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MICROFLORA OF THE LOWER CRETACEOUS MANNVILLE GROUP, EAST-CENTRAL ALBERTA

by Chaitanya Singh

Research Council of Alberta 87th Avenue and 114th Street Edmonton July, 1964

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Microflora of the Lower Cretaceous Mannville Group, East-Central Alberta

ABSTRACT

Three cored sections of the Lower Cretaceous Mannville Group from the subsurface of east-central Alberta were sampled for their microfloral content. The microflora recovered contains 53 genera and 120 species of microspores and pollen, 10 genera and 23 species of megaspores, 8 genera and 16 species of marine microplankton, and 2 specimens described as seeds. Sixteen microspore and pollen species, 7 megaspore species, and 2 microplankton species are new. The spore and pollen species are attributed to a megaflora composed of bryophytes, ferns, pteridosperms, cycads, and conifers; no angiosperm microfloral elements are present.

The Mannville microflora shows a complete gradation in evolutionary succession. The flora of the lower, continental McMurray Formation contains elements of the Wealden Arcellites [Pyrobolospora] flora, which shows that the base of the Mannville Group in east-central Alberta is not older than late Barremian. The microflora of the basal Deville Member is dated as late Barremian, and that of the overlying Ellerslie Member as Aptian. The upper "calcareous" member contains no diagnostic index species but is dated from its stratigraphic position as early to early middle Albian.

The microflora of the upper part of the Mannville Group, including the marine Clearwater and marine to continental Grand Rapids Formations, contains index species of Albian age, which support the middle Albian age assigned to these units on the basis of other fossil evidence.

The distribution of microplankton indicates a continental origin for the McMurray Formation, a marine origin for the Clearwater and lower Grand Rapids Formations, and a continental origin for the upper Grand Rapids Formation. The continental microflora suggests that a warm-temperate to subtropical humid climate prevailed in east-central Alberta during Mannville time.

INTRODUCTION

Palynological correlations have been applied widely to strata ranging from Silurian to Pleistocene in age. Most of the early investigations in palynology were restricted to the coal-bearing strata of the Paleozoic for the correlation of seams, and to Pleistocene deposits for glacial studies. However, during recent years, significant contributions have been made to Mesozoic palynology in northwestern Europe, Russia, Australia, and North America, where palynology has become established as a valuable research discipline for stratigraphic correlation and paleoecological and

evolutionary studies of floras. Several oil companies have collected substantial amounts of information about the spore and pollen complexes of Mesozoic strata in Canada and other countries and have applied it successfully to stratigraphic problems. It is anticipated that in future marine microplankton will be widely used for zoning of marine beds and will enable palynologists to extend their activity to the older, largely marine strata of pre-Silurian age.

Scope of the Project

Fossil pollen and spores are found in both freshwater and brackish to marine facies of the subsurface Lower Cretaceous Mannville Group of central Alberta. The brackish to marine middle portion of the Mannville (Clearwater Formation) has yielded foraminifera of middle Albian age, but the age of the continental lower Mannville (McMurray Formation), which contains only freshwater pelecypods and ostracodes, is in dispute.

The principal objectives of this study are to describe the microfloral assemblages and zones of the Mannville Group of east-central Alberta and to determine the age of the continental lower part of the Mannville. The broad plant groups which constitute the Mannville flora are also described, and a paleoecological and paleoclimatic interpretation is presented.

Previous Work

The first description of Lower Cretaceous microfloras in North America, from the coals of the Kootenai Formation in Montana, was published by Miner (1935b). Rouse (1959) published a paper on the Kootenay coal-measures of British Columbia. Groot and Penny (1960) subsequently described plant microfossils from the Potomac Group (Lower Cretaceous to lowermost Upper Cretaceous) of Maryland and Delaware in the United States. Pocock (1962) recently described the microfloral assemblages pertinent to the delineation of the Jurassic-Cretaceous boundary in the Western Canadian Plains, obtained from strata ranging in age from the Vanguard Formation (Late Jurassic) to the Wabiskaw Member of the Mannville Group (middle Albian). Pocock's samples were collected from 18 localities in Alberta and southern Saskatchewan, and although the investigation was meant to be only a reconnaissance study, it is a valuable guide to more detailed work. In addition, Pocock (in press) has described pollen and spores of the Chlamydospermidae and Schizaeacae from the upper Mannville equivalents in the Saskatoon area of Saskatchewan. Steeves also has made detailed studies on the Lower Cretaceous microfloras of Saskatchewan (in press).

Extensive work has been published on Lower Cretaceous microfloras of Europe. Thiergart (1949) attempted to construct a succession of microfloral zones from the Lower Keuper (Triassic) to Paleocene (Tertiary) of Germany and Austria. Dijkstra (1951) and Hughes (1955) have published

papers on the Wealden megaspores. Delcourt and Sprumont (1955, 1957) and Couper (1958) have described Mesozoic, especially the Wealden, spores and pollen of Europe. Deflandre (1936, 1937), Gocht (1957, 1959) and Eisenack (1958) have made important contributions to the study of Lower Cretaceous marine microplankton of Europe. In Russia, Bolkhovitina (1953, 1956 and 1959) and Maljavkina (1956, 1958) have carried out major studies on Mesozoic, especially Lower Cretaceous, palynology. Samoilovitch and Mchedlishvili (1961) have compiled the information available on pollen and spores of Jurassic to Paleocene ages in western Siberia.

In Australasia, Couper (1953, 1960) has published papers on Mesozoic and Cenozoic spores and pollen from New Zealand. Balme (1957) has described and illustrated Mesozoic spores and pollen grains from Western Australia. Cookson and Dettmann (1958a, 1958b and 1959) have published many papers on Mesozoic (especially Lower Cretaceous) microspores and megaspores of Australia. Cookson and Eisenack (1958, 1960 and 1962) have made significant contributions to the study of Mesozoic microplankton from Australia and New Guinea.

Acknowledgments

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LOCATION OF SAMPLES AND LABORATORY TECHNIQUES

Location of Samples

Cored sections of the Mannville Group were sampled in three wells from east-central Alberta (Fig. 1) for microfloral analysis. A total of 156 samples were selected from the shaly portions of the cored intervals and processed for microfloral content. The locations of the three wells, thicknesses of the Mannville Group and cored intervals, and number of samples from each well are shown in table 1.

Table 1. Thickness of Mannville Group, Cored Footage, and Number of Samples Analysed from the Three Wells Studied

Well	Location	Thickness of Mannville Group (feet)	Total Cored Footage	Number of Samples
Imperial Namao No. 1	Lsd. 12, Sec. 22, Tp. 54, R. 24, W. 4th Mer.	830	375	30
Anglo-Home-C. and E. Fort Augustus No. 1	Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.	854	854	92
Imperial Willingdon No. 1	Lsd. 14, Sec. 14, Tp. 55, R. 15, W. 4th Mer.	362	362	34

Sample depths and locations are given in tables 2, 3 and 4 (in pocket).

Sampling Procedure

The Mannville Group in each of the three wells studied (Fig. 1) consists of alternating dark grey shale, siltstone, and sandstone intervals ranging in thickness from less than one inch to several feet. Only the shaly and silty intervals in each well were sampled. Several spot samples were taken from an interval ranging from 2 to 10 feet thick and combined to give a representative sample for that interval. Even the sandier portions of the cores generally contained sufficient shale or siltstone partings to yield representative samples.

Sample Preparation

The sample preparation technique is based on procedures described by Funkhouser and Evitt (1959) and Staplin *et al.* (1960). The steps involved are summarized below (Note: after each chemical treatment, the samples were centrifuged and washed in distilled water):

(1) Ten to fifteen grams of sample were washed, crushed and placed in a polyethylene bottle. Calcareous samples were treated with 85 per cent orthophosporic acid diluted 50 per cent with distilled water.

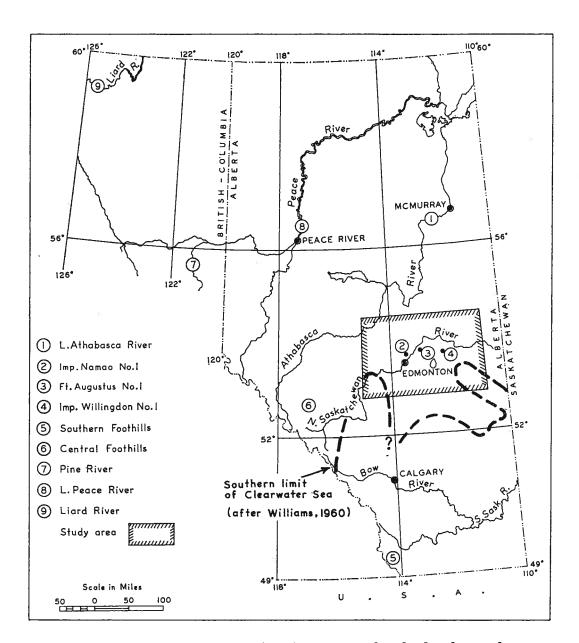


FIGURE 1. Index map of Alberta and northeastern British Columbia showing locations of wells studied and cited outcrop localities.

- (2) The sample was digested in 48 per cent hydrofluoric acid for 24 hours.
- (3) The sample was oxidized with fresh Schultze's solution for 15 to 20 minutes; coaly samples were oxidized for 3 to 4 hours.
- (4) The sample was suspended in 5 per cent potassium carbonate for 3 to 5 minutes, and then diluted in distilled water as soon as the

liquid turned dark brown. Care was taken at this stage not to dissolve the more fragile spores.

- (5) The sample was wet-sieved through a 100-mesh screen. Material remaining on the sieve was searched for megaspores.
- (6) The material passing through sieve was suspended in zinc bromide heavy liquid with a specific gravity of 2 and then centrifuged. Organic material collected at the top of the test tube and was removed for mounting.
- (7) The organic residue was mounted in corn syrup on glass microscope slides. A few samples were also mounted in polyvinyl alcohol (Elvanol Grade 51-05) as permanent mounts.

Counting Procedure

Generally, three slides per sample were examined by traversing each slide at a magnification of $\times 125$ lengthwise along lines 5 mm. apart. Identifiable and well-preserved specimens of various species were counted and recorded as abundant (10 or more specimens), common (5 to 9 specimens), rare (2 to 4 specimens), or single (1 specimen). Thus, a rough estimate of the relative frequency of each species in each sample was made. Three or more slides from the same sample were searched again under low power ($\times 31.25$) for rarer specimens.

Photomicrography

Photomicrographs were taken on a Carl Zeiss Polarizing Photomicroscope. Adox KB14 35 mm. film was used, and the photographs were printed on Kodak Polycontrast F single-weight paper. Polycontrast filters were used to produce sufficient contrast on the prints. A blue filter was used normally in taking photographs, but for very dark and opaque spores a dark red filter was used. Some oil-immersion photomicrographs were also taken.

All figured specimens are shown on the plates at a magnification of $\times 500$ to emphasize the relative size-differences. In addition, some of the finer details are illustrated at higher magnifications.

Designation and Preservation of Type Specimens

Most holotypes have been preserved as single spore or pollen slides; holotypes too small or too fragile to be removed have been left on the composite slides.

Holotypes on the single spore or pollen slides have been designated as follows:

(1) by the serial number of the slide, preceded either by Micro. (microspore or microplankton) or Mega. (megaspore) (e.g. Micro. 140).

- (2) by the code of the type locality:
 - IN = Imperial Namao No. 1 well
 - FA = Anglo-Home-C. and E. Fort Augustus No. 1 well
 - IW = Imperial Willingdon No. 1 well
- (3) by the depth interval (in feet) from which the sample was obtained (e.g. IN 3716-3726).
- (4) by the stage co-ordinates. The "vertical reading" is given first, and the "horizontal reading" next (e.g. 3/36). The name of the species is given on each slide.

To facilitate the locating of a holotype, a small red or blue waterproofink dot has been placed close to the specimen. Thus, it can be easily located without using the co-ordinates.

Holotypes on the composite slides have been designated as follows:

- (1) by the code of the type locality.
- (2) by the depth interval.
- (3) by the number of the slide for the sample from that depth interval.

In many cases more than five slides were made from one sample. Thus, for example, the designation FA 2842-2851-4 means that the type locality is Anglo-Home-C. and E. Fort Augustus No. 1 well, the sample was taken between the depths of 2842 and 2851 feet, and the slide is the fourth from that sample. No serial number is given to the slide in this case. In all other respects the designation of the holotype on a composite slide is the same as for single spore or pollen slides.

All holotypes and other figured specimens, slides, processed residues, and unprocessed portions of samples are deposited in the paleobotanical collection of the Research Council of Alberta.

STRATIGRAPHY OF THE MANNVILLE GROUP

Definition of the Mannville Group

Nauss (1945, 1947) introduced the name Mannville Formation for a succession of Lower Cretaceous continental and marine strata lying between the eroded surface of the Paleozoic and the marine Colorado Shale in the subsurface of the Plains of east-central Alberta. Badgley (1952) raised the Mannville Formation of the Edmonton-Lloydminster area to group status and divided it into the three formational units recognized in outcrops to the northeast on the Athabasca River (McLearn, 1917). These are, in ascending order, the McMurray, Clearwater, and Grand Rapids Formations. He excluded from this definition of the Mannville Group an underlying succession of detrital and residual matter deposited in depressions on the Paleozoic surface, for which he proposed the name Deville Formation. Williams (1960) accepted Badgley's threefold division of the Mannville Group but included in it the underlying Deville Formation as the basal member of the McMurray Formation. He called the middle part of the McMurray Formation the Ellerslie Member after Hunt's (1950) unit which spans approximately the same stratigraphic interval, and the upper part the "calcareous" member, an informal term proposed by Glaister (1959) to replace Hunt's (op. cit.) term, "ostracode zone". Williams' terminology is used in this report.

McMurray Formation

The McMurray Formation in the Edmonton area usually consists of a basal unit of residual detritus called the Deville Member, a middle-quartz-sandstone succession known as the Ellerslie Member, and an upper set of calcareous shaly beds which is termed informally the "calcareous" member or "ostracode zone" (Williams, 1960). The top of the formation is marked by the basal glauconitic sandstone (Wabiskaw Member) of the overlying Clearwater Formation, and the base is marked by the unconformable contact with the underlying Paleozoic carbonates. Contacts between the three members of the McMurray Formation are usually gradational.

The McMurray Formation was deposited in a gently undulating series of subparallel northwest-trending valleys and ridges developed in the underlying Paleozoic surface (Fig. 2). For this reason, its thickness varies from 0 to about 350 feet, depending on local topography.

The Deville, Ellerslie and "calcareous" Members are 35 feet, 248 feet, and 42 feet thick, respectively, in Imperial Namao No. 1 well; 77 feet, 212 feet, and 45 feet thick, respectively, in Anglo-Home-C. and E. Fort Augustus No. 1 well, but all three members are missing through non-deposition from Imperial Willingdon No. 1 well (Fig. 3).

The Deville Member as described by Badgley (1952, p. 7) consists of "greenish grey, waxy shales; greenish grey, silty shales; greenish grey, shaly siltstones; greyish green, argillaceous, quartzose sandstones; and dark reddish brown shales and silty shales. Sideritic nodules are commonly embedded in the shales."

The name Ellerslie was applied by Hunt (1950) to the "Quartz Sand Series" (Layer, 1949) of the Edmonton area. The Ellerslie Member as described by Williams (1960) consists of "very fine- to medium-grained sandstone, siltstone, and silty, micaceous, somewhat carbonaceous grey shales . . . the sandstones typically contain 75 to 95 per cent quartz, 5 to 15 per cent rock fragments (mainly quartzites and metamorphic rocks) and 0 to 8 per cent orthoclase feldspar. Muscovite is common, especially in shaly laminae . . . In general, the lowest beds tend to be coarser grained, somewhat conglomeratic and occasionally cross-bedded; the middle portion becomes fine-grained and massive; and the upper beds tend to be very fine-grained sandstone to siltstone, more shaly and finely bedded to laminated. The characteristics of these beds coincide fairly well with Carrigy's (1959) subdivision of the type McMurray Formation."

The "calcareous" member (Glaister, 1959), or "ostracode zone" (Hunt, 1950), is composed of dark grey, slightly brownish to black, calcareous shales, silty shales, and thin calcareous sandstones. Sideritic coquinas of gastropod, pelecypod, ostracode, and fish remains are common.

Clearwater Formation

In the Edmonton area the Clearwater Formation consists mainly of dark grey, somewhat blocky marine shales, dark grey silty shales, and very fine- to medium-grained, glauconitic, "salt and pepper" sandstones. The lower part of the formation consists of a persistent glauconitic sandstone known as the Wabiskaw Member (Badgley, 1952), and the upper part mainly of dark grey marine shales interbedded with glauconitic siltstones and fine-grained sandstones. The Clearwater Formation is transitional with the underlying "calcareous" member of the McMurray Formation in Imperial Namao No. 1 and Anglo-Home-C. and E. Fort Augustus No. 1 wells but rests unconformably on Paleozoic carbonates in the Imperial Willingdon No. 1 well. The top of the Clearwater Formation is transitional, the upper shale beds interfingering with the overlying sandy beds of the Grand Rapids Formation.

The Clearwater Formation maintains a relatively constant thickness in east-central Alberta but becomes shalier at the expense of the overlying Grand Rapids Formation toward the north. The Wabiskaw Member and the overlying shale beds of the Clearwater Formation are 55 and 110 feet thick, respectively, in Imperial Namao No. 1 well; 70 and 195 feet thick, respec-

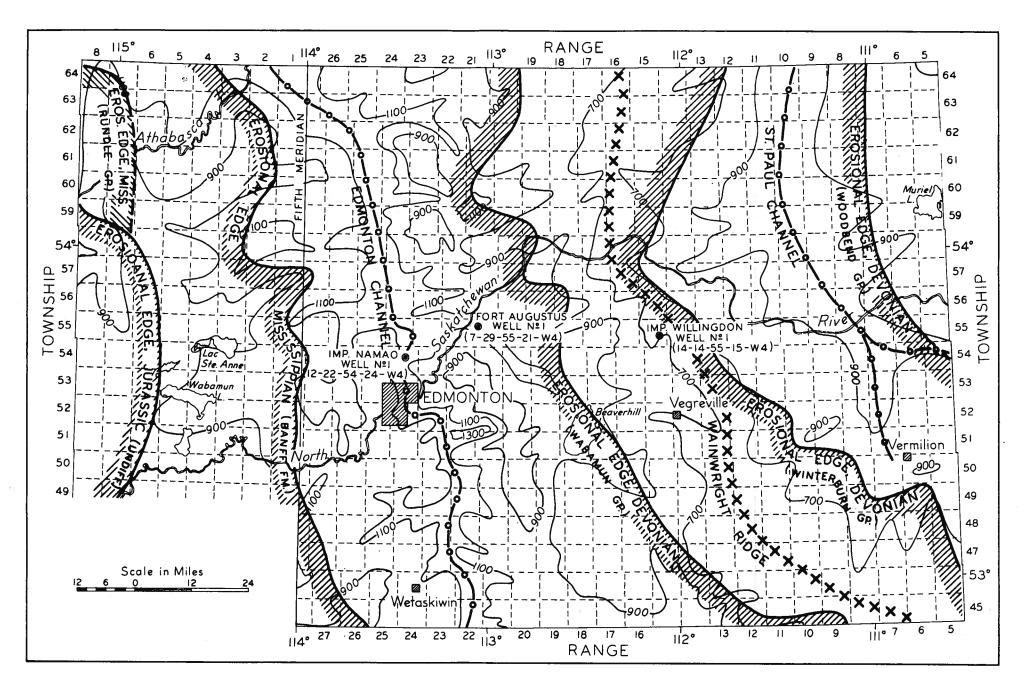


FIGURE 2. Map showing the geology of the pre-Mannville surface and thickness of Lower Cretaceous strata (pre-"Fish scale sand" interval) in east-central Alberta. After Williams (1960).

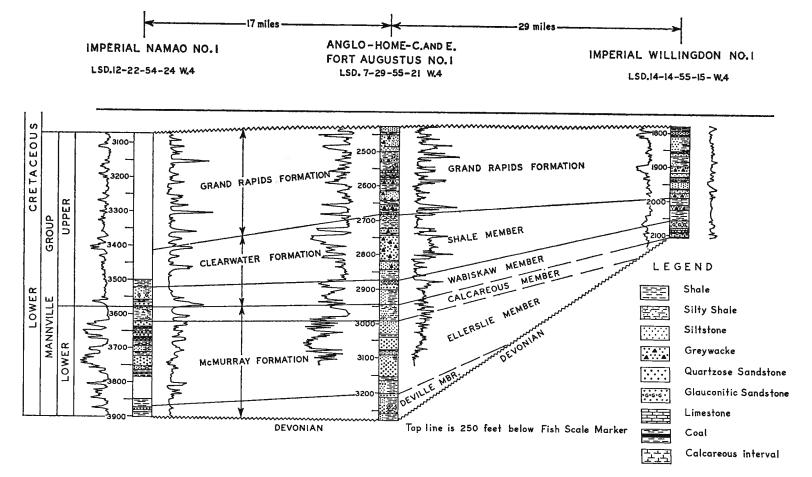


FIGURE 3. Columnar sections showing the correlation of the Mannville Group in the three wells studied.

tively, in Anglo-Home-C. and E. Fort Augustus No. 1 well, and 52 and 65 feet thick, respectively in Imperial Willingdon No. 1 well (Fig. 3).

The Wabiskaw Member in central Alberta is described by Williams (1960, p. 39) as follows: "The Wabiskaw Member consists of very fine-to medium-grained "salt and pepper" sandstones containing abundant sedimentary and low rank metamorphic rock fragments (including some chert), dark grey silty shales and thin stringers of siderite. The glauconite content is variable, both laterally and vertically, at one point attaining a concentration of about 12 per cent, and is predominantly dark green in colour . . . Throughout the area the top of the member is more distinct than the base and forms an easily recognized electric log and lithologic marker."

The shale member of the Clearwater Formation consists of massive, medium grey shale and silty shale with a few thin ironstone bands in the upper part, thin streaks of white micaceous sand, and increasingly glauconitic sandy shale beds toward the base.

Grand Rapids Formation

In the Edmonton area the Grand Rapids Formation consists mainly of medium-grained, well sorted, iron stained, feldspathic, "salt and pepper" sandstones, medium grey silty carbonaceous shale and coal. The lower part of the formation interfingers with the underlying Clearwater Shale and is transitional with that formation. The upper beds are more continental in aspect, and the upper boundary is placed at the contact with the overlying marine Joli Fou Shale, although thin, reworked quartzose sands—St. Edouard Member (Badgley, 1952)—are developed in places at the base of the Joli Fou and are difficult to distinguish from the underlying Grand Rapids sandstones.

The Grand Rapids Formation is 340 feet thick in the Imperial Namao No. 1 well, 255 feet thick in the Anglo-Home-C. and E. Fort Augustus No. 1 well and 209 feet thick in the Imperial Willingdon No. 1 well (Fig. 3).

Age and Correlation

The relationship of the Mannville Group of central Alberta to correlative strata in other parts of the Western Canada sedimentary basin is shown in figure 4. The McMurray Formation is correlative with the lower Blairmore, lower Luscar, and Gething Formations of the Foothills; and the McMurray and "Bullhead" Formations of the northern Plains. The Clearwater and Grand Rapids Formations are correlative with the middle Blairmore, upper Luscar and Mountain Park, and Moosebar and lower Commotion Formations of the Foothills, as well as the Loon River-Clearwater and Peace River-Grand Rapids Formations of the northern Plains.

	LOWER ATHABASCA RIVER			GUSTUS NO. I WELL AND L NAMAO NO. I WELL	IA	MPERIAL WILLINGDON NO. 1 WELL		SOUTHERN FOOTHILLS	CENTRAL FOOTHILLS	PINE RIVER B.C.	LOWER PEACE RIVER	LIARD RIVER B.C.
L.	A BICHE FORMATION		cor	ORADO GROUP	,	COLORADO GROUP		UPPER BLAIRMORE FORMATION	BLACKSTONE FORMATION		SHAFTESBURY FORMATION	
L	PELICAN FORMATION	٠	/IKI	NG FORMATION	٧	VIKING FORMATION						
),	OLI FOU FORMATION	JC	LI I	FOU FORMATION	٥١	OLI FOU FORMATION				HASLER FORMATION	PADDY MEMBER	
										COAL, CGL. VOILE UPPER SANDSTONE MEMBER	CADOTTE MEMBER	LEPINE FORMATION
ш	<u> </u>	╁	╁	111111	Щ					MIDDLE SHALE	HARMON MEMBER	
	GRAND RAPIDS FORMATION			GRAND RAPIDS		GRAND RAPIDS FORMATION	GROUP	l .	MOUNTAIN PARK FORMATION	MEMBER W O LOWER SANDSTONE MEMBER	NOTIKEWIN MEMBER	
FORMATION	SHALE MEMBER		UPPER	SHALE MEMBER	FORMATION	SHALE MEMBER	BLAIRMORE	BLAIRMORE			NOTE THE MEMBER	
CLEARWATER FO		GROUP		- KWATER	RWATER			FORMATION	N O	MOOSEBAR FORMATION	WILRICH MEMBER	GARBUTT FORMATION
1	WABISKAW MEMBER	=	4		CLEA	WABISKAW MEMBER		71	NARINE TONGUE CALCAREOUS		BLUESKY MEMBER	
M	CMURRAY FORMATION	MANNVILLE	9	CALCAREOUS MEMBER OLIVER MEMBER MEMBER				CALCAREOUS MEMBER SANDSTONE MEMBER	CALCAREOUS MEMBER	GETHING FORMATION	"BULLHEAD" FORMATION	
Ш	DEVILLE MEMBER	\prod		DEVILLE MEMBER			Τ	BLAIRMORE CGL.	CADOMIN CGL.	DUNLEVY FORMATION		
	DEVONIAN		DE	EVONIAN		DEVONIAN		JURASSIC	JURASSIC	JURASSIC	JURASSIC	TRIASSIC

FIGURE 4. Chart showing the correlation of Lower Cretaceous strata in Alberta and northeastern British Columbia.

The McMurray Formation and correlative strata are of dominantly nonmarine origin, although the beds in the upper part of the unit along the Athabasca River contain shallow-water arenaceous foraminifera (Mellon and Wall, 1956). In addition, throughout most of the Foothills and central Plains regions, the "calcareous" member at the top of the lower Blairmore-McMurray succession contains abundant fresh- or brackish-water molluscs and ostracodes (Loranger, 1951; Badgley, 1952), which has led to the name "ostracode zone" being applied to this unit (Hunt, 1950). Plant fossils are also abundant in the lower Blairmore strata of the Foothills (Bell, 1956), and a prolific microflora has been described from these and correlative beds by Pocock (1962).

Various ages have been assigned to the lower Blairmore-McMurray Formations on the basis of their fossil content. Loranger (op. cit.) dated the "calcareous" member as Aptian on the basis of its ostracode assemblage; Mellon and Wall (1961) dated the "calcareous" member as Albian on the basis of its foraminiferal content in the Barnsdall West Wabiskaw No. 1 well; and Pocock (op. cit.) dated the lower Blairmore-McMurray succession as Neocomian on the basis of its microfloral content. Thus, there is some conflict as to the age of this unit in various parts of the Western Canada sedimentary basin.

In contrast, the Clearwater Formation and equivalent strata are of marine origin and have yielded a prolific microfauna from various parts of the Foothills and Plains (Stelck et al., 1956; Mellon and Wall, 1961; Mellon et al., 1963), which has been dated as middle Albian on the basis of its association with the ammonite Subarcthoplites mcconnelli (Whiteeaves-. The overlying Grand Rapids Formation in central Alberta contains no diagnostic marine fossils but does contain a megaflora that can be correlated with the middle Blairmore and lower Commotion floras of the Foothills (C. R. Stelck, pers. comm.). This flora, from its association with the underlying Clearwater microfauna, is also dated as middle Albian. However, dicotyledonous elements, such as those found in the upper Blairmore and Commotion Formations of the Foothills, have not been described from the Grand Rapids Formation (Mellon et al., 1963).

Several fossil assemblages are present in the three wells sampled for this study.

Williams (1960) reported the following megafauna from the Imperial Namao No. 1 well:

Wabiskaw Member

Murraia naiadiformis Russell Pinna? sp. Eupera sp. cf. E. onestae (McLearn) Scalez sp. 14

"calcareous" member

Viviparus murraiensis Russell

Melania multorbis Russell

Onestia? sp.

Murraia sp.

Sphaerium sp.

Corbula? sp. cf. C. palliseri McLearn

Solecurtis? sp.

Ellerslie Member

Astarte natosini McLearn

Melania multorbis Russell.

Mellon and Wall (1961) reported the following microfauna from the Anglo-Home-C. and E. Fort Augustus No. 1 well:

"calcareous" member

Bairdiocypris albertensis Loranger

Candona stirlingensis Loranger

Cythereis calmontensis Loranger

Cythereis inflata Loranger

Metacypris angularis Loranger (not Peck)

Metacypris persulcata Loranger (not Peck).

Clearwater and Grand Rapids Formations

Ammobaculites fragmentaria Cushman

Ammomarginulina sp. cf. A. obliquus Loeblich and Tappan

Gaudryina sp. cf. G. hectori Nauss

Haplophragmoides gigas minor Nauss

Haplophragmoides sp.

Miliammina sproulei Nauss

Miliammina subelliptica Mellon and Wall

Proteonina sp.

Reophax sp.

Psamminopelta sp. cf. P. bowsheri Tappan

Trochammina sp.

Verneuilinoides cummingensis (Nauss)

Globulina lacrima canadensis Mellon and Wall

Globulina sp.

Marginulinopsis collinsi Mellon and Wall

Quadrimorphina albertensis Mellon and Wall.

Williams (1960) reported the following microfauna from the Imperial Namao No. 1 well, from the Clearwater shale member:

Ammobaculites humei Nauss

Bathysiphon sp.

Nodosinella sp.

Pseudonodosaria clearwaterensis Mellon and Wall

Saracenaria projectura Stelck and Wall
Dentalina sp.
Globulina lacrima canadensis Mellon and Wall
Marginulinopsis collinsi Mellon and Wall
Bimonilina [Tritaxia] athabascensis (Mellon and Wall)
Haplophragmoides gigas minor Nauss.

Only shallow-water arenaceous foraminifera were recovered by the writer from the Imperial Willingdon No. 1 well, which is situated on the flank of a Paleozoic "high". This suite consists of the following species:

Grand Rapids Formation

Miliammina sproulei Nauss Verneuilinoides cummingensis (Nauss) Ammobaculites sp.

Clearwater shale member

Haplophragmoides gigas minor Nauss
Haplophragmoides sluzari Mellon and Wall
Ammobaculites humei Nauss
Eggerella sp.
Leptodermella sp.
Psamminopelta sp. cf. P. bowsheri Tappan
Miliammina sproulei Nauss
Bimonilina [Tritaxia] athabascensis (Mellon and Wall)
Reophax sp.
Trochammina sp.
Ammodiscus sp.

Williams (1960) reported the following megaflora from the Imperial Namao No. 1 well, in the Ellerslie Member:

Pityophyllum nordenskjöldi (Heer) Krystofovich Sphenopteris sp.

A more extensive flora was collected by G. B. Mellon and J. H. Wall from the Anglo-Home-C. and E. Fort Augustus No. 1 well, from the Grand Rapids Formation between 2469 and 2555 feet. The flora, identified by C. R. Stelck, consists of the following species:

Sphenopteris brulensis Bell
Cladophlebis sp.
Sagenopteris sp. cf. S. elliptica Fontaine
Ptilophyllum sp. cf. P. hirtum Bell
Ptilophyllum montanense (Fontaine)
Nilssonia canadensis Bell
Cyparissidium? sp. cf. C.? gracile? Heer
Athrotaxites berryi Bell
Pagiophyllum ambiguum (Heer) Seward.

A few plant fossils were collected by the writer from the Grand Rapids Formation in the Imperial Willingdon No. 1 well between depths of 1846 and 1881 feet. The flora consists of the following species:

Athrotaxites berryi Bell Sphenopteris sp. cf. Ruffordia goepperti (Dunker) Seward.

The Ellerslie Member and "calcareous" member assemblages listed above contain only long-ranging or nondescript species, the age of which is in dispute. However, the Clearwater and Grand Rapids microfaunal assemblages verify a middle Albian age for these units in the three wells.

Depositional Environment and Paleogeography

The Mannville Group in central Alberta consists of a succession of alternating continental, marine, and shoreline beds that forms part of a much larger body of sediments deposited immediately prior to and during the advance of Early Cretaceous boreal seas over much of western Canada.

The basal McMurray Formation appears to be dominantly of continental origin. The Deville beds at the base consist partly of oxidized residual detritus, developed through slow weathering of the underlying Paleozoic carbonates, that grades into the overlying fluviatile quartzose sandstones and silty shales of the Ellerslie Member. The calcareous, ostracode-bearing beds at the top of the formation appear to mark a change from definitely continental to marine conditions of sedimentation, as many of these fossils have been interpreted as brackish-water types.

The Wabiskaw Member of the Clearwater Formation marks the farthest advance of the boreal Early Cretaceous sea (Fig. 1). The glauconitic sands themselves are probably near-shore bar deposits, whereas the overlying Clearwater shales are indicative of deeper-water conditions. The gradational contact between the Clearwater and overlying Grand Rapids Formations marks the gradual retreat of the sea to the north, and a return to continental conditions of sedimentation (including conditions favorable to the formation of coal seams) which prevailed in late Grand Rapids time.

STRATIGRAPHIC PALYNOLOGY OF THE MANNVILLE GROUP

Introduction

Examination of core samples from three wells in east-central Alberta shows that the Mannville Group contains a rich microflora. One hundred and sixty-one species are listed and described in the section on Formal Descriptions, of which 120 species are identified as microspores and pollen, 23 species as megaspores, 2 species as seeds, and 16 species as microplankton. Most of these species have been previously described; 16 species of microspores and pollen, 7 species of megaspores, and 2 species of microplankton are new.

Certain species of spores and pollen, described here as "index species", with restricted stratigraphic ranges and widespread distribution, are very useful for intercontinental correlations. However, because environmental conditions are not everywhere similar at the same time, a species may appear at different times in different places, depending upon the availability of suitable conditions. Conversely, climatic and ecologic changes may cause a species to become extinct in one part of the world, whereas it may survive elsewhere for a longer period of time. Thus, environmental and geographic barriers hinder the uniform distribution of species and restrict them to definite areas of the world. Therefore, it is necessary to establish the local geologic range, the entrance level, and the acme or peak zone for each index species from a large number of localities distributed all over the world in order to establish its total geologic range. When many index species with known stratigraphic ranges and entrance levels are found in a bed, its age can be ascertained with a greater degree of certainty.

Many of the previously described Mannville microfloral species are long-ranging forms of little stratigraphic value. Their stratigraphic distribution is shown in tables 2, 3, and 4 for each of the three wells studied, but no further comment on their presence in the Mannville Group is warranted here. Only those previously described or new species with a restricted stratigraphic distribution are discussed below under the caption of "index species." These include species that to date have not been found outside of western Canada and, therefore, are useful for local correlations only, as well as stratigraphically restricted species with a wide geographic distribution.

The geological ranges of the Mannville Group index species are not sufficiently narrow to be restricted to a member of the group. Therefore, in order to eliminate the possibility of misinterpretation as a result of reworking or the continuance of older index species at younger levels, the

following rules have been used in interpreting the age of the Mannville microflora:

- (1) Only the entrance levels of the index species have been used to determine the age of a member. The "entrance level" is defined as the oldest known level at which a species makes its first appearance in the geologic column. "First appearance", on the other hand, simply means the level of first appearance of a species in a particular section. Where older beds are missing, long-ranging species commonly make their first appearance in beds younger than those in which they make their entrance.
- (2) Only the youngest species in a member have been used to determine its age.

Index Species of the Mannville Group

Statistical studies involving counts of the relative abundances of selected species have not been made. Such studies are used only for local correlations as they reflect local changes in environment. However, rough estimates of the relative abundance of each species in each sample have been recorded in tables 2, 3 and 4 (in pocket), and a quantitative estimate of the relative abundance and stratigraphic distribution of the megaspores in the Mannville Group is given in table 5. The stratigraphic distribution of index species in the Mannville Group for all three wells is summarized in table 6.

The index species in each of the Mannville stratigraphic units are listed below. The spore and pollen species are grouped according to their relative value as age indicators as follows:

- Group A: Index species with youngest Early Cretaceous entrance levels;
- Group B: Index species with older Early Cretaceous entrance levels;
- Group C: Index species with Jurassic entrance levels;
- Group D: Index species found only in the Mannville Group and equivalent strata.

McMurray Formation, Deville Member

Forty-four species of microspores and pollen and six species of megaspores were recorded from the Deville Member. All 50 species make their first appearance in east-central Alberta in the Deville Member as it overlies Paleozoic strata unconformably. However, their first appearance should not be confused with their entrance level, for strata of Berriasian to Hauterivian ages are probably not present at the base of the Mannville Group in central Alberta.

The index species are listed below:

Group A

Trilobosporites hannonicus (Delcourt and Sprumont) Potonié; entrance level: Aptian?, Belgian "Wealden".

Pilosisporites verus Delcourt and Sprumont; entrance level: Aptian?, Belgian "Wealden".

Couperisporites complexus (Couper) Pocock; entrance level: Barremian, English Wealden.

Dijkstraisporites helios (Dijkstra) Potonié; entrance level: upper Barremian, English Wealden.

Arcellites disciformis Miner, emend. Ellis and Tschudy (?=Pyrobolospora hexapartita (Dijkstra) Hughes); resembles P. hexapartita so closely that the two are probably conspecific.¹

Entrance level of *P. hexapartita* is in the upper Barremian (Wealden Marls) of the English Wealden. *A. disciformis* itself has been reported from the Albian or Cenomanian of the central United States (Ellis and Tschudy, 1964) and Greenland (Miner, 1035a). The one exception to an Albian or Cenomanian age is its occurrence in the Patuxent Formation of Virginia reported by Chaloner (Ellis and Tschudy, 1964). The age of the Patuxent Formation, however, is uncertain, having been dated as Berriasian (Stephenson *et al.*, 1942) to Aptian-Albian (Spangler and Peterson, 1950).

Group B

Appendicisporites tricornitatus Weyland and Greifeld; entrance level: top of Berriasian, Fairlight Clay of the English Wealden.

Appendicisporites crimensis (Bolkhovitina) Pocock; entrance level: Hauterivian, Crimea, Russia.

Cicatricosisporites mediostriatus (Bolkhovitina) Pocock; entrance level: Hauterivian, Crimea, Russia.

Trilobosporites apiverrucatus Couper; entrance level: Berriasian, Fairlight Clay of the English Wealden.

¹In a recent paper Potter (1963) has transferred *Pyrobolospora hexapartita* (Dijkstra) Hughes to the genus *Arcellites*. Ellis and Tschudy (1964, p. 76) have subsequently pointed out that *A. hexapartitus* (Dijkstra) Potter is distinct from *A. disciformis* Miner, emend. Ellis and Tschudy.

Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.; entrance level: Berriasian, Fairlight Clay of the English Wealden.

Schizosporis reticulatus Cookson and Dettmann; entrance level: Neocomian, South Australia.

Schizosporis parvus Cookson and Dettmann; entrance level: Albian, South Australia.

Maexisporites obolus (Dijkstra) Potonié; entrance level: Hauterivian, English Wealden.

Group C

Appendicisporites cooksonii (Balme) Pocock; known range: Callovian to upper Albian, Western Australia.

Dictyotriletes pseudoreticulatus (Couper) Pocock; known range: upper Purbeck to Lower Cretaceous, in various regions.

Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont; known range: upper Purbeck to Lower Cretaceous, in various regions.

Staplinisporites caminus (Balme) Pocock; known range: Oxfordian to Aptian, Western Australia.

Group D

Appendicisporites jansonii Pocock

Trilobosporites canadensis Pocock

Concavissimisporites parkinii (Pocock) n. comb.

Rouseisporites reticulatus Pocock

Cooksonites variabilis Pocock

Cooksonites reticulatus Pocock

Cedripites canadensis Pocock

Equisetosporites concinnus n. sp.

Arcellites rugosus n. sp.

The 5 species listed under group A are those with the youngest entrance levels recorded from Lower Cretaceous strata outside of western Canada. They indicate that the upper part of the Deville Member is not older than late Barremian in age.

The 12 species listed under groups B and C are those that make their entrance elsewhere in older strata of Cretaceous or Jurassic age. Their appearance at the same level in the Deville Member also indicates that pre-Barremian strata are not present at the base of the Mannville Group in central Alberta. None of the group C species, except *Pilosisporites trichopapillosus*, is common in the Clearwater and Grand Rapids Formations, where their rare presence is probably due to reworking.

McMurray Formation, Ellerslie Member

Ninety-five species of microspores and pollen and sixteen species of megaspores were recorded from the Ellerslie Member. Of these, 66 species make their first appearance in central Alberta in this member. Of the 50 species recorded from the Deville Member, only 5 do not persist into the Ellerslie Member. Their absence does not have any stratigraphic significance, as three of these are present again in the upper part of the Mannville Group. Thus, the microfloral assemblages from the Deville and Ellerslie Members basically are similar, although a few younger index species make their entrance in the Ellerslie Member.

The index species are listed below:

Group A

Cicatricosisporites perforatus (Baranov et al.) n. comb.; entrance level: Aptian, Siberia, U.S.S.R.

Trilobosporites trioreticulosus Cookson and Dettmann; entrance level: Aptian, eastern Australia.

Group B

Appendicisporites sp. cf. A. pschekhaensis (Bolkhovitina) Pocock; entrance level: Neocomian, Russia.

Taurocusporites segmentatus Stover; known range: Lower Cretaceous, Maryland, U.S.A.

Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann; known range: Neocomian to Albian, eastern Australia; Lower to Upper Cretaceous, U.S.S.R.

Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock; known range: ?-Albian, eastern Australia.

Parvisaccites radiatus Couper; entrance level: Berriasian in Fairlight Clay of the English Wealden, peak zone: Barremian-Aptian in the Weald Clay, Weald Shales, and Lower Greensand.

Horstisporites reticuliferus (Dijkstra) Potonié; known range: Neocomian, Wealden of the Netherlands.

Maexisporites soldanellus (Dijkstra) Potonié; known range: Berriasian to the lowermost Aptian, English Wealden.

Appendicisporites tricornitatus**

Appendicisporites crimensis**

Cicatricosisporites mediostriatus**

Trilobosporites hannonicus*

Trilobosporites apiverrucatus**

Pilosisporites verus*

Concavissimisporites punctatus**

Couperisporites complexus*

Schizosporis reticulatus**

Maexisporites obolus**

Dijkstraisporites helios*

Arcellites disciformis*

- * in group A, Deville Member.
- ** in group B, Deville Member.

