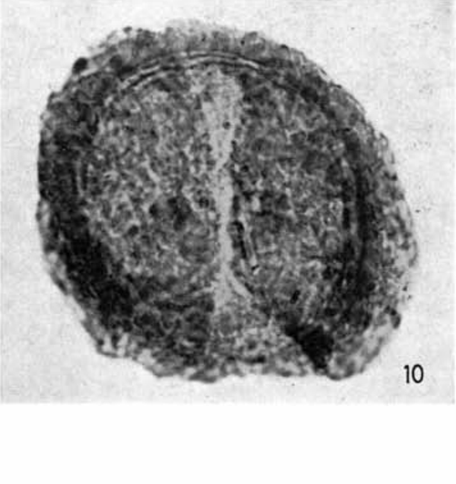

10

PLATE X

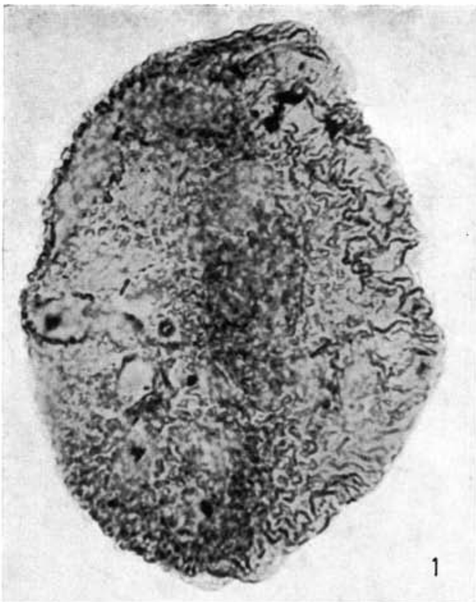
Spitsbergen. × 750

Figs. 1–4. *Tsugaepollenites viridifluminipites* (WODEH.) POT. – Figs. 1, 2. S. 184 (Sarsbukta), two different foci. – Fig. 3. S. 183 (do.). – Fig. 4. S. 177 (do.). – P. 45.

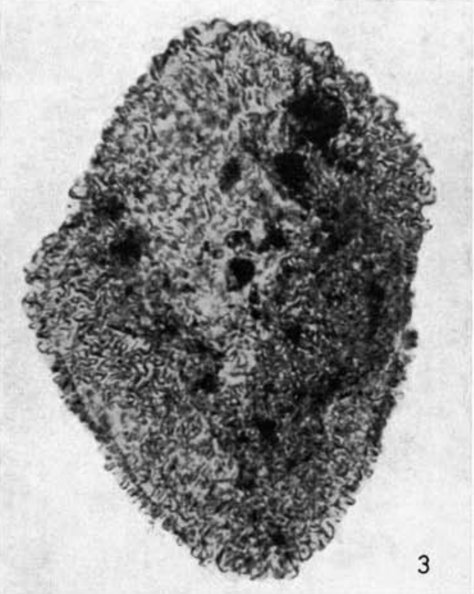
Fig. 5. *Abietipites arcticus* n. sp. – S. 143 (L 2, roof). – P. 37.

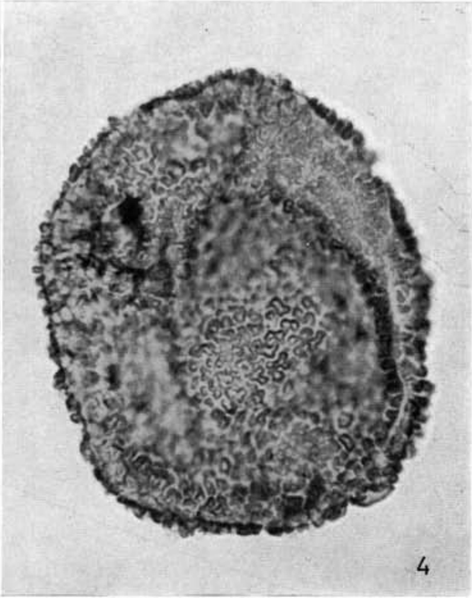
Fig. 6. *Inaperturopollenites* cf. *magnus* (POT.) TH. & PF. – 34: 10.9–83.5 (S 4, upper 100 cm). – P. 40.

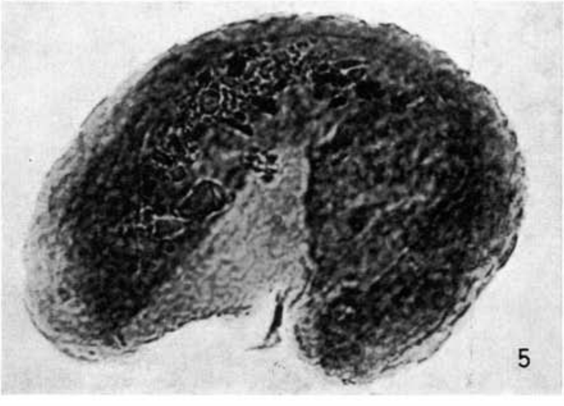
Plate X


1


2


3


4


5

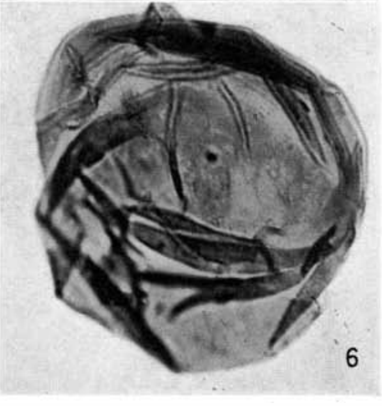

6

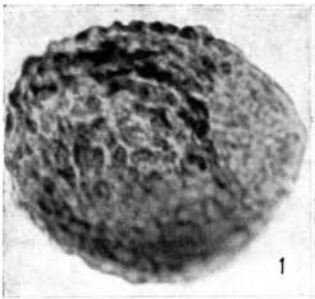
PLATE XI

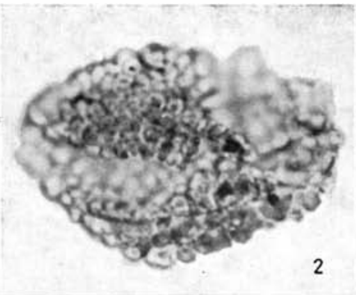
Spitsbergen. ×1000

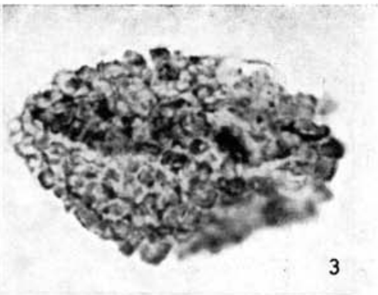
Figs. 1–9. *Sciadopityspollenites serratus* (Pot. & Ven.) Raatz. – Fig. 1. 33: 17.9–87.8 (S 4, upper 100 cm). – Figs. 2, 3. S. 266 (Sarsbukta), two different foci. – Fig. 4. 42: 14.3–84.3 (S 4, upper 100 cm). – Figs. 5, 6. 33: 14.9–78.7 (do.), two different foci. – Fig. 7. S. 172 (Sarsbukta). – Figs. 8, 9. 62: 15.3–85.0 (S 4, upper 100 cm), two different foci. – P. 42.

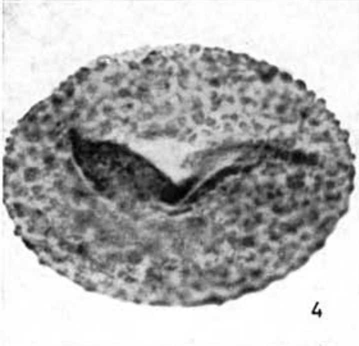
Figs. 10–16. *Inaperturopollenites* sp., Type A. – Fig. 10. 52: 19.8–78.1 (S 4, lower 34 cm). – Fig. 11. 52: 13.8–74.5 (do.). – Fig. 12. 34: 11.4–81.3 (S 4, upper 100 cm). – Fig. 13. 32: 13.7–81.4 (do.). – Fig. 14. 14: 18.1–81.1 (L 2, average). – Fig. 15. 34: 19.7–81.4 (S 4, upper 100 cm). – Fig. 16. 15: 16.8–84.3 (L 2, average). – P. 40.