Group C

Cicatricosisporites dorsostriatus (Bolkhovitina) n. comb., known range: Middle Jurassic to Aptian, Russia.

Appendicisporites cooksonii*

Dictyotriletes pseudoreticulatus*

Pilosisporites trichopapillosus*

Staplinisporites caminus*

* in group C, Deville Member.

Group D

Hymenozonotriletes mesozoicus Pocock

Aequitriradites variabilis Pocock

Rouseisporites laevigatus Pocock

Rouseisporites triangularis Pocock

Cedripites cretaceus Pocock

Podocarpidites ornatus Pocock

Podocarpidites canadensis Pocock

Arcellites incipiens n. sp.

Appendicisporites jansonii*

Trilobosporites canadensis*

Concavissimisporites parkinii*

Rouseisporites reticulatus*
Cooksonites variabilis*
Cooksonites reticulatus*
Cedripites canadensis*
Equisetosporites concinnus*
Arcellites rugosus*
* in group D, Deville Member.

The 2 species listed under group A, Cicatricosisporites perforatus and Trilobosporites trioreticulosus, are present at the base of the Ellerslie Member and are the first species of definite Aptian age to appear in the continental McMurray Formation. The 5 species listed under group A of the Deville Member are also present in the Ellerslie Member; however, they are of either Barremian or questionably Aptian age and have slightly older entrance levels than C. perforatus and T. trioreticulosus.

Species listed under groups B and C are longer-ranging forms with older entrance levels than those of group A and indicate only an early Cretaceous age for the Ellerslie Member.

McMurray Formation, "calcareous" member

Thirty-two species of microspores and pollen, one megaspore species, and three species of microplankton constitute the microfloral assemblage of the "calcareous" member. None of these species, except the three microplankton, is new; all 32 species of microspores and pollen are found in the underlying Ellerslie Member. The decline in both the abundance and variety of the microflora is undoubtedly due to the change in environment, the ostracode-rich beds of the "calcareous" member representing a near-shore, brackish-water facies that is transitional between the underlying Ellerslie continental beds and the overlying marine Wabiskaw Sandstone.

The 3 species of microplankton make their first appearance near the top of the "calcareous" member in the Imperial Namao No. 1 well. They are:

Palaeoperidinium cretaceum Pocock; known range: Cretaceous.

Pseudoceratium pelliferum Gocht; known range: Valanginian in northwest Germany to middle Albian in central Alberta.

Odontochitina operculata (Wetzel) Deflandre; known range: Hauterivian to Upper Cretaceous, northwestern Germany.

No valid conclusions concerning the age of the "calcareous" member can be drawn on the basis of the microflora, as no new and stratigraphically significant species make their first appearance in this member. The microplankton species are valuable only as indicators of a marine environment.

Clearwater Formation, Wabiskaw Member

Sixty-nine species of microspores and pollen, three species of megaspores, and nine species of microplankton were recorded from the Wabiskaw Member. Of the spore and pollen species, 60 continue from the McMurray Formation, and of the microplankton, 3 continue from the "calcareous" member of the McMurray Formation. Thus, only 18 species make their first appearance in the Wabiskaw Member: 12 spore and pollen species, and 6 microplankton species. The index species of the Wabiskaw Member are listed below:

Group A

Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) n. comb.; known range: Albian to Cenomanian, western Siberia, U.S.S.R.

Podocarpidites naumovai n. name for Podocarpidites major (Naumova) n. comb. which is homonymous with Podocarpidites major Couper, 1953; known range: lower and middle Albian near Aral Sea to Cenomanian in the northern Urals.

Group B

Appendicisporites sp. cf. Anemia trichacantha (Maljavkina) Markova, known range: Aptian to Cenomanian, Russia.

Appendicisporites tricornitatus*

Appendicisporites crimensis*

Appendicisporites sp. cf. A. pschekhaensis*

Cicatricosisporites mediostriatus*

Trilobosporites apiverrucatus*

Trilobosporites trioreticulosus*

Couperisporites complexus*

Aequitriradites spinulosus*

Verrucosisporites asymmetricus*

* in McMurray Formation.

Group C

Pilosisporites trichopapillosus*

* in McMurray Formation.

Group D

Appendicisporites perplexus n. sp. Aequitriradites variabilis*
Rouseisporites reticulatus*
Cedripites cretaceus*
Cedripites canadensis*
Podocarpidites canadensis*
in McMurray Formation.

Microplankton

Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; known range: Aptian to Senonian, in various regions.

Hystrichosphaeridium albertense Pocock

Hystrichosphaeridium irregulare Pocock

Baltisphaeridium sp.

Baltisphaeridium multispinosum n. sp.

Canningia colliveri Cookson and Eisenack; known range: Aptian, northern Queensland and Western Australia.

Palaeoperidinium cretaceum*

Pseudoceratium pelliferum*

Odontochitina operculata*

* in "calcareous" member.

The Clearwater Formation, including the Wabiskaw Member, is dated as middle Albian on the basis of the associated microfauna (Mellon and Wall, 1961), although elements of this microfauna are restricted to that part of the Clearwater Formation above the Wabiskaw Member in the three wells used for this study (Fig. 3).

The microfloral evidence also indicates an Albian age for the Wabiskaw Member through the presence of two species, Appendicisporites trichacanthus var. dissectus and Podocarpidites naumovai, which are found in strata ranging in age from Albian to Cenomanian in the U.S.S.R. Other spore and pollen species present are either long-ranging forms or make their entrance at lower levels in the Mannville Group.

The microplankton are of little value for precise age determinations and indicate only the prevalence of a marine environment.

Clearwater Formation, Shale Member

Fifty-four species of microspores and pollen, two species of megaspores, and twelve species of microplankton were recorded from the shale member of the Clearwater Formation. Of the spore and pollen species, 50 continue from either the McMurray Formation or Wabiskaw Member, and of the microplankton, 8 continue from the Wabiskaw Member. Thus, only 10 species make their first appearance in the shale member: 6 spore and pollen species, and 4 microplankton species. The index species of the Clearwater shale member are listed below:

Group B

Appendicisporites tricornitatus* Appendicisporites crimensis* Trilobosporites apiverrucatus* Aequitriradites spinulosus* Schizosporis reticulatus*

Podocarpidites naumovai*

* in McMurray Formation or Wabiskaw Member.

Group C

Pilosisporites trichopapillosus*

* in McMurray Formation or Wabiskaw Member.

Group D

Appendicisporites bifurcatus n. sp.

Minerisporites venustus n. sp.

Appendicisporites perplexus*

Aequitriradites variabilis*

Rouseisporites reticulatus*

Cedripites cretaceus*

Cedripites canadensis*

Podocarpidites canadensis*

* in McMurray Formation or Wabiskaw Member.

Microplankton

Palaeoperidinium granulatum n. sp.

Baltisphaeridium sp. cf. B. neptuni Eisenack; known range: Aptian, northern Germany.

Veryhachium reductum (Deunff) Jekhowsky; known range: Ordovician to Cenomanian, in various regions.

Pseudoceratium gochtii Pocock

Palaeoperidinium cretaceum*

Hystrichosphaeridium tubiferum*

Hystrichosphaeridium irregulare*

Baltisphaeridium sp.*

Baltisphaeridium multispinosum*

Pseudoceratium pelliferum*

Canningia colliveri*

Odontochitina operculata*

* in "calcareous" member or Wabiskaw Member.

None of the index species listed above is helpful in further refining the middle Albian age indicated for the Clearwater Formation by its microfaunal content (Mellon and Wall, 1961). The paucity of microflora in this member is probably due to the marine, off-shore environment in which it was deposited. However, two new local species, Appendicisporites bifurcatus and Minerisporites venustus, make their first appearance in this member, and Appendicisporites perplexus, which first appears in the Wabiskaw Member,

becomes abundant here. This indicates a gradual evolutionary change in the Mannville microflora, which is only partly masked by the prevalence of marine conditions of deposition during Clearwater time. A. perplexus continues into the lower part of the overlying Grand Rapids Formation but is absent from the uppermost beds of this unit.

The microplankton are most abundant in the Clearwater shale member, emphasizing its marine character, but are of no value in further refining the age of the unit.

Grand Rapids Formation

Eighty-three species of microspores and pollen, eleven species of megaspores, and ten species of marine microplankton were recorded from the Grand Rapids Formation. Most are present in the underlying older beds, and many of the McMurray spore and pollen species absent from the marine Clearwater Formation reappear in the Grand Rapids Formation. Fourteen species make their first appearance in this unit: 11 spore and pollen species, and 3 microplankton species. The index species of the Grand Rapids Formation are listed below:

Group A

Appendicisporites unicus (Markova) n. comb.; known range: Cenomanian, Siberia, U.S.S.R.

Arcellites reticulatus (Cookson and Dettmann) Potter; known range: Albian, South Australia.

Arcellites nudus (Cookson and Dettmann) Potter; known range: Albian, South Australia.

Group B

Appendicisporites tricornitatus*

Appendicisporites crimensis*

Appendicisporites sp. cf. A. pschekhaensis*

Appendicisporites sp. cf. Anemia trichacantha*

Cicatricosisporites mediostriatus*

Trilobosporites apiverrucatus*

Trilobosporites trioreticulosus*

Couperisporites complexus*

Taurocusporites segmentatus*

Aequitriradites spinulosus*

Verrucosisporites asymmetricus*

Schizosporis reticulatus*

Arcellites disciformis*

^{*} in McMurray or Clearwater Formations.

Group C

Pilosisporites trichopapillosus*

* in McMurray or Clearwater Formations.

Group D

Januasporites spiniferus n. sp.

Minerisporites macroreticulatus n. sp.

Appendicisporites bifurcatus*

Appendicisporites perplexus*

Aequitriradites variabilis*

Rouseisporites reticulatus*

Rouseisporites laevigatus*

Rouseisporites triangularis*

Cedripites cretaceus*

Cedripites canadensis*

Podocarpidites canadensis*

Minerisporites venustus*

* in McMurray or Clearwater Formations.

Microplankton

Gonyaulax sp. cf. G. jurassica Deflandre, known range: Oxfordian.

Baltisphaeridium longispinosum (Eisenack) Eisenack, known range: Ordovician, Europe.

 $\label{lem:very large} Very hachium\ irregulare\ {\it form}\ subhexahedron\ {\it Jekhowsky,}\ known\ range:$

Permian and Triassic.

Palaeoperidinium cretaceum*

Palaeoperidinium granulatum*

Hystrichosphaeridium tubiferum*

Baltisphaeridium sp.*

Baltisphaeridium multispinosum*

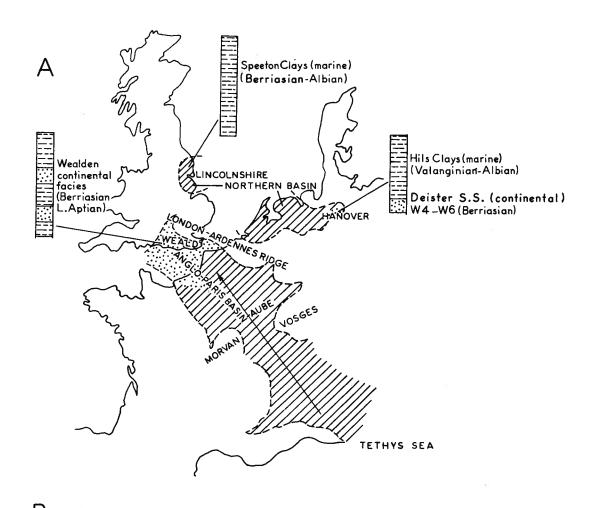
Veryhachium reductum*

Pseudoceratium pelliferum*

* in Clearwater Formation.

The Grand Rapids Formation is dated middle Albian on the basis of its microfauna (Mellon and Wall, op. cit.) and megaflora (C. R. Stelck, pers. comm.).

The presence of the two species Arcellites reticulatus and Arcellites nudus, listed under group A, supports an Albian age for the Grand Rapids Formation in east-central Alberta, but the presence of Appendicisporites unicus, hitherto found only in beds of Cenomanian age, is anomalous. A.



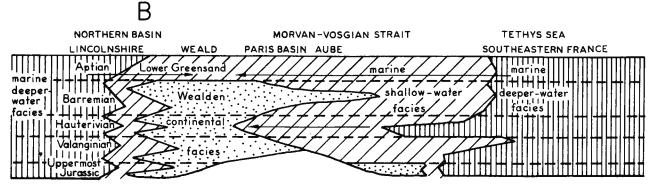


FIGURE 5. A. Geographic distribution of Wealden beds and correlative strata in northwestern Europe. B. Diagrammatic reconstruction of Lower Cretaceous facies between northern England and southeastern France.

unicus, however, is rare in the Grand Rapids, and although the present study shows that it makes its entrance during the Albian, it probably does not become abundant until the Cenomanian.

The microplankton are of no value as precise age indicators; the three species that make their first appearance in this part of the Mannville Group are older species that may be reworked from older strata and are represented only by a single specimen each. However, the microplankton are useful indicators of gross environment, and their distribution in the Grand Rapids Formation in Anglo-Home-C. and E. Fort Augustus No. 1 well and Imperial Willingdon No. 1 well shows that the formation is at least partly marine in origin throughout most of its thickness in east-central Alberta.

Age and Correlation of the Mannville Microflora

The gross age of the Mannville Group has been long established as Early Cretaceous on the basis of faunal and floral evidence. The precise age of the upper Mannville, including the Clearwater and Grand Rapids Formations, also is established as middle Albian, but the precise age of the lower Mannville (McMurray Formation) is still in dispute. This is largely due to the continental nature of the McMurray Formation, which in east-central Alberta contains only nonmarine or brackish-water invertebrates of doubtful value as age indicators in the upper part ("calcareous" member). The rare megafloral remains in the McMurray Formation are composed of long-ranging forms, so that any attempt to refine the age of this unit depends upon the nature of its microfloral content.

Undoubtedly, the most extensively investigated nonmarine strata of Early Cretaceous age are the Wealden beds in the Anglo-Paris Basin (Allen, 1955; Gignoux, 1955; Hughes, 1958), which interfinger to the southeast with marine, ammonite-bearing beds in the Paris Basin, and possibly to the north and east with marine beds in Lincolnshire and northern Germany (Fig. 5). Although the precise age of the Wealden has long been in dispute, Allen (op. cit.) has presented arguments to show that the English Wealden spans most of Early Cretaceous time, including beds of Berriasian to early Aptian ages. In addition, Hughes (1958) has established a partial microfloral correlation between the English Wealden and partially marine equivalent beds in Lincolnshire, the Netherlands, and northern Germany. Thus, the Wealden microfloral zones can be used with some degree of assurance in dating other successions of continental strata that contain similar microfloral elements.

Dijkstra (1951), Hughes (1955), and Couper (1958) have described various spore and pollen index species and genera that are useful in zoning and dating the English Wealden and correlative strata (Fig. 6). Hughes (1958) described three microfloras from the Wealden beds that range in age from Berriasian to early Aptian. Species of the two lower floras, the Verrutriletes and Thomsonia floras, are absent from the Mannville Group,

whereas elements of the upper flora, the Arcellites (Pyrobolospora) flora of late Barremian to early Aptian ages, are abundant in both the Deville and Ellerslie Members (Dijkstraisporites helios and Arcellites disciformis [? = Pyrobolospora hexapartita]). This indicates that the basal beds of the Mannville Group in central Alberta are not older than late Barremian. In keeping with this evidence, the entrance of the two species, Cicatricosisporites perforatus and Trilobosporites trioreticulosus, which make their entrance in Aptian strata of the U.S.S.R. and Australia, respectively, indicates that the overlying Ellerslie Member is of Aptian age.

There is no direct microfloral evidence for the age of the "calcareous" member in the three wells studied. No diagnostic spore or pollen species make their entrance at this level of the Mannville Group, although the presence of rare marine microplankton in the upper part of the member in the Imperial Namao No. 1 well shows that there is no break in sedimentation here. Thus, the "calcareous" member of the McMurray Formation is assigned an early to early middle Albian age (Fig. 6), inasmuch as it bridges the gap between the Ellerslie Member of Aptian age and the overlying marine Clearwater Formation of middle Albian age.

There is no obvious break in the continuity of the Mannville microflora; the key index species in the McMurray Formation continue into the overlying upper Mannville beds, although their numbers are diminished in the marine Clearwater Formation.

The upper Mannville (Clearwater and Grand Rapids) microflora supports the middle Albian age assigned to these beds on faunal evidence. Although diagnostic marine invertebrates are confined in the subsurface and in outcrop to the Clearwater and lower Grand Rapids Formations, the non-dicotyledonous character of the subsurface Grand Rapids megaflora indicates that the upper part of the unit is older than the late middle Albian dicotyledon-bearing beds in the upper part of the Commotion Formation in the British Columbia Foothills (Mellon et al., 1963; C. R. Stelck, pers. comm.). The Grand Rapids microflora contains no dicotyledonous elements and thus supports the pre-upper Commotion age assigned to this unit on megafloral evidence.

PALEOFLORAL RELATIONSHIPS AND PALEOECOLOGY OF THE MANNVILLE MICROFLORA

Comparison of the Mannville Megaflora and Microflora

A fossil microflora can be related to its megaflora with confidence only in cases where the spores or pollen are obtained from fructifications attached to identifiable vegetable remains. Thus, the megafloral affiliations suggested below for the Mannville microflora are tentative, for none of the megafloral remains present in the three wells studied contains fructifications with attached spores or pollen.

Megaflora	Microflora
Division—Pterophyta Order—Filicales	
	Some of the spores placed under Filicales e.g. <i>Deltoidospora</i> spp.
Family—Schizaeaceae? Sphenopteris sp. cf. Ruffordia	
goepperti	Cicatricosisporites spp.
Family—Osmundaceae Cladophlebis spp	Osmundacidites spp., Todisporites spp.
Division—Spermatophyta Class—Pteridospermae Order—Caytoniales	
Sagenopteris spp.	Vitreisporites spp.
Class—Gymnospermae Order—Cycadales or Bennettitales	
Ptilophyllum spp	Bennettiteaepollenites spp., Cycadopites carpentieri
Nilssonia sppOrder—Coniferales Family—Pinaceae?	Cycadopites spp.
•	Pityosporites spp., Alisporites spp. or other genera allied to Pinaceae.
Family—Araucariaceae? Pagiophyllum spp	Classopollis spp.

Paleoecology

The interpretation of fossil pollen frequencies is difficult owing to several factors:

(1) Vegetational frequencies may bear little relation to spore or pollen frequencies as different genera have different rates of pollen production (Davis and Goodlett, 1960).

- (2) Certain types of spores or pollen may be destroyed during or after deposition, whereas others may be preserved.
- (3) Different types of spores or pollen have different dispersal characteristics; heavier species are abundant in the source area, whereas lighter species are relatively more abundant away from the source area (Muller, 1959).

As a result, only a very general idea of the habitat of the Mannville flora can be obtained from the associated microflora.

Of the 72 genera and 161 species described in the present work, 53 genera and 120 species are microspores or pollen, 10 genera and 23 species are megaspores, 2 specimens have been described informally as seeds, and 8 genera and 16 species are marine microplankton. The present geographic distribution and habitat of the families and other taxa under which the above genera tentatively have been grouped are given in the list below.

Microspores and Pollen

Division—Bryophyta

Family—Sphagnaceae: 1 genus and 2 species. Cosmopolitan; found in peat bogs, acid moors, and pond margins; indicate a wet lowland terrain.

Division-Pterophyta

Family—Lycopodiaceae: 2 genera and 6 species. Cosmopolitan; found chiefly in subtropical and tropical forests but also extend into arctic and temperate zones. The Lycopodiaceae are not found in arid regions.

Family—Selaginellaceae: 1 genus and 2 species. Cosmopolitan; most species are found in the tropics in shaded, humid spots.

Family—Osmundacae: 3 genera and 3 species. Cosmopolitan; mainly temperate and tropical; various species live in shaded, moist woodlands.

Family—Schizaeaceae: 9 genera and 30 species. Mainly tropical and subtropical, although some species of *Schizaea* and *Lygodium* are found as far north as eastern Canada. The Schizaeaceae reached their climax both in diversity and abundance during the Early Cretaceous. Out of 84 species of fern spores in the Mannville, 30 species belong to the family Schizaeaceae.

Family—Gleicheniaceae: 1 genus and 2 species. Mainly tropical but also extend into the temperate regions.

Family—Cyatheaceae or Dicksoniaceae: 1 genus and 2 species. The Cyatheaceae are mostly tree ferns and are confined largely to the tropics and subtropics, with some forms in temperate regions, especially in the southern hemisphere. They live chiefly in humid forests. The majority of Dicksoniaceae are tropical, but a few are also found in temperate regions. The arborescent species are largely confined to the tropics, but several

species of *Dicksonia* are prominent ferns of the warm-temperate southern hemisphere.

Order—Filicales—Incertae Sedis: 18 genera and 39 species of microspores from the Mannville Group were placed under this broad group, the affinities of which are uncertain.

Division—Spermatophyta

Class—Pteridospermae

Family—Caytoniaceae: Only a single species was recovered. This family apparently became extinct in the Late Cretaceous.

Class—Gymnospermae

Order—Cycadales or Bennettitales: 2 genera and 6 species. Three species probably belong to the family Cycadaceae which is found exclusively in the tropics and subtropics at present. Although they usually are found in rocky and arid regions today, the presence of abundant *Nilssonia* and *Ptilophyllum* leaf impressions in the coal-bearing beds all over the world indicates that the cycads were not restricted to the arid zones in the past. The cycads were very abundant and widespread during the Jurassic and early Cretaceous.

The Bennettitales are extinct but probably flourished under a similar habitat as the Cycadales. Three species of pollen recorded from the Mannville Group probably belong to this order.

Order—Coniferales: 14 genera and 24 species. One species probably belongs to the family Taxodiaceae, 9 species to the family Pinaceae, 10 species to the family Podocarpaceae, and 4 species have undetermined affinities. In general, the conifers are distributed widely from subarctic to subtropical regions. South of latitude 40° north most of them are practically confined to the mountains, although there is an extensive pine belt running from Gulf Coasts to eastern Texas. Pinus is found mainly in the temperate regions of the northern hemisphere but also extends into subarctic and subtropical zones. Among the modern genera of the family Podocarpaceae, Phyllocladus is restricted at present to New Zealand, Tasmania, and Malasia; Dacrydium has a similar distribution but also is found in Chile; and Podocarpus is found mainly in the temperate regions of the southern hemisphere but also is present in Cuba, Mexico, central China and southern Japan in the northern hemisphere. In general, most of the conifers either indicate a cool climate or a moist upland habitat.

Order—Gnetales

Family—Ephedraceae: 1 genus and 3 species. Mainly tropical to temperate.

Found in scattered patches in hot to very cold, arid, mountainous, rocky, or desert regions. The Ephedraceae seem to have adapted themselves to

the extremes of hot and cold climates, requiring both climatic and edaphic dryness.

Megaspores

The botanical relationships of the megaspores are uncertain. Hughes (1955) considers that the elaborate and delicate appendages present on Arcellites indicate an aquatic habit. Cookson and Dettmann (1958b) postulated a probable relationship of this genus with the Hydropterideae, in particular with the family Marsiliaceae. If this is true, then the presence of Arcellites indicates an aquatic type of vegetation, perhaps indicative of a lowland, floodplain locus of deposition in which ponds and shallow lakes were common.

Microplankton

Order—Dinoflagellata

Family—Peridinidae: 1 genus and 2 species.

Family—Gonyaulacidae: Only a single species was recovered.

Order—Hystrichosphaeridea

Family—Hystrichosphaeridae: 3 genera and 9 species.

Incertae Sedis: 3 genera and 4 species.

All 16 species of microplankton indicate a brackish to marine environment.

In summary, there are five distinct floral elements present within the Mannville Group:

- (1) The fern flora consisting of ordinary ferns, tree ferns and water ferns. This flora was probably dominated by the family Schizaeaceae. A few species of pteridosperms are also associated with these.
- (2) The cycad flora belonging to the orders Cycadales and Bennettitales.
- (3) The conifer flora probably belonging predominantly to the families Pinaceae and Podocarpaceae.
- (4) The ephedralean flora, which is represented only by its pollen.
- (5) The marine microplankton.

Of these groups, the fern, cycad, and conifer elements were predominant in the continental, subaerial flora of southern and central Alberta during Mannville time, being especially abundant in the nonmarine fluviatile beds of the McMurray Formation and the upper Grand Rapids Formation. Probably, local and regional topographic variation gave rise to different vegetative associations, with ferns predominating in low flood-plain areas, and cycads and conifers in more elevated, better-drained areas.

In fact, some of the gymnosperm microfloral elements probably were derived from the more elevated continental areas to the south and west of the region under study, especially during Wabiskaw and Clearwater times. The ephedralean pollen, however, may have been derived from outside the general depositional basin that covered most of Alberta in Mannville time, as they indicate an arid, desert-like or mountainous climate. In contrast, the major continental floral elements of the Mannville Group indicate a warm-temperate to subtropical humid climate.

The relative abundances of spores and pollen and microplankton correlate well within the fluctuating continental and marine conditions of deposition implied by the lithology and faunal content of the Mannville Group. Thus, marine microplankton first appear in the brackish-water phases of the "calcareous" member, reach their peak abundance in the marine Clearwater Formation, and die out in the continental upper Grand Rapids Formation. Conversely, spores and pollen are most abundant in the continental Deville, Ellerslie, and upper Grand Rapids beds, and less common in the intervening brackish and marine beds.

SUMMARY AND CONCLUSIONS

The subsurface Mannville Group of east-central Alberta includes several hundred feet of alternating continental, marine, and near-shore sediments of Early Cretaceous age that can be divided, in ascending order, into the McMurray (continental to brackish), Clearwater (marine), and Grand Rapids (marine to continental) Formations. The Clearwater Formation contains a microfauna of middle Albian age, but the age of the underlying McMurray Formation has been long uncertain.

Three cored sections of the Mannville Group in east-central Alberta were sampled and analyzed for their microfloral content. The described microflora includes 120 species of microspores and pollen, 23 species of megaspores, 16 species of microplankton, and 2 specimens described informally as seeds. There are no indications of any major floral breaks within the Mannville Group; the microfloral succession shows a complete gradation in evolution.

The microfloral content of the continental McMurray Formation suggests that the base of the Mannville Group in east-central Alberta is not older than late Barremian in age. The basal Deville Member contains several index species which make their entrance elsewhere in late Barremian time. Both the Deville and the overlying Ellerslie Members contain elements of the Arcellites (Pyrobolospora) flora which makes its entrance in the English Wealden in late Barremian time. The Ellerslie also contains two index microspore species, Cicatricosisporites perforatus and Trilobosporites trioreticulosus, which make their entrance in the Aptian of the U.S.S.R. and Australia. The upper "calcareous" member contains microflora similar to that of the underlying beds as well as marine microplankton in its upper part. Thus, the continental Deville and Ellerslie Members are dated as late Barremian and Aptian, respectively, and the overlying transitional "calcareous" member is dated provisionally as early Albian to early middle Albian, as it spans the gap between the underlying Ellerslie Member and the overlying Clearwater Formation.

The microflora of the Clearwater Formation is dominated by marine microplankton which are valuable mainly as indicators of depositional environment. These are also present in the lower Grand Rapids Formation, which, however, contains in its upper part a megaflora of middle Albian age.

The continental microflora of the Mannville Group indicates that warm-temperate to subtropical humid climate prevailed in east-central Alberta during Early Cretaceous time. The relative abundance of spores and pollen versus microplankton is correlative with the fluctuating continental and marine conditions of deposition in the Mannville Group.

TAXONOMIC APPROACH

The taxonomy and nomenclature of fossil pollen and spores has been long a topic of controversy. Although complete uniformity is yet to be achieved, recently, there has been widespread agreement that the names applied to taxa based on fossil spores and pollen are to be governed by the International Code of Botanical Nomenclature (Montreal, 1959) as laid down in Article 7, Note 5. Palynologists all over the world are now working within the framework of the International Code, following the Linnaean system of binomial nomenclature, the usage of natural genera, organ-genera, and form-genera, and the principles of type method and priority (Singh, 1963).

Most of the present-day controversy is not in the field of nomenclature, but in the field of classification of fossil spores and pollen. The main controversy is whether a fossil spore or pollen specimen should be placed under a form-genus, organ-genus, or natural genus. The classification of a fossil specimen under any one of these taxa depends largely upon the individual judgment of a worker concerning the degree of botanical affinity displayed by the specimen. Some workers (e.g. Pierce, 1961), who are more concerned with the convenience of use rather than phylogenetic relationships, use a purely morphographic classification and place all their entities under formgenera. Even the "natural" classifications are partly artificial because often the details of ancestry are far from clear. Hence, the taxonomic approach may vary according to the personal philosophy of the worker, the introduction of new concepts of anatomical interpretations, or with the special requirements of the classification. However, the rules of formal nomenclature as laid down in the International Code of Botanical Nomenclature remain unaffected.

Inasmuch as the present state of knowledge concerning the natural relationships of fossil plant groups in rocks as old as Early Cretaceous is far from adequate, a systematic approach similar to that of Couper (1958) has been adopted in this work. It is noteworthy that Couper, who used names of natural genera (Couper, 1953, 1960) for Tertiary spores and pollen, did not consider natural names suitable for the Jurassic and Lower Cretaceous spores and pollen from England.

The salient features of the present taxonomic approach are as follows:

- (1) Potonié's (1956, 1958, 1960) morphographic system of classification has been used at the generic and specific levels only.
- (2) Only form-genera and organ-genera have been used. The International Code of Botanical Nomenclature (Montreal, 1959) defines these taxa as follows (Article 3, Note 1): "An organ-genus is a genus assignable to a family. A form-genus is a genus unassignable to a family, but it may be referable to a taxon of higher rank."

In consequence, natural generic designations assigned to some of the forms by previous authors have been placed in synonymy.

(3) The principles of priority and type method have been followed.

FORMAL DESCRIPTIONS

Family SPHAGNACEAE

Genus Sphagnumsporites Raatz, 1937

1934 Sporites stereoides Potonié and Venitz, Arb. Inst. Paläobot. Petrogr. Brennsteine, vol. 5, p. 11, pl. 1, fig. 4.

1937 Sphagnumsporites Reatz, Abhandl. Preuss. Geol. L.A. (Berlin), n.F., Heft 183,

1953

1953

p. 9. Stereisporites Pflug, Palaeontographica, Band 94, Abt. B, p. 53. Sphagnites Cookson, Australian J. Botany, vol. 1, p. 463, pl. 1, figs. 1-4. Sphagnumsporites stereoides (Potonié and Venitz) Potonié, Beih. Geol. Jahrb., 1956 Heft 23, p. 17 (type species).

Diagnosis: Trilete; laesurae simple, reaching the equator in some species; size small; equatorial outline triangular with convex sides; corners rounded, arched in some species; exine smooth, relatively thick and rigid.

SPHAGNUMSPORITES ANTIQUASPORITES (Wilson and Webster) Pocock, 1962

Plate 1, figure 1

- 1946 Sphagnum antiquasporites Wilson and Webster, Am. J. Botany, vol. 33,
- p. 271-278.

 Trilites australis Cookson, B.A.N.Z. Antarctic Res. Expedition, Rept. A2, p. 136,
- 1953
- pl. 15, figs. 58, 59.

 Sphagnites australis Cookson, Australian J. Botany, vol. 1, p. 463, pl. 1, figs. 1-4.

 Sphagnum punctaesporites Rouse, Micropaleont., vol. 5, p. 308, pl. 1, figs. 25, 26.

 Sphagnumsporites antiquasporites (Wilson and Webster) Pocock, Palaeontographica, Band 111, Abt. B, p. 32, pl. 1, figs. 1-3. 1962

Description: Trilete; laesurae simple, from ½ to ¾ of radius of spore; equatorial outline triangular with strongly convex sides; corners rounded; arcuate thickenings subtend the angles of the laesurae; 1-micron wide thickened zone around the equator; exine smooth.

Size range: Equatorial diameter 20 to 28 microns.

Distribution: Upper Jurassic, Cretaceous, and Tertiary. Abundant in the Mannville Group.

Affinity: In morphology, this spore is similar to the spores of recent species of Sphagnum.

Locality of figured specimen: Imperial Willingdon No. 1 well

- Depth 1781 to 1791 feet; Pl. 1, fig. 1. Grand Rapids Formation.
- Pl. 1, fig. 1. Slide No. Micro. 110; co-ord. 14.4/37.5.

Sphagnumsporites psilatus (Ross) Couper, 1958

Plate 1, figure 2

Trilites psilatus Ross, Bull. Geol. Inst. Univ. Upsala, vol. 34, p. 32, pl. 1, fig. 12. 1949 1958 Sphagnumsporites psilatus (Ross) Couper, Palaeontographica, Band 103, Abt. B, p. 131, pl. 15, figs. 1, 2.

Description: Trilete; laesurae simple, about ½ the radius of spore; equatorial outline triangular with strongly convex sides; corners rounded; arcuate thickenings subtend the angles of the laesurae; 3-micron wide thickened zone around the equator; exine moderately verrucose.

Size range: Equatorial diameter 30 to 33 microns.

Distribution: Iurassic and Cretaceous. Common in the Mannville Group.

Remarks: This species differs from Sphagnumsporites antiquasporites in its larger size, verrucose exine, and wider equatorial thickening.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 1, fig. 2. Depth 1921 to 1931 feet; Grand Rapids Formation.

Pl. 1, fig. 2. co-ord. 18/65.6. Slide No. IW1921-1931-1;

Family Lycopodiaceae

Genus Lycopodiumsporites Thiergart, 1938 ex Delcourt and Sprumont, 1955

1934 Sporites agathoecus Potonié, Arb. Inst. Paläobot. Petrogr. Brennsteine, vol. 4,

p. 43, pl. 1, fig. 25.

1938 Lycopodiumsporites agathoecus (Potonié) Thiergart, Jahrb. Preuss. Geol. L.A. (Berlin) (1937), vol. 58, p. 293, pl. 22, figs. 9, 10 (type species).

Diagnosis: Trilete; equatorial outline subtriangular; laesurae reaching equator in some species; distal surface reticulate with regular muri; muri high in some specimens; proximal surface unsculptured.

Remarks: The genus Lycopodiumsporites was validated in 1955 when a "lectogenotype", L. agathoecus (Potonié) Thiergart, 1938 was selected by Delcourt and Sprumont (1955, p. 31).

Lycopodiumsporites austroclavatidites (Cookson) Pocock, 1962

Plate 1, figures 3, 4

- 1953 Lycopodium austroclavatidites Cookson, Australian J. Botany, vol. 1, p. 469,
- pl. 2, fig. 35.

 1953 Lycopodium sp. (fastigiatum-volubile group) Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 19, pl. 1, fig. 2.

 1958 Lycopodium sporites clavatoides Couper, Palaeontographica, Band 103, Abt. B, p. 132, pl. 15, figs. 10-13.

 1959 Lycopodium reticulumsporites Rouse, Micropaleont., vol. 5, p. 309, pl. 2, figs. 1-3
- figs. 1-3.
- Lycopodiumsporites austroclavatidites (Cookson) Pocock, Palaeontographica, Band 111, Abt. B, pl. 1, figs. 5, 6. 1962

Description: Trilete; laesurae distinct, about ¾ of radius of spore; equatorial outline rounded-triangular; contact area of proximal face unornamented; distal surface and remainder of proximal face reticulate, lumen of reticulum 7 to 12 microns across; muri 1 micron thick, projecting up to 4 microns.

Size range: Equatorial diameter 30 to 40 microns.

Distribution: Jurassic and Lower Cretaceous. Common in the Mannville Group.

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 1, fig. 3.	Depth 1781 to 1791 feet;	Grand Rapids Formation.
Pl. 1, fig. 4.	Depth 1791 to 1801 feet;	Grand Rapids Formation.
Pl. 1, fig. 3.	Slide No. Micro. 96;	co-ord. 9.9/38.1.
Pl. 1, fig. 4.	Slide No. IW1791-1801-1;	co-ord, 5.9/66.

Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont, 1955

Plate 1, figures 5, 6

1949 Lycopodium cerniidites Ross, Bull. Geol. Inst. Univ. Upsala, vol. 34, p. 30, pl. 1, figs. 1, 2.

1955 Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 32.

Description: Trilete; laesurae over ¾ of radius of spore; commissures surrounded by a distinct margo; equatorial outline rounded-triangular; proximal face flat and smooth; distal face convex, ornamented by irregularly anastomosing low rugulae; exine thick.

Size range: Equatorial diameter 30 to 50 microns.

Distribution: Jurassic and Cretaceous. Rare in the Grand Rapids Formation. Upper Vanguard beds (Jurassic) in Saskatchewan (Pocock, 1962). Santonian of Sweden (Ross, 1949).

Affinity: This species closely resembles recent spores of Lycopodium cernuum.

Remarks: Specimens from east-central Alberta are larger than those described by Ross, which range in size from 24 to 29 microns. In all other respects they are identical.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 1, fig. 5. Depth 2442 to 2451 feet; Grand Rapids Formation. Imperial Willingdon No. 1 well

Pl. 1, fig. 6. Depth 1921 to 1931 feet; Grand Rapids Formation.

Pl. 1, fig. 5. Slide No. 169; co-ord. 11.8/40.8. Pl. 1, fig. 6. Slide No. 150; co-ord. 11/36.2.

Lycopodiumsporites marginatus n. sp.

Plate 1, figures 7-10

Description: Trilete; laesurae extending up to ¾ of the spore radius; commissures raised, about 3 microns wide; equatorial outline triangular with strongly convex sides; proximal surface smooth with a few irregular ridges; distal surface convex, reticulate with polygonal muri; reticulum very broad, ranging from 9 to 14 microns in diameter; muri 1 micron wide and raised into a membraneous network about 10 microns high, thickened and rod-like at intersections.

Size range: Equatorial diameter (including the membraneous zone) 50 to 60 microns.

Equatorial diameter of the holotype 60 microns.

Distribution: Aptian to middle Albian. Rare in Ellerslie and Wabiskaw Members and Grand Rapids Formation.

Remarks: Lycopodiumsporites marginatus resembles Woodsia reticulata (=Hymenozonotriletes reticulatus) Bolkhovitina, 1953. The latter can be distinguished by its larger size (65 to 70 microns), broader muri, laesurae which extend up to the equator, and larger lumina (20 to 25 microns).

The specific name is derived from "marginatus" (rimmed, bordered) and refers to the wide margin produced by the raised membraneous network around the spore body.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 1, figs. 8-10. Depth 3084 to 3093 feet; Ellerslie Member.

Pl. 1, fig. 7. Depth 3028 to 3037 feet; Ellerslie Member.

Holotype: Pl. 1, figs. 8-10. Slide No. FA 3084-3093-4; co-ord. 0.5/37.

Pl. 1, fig. 7. Slide No. FA 3028-3037-2; co-ord. 5/31.

Lycopodiumsporites sp. A

Plate 1, figure 11

Description: Trilete; commissures raised, with 5-micron wide thickened lips; laesurae reaching the equator; equatorial outline triangular; sides straight to slightly convex; proximal surface smooth; distal surface reticulate with polygonal muri; reticulum 8 to 10 microns in diameter; muri 3.5 microns wide and 3 to 4 microns high.

Size range: Equatorial diameter about 48 microns.

Distribution: Aptian to middle Albian. Very rare in the Ellerslie Member and the uppermost portion of the Grand Rapids Formation.

Remarks: This species has not been formally named; very few specimens were found, making it impossible to determine the variation within the species.

Because of its thick muri, this species is similar to some species of Dictyotriletes. However, the polygonal and raised muri of the distal reticulate surface are characteristic of the genus Lycopodiumsporites, rather than Dictyotriletes which has a low, flat, and rounded foveo-reticulate pattern.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 1, fig. 11. Depth 1781 to 1791 feet; Grand Rapids Formation. Pl. 1, fig. 11. Slide No. Micro. 98; co-ord. 13.1/39.3.

Genus Lycospora Schopf, Wilson and Bentall, 1944

1940 Cirratriradites micropapillatus Wilson and Coe, Am. Midland Naturalist, vol. 23,

p. 184, fig. 6.

Lycospora micropapillatus (Wilson and Coe) Schopf, Wilson and Bentall, Illinois State Geol. Surv., Rept. Invest. 91, p. 54, pl. 3, figs. 19-19b (type 1944

Diagnosis: Trilete; trilete mark distinct and simple, extending almost to the margin; cingulate; equatorial outline nearly circular to subtriangular; central body laevigate, infragranulate or granulate.

LYCOSPORA sp. Plate 1, figures 12-15

Description: Trilete; laesurae simple slits, extending almost to the margin of the central body, equatorial outline rounded-triangular; proximal surface granulate, distal surface verrucate, verrucae commonly anastomosing with irregular outline, so closely packed as to resemble narrow irregular lumina at low magnifications; distal face strongly convex; cingulum present but only slightly thicker than the body wall.

Size range: Equatorial diameter 30 microns.

Distribution: Middle Albian. Very rare. A single specimen was recorded from the Wabiskaw Member.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 1, figs. 12-15. Depth 2923 to 2932 feet; Wabiskaw Member. Pl. 1, figs. 12-15. Slide No. FA2923-2932-3; co-ord. 20.8/54.2.

Lycospora cretacea Pocock, 1962 Plate 1, figure 16

1962 Lycospora cretacea Pocock, Palaeontographica, Band 111, Abt. B, p. 34, pl. 1, figs. 12, 13.

Description: Trilete; laesurae reaching the margin of the central body but not extending onto the cingulum; equatorial outline subcircular to subtriangular; cingulate; cingulum 4 microns wide thinning towards equatorial margin; exine ornamented with scattered low verrucae; ornamentation reduced on proximal side.

Size range: Equatorial diameter 35 to 60 microns.

Distribution: Aptian to middle Albian. Common in the Ellerslie Member and Grand Rapids Formation.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 1, fig. 16.

Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 1, fig. 16.

Slide No. Micro. 91;

co-ord. 3.4/37.1.

Family Selaginellaceae

Genus Acanthotriletes Naumova, 1937?, 1939 ex Potonié and Kremp, 1954

1937 Acanthotriletes Naumova, Intern. Geol. Congr., 17th, Moscow, Absts. Papers,

p. 60-61. Spinoso-sporites ciliatus Knox, Trans. Proc. Bot. Soc. Edinburgh, p. 313, pl. 17, 1950 fig. 206.

Acanthotriletes ciliatus (Knox) Potonié and Kremp, Palaeontographica, Band 98, Abt. B, p. 83, pl. 14, fig. 257 (type species).

Diagnosis: Trilete; ciliate; spines closely crowded, attenuate, length greater than twice the diameter.

ACANTHOTRILETES VARISPINOSUS Pocock, 1962

Plate 1, figures 17, 18

1962 Acanthotriletes varispinosus Pocock, Palaeontographica, Band 111, Abt. B, p. 36, pl. 1, figs. 18-20.

Description: Trilete; laesurae about 3/4 of radius of spore; equatorial outline subcircular to subtriangular; proximal face flat, exine scabrate; distal face convex, exine spinose; spines pointed, about 6 microns long, base about 2 to 4 microns wide; distribution of spines irregular.

Size range: Equatorial diameter 20 to 40 microns.

Distribution: Lower Cretaceous. Rare in the Ellerslie Member and Grand Rapids Formation.

Affinity: This species closely resembles spores of the recent species Selaginella kraussiana and S. selaginoides.

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 1, fig. 17. Depth 1816 to 1826 feet; Grand Rapids Formation. Imperial Namao No. 1 well

Pl. 1, fig. 18. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 1, fig. 17. Slide No. IW1816-1826-3; co-ord. 14/42.

Pl. 1, fig. 18. Slide No. Micro. 59; co-ord. 6/44.

ACANTHOTRILETES LEVIDENSIS Balme, 1957

Plate 1, figure 19

1957 Acanthotriletes levidensis Balme, Australia, C.S.I.R.O., Coal Res. Sect., Ref. T.C. 25, p. 18, pl. 1, figs. 18, 19.

Description: Trilete; laesurae distinct, extending up to the margin, raised; ornamented on the distal side by regularly arranged conical processes 2 microns long and 1 micron wide at the base.

Size range: Equatorial diameter 20 to 35 microns.

Distribution: Lower Cretaceous. Rare in the Mannville Group. Lower Cretaceous, Western Australia (Balme, 1957).

Affinity: This species closely resembles spores of the recent species Selaginella subarborescens (Knox, 1950).

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 1, fig. 19.

Depth 3768 to 3778 feet;

Ellerslie Member.

Pl. 1, fig. 19.

Slide No. Micro. 53;

co-ord. 10.5/49.5.

Family OSMUNDACEAE

Genus Osmundacidites Couper, 1953

1953 Osmundacidites wellmanii Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 20, pl. 1, fig. 5 (type species).

Diagnosis: Trilete; laesurae about ¾ of the radius of spore; equatorial outline circular but commonly folded; exine ornamented with granular papillate structures.

OSMUNDACIDITES WELLMANII Couper, 1953

Plate 1, figure 20

(Synonymy as for genus)

Description: Trilete; laesurae about ¾ of radius of spore, simple; equatorial outline circular; exine 1 micron thick, with granular papillate structure; projections up to 1 micron above the surface.

Size range: Equatorial diameter 35 to 55 microns.

Distribution: Jurassic and Lower Cretaceous. Common in the Mannville Group.

Affinity: This species closely resembles *Todites hartzi* Harris, 1931, and *Osmundopsis plectophora* Harris, 1931, from the Lias of Greenland.

Remarks: Balme considers Osmundacidites comaumensis (Cookson) Balme, 1957, to be similar to but not identical with O. wellmanii, the latter having smaller and more regular ornamental processes. Osmunda-sporites elongatus Rouse, 1957, which has a size range of 55 to 89 microns, is larger

than O. wellmanii. The placing of these species in synonymy with O. wellmanii by Pocock (1962) is considered unjustified because of the several distinct types of ornamentation that are present on Mesozoic osmundaceous spores.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 1, fig. 20. Depth 1826 to 1836 feet; Grand Rapids Formation.

Pl. 1, fig. 20. Slide No. IW1826-1836-5; co-ord. 14.1/56.

Genus Rugulatisporites Pflug, in Thomson and Pflug, 1953

1953 Rugulatisporites quintus Thomson and Pflug, Palaeontographica, Band 94, Abt. B, p. 56, pl. 2, fig. 46 (type species).

Diagnosis: Trilete; laesurae faint, about % of the spore radius; equatorial outline roughly circular; exine ornamented with short rugulate muri or warts; distribution of rugulae irregular but dense.

RUGULATISPORITES sp.

Plate 1, figure 21

Description: Trilete; laesurae indistinct, extending up to % of the spore radius; equatorial outline rounded-triangular; exine thick and ornamented with densely packed rugulae both on proximal and distal surfaces.

Size range: Equatorial diameter 42 microns.

Distribution: Aptian. Very rare. A single specimen was recorded from the Ellerslie Member.

Affinity: This species is similar to the spores of the recent species Osmunda regalis.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 1, fig. 21. Depth 3075 to 3084 feet; Ellerslie Member.

Pl. 1, fig. 21. Slide No. Micro. 234; co-ord. 9.1/41.5.

Genus Todisporites Couper, 1958

1958 Todisporites major Couper, Palaeontographica, Band 103, Abt. B, p. 134, pl. 16, figs. 6-8 (type species).

Diagnosis: Trilete; laesurae simple, more than % of radius of spore; equatorial outline more or less circular; exine thin, smooth to finely scabrate.

Todisporites minor Couper, 1958

Plate 1, figure 22

1958 Todisporites minor Couper, Palaeontographica, Band 103, Abt. B, p. 135, pl. 16, figs. 9, 10.

Description: Trilete; laesurae simple, more than ¾ of radius of spore; equatorial outline circular; commonly folded; exine thin and smooth.

Size range: Equatorial diameter 30 to 50 microns.

Distribution: Middle Jurassic to Lower Cretaceous. Rare in the Mannville Group of east-central Alberta. Reported elsewhere in western Canada in strata ranging from Jurassic to Lower Cretaceous (Pocock, 1962). Bajocian of England (Couper, 1958).

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 1, fig. 22.

Depth 2607 to 2616 feet;

Grand Rapids Formation.

Pl. 1, fig. 22.

Slide No. Micro. 187:

co-ord. 11.5/40.5.

Family Schizaeaceae

Genus Appendicisporites Weyland and Krieger, 1953

1953 Appendicisporites tricuspidatus Weyland and Greifeld, Palaeontographica, Band 95, Abt. B, p. 42, pl. 11, fig. 54 (type species).

Diagnosis: Trilete; exine two-layered with a thick ektexine layer; equatorial outline more or less triangular; apical appendices short and conical or very long, and where long equaling or exceeding the equatorial diameter of the central body; ektexine covered with broad partially branching ridges more or less parallel to the equatorial sides of the spore; the ridges in the polar regions slightly bent towards the pole.

Remarks: The generic name Appendicisporites was proposed by Weyland and Krieger (1953), who designated Weyland and Greifeld's species A. tricuspidatus, described in the same publication, as the type species.

APPENDICISPORITES TRICORNITATUS Weyland and Greifeld, 1953

Plate 2, figure 1

1953 Appendicisporites tricornitatus Weyland and Greifeld, Palaeontographica, Band 95, Abt. B, p. 43, pl. 11, fig. 52.

Description: Trilete; laesurae about ¾ of the radius of spore; commissures raised on some specimens; equatorial outline triangular; distal face convex, ornamented with ridges 2 to 4 microns wide and spaced 1 to 4 microns apart, parallel to the sides of the spore; apical appendices 5 to 9 microns long.

Size range: Equatorial diameter 40 to 65 microns.

Distribution: Cretaceous. Abundant in the Mannville Group. First described from the lower Senonian of Germany (Weyland and Greifeld, 1953). Makes its first appearance at the top of the Berriasian in northwest Europe (Hughes, 1958).

Remarks: In their original description of Appendicisporites tricornitatus, Weyland and Greifeld (1953) refer to the apical appendices as small "thimble-like" projections. Couper (1958) restricted the species to forms with apical appendices between 5 to 9 microns for spores with equatorial

diameter between 45 to 65 microns. In all other descriptions and illustrations (Delcourt and Sprumont, 1955; Groot and Penny, 1960, etc.) the apical appendix is a small blunt process always less than 1/6 of the diameter of the spore. A. tricornitatus as illustrated by Pocock (1962, pl. 2, fig. 24) has processes that appear to be too long to fit Couper's definition of the species.

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 2, fig. 1. Depth 3706 to 3716 feet; Ellerslie Member.

Pl. 2, fig. 1. Slide No. Micro. 17; co-ord. 20/49.

Appendicisporites crickmayii Pocock, in press

Plate 2, figures 2, 3

In press Appendicisporites crickmayii Pocock, Grana Palynologica, vol. 5.

Description: Trilete; laesurae simple slits, reaching up to the margin of endexine in the apices; a distinct margo bordering the laesurae; equatorial outline triangular; sides straight to slightly concave; endexine smooth and thin; ektexine about 2 microns thick in the interapical section, becoming thicker at the apices to form hollow, rounded appendices between 6 to 10 microns long, 8 to 14 microns wide, and about 10 microns thick; both proximal and distal ektexine is ornamented with three sets of ribs, commonly corrugated, about 1.5 microns wide, spaced 1 micron apart, each set paralleling one side of the spore and adjacent sets fusing at the apices.

Size range: Equatorial diameter 35 to 48 microns.

Distribution: Aptian to middle Albian. Common in the Ellerslie Member. Rare in upper Mannville equivalent strata in Saskatchewan (Pocock, in press).

Remarks: The dimensions of the appendices and the outline of the sides in *Appendicisporites crickmayii* are variable. Figures 2 and 3, plate 2 illustrate the range of variation within this species. Figure 3 is closer to the holotype.

Localty of figured specimens: Imperial Namao No. 1 well

Pl. 2, figs. 2, 3. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 2, fig. 2. Slide No. Micro. 267; co-ord. 9/39.4.

Pl. 2, fig. 3. Slide No. Micro. 267; co-ord. 10/49.8.

Appendicisporites Jansonii Pocock, 1962

Plate 2, figure 4

1962 Appendicisporites jansonii Pocock, Palaeontographica, Band 111, Abt. B, p. 37, pl. 2, fig. 23.

Description: Trilete; laesurae reaching the margin of endexine in the apices; commissures raised; equatorial outline triangular; sides straight; spore wall composed of two layers; endexine thin and smooth; ektexine

ornamented on both proximal and distal faces with ridges about 3 microns wide and parallel to the sides, commonly branching, separated by furrows 1 micron wide; ridges fusing at the apices; ektexine thickening at the apices, forming thick blunt apical knobs 8 to 12 microns long; exine thick.

Size range: Equatorial diameter 56 to 147 microns. Average 100 microns.

Distribution: Barremian? to middle Albian. Common in the Mannville Group. According to Pocock (1962), this key form is restricted to the Ellerslie and "calcareous" Members. However, in east-central Alberta this species was found in the Deville Member and Grand Rapids Formation as well, extending its known range.

Remarks: This species can be distinguished from A. tricornitatus by its thick blunt apical knobs, straight sides, and larger size. Its size range has been extended from 56-87 microns (Pocock, 1962, p. 37) to 56-147 microns, based on measurements of 20 specimens.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 2, fig. 4. Depth 3213 to 3222 feet; Deville Member.

Pl. 2, fig. 4. Slide No. Micro. 259; co-ord. 9.3/42.1.

APPENDICISPORITES ERDTMANII Pocock, in press

Plate 2, figures 5-7

In press Appendicisporites erdtmanii Pocock, Grana Palynologica, vol. 5.

Description: Trilete; laesurae simple slits extending up to approximately % of the spore radius; equatorial outline triangular; sides convex; apices sharp; endexine thin and smooth; ektexine thick, ornamented on the proximal surface by ribs 3 to 4 microns wide, spaced about 1 micron apart, running parallel to the sides of the spore; ribs from the adjacent sides fused in pairs near the apices; distal ribs also running parallel to the sides except in the innermost area about 15 microns across over the distal pole where three ribs join to form a triangle about 5 microns across; ribs extending from the apices of this triangle and joining the adjacent ribs (Pl. 2, Fig. 7); ektexine is thickened on the apices to form conical appendices about 6 microns long and 7 microns wide.

Size range: Equatorial diameter 50 to 55 microns.

Distribution: Barremian? to middle Albian. Common in the Mannville Group. Pocock (in press) describes it from upper Mannville equivalent strata of Saskatchewan.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 2, figs. 5-7. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 2, figs. 5-7. Slide No. Micro. 113; co-ord. 9.6/38.2.

Appendicisporites cooksonii (Balme) Pocock, in press

Plate 2, figures 8-10

Anemia mitriformina Korzhenevskaya, Rept. Vses. Geol. Inst., Leningrad. 1939 Cicatricosisporites cooksonii Balme, Australia, C.S.I.R.O., Coal Res. Sect., Ref. T.C. 25, p. 19, pls. 1, 2, figs. 23-26.

1958 Anemia mitriformina Korzhenevskaya—Verbitskaya, Spore pollen complexes from Cretaceous sediments of Sutchenski Coal Basin, Russia, pl. 2, figs. 37, 37a.

1961 Anemia cooksonii (Balme) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 59, pl. 17, figs. 6a-e.

In press Appendicisporites cf. A. cooksonii (Balme) Pocock, Grana Palynologica, vol. 5.

Description: Trilete; laesurae simple straight slits, 20 microns long, extending up to the margin of endexine in the apices, bordered by a 2-micron wide margo; equatorial outline rounded-triangular; sides convex; apical angle well rounded; endexine thin and smooth; ektexine about 4 microns thick in the interapical section, thickening up to 12 microns at the apices, forming very broadly rounded blunt appendices; proximal ektexine ornamented by flat, 5-micron wide ribs, separated by furrows about 1.5 microns wide, with three ribs in each interapical area, parallel to their side, the outer rib forming an equatorial girdle; distal ektexine ornamented by a series of parallel rounded ribs, 5 microns wide, separated by furrows about 1.5 microns wide and disposed obliquely to one side of the spore from the opposite apex, these distal ribs merging with the equatorial girdle.

Size range: Equatorial diameter 45 to 55 microns.

Distribution: Jurassic (Callovian) to Albian. Abundant in the Deville and Ellerslie Members. Upper Mannville equivalent strata in Saskatchewan (Pocock, in press). Callovian to Albian, Western Australia and Queensland (Balme, 1957).

Remarks: Although Balme (1957) makes no mention of appendices or proximal rib pattern, both these features are visible on his figured specimens (plate 1, figure 23). There is no doubt that the Canadian specimens are conspecific with the Australian ones, as they are identical both in size range and in ornamentation.

Anemia mitriformina Korzhenevskaya, 1939, was not illustrated or validly published. Therefore C. cooksonii Balme, 1957, has priority.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 2, figs. 8-10. Depth 3213 to 3222 feet; Deville Member.

Pl. 2, figs. 8-10. Slide No. Micro. 261: co-ord. 11.8/40.8.

Appendicisporites crimensis (Bolkhovitina) Pocock, in press

Plate 2, figures 11, 12

1961 Anemia crimensis Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 55, pl. 15, fig. 8, pl. 17, fig. 7.
In press Appendicisporites cf. A. crimensis (Bolkhovitina) Pocock, Grana Palynologica,

Description: Trilete; laesurae simple slits, extending up to the margin of the endexine in the apices, bordered by raised lips; equatorial outline triangular; sides slightly convex; apices sharp; endexine smooth and thin; ektexine thickened at the apices to form broad and blunt appendices; both the proximal and distal ektexine ornamented by a few flat ribs about 3 to 4 microns wide, separated by furrows 0.5 microns wide; each set of ribs running parallel to its side of the spore and merging with the adjacent set near the apices.

Size range: Equatorial diameter 38 to 50 microns.

Distribution: Hauterivian to Albian. Abundant in the Mannville Group. Upper Mannville equivalent strata of Saskatchewan (Pocock, in press). Hauterivian to Albian, U.S.S.R.

Remarks: The Canadian specimens of A. crimensis appear to be identical with the specimen illustrated on plate 17, figure 7 by Bolkhovitina (1961). The specimen illustrated on plate 15, figure 8, in the same publication, however, is unlike the Canadian specimens. Bolkhovitina uses the protruding spherical shape of the appendices to distinguish this species from Anemia macrorhyza but also mentions that there are intergrading forms between these two species. The Canadian specimens are smaller than the Russian specimens, which are between 50 to 60 microns in size, and they also lack the characteristic protruding spherical appendices. They have not been placed in A. macrorhyza because this species has even larger dimensions than A. crimensis.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 2, figs. 11, 12. Depth 1816 to 1826 feet; Grand Rapids Formation. Pl. 2, figs. 11, 12. Slide No. Micro. 121; co-ord. 10.8/44.

Appendicisporites sp. cf. A. pschekhaensis (Bolkhovitina) Pocock, in press Plate 2, figure 13

1961 Anemia pschekhaensis Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 55, pl. 15, fig. 9.
 In press Appendicisporites cf. A. pschekhaensis (Bolkhovitina) Pocock, Grana Palynologica, vol. 5.

Description: Trilete; laesurae reaching up to the margin of endexine in the apices; equatorial outline triangular; sides straight to slightly convex; endexine smooth and thin; ektexine about 3 microns thick and forming an equatorial girdle about 2 microns wide, thickened at the apices to form appendices about 14 microns long and about 6 microns wide; proximal and distal surfaces ornamented with ribs about 2 to 3 microns wide and spaced 1 to 3 microns apart, running parallel to the sides of the spore and fusing at the apices with the appendices; on distal face, three adjacent ribs merging with each appendix, on the proximal face three ribs on each side running internally parallel to equatorial girdle.

Size range: Equatorial diameter (including appendices) about 58 microns.

Distribution: Neocomian to middle Albian. Rare in the Mannville Group. Upper Mannville equivalent strata of Saskatchewan (Pocock, in press). Neocomian, U.S.S.R.

Remarks: The holotype of A. pschekhaensis has large, slightly elongated, club-like appendices, whilst the Canadian specimens have long, slightly tapering appendices. These specimens are also smaller than the Russian specimens which have a size range between 70 to 80 microns.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 2, fig. 13. Depth 1781 to 1791 fe

Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 2, fig. 13.

Slide No. Micro. 95;

co-ord. 7.9/35.4.

APPENDICISPORITES sp.

Plate 2, figure 14

Description: Trilete; laesurae indistinct, probably reaching the margin of the endexine in the apices; equatorial outline triangular; sides concave; ektexine ornamented both on proximal as well as distal faces with 4 or 5 ribs, each about 6 microns wide, parallel to the sides, fusing at apices and spaced about 2 to 3 microns apart; ektexine comparatively thin in the interapical areas, becoming thicker at the apices to form hollow and rounded appendices about 25 microns long, 25 microns wide and 20 microns thick.

Size range: Equatorial diameter 84 microns.

Distribution: Barremian? Very rare. A single specimen was recorded from the top of the Deville Member.

Remarks: This specimen differs from Appendicisporites jansonii in having concave instead of straight sides, wider and fewer ribs, and larger appendices.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 2, fig. 14. Depth 3213 to 3222 feet; Deville Member.

Pl. 2, fig. 14. Slide No. Micro. 260; co-ord. 12.5/46.2.

Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) n. comb.

Plate 3, figures 1-6

Anemia trichacantha (Maljavkina) var. dissecta Markova, in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 73, pl. 18, figs. 3a-c.

Description: Trilete; laesurae straight with slightly raised lips, equal to the radius of the spore, extending to the base of the appendices; equatorial outline triangular with slightly convex sides; endexine smooth and thin; ektexine thick and coarse, thickened at the apices to form slightly elongated to rounded appendices 14 microns wide, and 11 to 14 microns long; the ektexine on the proximal side ornamented with tightly packed ribs 3 to 6 microns wide, spaced about 1 micron apart, running parallel to the sides of the spore; the ribs on the distal side also running parallel to the sides, having the same dimensions as the proximal ones but with the ends of the adjacent ribs fusing to form a ridge running from the inner area to the appendices (Pl. 3, Fig. 3); the surface of both the proximal and distal ribs perforated by double or triple rows of pores, in most places these pores joining to give rise to numerous transverse grooves making notches on the margin of the ribs (Pl. 3, Fig. 6).

Size range: Equatorial diameter (including appendices) 97 microns.

Distribution: Albian to Cenomanian. Very rare. A single specimen of this species was recorded from the Wabiskaw Member. Albian and Cenomanian of western Siberia.

Remarks: The Canadian specimen of A. trichacanthus var. dissectus is larger than the Russian holotype, which has an equatorial diameter of 68 microns. The ribs are also slightly wider on the Canadian specimen.

Locality of figured specimen: Fort Augustus No. 1 well

Depth 2932 to 2938 feet; Wabiskaw Member. Pl. 3, figs. 1-6.

Slide No. Micro. 217; co-ord. 10/39.9. Pl. 3, figs. 1-6.

Appendicisporites sp. cf. Anemia trichacantha (Maljavkina) Markova, 1961

Plate 4, figures 1-3

?Plicatella trichacantha f. typica Maljavkina, Designation of spores and pollen in Jurassic and Cretaceous, p. 61, pl. 11, fig. 7.

1958 Anemia aurifera Verbitskaya, Spore and pollen complexes of Cretaceous deposits of Sutchanski Coal Basin, p. 317, pl. 2, fig. 38.

1961 Anemia trichacantha (Maljavkina) Markova, in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 73, pl. 18, figs. 2a-c.

In press Appendicisporites trichacanthus trichacanthus (Maljavkina) Pocock, Grana Palynologica, vol. 5.

Description: Trilete; commissures raised, distinct only up to ½ of the spore radius, obscured by merging with the ribs near the apices; equatorial outline triangular with straight to slightly convex sides; apices sharp with appendices about 8 to 12 microns long and 6 microns wide; endexine thin and smooth; ektexine thick with a proximal ornamentation of three sets of ribs, each parallel to its side of spore; ribs 2 microns wide spaced from 1 to 2 microns apart; area around the raised laesurae smooth; distal ornamentation composed of first set of ribs forming an equatorial girdle, second set of ribs connecting the apices and more or less parallel to the commissures on the proximal side, and third innermost set of ribs with an irregular pattern.

Size range: Equatorial diameter 50 to 65 microns.

Distribution: Aptian to Cenomanian. Rare in the Wabiskaw Member and Grand Rapids Formation. Aptian, Albian, and Cenomanian of Russia.

Remarks: In the description of Anemia trichacantha, Markova (1961) mentions that the laesurae are equal to the radius of the spore. On most of the Alberta specimens, however, the commissures are raised and distinct only up to ½ the radius of the spore; beyond this they merge with the rib pattern and become indistinguishable. The appendices are definitely larger on the Russian specimens, ranging between 13 to 17 microns in length and 10 microns in width. Markova appears not to have noticed the details of the distal ornamentation, which are not the same as on the proximal face. The specimens described by Markova (1961) have a size range between 53 to 60 microns, whereas Maljavkina's (1949) specimens have a size range between 120 to 140 microns. Yet they have been treated as the same species. The specimens should perhaps be re-examined with a view to revision, for such a range of variation within a single species appears to be improbable.

Locality of figured specimen: Fort Augustus No. 1 well
Pl. 4, figs. 1-3. Depth 2905 to 2914 feet; Wabiskaw Member.
Pl. 4, figs. 1-3. Slide No. FA2905-2914-2; co-ord. 20.8/52.

Appendicisporites unicus (Markova) n. comb.

Plate 4, figures 4-6

1961 Anemia unica Markova, in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 79, pl. 20, figs. 3a-b.

Description: Trilete; laesurae straight and simple slits, equal to the radius of the body; equatorial outline triangular with straight to slightly convex sides; apical appendices thin, elongated, slightly swollen and rounded at the tips, 14 microns long and 3 to 4 microns wide; a few smaller projections continuous with the ribs present at the base of each appendix; proximal face ornamented by about four sets of ribs each 2 to 4 microns wide, parallel to their sides, and spaced from 2 to 4 microns apart; on the distal face only the outer two ribs parallel to their sides; the rest of the inner area ornamented by ribs running along a curvature between two sides (Pl. 4, Fig. 6); distal ribs corrugate.

Size range: Equatorial diameter of body (without appendices) 38 microns.

Length of appendices about 14 microns.

Distribution: Albian to Cenomanian. Very rare. Two specimens were recorded from the Grand Rapids Formation. Cenomanian Stage of Siberia.

Remarks: The Canadian specimens of A. unicus appear to be identical with those illustrated and described from Russia. However, Markova has neither illustrated nor described the details of the distal ornamentation.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 4, figs. 4-6. Depth 2607 to 2616 feet; Grand Rapids Formation.

Pl. 4, figs. 4-6. Slide No. Micro. 186; co-ord. 11.8/39.5.

APPENDICISPORITES BIFURCATUS n. sp.

Plate 5, figures 1-5

Description: Trilete; laesurae simple and straight slits, extending to the margin of endexine at the base of the appendices, bordered by a thickened margo, 5 microns wide, on either side; equatorial outline circular to triangular with convex sides; endexine thin and smooth; ektexine thick, forming very thick appendices about 20 microns long and about 12 to 15 microns wide at the apices; appendices very thick in a vertical section and usually split into two to three branches depending upon the degree of inflation of the spore; ektexine on the proximal side ornamented by about fifteen sets of ribs, each about 2 microns wide and spaced about 0.5 microns apart, and parallel to each side; the ribs closer to the centre of the spore merging at their extremities with the thickened margo bordering the laesurae, only the outer ribs reaching the apices; ektexine on the distal side ornamented by the same number of ribs with similar width and spacing; the ribs closer to the outer margin converging at the base of the appendices, but each rib at the distal pole fusing with the one just outside it and so on, the last one reaching to the apex; a triangular area about 15 microns in diameter cut off at the distal pole with complex ribbing pattern, having ribs parallel to only two sides; ribs commonly branched.

Size range: Equatorial diameter (including appendices) 85 to 95 microns.

Equatorial diameter of the holotype (including appendices) 94 microns.

Distribution: Middle Albian. Rare in the shale member of the Clearwater Formation and in the Grand Rapids Formation.

Remarks: The specific name is derived from "bifurcatus" (divided, branched into two) and refers to the appendices which are usually split.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 5, figs. 1, 2, 4, 5. Depth 2842 to 2851 feet; Clearwater Formation, shale member.

Imperial Willingdon No. 1 well

Pl. 5, fig. 3. Depth 1911 to 1921 feet; Grand Rapids Formation.

Holotype: Pl. 5, figs. 1, 2, 4, 5. Slide No. 203; co-ord. 11.5/40.9. Pl. 5, fig. 3. Slide No. 153; co-ord. 12.5/38.

Appendicisporites perplexus n. sp.

Plate 5, figures 6-9

Description: Trilete; laesurae simple slits or slightly gaping, bordered by thickened lips which become narrower and thinner towards the extremities; laesurae about 34 of the spore radius, extending up to the base of the appendices; equatorial outline triangular with straight sides and rounded apices; proximal exine thin and smooth, thickened only in the area bordering the laesurae; ribbing pattern consisting of an equatorial girdle about 5 microns wide; distal surface convex; distal ektexine ornamented by a thickened triangular shield probably due to an extreme development and fusion of the ribs; the sides of thickened shield concave, the inner area of the shield variously excavated with holes (X, Y, and Z, Fig. 7) representing the reduced furrows between the ribs; the ornamentation pattern in the inner area very variable, but the average pattern roughly indicating that the shield splits into another set of single inner ribs, each parallel to a side of the shield; mode of separation of inner and outer ribs very variable, commonly in the form of an irregular large hole, resulting in complete separation, but also as a narrow groove; the distal triangular shield, diameter about 35 microns, at a higher level than the equatorial girdle; apices of the shield thickened to form internal cushions about 7 microns long and equally wide where they meet the equatorial girdle.

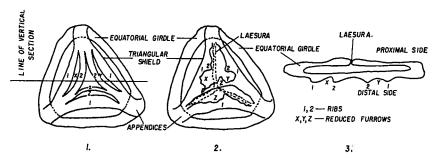


FIGURE 7. Appendicisporites perplexus n. sp. 1. Diagrammatic interpretation of distal ornamentation. 2. Observed distal ornamentation. 3. Vertical section.

Size range: Equatorial diameter 34 (41) 45 microns. Equatorial diameter of the holotype 44.2 microns.

Distribution: Middle Albian. Abundant in the Clearwater and Grand Rapids Formations.

Remarks: Spores similar to Appendicisporites perplexus n. sp. have been described by Pocock (in press) as A. degeneratus Thiergart, 1953. There are very few points of similarity between the Canadian specimens and the holotype of A. degeneratus (Thiergart, 1953, p. 55, pl. 14, fig. 4), which was described from the Cenomanian of Germany. The size range of the Canadian specimens based on the equatorial diameters of 20 spores is as follows:

2 spores: 34 microns, 2 spores: 39.1 microns, 9 spores: 40.8 microns, 5 spores: 43.2 microns, and 1 spore: 44.2 microns. These measurements indicate that the size of this species is fairly uniform, and further checking yielded no spores with a larger equatorial diameter than 45 microns. In contrast, the equatorial diameter of the holotype of A. degeneratus is 80 microns. The appendices in the Canadian specimens seldom protrude beyond the apical margin, whereas the holotype of A. degeneratus has been illustrated and described by Thiergart as having "projections on the apices forming short horns," A. degeneratus has a distinct and prominent rib pattern on the distal face, whereas the Canadian specimens have only a thickened, triangular distal shield excavated in various manners by holes or furrows which only vaguely resemble a rib pattern. The size and morphological differences between A. degeneratus and the Canadian specimens justify the creation of Appendicisporites perplexus n. sp.

Zonales sp. Bennie and Kidston (Thiergart, 1953, p. 57, pl. 14, fig. 5), with a size range of 74 to 92 microns, is similar to A. perplexus in having an equatorial girdle and inner triangular zone. However, it is larger, has no appendices, and the details of ornamentation on the inner triangular zone are not clear.

The specific name is derived from "perplexus" (intricate, involved) and refers to the intricate distal ornamentation.

Type locality: Fort Augustus No. 1 well

Depth 2496 to 2505 feet; Grand Rapids Holotype: Pl. 5, figs. 6, 8, 9.

Formation.

Pl. 5, fig. 7. Depth 2842 to 2851 feet; Clearwater

Formation, shale member.

co-ord. 10.8/38.5. Holotype: Pl. 5, figs. 6, 8, 9. Slide No. Micro. 174;

Pl. 5, fig. 7. Slide No. FA2842-2851-4; co-ord. 10.5/71.

Genus Cicatricosisporites Potonié and Gelletich, 1933

Cicatricosisporites dorogensis Potonié and Gelletich, Sitzber. Ges. Naturf. Freunde (Berlin), vol. 33, p. 522, pl. 1, figs. 1-5 (type species).

Mohria—Typus, Thiergart, Palaeontographica, Band 89, Abt. B, p. 22.

Mohrioidites Thiergart, Geol. Jahrb., vol. 65, p. 84.

Mohrioisporites dorogensis Potonié, Palaeontographica, Band 91, Abt. B, p. 135,

pl. 20, fig. 14.

Mohrioisporites australiensis Cookson, Australian J. Botany, vol. 1, p. 470, pl. 2, 1953 figs. 31-34.

Cicatricosisporites australiensis (Cookson) Potonié, Beih. Geol. Jahrb., Heft 23, 1956

p. 48. Mohria dorogensis (Potonié) Markova, in Samoilovitch et al., Trudy Vses. Neft. 1961 Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 86, pl. 22, fig. 4.

Diagnosis: Trilete; exine two-layered and sculptured with muri or ridges of uniform width and height; canaliculate to cicatricose; muri more or less parallel to the equator. Equatorial outline regularly crenate, with no tendency to thicken at the apices.

CICATRICOSISPORITES DOROGENSIS Potonié and Gelletich, 1933

Plate 6, figure 1

(Synonymy as for genus)

Description: Trilete; laesurae reaching or almost reaching the equator; commissures raised in some specimens; equatorial outline rounded-triangular with straight, slightly convex or slightly concave sides; proximal face flat; distal face convex; ektexine ornamented with occasionally branching flat-topped ribs, 1 to 5 microns broad and spaced 0.5 to 3 microns apart, oblique to the sides of the spore, present on distal as well as proximal face forming a "criss-cross" pattern; wide variation in size and in thickness and spacing of ribs.

Size range: Equatorial diameter 30 to 55 microns.

Distribution: Jurassic (Purbeckian) to Tertiary. Abundant throughout the Mannville Group.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 6, fig. 1. Depth 2095 to 2098 feet; Wabiskaw Member.

Pl. 6, fig. 1. Slide No. IW2095-2098-1; co-ord. 0/44.

CICATRICOSISPORITES DORSOSTRIATUS (Bolkhovitina) n. comb.

Plate 6, figures 2-4

1956 Anemia dorsostriata Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 2, p. 60, pl. 7, figs. 95a-b.

Description: Trilete; laesurae extending up to the equatorial girdle, bordered by slightly thickened lips; equatorial outline rounded-triangular; ornamentation consisting of an equatorial girdle, 5 to 7 microns wide and 10 to 12 ribs, 4 to 7 microns wide, closely packed together, running completely across the distal surface including the equatorial girdle; proximal surface ornamented by an outer set of ribs running just inside the equatorial girdle; the second set of ribs, inside the outer set, very wide (maximum width about 12 microns) with corrugated margin bordering the laesurae which cut across both of these inner ribs, reaching the inner margin of the equatorial girdle.

Size range: Equatorial diameter 48 to 55 microns.

Distribution: Middle Jurassic to Albian. Rare in the Ellerslie Member and shale member of the Clearwater Formation. Middle Jurassic, Neocomian, and Aptian, U.S.S.R.

Remarks: The Canadian specimens of *C. dorsostriatus* appear to be identical with those described by Bolkhovitina (1956, 1961). However, they are slightly larger than the Russian specimens, which have an average size of 45 microns and a maximum size of 49 microns. Also, Bolkhovitina (*op. cit.*) does not show the distal ribs continuing onto the equatorial girdle, nor

does she illustrate fully the details of the distal and proximal ornamentation. However, Bolkhovitina's (1961, pl. 15, fig. 4c) specimens show the proximal ornamentation with the wide corrugated ribs bordering the laesurae.

Locality of figured specimen: Fort Augustus No. 1 well
Pl. 6, figs. 2-4. Depth 2689 to 2699 feet; Clearwater Formation,
shale member.
Pl. 6, figs. 2-4. Slide No. Micro. 163; co-ord. 11/41.2.

CICATRICOSISPORITES PERFORATUS (Baranov, Nemkova and Kondratiev)
n. comb.

Plate 6, figures 5-7

Anemia perforata Baranov, Nemkova and Kondratiev, Impression of leaves and spectrum of spores and pollen of a horizon with flora from Mikhailovska Formation from the river Kem, p. 202, pl. 2, fig. 22.

1961 Mohria perforata (Baranov et al.) Markova, in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 85, pl. 22, figs. 3a-b.

Description: Trilete; commissures raised with thick lips, laesurae straight and equal to the radius of the spore; equatorial outline triangular, rounded at the corners; sides convex; proximal surface ornamented by 3 to 5 sets of ribs, 3 to 5 microns wide, spaced 1 micron apart and running parallel to their side; distal surface ornamented by about 10 ribs, 4 to 6 microns wide and spaced 1 micron apart, disposed obliquely to one side of the spore from the opposite apex; a single row of holes present on both the distal as well as proximal ribs, 1 micron in diameter, distributed along their whole length and spaced about 3.5 microns apart.

Size range: Equatorial diameter 48 to 58 microns.

Distribution: Aptian to Turonian. Abundant at the base of the Ellerslie Member. Present also in the Colorado Group (Upper Cretaceous) according to Pocock (pers. comm.). Aptian to Turonian, U.S.S.R.

Remarks: Insofar as *C. perforatus* has no appendices, it appears closer to the genus *Mohria* than to *Anemia*. Because of the uncertainty of the natural relationships, it appears preferable to place this species in the organgenus *Cicatricosisporites*.

The Canadian specimens are larger than the Russian ones, the latter ranging between 35.4 to 36.8 microns.

Locality of figured specimen: Imperial Namao No. 1 well Pl. 6, figs. 5-7. Depth 3860 to 3870 feet; Ellerslie Member. Pl. 6, figs. 5-7. Slide No. Micro. 48; co-ord. 12.5/46.

CICATRICOSISPORITES MEDIOSTRIATUS (Bolkhovitina) Pocock, 1962

Plate 6, figure 8

1961 Pelletieria mediostriata Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 66, pl. 19, figs. 3a-b, pl. 21, figs. 1a-c.

In press Cicatricosisporites mediostriatus (Bolkhovitina) Pocock, Grana Palynologica,

Description: Trilete; laesurae simple slits bordered by raised lips, more than 3/3 of radius of spore; equatorial outline circular to subcircular; endexine smooth and thin; ektexine thicker, ornamented with ribs about 2 microns wide and spaced about 1 micron apart, in places branching; the pattern of ribbing on the proximal face irregular and not very distinct; the distal face ornamented with two sets of ribs, the ribs of each set parallel to one another, and intersecting the ribs of the other set to form a rhombic net.

Size range: Equatorial diameter 40 to 50 microns.

Distribution: Hauterivian to Turonian. Common throughout the Mannville Group. Upper Mannville equivalent strata of Saskatchewan (Pocock, in press).

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 6, fig. 8. Depth 3686 to 3696 feet; Ellerslie Member.

Pl. 6, fig. 8. Slide No. Micro. 29:

co-ord. 14.2/47.2.

CICATRICOSISPORITES ORBICULATUS n. sp.

Plate 6, figures 9-12

Description: Trilete; laesurae about ¾ of the spore radius; commissures raised with lips 2.5 microns thick on either side; equatorial outline circular; ektexine thick and ornamented with ribs 1.5 to 2 microns wide, spaced about 0.5 microns apart; proximal surface slightly convex with about 8 ribs arranged more or less parallel to the sides, and whose arrangement may be disturbed due to compression or twisting; the ribs near the proximal pole of the spore terminating at the thickened margin of the laesurae, only the outer ribs converging at the extremities of the laesurae; distal surface markedly convex with numerous slightly sinuous ribs running right across the face from one end to the other, and forming a crenulate margin.

Size range: Equatorial diameter about 34 microns.

Equatorial diameter of the holotype 34 microns.

Distribution: Aptian. Rare. A few specimens were found at the base of the Ellerslie Member.

Remarks: The specific name is derived from "orbiculatus" (round, circular outline) and refers to the circular equatorial outline.

Type locality: Imperial Namao No. 1 well

Holotype: Pl. 6, figs. 9-12. Depth 3860 to 3870 feet; Ellerslie Member. Holotype: Pl. 6, figs. 9-12. Slide No. IN3860-3870-8; co-ord. 4.5/33.4.

CICATRICOSISPORITES Sp. A

Plate 7, figures 1-3

Description: Trilete; laesurae reaching the equatorial margin; commissures raised, thick and 8 microns wide; equatorial outline triangular with convex sides; endexine thin and smooth; ektexine thicker, ornamented with ribs about 2 microns wide and spaced 0.8 microns apart, commonly branching; pattern of ribbing on the proximal face oblique to the sides, approximately parallel to one of the commissures and terminating at the other commissure; distal face ornamented by branching ribs running right across the face from one end to the other, ribs disposed obliquely to the sides, resulting in a crenulate margin.

Size range: Equatorial diameter 60 microns.

Distribution: Middle Albian. Very rare. A single specimen was recorded from the Wabiskaw Member.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 7, figs. 1-3. Depth 2932 to 2938 feet; Wabiskaw Member.

Pl. 7, figs. 1-3. Slide No. FA2932-2938-3; co-ord. 13/37.

CICATRICOSISPORITES Sp. B

Plate 7, figures 4-6

Description: Trilete; laesurae simple slits extending up to ¾ of the spore radius; equatorial outline triangular with slightly convex sides and broadly rounded apices; ektexine on the proximal side ornamented with ribs about 3 microns wide and spaced about 0.5 microns apart, the outer 3 ribs parallel to the sides, and continuous around the apices; the inner ribs terminating at the laesurae and discontinuous around the apices; the distal ektexine similarly ornamented with 2 to 3 outer ribs continuous around the apices, the rest of the ribs extending completely across the inner distal face.

Size range: Equatorial diameter 46 microns.

Distribution: Middle Albian. Very rare. A single specimen was found in the Grand Rapids Formation.

Remarks: The outer ribs, continuous around the apices, suggest an affinity with *Chomotriletes*, which has similar concentric rings. Also, the obliquely oriented ribs are quite common in the genus *Chomotriletes*. However, the distinct trilete mark, triangular shape, and the discontinuous inner

ribs around the apices do not warrant its inclusion in the genus Chomotriletes.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 7, figs. 4-6. Depth 2562 to 2571 feet; Grand Rapids Formation.

Pl. 7, figs. 4-6. Slide No. Micro. 264; co-ord. 11/37.2.

Genus Chomotriletes Naumova, 1937?, 1939 ex Naumova, 1953

1937 Chomotriletes Naumova, Intern. Geol. Congr., 17th, Moscow, Absts. Papers, p. 60-61.

1953 Chomotriletes vedugensis Naumova, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR, vol. 143, p. 39, pl. 7, fig. 21 (type species).

Diagnosis: Trilete mark very faint or absent; equatorial outline irregularly circular to broadly subtriangular; very characteristic ornamentation consisting of concentric ridges on at least one face; these ridges may or may not be continuous.

Remarks: Owing to the very broad diagnosis of the genus Chomotriletes, some authors (e.g. Bolkhovitina, 1953, p. 35) have placed in this genus forms which probably should be assigned to Cicatricosisporites, Corrugatisporites, or Appendicisporites. However, this might have been avoided if attention were paid to the fact that the genus Chomotriletes has numerous continuous or discontinuous circular and concentric ridges, and a faint or no trilete mark. To avoid further confusion, it seems necessary to place in the genus Chomotriletes only those forms which have numerous circular and concentric ridges, and to exclude trizonate forms with distinct trilete marks. Stover (1962) has proposed a new genus Taurocusporites to receive such trizonate and trilete forms. However, his emendation of the genus Chomotriletes to include only alete spores does not appear to be valid. When Naumova (1937) first described Chomotriletes, she noted that it is similar to trilete spores with concentric zones around the trilete mark, as found in the sub-division Azonotriletes Luber, 1935. However, Naumova designated a type species for the genus Chomotriletes only in 1953. In describing the type species Chomotriletes vedugensis, Naumova (1953) mentions only "mark of laesurae not observed". However, this does not mean that laesurae do not exist. In his generic diagnosis of Chomotriletes, Potonié (1958, p. 22) states that the "trilete rays are absent or faintly developed". Also, contrary to what Stover claims, Chomotriletes alutaceous Luber, 1955 does possess a trilete mark (Bolkhovitina, pers. comm.). The name Chomotriletes itself indicates that only trilete spores should be included in this genus. Under these circumstances, the restriction of the genus Chomotriletes to only alete forms by Stover (1962) does not appear to be justified.