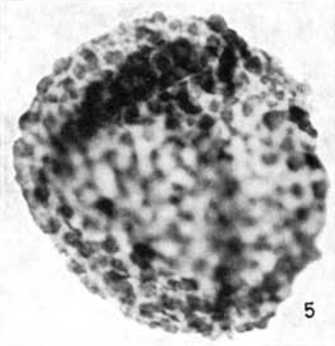
Plate XI

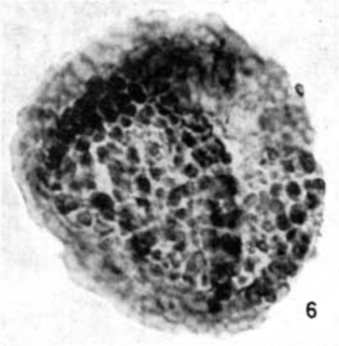

1

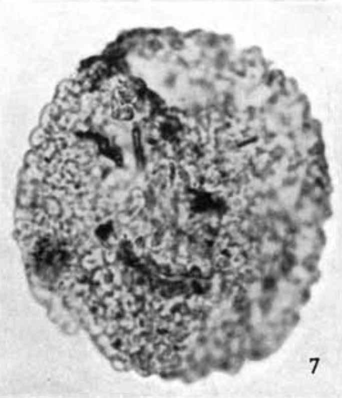

2

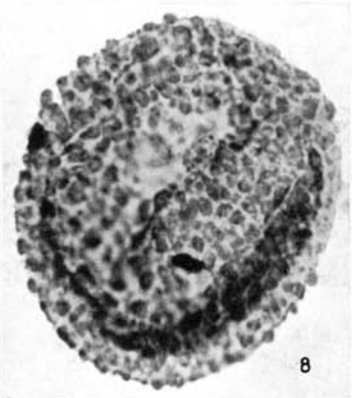

3

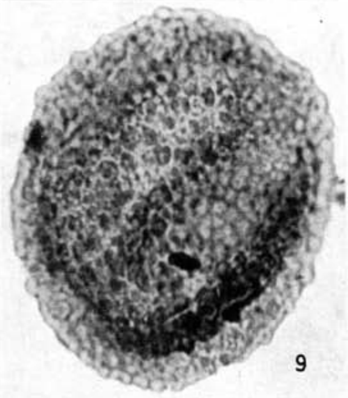

4


5


6


7

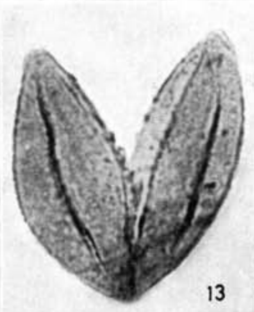

8

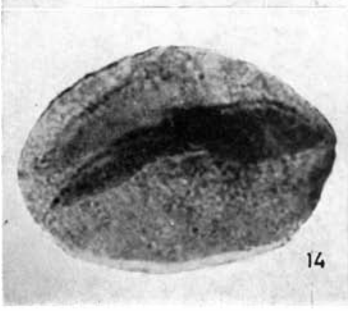

9

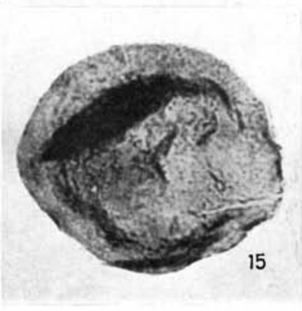

10


11


12


13


14


15

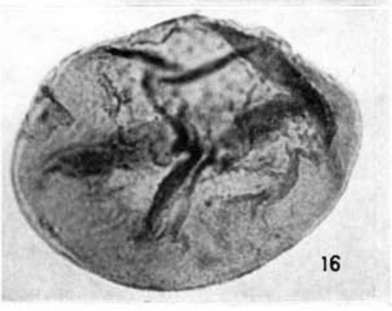

16

PLATE XII

Spitsbergen. × 1000

Figs. 1–4. *Inaperturopollenites* sp., Type B. – Figs. 1, 2. 5: 17.0–84.9 (S 3), two different foci. – Fig. 3. 5: 14.0–85.2 (do.). – Fig. 4. Type B_1, 51: 18.1–80.7 (S 4, lower 34 cm). – P. 41.

Figs. 5–9. *Sequoiapollenites* sp. – Fig. 5. 66: 15.0–86.0 (L 2, 14–18 cm below roof). – Fig. 6. 34: 10.1–93.8 (S 4, upper 100 cm). – Fig. 7. 4: 12.5–82.1 (L 2, average). – Fig. 8. 4: 13.9–78.4 (do.). – Fig. 9. 4: 15.9–79.6 (do.). – P. 44.

Fig. 10. Non-aperturate reticulate grain. – S. 137 (L 2, 24–28 cm below roof). – P. 46.

Figs. 11, 12. *Monocolpopollenites* sp. – Fig. 11. S. 267 (Sarsbukta). – Fig. 12. S. 264 (do.). – P. 47.

Figs. 13–19. *Tricolpopollenites haraldii* n. sp. – Figs. 13, 14. Holotype, 59: 10.0–82.8 (L 2, roof), two different foci. – Figs. 15, 16. S. 91 (L 2, average), do. – Fig. 17. 14: 8.3–86.6 (do.). – Figs. 18, 19. 25: 15.5–73.8 (do.), two different foci. – P. 48.

Fig. 20. *Tricolpopollenites* sp., Type A. – 15: 13.6–76.0 (L 2, average). – P. 48.

Figs. 21, 22. *Tricolpopollenites* sp., Type B. – 25: 18.0–75.9 (L 2, average), two different foci. – P. 48.

Fig. 23. *Tricolpopollenites* sp., Type C. – 14: 4.8–81.4 (L 2, average). – P. 49.

Figs. 24–27. *Trudopollis barentsii* n. sp. – Figs. 24, 25. Holotype, S. 115 (L 2, roof), two different foci. – Fig. 26. 57: 17.0–77.6 (do.). – Fig. 27. 57: 16.4–84.4 (do.). – P. 49.

Figs. 28–31. *Trudopollis rotundus* n. sp. – Figs. 28, 29. Holotype, S. 123 (L 2, roof), two different foci. – Figs. 30, 31. 60: 6.2–83.1 (do.), do. – P. 51.

Plate XII

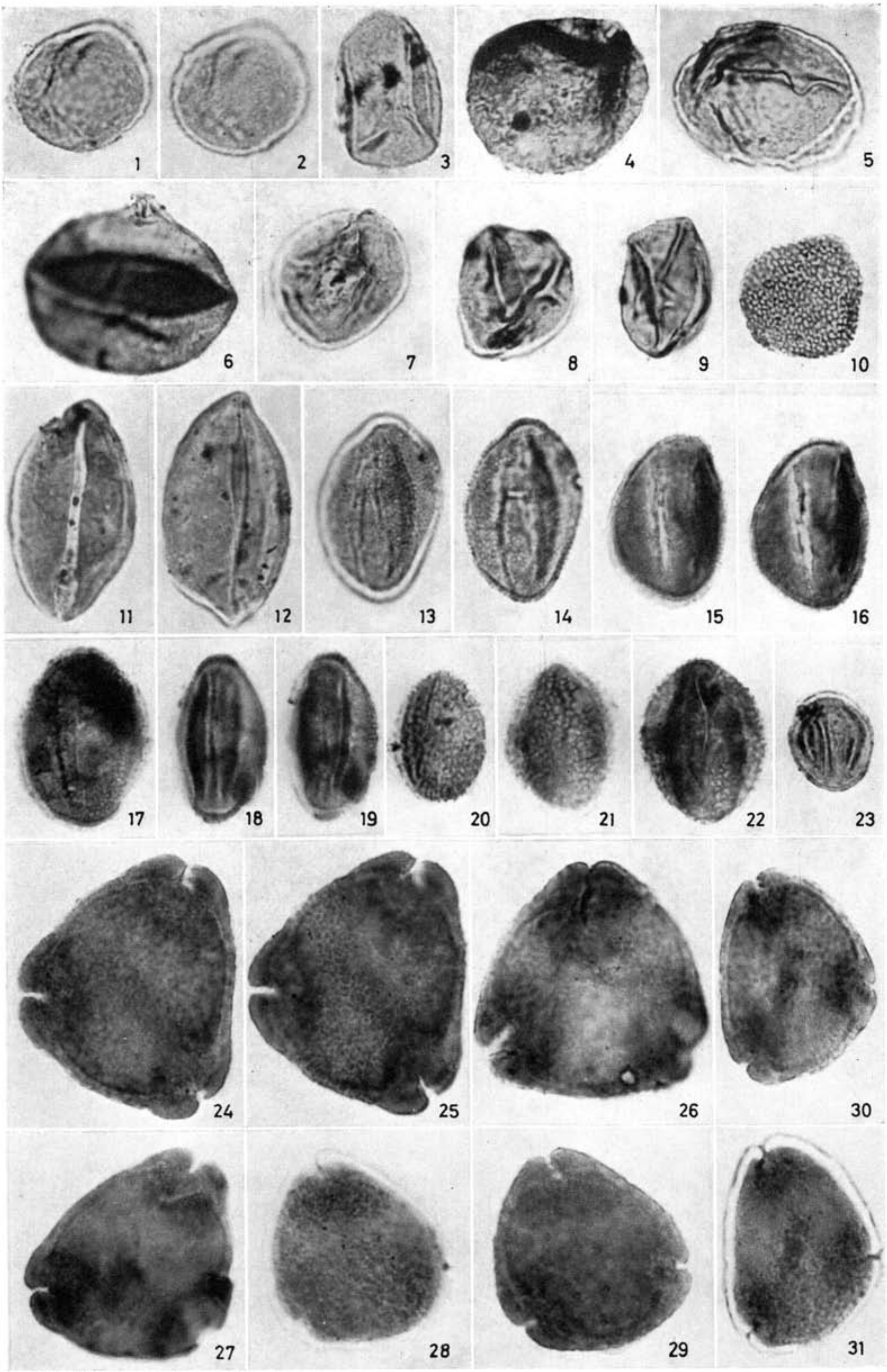

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
30
27
28
29
31

PLATE XIII

Spitsbergen. ×1000

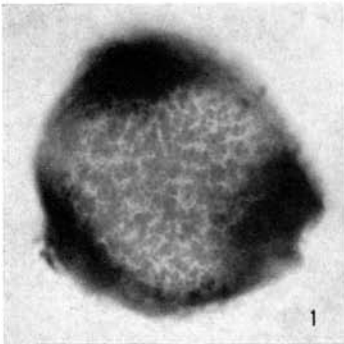
Figs. 1–5. *Trudopollis resistens* n. sp. – Figs. 1–4. Holotype, 61: 15.0–80.6 (L 2, roof), four successive foci. - Fig. 5. 25: 15.7–82.7 (L 2, average). – P. 50.

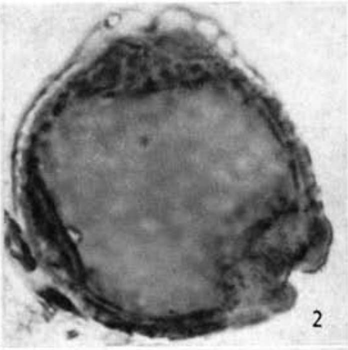
Fig. 6. *Trudopollis* sp., Type A. – 57: 17.4–86.3 (L 2, roof). – P. 52.

Figs. 7–12. *Trudopollis* sp., Type B. – Figs. 7–9. 41: 15.3–69.6 (L 3), three successive foci. – Figs. 10–12. 19: 13.3–76.8 (L 3, 36 m), do. – P. 53.

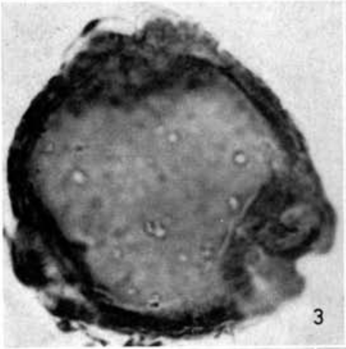
Figs. 13–16. *Trudopollis* (?) sp., Type C. – Figs. 13, 14. S. 123 (L 2, roof), two different foci. – Figs. 15, 16. 57: 12.5–79.2 (do.), do. – P. 54.

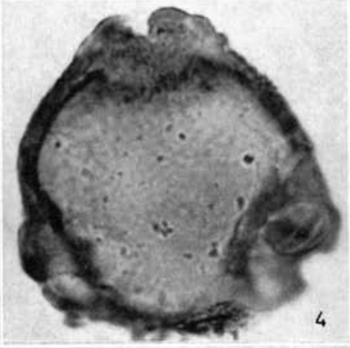
Plate XIII

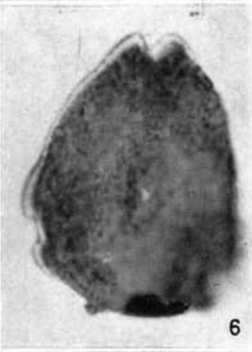

1

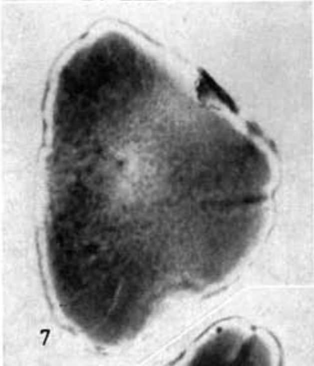

2

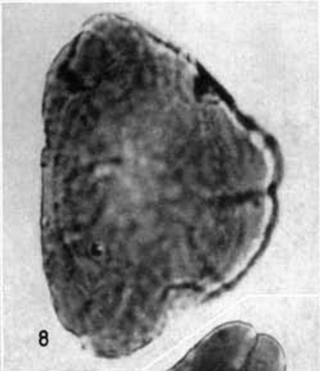

5


3

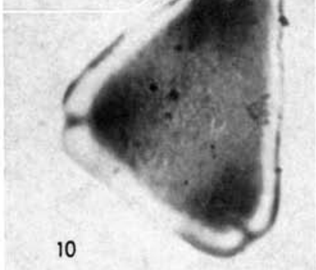

4


6

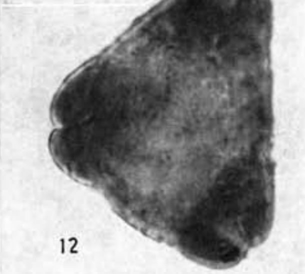

7

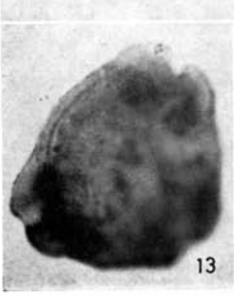

8

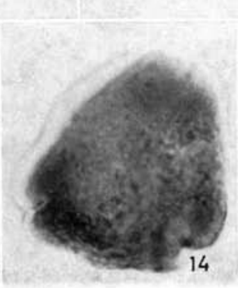

9

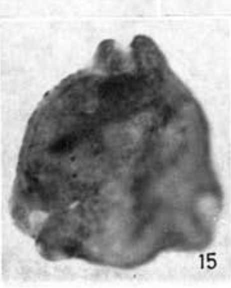

10


11


12


13


14


15

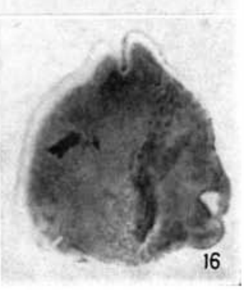

16

PLATE XIV

Spitsbergen. ×1000

Figs. 1–8. *Tetrapollis conspectus* n. sp. – Fig. 1. Holotype, 54: 10.0–90.6 (L 2, roof). – Figs. 2–4. 57: 15.3–84.7 (do.), three successive foci. – Fig. 5. 57: 10.9–88.2 (do.). – Fig. 6. 57: 18.3–77.3 (do.). – Fig. 7. 57: 11.9–74.8 (do.). – Fig. 8. 57: 18.7–85.9 (do.). – P. 54.

Figs. 9–12. *Tetrapollis quadratus* n. sp. – Figs. 9, 10. Holotype, S. 130 (L 2, roof), two different foci. – Figs. 11, 12. S. 131 (do.), do. – P. 56.

Fig. 13. *Tetrapollis* sp. (cf. *Trudopollis resistens*). – 69: 17.0–81.5 (L 2, roof). – P. 57.

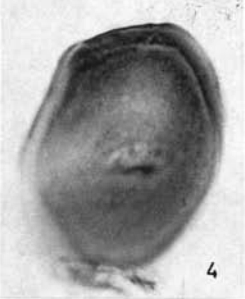
Figs. 14–20. *Myricipites speciosus* n. sp. – Fig. 14. 59: 17.4–82.9 (L 2, roof). – Figs. 15, 16. Holotype, 59: 17.4–83.1 (do.), two different foci. – Figs. 17, 18. 57: 18.6–80.5 (do.), do. - Fig. 19. 57: 17.2–86.3 (do.). – Fig. 20. 57: 17.6–86.0 (do.). – P. 57.