Chomotriletes almegrensis Pocock, 1962

Plate 7, figure 7

Chomotriletes almegrensis Pocock, Palaeontographica, Band 111, Abt. B, p. 38, pl. 2, figs. 27-29.

Description: Alete; equatorial outline circular to subcircular; exine twolayered; the outer layer ornamented with ridges about 1 micron wide and 1 micron high, separated from each other by a furrow about 0.5 microns wide; the ridges on one face running obliquely across the spore, and then folded back on themselves to form a type of sulcus; the ridges on the opposite face arranged in concentric circles parallel to the equatorial margin, the ridges being discontinuous and broken.

Size range: Equatorial diameter 38 microns.

Distribution: Aptian to middle Albian. Very rare. A single specimen of this species was found in the Grand Rapids Formation. Also in the Ellerslie Member (Pocock, 1962).

Affinity: The exine structure and the ornamentation indicate a schizaeaceous affinity.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 7, fig. 7. Depth 2598 to 2607 feet; Grand Rapids Formation.

Pl. 7, fig. 7. Slide No. Micro. 179; co-ord. 11.5/39.

Genus Schizaeoisporites Potonié, 1951

1934 Sporites dorogensis Potonié (part), Arb. Inst. Paläobot. Petrogr. Brennsteine,

vol. 4, p. 40-41, pl. 1, fig. 22.

Schizaea eocenica Selling, Medd. Göteborgs Bot. Trädgard, vol. 16, p. 66, pl. 4, 1944 fig. 44.

1949 Sporites dorogensis Potonié—Thiergart, Palaeontographica, Band 89, Abt. B, pls. 4, 5, figs. 35, 36.

1951 Schizaeoisporites pseudodorogensis Potonié, Palaeontographica, Band 91, Abt. B, p. 144, pl. 20, fig. 19.

1952 Cicatricoso-sporites pseudodorogensis (Potonié) Pflug, Paläont. Z., vol. 26, pl. 7,

Schizaeoisporites eocenicus (Selling) Potonié, Beih. Geol. Jahrb., Heft 23, p. 81, pl. 11, fig. 108 (type species).

Diagnosis: Monolete spores; cicatricose to canaliculate exine; laesura has a ridge on either side.

SCHIZAEOISPORITES EOCENICUS (Selling) Potonié, 1956

Plate 7, figures 8, 9

(Synonymy as for genus)

Description: Monolete; laesura about 3/3 of total length of spore; equatorial outline bean-shaped; exine ornamented by narrow ridges, about 1.5 microns wide, parallel with one another and with the laesura; ridges separated by furrows about 0.5 microns wide, and with some tendency to

converge towards the ends of the spore, where they are continuous with ridges from the other side, commonly branched.

Size range: Length 65 microns. Breadth 38 microns (average).

Distribution: Lower Cretaceous to Eocene. Rare in the Ellerslie Member and Clearwater Formation. Eocene of Germany (Potonié, 1934).

Locality of figured specimens: Fort Augustus No. 1 well Pl. 7, fig. 8. Depth 2833 to 2842 feet; Clearwater Formation, shale member. Pl. 7, fig. 9. Depth 2932 to 2938 feet; Wabiskaw Member. Pl. 7, fig. 8. Slide No. Micro. 202; co-ord. 11/41.5. Pl. 7, fig. 9. Slide No. Micro. 213; co-ord. 11.5/40.

Schizaeoisporites phaseolus Delcourt and Sprumont, 1955 Plate 7, figures 10, 11

1955 Schizaeoisporites phaseolus Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 46-47.

Description: Monolete; laesura about \(^2\)3 total length of spore; equatorial outline bean-shaped; area around the laesura unornamented; rest of the spore ornamented by parallel ridges about 2 microns wide, running obliquely to the laesura forming a "criss-cross" pattern; ridges separated by furrows I micron wide, commonly branched and continuous with the ridges on the opposite side.

Size range: Length 48 microns. Breadth 28 microns (average).

Distribution: Lower Cretaceous. Rare in the Mannville Group. "Wealden" of Belgium (Delcourt and Sprumont, 1955).

Remarks: The Canadian specimens are smaller than those found in Europe (length 59 to 68 microns, breadth 35 to 50 microns).

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 7, fig. 10. Depth 1781 to 1791 feet; Grand Rapids Formation. Fort Augustus No. 1 well

Pl. 7, fig. 11. Depth 2860 to 2869 feet; Clearwater Formation, shale member.

Pl. 7, fig. 10. Slide No. IW1781-1791-1; co-ord. 4.2/62.2. Pl. 7, fig. 11. Slide No. Micro. 204; co-ord. 10.4/38.1.

Genus Dictyotrilletes Naumova, 1937 ex Potonié and Kremp, 1955

- Sporonites bireticulatus Ibrahim in Potonié, Ibrahim and Loose, Neues Jahrb. Mineral., Geol. Paläont., Band 67, Abt. B, p. 447-449, pl. 14, fig. 1. Reticulatisporites bireticulatus Ibrahim, doctor. diss., Tech. Hochschule zu Berlin (privately published), p. 35, pl. 1, fig. 1. Dictyriletes Naumova, Intern. Geol. Congr., 17th, Moscow, Absts. Papers,
- 1937 p. 60-61.
- Dictyotriletes bireticulatus (Ibrahim) Potonié and Kremp, Palaeonitographica, Band 98, Abt. B, p. 106-107, figs. 28, 29 (type species). 1955

Diagnosis: Trilete; equatorial outline subtriangular to subcircular; proximal face flat, levigate; distal face reticulate, strongly convex; the mesh structure of the exine surface composed of low and flat muri, lumina shallow.

Remarks: Reticulatisporites can be distinguished from this genus by its high muri which project into an outer membrane.

DICTYOTRILETES PSEUDORETICULATUS (Couper) Pocock, 1962

Plate 7, figures 12, 13

1958 Klukisporites pseudoreticulatus Couper, Palaeontographica, Band 103, Abt. B, p. 138, pl. 19, figs. 8-10.

1962 Dictyotriletes pseudoreticulatus (Couper) Pocock, Palaeontographica, Band 111, Abt. B, p. 41, pl. 3, figs. 46, 47.

Description: Trilete; laesurae almost reaching equator; equatorial outline rounded-triangular; sides convex to straight; proximal face flat and smooth except around equator where distal sculpture encroaches; distal face strongly convex, with clear foveo-reticulate sculpture; lumina from 3 to 5 microns wide and spaced 2 to 4 microns apart; muri flat.

Size range: Equatorial diameter 30 to 60 microns.

Distribution: Upper Jurassic to Lower Cretaceous. Common throughout most of the Mannville Group. Upper Vanguard (Jurassic) of Saskatchewan (Pocock, 1962). Purbeckian and Wealden of England (Couper, 1958).

Affinity: According to Couper (1958), this species has affinities with the Jurassic schizaeaceous plants *Klukia exilis*, *Stachypteris hallei*, etc.

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 7, fig. 12. Depth 1781 to 1791 feet; Grand Rapids Formation. Imperial Namao No. 1 well

Pl. 7, fig. 13. Depth 3726 to 3736 feet; Ellerslie Member.

Pl. 7, fig. 12. Slide No. Micro. 93; co-ord. 13.2/36.5.

Pl. 7, fig. 13. Slide No. Micro. 33; co-ord. 10.5/47.8.

Genus Klukisporites Couper, 1958

1958 Klukisporites variegatus Couper, Palaeontographica, Band 103, Abt. B, p. 137, pl. 19, figs. 6, 7 (type species).

Diagnosis: Trilete; laesurae long, about ¾ of radius of spore, commissures raised, bordered by a margo; equatorial contour rounded-triangular; distal surface with foveolate, foveo-reticulate or incomplete foveolate pattern consisting of convolute anastomosing ridges; contact area of proximal surface with greatly reduced sculpture; exine thick.

Remarks: The generic diagnosis has been slightly altered to include specimens showing an incomplete foveolate pattern of convolute and anastomosing ridges.

KLUKISPORITES Sp.

Plate 8, figure 1

Description: Trilete; laesurae simple slits, about 3/4 of radius of spore, flanked by slightly raised lips; equatorial outline triangular with convex sides and rounded apices; proximal surface smooth except at the apices where the distal ornament passes on to it; distal surface ornamented with convolute anastomosing ridges about 4 microns high and 4 to 6 microns wide which in some specimens enclose an area 10 to 12 microns in diameter, creating an effect of discontinuous and degenerating coarse foveolate pattern; exine thick.

Size range: Equatorial diameter 51 microns.

Distribution: Middle Albian. Very rare. Two specimens were recorded from the uppermost portion of the Grand Rapids Formation.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 8, fig. 1. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 8, fig. 1. Slide No. Micro. 122; co-ord. 6.4/45.

Genus Lygodioisporites Potonié, 1951, emend.

1934 Sporites solidus Potonié, Arb. Inst. Paläobot. Petrogr. Brennsteine, vol. 4, p. 42,

1951

pl. 1, fig. 35.

Lygodioisporites solidus (Potonié) Potonié, Palaeontographica, Band 91, Abt. B, p. 144, pl. 20, figs. 12, 13 (type species, subsequent designation).

Corrugatisporites solidus (Potonié) Thomson and Pflug, Palaeontographica, Band 94, Abt. B, pl. 2, figs. 37, 38, 40-43.

Emended diagnosis: Trilete microspores, laesurae extending from 1/2 to 4/5 of the spore radius, equatorial outline triangular with strongly convex to nearly straight sides and well-rounded apices, ornamentation consisting of irregularly arranged, coarse, intersecting rounded ridges with projecting tubercles running in radial or other directions, spherical verrucae which may be dense or sparse, or confluent tubercles.

Remarks: Ornamentation is evenly distributed over the spore surface and does not show any tendency towards concentration at the apices as in the case of the genus Trilobosporites. The tuberculate ridges do not run parallel to the equatorial margin as in the genus Corrugatisporites.

Lygodioisporites is here emended to include spores with shorter laesurae also, so that all the heavily ornamented species which are morphologically similar to the spores of Lygodium may be grouped under the genus Lygodioisporites. These are characterized by a loosely attached and easily detachable ektexine.

Lycodioisporites sp. A

Plate 8, figure 2

Description: Trilete; laesurae simple slits, bordered by thick and wide lips, about 3 to 4 microns in width, narrowing towards the extremities, extending up to ½ of the spore radius; equatorial outline triangular with straight sides and broadly rounded apices; proximal surface slightly flat; distal surface convex; both surfaces ornamented with flat, sparsely distributed verrucae: ektexine with ornamentation torn off from some areas on the proximal surface revealing smooth endexine; exine double-layered, about 4 microns thick.

Size range: Equatorial diameter 65 microns.

Distribution: Middle Albian. Very rare. A single specimen was recorded from the Wabiskaw Member.

Locality of figured specimen: Fort Augustus No. 1 well

Depth 2923 to 2932 feet; Pl. 8, fig. 2.

Wabiskaw Member.

Pl. 8, fig. 2.

Slide No. Micro. 200:

co-ord. 11.2/39.5.

LYGODIOISPORITES Sp. B

Plate 8, figure 3

Description: Trilete; laesurae gaping, extending up to 3/4 of the spore radius; equatorial outline triangular; sides straight; apices broadly rounded; exine of both the proximal and distal surfaces densely verrucate; diameter of the verrucae 3 to 4 microns; exine thick.

Size range: Equatorial diameter 58 microns.

Distribution: Middle Albian. Very rare in the Wabiskaw Member and the Grand Rapids Formation.

Remarks: This species has not been formally named as only a few specimens were found.

Locality of figured specimen: Fort Augustus No. 1 well

Depth 2451 to 2460 feet; Pl. 8, fig. 3. Grand Rapids Formation.

Slide No. Micro. 176; co-ord. 11/39. Pl. 8, fig. 3.

Genus Lygodiumsporites Potonié, Thomson and Thiergart, 1950, emend.

1933 Punctatisporites adriennis Potonié and Gelletich, Sitzber. Ges. Naturf. Freunde

runciansporties aariennis rotonie and Gelletich, Sitzber. Ges. Naturi. Freunde (Berlin), vol. 33, p. 521, pl. 2, fig. 14.

Lygodiumsporites adriennis (Potonié and Gelletich) Potonié, Thomson and Thiergart, Geol. Jahrb., vol. 65, p. 45, pl. A, fig. 7, pl. C, fig. 2.

Lygodiumsporites adriennis (Potonié and Gelletich) emend. Potonié, Beih. Geol. Jahrb., Heft 23, p. 19, pl. 1, fig. 11 (type species).

Leiotriletes adriennis (Potonié and Gelletich) Krutzsch subsp. adriennis, Geologie, Labra 8, p. 1-425 1950

1956

1959 Jahrg. 8, p. 1-425. Emended diagnosis: Trilete microspores, laesurae extending from 1/2 to 4/5 of the spore radius, equatorial outline rounded-triangular, apices broadly rounded, exine smooth to subgranulose.

Remarks: Potonié (1956) restricted this genus to include spores with laesurae shorter than ½ the spore radius. However, forms such as Sporites adriennis (Potonié and Gelletich, 1933) Thiergart, 1949 form mesozoicus Thiergart, 1949 (pls. 4, 5, fig. 9) and subspecies such as Leiotriletes adriennis (Potonié and Gelletich, 1933) Krutzsch, 1959 subfsp. pseudomaximus (Thomson and Pflug, 1953) Krutzsch, 1959 (see Kedves, 1961, p. 112-114, pl. 3, figs. 3-6), with laesurae extending from 2/3 to 4/5 of the spore radius, have already been created within the species adriennis. In these cases species adriennis was transferred to the genera Sporites or Leiotriletes, which have wide generic circumscriptions. Thus, Potonié's (1956) restriction is not serving any useful purpose. Therefore, the generic circumscription of Lygodiumsporites has been emended here to include spores with longer laesurae as well, so that all the smooth to subgranulose species morphologically similar to the spores of Lygodium may be grouped under the genus Lygodiumsporites.

LYGODIUMSPORITES sp. A

Plate 8, figure 4

Description: Trilete; laesurae as slits, bordered by thickened lips about 3 microns wide on either side, narrowing towards the extremities, nearly reaching the equator; equatorial outline triangular with convex sides and broadly rounded apices; exine smooth; distal surface strongly convex; exine double-layered about 6 microns thick; color dark brown.

Size range: Equatorial diameter 60 microns.

Distribution: Aptian to middle Albian. Very rare. Only two specimens of this species were recorded, one from the Ellerslie Member, and the other from the Grand Rapids Formation.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 8, fig. 4. Depth 3010 to 3019 feet; Ellerslie Member.

Pl. 8, fig. 4. Slide No. Micro. 224; co-ord. 10/40.

Lygodiumsporites sp. B

Plate 8, figure 5

Description: Trilete; laesurae simple slits, nearly reaching the equator, with a hole at the raised extremity of each laesura; equatorial outline triangular with straight sides and broadly rounded apices; distal surface convex; exine very finely granulate; double-layered; 4 to 5 microns thick.

Size range: Equatorial diameter 85 microns.

Distribution: Middle Albian. Very rare in the Clearwater Formation and upper portion of the Grand Rapids Formation.

Remarks: This species has not been formally named as only a few specimens were found.

Lygodiumsporites sp. B is nearly identical with Sporites adriennis Potonié form mesozoicus Thiergart, 1949, but is larger in size. It is also similar to Hymenophyllumsporites deltoidus Rouse, 1957, but lacks ribbonlike lists bordering the laesurae, which are diagnostic of the latter.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 8, fig. 5. Depth 1816 to 1826 feet; Grand Rapids Formation.

Pl. 8, fig. 5.

Slide No. Micro. 124:

co-ord. 10.1/34.2.

Genus Neoraistrickia Potonié, 1956

1953 Trilites truncatus Cookson, Australian J. Botany, vol. 1, p. 471, pl. 2, fig. 36. 1956 Neoraistrickia truncatus (Cookson) Potonié, Beih. Geol. Jahrb., Heft 23, p. 34, pl. 3, fig. 32 (type species).

Diagnosis: Trilete; laesurae reaching equator; equatorial outline rounded-triangular; exine ornamented by not too densely distributed clavate spines, with broadened tips; spines relatively thinner than those present on genus Raistrickia.

NEORAISTRICKIA? Sp.

Plate 8, figures 6, 7

Description: Trilete; laesurae reaching equator; commissures raised, narrow; equatorial outline rounded-triangular; both proximal as well as distal exine ornamented sparsely by 0.5-micron thick and 3.5-micron long clavate spines; exine thin.

Size range: Equatorial diameter (including spines) 42 microns.

Distribution: Aptian. Very rare. A single specimen was found near the base of the Ellerslie Member.

Remarks: The specimen has much thinner clavate spines than other forms placed in Neoraistrickia and, therefore, is referred to this genus with question. It cannot be placed in the genus Pilosisporites, because it is ornamented with distinctly clavate spines, whereas Pilosisporites has pointed spines.

Locality of figured specimen: Fort Augustus No. 1 well

Depth 3174 to 3179; Pl. 8, figs. 6, 7.

Ellerslie Member.

Pl. 8, figs. 6, 7. Slide No. Micro. 251;

co-ord. 11/41.

Family GLEICHENIACEAE

Genus Gleicheniidites Ross, 1949 ex Delcourt and Sprumont, 1955

- 1949 Gleicheniidites senonicus Ross, Bull. Geol. Inst. Univ. Upsala, vol. 34, p. 31, pl. 1, figs. 3, 4 (type species).
- 1955 Gleicheniidites senonicus Ross ex Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 26 (designation of type species and generic diagnosis).
- 1957 Gleichenia concavisporites Rouse, Can. J. Botany, vol. 35, p. 363, pl. 2, figs. 36, 48, pl. 3, fig. 49.
- 1961 Gleichenia senonica (Ross) Grigorjeva, in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 46, pl. 13, figs. 1a-b, 2a-b, 3a-b.

Diagnosis: Trilete; laesurae simple, reaching or almost reaching the equator; equatorial outline triangular; apices sharply arcuate; sides usually concave to straight; exine smooth.

GLEICHENHIDITES SENONICUS Ross, 1949

Plate 8, figures 8, 9

(Synonymy as for genus)

Description: Trilete; laesurae simple, reaching the equator; equatorial outline triangular; apices sharply arcuate; sides usually straight to concave; proximal face flat; distal face strongly convex; proximo-distal flattening resulting in three folds on the distal side, parallel to the outer margin of the spore; exine smooth, 1 micron or less thick.

Size range: Equatorial diameter 20 to 38 microns.

Distribution: Jurassic and Cretaceous. Abundant.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 8, fig. 8.	Depth 2815 to 2824 feet;	Clearwater Formation,
		shale member.
Pl. 8, fig. 9.	Depth 2782 to 2785 feet;	Clearwater Formation,
		shale member.
Pl. 8, fig. 8.	Slide No. Micro. 194;	co-ord. 12/40.
Pl. 8, fig. 9.	Slide No. FA2782-2785-3;	co-ord. 20/51.6.

GLEICHENHIDITES sp. cf. G. CIRCINIDITES (Cookson) n. comb.

Plate 8, figures 10, 11

1953 Gleichenia circinidites Cookson, Australia J. Botany, vol. 1, p. 464, pl. 1, figs. 5, 6.

1957 Gleichenia cf G. circinidites Cookson—Balme, Australia, C.S.I.R.O., Coal Res. Sect., Ref. T.C. 25, p. 23, pl. 3, figs. 42-44.

Description: Trilete; laesurae bordered by thin lips, reaching the equator; equatorial outline triangular; apices pointed and rhombic in shape; sides straight to slightly concave; proximal face flat; distal face strongly convex; proximo-distal compression of the tetrad resulting in interapical foldings characteristic of the spores in family Gleicheniaceae; the dark lines

on plate 8, figure 11 perhaps represent a diffraction pattern related to the thickened zones.

Size range: Equatorial diameter 27.5 microns.

Distribution: Upper Jurassic to Lower Cretaceous, and Eocene? Rare in the Clearwater shale member and Grand Rapids Formation. Upper Jurassic and Lower Cretaceous of Western Australia (Balme, 1957); Eocene of Western Australia (Cookson, 1953).

Remarks: The specimens described by Balme (1957) from Western Australia are very similar to this species, whereas Cookson's (1953) specimens are larger.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 8, figs. 10, 11. Depth 1781 to 1791 feet; Grand Rapids Formation. Pl. 8, figs. 10, 11. Slide No. Micro. 102; co-ord. 11.7/39.8.

Family Cyatheaceae or Dicksoniaceae

Genus Cyathidites Couper, 1953

1953 Cyathidites australis Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 27, pl. 2, figs. 11, 12 (type species).

Diagnosis: Trilete; laesurae simple, over ¾ of the radius of spore; equatorial outline triangular; apices broadly rounded; sides concave; proximal face slightly convex, and distal face markedly convex; exine psilate.

Remarks: Cyathidites can be distinguished from Deltoidospora by its concave sides and thin exine. Deltoidospora has straight to slightly convex sides, and the exine is about 5 microns thick. Concavissimisporites can be distinguished from both of these genera by the presence of subgranulose to verrucose exine ornamentation.

Cyathidites australis Couper, 1953

Plate 8, figure 12

(Synonymy as for genus)

Description: Trilete; laesurae simple and long, almost reaching the equator; equatorial outline triangular; apices broadly rounded; sides slightly concave; distal face convex; exine smooth, about 2 microns thick.

Size range: Equatorial diameter 50 to 65 microns.

Distribution: Jurassic and Lower Cretaceous. Very rare in the Mannville Group.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 8, fig. 12. Depth 1791 to 1801 feet; Grand Rapids Formation.

Pl. 8, fig. 12. Slide No. Micro. 137; co-ord. 11.1/43.

Cyathidites minor Couper, 1953

Plate 8, figure 13

1953 Cyathidites minor Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 28, pl. 2, fig. 13.

Description: Trilete; laesurae simple, over 3/4 of the radius of spore; equatorial outline triangular; apices broadly rounded; sides slightly concave; distal face convex; exine smooth, 1 to 2 microns thick.

Size range: Equatorial diameter 25 to 45 microns.

Distribution: Jurassic and Cretaceous. Abundant throughout the Mannville Group. The lower part of the Gravelbourg Formation (Jurassic) to the Colorado Group (Upper Cretaceous) in western Canada (Pocock, 1962). Reported from the same levels in New Zealand and England (Couper 1953, 1958).

Affinity: Couper (1958) found a close similarity between this species and fertile specimens of Mesozoic species of Coniopteris hymenophylloides, Dicksonia mariopteris, and other cyatheaceous or dicksoniaceous ferns.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 8, fig. 13. Depth 1816 to 1826 feet; Grand Rapids Formation.

Pl. 8, fig. 13. Slide No. Micro. 123; co-ord. 13.1/39.1.

Order FILICALES—INCERTAE SEDIS

Genus Trilobosporites Pant, 1954 nom. nud. ex Potonié, 1956

1955 Concavisporites hannonicus Delcourt and Sprumont, Mém. Soc. Géol. Belgique,

n.s., vol. 4, p. 24, pl. 2, fig. 3.

Trilobosporites hannonicus (Delcourt and Sprumont) Potonié, Beih. Geol. Jahrb., 1956 Heft 23, p. 55, pl. 7, fig. 68 (type species, subsequent designation).

Diagnosis: Trilete; equatorial outline triangular; sides more or less concave; apices rounded with thickened exine.

Trilobosporites hannonicus (Delcourt and Sprumont) Potonié, 1956

Plate 8, figures 14, 15

(Synonymy as for genus)

Description: Trilete; laesurae reaching about 3/4 of radius of spore; margo present on most specimens; equatorial outline triangular, with concave to straight sides; proximal face flat; distal face convex; exine doublelayered with granular to verrucate ornamentation on both proximal and distal surfaces; ektexine thickened on the rounded apices in the form of a cap, with verrucate surface.

Size range: Equatorial diameter 60 to 75 microns.

Distribution: Barremian? to Aptian. Common in the Deville and Ellerslie Members. "Wealden" of Belgium (Delcourt and Sprumont, 1955).

Remarks: *Trilobosporites hannonicus* is similar to species of *Triquitrites* from Paleozoic strata but can be distinguished by its having only an ektexinal thickening in the form of a cap on the rounded apices without any protuberance, whereas similar species of *Triquitrites* have apices with thickened protuberances which are distinct from the main body.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 8, fig. 14.	Depth 3213 to 3222 feet;	Deville Member.
Pl. 8, fig. 15.	Depth 3222 to 3231 feet;	Deville Member.
Pl. 8, fig. 14.	Slide No. Micro. 257;	co-ord. 10.8/43.5.
Pl. 8. fig. 15.	Slide No. Micro. 256;	co-ord. 10.2/40.2.

TRILOBOSPORITES APIVERRUCATUS Couper, 1958

Plate 8, figures 16-18

1958 Trilobosporites apiverrucatus Couper, Palaeontographica, Band 103, Abt. B, p. 142, pl. 21, figs. 11-13.

Description: Trilete; laesurae about ¾ of radius of spore; margo present on most specimens; equatorial outline triangular; sides strongly concave to straight; proximal face flat; distal face convex; polar ornamentation on both proximal and distal surfaces composed of only small verrucae; scabrate sculpture only in some specimens; apical ornamentation always more pronounced with verrucae averaging about 5 microns in diameter; in some smaller specimens the apical ornamentation reduced to a coarse granulation; in some coarsely ornamented specimens larger verrucae border the margo; exine 2 to 3 microns thick, a little thicker at the apices.

Size range: Equatorial diameter 35 to 90 microns.

Distribution: Berriasian to middle Albian. Common throughout the Mannville Group, though it is more abundant in the McMurray Formation. Makes first appearance in the Fairlight Clay (Berriasian) of England (Couper, 1958).

Affinity: The affinity is not certain, although the thickened apices suggest a dicksoniaceous origin.

Remarks: This species closely resembles *Trilobosporites trioreticulosus* Cookson and Dettmann, 1958, but the latter has shallow lumina with polygonal muri on the apices instead of verrucae.

Locality of figured specimens: Imperial Willingdon No. 1 well Pl. 8, fig. 16. Depth 2085 to 2095 feet; Wabiskaw Member.

Imperial Namao No. 1 well

Pl. 8, fig. 17. Depth 3726 to 3736 feet; Ellerslie Member.

Fort Augustus No. 1 well

Pl.	8, fig.	18.	Depth 2905 to 2914 feet;	Wabiskaw Member.
Pl. 8	8, fig. 8, fig. 8, fig.	17.	Slide No. Micro. 89; Slide No. Micro. 32; Slide No. FA2905-2914-1;	co-ord. 8.5/44.2. co-ord. 11.8/43. co-ord. 0.8/61.2.

TRILOBOSPORITES CANADENSIS Pocock, 1962

Plate 8, figures 19, 20

1962 Trilobosporites canadensis Pocock, Palaeontographica, Band 111, Abt. B, p. 44, pl. 4, figs. 63-68.

Description: Trilete; laesurae simple, almost reaching equator; equatorial outline triangular; sides concave to straight; general surface strongly verrucose; verrucae arising from thick ektexine, average size 9 microns in diameter and 4.5 microns in height, very well rounded and dome-shaped; on the proximal face the verrucae present in the apical areas, bordering the laesurae in a single line, and around the equator; on the distal face the verrucae present in apical areas, in the centre of the face and around the equator; exine thick, ranging from 6 microns at the apices to 3 microns on the rest of the body.

Size range: Equatorial diameter 45 to 75 microns.

Distribution: Barremian? to middle Albian? Rare to common in the Deville and Ellerslie Members (Pocock, 1962). The few specimens in the Clearwater Formation are probably reworked.

Remarks: The ornamentation in *Trilobosporites canadensis* is extremely variable: it ranges from subdued—similar to *Trilobosporites bernissartensis* (Delcourt and Sprumont) Potonié—to heavy, with large bulbous verrucae covering the entire spore surface.

Locality of figured specimens: Imperial Namao No. 1 well

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Pl. 8, fig. 19.	Depth 3768 to 3778 feet;	Ellerslie Member.
Pl. 8, fig. 20.	Depth 3706 to 3716 feet;	Ellerslie Member.
Pl. 8, fig. 19.	Slide No. Micro. 40;	co-ord. 9/51.
Pl. 8, fig. 20.	Slide No. Micro. 18;	co-ord. 17.5/38.2.

Trilobosporites trioreticulosus Cookson and Dettmann, 1958

Plate 9, figures 1, 2

1958 Trilobosporites trioreticulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n.s., vol. 70, pt. 2, p. 109, pl. 17, figs. 1-3.
1961 Lygodium trioreticulosus (Cookson and Dettmann) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 100, pl. 35, figs. 5a-d, pl. 38, fig. 8.

Description: Trilete; equatorial outline triangular with broadly rounded apices and straight to slightly concave sides; laesurae about 34 the radius of spore with usually thickened margo; the apices ornamented with a

shallow reticulum consisting of polygonal to rounded lumina and broad muri; exine 2 to 3 microns thick, with scabrate surface.

Size range: Equatorial diameter 55 to 80 microns.

Distribution: Aptian to Albian. Abundant in the Ellerslie Member, rare in the Grand Rapids Formation. Aptian to Albian of eastern Australia (Cookson and Dettmann, 1958a).

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 9, fig. 1.	Depth 2983 to 2992 feet;	"calcareous" member
Pl. 9, fig. 2.	Depth 2932 to 2938 feet;	Wabiskaw Member.
Pl. 9, fig. 1.	Slide No. FA2983-2992-3;	co-ord. 19.8/71.8.
Pl. 9, fig. 2.	Slide No. Micro. 216;	co-ord. 12.9/42.9.

TRILOBOSPORITES MINOR Pocock, 1962

Plate 9, figure 3

1962 Trilobosporites minor Pocock, Palaeontographica, Band 111, Abt. B, p. 44, pl. 4, figs. 61, 62.

Description: Trilete; laesurae about ½ of radius of spore, simple; equatorial outline triangular; sides straight to slightly concave; apices rounded; exine scabrate; apiculae concentrated at the apices on both proximal and distal faces, and also bordering the laesurae on either side.

Size range: Equatorial diameter 30 to 40 microns.

Distribution: Aptian to middle Albian. Common throughout the Mannville Group, except the Deville Member.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 9, fig. 3. Depth 1816 to 1826 feet; Grand Rapids Formation. Pl. 9, fig. 3. Slide No. Micro. 119; co-ord. 17.1/45.9.

Genus Pilosisporites Delcourt and Sprumont, 1955

- 1949 Sporites trichopapillosus Thiergart, Palaeontographica, Band 89, Abt. B, p. 22, pls. 4, 5, fig. 18.
- 1955 Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 34, pl. 3, fig. 3 (type species).
- 1961 Lygodium trichopapillosus (Thiergart) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 102, pl. 38, figs. 1a-b.

Diagnosis: Trilete; laesurae do not reach the equator; equatorial contour triangular; sides slightly convex, straight or concave; ornamentation echinate; fimbriae, capilli or short thin spines cover all or large parts of the surface.

Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

Plate 9, figure 4

(Synonymy as for genus)

Description: Trilete; laesurae ³/₄ of radius of spore, bordered by margo; equatorial outline triangular; sides slightly convex to slightly concave; proximal surface flattened; distal surface strongly convex; ornamentation echinate; spines curved with sharp points, from 5 to 10 microns long, arising from an outer exine coat, the spines in some specimens tending to be slightly crowded at the apices; exine 3 to 4 microns thick.

Size range: Equatorial diameter 50 to 85 microns.

Distribution: Upper Jurassic to middle Albian. Common throughout the Mannville Group. Purbeck to Wealden of England (Couper, 1958). "Wealden" of Belgium (Delcourt and Sprumont, 1955).

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 9, fig. 4. Depth 3850 to 3860 feet;

Ellerslie Member.

Pl. 9, fig. 4.

Slide No. Micro. 79;

co-ord, 14/49.

Pilosisporites verus Delcourt and Sprumont, 1955

Plate 9, figure 5

1955 Pilosisporites verus Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 35, pl. 4, fig. 1.

1961 Lygodium verus (Delcourt and Sprumont) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 103, pl. 38, figs. 3a-b.

Description: Trilete; laesurae 3/4 of radius of spore, bordered by margo; equatorial outline triangular; sides slightly concave to slightly convex; corners well rounded; proximal surface flattened; distal surface convex; spines concentrated in the apical areas only on both sides, from 5 to 10 microns long; inter-radial areas finely punctate on both proximal and distal surfaces; exine about 2 microns thick.

Size range: Equatorial diameter 50 to 75 microns.

Distribution: Barremian? to middle Albian? Common in the Deville, Ellerslie and Wabiskaw Members; only one specimen was found in the Grand Rapids Formation. "Wealden" of Belgium (Delcourt and Sprumont, 1955).

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 9, fig. 5. Depth

Depth 3768 to 3778 feet;

Ellerslie Member.

Pl. 9, fig. 5.

Slide No. Micro. 270;

co-ord. 12.5/41.5.

Genus Concavissimisporites Delcourt and Sprumont, 1955, emend. Delcourt,

Dettmann and Hughes, 1963

1955 Concavissimisporites verrucosus Delcourt and Sprumont, Mém. Soc. Géol.

Belgique, n.s., vol. 4, p. 25, pl. 2, fig. 1a (type species).

Lygodium verrucosus (Delcourt and Sprumont) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 40, p. 100, pl. 37, figs. 2a-b.

Lygodium Swartz—Ivanova (part) in Samoilovitch et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 90.

Concavisporites verrucosus (Delcourt and Sprumont) Pocock (part), Palaeontographica, Band 111, Abt. B, p. 46, pl. 5, fig. 73.

Concavisimisporites verrucosus Delcourt and Sprumont, emend. Delcourt et al., Palaeont., vol. 6, p. 285, pl. 42, figs. 5-7.

Diagnosis: Microspores trilete; outline triangular with concave to almost straight sides. Exine of uniform thickness (inclusive of sculpture), subgranulose to verrucose, granules or verrucae more or less uniformly developed and evenly distributed over entire spore surface.

Remarks: The generic diagnosis has been slightly emended here to include subgranulose and granulose spores.

Originally the genus Concavissimisporites included spores with strongly concave ("concavissime") sides. However, the degree of concavity of the sides cannot form the basis for a new genus, as the sides usually vary from weakly to strongly convace within the same species. Uncompressed or inflated specimens commonly display strongly concave sides (see Delcourt et al., 1963, pl. 42, figs. 1-4) within the same species. As emended by Delcourt et al. (1963), Concavissimisporites now contains spores with concave to almost straight sides.

Concavisporites Pflug, 1953 can be distinguished from Concavissimisporites by the presence of kyrtomes (=tori, formed by an abruptly convex exine area surrounding the laesurae which is reduced to three arcuate folds in the proximal interradial regions on compressed spores) and by its more or less smooth surface. The synonymizing of the two above-mentioned genera by Pocock (1962, p. 47) is, therefore, considered unjustified. Delcourt and Sprumont (1955), Couper (1958) and Pocock (1962) erroneously assigned to the genus Concavisporites many species that do not have kyrtomes around the laesurae and that commonly have verrucose surfaces. Margo or laesurate lips, which these authors probably confused with kyrtomes, are actually oblique exposures of a slightly thickened exine adjoining the laesurae, and undehisced or uncompressed spores do not show them. The margo does not result in arcuate folds in the proximal interradial regions after compression of the spore. All species of the genus Concavisporites illustrated by Thomson and Pflug (1953) show these interradial arcuate folds on the proximal surface, and all are characterized by the presence of kyrtomes and smooth surfaces with concave sides. The granulose to verrucose specimens without kyrtomes erroneously assigned to Concavisporites should, therefore, be transferred to the newly emended genus Concavissimisporites.

It is felt that the genus Concavissimisporites should not be restricted to include only verrucose spores as proposed by Delcourt et al. (1963). The shape of the spore; the position, shape, length, and number of the germinal apertures; the nature of the exine adjoining the laesurae; and the pattern of ornamentation or the complete absence of it are far more reliable criteria for subdivision at the generic level than a mere change in the degree of ornamentation, such as granulose to verrucose. In fact, the difference between granulose and a verrucose ornamentation is entirely arbitrary. Originally, species with subgranulose ornamentation, such as "Concavisporites" subgranulosus Couper, 1958, were placed in the same genus as strongly verrucose species, such as "Concavisporites" variverrucatus Couper, 1958. Spores with concave sides and ornamentation varying from subgranulose to verrucose appear to form a normal morphographic group, for the ornamentation is commonly gradational. Therefore, the generic diagnosis has been slightly emended here to include subgranulose and granulose spores, as well as verrucose spores, within the genus Concavissimisporites.

Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.

Plate 9, figures 6, 7

1955 Concavisporites punctatus Delcourt and Sprumont, Mém. Soc. Géol. Belgique,

n.s., vol. 4, p. 25, pl. 1, fig. 8, pl. 2, fig. 2.

1955 Concavisporites baldurnensis Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 24, pl. 1, figs. 7a-b.

1955 Cingulatisporites cavus Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 38, fig. 8.

1958 Concavisporites punctatus Delcourt and Sprumont—Couper, Palaeontographica, Band 103, Abt. B, p. 142, pl. 22, figs. 1-3.

1962 Concavisporites punctatus Delcourt and Sprumont—Pocock, Palaeontographica, Band 111, Abt. B, p. 46, pl. 5, fig. 72.

1963 Cyathidites punctatus (Delcourt and Sprumont) Delcourt et al., Palaeont., vol. 6,

p. 283, pl. 42, figs. 1-4. In press Lygoidites punctatus (Delcourt and Sprumont) Pocock, Grana Palynologica,

Description: Trilete; laesurae around ¾ of radius of spore; a distinct margo bordering the commonly gaping laesurae, narrowing sharply towards the ends; equatorial outline triangular; sides mostly concave, but in some specimens straight; apices well rounded; indistinct subgranulose ornamentation on both proximal and distal surfaces; highly oxidized or badly preserved specimens have a surface with rather undulose appearance.

Size range: Equatorial diameter 55 to 75 microns.

Distribution: Berriasian to Aptian. Common in the McMurray Formation, but rare in the Clearwater and Grand Rapids Formations. Makes first appearance in the Berriasian of England (Couper, 1958). "Wealden" of Belgium (Delcourt and Sprumont, 1955).

Remarks: The transfer of "Concavisporites" punctatus to the genus Cyathidites by Delcourt et al. (1963) appears unjustified. From the original illustrations (Delcourt and Sprumont, 1955, pl. 1, fig. 8 and pl.

2, fig. 2) and subsequent illustrations (Couper, 1958, pl. 22, figs. 1-3) of "Concavisporites" punctatus, it is evident that the species is not psilate like Cyathidites. Couper's (1958, p. 142) remark that the exine is "not distinctly sculptured" does not mean that it is psilate, for he goes on to say that the exine does have a "rather undulose appearance". The sculpture of this species is indeed faint and varies from subgranulose to "undulose", depending upon the quality of preservation and the degree of oxidation. The holotype illustrated by Delcourt and Sprumont (1955, pl. 1, fig. 8) clearly shows an "undulose" surface. Canadian specimens are conspecific with the European specimens, and, as neither have a psilate exine, their transfer to Concavissimisporites is considered more justifiable than to Cyathidites.

Locality of figured specimens: Fort Augustus No. 1 well
Pl. 9, fig. 6. Depth 2815 to 2824 feet; Clearwater Formation, shale member.

Imperial Willingdon No. 1 well

Pl. 9, fig. 7. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 9, fig. 6. Slide No. Micro. 197; co-ord. 10.5/40.5. Pl. 9, fig. 7. Slide No. Micro. 100; co-ord. 14/37.1.

CONCAVISSIMISPORITES PARKINII (Pocock) n. comb.

Plate 9, figure 8

1962 Concavisporites parkinii Pocock, Palaeontographica, Band 111, Abt. B, p. 46, pl. 4, fig. 71.

Description: Trilete; laesurae about ¾ of radius of spore; a weakly developed margo may or may not be present; commissures always raised; equatorial outline triangular; sides weakly to strongly concave; both proximal and distal surfaces uniformly subgranulose; exine 4 microns thick.

Size range: Equatorial diameter 55 to 85 microns.

Distribution: Barremian? to Aptian. Common in the Deville and the Ellerslie Members. The few specimens found in overlying strata are probably reworked.

Locality of figured specimen: Imperial Namao No. 1 well Pl. 9, fig. 8. Depth 3850 to 3860 feet; Ellerslie Member. Pl. 9, fig. 8. Slide No. Micro. 67; co-ord. 14.5/37.2.

Concavissimisporites variverrucatus (Couper) n. comb.

Plate 9, figures 9-11

1958 Concavisporites variverrucatus Couper, Palaeontographica, Band 103, Abt. B, p. 142, pl. 22, figs. 4, 5.
 1961 Lygodium variverrucatus (Couper) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk

SSSR, vol. 40, p. 100, pl. 36, fig. 5.

Description: Trilete; laesurae about ¾ of radius of spore; margo weakly developed; equatorial outline triangular; sides concave; apices well

rounded; both proximal and distal surfaces ornamented with verrucae varying from 1.5 to 5 microns in diameter in different specimens and projecting up to 2 microns above the general surface; exine 2 to 4 microns thick.

Size range: Equatorial diameter 40 to 70 microns.

Distribution: Bajocian to middle Albian. Abundant throughout the Mannville Group. Gristhorpe Beds (Bajocian), Purbeck Beds, and Wealden of England (Couper, 1958).

Remarks: This species is variable in size, shape, and spacing of the verrucae. No specimens exceeding 70 microns in size were encountered. C. variverrucatus is much smaller in size than C. verrucosus (74 to 90 microns) and C. crassatus (78 microns).

Locality of figured specimens: Fort Augustus No. 1 well Pl. 9, figs. 9, 11. Depth 3093 to 3102 feet; Ellerslie Member.

Imperial Namao No. 1 well

Pl. 9, fig. 10.	Depth 3686 to 3696 feet;	Ellerslie Member.
Pl. 9, fig. 9.	Slide No. Micro. 236;	co-ord. 12.9/41.
Pl. 9, fig. 10.	Slide No. Micro. 13;	co-ord. 8/58.8.
Pl. 9, fig. 11.	Slide No. Micro. 242;	co-ord. 10.5/41.5.

CONCAVISSIMISPORITES SD.

Plate 9, figure 12

Description: Trilete; equatorial outline triangular; sides very concave, apices well rounded; the laesurae not extending to the margin of the equator; the spore wall composed of two layers, a thin inner layer (endexine) and a thick outer layer (ektexine); proximal and distal surfaces have a rather undulose appearance.

Size range: Equatorial diameter 44 microns. Thickness of exine 5 microns.

Distribution: Aptian. Very rare. A single specimen was recorded from the Ellerslie Member.