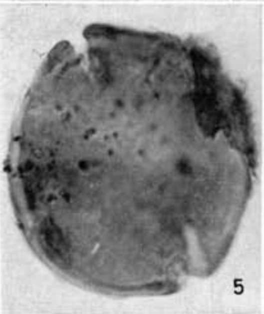
Plate XIV


1


2

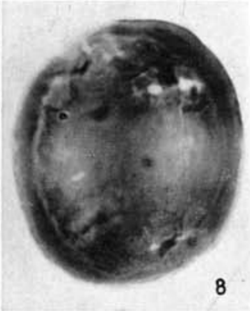

3

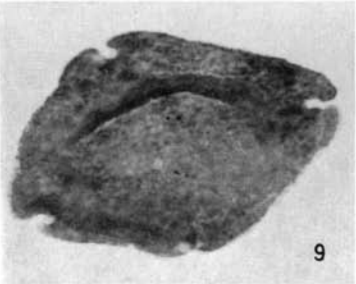

4


5

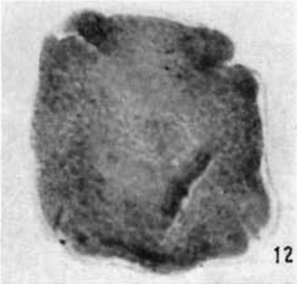

6

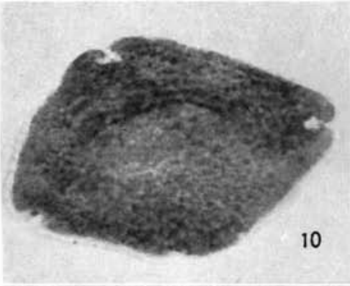

7

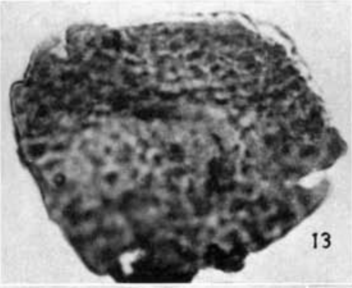

8

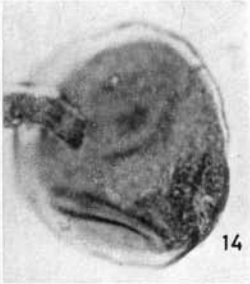

9


11

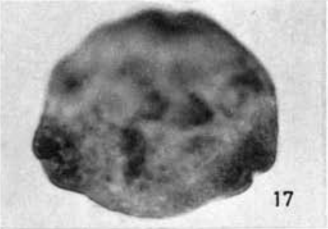

12


10

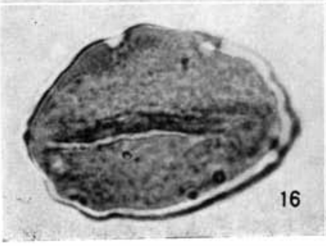

13

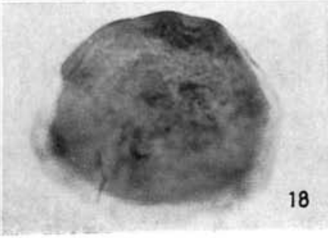

14


15


17


19


16


18

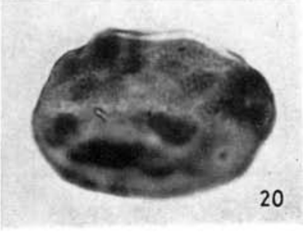

20

PLATE XV

Spitsbergen. ×1000

Figs. 1, 2. *Myricipites* sp. – Fig. 1. S. 197 (Sarsbukta). – Fig. 2. S. 199 (do.). – P. 58.

Figs. 3–9. Triporates, Type A. – Figs. 3, 4. S. 175 (Sarsbukta), two different foci. – Fig. 5. S. 262 (do.). – Fig. 6. S. 1 (L 3, 25 m). – Figs. 7, 8. 14: 18.3–83.2 (L 2, average), two different foci. – Fig. 9. 25: 17.3–77.0 (do.). – P. 59.

Figs. 10–12. Triporates, Type B. – Fig. 10. 69: 13.7–77.2 (L 2, roof). – Fig. 11. 52: 19.6–77.1 (S 4, lower 34 cm). – Fig. 12. 47: 7.0–79.1 (do.). – P. 59.

Figs. 13–16. Triporates, Type C. – Figs. 13–15. 14: 10.3–84.5 (L 2, average), three successive foci. – Fig. 16. S. 96. (do.) – P. 60.

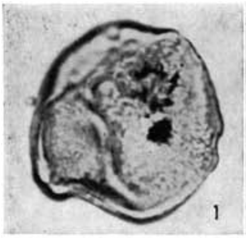
Fig. 17. Triporates, Type F. – 65: 18.4–83.7 (L 2, 7–11 cm below roof). – P. 61.

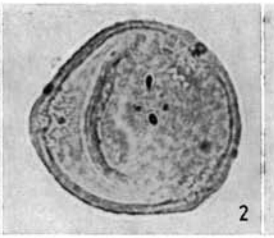
Figs. 18–21. Triporates, Type E. – Figs. 18, 19. 20: 19.7–88.9 (S 2), two different foci. – Figs. 20, 21. 20: 13.2–87.7 (do.), do. – P. 60.

Figs. 22–25. Triporates? type. – Fig. 22. 14: 9.4–78.6 (L 2, average). – Fig. 23. S. 27 (L 3, 36 m). – Figs. 24, 25. 54: 9.9–86.8 (L 2, roof), two different foci. – P. 61.

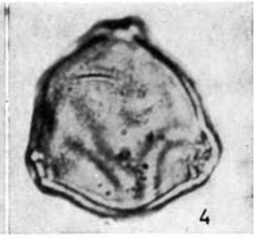
Fig. 26. Triporates, Type D. – 57: 10.9–88.0 (L 2, roof). – P. 60.

Plate XV

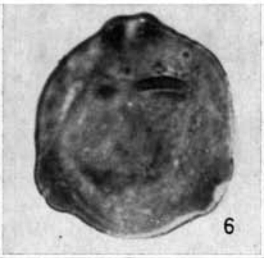

1


2


3

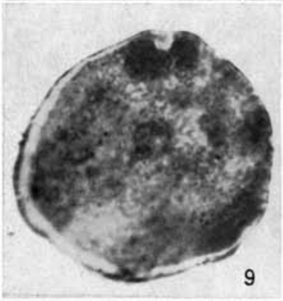

4

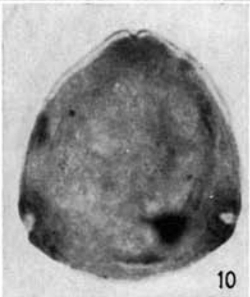

5

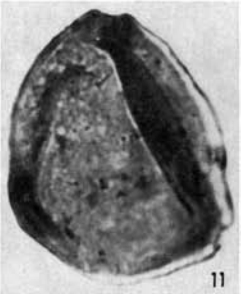

6


7

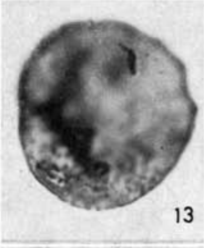

8


9

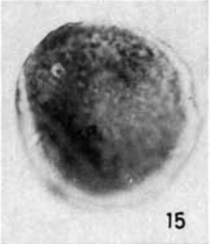

10


11


12


13

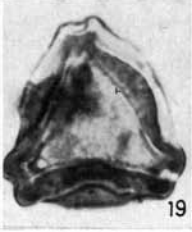

14

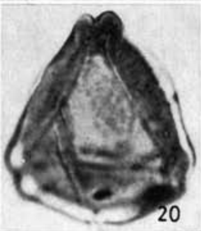

15


16

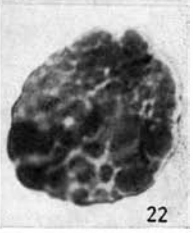

17

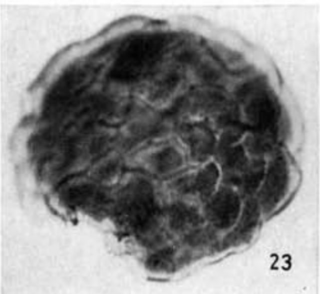

18


19


20


21


22


23


24


25


26

PLATE XVI

Spitsbergen. ×1000

Figs. 1–4. *Alnipollenites* sp., Type A. – Fig. 1. 14: 12.6–76.0 (L 2, average). – Fig. 2. S. 133 (L 2, roof). – Fig. 3. 25: 6.6–82.1 (L 2, average). – Fig. 4. 25: 9.4–84.5 (do.). – P. 62.

Figs. 5–9. *Alnipollenites* sp., Type B. – Fig. 5. 15: 11.9–86.8 (L 2, average). – Fig. 6. 14: 11.4–73.7 (do.). – Figs. 7, 8. S. 265 (Sarsbukta), two different foci. – Fig. 9. S. 253 (do.). – P. 62.

Fig. 10. *Alnipollenites* sp., Type C. – 14: 9.3–87.0 (L 2, average). – P. 62.

Figs. 11, 12. *Polyatriopollenites* cf. *stellatus* (Pot.) Pf. – 90: 12.3–84.1 (Sarsbukta), two different foci. – P. 63.

Figs. 13, 14. *Juglanspollenites* sp. – S. 166 (Sarsbukta), two different foci. – P. 64.