Remarks: This specimen could be an uncompressed or inflated spore belonging to *C. punctatus*, except that its wall is too thick.

Locality of figured specimen: Fort Augustus No. 1 well
Pl. 9, fig. 12. Depth 3010 to 3019 feet; Ellerslie Member.
Pl. 9, fig. 12. Slide No. Micro. 225; co-ord. 11.2/39.2.

Genus Deltoidospora Miner, 1935, emend. Potonié, 1956

1935 Deltoidospora hallii, Miner, Am. Midland Naturalist, vol. 16, p. 618, pl. 24, fig. 7.
 1956 Deltoidospora hallii, Miner, emend. Potonié, Beih. Geol. Jahrb., Heft 23, p. 13, pl. 1, fig. 1 (type species).

Diagnosis: Trilete; laesurae simple, more than ¾ of spore radius; equatorial outline triangular with rounded apices; sides mostly straight, but may be slightly concave to convex; exine smooth.

Remarks: Miner (1935b) proposed the genus *Deltoidospora* to accommodate the deltoid and subdeltoid spores associated with ferns, such as *Cladophlebis*, *Laccopteris*, and *Gleichenites*. Most of the Mesozoic deltoid spores show close affinity with the spores of recent fern families, such as the Cyatheaceae, Polypodiaceae, and Gleicheniaceae, but cannot be assigned to them yet with certainty. The form-genus *Deltoidospora* is, therefore, considered appropriate for all of the above-mentioned deltoid and subdeltoid spores.

Deltoidospora is distinguished from the genus Cyathidites Couper, 1953 by its very thick exine (about 5 microns) and its deltoid shape with usually straight to slightly convex sides. Cyathidites has a thin exine and concave sides.

Deltoidospora hallii Miner, 1935

Plate 9, figures 13, 14

(Synonymy as for genus)

Description: Trilete; laesurae simple, more than 3/3 of spore radius; equatorial outline triangular with rounded apices; sides mostly straight but ranging from slightly concave to convex; exine smooth and thin.

Size range: Equatorial diameter 30 to 40 microns.

Distribution: Mesozoic. Common throughout the Mannville Group.

Locality of figured specimens: Imperial Namao No. 1 well Pl. 9, fig. 13. Depth 3768 to 3778 feet; Ellerslie Member. Pl. 9, fig. 14. Depth 3726 to 3736 feet; Ellerslie Member. Pl. 9, fig. 13. Slide No. Micro. 42; co-ord. 4.2/45.5. Pl. 9, fig. 14. Slide No. Micro. 30; co-ord. 6/48.

Deltoidospora psilostoma Rouse, 1959

Plate 9, figure 15

1959 Deltoidospora psilostoma Rouse, Micropaleont., vol. 5, p. 311, pl. 2, figs. 7, 8.

Description: Trilete; laesurae simple, more than % of spore radius, generally gaping; equatorial outline triangular, with well-rounded apices; sides straight to slightly concave or convex; exine smooth to weakly punctate, 3 to 6 microns thick.

Size range: Equatorial diameter 40 to 60 microns.

Distribution: Upper Jurassic to Upper Cretaceous. Common throughout the Mannville Group, as well as the Gravelbourg (Jurassic) Formation and Colorado Group (Upper Cretaceous) of western Canada (Pocock, 1962).

Locality of figured specimen: Imperial Namao No. 1 well Pl. 9, fig. 15. Depth 3716 to 3726 feet; Ellerslie Member. Pl. 9, fig. 15. Slide No. Micro. 25; co-ord. 3/36.

Deltoidospora junctum (Kara-Murza) n. comb.

Plate 9, figure 16

1956 Cibotium junctum Kara-Murza—Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 2, p. 37, pl. 3, figs. 25a-e.

Description: Trilete; commissures raised and nearly reaching the equator, bordered by a margo about 1 micron wide on each side; equatorial outline of the spore deltoid with slightly concave sides; apices rounded to rhombic in shape; proximal exine smooth; distal exine with a thickening perpendicular to the apices along which the exine is folded on itself (Fig. 8).

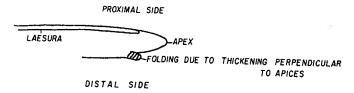


FIGURE 8. Deltoidospora junctum (Kara-Murza) n. comb. Vertical section close to the apex.

Size range: Equatorial diameter about 30 microns.

Distribution: Upper Jurassic to Lower Cretaceous. Very rare in the Mannville Group. Upper Jurassic to Lower Cretaceous, U.S.S.R.

Remarks: The Canadian specimens seem to be identical with the specimen illustrated on plate 3, figure 25d by Bolkhovitina (1956). However, her interpretation of a "partition" perpendicular to the apices is considered incorrect; at low magnifications the foldings on the distal side give the false impression of being partitions.

Tripartina paradoxiformis Maljavkina, 1956 (pl. 5, fig. 6) is also similar to Deltoidospora junctum, but it has not been described. The genus Tripartina Maljavkina, 1949, is not used here to accommodate D. junctum because so many different spore-forms have been placed in Tripartina that it no longer constitutes a uniform unit. Neither the original nor the emended generic diagnosis of Tripartina by Potonié (1960) makes any reference to the foldings perpendicular to the apices. The form-genus Deltoidospora

appears to be more suitable for the present species because of its deltoid shape, smooth exine, and elongate laesurae.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 9, fig. 16. Depth 2496 to 2505 feet; Grand Rapids Formation.

Pl. 9, fig. 16. Slide No. Micro. 201; co-ord. 11.8/40.

Genus Hymenozonotriletes Naumova, 1937 ex Naumova, 1953

1937 Hymenozonotriletes Naumova, Intern. Geol. Congr., 17th, Moscow, Absts. Papers, p. 60-61.

1953 Hymenozonotriletes polyacanthus Naumova, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR, vol. 143, p. 27, pl. 4, fig. 11 (type species).

Diagnosis: Trilete microspores with a membraneous zona; equatorial outline subtriangular; exine covered with cones or spines.

Hymenozonotriletes mesozoicus Pocock, 1962

Plate 9, figures 17-19

1962 Hymenozonotriletes mesozoicus Pocock, Palaeontographica, Band 111, Abt. B, p. 49, pl. 5, figs. 85, 86.

Description: Trilete; zonate; laesurae over ½ the radius of spore; commissures simple slits; equatorial outline triangular; sides convex; exine double-layered; smooth endexine overlain by ornamented extexine extending beyond the central body both distally and proximally, fusing to form a narrow, uniform, equatorial zona; three folds on the extexine paralleling the laesurae and extending up to the margin of the zona on the proximal surface; proximal extexine with only a few scattered short spines but the distal extexine scabrate, bearing densely packed short spines near the pole, the spines becoming more sparse towards the equator; some of these spines joined at their bases to form irregular ridges; zona thin, hyaline and altogether absent on some badly preserved specimens.

Size range: Total equatorial diameter (including zona) 50 to 62 microns.

Equatorial diameter (excluding zona) 45 to 55 microns. Width of zona 5 microns.

Distribution: Aptian to lower Albian? Abundant in the Ellerslie and "calcareous" Members. Rare specimens found in younger Mannville strata are probably reworked.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 9, figs. 17-19. Depth 3093 to 3102 feet; Ellerslie Member.

Pl. 9, figs. 17-19. Slide No. Micro. 223; co-ord. 10.2/41.

HYMENOZONOTRILETES PSEUDOALVEOLATUS (Couper) n. comb.

Plate 10, figures 1-3

1958 Cingulatisporites pseudoalveolatus Couper, Palaeontographica, Band 103, Abt. B, p. 147, pl. 25, figs. 5, 6.

Description: Trilete; zonate; laesurae reaching the inner margin of zona; commissures raised; equatorial outline rounded-triangular; both proximal and distal surfaces bearing short and thick papillae commonly fused at the bases; zona hyaline, narrow, delicate and rather irregular in outline.

Size range: Total equatorial diameter (including zona) 55 microns.

Equatorial diameter (excluding zona) 44 microns.

Width of the zona 3.5 microns.

Spacing of the papillae 2 to 3 microns apart.

Distribution: Bajocian to middle Albian. Very rare. A single specimen was recorded from the Grand Rapids Formation. Bajocian to Aptian of England (Couper, 1958).

Remarks: There are many examples where spores belonging to different morphological types and bearing no resemblance to the type species have been assigned to the genus Cingulatisporites; the original generic diagnosis (Thomson and Pflug, 1953; Potonié, 1956) has been ignored, and no distinction has been made between the terms "zona" and "cingulum". "Cingulatisporites" pseudoalveolatus Couper, 1958, is zonate and not cingulate. Moreover, its papillate surface is too heavily ornamented for the inclusion of this species in the genus Cingulatisporites which, according to its generic diagnosis, is "never strongly ornamented". The species, however, conforms completely to the generic description of Hymenozonotriletes and has been placed in that genus here.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 10, figs. 1-3. Depth 1921 to 1931 feet; Grand Rapids Formation. Pl. 10, figs. 1-3. Slide No. Micro. 156; co-ord. 10.5/38.5.

Genus Couperisporites Pocock, 1962

Cingulatisporites complexus Couper, Palaeontographica, Band 103, Abt. B, p. 145, pl. 24, figs. 1, 2.
 Couperisporites complexus (Couper) Pocock, Palaeontographica, Band 111, Abt.

B, p. 50, pl. 6, figs. 91-94 (type species).

Diagnosis: Trilete; rigid trilete mark reaching the zona and extending almost to the equatorial margin and in some species bifurcating at the tips; proximal exine thin, smooth to granulate; distal surface of the central body with a narrow outer zone thickened with rugulate ornaments just inside the zona, and a wide inner area with polygonal-based hollow bosses each carrying a short thick spine.

Remarks: The genus Couperisporites can be distinguished from Cirratriradites by the absence of distal polar thickenings and the radial

ornaments. It differs from Cingulatisporites in that the zona is more than 1/5 of the spore diameter, the laesurae cross onto the zona, the ornamentation is heavier, and a zona rather than a cingulum surrounds the body.

> Couperisporites complexus (Couper) Pocock, 1962 Plate 10, figures 4-10

(Synonymy as for genus)

Description: Trilete; laesurae reaching onto the zona and bifurcating, forming lips which merge laterally into the zona; commissures raised; equatorial outline rounded-triangular; proximal exine thin, smooth to punctate; distal surface of the central body with an outer zone 5 to 8 microns wide thickened with rugulate ornament, just inside the zona and parallel to the equator, and a wide inner area completely covered with polygonal-based hollow bosses about 5 microns wide at the base, each carrying a short solid spine about 3 microns long; zona hyaline, 12 to 20 microns wide, ornamented with short thick spines about 3 microns broad and 2 microns high, spaced irregularly 5 to 10 microns apart.

Size range: Equatorial diameter (including zona) 80 to 132 microns.

Distribution: Barremian to middle Albian. Common throughout the Mannville Group. Barremian of England (Hughes, 1958).

Locality of figured specimens: Imperial Willingdon No. 1 well

- Depth 1781 to 1791 feet; Grand Rapids Formation. Pl. 10, figs. 4, 8.
- Pl. 10, figs. 5, 6, 7. Depth 1911 to 1921 feet; Grand Rapids Formation. Imperial Namao No. 1 well
- Pl. 10, figs. 9, 10. Depth 3850 to 3860 feet; Ellerslie Member.
- co-ord. 10/37.8. Pl. 10, figs. 4, 8. Slide No. Micro. 73;
- Pl. 10, figs. 5, 6, 7. Slide No. Micro. 155; co-ord. 11.5/39.
- co-ord. 10/41. Pl. 10, figs. 9, 10. Slide No. Micro. 268;

Genus Staplinisporites Pocock, 1962

1957 Cingulatisporites caminus Balme, Australia, C.S.I.R.O., Coal Res. Sect., Ref. T.C.

25, p. 27, pl. 5, figs. 62, 63.

1962 Staplinisporites caminus (Balme) Pocock, Palaeontographica, Band 111, Abt. B, p. 49, pls. 5, 6, figs. 87-90 (type species).

Diagnosis: Trilete; well-developed raised commissures; equatorial outline rounded-triangular; proximal exine thin, smooth to granulose; distal surface ornamented by concentric and radial bands of exinal thickening, the distal pole carrying a thickened granulose boss which may become detached leaving a thin granulose area.

Remarks: Although the genus Staplinisporites closely resembles Cirratriradites, the equatorial zone clearly does not have the nature of a flange so characteristic of Cirratriradites. On the other hand, although Balme (1957) mentions in his description of Cingulatisporites caminus that the laesurae extend only up to the junction of the central body and cingulum, his figured specimens (pl. 5, figs. 62, 63) show the laesurae reaching the equator. Because the laesurae clearly extend onto the equatorial zone, these specimens cannot be included within the genus Cingulatisporites.

STAPLINISPORITES CAMINUS (Balme) Pocock, 1962

Plate 11, figures 1-4

(Synonymy as for genus)

Description: Trilete; laesurae reaching the equator; commissures well developed and raised; equatorial outline rounded-triangular; proximal surface with thin, smooth to slightly granulose exine; distal surface two-layered, with two concentric bands of thickened exine 2 to 3 microns wide, the outer band separating off a 5-micron wide equatorial zone, the inner band surrounding the distal pole, separating off a circular area; the two bands joined by radial bands, which also extend onto the equatorial zone; the distal pole possessing a granulose thickened boss, which may become detached leaving a thin granulose area exposed.

Size range: Equatorial diameter 35 to 45 microns.

Distribution: Upper Jurassic and Lower Cretaceous. Common in the Deville and Ellerslie Members. Pocock (1962) reports it as rare in the upper parts of the Jurassic Fernie and Vanguard Formations and throughout the Mannville Group. Oxfordian to Aptian in Western Australia (Balme, 1957).

Locality of figured specimens: Imperial Namao No. 1 well

Pl. 11, fig. 1. Depth 3742 to 3743 feet; Ellerslie Member. Fort Augustus No. 1 well

Pl. 11, figs. 2-4. Depth 3213 to 3222 feet; Deville Member.

Pl. 11, fig. 1. Slide No. Micro. 36; co-ord. 16.4/53.5. Pl. 11, figs. 2-4. Slide No. Micro. 243; co-ord. 11.1/39.1.

Genus Taurocusporites Stover, 1962

1962 Taurocusporites segmentatus Stover, Micropaleont., vol. 8, p. 55, pl. 1, figs. 1-14 (type species).

Diagnosis: Spores radial; trilete; equatorial outline convexly triangular to subcircular. Proximal surface smooth or ornamented; distal surface trizonate. Trilete distinct; lips weakly developed to prominent, smooth or segmented.

Remarks: The erection of the new form-genus *Taurocusporites* Stover, 1962 appears to be justified insofar as it can be easily distinguished by its trizonate distal surface and a distinct trilete mark from *Chomotriletes* Naumova, 1937 ex Naumova 1953, in spite of the fact that both possess circular concentric ridges and grooves. However, Stover's emendation of

the genus *Chomotriletes* to include only alete spores does not appear to be valid, for reasons discussed earlier under that genus. Thus, although *Taurocusporites* can be recognized as a new genus, some of the species described by Bolkhovitina, Luber, and Naumova should be retained in *Chomotriletes*.

Taurocusporites segmentatus Stover, 1962

Plate 11, figure 5

(Synonymy as for genus)

Description: Trilete; laesurae extending almost up to the equator and always bounded by smooth or transversely segmented lips; equatorial outline convexly triangular to subcircular with a smooth to slightly crenulate margin, the "crenulations" being short radial cracks developed along the outer margin of the spore; distal surface unornamented and divided into three concentric areas (trizonate); the three relatively wide, thick, dark zones separated from each other by two narrow, thin, light, more or less circular grooves, the outer groove being wider and more uniform in width than the inner one; the proximal surface ornamented with low, irregularly shaped verrucae closely packed and forming a negative reticulum; equatorial area commonly unornamented; exine 2 to 4 microns thick at the equator, but thinner over the unornamented parts and in the grooves.

Size range: Equatorial diameter 40 to 50 microns.

Length of laesurae 20 microns.

Width of the lips 6 to 8 microns.

Width of the outer zone 6 to 9 microns.

Width of the middle zone 6 to 11 microns.

Diameter of the inner zone 10 to 17 microns.

Distribution: Lower Cretaceous. Locally abundant in the Ellerslie Member and Grand Rapids Formation. Lower Cretaceous, Maryland, U.S.A.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 11, fig. 5. Depth 1816 to 1826 feet; Grand Rapids Formation. Pl. 11, fig. 5. Slide No. Micro. 144; co-ord. 10.2/41.

Taurocusporites reduncus (Bolkhovitina) Stover, 1962

Plate 11, figure 6

1953 Chomotriletes reduncus Bolkhovitina, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR, vol. 145, p. 35, pl. 3, figs. 23, 24.
1962 Taurocusporites reduncus (Bolkhovitina) Stover, Micropaleont., vol. 8, p. 57, pl. 1, figs. 15-21.

Description: Trilete; laesurae extending, faintly, almost up to the equator; lips bordering the laesurae absent from most specimens, but faintly developed in some cases; equatorial outline subcircular with smooth to slightly crenulate margin; distal surface unornamented and divided into three

concentric areas; the thickened zones irregularly circular with many indentations, and with incomplete marginal thickening in some specimens (Pl. 11, Fig. 6); proximal surface unornamented; exine about 3 microns thick at the equator, but less than 1 micron on the proximal surface.

Size range: Equatorial diameter 36 to 46 microns.

Length of laesurae about 20 microns.

Width of outer zone about 7 microns.

Width of middle zone about 6 microns.

Diameter of inner zone about 12 microns.

Distribution: Middle Jurassic to Upper Cretaceous. Rare in the McMurray and Grand Rapids Formations. Middle Jurassic of Pakistan, Denmark, and the Yakutiya region of the U.S.S.R. Lower Cretaceous of Maryland, U.S.A. Lower Cretaceous (Aptian) and Upper Cretaceous (Senonian) of western Kazakhstan, U.S.S.R.

Remarks: Taurocusporites reduncus differs from T. segmentatus in the absence of the lips or in having only faintly developed unsegmented lips bordering the laesurae, and in an unormamented proximal surface. T. triangularis (Bolkhovitina) Stover, 1962 can be distinguished from T. reduncus by the presence of lips and smooth, circular distal zones, which are distinct from the indented thickened ridges on the distal surface of T. reduncus.

Locality of figured specimen: Imperial Willingdon No. 1 well
Pl. 11, fig. 6. Depth 1816 to 1826 feet; Grand Rapids Formation.
Pl. 11, fig. 6. Slide No. Micro. 144; co-ord. 11.4/39.

Taurocusporites minor n. sp.

Plate 11, figures 7-11

Description: Trilete; laesurae extending almost up to the equator, and bordered by a distinct, smooth, 1.5-micron wide lip on either side; equatorial outline convexly triangular to subcircular with smooth margin; proximal surface flat and unornamented; distal surface convex, unornamented, and trizonate; the exine at the distal pole slightly thinner, surrounded by a cap-like area of darker and thicker exine bearing on the margin small pits about 1 micron in diameter; slightly thickened strips of exine radiating between these pits; area of thinner exine about 3 microns wide surrounding this thick cap-like zone, in turn surrounded by a thickened equatorial zone 3 microns wide.

Size range: Equatorial diameter of holotype 27 microns.

Length of laesurae about 12 microns.

Width of lips about 1.5 microns each.

Width of the outer zone about 3 microns.

Width of the middle zone about 6 microns.

Diameter of the inner thin zone about 9 microns.

Distribution: Aptian to middle Albian. Rare in the Ellerslie and Wabiskaw Members.

Remarks: Taurocusporites minor n. sp. is a spore of trizonate and radial structure with a distinct trilete mark. It is conformable with the diagnosis given for the genus Taurocusporites by Stover (1962). T. minor n. sp. is close to T. reduncus, which has indented thickened zones, but the former can be distinguished by its distinct trilete mark with wide lips, and by the pits (instead of indentations) surrounding the second thickened zone.

This species is also very similar to Leiotriletes incertus Bolkhovitina, 1956, from which it can be distinguished only by its much smaller size. It is not clear why Bolkhovitina (1956) placed such distinctly trizonate forms as L. bujargiensis and L. incertus in the genus Leiotriletes. Although both the descriptions and the illustrations by Bolkhovitina are very sketchy, it appears that both species should be transferred to the genus Taurocusporites Stover, 1962.

Type locality: Fort Augustus No. 1 well Holotype: Pl. 11, figs. 7-11. Slide No. FA2923-2932-3; Wabiskaw Member. Holotype: Pl. 11, figs. 7-11. Depth 2923 to 2932 feet; co-ord. 9.8/36.1.

Genus Aequitriradites Delcourt and Sprumont, 1955, emend. Cookson and Dettmann, 1961

Aequitriradites dubius Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s.,

vol. 4, p. 45, pl. 3, fig. 7 (type species).

Aequitriradites Delcourt and Sprumont, emend. Cookson and Detumann, Palaeont., vol. 4, p. 426, pl. 52, figs. 1-12. 1961

Diagnosis: Trilete microspores with a membraneous zona. Laesurae distinct or only faintly represented, especially towards the proximal pole. Exine entire or perforated distally. Where perforated, the opening is formed as the result of a natural exinous breakdown about the distal pole. Sculptural elements various.

Remarks: Aequitriradites differs from Cirratriradites in the absence of foveae (a sculpture pattern which consists of thinner depressed areas of the exine surrounded by raised, thickened muri). Instead, some specimens of Aequitriradites show an opening in the distal exine. The radial ornamentation so characteristic of *Cirratriradites* is also absent in *Aequitriradites*.

Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, 1961

Plate 11, figures 12, 13

Cirratriradites spinulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n.s., 1958

vol. 70, pt. 2, p. 113, pl. 18, figs. 9-13, pl. 19, figs. 1-5.

Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann,
Palaeont., vol. 4, p. 426, pl. 52, figs. 1-12.

Selaginellidites spinulosus (Cookson and Dettmann) Krasnova, in Samoilovitch 1961

et al., Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 177, p. 41, pl. 11, figs. 2a-b, 3a-b. 1961

Description: Weakly trilete; laesurae variable in extent and prominence, absent from some specimens, in some visible on the zona only, in others traceable to within a short distance of the proximal pole; equatorial outline subtriangular to subcircular; central body surrounded by a membraneous zona overlapping the distal face for a short distance; proximal face smooth to faintly scabrate; distal face probably two-layered and ornamented with densely arranged spinules having polygonal bases, ranging in diameter from 1 to 4 microns, and becoming widely dispersed and smaller towards the equator of the central body; exine of the central body about 2 to 4 microns thick; zona membraneous, scabrate, 5 to 15 microns wide.

Size range: Equatorial diameter (including zona) 55 to 90 microns.

Distribution: Cretaceous. Abundant throughout the Mannville Group, but absent from the Deville Member. Lower Cretaceous of eastern Australia (Cookson and Dettmann, 1958a). Lower and Upper Cretaceous of the Vilyui Basin, U.S.S.R. (Bolkhovitina, 1959).

Remarks: Aequitriradites spinulosus can be easily distinguished from A. variabilis as the latter has a very irregular outline, less dense ornamentation, generally indistinct laesurae, and a central body with circular outline.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 11, fig. 12. Depth 3093 to 3102 feet; Ellerslie Member. Imperial Willingdon No. 1 well

Pl. 11, fig. 13. Depth 1931 to 1941 feet; Grand Rapids Formation.

Pl. 11, fig. 12. Slide No. Micro. 237; co-ord. 11.9/38.1. Pl. 11, fig. 13. Slide No. Micro. 157; co-ord. 12.5/41.

Aequitriradites variabilis Pocock, 1962

Plate 11, figures 14, 15

1962 Aequitriradites variabilis Pocock, Palaeontographica, Band 111, Abt. B, p. 51, pl. 6, figs. 98-100.

Description: Weakly trilete; laesurae indistinct, absent from some specimens, where visible reaching onto the zona almost to the equator; equatorial outline generally very irregular, in some specimens rounded-triangular; central body circular in equatorial section, and surrounded by a hyaline zona overlapping the distal face by about 5 microns; proximal surface smooth to scabrate; distal surface probably two-layered, and ornamented with baculae 4 to 5 microns long, spaced about 5 microns apart; each bacula arises from a polygonal base, about 4 microns in diameter; rounded granules interspersed between the baculae; distal exine about 3 microns thick; zona hyaline, membraneous, scabrate, with a few scattered granules; width of zona 8 to 18 microns.

Size range: Equatorial diameter (including zona) 60 to 90 microns.

Distribution: Barremian? to middle Albian. Common throughout the Mannville Group.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 11, fig. 14. Depth 2896 to 2905 feet; Wabiskaw Member. Imperial Namao No. 1 well

Pl. 11, fig. 15. Depth 3716 to 3726 feet; Ellerslie Member.

Pl. 11, fig. 14. Slide No. Micro. 198; co-ord. 11.8/42.8.

Pl. 11, fig. 15. Slide No. Micro. 21; co-ord. 11.6/45.2.

Genus Rouseisporites Pocock, 1962

1962 Rouseisporites reticulatus Pocock, Palaeontographica, Band 111, Abt. B, p. 53, pl. 7, figs. 101-105 (type species).

Diagnosis: Alete or trilete; equatorial outline convexly triangular with narrow equatorial flange—reduced to an apical flange in some species—laesurae absent from some species, where present indistinct and terminated by extensions of the equatorial flange; the spore body with extensions only in the apical portions in some species; some apical extensions penetrated by holes which may or may not visibly penetrate the central body; some species with a Y-shaped distal ornamentation.

Rouseisporites reticulatus Pocock, 1962

Plate 11, figures 16, 17

(Synonymy as for genus)

Description: Trilete; laesurae faintly developed, reaching the equator, terminated by three holes penetrating the equatorial flange; equatorial outline rounded-triangular; equatorial flange about 5 microns wide on the sides and 8 microns at the apices; distal face convex, traversed by ridges 2 microns wide demarcating polygonal areas 14 to 22 microns in diameter, surface smooth; proximal face less convex, finely reticulate, ornamentation parallel to the laesurae and more distinct near them, being reduced to granulose, in the interradial areas.

Size range: Equatorial diameter (including equatorial flange) 50 to 63 microns.

Distribution: Barremian? to Albian. Common throughout the Mannville Group. Cingulatisporites euskirchensoides Delcourt and Sprumont, 1955, (see below) is present in the "Wealden" of Belgium and in the Aptian-Albian of eastern Australia and New Guinea (Cookson and Dettmann, 1958a).

Affinity: The apical holes indicate an affinity with the bryophyte genus *Riccia*.

Remarks: This species appears to be conspecific with Cingulatisporites euskirchensoides Delcourt and Sprumont, 1955, although the sketch drawn by Delcourt and Sprumont is inadequate. Later illustrations of C. euskirchensoides (Cookson and Dettmann, 1958a, pl. 17, fig. 5) show clearly the apical holes penetrating the equatorial flange, also found in R. reticulatus, although no mention was made of these structures by the authors. It is obvious that these forms do not agree with the generic circumscription of Cingulatisporites, and that the erection of a new genus to accommodate them was necessary. The creation of the new species also seems to be justified in the absence of adequate illustrations and description for the holotype of C. euskirchensoides.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 11, fig. 16. Depth 3037 to 3046 feet; Ellerslie Member. Imperial Willingdon No. 1 well

Pl. 11, fig. 17. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 11, fig. 16. Slide No. Micro. 231; co-ord. 10.8/42.5. Pl. 11, fig. 17. Slide No. Micro. 94; co-ord. 5.1/41.

Rouseisporites laevigatus Pocock, 1962

Plate 11, figure 18

1962 Rouseisporités laevigatus Pocock, Palaeontographica, Band 111, Abt. B, p. 53, pl. 7, figs. 106-109.

Description Alete; some specimens having a very faint trilete mark from the apices to the proximal pole; equatorial outline triangular; sides convex; apices moderately sharp; equatorial flange thin, widening at the apices, and with slight indications of a pore; exine scabrate on both sides; proximal face flat; distal face convex, with corrugate ridges radiating from the pole, progressively reduced towards the equator; perispore absent or present.

Size range: Equatorial diameter 50 to 66 microns.

Distribution: Aptian to Albian. Rare in the Ellerslie Member and the Grand Rapids Formation.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 11, fig. 18. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 11, fig. 18. Slide No. Micro. 101; co-ord. 13.5/45.

Rouseisporites triangularis Pocock, 1962

Plate 11, figure 19

1962 Rouseisporites triangularis Pocock, Palaeontographica, Band 111, Abt. B, p. 54, pl. 7, figs. 110, 111.

Description: Trilete; laesurae faint, reaching up to ¾ of the radius of the spore, and terminating at the conical depression at the apices of the spore body; equatorial outline triangular; sides convex; apices moderately sharp; equatorial flange reduced, present as three conical structures 5 microns wide at the apices only; proximal exine scabrate; distal exine marked by a distinct Y-shaped ridge which alternates with the faint proximal trilete mark, the distal pole commonly with reticulate ridges, reduced to a scabrate structure radiating towards the equator.

Size range: Equatorial diameter (including flanges at apex) 38 to 50 microns.

Distribution: Aptian to Albian. Rare in the Ellerslie Member and Grand Rapids Formation. *Cingulatisporites simplex* Cookson and Dettmann, 1958, (see below) has been described from the Lower Cretaceous (Albian?) of eastern Australia.

Remarks: One illustration of Cingulatisporites simplex (Cookson and Dettmann, 1958a, pl. 17, fig. 7) clearly shows the distal Y-shaped ridge alternating with the faint proximal trilete mark. The apical flanges appear to have been eroded. The holotype (pl. 17, fig. 8), however, does not show these features, and the morphological interpretations drawn by the authors are entirely different. They consider the distal Y-shaped ridge to be the actual trilete mark. Therefore, no changes in taxonomy are justified without examining the actual specimens.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 11, fig. 19. Depth 3174 to 3179 feet; Ellerslie Member. Pl. 11, fig. 19. Slide No. Micro. 252; co-ord. 10.4/42.4.

Genus Cooksonites Pocock, 1962

1962 Cooksonites variabilis Pocock, Palaeontographica, Band 111, Abt. B, p. 54, pl. 7, figs. 112-117 (type species).

Diagnosis: Alete or rarely trilete; exine thick, usually internally striate, covering the entire proximal surface of the central body, extending to the distal surface beyond the equator and thinning over an approximately circular area surrounding the distal pole.

Remarks: The genus Cooksonites differs from Knoxisporites in that the patella encloses the proximal and not the distal surface, and in lacking the triradiate thickened bands on the distal surface. It differs from Tholisporites in that the patella encloses the proximal and not the distal surface.

Cooksonites variabilis Pocock, 1962

Plate 12, figures 1-3

(Synonymy as for genus)

Description: Alete or rarely trilete; laesurae ½ the radius of spore, simple; equatorial outline oval to subcircular or subtriangular; exine two-layered; a patella (the thickened ektexine layer) covering the entire proximal

surface of the central body and extending to the distal surface, thinner over the proximal pole and thicker at the equator; bands of differential thickening across the proximal face present in a few specimens; patella smooth, and partly covering the distal surface; central body exposed over an approximately circular area surrounding the distal pole; distal pole ornamented by a meshwork of polygonal plates; equatorial thickness of the patella 8 to 12 microns and thickness at the proximal pole 4 to 5 microns; diameter of the distal exposed area 35 to 40 microns; color dark brown.

Size range: Equatorial diameter 60 to 70 microns.

Distribution: Barremian? to middle Albian. Abundant in the Ellerslie Member, rare in other parts of the Mannville Group.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 12, fig. 1. Depth 3174 to 3179 feet; Ellerslie Member. Imperial Willingdon No. 1 well

Pl. 12, figs. 2, 3. Depth 1911 to 1921 feet; Grand Rapids Formation.

Pl. 12, fig. 1. Slide No. Micro. 254; co-ord. 10.9/42. Pl. 12, figs. 2, 3. Slide No. IW1911-1921-5; co-ord. 16.4/67.9.

Cooksonites reticulatus Pocock, 1962

Plate 12, figures 4-7

1962 Cooksonites reticulatus Pocock, Palaeontographica, Band 111, Abt. B, p. 55, pl. 8, figs. 118-120.

Description: Alete; equatorial outline rounded-triangular; exine about 15 microns thick, the two layers of exine indistinguishable; exine internally and radially striate; thin exine raised above the surface of the spore as a low dome around the distal pole over a circular area of 30 to 40 microns; the exine on the proximal surface ornamented by a network of pits connected by fine grooves, this ornamentation also extending onto the thick distal exine bordering the thin, domed, distal polar zone; distal polar zone ornamentation reticulate with very thin muri and lumina about 3 microns in diameter; apiculae commonly developed where the muri join; ornamentation less pronounced near the outer margin of the dome; color dark orange-brown.

Size range: Equatorial diameter 55 to 72 microns.

Distribution: Barremian? to middle Albian. Rare in the Deville Member and Grand Rapids Formation, more common in the Ellerslie Member.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 12, figs. 4-7. Depth 3010 to 3019 feet; Ellerslie Member.

Pl. 12, figs. 4-7. Slide No. Micro. 226; co-ord. 12.5/42.

Genus Januasporites Pocock, 1962, emend.

1962 Januasporites reticularis Pocock, Palaeontographica, Band 111, Abt. B, p. 56, pl. 8, figs. 121-123 (type species).

Emended diagnosis: Alete microspores; commonly showing the rudiments of a non-functional tetrad scar on the ektexine of the proximal contact zone; exine two-layered; ektexine thin, absent over a more or less circular area on the distal face, endexine also thin in this circular area; ektexine forming a narrow hyaline zona around the central body; equatorial outline rounded-triangular; endexine smooth to scabrate; both proximal and distal ektexine ornamentation either reticulate, corrugate or spinose.

Remarks: This genus has been emended with the consent of the original author. When Pocock (1962) erected the genus *Januasporites*, he could not determine the range of variation because he had only one species. More detailed observations on both tetrads and single spores during the present study have made certain alterations in the generic diagnosis necessary. *Januasporites* now encompasses spores with a two-layered exine, with the ektexine being quite loose and hyaline, and with a more or less circular thin area on the distal face.

Januasporites spiniferus n. sp.

Plate 12, figures 8-12

Description: Alete microspores; equatorial outline rounded-triangular, most specimens showing the rudiments of a non-functional, faint tetrad scar on the ektexine of the proximal contact zone; exine two-layered, endexine thick and smooth; ektexine thin, absent over a more or less circular area averaging 28 microns in diameter on the distal face; endexine also thin in this circular zone (perhaps the distal germinal area); ektexine forming a 2- to 5-micron wide hyaline zona around the central body; both proximal and distal ektexine ornamented with hyaline spines about 4 to 8 microns long, and 0.2 to 2 microns wide, very variable in shape, and commonly broadening at the tips; distribution of the spines sparse.

Size range: Equatorial diameter (total) 55 to 60 microns.

Equatorial diameter of the holotype (total) 57.4 microns.

Distribution: Middle Albian. Common near the top of the Grand Rapids Formation.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 12, fig. 8. Depth 2496 to 2505 feet; Grand Rapids Formation.

Pl. 12, figs. 9-12. Depth 2496 to 2505 feet; Grand Rapids Formation.

Holotype: Pl. 12, fig. 8. Slide No. Micro. 126; co-ord. 12.2/37.

Pl. 12, fig. 9. Slide No. Micro. 126; co-ord. 12/38.

Pl.	12,	fig.	10.	Slide	No.	Micro.	239;	co-ord.	8.5/43.2.
Pl.	12,	fig.	11.	Slide	No.	Micro.	238;	co-ord.	11/46.
Pl.	12,	fig.	12.	Slide	No.	Micro.	238;	co-ord.	11.2/48.1.

Genus Verrucosisporites Ibrahim, 1933, emend. Potonié and Kremp, 1954

Sporonites verrucosus Ibrahim, in Potonié, Ibrahim and Loose, Neues Jahrb. Mineral., Geol. Paläont., Band 67, Abt. B, p. 448, pl. 15, fig. 17.

1933 Verrucosi-sporites verrucosus Ibrahim, doctor. diss., Tech. Hochschule zu Berlin (privately published), p. 25, pl. 2, fig. 17.

1955 Verrucosisporites verrucosus Ibrahim, emend. Potonié and Kremp, Palaeontographica, Band 98, Abt. B, p. 69, pl. 13, fig. 196 (type species).

Diagnosis: Trilete; circular to subcircular in equatorial outline; exine covered with thickly crowded broad-based warts more or less irregularly rounded or in some cases arcuate.

Remarks: The genus Verrucosisporites differs from Apiculatisporis Potonié and Kremp, 1956 in that it is not entirely circular and does not have tapered cones as ornamentation. It differs from Granulatisporites in that the warts are not so small and spherical in shape, and from Converrucosisporites in not having a triangular to subtriangular outline.

The genus Apiculatisporites Ibrahim, 1933, has now been merged with Tuberculatisporites Ibrahim, 1932. Ibrahim included megaspores as well as microspores in his genus Apiculatisporites. He designated a megaspore Triletes VI Bennie and Kidston as the type species for Apiculatisporites. Subsequently it was found that Triletes VI belonged to the genus Tuberculatisporites. Therefore, Apiculatisporites was included in the genus Tuberculatisporites (according to the International Code of Botanical Nomenclature the generic name is attached with its type species). For the remaining species of the genus a new generic name Apiculatisporis Potonié and Kremp, 1956, was proposed. However, specimens of Apiculatisporites figured by Cookson and Dettmann (1958a) are closer to Verrucosisporites in character and were transferred, therefore, to it by Pocock (1962).

Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, 1962 Plate 13, figures 1, 2

Apiculatisporites asymmetricus Cookson and Dettmann, Proc. Roy. Soc. Victoria,

n.s., vol. 70, pt. 2, p. 100, pl. 14, figs. 11, 12. Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, Palaeontographica, Band 111, Abt. B, p. 56, pl. 8, figs. 124-126. 1962

Description: Trilete; laesurae indistinct, over \% of radius of spore; equatorial outline variable, subtriangular to subcircular; sides invariably convex; exine about 2 to 3 microns thick, ornamented on both the distal and proximal surfaces by irregularly shaped, flat-topped verrucae with an average diameter of 1.5 microns and a height of less than 1 micron.

Size range: Equatorial diameter 35 to 60 microns.

Distribution: Aptian to Albian. Common in the Ellerslie Member, rare in the Wabiskaw Member and Grand Rapids Formation. Albian of eastern Australia (Cookson and Dettmann, 1958a).

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 13, fig. 1. Depth 1781 to 1791 feet; Grand Rapids Formation. Fort Augustus No. 1 well

Pl. 13, fig. 2. Depth 3093 to 3102 feet; Ellerslie Member.

Pl. 13, fig. 1. Slide No. IW1781-1791-1; co-ord. 18.9/30.9.

Pl. 13, fig. 2. Slide No. FA3093-3102-1; co-ord. 9.8/57.

VERRUCOSISPORITES ROTUNDUS n. sp.

Plate 13, figure 3

Description: Trilete; laesurae simple slits, about 3/3 of the radius of spore; equatorial outline nearly circular; proximal surface slightly convex; distal surface markedly convex; both proximal and distal surfaces ornamented by flat and rounded verrucae ranging from 2 to 5 microns in diameter, densely packed, reaching up to the laesurae; exine thick; color yellowish brown.

Size range: Equatorial diameter 45 to 50 microns.

Equatorial diameter of the holotype 46 microns.

Distribution: Aptian. Rare; a few specimens were found in the Ellerslie Member.

Remarks: This species has been placed in the genus Verrucosisporites, because of its nearly circular outline. It can be distinguished from Verrucosisporites obscurilaesuratus Pocock, 1962, by its more distinct laesurae, and by its regular, rounded verrucae of smaller size. It differs from Lygodioisporites perverrucatus Couper, 1958, in having a much smaller size.

Type locality: Imperial Namao No. 1 well

Holotype: Pl. 13, fig. 3. Depth 3742 to 3743 feet; Ellerslie Member. Holotype: Pl. 13, fig. 3. Slide No. Micro. 37; co-ord. 11/38.

VERRUCOSISPORITES sp.

Plate 13, figure 4

Description: Trilete; laesurae indistinct, about % the radius of spore; equatorial outline rounded-triangular; margin uneven; distal surface convex; both proximal and distal surfaces ornamented by flat and irregular-shaped verrucae 2 to 6 microns in diameter, densely packed, spaced about 0.5 microns apart; color yéllow-brown.

Size range: Equatorial diameter 51 microns.

Distribution: Middle Albian. Very rare; a few specimens were found near the base of the Clearwater shale member.

Remarks: This species is similar to Verrucosisporites obscurilaesuratus Pocock, 1962, but the size of the verrucae is distinctly larger, and the equatorial outline is rounded-triangular.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 13, fig. 4. Depth 2860 to 2869 feet; Clearwater Formation,

shale member.

Pl. 13, fig. 4. Slide No. Micro. 205:

co-ord. 11.2/42.

Genus Microreticulatisporites Knox, 1950, emend. Potonié and Kremp, 1954

1933 Reticulati-sporites lacunosus Ibrahim, doctor. diss., Tech. Hochschule zu Berlin

(privately published), p. 36, pl. 6, fig. 50.

1950 Microreticulati-sporites lacunosus (Ibrahim) Knox, Trans. Proc. Bot. Soc. Edinburgh, p. 320, pl. 18, fig. 240.

1955 Microreticulatisporites lacunosus Knox, emend. Potonié and Kremp, Palaeontographica, Band 98, Abt. B, p. 96, figs. 24, 25 (type species).

Diagnosis: Trilete; equatorial outline triangular to circular; margin crenate to undulating; exine extrareticulate with small lumina having diameters not more than 6 microns, muri in some cases imperfect, branched, and of variable height.

Remarks: The genus Microreticulatisporites was revised and restricted by Potonié and Kremp (1954). They provided it with a type species which Knox (1950) had failed to designate, and excluded monolete forms and certain other forms belonging to other genera.

Affinity: This genus may have affinities with the Noeggerathiales (Knox, 1950).

MICRORETICULATISPORITES UNIFORMIS n. sp.

Plate 13, figures 5-7

1962 Microreticulatisporites sp. A Pocock, Palaeontographica, Band 111, Abt. B, p. 57, pl. 8, fig. 128.

Description: Trilete; laesurae more than 3/4 of spore radius; equatorial outline triangular; sides slightly convex to straight; margin crenate; apices rounded; distal surface ornamented by regular reticulate pattern, the reticulate pattern passing onto the proximal surface also for a short distance; most of the proximal surface smooth; lumina 2 to 3 microns in diameter; muri 1 to 2 microns in width.

Size range: Equatorial diameter 44 to 48 microns.

Distribution: Aptian to middle Albian. Common throughout the Mannville Group, except in the Deville Member where it is absent.

Remarks: The specific name is derived from "uniformis" (uniform) and refers to the uniform reticulate pattern of the species.

Type locality: Imperial Willingdon No. 1 well

Holotype: Pl. 13, fig. 5. Depth 1781 to 1791 feet; Grand Rapids

Formation.

Pl. 13, fig. 6. Depth 1791 to 1801 feet; Grand Rapids

Formation.

Pl. 13, fig. 7. Depth 1826 to 1836 feet;

Grand Rapids Formation.

Holotype: Pl. 13, fig. 5. Slide No. Micro. 99;

co-ord. 10.9/38.9.

Pl. 13, fig. 6. Slide No. IW1791-1801-3;

co-ord. 6.5/53.

Pl. 13, fig. 7. Slide No. IW1826-1836-3;

co-ord. 19.9/36.2.

Genus Granulatisporites Ibrahim, 1933, emend. Potonié and Kremp, 1954

Granulatisporites granulatus Ibrahim, doctor. diss., Tech. Hochschule zu Berlin (privately published), pl. 6, fig. 51 (type species).

1955 Granulatisporites granulatus Ibrahim, emend. Potonié and Kremp, Palaeontographica, Band 98, Abt. B, p. 56, pl. 12, figs. 157-160.

Diagnosis: Trilete; subtriangular; exine densely granulose; granules rather spherical and of approximately equal size over-all.

Granulatisporites sp.

Plate 13, figure 8

Description: Trilete; commissures raised, nearly reaching the equator; equatorial outline triangular with strongly convex sides; both distal and proximal exine densely granulose, granules spherical and about 1 micron in diameter, distal surface convex.

Size range: Equatorial diameter 30 microns.

Distribution: Barremian? to middle Albian. Very rare; a few specimens were found in the Deville Member and the Clearwater shale member.

Locality of figured specimen: Fort Augustus No. 1 well

Depth 2782 to 2785 feet; Pl. 13, fig. 8.

Clearwater Formation,

shale member.

Slide No. FA2782-2785-1; Pl. 13, fig. 8.

co-ord. 0.2/50.5.

Genus Laevigatosporites Ibrahim, 1933, emend. Schopf, Wilson and

Bentall, 1944

1932

Sporonites vulgaris Ibrahim in Potonié, Ibrahim and Loose, Neues Jahrb. Mineral., Geol. Paläont., Band 67, Abt. B, p. 448, pl. 15, fig. 16.

Laevigato-sporites vulgaris (Ibrahim) Ibrahim, doctor. diss., Tech. Hochschule zu Berlin (privately published), p. 39-40, pl. 2, fig. 16 (type species). 1933

1934 Laevigato-sporites vulgaris forma major Loose, Arb. Inst. Palaobot. Petrogr.

Brennsteine, vol. 4, p. 158, pl. 7, fig. 12.

Laevigato-sporites Ibrahim, emend. Schopf et al., Illinois State Geol. Surv., Rept.

Invest. 91, p. 36, pl. 1, figs. 5-5b.

1950 Laevigato-sporites ovalis Kosanke, Illinois State Geol. Surv. Bull. 74, p. 29, pl. 5, fig. 7.

Diagnosis: Monolete; outline smooth; laevigate to infrapunctate; equatorial outline ovoid; meridional outline bean-shaped, exine without sculpture; monolete mark straight.

Affinity: The smaller-sized species of Laevigatosporites are very similar to forms obtained from filicinean type fructifications. Forms 50 microns in length have been referred to the Calamariaceae by Fredda Reed (1938, p. 333). However, the monolete bean-shaped form indicates a close affinity with the families Polypodiaceae and Dennstaedtiaceae.

Laevigatosporites ovatus Wilson and Webster, 1946

Plate 13, figures 9-11

Laevigatosporites ovatus Wilson and Webster, Am. J. Botany, vol. 33, p. 271-278, Laevigatosporites ovatus Wilson and Webster-Rouse, Can. J. Botany, vol. 35, p. 355, pl. 1, fig. 3.

Description: Monolete; suture straight, about 1/2 of spore length, mostly gaping; outline kidney-shaped; exine smooth, I micron thick; a thin perispore present in some specimens.

Size range: Length 34 to 55 microns. Breadth 22 to 35 microns. Length to breadth ratio (average) 1.5.

Distribution: Upper Jurassic and Cretaceous. Abundant throughout the Mannville Group, and in other strata elsewhere.

Locality of figured specimens: Imperial Namao No. 1 well

Pl. 13, figs. 9, 11. Depth 3768 to 3778 feet; Ellerslie Member. Imperial Willingdon No. 1 well

Pl. 13, fig. 10. Depth 1781 to 1791 feet; Grand Rapids Formation.

Pl. 13, fig. 9. Slide No. Micro. 75: co-ord. 13/39.5.

Pl. 13, fig. 10. Slide No. Micro. 112: co-ord. 16/39.

Pl. 13, fig. 11. Slide No. Micro. 75; co-ord. 13/39.5.

Genus Dictyotosporites Cookson and Dettmann, 1958

1958 Dictyotosporites speciosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n.s., vol. 70, pt. 2, p. 107, pl. 16, figs. 11-16, pl. 18, fig. 1 (type species).

Diagnosis: Trilete microspores; laesurae inconspicuous before opening; laesurae reaching or almost reaching the margin; exine ornamented on both surfaces by a reticulate membrane, consisting of a primary reticulum and one or more superimposed reticula.

DICTYOTOSPORITES sp. cf. D. SPECIOSUS Cookson and Dettmann, 1958

Plate 13, figures 12, 13

(Synonymy as for genus)

Description: Trilete; laesurae extending up to equator, bordered by thin lips, equatorial outline rounded-triangular; proximal surface flat; distal surface strongly convex; exine about 5 microns thick; reticulation pattern indistinct, but some muri visible arising from the surface forming the marginal membraneous network, muri about 3 microns high.

Size range: Equatorial diameter 36 microns.

Distribution: Neocomian to middle Albian. Very rare. A single specimen was recorded from the base of the Wabiskaw Member. Neocomian and Aptian of eastern Australia (Cookson and Dettmann, 1958a).

Remarks: Dictyotosporites sp. cf. D. speciosus cannot be linked with the species originally described by Cookson and Dettmann (1958a) with any degree of certainty. It is slightly smaller, with a more continuous rather than ragged outer lace-like zone. The reticulate pattern is also not distinctly visible.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 13, figs. 12, 13. Depth 2938 to 2947 feet; Wabiskaw Member. Pl. 13, figs. 12, 13. Slide No. FA2938-2947-2; co-ord. 5/59.8.

Genus Schizosporis Cookson and Dettmann, 1959

1959 Schizosporis reticulatus Cookson and Dettmann, Micropaleont., vol. 5, p. 213, pl. 1, figs. 1-4 (type species).

Diagnosis: Microspores medium to large, with an equatorial line or furrow along which a separation into two approximately equal parts takes place.

SCHIZOSPORIS RETICULATUS Cookson and Dettmann, 1959

Plate 13, figure 14

(Synonymy as for genus)

Description: Spore biconvex, flattened at the poles; circular in polar view; elliptical in equatorial view; splitting equatorially into two nearly equal parts; exine thick, reticulate, with muri 1 micron wide, lumina mostly 6-sided, 8 to 10 microns in diameter.

Size range: Equatorial diameter 102 microns. Ranging from 90 to 135 microns (Cookson and Dettmann, 1959).

Distribution: Neocomian to Albian and Cenomanian? Very rare in the Mannville Group. Neocomian-Aptian to Cenomanian? of eastern Australia (Cookson and Dettmann, 1959).

Remarks: The specimens from the Mannville Group are few and poorly preserved. The two layers of exine could not be detected. However, on the basis of the hexagonal muri, biconvex nature, and the size-range, these specimens can be classified as *Schizosporis reticulatus*.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 13, fig. 14. Depth 2442 to 2451 feet; Grand Rapids Formation.

Pl. 13, fig. 14. Slide No. Micro. 170; co-ord. 10/36.9.

Schizosporis parvus Cookson and Dettmann, 1959

Plate 13, figure 15

1959 Schizosporis parvus Cookson and Dettmann, Micropaleont., vol. 5, p. 216, pl. 1, figs. 15-20.

Description: Spore elliptical in both equatorial and polar views; splitting equatorially into two elongate, boat-shaped equal halves; exine smooth, two-layered.

Size range: Equatorial diameter (length) about 90 microns. Ranging from 65 to 90 microns (Cookson and Dettmann, 1959).

Polar diameter (width) about 60 microns. Ranging from 35 to 50 microns (Cookson and Dettmann, 1959).

Distribution: Barremian? to Albian and Cenomanian? Very rare. Only one specimen each was recorded from the Deville Member and the Grand Rapids Formation. Albian and Cenomanian? of eastern Australia (Cookson and Dettmann, 1959).

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 13, fig. 15. Depth 2505 to 2514 feet; Grand Rapids Formation.

Pl. 13, fig. 15. Slide No. Micro. 178; co-ord. 11.5/40.

Schizosporis rugulatus Cookson and Dettmann, 1959

Plate 13, figure 16

1959 Schizosporis rugulatus Cookson and Dettmann, Micropaleont., vol. 5, p. 216, pl. 1, figs. 5-9.

Description: Spore circular in polar view, biconvex in equatorial view, flattened at the poles; splitting equatorially into two equal saucer-shaped sections; exine double-layered; ektexine ornamented with sinuous ridges uniting in some cases to form a small-meshed, shallow reticulum.

Size range: Equatorial diameter about 78.2 microns. Ranging from 82 to 112 microns (Cookson and Dettmann, 1959).

Distribution: Aptian to Albian and Cenomanian? Very rare; recorded from the Ellerslie and "calcareous" Members (Pocock, 1962), but only one specimen was found in the Grand Rapids Formation in east-central Alberta.

Albian and Cenomanian? of eastern Australia (Cookson and Dettmann, 1959).

Remarks: The Canadian specimens have a smaller average size (Pocock, 1962) than the Australian ones, but in other respects they are identical with them.

Locality of figured specimen: Imperial Willingdon No. 1 well

Depth 1781 to 1791 feet; Grand Rapids Formation. Pl. 13, fig. 16.

Pl. 13, fig. 16. co-ord. 9.3/39.1. Slide No. Micro. 104;

Family Caytoniaceae

Genus Vitreisporites Leschik, 1955, emend. Jansonius, 1962

1955 Vitreisporites signatus Leschik, Schweiz. Paläont. Abhandl., p. 53, pl. 8, fig. 10 (type species).

1962 Vitreisporites Leschik, emend. Jansonius, Palaeontographica, Band 110, Abt. B, p. 55.

Diagnosis: Bisaccate; central body oval in polar view; longer than broad; bladders finely reticulate and proximally attached at equator; distally reaching almost to distal pole, leaving only a straight narrow germinal area; over-all size usually less than 35 microns; bladders large in relation to central body.

Remarks: The genus Vitreisporites was emended by Jansonius (1962) because the faint trilete mark mentioned by Leschik (1955) in the original generic diagnosis is not present. Also, the size of the central body, restricted to less than 20 microns by Leschik, can be larger. Jansonius has given a more accurate generic diagnosis. Pityopollenites Reissinger, 1950, was considered invalid because Reissinger gave no generic diagnosis. Caytonipollenites Couper, 1958, is a junior synonym of Vitreisporites Leschik, 1955.

VITREISPORITES PALLIDUS (Reissinger) Nilsson, 1958

Plate 14, figure 1

1938 Pityosporites pallidus Reissinger, Palaeontographica, Band 84, Abt. B, p. 14. 1950 Pityopollenites pallidus Reissinger, Palaeontographica, Band 90, Abt. B, p. 109,

pl. 15, figs. 1-5. Pollen of *Masculostrobus* E'Carp.—Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, pl. 51, pl. 1, fig. 6.

1958 Caytonipollenites pallidus (Reissinger) Couper, Palaeontographica, Band 103,

Abt. B, p. 150, pl. 26, figs. 7, 8.

1958 Vitreisporites pallidus (Reissinger) Nilsson, Publ. Inst. Mineral., Paleont. Quaternary Geol., Univ. Lund, no. 53, p. 77-78.

Description: Bisaccate; central body oval in polar view; longer than broad; exine less than 1 micron thick; bladders finely reticulate and proximally attached at equator; a distal sulcus present on some specimens; bladders large in relation to central body.

Size range: Total breadth of grain 20 (31) 40 microns.

Breadth of central body 6 (9) 12 microns.

Length of central body 12 (17) 20 microns.

Breadth of bladders 7 (12) 18 microns.

Length of bladders 12 (17) 20 microns.

Distribution: Jurassic and Cretaceous. Abundant throughout the Mannville Group.

Affinity: Indistinguishable from the pollen grains of *Caytonanthus*. Has a strong affinity with the family Caytoniaceae.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 14, fig. 1. Depth 1816 to 1826 feet; Grand Rapids Formation. Pl. 14, fig. 1. Slide No. Micro. 118; co-ord. 14.1/37.5.

Order Cycadales or Bennettitales

Genus Cycadopites Wodehouse, 1933 ex Wilson and Webster, 1946

1933 Cycadopites Wodehouse, Bull. Torrey Botan. Club, vol. 60, p. 483, fig. 56.
1946 Cycadopites follicularis Wilson and Webster, Am. J. Botany, vol. 33, p. 274, pl. 1, fig. 7 (type species designated by Potonié, 1958).

Diagnosis: Monosulcate pollen grains of more or less spindle-form shape; sulcus extending the total length of grain and broadening at the longitudinal ends; sulcus usually closed in the middle by furrow edges overlapping in shrinkage.

It is felt that the synonymy for the genus Cycadopites given by Jansonius (1962) would make this genus too broad to be of any stratigraphic use. Although Cycadopites as a group is quite monotonous and lacks distinguishing features, the various genera distinguished by Potonié (1958) under his subturma Intortes Naumova, 1937, emend. Potonié, 1958, should stand. The general shape, exine ornamentation, length to breadth ratio, and the shape of the sulcus should enable a meaningful subdivision of the monosulcate pollen.

CYCADOPITES FRAGILIS n. sp.

Plate 14, figure 2

1962 Monosulcites minimus Cookson—Pocock, Palaeontographica, Band 111, Abt. B, p. 77, pl. 13, figs. 206-208.

Description: Monosulcate pollen grains; sulcus broad; furrow edges rarely overlapping in middle; sulcus extending the whole length of the grain, and broadening at the longitudinal ends; outline fusiform; exine smooth, thin and fragile; lips 6 microns wide.

Size range: Length 29 to 38 microns. Holotype 33 microns. Breadth 15 to 26 microns. Holotype 20 microns. Length to breadth ratio 1.4 (1.6) 2.0.

Distribution: Jurassic and Cretaceous. Common throughout the Mannville Group.

Affinity: Shows a distinct affinity with the cycadophytes.

Remarks: The specimens described and illustrated as *Monosulcites minimus* by Pocock (1962) belong to the genus *Cycadopites*. *Monosulcites* has an oval to subcircular boat-like shape. Unlike *Cycadopites*, its sulcus has maximum width in the middle, is narrower, and is closed at the longitudinal ends.

Type locality: Imperial Willingdon No. 1 well

Holotype: Pl. 14, fig. 2. Depth 1816 to 1826 feet;

Grand Rapids Formation.

Holotype: Pl. 14, fig. 2. Slide No. Micro. 117;

co-ord. 12/40.8.

CYCADOPITES CARPENTIERI (Delcourt and Sprumont) n. comb.

Plate 14, figure 3

1955 Monosulcites carpentieri Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 54, fig. 14.

Description: Monosulcate; sulcus running entire length of grain, broadening at the longitudinal ends; grains long and narrow in polar view; exine smooth, about 1 micron thick.

Size range: Length about 53 microns.

Breadth about 19 microns.

Length to breadth ratio (average) 2.8.

Distribution: Middle Jurassic to Lower Cretaceous. Rare in the Ellerslie and Wabiskaw Members, and Grand Rapids Formation. Middle Jurassic to Lower Cretaceous of England (Couper, 1958).

Affinity: This species closely resembles the pollen of Williamsonia spectabilis Nathorst, 1909, and appears to have a bennettitalean affinity (Couper, 1958).

Remarks: Although the sketches of *Monosulcites carpentieri* by Delcourt and Sprumont (1955) are not suitable for close comparison, the Alberta specimens agree fairly well with the illustrations of this species by Couper (1958). They are also very close to *Entylissa deterius* Balme, 1957, with which the species may be conspecific.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 14, fig. 3. Depth 2905 to 2914 feet; Wabiskaw Member.

Pl. 14, fig. 3. Slide No. FA2905-2914-3; co-ord. 18.6/40.5.

CYCADOPITES FORMOSUS n. sp.

Plate 14, figures 4, 5

Description: Monosulcate; sulcus running entire length of grain; furrow edges mostly overlapping in the middle, broadening at the longitudinal ends; grains wide in polar view; exine smooth, about 2 microns thick; lips 6 to 12 microns wide.

Size range: Length 50 to 65 microns. Holotype 52 microns. Breadth 30 to 45 microns. Holotype 34 microns. Length to breadth ratio (average) 1.45.

Distribution: Aptian to middle Albian. Common in the Ellerslie, Wabiskaw and Clearwater shale Members.

Remarks: Cycadopites formosus is wider and larger than Cycadopites follicularis Wilson and Webster, 1946, emend. Rouse, 1959.

The specific name is derived from "formosus" (beautiful, handsome).

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 14, fig. 4. Depth 2040 to 2042.5 feet; Clearwater Formation, shale member.

Imperial Willingdon No. 1 well

Pl. 14, fig. 5. Depth 2689 to 2699 feet; Clearwater Formation, shale member.

Holotype: Pl. 14, fig. 4. Slide No. Micro. 182; co-ord. 10/37.8. Pl. 14, fig. 5. Slide No. Micro. 158; co-ord. 11/41.

CYCADOPITES Sp.

Plate 14, figure 6

Description: Monosulcate; sulcus running entire length of grain; furrow edges only slightly overlapping in the middle; sulcus widening at the longitudinal ends; exine very faintly granulose; width about ½ the length, size very large, lips 24 to 28 microns wide.

Size range: Length 104 microns.

Breadth 57 microns.

Length to breadth ratio 1.82.

Distribution: Aptian to middle Albian. Very rare; a few specimens were found in the Ellerslie and Wabiskaw Members.

Remarks: This species has not been formally named as only a few specimens were found.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 14, fig. 6. Depth 2932 to 2938 feet; Wabiskaw Member.

Pl. 14, fig. 6. Slide No. Micro. 220; co-ord. 10.2/38.9.

Genus Bennettiteaepollenites Thiergart, 1949, emend. Potonié, 1958

1949 Bennettiteaepollenites lucifer Thiergart, Palaeontographica, Band 89, Abt. B,

p. 10, pl. 3, fig. 5 (type species).

1958 Bennettiteaepollenites Thiergart, emend. Potonié, Beih. Geol. Jahrb., Heft 31, p. 86, pl. 10, figs. 114-116.

Diagnosis: Outline oval; width about % the length of the grain; exine smooth; exine has three folds along the long axis which do not reach the margin, of these, two folds are close to one another while the third one is on the opposite side.

BENNETTITEAEPOLLENITES MINIMUS n. sp.

Plate 14, figure 7

Description: Outline oval; width only slightly less than the length of the grain; exine smooth; distance between the proximal folds about 6 microns, width of the folds about 2 microns; other features as for genus.

Size range: Length 25 to 30 microns. Holotype 27.2 microns. Width 20 to 23 microns. Holotype 22 microns.

Distribution: Barremian? to middle Albian. Rare in the Deville and Ellerslie Members, and Grand Rapids Formation.

Affinity: Has a bennettitalean affinity.

Type locality: Imperial Willingdon No. 1 well

Holotype: Pl. 14, fig. 7. Depth 1951 to 1961 feet;

Grand Rapids Formation.

Holotype: Pl. 14, fig. 7. Slide No. IW1951-1961-1;

co-ord. 16.2/54.

BENNETTITEAEPOLLENITES Sp.

Plate 14, figure 8

Description: Outline elongated oval; width about ½ the length of the grain; exine smooth; distance between the proximal folds about 2 microns; width of the folds 6 to 8 microns; other features as for genus.

Size range: Length about 82 microns. Width about 40 microns.

Distribution: Aptian. Rare. One specimen was found near the base of the Ellerslie Member.

Remarks: This species has been placed provisionally in the genus Bennettiteaepollenites because its width is only about ½ the length of the

grain, whereas, according to the generic diagnosis, it should be about % of the length. However, other features, such as the distribution and structure of the folds, are the same as for the genus Bennettiteaepollenites.

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 14, fig. 8. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 14, fig. 8.

Slide No. Micro. 78;

co-ord. 7.8/39.

Order Coniferales

Genus Perinopollenites Couper, 1958

1958 Perinopollenites elatoides Couper, Palaeontographica, Band 103, Abt. B, p. 152, pl. 27, figs. 9-11 (type species).

Diagnosis: Monoporate; pore not always clearly shown, grains originally more or less spherical, folding readily; exine consisting of two distinct layers, the outer loosely fitting.

Perinopollenites elatoides Couper, 1958

Plate 14, figure 9

(Synonymy as for genus)

Description: Monoporate; pore not always clearly shown; equatorial outline circular; a loosely fitting, thin and scabrate perispore, wrinkling and tearing easily, surrounding the central body; central body slightly thicker than the perispore, smooth to scabrate.

Size range: Total equatorial diameter (including perispore) 48 microns. Ranges from 38 to 50 microns (Pocock, 1962). Equatorial diameter of the central body (excluding perispore) 30 microns. Ranges from 28 to 36 microns (Pocock, 1962).

Distribution: Jurassic and Lower Cretaceous. Very rare in the Mannville Group.

Affinity: These are probably the pollen of *Elatides williamsonii*, which belongs to the family Taxodiaceae (Couper, 1958).

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 14, fig. 9.

Depth 3174 to 3179 feet;

Ellerslie Member.

Pl. 14, fig. 9.

Slide No. Micro. 253;

co-ord. 12.2/39.5.

Genus Alisporites Daugherty, 1941, restr. Potonié and Kremp, 1956

1941 Alisporites opii Daugherty, Carnegie Inst. Washington Publ. 526, p. 98, pl. 34, fig. 2 (type species).

1956 Alisporites opti Daugherty, restr. Potonié and Kremp, Palaeontographica, Band 99,

Abt. B, p. 176-177, fig. 82.

Alisporites Daugherty, emend. Rouse, Micropaleont., vol. 5, p. 314, pl. 1, 1959 figs. 10-16.

Diagnosis: Bisaccate pollen without trilete mark; equatorial outline including sacci circular to oval; distal furrow parallel-sided, not covered by the bladders; length of the central body the same as that of the bladders; central body not clearly defined; bladders thin, reticulate and very slightly distally pendant.

Remarks: The original diagnosis of the genus Alisporites by Daugherty (1941) was not very precise. Therefore, Potonié and Kremp (1956) and Potonié (1958) restricted this genus and gave a more precise diagnosis which has been followed here. Rouse (1959, p. 315) emended Alisporites, proposing that: "Alisporites should be limited in reference to fossil pollen grains with two air bladders diametrically opposed in general pinaceous habit, but which do not have the bladders inclined distally or obviously attached to a central body as in the grains of the Pinaceae and Podocarpaceae". However, a closer examination of better preserved specimens do show an ill-defined central body, and an equatorial view of a grain shows slightly distally pendant bladders. In his diagnosis Rouse (1959, p. 314) mentions: "two bladders diametrically opposed, united in the region of the proximal furrow", but the interpretation of Potonié (1958) appears to be more accurate. Following the general morphological pattern of bisaccate pollen, Potonié interprets the furrow to be distal, the parallel sides of which mark the bladder bases. The bladders are not united in the region of furrow which, on the contrary, marks an area where the central body is not covered by the bladders.

A well-marked, parallel-sided distal furrow or leptoma (= tenuitas) and only slightly distally pendant bladders distinguish the genus *Alisporites* from *Pityosporites*.

Affinity: The genus Alisporites has probable affinities with the family Pinaceae (Rouse, 1959).

ALISPORITES sp. cf. A. MICROSACCUS (Couper) Pocock, 1962
Plate 14, figure 10

1958 Pteruchipollenites microsaccus Couper, Palaeontographica, Band 103, Abt. B, p. 151, pl. 26, fig. 13, 14.
1962 Alisporites cf. A. microsaccus (Couper) Pocock, Palaeontographica, Band 111, Abt. B, p. 61, pl. 9, figs. 138, 139.

Description: Bisaccate; central body ill-defined, longer than broad; bladders poorly developed, longer than broad resulting in a circular outline in equatorial view; reticulum on bladders about 1.5 microns in diameter; bladders slightly distally pendant covering most of the distal face, leaving only a narrow parallel-sided ill-defined distal furrow; bladders merging into a proximal cap with scabrate exine.

Size range: Total breadth of grain 43 (70) 85 microns.

Breadth of central body 35 (55) 68 microns.

Length of central body 50 (70) 90 microns. Breadth of bladders 20 (35) 48 microns. Length of bladders 43 (70) 88 microns. Width of distal furrow 5 (8) 12 microns.

Distribution: Upper Jurassic and Lower Cretaceous. Rare throughout the Mannville Group. Present in Fernie and Vanguard Formations (Jurassic) of western Canada (Pocock, 1962).

Remarks: The genus Pteruchipollenites Couper, 1958 is indistinguishable from Alisporites. Therefore, Pteruchipollenites microsaccus Couper, 1958 is referred to the genus Alisporites. Alisporites sp. cf. A. microsaccus (Couper) Pocock is, however, larger than the specimens described by Couper.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 14, fig. 10. Depth 3036 to 3046 feet; Ellerslie Member. Pl. 14, fig. 10. Slide No. Micro. 230; co-ord. 11.5/40.5.

Alisporites thomasii (Couper) Pocock, 1962

Plate 14, figures 11, 12

1958 Pteruchipollenites thomasii Couper, Palaeontographica, Band 103, Abt. B, p. 150, pl. 26, figs. 10-12.

1959 Alisporites bilateralis Rouse, Micropaleont., vol. 5, p. 316, pl. 1, figs. 10, 11.
1962 Alisporites thomasii (Couper) Pocock, Palaeontographica, Band 111, Abt. B, p. 62, pl. 9, figs. 142-144.

Description: Bisaccate; central body ill-defined, longer than broad to more or less circular in equatorial section; bladders well developed and of the same size as the central body, giving the whole grain a smooth, oval shape; proximal cap thick; bladders slightly distally pendant, well developed; the bladder bases marked distinctly by a narrow parallel distal furrow; exine thin-walled, finely reticulate.

Size range: Total breadth of grain 47 (60) 74 microns. Breadth of central body 28 (34) 42 microns. Length of central body 37 (44) 55 microns. Breadth of bladders 15 (25) 35 microns. Length of bladders 35 (45) 55 microns. Width of distal furrow 5 (10) 15 microns.

Distribution: Jurassic and Lower Cretaceous. Abundant throughout the Mannville Group. Jurassic of England (Couper, 1958).

Remarks: Pityosporites similis Balme, 1957, is probably conspecific with A. thomasii.

Locality of figured specimens: Fort Augustus No. 1 well Pl. 14, fig. 11. Depth 2815 to 2824 feet; Clearwater Formation, shale member.

Imperial Willingdon No. 1 well

Pl.	14, fig.	12.	Depth	1781	to	1791	feet;	Grand	Rapids	Formation.
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Pl. 14, fig. 11. Slide No. Micro. 196; co-ord. 11.9/38. Pl. 14, fig. 12. Slide No. Micro. 111; co-ord. 12.6/45.8.

ALISPORITES ROTUNDUS Rouse, 1959

Plate 14, figures 13, 14; plate 15, figures 1, 2

1959 Alisporites rotundus Rouse, Micropaleont., vol. 5, p. 316, pl. 1, figs. 15-16.

Description: Bisaccate; central body ill-defined and circular in equatorial section; bladders well developed and as long or longer than the central body, giving the whole grain a smooth, oval shape; proximal cap thick; bladders distally attached and slightly distally pendant, covering most of the distal face, leaving only a narrow parallel-sided distal furrow, the furrow sides marking the bladder bases; ornamentation coarsely reticulate on lateral regions, grading into finely reticulate to smooth in the region of the distal furrow.

Size range: Total breadth of grain 75 (95) 120 microns.

Breadth of central body 45 (53) 65 microns.

Length of central body 55 (65) 75 microns.

Breadth of bladders 32 (43) 53 microns.

Length of bladders 58 (65) 78 microns.

Width of distal furrow 8 (12) 15 microns.

Distribution: Upper Jurassic? and Lower Cretaceous. Abundant throughout the Mannville Group. First described by Rouse (1959) from the Kootenay Formation (Upper Jurassic?) of western Canada.

Remarks: This species is very similar to Alisporites opii Daugherty, restricted Potonié and Kremp, 1956, but can be distinguished from it by its thinner proximal cap. Abietineaepollenites microalatus Potonié, 1951, and Pityosporites grandis (Cookson) Balme, 1957, also closely resemble A. rotundus.

	Locality of figu	ured specimens: Fort Augus	tus No. 1 well
Pl.	14, figs. 13, 14	Depth 2815 to 2824 feet;	•
Pl.	15, fig. 2.	Depth 2860 to 2869 feet;	shale member. Clearwater Formation, shale member.
	Imperial Willin	ngdon No. 1 well	
Pl.	15, fig. 1.	Depth 1816 to 1826 feet;	Grand Rapids Formation.
Pl.	14, fig. 13.	Slide No. Micro. 167;	co-ord. 12/37.5.
Pl.	14, fig. 14.	Slide No. Micro. 168;	co-ord. 12/38.
Pl.	15, fig. 1.	Slide No. Micro. 148;	co-ord. 12/38.5.
Pl.	15, fig. 2.	Slide No. Micro. 206;	co-ord. 11.5/43.

Genus Cedripites Wodehouse, 1933

1933 Cedripites eocenicus Wodehouse, Bull. Torrey Botan. Club, vol. 60, p. 489-490, fig. 13 (type species).

Diagnosis: Bisaccate pollen with thick proximal cap and somewhat curved marginal crest; bladders fused with proximal cap giving the impression of continuity along the proximal pole; bladders concave on the distal side, partially covering the central body in that region.

Affinity: Cedripites has a morphological pattern similar to pollen of the modern genus Cedrus, family Pinaceae.

Cedripites cretaceus Pocock, 1962

Plate 15, figures 3-5

1962 Cedripites cretaceus Pocock, Palaeontographica, Band 111, Abt. B, p. 63, pls. 9, 10, figs. 145-148.

Description: Bisaccate; central body oval to somewhat circular in equatorial outline; proximal cap thick; bladders distally pendant, concave on distal side partially covering the central body in that region; the exine of the bladders fused with the exine of the proximal cap giving the impression of continuity along the proximal pole; slight flexure present at the point of attachment of bladders with the body; bladders reticulate, proximal cap granulose.

Size range: Total breadth of grain 75 (85) 100 microns.

Breadth of central body 58 (62) 66 microns.

Length of central body 52 (53) 55 microns.

Breadth of bladders 36 (42) 50 microns.

Length of bladders 58 (59) 60 microns.

Thickness of proximal cap 5 microns.

Distribution: Barremian? to middle Albian. Abundant in the Mannville Group, including the Deville Member where it has been found by Pocock (1962).

	Locality of	figured specimens: Fort Aug	ustus No. 1 well
Pl.	15, fig. 3.	Depth 3084 to 3093 feet;	Ellerslie Member.
Pl.	15, fig. 4.	Depth 2514 to 2523 feet;	Grand Rapids Formation.
Pl.	15, fig. 5.	Depth 2782 to 2785 feet;	Clearwater Formation,
			shale member.
Pl.	15, fig. 3.	Slide No. Micro. 235;	co-ord. 11.6/43.8.
Pl.	15, fig. 4.	Slide No. Micro. 181;	co-ord. 11.8/39.5.
Pl.	15, fig. 5.	Slide No. Micro. 188;	co-ord. 12/38.5.

CEDRIPITES CANADENSIS Pocock, 1962

Plate 15, figure 6

1962 Cedripites canadensis Pocock, Palaeontographica, Band 111, Abt. B, p. 63, pl. 10, figs. 149, 150.

Description: Bisaccate; equatorial outline of the central body circular; bladders distally pendant, concave, and covering a part of distal surface; bladders and the central body in the same sweeping curve in lateral view; bladders shorter than the central body in distal view; exine of proximal cap granulose, distal furrow straight; bladders reticulate.

Size range: Total breadth of the grain 60 to 90 microns.

Breadth of the central body 40 to 70 microns.

Height of the central body 37 to 60 microns.

Distribution: Barremian? to middle Albian. Rare in the Mannville Group.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 15, fig. 6. Depth 3174 to 3179 feet; Ellerslie Member.

Pl. 15, fig. 6. Slide No. Micro. 247; co-ord. 10/39.

Genus Parvisaccites Couper, 1958

1958 Parvisaccites radiatus Couper, Palaeontographica, Band 103, Abt. B, p. 154, pl. 29, figs. 5-8, pl. 30, figs. 1, 2 (type species).

Diagnosis: The grain generally broader than long; bladders very small in comparison with the central body of the grain; radially arranged thickenings on distally pendant bladders; proximal cap and crest well developed.

Remarks: The genus *Parvisaccites* can be distinguished from *Podocarpidites* by its relatively smaller bladders, which are shorter in length than the central body, and the radial thickenings on the bladders.

Affinity: *Parvisaccites* is very similar to pollen of the modern genus *Dacrydium*, family Podocarpaceae, which also has small radially thickened bladders.

Parvisaccites radiatus Couper, 1958

Plate 15, figure 7

(Synonymy as for genus)

Description: Bisaccate; grain broader than long; central body more or less circular in equatorial outline; bladders shorter and smaller than the central body of the grain; bladders distally pendant; radially arranged thickenings running from the base of the bladders to the margin; indistinct reticulation also present on the bladders; proximal cap and marginal crest well developed; distal furrow smooth.

Size range: Total breadth of grain 45 to 75 microns. Breadth of central body 40 to 50 microns. Length of central body (average) 38 microns. Breadth of bladders (average) 22 microns. Length of bladders (average) 32 microns.

Distribution: Berriasian to middle Albian. Common in the Ellerslie Member, extending into the Clearwater Formation. Makes its first appearance in the Fairlight Clay (Berriasian) of England, becoming abundant in the Weald Marl and Lower Greensand (Couper, 1958).

Locality of figured specimen: Fort Augustus No. 1 well Pl. 15, fig. 7. Depth 3010 to 3019 feet; Ellerslie Member. Pl. 15, fig. 7. Slide No. Micro. 211; co-ord, 10/40.

Genus Phyllocladidites Cookson, 1947 ex Couper, 1953

1947 Disaccites (Phyllocladidites) mawsonii Cookson, B.A.N.Z. Amtarctic Res.

Expedition, Rept. A2, p. 133, pl. 14, figs. 22-28.

1953 Dacrydiumites mawsonii (Cookson) Cookson, Australian J. Botany, vol. 1, p. 66,

Bull. 22, p. 38, pl. 9, fig. 135 (type species).

Dacrydiumites mawsonii (Cookson) Cookson, Australian J. Botany, vol. 1, p. 66, 1953 pl. 1, figs. 9-26.

Dacrydium mawsonii (Cookson) Cookson, Proc. Roy. Soc. Victoria, vol. 69, p. 53. 1957 1960 Dacrydiumites mawsonii Cookson-Couper, New Zealand Geol. Surv. Paleont. Bull. 32, p. 43, pl. 3, figs. 7, 8.

Diagnosis: Bisaccate; equatorial outline of the body circular, oval or polygonal; proximal cap distinct and extending onto the distal surface; bladders very small with indistinct reticulum, strongly distally pendant; bladders not extending far beyond the equator of the central body; a broad, clearly defined distal furrow present between the two bladders; bladders commonly thick and rigid; exine firm, finely granular, and conspicuously thickened at the proximal root of each bladder close to the equatorial margin.

Remarks: Phyllocladidites Cookson, 1947, was proposed not as a new genus but as a new sporotype. Couper (1953) validated Phyllocladidites as a genus by designating Phyllocladidites mawsonii as the type species. Meanwhile, Cookson (1953) changed the name Phyllocladidites to Dacrydiumites, demonstrating its relation to Dacrydium. However, this change in name is unwarranted because Phyllocladidites is a form-genus and so could have been transferred to the status of an organ-genus without a change in name or diagnosis; the probable relationships could have been expressed in the description. Cookson (1957) subsequently appeared to be convinced of its definite taxonomic position and transferred it to the natural genus Dacrydium.

Affinity: The probable affinity of Phyllocladidites is with Dacrydium, family Podocarpaceae.

PHYLLOCLADIDITES MAWSONII form VERRUCOSUS (Cookson) n. comb.

Plate 15, figures 8, 9

1957 Dacrydium mawsonii forma verrucosus Cookson, Proc. Roy. Soc. Victoria, vol. 69, p. 47, 53, pl. 9, figs. 15, 16.

Description: Bisaccate; equatorial outline of the grain oval to ellipsoidal, varying in shape according to the degree of expansion; exine of the proximal cap ornamented by well-defined and closely arranged verrucae; bladders small with indistinct reticulum, strongly distally pendant, not extending far beyond the equator of the central body in polar view; a broad, clearly defined distal furrow present between the bladders; exine firm and slightly thickened at the proximal root of each bladder close to the equatorial margin.

Size range: Total breadth of grain 50 to 57 microns.

Breadth of central body 40 to 46 microns.

Height of central body 28 to 32 microns.

Distribution: Lower Cretaceous to Lower Eocene. Very rare in the Wabiskaw and Ellerslie Members. Abundant in the southern hemisphere, where it has been reported from Australia, New Zealand, and Antarctica in rocks ranging from Early Cretaceous to Eocene in age.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 15, fig. 8.	Depth 2896 to 2905 feet;	Wabiskaw Member.
Pl. 15, fig. 9.	Depth 3075 to 3084 feet;	Ellerslie Member.
Pl. 15, fig. 8.	Slide No. Micro. 207;	co-ord. 12.1/42.9.
Pl. 15, fig. 9.	Slide No. FA3075-3084-4;	co-ord. $0/46.2$.

PHYLLOCLADIDITES Sp.

Plate 15, figure 10

Description: Bisaccate; equatorial outline of the body circular; exine finely granular; bladders elongated, narrow, strongly distally pendant, small, not extending beyond the equator of the central body in polar view; bladders thick with no indication of a reticulum and attached by their whole length to the distal surface of the central body; a broad, clearly defined distal furrow present between the bladders.

Size range: Total breadth of grain 62 microns.

Breadth of central body 58 microns.

Length of central body 60 microns.

Breadth of bladders 20 microns.

Length of bladders 42 microns.

Distribution: Middle Albian. Very rare. A single specimen was recorded from the Wabiskaw Member.

Remarks: The described specimen is close to Podocarpidites otagoensis Couper, 1953, both in dimensions as well as shape. However, the bladders appear to be thicker, and the proximal cap or the marginal crest cannot be clearly distinguished on the central body.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 15, fig. 10. Depth 2932 to 2938 feet; Wabiskaw Member.

Pl. 15, fig. 10. Slide No. Micro. 214: co-ord. 11/42.8.

Genus Podocarpidites Cookson, 1947 ex Couper, 1953

1947 Podocarpidites ellipticus Cookson, B.A.N.Z. Antarctic Res. Expedition, Rept. A2, p. 131, pl. 13, figs. 5-7 (type species).
 1953 Podocarpidites ef. ellipticus Cookson—Couper, New Zealand Geol. Surv. Paleont.

Bull. 22, p. 35.

Pityosporites cf. P. ellipticus (Cookson) Balme, Australia, C.S.I.R.O., Coal Res. Sect., Ref. T.C. 25, p. 35, pls. 9, 10, figs. 104-107. 1957

Diagnosis: Bisaccate pollen grains; equatorial outline of the central body oval to polygonal; marginal crest visible; bladders large and distally pendant and covering the distal surface except for a parallel-sided area corresponding to the distal leptoma; length of the central body always less than length of the bladders. This genus includes bisaccate forms with a very distinct central body, marginal crest, and large, slightly pendant bladders.

Remarks: Couper (1953) emended Cookson's (1947) diagnosis of Podocarpidites to include fossil pollen with more than two air bladders, on the basis that the number of bladders varies among the modern Podocarpaceae, and is not limited to two. Since Podocarpidites was proposed by Cookson as a sporotype, it was never meant to accommodate all the pollen grains of the family Podocarpaceae. The emendation by Couper is, therefore, not justified, and Cookson's original diagnosis restricting the genus Podocarpidites to bisaccate forms only should stand, particularly as Cookson (1947) proposed another form-genus—Microcachryidites—to accommodate pollen grains with a variable number of bladders.

Since Pityosporites has been redescribed and restricted by Manum (1960), it can no longer be used in the broad sense of Balme (1957), and transfer of Podocarpidites ellipticus to the genus Pityosporites by Balme (op. cit.) is, therefore, considered unjustified.

Affinity: The pollen of the form-genus Podocarpidites are similar to those of the modern family Podocarpaceae.

Podocarpidites sp. cf. P. ellipticus Cookson, 1947

Plate 15, figure 11

(Synonymy as for genus)

Description: Bisaccate; equatorial outline of the central body oval to almost circular; marginal crest distinct; bladders large, thin-walled, distally pendant with fine reticulation and a faint indication of radial ornamentation; proximal cap and marginal crest granulose.

Size range: Total breadth of grain 48 (62) 73 microns.

Breadth of central body 30 (36) 42 microns.

Length of central body 34 (41) 55 microns.

Breadth of bladders 24 (30) 35 microns.

Length of bladders 40 (50) 61 microns.

Distribution: Jurassic to Tertiary. Abundant throughout the Mannville Group. Jurassic and Cretaceous of Western Australia (Balme, 1957). Tertiary of Antarctica (Cookson, 1947).

Remarks: The Canadian specimens of *Podocarpidites* sp. cf. *P. ellipticus* are slightly larger than those from Australia and New Zealand.

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 15, fig. 11. Depth 1781 to 1791 feet; Grand Rapids Formation. Pl. 15, fig. 11. Slide No. Micro. 115; co-ord. 5/38.4.

Podocarpidites multesimus (Bolkhovitina) Pocock, 1962

Plate 15, figures 12, 13

1956 Podocarpus multesima Bolkhovitina, Trudy Geol. Inst., Akad. Nauk SSSR, vol. 2, p. 127, pl. 24, fig. 235.
1962 Podocarpidites multesimus (Bolkhovitina) Pocock, Palaeontographica, Band 111, Abt. B, p. 67, pls. 10, 11, figs. 161-163.