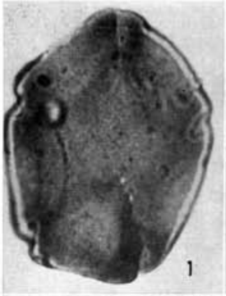
Figs. 15, 16. *Periporopollenites* sp. – Fig. 15. 28: 17.6–81.4 (S 2). – Fig. 16. 21: 3.3–80.2 (S 2). – P. 64.

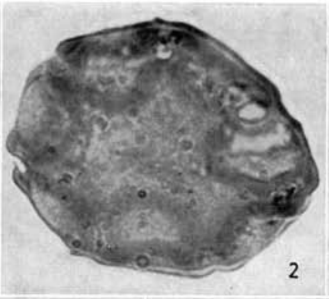
Figs. 17–19. Incertae sedis, Type B. – Fig. 17. 26: 11.8–70.6 (L 2, average). – Figs. 18, 19. S. 61 (U 5). – P. 65.

Figs. 20, 21. Incertae sedis, Type C. – Fig. 20. 25: 10.5–71.8 (L 2, average). – Fig. 21. 25: 16.8–74.5 (do.). – P. 66.

Fig. 22. Incertae sedis, Type A (cf. *Oculopollis*). – 68: 8.9–86.8 (L 2, roof). – P. 65.

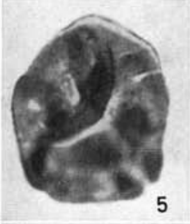
Plate XVI


1

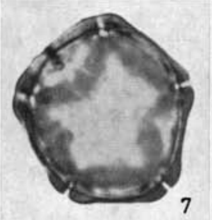

2

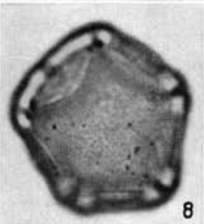

3

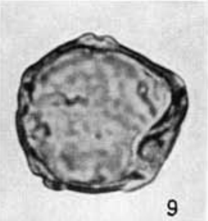

4

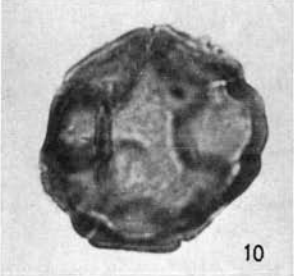

5

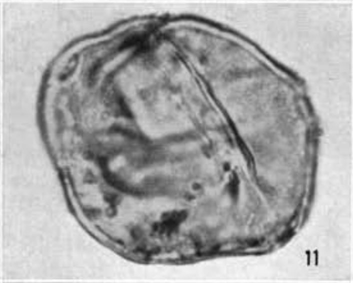

6

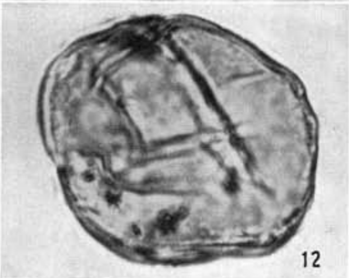

7

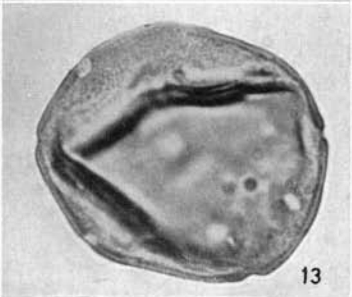

8

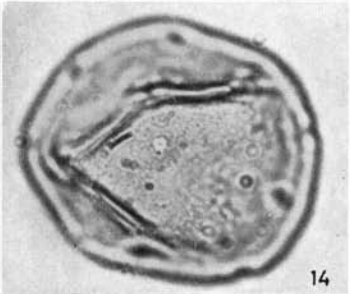

9


10


11


12

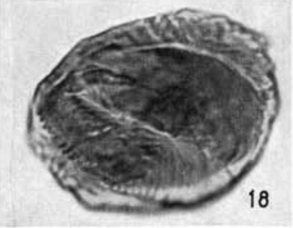

13

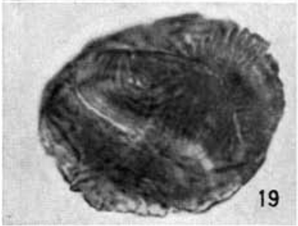

14

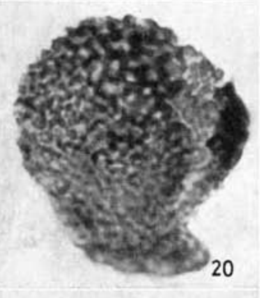

15


16


17


18


19


20


21

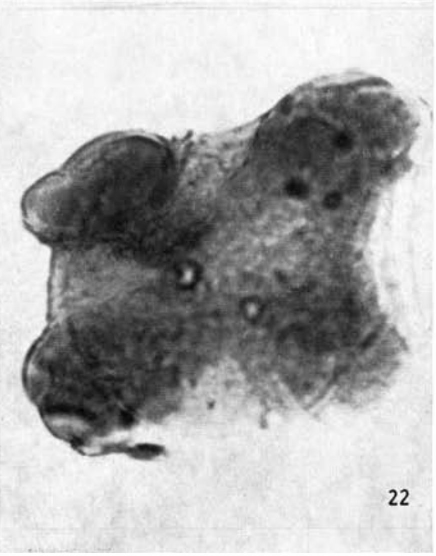

22

PLATE XVII

Ellesmere Island (figs. 1–5), Greenland (fig. 6).

×750

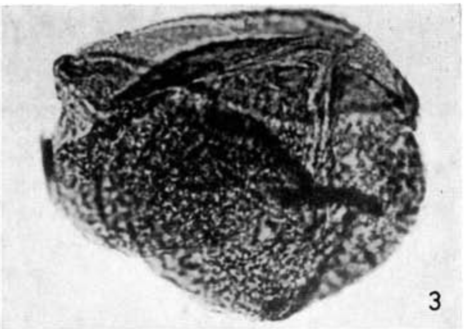
Figs. 1–3. *Abietineaepollenites* sp., Ellesm. Type A. – Figs. 1, 2. 117: 14.4–85.1, two different foci. – Fig. 3. 115: 17.6–78.3. – P. 96.

Figs. 4, 5. *Abietineaepollenites* sp., cf. Spitsb. Type B. – Fig. 4. 115: 8.2–75.5. – Fig. 5. 117: 15.4-75.9, end view. – P. 97.

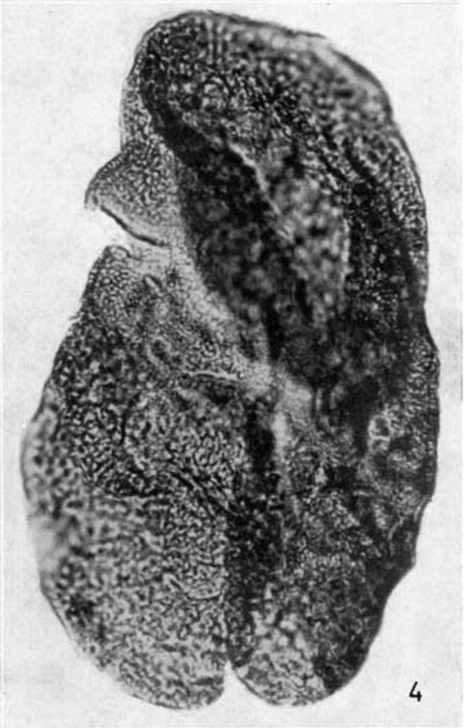
Fig. 6. Two-winged grain with traces of microbial activity. – 111: 14.6–80.7. – P. 100.