Description: Bisaccate; equatorial outline of the central body more or less circular; marginal crest present; proximal cap granulose; bladders longer than the central body; distally pendant; one bladder greatly enlarged in some deviant forms; bladders finely reticulate with faint indications of radial ornamentation.

Size range: Total breadth of grain 58 (68) 77 microns.

Breadth of central body 25 (32) 36 microns.

Length of central body 25 (33) 37 microns.

Breadth of bladders 28 (34) 40 microns.

Length of bladders 38 (45) 53 microns.

Distribution: Jurassic and Cretaceous. Abundant throughout the Mannville Group. Lower Jurassic of the Vilyui Basin, U.S.S.R. (Bolkhovitina, 1956).

Remarks: *Podocarpidites biformis* Rouse, 1957, has been placed in synonymy with *Podocarpidites multesimus* by Pocock (1962). As the former has a larger size-range (75-90 microns), coarsely reticulate bladders, and also a dense reticulation on the central body, it is probably not conspecific with *P. multesimus*.

Locality of	figured specimens: Imperial	Namao No. 1 well
Pl. 15, fig. 12.	Depth 3582 to 3592 feet;	"calcareous" member.
Pl. 15, fig. 13.	Depth 3696 to 3706 feet;	Ellerslie Member.
Pl. 15, fig. 12.	Slide No. Micro. 7;	co-ord. 4.2/47.8.
Pl. 15, fig. 13.	Slide No. Micro. 15;	co-ord. 2.2/58.8.

Podocarpidites ornatus Pocock, 1962

Plate 15, figure 14

1962 Podocarpidites ornatus Pocock, Palaeontographica, Band 111, Abt. B, p. 67, pl. 11, figs. 164-166.

Description: Bisaccate; equatorial outline of the central body subcircular with crenulate margin; length of central body more than the breadth; marginal crest present; length of the bladders approximately equal to the length of the central body; bladders distally pendant and mainly distally attached, the points of attachment extending well onto the proximal side; distal furrow narrow with parallel sides; proximal cap granulose to verrucose; bladders finely reticulate with a faint indication of radial ornamentation.

Size range: Total breadth of grain 70 to 92 microns.

Breadth of central body 40 to 56 microns.

Length of central body 50 to 60 microns.

Breadth of bladders 32 to 42 microns.

Length of bladders 45 to 65 microns.

Distribution: Aptian. Rare, restricted to the Ellerslie Member.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 15, fig. 14. Depth 3165 to 3174 feet; Ellerslie Member. Pl. 15, fig. 14. Slide No. Micro. 245; co-ord. 11.1/40.2.

Podocarpidites minisculus n. sp.

Plate 15, figures 15, 16

Description: Bisaccate; central body oval; length of central body more than the breadth; marginal crest present; bladders distally pendant, longer than the central body and very thin walled; proximal cap scabrate; bladders finely reticulate.

Size range: Total breadth of grain 48 to 56 microns. Holotype 51 microns.

Breadth of central body 28 to 39 microns. Holotype 30.6 microns.

Length of central body 30 to 41 microns. Holotype 40.8 microns.

Height of central body 25 to 31 microns.

Breadth of bladders 19 to 22 microns. Holotype 22 microns. Length of bladders 40 to 48 microns. Holotype 47.5 microns. Distribution: Aptian to middle Albian. Rare in the Mannville Group.

Remarks: This species is very close in appearance to the specimens of *Podocarpidites* sp. cf. *P. decorus* (Bolkhovitina, 1953) Pocock, 1962 (pl. 10, figs. 159, 160), for which there are certain discrepancies in measurements. Pocock (1962, p. 66) gives the length of the central body as 29 (31) 39 microns and the length of the bladders as 20 (28) 36 microns, which means that the central body is longer than the bladders. If this is so, these specimens should not have been placed under the form-genus *Podocarpidites* because its generic diagnosis clearly states "the length of the central body is always less than the length of the bladders". On the other hand, the specimens illustrated by Pocock do have a central body whose length is less than the length of the bladders. If this is true, his specimens have nothing in common with the holotype of *Podocarpus decora* Bolkhovitina, 1953, with which he compared his specimens. *P. decora* has very minute and short bladders and an elongated body, characters that do not fit the generic diagnosis of the form-genus *Podocarpidites*.

The specific name is derived from "minisculus" (rather small) and refers to the small size of the species.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 15, fig. 15. Depth 2689 to 2699 feet; Clearwater

Formation, shale member.

Pl. 15, fig. 16. Depth 2598 to 2607 feet; Grant Control of the Con

Grand Rapids Formation.

Holotype: Pl. 15, fig. 15. Slide No. Micro. 183;

co-ord. 11/40.5.

Pl. 15, fig. 16. Slide No. Micro. 180;

co-ord. 12/38.8.

Podocarpidites canadensis Pocock, 1962

Plate 16, figures 1-3

1962 Podocarpidites canadensis Pocock, Palaeontographica, Band 111, Abt. B, p. 66, pl. 10, figs. 157, 158.

Description: Bisaccate; equatorial outline of the central body foursided to subcircular; marginal crest present; bladders distally pendant and longer than the central body; distal furrow with concave lips; proximal crest and cap granulose; bladders reticulate with faint indications of radial ornamentation.

Size range: Total breadth of grain 90 (115) 130 microns.

Breadth of central body 50 (65) 80 microns.

Length of central body 45 (60) 75 microns.

Breadth of bladders 43 (48) 58 microns.

Length of bladders 54 (70) 90 microns.

Distribution: Barremian? to middle Albian. Common in the Ellerslie Member and rare in the overlying strata. Reported also from the Deville Member (Pocock, 1962).

Remarks: P. canadensis can be distinguished from Podocarpus major (Naumova) Bolkhovitina by its shorter bladders.

Locality of figured specimens: Fort Augustus No. 1 well

Pl.	16, fig. 1.	Depth 3174 to 3179 feet;	Ellerslie Member.
			ZINCIDIO MICHIDOL.

Pl. 16, fig. 3. Depth 3093 to 3102 feet; Ellerslie Member.

Imperial Namao No. 1 well

Pl. 16, fig. 2. Depth 3582 to 3592 feet; "calcareous" member.

Pl.	16,	fig.	1.	Slide	No.	Micro.	250:	co-ord.	10.8/43.2.
Pl.	16,	fig.				Micro.			6.5/44.
Pl.	16,	fig.	_			Micro.	,		11/44.8

Aberrant Podocarpidites pollen

Plate 16, figure 4

Description: Bisaccate; bladders rigid with a thickened strip running across at their bases. Total breadth of the grain 63 microns. A single specimen was recorded.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 16, fig. 4. Depth 2932 to 2938 feet; Wabiskaw Member. Pl. 16, fig. 4. Slide No. Micro. 219; co-ord. 9.9/40.1.

PODOCARPIDITES Sp.

Plate 16, figure 5

Description: Bisaccate; central body oval and broader than long, marginal crest present; bladders distally pendant and very close to one another; distal furrow with concave lips; cap granulose; bladders coarsely reticulate with faint indications of radial ornamentation.

Size range: Total breadth of grain 142 microns.

Breadth of central body 88 microns.

Length of central body 82 microns.

Breadth of bladders 68 microns.

Length of bladders 104 microns.

Distribution: Aptian. Very rare. In central Alberta as single specimen of this species was recorded from the Ellerslie Member.

Remarks: This species is similar to *Podocarpus andiniformis* Bolkhovitina, 1956, but in the latter the central body is longer than broad.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 16, fig. 5. Depth 3174 to 3179 feet; Ellerslie Member.

Pl. 16, fig. 5. Slide No. Micro. 248; co-ord. 9.6/40.5.

PODOCARPIDITES NAUMOVAI n. name

Plate 16, figure 6

1937 Platysaccus major Naumova, Intern. Geol. Congr., 17th Moscow, Absts. Papers,

p. 60-61.

1953 Podocarpus major (Naumova) Bolkhovitina, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR, vol. 145, pl. 11, figs. 8, 9.

not 1953 Podocarpidites major Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 36, pl. 4, fig. 40.

Description: Bisaccate; equatorial outline of the central body oval with a breadth approximately twice the length; body of the pollen as a whole very much elongated in width; bladders longer than the body, distally pendant, attached with a concave base; distal furrow very wide with convex sides; bladders distinctly reticulate with a marked radial pattern closer to the margin.

Size range: Total breadth of grain 116 microns.

Breadth of central body 66 microns.

Length of central body 38 microns.

Breadth of bladders 50 microns.

Length of bladders 58 microns.

Width of distal furrow 15 microns.

Distribution: Albian to Cenomanian. Very rare, a few specimens were recorded from the Clearwater Formation. Lower and middle Albian and Cenomanian of the U.S.S.R.

Remarks: Podocarpus major (Naumova) Bolkhovitina, 1953, is transferred to the form-genus Podocarpidites. However, the name Podocarpidites major (Naumova) n. comb. would be a later homonym of Podocarpidites major Couper, 1953, and would, therefore, be invalid under Article 64 of the International Code of Botanical Nomenclature (1959). Thus, a new name Podocarpidites naumovai has been given to this species according to the Article 55 (1) of the Code (1959).

The species has been renamed in honor of S. N. Naumova, who first described this species.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 16, fig. 6. Depth 2782 to 2785 feet; Clearwater Formation,

shale member.

Pl. 16, fig. 6. Slide No. Micro. 190;

co-ord. 12.5/39.

Genus Piceaepollenites Potonié, 1931

1931 Piceaepollenites alatus Potonié, Jahrb. Preuss. Geol. L.A. (Berlin), vol. 52, p. 5, fig. 31 (type species).
1938 Piceapollenites Thiergart, Jahrb. Preuss. Geol. L.A. (Berlin), vol. 58, p. 306.

Diagnosis: Bisaccate pollen grains; equatorial outline more or less oval; bladders small in comparison to the body; bladders nearly as long as the body, resulting in a more or less uninterrupted oval outline in polar view; in lateral view a small re-entrant angle visible between the bladder and body; base of the bladders reaching beyond the equator on proximal side; body texture finely granular, bladders coarsely reticulate.

Affinity: The genus Piceaepollenites is morphologically similar to pollen of the modern genus Picea, family Pinaceae.

PICEAEPOLLENITES sp.

Plate 16, figure 7

Description: Bisaccate; bladders small in comparison to the body; in lateral view a small re-entrant angle visible between the bladder and body; bladders nearly as long as the body, and longer than broad; base of the bladders reaching beyond the equator on proximal side; body texture granular, bladders coarsely reticulate.

Size range: Length of the body 112 microns. Length of the bladders 100 microns. Breadth of the bladders 60 microns. Total breadth of grain about 180 microns (inferred).

Distribution: Middle Albian. Very rare. A single specimen was found in the Wabiskaw Member.

Remarks: This specimen is very similar to Picea grandivescipites Wodehouse, 1933, illustrated by Rouse (1957, pl. 2, fig. 11), but appears to be larger.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 16, fig. 7. Depth 2905 to 2914 feet; Wabiskaw Member.

Pl. 16, fig. 7. Slide No. Micro. 209; co-ord. 11.4/41.2.

Genus Pityosporites Seward, 1914, emend. Manum. 1960

1914 Pityosporites antarcticus Seward, British Antarctic (Terra Nova) Expedition 1910,

Nat. Hist. Rept., Geol. 1, p. 23, pl. 8, fig. 45 (type species).

Pityosporites Seward, emend. Potonié and Klaus, Geol. Jahrb., vol. 68, p. 534.

Pinuspollenites Raatz ex Potonié, Beih. Geol. Jahrb., Heft 31, p. 62, pl. 8, 1958

1960 Pityosporites antarcticus Seward, emend. Manum, Nytt Mag. Bot., vol. 8, p. 14, pl. 1, figs. 1-4.

Diagnosis: Bisaccate pollen grains; bladders distally pendant, narrowing towards their roots and diverging; proximally the roots reaching the equator of the body or slightly beyond it; distally the roots are separated by a more or less narrow furrow; bladders reticulate; body wall smooth or very finely sculptured; exine thickness moderate and not conspicuously increasing towards the roots of the bladders.

Remarks: Potonié and Klaus (1954) emended Seward's diagnosis of the form-genus *Pityosporites* without examining the holotype. Manum (1960) re-examined the holotype and found that some of the characters attributed to the genus by Potonié and Klaus were erroneous to such an extent that the emended genus excluded the type species itself. Manum's new diagnosis, based on a detailed examination of the holotype, restricts the use of the genus *Pityosporites*. Balme's (1957) suggestion that the genus *Pityosporites* should serve as a morphographic category for all isolated fossil bisaccate pollen lacking characters which would distinguish them from abietineous pollen is unacceptable. His placing of species belonging to *Vitreisporites* and *Podocarpidites* under *Pityosporites* is not justified.

Affinity: Seward (1914) suggested that *Pityosporites* had an affinity with the family Pinaceae, though he admitted that "on geographical grounds it would seem more probable that the spores belonged to some plant allied to *Podocarpus*, *Dacrydium* or *Microcachrys*".

PITYOSPORITES CONSTRICTUS n. sp.

Plate 16, figures 8, 9

Description: Bisaccate; bladders distally pendant, narrowing towards their roots and diverging; the roots reaching slightly beyond the equator; the space separating the two bladders on the distal side about 15 microns wide; central body oval, broader than long; bladders reticulate; body finely granulate; exine uniformly thick.

Size range: Total breadth of grain 70 to 80 microns. Holotype 74 microns.

Breadth of central body 45 to 55 microns. Holotype 50 microns.

Length of central body 37 to 48 microns. Holotype 42 microns.

Breadth of bladders 27 to 34 microns. Holotype 29 microns. Length of bladders 35 to 42 microns. Holotype 40 microns. Width of distal furrow about 15 microns.

Distribution: Aptian to middle Albian. Rare in Ellerslie Member and Clearwater Formation.

Remarks: The specific name is derived from "constrictus" (constricted) and refers to the narrowing of the bladders towards their roots.

Type locality: Fort Augustus No. 1 well Holotype: Pl. 16, fig. 8. Depth 3010 to 3019 feet; Ellerslie Member. Imperial Namao No. 1 well

Pl. 16, fig. 9. Depth 3778 to 3784 feet; Ellerslie Member.

Holotype: Pl. 16, fig. 8. Slide No. Micro. 228;

co-ord. 9.2/43.5.

Pl. 16, fig. 9. Slide No. Micro. 63;

co-ord. 11/36.3.

PITYOSPORITES ALATIPOLLENITES (Rouse) n. comb.

Plate 16, figure 10

1959 Pinus alatipollenites Rouse, Micropaleont., vol. 5, p. 314, pl. 1, fig. 7.

Description: Bisaccate pollen grains; bladders distally pendant, slightly constricted towards the base, diverging; bladders small as compared to the body, their base barely reaching the equator of the body; the space separating the two bladders on the distal side about 16 microns wide; central body elliptical, broader than long, ornamentation finely to coarsely reticulate; bladders coarsely reticulate; exine uniformly thick.

Size range: Total breadth of grain about 65 microns.

Breadth of central body about 51 microns.

Height of central body about 41 microns.

Width of bladders about 24 microns.

Width of distal furrow about 16 microns.

Distribution: Upper Jurassic? to Upper Cretaceous. Rare in the Ellerslie and Clearwater shale Members and Grand Rapids Formation. Kootenay Formation (Upper Jurassic?) and Brazeau Group (Upper Cretaceous) of western Canada (Rouse, 1959).

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 16, fig. 10.

Depth 1826 to 1836 feet;

Grand Rapids Formation.

Pl. 16, fig. 10. Slide No. Micro. 151;

co-ord. 9.5/39.8.

Aberrant Pityosporites pollen

Plate 16, figure 11

Description: Bisaccate; bladders strongly distally pendant and constricted at the base, body consisting of two pollen grains grown together, separation having failed on the proximal side. Total breadth of grains 56 microns; breadth of the central body 40 microns.

Remarks: A single specimen was recorded.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 16, fig. 11. Depth 3174 to 3179 feet;

Ellerslie Member.

Pl. 16, fig. 11.

Slide No. Micro. 246;

co-ord. 9.8/42.

Genus Tsucaepollenites Potonié and Venitz, 1934

Sporonites igniculus Potonié, Z. Braunkohle, Heft 30, p. 556, fig. 2.
Tsugaepollenites igniculus (Potonié) Potonié and Venitz, Arb. Inst. Paläobot.
Petrogr. Brennsteine, vol. 5, p. 17, pl. 1, fig. 8 (type species).
Tsugapollenites Raatz, Abhandl. Preuss. Geol. L.A. (Berlin), n.F., Heft 183,

1937

Diagnosis: Pollen grains; equatorial outline more or less circular, with a narrow equatorial velum, frill-like, radially folded; outer margin irregularly undulating to indented; exine of central body rugulate.

Tsugaepollenites mesozoicus Couper, 1958

Plate 17, figure 1

1958 Tsugaepollenites mesozoicus Couper, Palaeontographica, Band 103, Abt. B, p. 155, pl. 30, figs. 8-10.

Description: Grains saccate; equatorial outline circular to broadly elliptical; equatorial velum quite narrow; exine of distal surface very thin and almost smooth over a circular area surrounded by a fringe of saccate projections; exine at the proximal pole also saccate, the sacci not as well developed as around the equator; ornamentation of the polar area gradually merging into the pattern of the equatorial fringe.

Size range: Equatorial diameter (including fringe) 40 to 85 microns.

Distribution: Jurassic and Cretaceous. Very rare in the Mannville Group. Gravelbourg Formation (Jurassic) to the Colorado Group (Upper Cretaceous) of western Canada (Pocock, 1962).

Affinity: T. mesozoicus resembles pollen of the recent species of Tsuga, such as Tsuga canadensis, of the family Pinaceae.

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 17, fig. 1. Depth 3748 to 3758 feet; Ellerslie Member.

Pl. 17, fig. 1. Slide No. Micro. 57;

co-ord. 5.2/49.9.

Genus Classopollis Pflug, 1953, emend. Pocock and Jansonius, 1961

1950 Conifer pollen. Reissinger, Palaeontographica, Band 90, Abt. B, p. 114, pl. 14, figs. 15, 16.

1953 Classopollis classoides Pflug, Palaeontographica, Band 95, Abt. B, p. 91, pl. 16, figs. 29-31 (type species).

1961 Classopollis classoides Pflug, emend. Pocock and Jansonius, Micropaleont., vol. 7, p. 439-449, pl. 1.

Diagnosis: Distally monoporate pollen, pore not always clearly shown; equatorial outline spherical or oval, and lateral view flattened acorn-shaped; exine two-layered; ektexine absent from a circular area around the distal pole and from a triangular area around the proximal pole; endexine at the proximal pole showing a faint trilete scar without any germinal function; striations, marking a zone of exinal thickening, present in a band surrounding the equator.

Discussion: Pflug's (1953) original generic diagnosis "tricolporate, rarely tetracolporate" for Classopollis is inaccurate. Couper (1958) emended Pflug's diagnosis, but, although most of his morphological interpretations are correct, he designated Classopollis torosus (Reissinger, 1950) Couper, 1958, as the type species, placing C. classoides Pflug, 1953, in synonymy. They do not, however, appear to be conspecific (Potonié, 1960). Couper (1958) also failed to mention the monoporate nature of the grains. Therefore, emendation of the generic diagnosis by Pocock and Jansonius (1961) appears to be justified.

Affinity: Classopollis type pollen were produced by plants of gymnospermous affinity probably belonging to the genera Cheirolepis, Pagiophyllum, or Brachyphyllum.

Classopollis classomes Pflug, emend. Pocock and Jansonius, 1961 Plate 17, figure 2

(Synonymy as for genus)

Description: Distally monoporate pollen with only a faint indication of a pore; spherical in shape; exine two-layered, ektexine absent from the poles, a very faint, small (rays less than 3 microns), and non-functional trilete mark present at the proximal pole in some cases; striations on a zone of exinal thickening present in a band surrounding the equator; commonly occurring in tetrads.

Size range: Polar diameter (average) 23 microns. Equatorial diameter (average) 28 microns.

Distribution: Jurassic and Cretaceous. Common in the Ellerslie and Wabiskaw Members. Vanguard Formation (Upper Jurassic) of Saskatchewan (Pocock, 1962). First described from the Lias of Europe (Pflug, 1953).

Locality of figured specimen: Imperial Namao No. 1 well

Pl. 17, fig. 2. Depth 3726 to 3736 feet; Ellerslie Member. co-ord. 16.1/41.2.

Pl. 17, fig. 2. Slide No. Micro. 60;

Genus Leioaletes Staplin, 1960

1960 Leioaletes aliquandostriatus Staplin, Palaeontographica, Band 107, Abt. B, p. 5, pl. 1, fig. 1 (type species).

Diagnosis: Spores without germinal sutures but occasionally with a few very fine indistinct grooves parallel to the long axis of the spore; shape ellipsoidal; sculpture minor.

Affinity: The genus Leioaletes is morphologically similar to pollen of Podozamites.

LEIOALETES CALVATUS n. sp.

Plate 17, figure 3

Description: Alete; outline ellipsoidal with well-rounded ends, exine smooth, but in some specimens corroded, color light yellow.

Size range: Length about 67 microns. Holotype 67 microns. Breadth about 28 microns. Holotype 28 microns.

Distribution: Middle Albian. Rare. A few specimens were found in the Grand Rapids Formation.

Remarks: The specific name is derived from "calvatus" (bald, made bare) and refers to the smooth exine of the species.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 17, fig. 3. Depth 2478 to 2487 feet; Grand Rapids

Formation.

Holotype: Pl. 17, fig. 3. Slide No. Micro. 172;

co-ord. 10.5/39.

Genus Exesipollenites Balme, 1957

1957 Exesipollenites tumulus Balme, Australia, C.S.I.R.O., Ref. T.C. 25, p. 39, pl. 11, figs. 123-125 (type species).

Diagnosis: Pollen grains with circular or oval outline; smooth to faintly granulose; exine darker in a circular or triangular area at one of the poles; a circular area of exinal thinning in the centre of this dark area; the darker area of exine gradually becoming lighter and thinner towards the equator.

Affinity: These are probably related to the family Taxodiaceae or Cupressaceae.

Exesipollenites tumulus Balme, 1957

Plate 17, figures 4, 5

(Synonymy as for genus)

Description: Pollen grains with circular outline; exine about 2 microns thick, with a few scattered granules; one of the poles marked by a darker exine in a circular area, about 15 microns in diameter, containing in the centre a circular area of exinal thinning about 4 microns in diameter; the darker area of the exine gradually becoming lighter towards the equator.

Size range: Equatorial diameter 25 to 35 microns.

Distribution: Lower Jurassic to middle Albian. Common throughout the Mannville Group. However, Balme (1957) believes it to be restricted to the Lower Jurassic in Western Australia.

Remarks: Exesipollenites tumulus Balme, 1957, closely resembles Spheripollenites scabratus Couper, 1958, with which it may be synonymous

in part. However, the two can be distinguished, for S. scabratus has no dark circular area around one pole or a distinct circular depression in it. Also, its exine is thin and has distinct scabrate ornamentation.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 17, fig. 4.	Depth 2782 to 2785 feet;	Clearwater Formation,
		shale member.
Imporial W	illingdon No. 1 II	

Imperial Willingdon No. I well

_	-				
Pl. 17, fig.	5. Dep	th 2095 to	2098 feet;	Wabiskaw	Member.

Pl. 17, fig. 4.	Slide No. Micro.	191;	co-ord.	10.2/37.8.
Pl. 17, fig. 5.	Slide No. Micro.	159;	co-ord.	10.2/39.2.

Genus Eucommidites Erdtman, 1948, emend. Hughes, 1961

1948

Tricolpites (Eucommidites) troedssonii Erdtman, Geol. Fören. Stockholm Förh., vol. 70, p. 267, figs. 5-10, 13-15.

Trifossapollenites Rouse (part), Can. J. Botany, vol. 35, p. 372, pl. 3, figs. 65, 66.

Eucommidites troedssonii Erdtman—Couper, Palaeontographica, Band 103, Abt. B, p. 160, pl. 31, figs. 23-27 (type species).

1961 Eucommiidites troedssonii Erdtman-Hughes, Palaeont., vol. 4, p. 292, pl. 37,

Diagnosis: Pollen grains with oval equatorial outline; one face flat with a long, median furrow with rounded ends, parallel with the long axis; in the unexpanded condition, the margins of this furrow close over it in the middle in some cases; opposite face more convex, bearing a ring-furrow near the margin separating the larger part of the face (zonisulcate condition); exine in the ring-furrow thin and the ring incomplete at the ends of the long axis in some specimens.

Remarks: The orientation of the pollen of Eucommidites is as yet uncertain. If its morphology is compared with Classopollis, which is very similar to it, then the ring-furrow must be distal and the median furrow proximal. On the other hand, the median furrow is very similar to the distal furrow of a cycad pollen. This problem will remain unsolved until the grain has been seen in its tetrad.

Erdtman (1948) misinterpreted the morphology of Eucommidites as tricolpate, so that Couper (1958) had to emend it, although his diagnosis is not very accurate. Hughes (1961) emended the genus again, interpreting Couper's 'two minor "colpi" as "a ring-furrow which may be complete or broken". Use of the term "colpi" to describe pollen of gymnospermous origin is inaccurate. Also, the interpretation of the orientation and position of the poles has been omitted by Hughes in the absence of conclusive evidence, along with such terms as "monosulcate" "distal sulcus", "proximal or distal face".

Rouse (pers. comm.) now considers Trifossapollenites Rouse, 1957, to be distinct from the genus Eucommiidites. It differs from Eucommiidites in having a long central furrow and two short lateral furrows, all on the same surface. His original specimens from the Oldman Formation (Upper Cretaceous) belong to the genus *Trifossapollenites*. However, he agrees that at least some of the specimens from the Kootenay Formation (Upper Jurassic to Lower Cretaceous) assigned to the genus *Trifossapollenites* (Rouse, 1959) should be placed in the genus *Eucommidites*.

Affinity: Recently, Hughes (1961) found Eucommiidites type-pollen in the micropyle and pollen chamber of a dispersed Lower Cretaceous seed, Spermatitis pettensis Hughes, 1961, which is clearly a gymnospermous ovule. The present interpretation of the morphology of the genus Eucommiidites tends to show its affinity with cycadophytes, Ginkgoales, and perhaps Chlamydospermales. The original suggestion by Erdtman (1948) of a possible angiospermous origin and tricolpate nature of the pollen of Eucommiidites is contradicted by the recent findings.

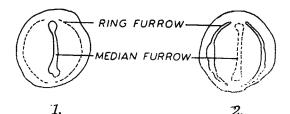


FIGURE 9. Eucommidites troedssonii
Erdtman. 1. Front view showing median furrow. 2. Back
view showing ring-furrow (incomplete at the ends).

EUCOMMIDITES TROEDSSONII Erdtman, emend. Hughes, 1961

Plate 17, figures 6-9

(Synonymy as for genus)

Description: Pollen grains with oval equatorial outline; a median furrow present on the flat face, extending almost the whole length of the grain, parallel with the long axis, ends of the furrow being rounded; opposite face more convex, bearing a ring-furrow near the margin, incomplete at the ends in the long axis in some cases; exine in the ring-furrow thin.

Size range: Length (average) 28 microns. Breadth (average) 24 microns.

Distribution: Jurassic and Lower Cretaceous. Common throughout the Mannville Group, as well as other late Jurassic and early Cretaceous strata of western Canada (Pocock, 1962). Lower Lias of Sweden (Erdtman, 1948) and the Middle and Upper Jurassic and the Wealden of England (Couper 1958).

Locality of figured specimens: Imperial Willingdon No. 1 well Pl. 17, fig. 6. Depth 2095 to 2098 feet; Wabiskaw Member.

Fort Augustus No. 1 well

Pl. 17, figs. 7-9. Depth 2607 to 2616 feet; Grand Rapids Formation.

Pl. 17, fig. 6. Slide No. Micro. 162; co-ord. 10.2/39.2. Pl. 17, figs. 7-9. Slide No. FA2607-2616-1; co-ord. 0/74.

Family EPHEDRACEAE

Genus Equisetosporites Daugherty, 1941, emend.

1941 Equisetosporites chinleana Daugherty, Carnegie Inst. Washington Publ. 526,

p. 63, pl. 24, fig. 4 (type species). **PEphedripites Bolkhovitina, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR, vol. 145, 1953

p. 60, pl. 9, fig. 15.
Ephedracites Maljavkina, Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., vol. 119, p. 115, pl. 4, 7.
Ephedra chinleana (Daugherty) Scott, Micropaleont., vol. 6, p. 271, pl. 1, figs. 1958

1960 1, 8, 10-12, 14-18, text-figs. 1, 2.

1961 Striainaperturites Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.

Emended diagnosis: Acolpate pollen grains; ellipsoid; in some species narrower at one end; exine two-layered; smooth endexine overlain by ektexine; ektexinous ridges unbranched, straight, 2 to 12 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, 8 to 25 in number; in a vertical section along the width the ridges semi-circular in outline rather than angular, narrow furrows flanking the ridges abruptly, 1 to 3.5 microns wide, unbranched, straight; criss-cross appearance of the ridges commonly produced by the twisting of the grains during fossilization — not a reliable specific character; ridges mostly coalescing just before reaching the longitudinal ends, the furrows thus not reaching the margin, resulting in a simple unsculptured area at the longitudinal ends; ektexine usually markedly thickened at the longitudinal ends; four distinct areas of convergence of ridges present in some species, two such areas of convergence near each longitudinal end being opposite to subopposite, 1 to 3 marginal ridges joining at the longitudinal ends and being continuous on the other side in some species.

Remarks: The genus Equisetosporites is here emended to include all ephedralean pollen similar in appearance to Equisetosporites chinleana Daugherty, 1941, and Ephedra pollen Type D (Steeves and Barghoorn, 1959). This genus excludes forms similar to Gnetaceaepollenites Thiergart, 1938 and Ephedra pollen Types A, B and C (Steeves and Barghoorn, 1959), which are characterized by the presence of few angular ridges alternating with branching or sinuous colpi.

Equisetosporites belongs to the family Ephedraceae rather than the Schizaeaceae because of its wide, low, gently rounded, unbranched ridges; whereas, in the Schizaeaceae, the ridges are narrower, high, and are usually branched. The genus Equisetosporites, like modern pollen of the family Ephedraceae, has ridges that coalesce just before reaching the longitudinal ends, becoming discontinuous in a simple unsculptured area at each longitudinal end. In the Schizaeaceae, the ridges from the opposite surfaces join in sequence and are continuous. Equisetosporites is apparently acolpate, whereas the recent as well as fossil species of the genus Schizaea are monolete. Equisetosporites in most cases has an ektexinous thickening at the longitudinal ends, which is typical of Ephedra pollen Type D (Steeves and Barghoorn, 1959). No such thickening is found in the family Schizaeaceae.

The pollen of Equisetosporites are similar to the Ephedra pollen Type D (Steeves and Barghoorn, 1959) and to the pollen grains of the extant species Ephedra breana. The asymmetrical ridge pattern, where 1 to 3 marginal ridges join at the longitudinal ends and are continuous on the other side, as described in the case of the Triassic species, Equisetosporites chinleana, is not, however, typical of most modern Ephedra pollen except for certain species, such as Ephedra strobilacea, E. wraithiana, and E. foliata, which show comparable ridge patterns at the longitudinal ends. Moreover, no living species of Ephedra produce ellipsoid pollen narrower at one longitudinal end, as described here, and it cannot be definitely asserted that the modern genus Ephedra, in its present sense, existed in the Mesozoic Era. The writer is in complete agreement with Hughes (1961, p. 295) who states: "Palynological evidence of the widespread existence of plants similar to the Chlamydospermales in Mesozoic times is accumulating; no progress has yet been made, however, with macrofossil identification of the group. In this connection I regret the placing of fossil pollen species in extant genera such as Ephedra (Scott, 1960), which is likely to be a hindrance to understanding, if not actually contrary to the Rules of Nomenclature (Potonié, 1960, p. 21). If there was a Mesozoic group at all, it is unlikely that its members will prove to be close in affinity to the three surviving relict genera; as has been shown many times with other groups, the evidence of a single organ is quite insufficient". Only future macrofossil evidence will throw conclusive light on the past relationships within the family Ephedraceae. Meanwhile, it is considered more suitable to place the ephedralean pollen in the organ-genus Equisetosporites, which belongs to the family Ephedraceae, but not necessarily to the genus Ephedra.

The genus Equisetosporites was erected by Daugherty (1941) to include "spherical spores with two tightly wrapped elators" from the Chinle Formation (Upper Triassic), which he compared with the spores of recent Equisetales. Scott (1960) re-examined the holotype of Equisetosporites chinleana and compared it with better preserved ephedralean pollen from the same formation. From the illustrations, Scott's interpretation—that the so-called "elators" are actually ektexinous ridges, and that the spherical spore is the inner smooth endexine which has become detached from the ektexine—is quite convincing. The writer agrees with Scott that the pollen originally placed in the genus Equisetosporites are morphologically similar to those of the extant genus Ephedra, and not Equisetales. However, for reasons given above, the transfer of Equisetosporites to the extant genus Ephedra does not seem to be appropriate under the circumstances. The

natural genus Ephedra can be validly used in this case and have priority only if the synonymizing of the two genera Equisetosporites and Ephedra by Scott (1960) is accepted. If, however, it is not accepted, not only is the use of the name Ephedra for the pollen described under the name Equisetosporites invalid, but also the transfer of the type species Equisetosporites chinleana to the natural genus Ephedra cannot be construed as valid. Under these circumstances the genus Equisetosporites cannot be interpreted as having lost its type species and continues to remain valid. Insofar as the genus Equisetosporites has priority, no new names or later synonyms, such as Striainaperturites, can be validly used in its place. The name Equisetosporites cannot be rejected on the grounds of being inappropriate or unsuitable (see Art. 62 of Inter. Code of Bot. Nomen. 1959), and there is no other provision in the Code under which the name Equisetosporites can be rejected. Therefore, once it has been decided not to use the extant genus Ephedra, there is no alternative but to use the organgenus Equisetosporites.

Ephedripites Bolkhovitina, 1953, was later transferred by its author to Schizaea, probably because she considered the opening on the holotype to be monolete in nature. The holotype has thickenings at the longitudinal ends; and the ridges are unbranched, flat, and few in number. If the ridges are actually discontinuous at the longitudinal ends, and all the grains do not show the "monolete" mark—which could easily be a rupture along one of the furrows — then these grains would be more ephedralean than schizaeaceous in nature. However, their affinity remains doubtful, and the genus is invalid under Article 34(1) of the International Code of Botanical Nomenclature (1959).

Ephedracites Maljavkina, 1958, and Striainaperturites Pierce, 1961, are junior synonyms of Equisetosporites.

The position of the two morphological poles in the acolpate pollen grains of Equisetosporites is uncertain. The use of the terms "poles", for referring to the longitudinal ends of the pollen (Scott, 1960) and "polar axis", for the line joining the two longitudinal ends (Steeves and Barghoorn, 1959) in the case of the ephedralean pollen, does not seem to be appropriate. The term pole should be used in relation to the orientation of a pollen or spore in a tetrad. The side facing the points of contact in a tetrad should be called the proximal pole and the opposite surface facing outward, the distal pole. The exact position of these two morphological poles is uncertain in Equisetosporites. Therefore, the line drawn across the maximum width of the pollen grain has been referred to as the maximum breadth, the line joining the two longitudinal ends as the longitudinal axis, and the distance between the longitudinal ends as the length (Fig. 10).

Although the pollen of *Equisetosporites* were acolpate, they probably germinated by splitting along one of the furrows.

Equisetosporites concinnus n. sp.

Plate 17, figures 10-15

Description: Acolpate pollen grains; ellipsoid, always narrower at one end; exine two-layered; smooth endexine overlain by a thicker ektexine; ektexinous ridges unbranched, straight, 7 to 10 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, 10 to 12 in number; furrows narrow, about 1 micron wide, unbranched, straight; some grains presenting a criss-cross pattern of ridges produced by the twisting of the grains during fossilization; ridges coalescing just before reaching the longitudinal ends, the furrows thus not reaching the margin; simple unsculptured area where all ridges fused present at the longitudinal ends; ektexine, normally 1 micron thick, thickened to about 3 microns at the longitudinal ends.

Size range: Length 75 (82.6) 92 microns. Holotype 92 microns. Maximum breadth 32 (34.8) 40 microns. Holotype 32 microns. Ratio of length to maximum breadth 1.9 (2.4) 2.9.

Distribution: Barremian? to Aptian. Abundant at only one level in the Ellerslie Member. A single specimen was found in the Deville Member.

Remarks: The specific name is derived from "concinnus" (beautiful, neat).

Type locality: Imperial Namao No. 1 well

Holotype: Pl. 17, figs. 13-15. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 17, figs. 10-12. Depth 3850 to 3860 feet; Ellerslie Member.

Slide No. IN3850-3860-3; co-ord. 22.1/54. Pl. 17, fig. 10.

Slide No. Micro. 83;

Slide No. Micro. 58: Pl. 17, fig. 11.

co-ord. 17/39.5. co-ord. 14.1/48.2.

Pl. 17, fig. 12. Holotype: Pl. 17, figs. 13-15. Slide No. Micro. 82; co-ord. 17.7/48.

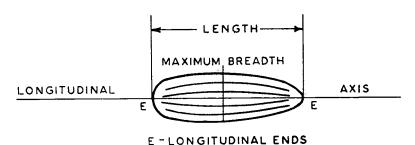


FIGURE 10. Orientation of Equisetosporites pollen grain.

Equisetosporites sp. cf. E. ovatus (Pierce) n. comb.

Plate 17, figure 16

1961 Striainaperturites ovatus Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.

Description: Acolpate pollen grains; ellipsoid, narrower at one end; exine two-layered; smooth endexine overlain by a thicker ektexine; ektexinous ridges unbranched, straight, about 4 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, about 12 to 15 in number; furrows narrow, about 1 micron wide, unbranched, straight; ridges coalescing just before reaching the longitudinal ends, furrows thus not reaching the margin; ektexine thickened at the longitudinal ends.

Size range: Length about 54 microns.

Maximum breadth about 28 microns.

Ratio of length to maximum breadth about 1.9.

Distribution: Aptian to Cenomanian. Very rare. A single specimen was recorded from the Ellerslie Member. Cenomanian of Minnesota, U.S.A. (Pierce, 1961).

Remarks: This species is very similar to Equisetosporites ovatus (Pierce, 1961) n. comb., but differs in having a slightly larger size, narrower and more numerous ridges. Equisetosporites ovatus is 47 by 23 microns in size and has 8 to 9 ridges each about 6 microns in width. As E. ovatus was described on the basis of two specimens only, the range of variation within the species could not have been determined with certainty. Probably the Alberta specimen comes within the range of variation of this species.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 17, fig. 16. Depth 3046 to 3054 feet; Ellerslie Member. Pl. 17, fig. 16. Slide No. Micro. 232; co-ord. 10.9/41.9.

Equisetosporites albertensis n. sp.

Plate 17, figures 17, 18

Description: Acolpate pollen grains; ellipsoid, width equal at both the ends; exine two-layered; smooth endexine overlain by a thicker ektexine; ektexinous ridges unbranched, straight, about 10 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, about 12 in number; furrows narrow, about 1 micron wide, unbranched, straight; criss-cross pattern of ridges (Pl. 17, Figs. 17, 18) apparently produced by the twisting of the grain during fossilization; ridges coalescing just before reaching the longitudinal ends, the furrows thus not reaching the margin; a simple unsculptured area where all the ridges fuse present at the longitudinal ends; ektexine, normally only 1 micron thick, thickened to about 3 microns at the longitudinal ends.

Size range: Length 100 to 115 microns. Holotype 106 microns.

Maximum breadth 33 to 38 microns. Holotype 34 microns.

Ration of length to maximum breadth about 3.1.

Distribution: Aptian. Rare. Present at one level near the base of the Ellerslie Member.

Type locality: Imperial Namao No. 1 well

Pl. 17, figs. 17, 18. Depth 3850 to 3860 feet; Ellerslie Member.

Pl. 17, figs. 17, 18. Slide No. Micro. 81;

co-ord. 8.5/39.5.

MARINE MICROPLANKTON

Order DINOFLAGELLATA

Family Peridinidae

Genus Palaeoperidinium Deflandre, 1934

1934 Palaeoperidinium Deflandre, Compt. Rend. Acad. Sci., vol. 199, p. 967-968.

Diagnosis: Fossil vesicle of general peridinous appearance; plated, but tabulation not well enough preserved to allow more precise generic assignment.

Remarks: *Palaeoperidinium* Deflandre, 1934, was proposed as a collective group, and therefore no type species was designated.

Palaeoperidinium is distinguished from the genus Gonyaulax Diesing, 1866, by its lack of precise tabulation and plates.

Palaeoperidinium cretaceum Pocock, 1962

Plate 18, figure 1

1962 Palaeoperidinium cretaceum Pocock, Palaeontographica, Band 111, Abt. B, p. 80, pl. 14, figs. 219-221.

Description: Theca longer than broad; epitheca long and tapering to a point on which a solid apical horn commonly present; a spiral equatorial girdle distinctly developed in the middle; hypotheca convex and carrying two unequal antapical horns; thecal wall very thin, colorless with no indication of plates or longitudinal furrow; surface scabrate to finely granulose.

Size range: Length 80 to 95 microns.

Breadth 50 to 70 microns.

Length of the longer antapical horn 12 to 23 microns. Length of the shorter antapical horn 4 to 8 microns.

Distribution: Cretaceous. Abundant in the Clearwater and lower Grand Rapids Formations; present also at the top of the "calcareous" member.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 18, fig. 1.

Depth 2598 to 2607 feet; Grand Rapids Formation.

Pl. 18, fig. 1.

Slide No. Micro. 130;

co-ord. 13/42.

PALAEOPERIDINIUM GRANULATUM n. sp.

Plate 18, figures 2, 3

Description: Test nearly circular, approximately as long as broad; apical horn averaging 1/5 of the total length, solid to partly solid, short and conical, arising abruptly from the epitheca; a spirally winding membraneous structure commonly present on the apical horn; body distinctly granulose, the equatorial girdle in the middle marked by two prominent lines bearing longer spinules; no plates or longitudinal furrow visible; one longitudinal fold and two horizontal folds, one on each surface usually present.

Size range: Total length (including apical horn) 96 to 115 microns. Holotype 100 microns.

> Length of the test 80 to 89 microns. Holotype 82 microns. Breadth of the test 80 to 88 microns. Holotype 83 microns. Length of the apical horn 16 to 26 microns. Holotype 18 microns.

Distribution: Middle Albian. Common in the shale member of the Clearwater Formation and the lower Grand Rapids Formation.