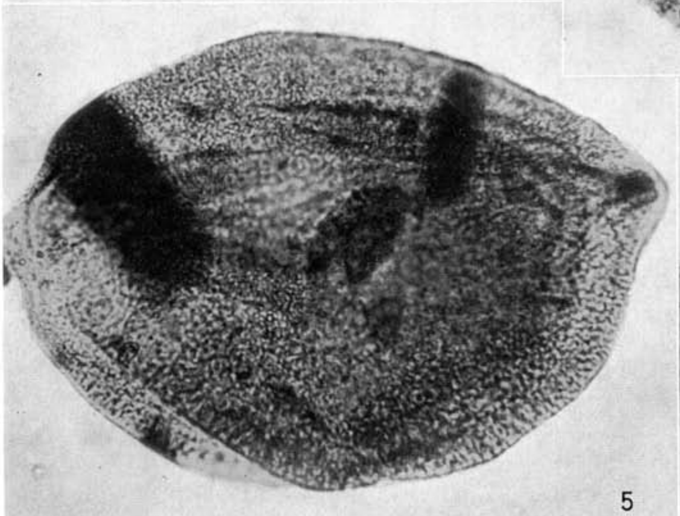
Plate XVII


1


3


2


4


5

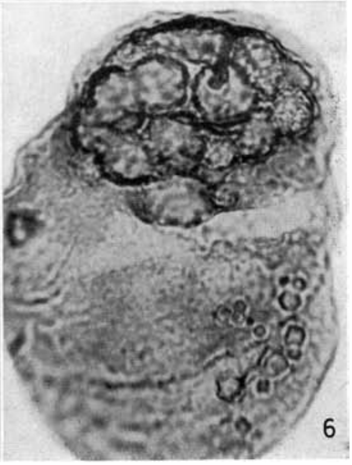

6

PLATE XVIII

Ellesmere Island. ×750

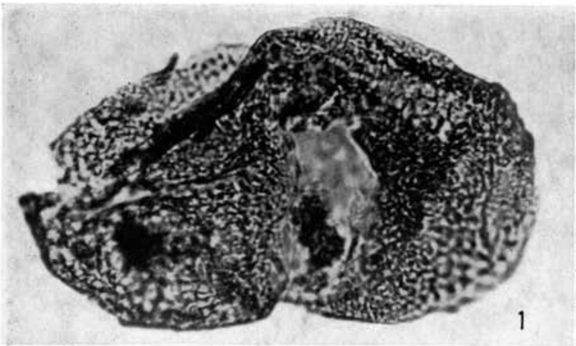
Figs. 1, 2. *Abietineaepollenites* sp., Ellesm. Type B. – Fig. 1. 115: 11.5–82.6. – Fig. 2. 112: 5.3–86.5. – P. 96.

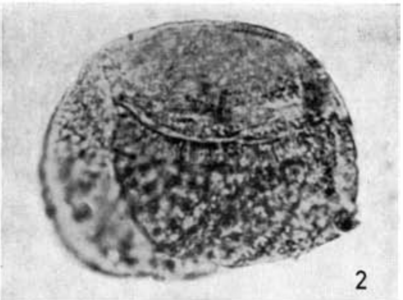
Figs. 3, 4. cf. *Pityosporites* sp., Ellesm. Type A. – Fig. 3. 117: 13.2–77.0. – Fig. 4. 117: 8.3–80.4. – P. 97.

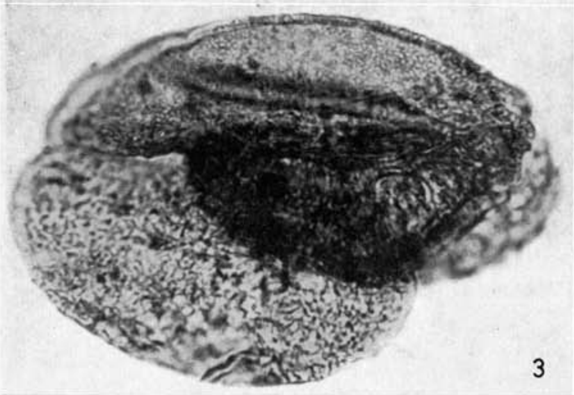
Figs. 5, 6. cf. *Pityosporites* sp., Ellesm. Type B. – Fig. 5. 117: 14.0–84.8. – Fig. 6. 117: 15.4–76.5. – P. 97.

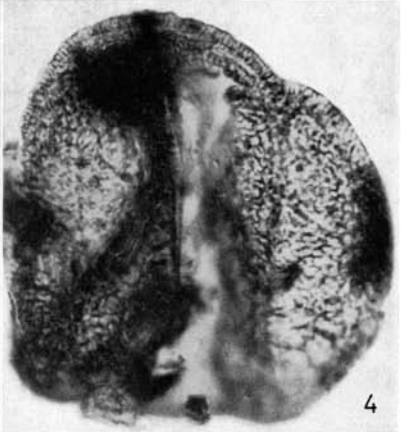
Figs. 7, 8. cf. *Pityosporites* sp., Ellesm. Type C. – Fig. 7. 115: 6.4–82.3. – Fig. 8. 117: 10.6–79.0, only a part of the cap in focus. – P. 97.

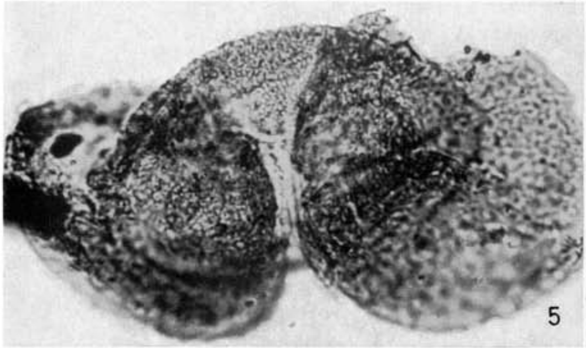
Plate XVIII

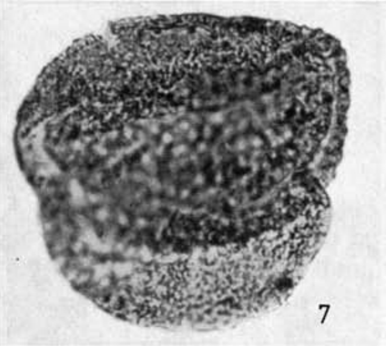

1

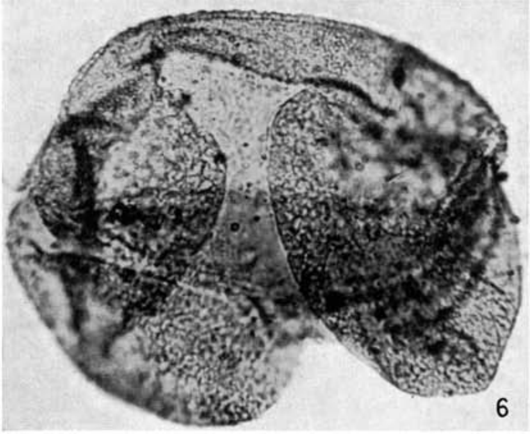

2


3


4


5


7


6

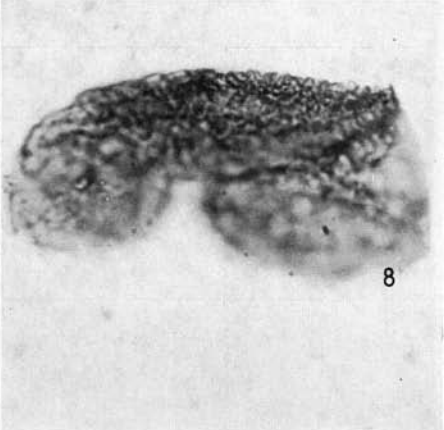

8

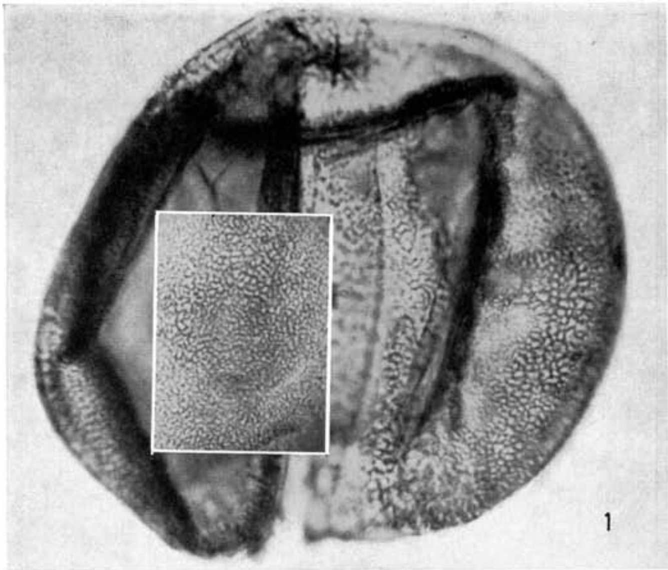
PLATE XIX

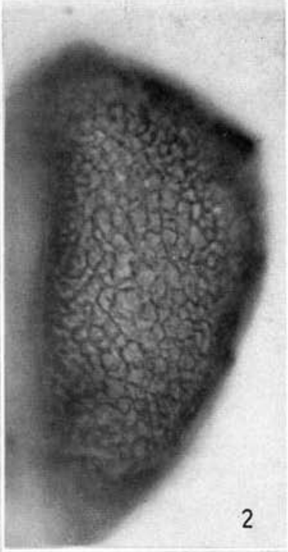
Iceland (Tröllatunga). ×750

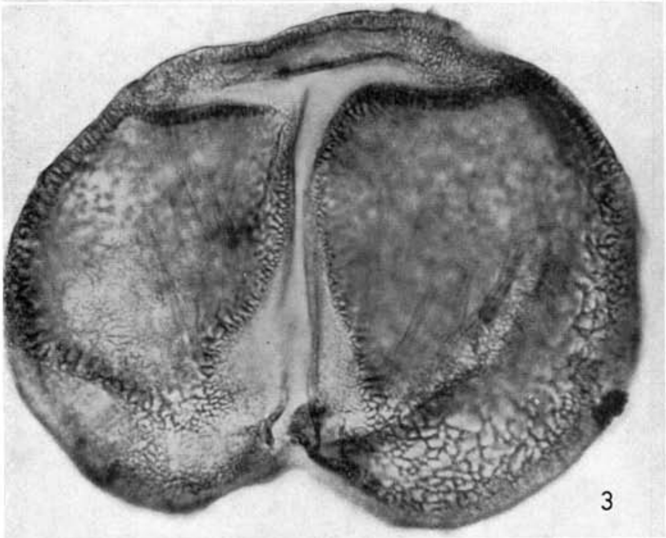
Figs. 1–3. *Abietineaepollenites* sp., cf. Spitsb. Type B. – Figs. 1, 2. 109: 12.9–74.7; inset in fig. 1 shows reticulum of cap; fig. 2, reticulum of bladder, distal end. – Fig. 3. 109: 16.9–91.7. – P. 106.

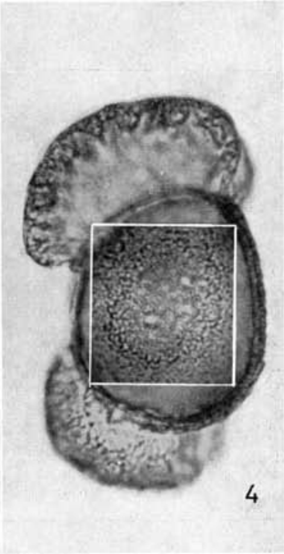
Figs. 4, 5. *Pityosporites* cf. *labdacus* (Pot.) Th. & Pf. – 106: 6.7–80.9; inset in fig. 4 shows surface pattern of cap. – P. 106.

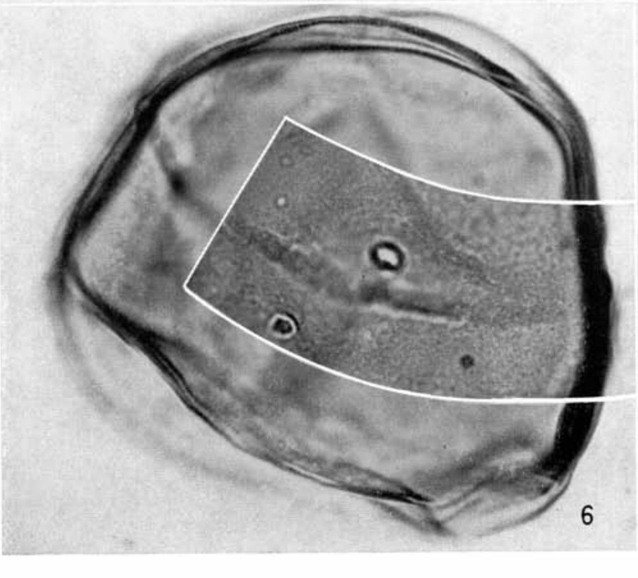
Fig. 6. *Inaperturopollenites* cf. *magnus* (Pot.). Th. & Pf. – 103: 13.1–95.5; inset shows exine surface in focus. – P. 106.


1


2


3


4


6

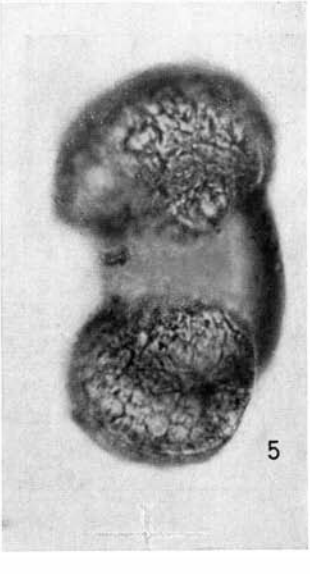

5

PLATE XX

Ellesmere Island (figs. 1–7, 21, 22), Greenland (figs. 13–15),
Iceland (Tröllatunga, figs. 8–12, 16–20)
×1000

Figs. 1, 2. Triletes? – Fig. 1. 116: 9.1–84.9. – Fig. 2. 116: 18.2–75.5. – P. 96.

Figs. 3, 4. *Sciadopityspollenites serratus* (POT. & VEN.) RAATZ. – 116: 12.8–77.9, two different foci. – P. 98.

Fig. 5. Periporate grain (*Carya*). – 116: 5.4–79.6. – P. 98.

Figs. 6, 7. *Inaperturopollenites* sp., cf. Spitsb. Type A. - Fig. 6. 115: 14.9–75.4. – Fig. 7. 115: 6.0–84.3. – P. 98.

Fig. 8. *Reticulatisporites* sp., Type B. – 107: 10.0–80.1. – P. 105.

Figs. 9, 10. *Reticulatisporites* sp., Type A. – 105: 7.8–74.6, two different foci. – P. 105.

Figs. 11, 12. *Tricolpopollenites striatus* PF., "Form Tr.". – 107: 20.9–86.3, two different foci. – P. 107.

Fig. 13. Trilete spore (gleichenioid). – 110: 11.6–77.6. – P. 102.

Figs. 14, 15. *Sciadopityspollenites serratus* (POT. & VEN.) RAATZ. – 111: 18.1–87.0, two different foci. – P. 101.

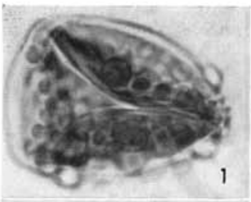
Figs. 16, 17. *Tricolpopollenites* sp., Iceld. Type B. – 104: 21.3–80.8, two different foci. – P. 107.

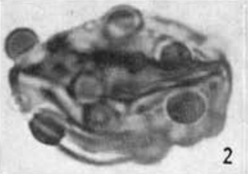
Fig. 18. *Tricolpopollenites* sp., Iceld. Type A. – 104: 21.4–80.8. - P. 107.

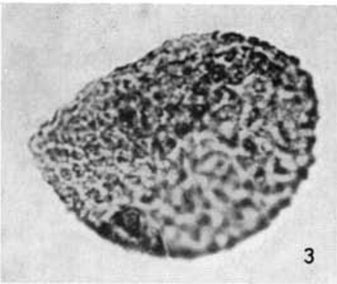
Figs. 19, 20. Triporates, cf. Spitsb. Type A. – Fig. 19. 105: 4.6–76.2. – Fig. 20. 103: 19.6–56.0. – P. 108.

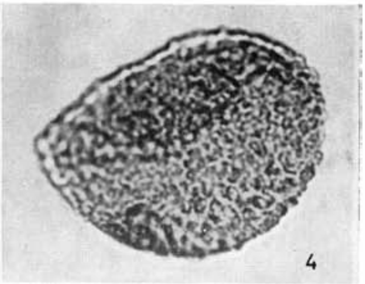
Figs. 21, 22. Triporates, cf. Spitsb. Type A. – 113: 4.7–79.0, two different foci. – P. 98.

Plate XX


1


2


3

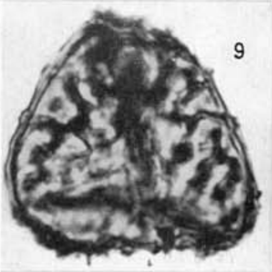

4

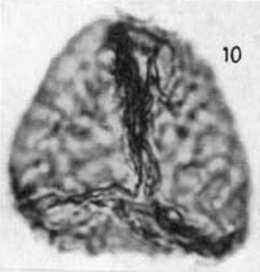

5

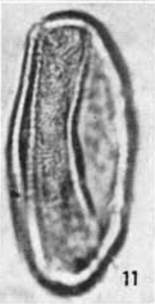

6


7

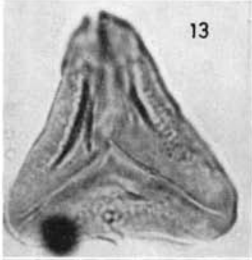

8

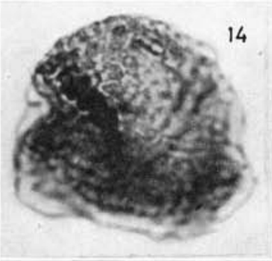

9

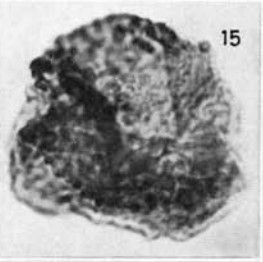

10

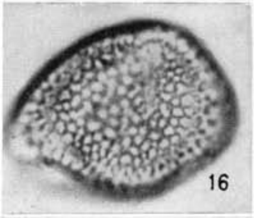

11

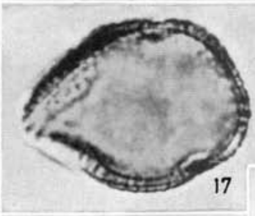

12

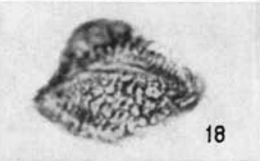

13

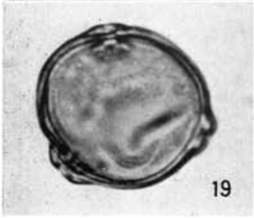

14

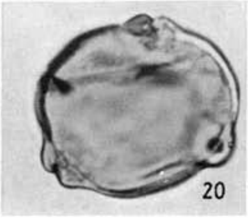

15

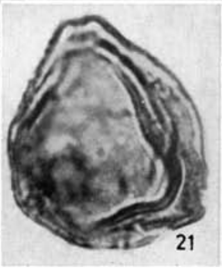

16


17


18


19


20


21


22

SKRIFTER

Skrifter nr. 1—99, see numbers of Skrifter previous to Nr. 100.

Nr.

100. Padget, Peter: *Notes on some Corals from Late Paleozoic Rocks of Inner Isfjorden, Spitsbergen.* 1954. Kr. 1.00.
101. Mathisen, Trygve: *Svalbard in International Politics 1871—1925.* 1954. Kr. 18.00.
102. Rodahl, Kåre: *Studies on the Blood and Blood Pressure in the Eskimo, and the Significance of Ketosis under Arctic Conditions.* 1954. Kr. 10.00.
103. Løvenskiold, H. L.: *Studies on the Avifauna of Spitsbergen.* 1954. Kr. 16.00.
104. Hornbæk, Helge: *Tidal Observations in the Arctic 1946—52.* 1954. Kr. 2.50.
105. Abs, Otto und Hans Walter Schmidt: *Die arktische Trichinose und ihr Verbreitungsweg.* 1954. Kr. 4.00.
106. Major, Harald and Thore S. Winsnes: *Cambrian and Ordovician Fossils from Sørkapp Land, Spitsbergen.* 1955. Kr. 4.00.
107. Feyling-Hanssen, Rolf W.: *Stratigraphy of the Marine Late-Pleistocene of Billefjorden, Vestspitsbergen.* 1955. Kr. 22.00.
108. Feyling-Hanssen, Rolf W.: *Late-Pleistocene Deposits at Kapp Wijk, Vestspitsbergen.* 1955. Kr. 3.00.
109. Donner, J. J. and R. G. West: *The Quaternary Geology of Brageneset, Nordaustlandet, Spitsbergen.* 1957. Kr. 5.00.
110. Lundquist, Kaare Z.: *Magnetic Observations in Svalbard 1596—1953.* 1957. Kr. 6.00.
111. Sverdrup, H. U.: *The Stress of the Wind on the Ice of the Polar Sea.* 1957. Kr. 2.00.
112. Orvin, Anders K.: *Supplement I to the Place-names of Svalbard. Dealing with new Names 1935—55.* 1958. Kr. 13.00.
113. Soot-Ryen, Tron: *Pelecypods from East-Greenland.* 1958. Kr. 4.00.
114. In preparation.
115. Groom, G. E. and M. M. Sweeting: *Valleys and Raised Beaches in Bünsow Land, Central Vestspitsbergen.* 1958. Kr. 3.00.
116. Svendsen, Per: *The Algal Vegetation of Spitsbergen.* 1959. Kr. 7.00.
117. Heintz, Natascha: *The Downtonian and Devonian Vertebrates of Spitsbergen. X. Two new Species of the Genus Pteraspis from the Wood Bay Series in Spitsbergen.* 1960. Kr. 3.00.
118. Rodahl, Kåre: *Nutritional Requirements under Arctic Conditions.* 1960. Kr. 8.00.
119. Rapp, Anders: *Talus Slopes and Mountain Walls at Tempelfjorden, Spitsbergen.* 1960. Kr. 25.00.
120. Orvin, Anders K.: *The Place-names of Jan Mayen.* 1960. Kr. 14.00.
121. Carstens, Harald: *Cristobalite-Trachytes of Jan Mayen.* 1961. Kr. 3.00.
122. Holland, Michael Frank William: *The Geology of Certain Parts of Eastern Spitsbergen.* 1961. Kr. 12.00.
123. Lunde, Torbjørn: *On the Snow Accumulation in Dronning Maud Land.* 1961. Kr. 9.00.
124. Rønning, Olaf I.: *Some New Contributions to the Flora of Svalbard.* 1961. Kr. 3.00.
125. Svein Manum: *Studies in the Tertiary Flora of Spitsbergen, with Notes on Tertiary Floras of Ellesmere Island, Greenland, and Iceland. A Palynological Investigation.* 1962. Kr. 26.00.

CHARTS

				Kr.
501	Bjørnøya	1: 40,000	1932	10.00
502	Bjørnøyfarvatnet	1:350,000	1937	10.00
503	Frå Bellsund til Forlandsrevet med Isfjorden	1:200,000	1932	10.00
504	Frå Sørkapp til Bellsund	1:200,000	1934	10.00
505	Norge–Svalbard, northern sheet	1:750,000	1933	10.00
506	» » southern »	1:750,000	1933	10.00
507	Nordsvalbard	1:600,000	1934	10.00
508	Kongsfjorden og Krossfjorden	1:100,000	1934	10.00
509	Frå Storfjordrenna til Forlandsrevet med Isfjorden	1:350,000	1946	10.00
510	Frå Kapp Linné med Isfjorden til Sorgfjorden	1:350,000	1946	10.00
511	Østgrønland, fra Liverpool Kyst til Store Koldeweys Ø (rev. 1958)	1:600,000	1937	10.00
512	Jan Mayen	1:100,000	1955	10.00
513	Svalbard-Havner	various	1959	10.00
514	Barentshavet	1:2,000,000	1960	10.00
515	Svalbard–Grønland	1:2,000,000	1962	10.00

The charts are distributed by Norges Sjøkartverk, Stavanger.

MAPS

General, geographical, topographical, and technical maps:

DRONNING MAUD LAND

				Kr.
Giæverryggen	F 5	1:250,000	1962	5.55
Borgmassivet	F 6	1:250,000	1962	5.55
Kirwanveggen	F 7	1:250,000	1961	5.55
Ahlmannryggen	G 5	1:250,000	1961	5.55
Jutulstraumen	G 6	1:250,000	1961	5.55
Neumayerskarvet	G 7	1:250,000	1961	5.55
Jutulgryta	H 5	1:250,000	1961	5.55
H. U. Sverdrupfjella	H 6	1:250,000	1961	5.55
Sør-Rondane		1:250,000	1957	5.55

GRØNLAND, Austgrønland

Eirik Raudes Land frå Sofiasund til Youngsund	1:200,000	1932	2.20	Out of print.
Claveringøya	1:100,000	1937	....	Published by NSIU 1937. Limited stock, not for sale.
Geographical Society-øya	1:100,000	1937	....	
Jordan Hill	1:100,000	1937	....	

JAN MAYEN

Jan Mayen		1:100,000	1955	2.20	Preliminary map.
Sør-Jan	Sheet 1	1: 50,000	1959	5.55	Also as supplement to Skrifter Nr. 120.
Nord-Jan	» 2	1: 50,000	1959	5.55	

SVALBARD

Svalbard		1:2,000,000	1958	2.20	Latest edition.
Kongsfjorden	A 7	1:100,000	1962	5.55	
Prins Karls Forland	A 8	1:100,000	1959	5.55	
Isfjorden	B 9	1:100,000	1955	5.55	
Van Mijenfjorden	B 10	1:100,000	1948	5.55	
Van Keulenfjorden	B 11	1:100,000	1952	5.55	
Torellbreen	B 12	1:100,000	1953	5.55	
Adventdalen	C 9	1:100,000	1950	5.55	
Markhambreen	C 12	1:100,000	1957	5.55	
Sørkapp	C 13	1:100,000	1947	5.55	
Adventfjorden–Braganzavågen		1:100,000	1941	2.20	
Hopen		1:100,000	1949	2.20	Preliminary map.
The Claims to Land in Svalbard		1: 50,000	1927	2.20	each. Nos. 1–33.
Bjørnøya		1: 25,000	1925	5.55	New ed. 1944 and 1955. Also as supplement to Skrifter Nr. 86.
Bjørnøya		1: 10,000	1925	....	6 sheets. Out of print.

The maps are distributed by Norges Geografiske Oppmåling, St. Olavs gt. 32, Oslo.

Wall map:				
Norden og Norskehavet	1:2,500,000	1959	....	Revised edition.

Obtainable through H. Aschehoug & Co. (W. Nygaard) A/S, Oslo.

A. W. BRØGGERS BOKTRYKKERI A/S - OSLO