Remarks: Palaeoperidinium nudum Downie, 1957, can be distinguished from P. granulatum n. sp. by its longer apical horn, which is 1/3 of the total length of the body, elongated test, and smooth transparent wall. P. ventriosum Deflandre, 1935, has a much smaller apical horn compared with the size of the body and has over-all dimensions smaller than P. granulatum n. sp.

The specific name is derived from "granulatum" (granular, granulated) and refers to the granulose surface of the body.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 18, fig. 3. Depth 2598 to 2607 feet;

Grand Rapids Formation.

Pl. 18, fig. 2. Depth 2598 to 2607 feet;

Grand Rapids Formation.

Holotype: Pl. 18, fig. 3. Slide No. Micro. 129;

co-ord. 13.1/42.1.

Pl. 18, fig. 2. Slide No. Micro. 129;

co-ord. 13.1/42.1.

Family Gonyaulacidae

Genus Gonyaulax Diesing, 1866

Goniaulax Diesing, Sitzber. Akad. Wiss. Wien, Math. Naturw. Kl., vol. 52, 1883

Goniaulax polyedra Stein, pl. 4, figs. 7-9. 1911 Gonyaulax polyedra Stein—Kofoid, Univ. California (Berkeley) Publ. Zool., vol. 8, p. 187-300, tables 9-19, 5 figs. (type species). Diagnosis: Dinoflagellates with plated tests; 3 to 6 apical plates; 0-4 anterior intercalary plates; 6 precingular plates; 6 postcingular plates; 0-1 posterior intercalary plate; 1 antapical plate (tabulation formula: 3-6, 0-4a, 6", 6", 0-1p, 1""); sutures separating the plates bear high serrated or spinose flanges; longitudinal furrow extends to the apex.

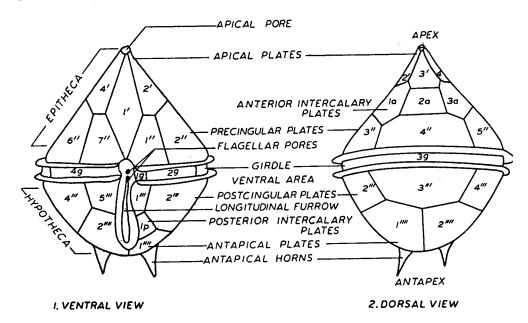


FIGURE 11. Dinoflagellate terminology and tabulation (after Evitt, 1961). Apical plates ('); anterior intercalary plates (a); precingular plates ("); girdle plates (g); postcingular plates (""); posterior intercalary plates (p); antapical plates ("").

Gonyaulax sp. cf. G. jurassica Deflandre, 1938

Plate 18, figure 4

1938 Gonyaulax jurassica Deflandre, Compt. Rend. Acad. Sci., vol. 206, p. 688, fig. 2.

Description: Test ellipsoidal; a well-developed apical horn, not as long as in *G. jurassica*; a well-defined spiral equatorial furrow, tabulation pattern not completely established but apparently 3', 6", 6", 1p, 1""; sutures bearing high serrated flanges.

Size range: Total length 112 microns.

Apical horn 20 microns.

Width of body 98 microns.

Distribution: Oxfordian to middle Albian? Very rare. Only one specimen was recorded near the base of the Grand Rapids Formation and may be reworked. To date, it has been reported only from the Upper Jurassic of the United States, Europe, and Australia.

Locality of figured specimen: Fort Augustus No. 1 well
Pl. 18, fig. 4. Depth 2607 to 2616 feet; Grand Rapids Formation.
Pl. 18, fig. 4. Slide No. Micro. 185; co-ord. 11.5/39.5.

Order Hystrichosphaeridea

Family Hystrichosphaeridae

Genus Hystrichosphaeridium Deflandre, 1937, restr. Eisenack, 1958

- 1838 Xanthidium tubiferum Ehrenberg, Abhandl. Kön. Akad. Wiss. (Berlin), pt. 1, fig. 19.
- 1933 Hystrichosphaera tubifera Wetzel, Palaeontographica, Band 77, Abt. A, p. 40; Band 78, Abt. A, fig. 16.
- 1937 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, Ann. Paléont., vol. 26,
- p. 69, pl. 13, figs. 2, 4, 5 (type species).

 1958 Hystrichosphaeridium Deflandre, restr. Eisenack, Neues Jahrb. Geol. Paläont.,
 Abhandl., vol. 106, p. 399-400.

Diagnosis: Hystrichosphaeridae with spherical to oval non-plated central vesicle bearing numerous, well-disposed, generally similar, commonly funnel-shaped processes, widening and opening towards the outer end.

Remarks: Eisenack (1958) restricted the genus *Hystrichosphaeridium* to only those forms in which the processes are open at the outer ends. He created a new genus, *Baltisphaeridium*, to include forms whose processes are closed at the outer ends. *Hystrichosphaeridium* can be distinguished from *Hystrichosphaera* by the spiral girdle-like structure and conspicuous polygonal areas on the vesicle of the latter.

Affinity: Some hystrichospheres are perhaps dinoflagellate cysts with an apical archeopyle, in which both rupture lines and processes indicate the characteristic tabulation of an original outer wall that has not been preserved. The processes are interpreted as structures that braced the cyst against a now missing outer wall. Evitt (1961) has illustrated the apical archeopyle where the cyst has ruptured, and also polygonal areas on the wall of the cyst itself which reflect the characteristic tabulation of the original outer wall that has not been preserved. However, a tabulated outer wall, to substantiate this very plausible hypothesis, has not yet been found.

Hystrichospheres are most probably a polyphyletic group representing the eggs, cysts, and tests of bryozoans, desmids, crustaceans, and flagellates (Deflandre, 1947). Their similarity in external morphology does not indicate a close genetic relationship. Eisenack (1954), however, believes in a monophyletic origin of hystrichospheres and treats them as a single group of related organisms which have shown evolutionary changes with time.

Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, 1937

Plate 18, figure 5

(Synonymy as for genus)

Description: Vesicle circular to ellipsoidal in outline with smooth surface; processes tubular, narrow, hollow and of uniform width broadening out into a funnel-shaped structure opening at the outer ends; processes long in comparison with vesicle diameter; lips of the processes irregular and bearing recurved spines.

Size range: Diameter of vesicle 34 microns.

Length of processes 20.4 microns.

Width of processes at the base 3 microns. Width of processes at the apex 22 microns.

Number of processes 10.

Distribution: Aptian to Senonian. Common in the Clearwater and lower Grand Rapids Formations. Also in Colorado Group (Upper Cretaceous) of western Canada (Pocock, 1962). Aptian (Deflandre, 1937) to Upper Cretaceous (Eisenack, 1958) of Europe.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 18, fig. 5.

Depth 2095 to 2098 feet;

Wabiskaw Member.

Pl. 18, fig. 5.

Slide No. Micro, 127;

co-ord. 10.5/40.5.

Hystrichosphaeridium albertense Pocock, 1962

Plate 18, figures 6, 7

1962 Hystrichosphaeridium albertense Pocock, Palaeontographica, Band 111, Abt. B, p. 82, pl. 15, figs. 226, 227.

Description: Vesicle thin, smooth and circular in outline; processes trumpet-shaped, being narrow at the base and broadening out continuously towards the apex; processes hollow, opening at the apex and long in comparison with the vesicle diameter; lips of the processes irregular and frayed.

Size range: Diameter of vesicle 44 (48) 52 microns.

Length of processes 22 (27.5) 33 microns.

Width of processes at base 3 (5) 10 microns.

Width of processes at the apex 14 (23) 32 microns.

Number of processes 12 to 16.

Distribution: Lower? to middle Albian. Rare in the Wabiskaw Member. Reported from the Garbutt Formation of the Northwest Territories (Pocock, 1962).

Remarks: This species differs from *Hystrichosphaeridium salpingo-phorum* Deflandre in being larger, having more complex lips on the processes and more rapid widening of the processes towards the apex.

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 18, fig. 6. Depth 2095 to 2098 feet; W. Pl. 18, fig. 7. Depth 2098 to 2101 feet: W.

Wabiskaw Member.

Pl. 18, fig. 7. Depth 2098 to 2101 feet; Pl. 18, fig. 6. Slide No. Micro. 160;

Wabiskaw Member.

Pl. 18, fig. 7. Slide No. Micro. 161;

co-ord. 11.4/38.2. co-ord. 10.1/36.1.

Hystrichosphaeridium irregulare Pocock, 1962 Plate 19, figures 1-4

1962 Hystrichosphaeridium irregulare Pocock, Palaeontographica, Band 111, Abt. B, p. 82, pl. 15, figs. 228, 229.

Description: Vesicle thin, smooth and circular in outline; processes funnel-shaped, narrow to very wide and generally variable in shape; processes hollow and open at the apex; lips of the processes wide and irregular, serrate with serration commonly extending down the body of the processes in irregular manner, lips commonly spinose.

Size range: Diameter of vesicle about 63 microns.

Length of processes about 41 microns.

Width of processes at base 3 to 8 microns.

Width of processes at apex 14 to 36 microns.

Number of processes 12.

Distribution: Lower? to middle Albian. Common in the Clearwater Formation. Reported from the Garbutt Formation of the Northwest Territories (Pocock, 1962).

Locality of figured specimen: Imperial Willingdon No. 1 well Pl. 19, figs. 1-3. Depth 2055 to 2065 feet; Wabiskaw Member. Pl. 19, figs. 1-3. Slide No. Micro. 88; co-ord. 8.9/36.5.

Genus Baltisphaeridium Eisenack, 1958

1931 Hystrichosphaeridium longispinosum Eisenack, Paläont. Z., vol. 13, p. 74-118.
 1958 Baltisphaeridium longispinosum (Eisenack) Eisenack, Neues Jahrb. Geol. Paläont., Abhandl., vol. 106, p. 398 (type species).

Diagnosis: Hystrichospheres with globular to oval body devoid of any plates, and bearing numerous processes, branched or unbranched, but always hollow and closed at the outer end.

Baltisphaeridium longispinosum (Eisenack) Eisenack, 1958

Plate 19, figure 5

(Synonymy as for genus)

Description: Vesicle spherical, thin-walled with some circular foldings caused by the flattening of the sphere; about 33 very thin and elongated hollow processes, tapering and closed at the outer end, distributed over the whole surface of the sphere; processes longer than the radius of the test, and broadened slightly at the base.

Size range: Diameter of the vesicle 48 microns.

Length of the processes about 32 microns.

Width of the processes 2 to 3 microns.

Number of processes about 33.

Distribution: Probably reworked from Ordovician strata. A single specimen was found in the upper portion of the Grand Rapids Formation.

Remarks: This specimen is considered by Prof. A. Eisenack to be Baltisphaeridium longispinosum form filifera, described by him from the Ordovician strata of Estonia. However, the number of processes in B. longispinosum is less than 25, while the Alberta specimen has 33 processes. It is considered that the description of B. longispinosum should be emended to allow inclusion of specimens possessing more than 25 processes.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 19, fig. 5.

Depth 1816 to 1826 feet;

Grand Rapids Formation.

Pl. 19, fig. 5.

Slide No. Micro. 145;

co-ord. 10/39.5.

Baltisphaeridium sp. cf. B. Neptuni Eisenack, 1958

Plate 19, figures 6, 7

1958 Baltisphaeridium neptuni Eisenack, Neues Jahrb. Geol. Paläont., Abhandl., vol. 106, p. 399, pl. 26, figs. 7, 8.

Description: Vesicle thin-walled, spherical to oval, bearing a few cylindrical to slightly conical, thin-walled, hollow processes with broad bases and closed at the outer ends, bifurcating at the tips into three (rarely 2 or 4) divergent, widely spaced, pointed and tapering spines; length of the processes about ½ the diameter of the vesicle.

Size range: Total diameter of the specimen 60 microns.

Diameter of the vesicle 40 microns.

Length of the processes 12 microns.

Width of the processes at base 7 microns.

Width of the processes at apex 1.5 microns.

Length of spines 2.5 microns.

Number of processes about 15.

Distribution: Aptian to middle Albian. Very rare. A single specimen was recorded from the shale member of the Clearwater Formation. Aptian of northern Germany (Eisenack, 1958).

Affinity: Probably a dinoflagellate cyst.

Remarks: The Canadian specimens differ from the forms described by Eisenack in having shorter processes. However, in his description Eisenack states that "the processes are about ½ the diameter of the vesicle or somewhat less". Although the diameter of the vesicle comes within the size-range given by Eisenack, the total diameter of the specimen is about 15 microns less than the minimum. This is because of shorter processes. In other respects, the form described above is closely similar to *Baltisphaeridium neptuni* Eisenack, 1958.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 19, figs. 6, 7. Depth 2717 to 2725 feet; Clearwater

Clearwater Formation, shale member.

Pl. 19, figs. 6, 7. Slide No. Micro. 184;

co-ord. 11.5/40.5.

BALTISPHAERIDIUM Sp.

Plate 19, figure 8

Description: Vesicle oval, thin-walled; processes short, numerous, thin, repeatedly and irregularly branched distally, distributed all over the body.

Size range: Total diameter of the specimen 37 microns.

Length of the vesicle 30 microns. Breadth of the vesicle 25 microns. Length of the processes 3 microns.

Distribution: Middle Albian. Rare in the Clearwater and lower Grand Rapids Formations.

Remarks: Baltisphaeridium multispinosum n. sp. and Baltisphaeridium sp. have been placed in Baltisphaeridium rather than Micrhystridium, because the diameter of the vesicle is larger than 20 microns. According to the generic diagnosis, Micrhystridium has a vesicle which is less than 20 microns.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 19, fig. 8. Depth 2717 to 2725 feet; Clearwater Formation,

shale member.

Pl. 19, fig. 8. Slide No. Micro. 132;

co-ord. 5.9/42.5.

Baltisphaeridium multispinosum n. sp.

Plate 20, figures 1, 2

Description: Vesicle circular, thin-walled; length of processes about ¼ of the diameter of the body, unbranched, thin, tapering and closed at the outer end, broadening slightly towards the base; vesicle densely covered with processes distributed all over the surface; some processes bifurcating at the tips.

Size range: Total diameter of the specimens 62 to 74 microns. Holotype 62 microns.

Diameter of the vesicle 40 to 50 microns. Holotype 41 microns.

Length of the processes 10 to 15 microns. Holotype 10 microns.

Width of the processes 0.5 to 1 micron. Holotype 1 micron.

Distribution: Middle Albian. Abundant in the Clearwater Formation, rare in the Grand Rapids Formation.

Remarks: The specific name is derived from "multispinosum" (with many spines) and refers to the numerous thin and tapering processes which cover the vesicle.

Type locality: Imperial Willingdon No. 1 well

Holotype: Pl. 20, fig. 1. Depth 2098 to 2101 feet; Wabiskaw Member.

Pl. 20, fig. 2. Depth 2098 to 2101 feet; Wabiskaw Member.

Holotype: Pl. 20, fig. 1. Slide No. Micro. 135; co-ord. 9.8/40.9.

> Pl. 20, fig. 2. Slide No. Micro. 135; co-ord. 12.3/38.1.

Genus Veryhachium Deunff, 1954

1954 Veryhachium trisulcum Deumff, Compt. Rend. Soc. Géol. France, p. 305-307

Veryhachium trisulcum Deunff, Bull. Soc. Géol. Mineral. Bretagne, n.s., fasc. 2, 1958 p. 27, pl. 1, figs. 4, 13.

Diagnosis: Outline globular, ovoid, subpolyhedral or triangular with concave to convex margin; most common forms triangular or prismatic, with three and in some cases four simple long processes, hollow with closed tips and connected with the central body; number of processes always less than 10; number of processes increasing with increased sphericity.

Affinity: The affinity of this genus is doubtful. Deunff (1958) and most other workers believe that it belongs to the family Hystrichosphaeridae. Baschnagel (1942), however, considers it to be an alga belonging to the class Chlorophyceae, whereas Evitt (1961) considers it to be a nondinoflagellate cyst.

VERYHACHIUM REDUCTUM (Deunff) Jekhowsky, 1961

Plate 20, figure 3

Veryhachium trisulcum Deunff var. reductum Deunff, Bull. Soc. Géol. Mineral.

Bretagne, n.s., fasc. 2, p. 27, pl. 1, figs. 1, 3, 8, 10, 11.

Veryhachium reductum (Deunff) Jekhowsky, Rev. Micropaleont., vol. 3, p. 210-212, pl. 2, figs. 22-44.

Description: Central body triangular; sides slightly convex; three long processes, one at each apex; processes acicular, rigid, opening into the central body and closed at their extremity.

Size range: Width between the base of two processes 35 to 40 microns. Length of the processes 15 to 25 microns. Width of the processes at the base 2 to 4 microns.

Distribution: Ordovician to Cenomanian. Present only in the upper part of the Grand Rapids Formation. It has been reported from the Ordovician of Brittany, France; Ordovician to Lower Carboniferous of the Sahara; Permo-Trias of Yugoslavia, Tunisia, Libya, Madagascar, and the Soviet Arctic; the Triassic of northwestern Australia; Aptian to Cenomanian of Western Australia.

Remarks: This species was found to be polymorphic by Jekhowsky (1961), who distinguished three "forms" corresponding to three intergrading but distinct morphologic groups. However, in the presence of intermediate forms, such distinctions are not apparent. The Alberta specimens are closest in appearance to Veryhachium reductum (Deunff) Jekhowsky, 1961 form reductum. There are some differences in size of specimens described by various authors. According to Deunff (1958), the size-range is 20 to 40 microns. Jekhowsky (1961) gives a size-range of 10 to 25 microns, whereas Cookson and Eisenack (1962) have specimens with a size-range from 44 to 60 microns. However, these may not be the same species, in which case specific distinctions may be made in the future according to size groupings.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 20, fig. 3. Depth 1816 to 1826 feet; Grand Rapids Formation.

Pl. 20, fig. 3. Slide No. Micro. 116; co-ord. 9.2/46.

. VERYHACHIUM IRREGULARE form SUBHEXAHEDRON Jekhowsky, 1961

Plate 20, figure 4

1961 Veryhachium? irregulare forme subhexaedron Jekhowsky, Rev. Micropaleont., vol. 3, p. 208-210, pl. 1, figs. 1-3.

Description: Outline of the central body subhexahedral, convex, with six appendages, one at each apex; in flattened condition shape roughly quadrangular, with four of the appendages showing on the four corners and the remaining two appendages on the front and back surfaces; appendages conical and hollow, opening into the central body and closed at the extremity; form and dimensions of these appendages in some cases variable in the same individual.

Size range: Diameter of the central body 20.4 microns. Length of processes 10 microns.

Distribution: Permian to middle Albian? Very rare in the upper part of the Grand Rapids Formation. It has also been reported from the Permo-Trias of Brazil and Yugoslavia, and from the Anisian and the Norian of the U.S.S.R.

Affinity: Probably a cyst.

Remarks: This species is considered polymorphic by Jekhowsky (1961), with four distinct "forms".

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 20, fig. 4. Depth 1816 to 1826 feet; Grand Rapids Formation.

Pl. 20, fig. 4. Slide No. Micro. 149; co-ord, 11.2/42.

INCERTAE SEDIS

Genus Pseudoceratium Gocht, 1957

1957 Pseudoceratium pelliferum Gocht, Paläont. Z., vol. 31, p. 166-168, pl. 18, figs. 1, 2 (type species).

Diagnosis: Theca of organic substance (shaped like a peridinian), characterized by several elongated horns; plates, girdle system and furrow absent; theca smooth or covered with short processes, apical part commonly separated by an irregular line of rupture.

Affinity: Evitt (1961) considers *Pseudoceratium* to be a dinoflagellate motile stage.

PSEUDOCERATIUM PELLIFERUM Gocht, 1957

Plate 20, figures 5, 6

(Synonymy as for genus)

Description: Theca flattened; outline asymmetrically triangular with convex sides, longer than broad, with a strongly developed apical horn, and two shorter, unequal, and widely divergent antapical horns; one antapical horn much reduced in or absent from some specimens; apical horn and the larger antapical horn very commonly in one axis; body more or less densely covered with rounded, blunt, and setaceous processes, with broadened distal ends; setae single, or two or more fused at the base, not developed uniformly, those on the horns being longer; setae at right angles to the theca on the main part of the body, but at acute angles closer to the horns thus presenting a serrated outline; setae probably hollow; apical portion of the cell in some specimens detached along a line of weakness above the equatorial zone; line of rupture irregular and probably representing an apical archeopyle.

Size range: Length of theca 75 to 95 microns.

Breadth of theca 60 to 85 microns.

Length of apical horn 20 to 50 microns.

Length of antapical horns about 11 microns (not complete-

ly preserved).

Length of spines 5 microns.

Distribution: Valanginian to middle Albian. Common. Present at the top of the "calcareous" member and in the Clearwater and Grand Rapids Formations. Reported from the Garbutt Formation of the Northwest Territories (Pocock, 1962). First described from the Valanginian to Aptian of northwestern Europe.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 20, fig. 5.	Depth 2607 to	2616 feet;	Grand Rapids Formation.
Pl. 20, fig. 6.	Depth 2598 to	2607 feet;	Grand Rapids Formation.

Pl. 20, fig. 5. Slide No. FA2607-2616-1; co-ord. 10/32.

Pl. 20, fig. 6. Slide No. Micro. 128; co-ord. 16/37.

PSEUDOCERATIUM GOCHTII Pocock, 1962

Plate 20, figure 7

1962 Pseudoceratium gochtii Pocock, Palaeontographica, Band 111, Abt. B, p. 79, pl. 14, figs. 213, 214.

Description: Theca roughly ellipsoidal, longer than broad; equatorial girdle, plates and longitudinal furrow not developed; wall thin, smooth, hyaline; apex convex, terminated by a long solid apical horn very variable in length; two antapical horns of more or less equal length.

Size range: Total length of body (including the horns) 93.5 microns.

Length of theca 59.4 microns.

Breadth of theca 34 microns.

Length of apical horn 20.5 microns.

Length of antapical horns 10.2 and 13.6 microns.

Distribution: Cretaceous. Very rare. A single specimen was recorded from the shale member of the Clearwater Formation. Lower and Upper Cretaceous in western Canada (Pocock, 1962).

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 20, fig. 7. Depth 2782 to 2785 feet;

Clearwater Formation,

shale member.

Pl. 20, fig. 7.

Slide No. Micro. 192;

co-ord. 10.8/40.2.

Genus Canningia Cookson and Eisenack, 1960

1960 Canningia reticulata Cookson and Eisenack, Palaeont., vol. 2, p. 251, pl. 38, figs. 1, 2 (type species).

Diagnosis: Shell flattened, roughly five-sided to almost circular with a slight apical prominence and broadly indented base; basal projections (corresponding to antapical horns) either equal or unequal and commonly differ slightly in shape; equatorial girdle either absent or faintly indicated both on the surface or by re-entrant angles at the sides; shell opens by a proximal break, resulting in the complete detachment of the apical region.

Affinity: Canningia represents a dinoflagellate motile stage (Evitt, 1961).

Canningia colliveri Cookson and Eisenack, 1960

Plate 20, figure 8

1960 Canningia colliveri Cookson and Eisenack, Palaeont., vol. 2, p. 251, pl. 38, figs. 3, 4.

Palaeohystrichophora brevispinosa Pocock, Palaeontographica, Band 111, Abt. B, p. 81, pl. 14, figs. 222, 223.

Description: Theca somewhat longer than broad, widest at equator; apical projection conical, prominent; two antapical projections always unequal, with one projection invariably longer and sharper; antapical projec-

tions less prominent than the apical projection; equatorial girdle not seen; wall thin and closely to sparsely spinulate; spines short on the body, but 3 to 5 microns long on the apical and antapical projections; all specimens showing a rupture below the base of the apical projection, representing the apical archeopyle; theca opens by the complete detachment of the apical region at the place of rupture.

Size range: Length 102 (114) 127 microns. Breadth 68 (80.5) 92 microns. Length to breadth ratio 1.29 (1.42) 1.61.

Distribution: Aptian to middle Albian. Common in the Clearwater Formation. Reported from the Garbutt Formation of the Northwest Territories (Pocock, 1962). Aptian of Queensland and Western Australia (Cookson and Eisenack, 1960).

Remarks: The stratigraphic distribution of Palaeohystrichophora brevispinosa Pocock, 1962, is the same as for the specimens described above as Canningia colliveri Cookson and Eisenack, 1960.

The holotype of C. colliveri is 107 microns long and 100 microns wide, and the paratype is 106 microns long and 90 microns wide. The dimensions of P. brevispinosa Pocock, 1962, are 110 (114) 120 microns long and 69 (98) 110 microns wide. The dimensions as well as the length to breadth ratio of P. brevispinosa are well within the range of variation in C. colliveri. The equatorial girdle is also shown faintly by some specimens of C. colliveri. The body of the paratype is spinulate and suggests a variation both in length as well as density of the spines. Both C. colliveri as well as P. brevispinosa have unequal, short, blunt antapical processes. The genus Palaeohystrichophora has a typically fusiform shape, and the hypotheca is terminated by a single antapical process. Therefore, P. brevispinosa Pocock, 1962, has been transferred to C. colliveri Cookson and Eisenack, 1960, with which it is identical.

Locality of figured specimen: Imperial Willingdon No. 1 well Depth 2085 to 2095 feet; Wabiskaw Member. Pl. 20, fig. 8. Pl. 20, fig. 8. Slide No. Micro. 133; co-ord. 10.2/39.5.

Genus Odontochitina Deflandre, 1935

1933 Ceratium (Euceratium) operculatum Wetzel, Palaeontographica, Band 77, Abt.

A, p. 170, pl. 2, figs. 21, 22.

Odontochitina silicorum Deflandre, Bull. Biologique, vol. 69, p. 234, pl. 9, 1935

Odontochitina operculata (Wetzel) Deflandre in Deflandre and Cookson, 1955 Australian J. Marine Freshwater Res., vol. 6, p. 291, pl. 3, figs. 5, 6 (type

Odontochitina silicorum Deflandre-Pocock, Palaeontographica, Band 111, Abt. B, p. 78, pl. 14, figs. 211, 212.

1962

Diagnosis: Dinoflagellate cyst with chitinous wall; body globular, with one long apical and two antapical horns; apical archeopyle, marked by a line of weakness below the apex, dividing the body into two unequal parts; a distinct inner wall visible at the horn bases within the outer wall, equatorial girdle and tabulation absent.

Remarks: Pocock (1962) has treated this genus as a representative of a motile stage. In this connection, he mentions (p. 78) an "equatorial groove not always well marked although there is always a line of weakness around the equator". This observation is incorrect. In specimens figured here, the line of weakness is more apical in position and perhaps represents an apical archeopyle rather than an equatorial groove.

Affinity: According to Evitt (1961), the entirely smooth wall of Odontochitina suggests that it is a dinoflagellate cyst, rather than the theca of a motile stage. The presence of an inner wall within the outer wall at the horn bases indicates that Odontochitina is a cyst within a cyst like Wetzeliella (Evitt, op. cit.).

Odontochitina operculata (Wetzel) Deflandre, 1955 Plate 20, figures 9, 10

(Synonymy as for genus)

Description: Dinoflagellate cyst with thin chitinous wall, entirely smooth, hyaline, with no trace of an equatorial girdle or tabulation; body elongated oval in polar outline and circular in equatorial outline; apical archeopyle, marked by a line of weakness close to the base of the apical horn, dividing the body into two unequal parts; one long apical and two antapical horns on the body; one antapical horn in direct axial continuation of the lower part of the body, the other branching off from near the equator; an inner wall visible at the horn bases.

Size range: Total length 220 to 400 microns.

Body length 68 to 100 microns; width 35 to 60 microns.

Apical horn length 100 to 200 microns.

Antapical horns length 90 to 150 microns; 50 to 100 microns.

Distribution: Hauterivian to Upper Cretaceous. Abundant. Ranges from the top of the "calcareous" member to the Clearwater Formation. Also in the Colorado Group (Upper Cretaceous) of western Canada (Pocock, 1962). Hauterivian to Upper Cretaceous in northwestern Europe (Gocht, 1959), and Albian to lower Turonian in Australia (Cookson and Eisenack, 1958).

Remarks: A large proportion of specimens are broken into two along the apical archeopyle.

Locality of figured specimens: Fort Augustus No. 1 well
Pl. 20, fig. 9, 10. Depth 2717 to 2725 feet; Clearwater Formation,
shale member.
Pl. 20, fig. 9. Slide No. Micro. 164; co-ord. 11/41.
Pl. 20, fig. 10. Slide No. Micro. 131; co-ord. 16.5/46.5.

MEGASPORES

Prior to 1954 nearly all megaspores were placed in a single genus, Triletes, a practice which Harris (1961) is still following. Potonié and Kremp (1954) and Potonié (1956, 1958) revised the megaspore genera grouped under Triletes and created numerous genera based purely on spore morphology. Potonié (1956), however, raised the genus Triletes to the level of turma (division), and introduced Trileites Erdtman, 1945 ex Potonié, 1956, as a form-genus. This does not appear to be justified, as Triletes Reinsch, 1881, emend. Schopf, 1938, has priority as a form-genus.

Chaloner (1959, p. 322) and Harris (pers. comm.) both feel that this purely morphographic classification by Potonié and Kremp (1954) and Potonié (1956) cuts across known biological relationships. Chaloner gives the example of spores borne by Sigillaria which were placed under two distinct form-genera on the basis of difference in wall decoration. This problem is also present in the case of microspores, and attention should be paid to the studies made on spore-containing megasporangiate fructifications in proposing a fossil-megaspore classification.

At present there is a tendency towards increasing the multiplicity of megaspore genera, most of which, as pointed out by Chaloner (*ibid.*) in the case of Sigillaria, are based only on characters of specific value. This results in an exaggerated impression of the degree of difference between different assemblages, and there is an obvious necessity to circumscribe the megaspore genera as close as possible to the natural system. On the other hand, some splitting of the rather diversified entities that had accumulated under the genus *Triletes* is clearly desirable, and in this work the genus *Triletes* is used as emended by Schopf (1938), and the form-genera *Horstisporites*, Verrutriletes, Erlansonisporites, Maexisporites, Dijkstraisporites, and Arcellites—all of which had been previously placed in the old genus Triletes—are distinguished from one another.

Genus Triletes Reinsch, 1881, emend. Schopf, 1938

1881 Triletes Reinsch, Neue Untersuchungen über die Mikrostruktur der Steinkohle des Carbon, der Dyas und Trias, Leipzig.

1884 Triletes Reinsch, Micro-Palaeophytologia formationis carboniferae: vol. 1,

Erlangae, Germania, Theo. Krische, p. vii+80, pls. 1-66.

1886 Triletes I Bennie and Kidston, Proc. Roy. Phys. Soc. Edinburgh, vol. 9, p. 107,

pl. 3, figs. 1a-b.

1932 Sporonites reinschi Ibrahim in Potonié, Ibrahim and Loose, Neues Jahrb. Mineral.,

Geol Palicott Band 67 Abt B. p. 449 pl. 17 fig. 28

Geol. Paläont., Band 67, Abt. B, p. 449, pl. 17, fig. 28.

33 Laevigati-sporites reinschi (Ibrahim) Ibrahim, doctor. diss., Tech. Hochschule zu Berlin (privately published), p. 18, pl. 4, fig. 28.

zu Berlin (privately published), p. 18, pl. 4, fig. 28.

1934 Reticulati-sporites reinschi (Ibrahim) Loose, Arb. Inst. Paläobot. Petrogr.
Brennsteine, vol. 4, p. 157.

1934 Sporites primus Wicher, Arb. Inst. Paläobot. Petrogr. Brennsteine, vol. 4, p. 169.
 1938 Triletes reinschi (Ibrahim) Schopf, Illinois State Geol. Surv., Rept. Invest. 50, p. 0-73 (type species).

Diagnosis: Megaspores; radially symmetrical; equatorial outline more or less circular; proximal side marked by triradiate sutures or cracks

separating three equal contact faces; arcuate ridges connecting the ends of the rays may be present in some species; distal surface smooth or slightly granulate to rugulate, ornamentation generally less well developed on proximal than on distal surface; equatorial diameter exceeding 150 microns; usually very large, up to or more than 3 mm.

Triletes persimilis Harris, 1935

Plate 21, figure 1

1935 Triletes persimilis Harris, Medd. Gronland, vol. 112, p. 165, pl. 25, fig. 4.

Description: Spore more or less circular; spore wall commonly sunken; proximal side marked by a very distinct triradiate crack separating three equal contact faces, spore commonly split into three equal portions along these cracks; triradiate ridge present on the margin of the cracks, in undehisced specimens the triradiate ridge extending up to ¾ the radius of the spore; cracks present along the triradiate ridge in dehisced specimens, the arms of the ridge extending up to the margin of the spore; spore wall smooth; arcuate ridges absent.

Size range: Equatorial diameter 400 to 600 microns.

Width of the triradiate ridges 15 microns.

Height of the triradiate ridges 10 to 20 microns.

Thickness of the exine 20 microns.

Distribution: Rhaetic-Liassic to Senonian. Very rare. A single specimen was found in the Grand Rapids Formation. Recorded elsewhere from the Rhaetic-Liassic of east Greenland (Harris, 1935), the Wealden of England (Dijkstra, 1951), and the Senonian of the Netherlands (Dijkstra, 1949).

Locality of figured specimen: Imperial Willingdon No. 1 well
Pl. 21, fig. 1. Depth 1816 to 1826 feet; Grand Rapids Formation.
Pl. 21, fig. 1. Slide No. Mega. 27; co-ord. 11/68.

TRILETES sp. A

Plate 21, figure 2

Description: Trilete megaspore; equatorial outline circular; surface smooth; proximal side marked by triradiate ridges, 60 to 100 microns high at their extremities, and joining at the proximal pole with a height of 20 microns; length of the triradiate ridges about $\frac{2}{3}$ of the spore radius; laesurae present as cracks on the triradiate ridges.

Size range: Equatorial diameter 641 microns.

Distribution: Aptian. Very rare. A single specimen was recorded from the middle of the Ellerslie Member. Locality of figured specimen: Fort Augustus No. 1 well Pl. 21, fig. 2. Depth 3111 to 3120 feet; Ellerslie Member. Pl. 21, fig. 2. Slide No. Mega. 90; co-ord. 14/34.5.

TRILETES Sp. B

Plate 21, figure 3

Description: Trilete megaspore; equatorial outline circular; surface coarsely granular; proximal side marked by raised and sinuous triradiate ridges nearly reaching the equator; laesurae present as cracks on the triradiate ridges.

Size range: Equatorial diameter 397 microns.

Distribution: Aptian. Very rare. A single specimen was recorded from the middle of the Ellerslie Member.

Locality of figured specimen: Fort Augustus No. 1 well Pl. 21, fig. 3. Depth 3111 to 3120 feet; Ellerslie Member. Pl. 21, fig. 3. Slide No. Mega. 89; co-ord. 10/37.

Genus Horstisporites Potonié, 1956

1951 Triletes reticuliferus Dijkstra, Mededel. Geol. Sticht., n.s., no. 5, p. 10, pl. 2, figs. 12, 13.
1956 Horstisporites reticuliferus (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 44-45, pl. 5, fig. 51 (type species).

Diagnosis: Trilete megaspores; equatorial outline circular to faintly subtriangular, trilete mark about half the radius of the spore or longer, contact faces and arcuate ridges not distinguishable, entire exine alveolar or reticulate.

Horstisporites reticuliferus (Dijkstra) Potonié, 1956

Plate 21, figures 4, 5

(Synonymy as for genus)

Description: Trilete megaspore; body spherical; triradiate ridges somewhat flexuous and extending only up to ½ of the spore radius, about 120 microns high and 20 microns wide at the top, widening towards the base; contact faces and arcuate ridges not distinguishable; entire surface heavily reticulate with flap-like muri 30 to 40 microns high irregularly outlining the lumina; muri 15 to 20 microns wide; reticulum 40 to 70 microns in diameter.

Size range: Equatorial diameter 450 to 840 microns.

Distribution: Neocomian to Aptian. Common near the base of the Ellerslie Member. First described from the Wealden of the Netherlands (Dijkstra, 1951).

Remarks: This thickness of the muri depends largely on the amount of abrasion and oxidative maceration. The muri are thin and high on wellpreserved specimens, but thick and low on poorly preserved ones.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 21, figs. 4, 5. Depth 3188 to 3197 feet; Ellerslie Member.

Pl. 21, fig. 4. Slide No. Mega. 95;

co-ord, 11.5/64.

Pl. 21, fig. 5. Slide No. Mega. 95:

co-ord. 14.5/67.5.

Genus Verrutriletes Van der Hammen, 1954 ex Potonié, 1956

1949 Triletes compositipunctatus Dijkstra, Mededel. Geol. Sticht., n.s., no. 3, p. 22,

1954

pl. 1, fig. 8.

Verrutriletes Van der Hammen, Bot. Geol. (Bogota), vol. 2, p. 14. 1956 Verrutriletes compositipunctatus (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 28, pl. 3, figs. 24, 25 (type species).

Diagnosis: Trilete megaspores; equatorial as well as meridional outline approximately circular to subtriangular; trilete rays not reaching the equator; arcuate ridges indistinct; exine ornamented with hemispherical warts to low coni of various sizes, fused at the bases with one another in some species; contact area smooth (V. carbunculus) or ornamented with small verrucae to coni (V. dubius), or not differentiated, and covered with the same ornamentation as the rest of the spore surface (V. compositipunctatus).

Remarks: Verrutriletes Van der Hammen, 1954 was a nomen nudum until Potonié (1956) designated a type species and published a generic diagnosis with illustrations.

VERRUTRILETES sp. cf. V. COMPOSITIPUNCTATUS (Dijkstra) Potonié, 1956 Plate 21, figure 6

(Synonymy as for genus)

Description: Trilete megaspore; equatorial outline subtriangular; proximal surface slightly convex, the distal surface strongly convex; trilete cracks present on very conspicuous triradiate ridges about 25 microns high and about 35 microns broad, extending up to 4/5 of the spore radius; arcuate ridges not seen; exine ornamented with irregular warts 5 to 25 microns in diameter and 5 to 15 microns high; spore wall very thick.

Size range: Equatorial diameter 330 microns.

Distribution: Aptian to Senonian. Rare in the Ellerslie and Wabiskaw Members. Senonian of the Netherlands (Dijkstra, 1949).

Remarks: The Dutch specimens of Verrutriletes compositipunctatus have a more rounded outline with fewer, more rounded, and larger verrucae on the surface than the Alberta specimens.

Locality of figured specimen: Imperial Namao No. 1 well Pl. 21, fig. 6. Depth 3572 to 3582 feet; Wabiskaw Member.

Pl. 21, fig. 6. Slide No. Mega. 119;

co-ord. 11/37.5.

Genus Erlansonisporites Potonié, 1956

1932 Selaginellites erlansonii Miner, J. Washington Acad. Sci., vol. 22, p. 500-501, fig. 1.
1956 Erlansonisporites erlansonii (Miner) Potonié, Beih. Geol. Jahrb., Heft 23, p. 46-47, pl. 5, fig. 53 (type species).

Diagnosis: Trilete megaspores; outline circular; the trilete mark completely covered by strong reticulation in some cases, thus being partially visible or not visible; muri on the reticulum transformed into thin and high membraneous lamellae equally well developed all over the exine.

Erlansonisporites reticulatus n. sp.

Plate 22, figures 1, 2

Description: Trilete megaspore; outline of the spore completely circular; in some specimens trilete mark entirely covered by strong reticulation and partially or not at all visible; faint trilete crack about ½ the length of the spore radius visible where the high membraneous lamellae on the muri of the reticulum destroyed by oxidative maceration; arcuate lamellae absent; contact faces not distinguishable; a coarse network of muri 4 to 7 microns wide, forming circular to elongate lumina 34 to 60 microns in diameter, present all over the spore surface; muri of the reticulum transformed into thin and membraneous lamellae about 60 microns high, equally well developed all over the exine, but better preserved around the periphery due to flattening of the spherical body.

Size range: Equatorial diameter of body (including the lamellae)
580 to 660 microns. Holotype 580 microns.
Equatorial diameter of body (excluding the lamellae)
480 to 550 microns. Holotype 480 microns.
Length of the lamellae about 60 microns.

Distribution: Aptian to middle Albian. Rare. A few specimens were recorded from the Ellerslie Member and the Grand Rapids Formation.

Remarks: This species can be distinguished from *Erlansonisporites* erlansonii (Miner) Potonié, 1956, by its smaller size and larger number of lumina with smaller diameter.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 22, fig. 1. Depth 2460 to 2469 feet; Grand Rapids
Formation.

Pl. 22, fig. 2. Depth 3156 to 3165 feet; Ellerslie Member.

Holotype: Pl. 22, fig. 1. Slide No. Mega. 28; co-ord. 11.5/40.

Pl. 22, fig. 2. Slide No. Mega. 91; co-ord. 11/37.

Erlansonisporites sparassis? (Murray) Potonié, 1956

Plate 22, figures 3-9

1939 Triletes sparassis Murray, Geol. Mag., vol. 76, p. 480, text-figs. 3, 4.
1956 Erlansonisporites sparassis (Murray) Potonié, Beih. Geol. Jahrb., Heft 23, p. 47.
1961 Triletes sparassis Murray—Harris, The Yorkshire Jurassic Flora, pt. 1, British Museum (Natural History), London, p. 57, text-figs. 18 A-D.

Description: Trilete megaspore; body of the spore nearly spherical; triradiate ridges about $\frac{2}{3}$ as long as the spore radius; arcuate lamellae absent; contact faces not distinguishable; coarse network of ridges with wide and irregular meshes present all over the spore surface; membraneous lamellae 40 to 60 microns high present on the network of ridges (Pl. 22, Figs. 3, 4).

Size range: Equatorial diameter (maximum) 390 (434) 461 microns.

Distribution: Middle Jurassic to Aptian. Abundant locally in the Ellerslie Member. Middle Jurassic of England (Murray, 1939; Harris, 1961).

Remarks: It is not possible to identify this species with any degree of certainty because no complete specimens with membraneous lamellae were preserved. Some specimens with lamellae covered by sediment were initially seen. However, the application of further oxidative maceration, to make the spore more translucent, and to expose the trilete mark, partially destroyed the membraneous lamellae.

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Erlansonisporites globosus n. sp.

Plate 23, figures 1, 2

Description: Trilete megaspore; outline of the spore completely circular; trilete mark clearly visible, membraneous lamellae on the muri not very high; trilete crack extending up to ¾ of the spore radius or nearly reaching the equator; arcuate lamellae absent; contact faces not distinguishable; coarse network of muri about 5 microns wide, forming circular to angular lumina about 24 microns in diameter, present all over the spore surface; muri about 20 to 30 microns high, becoming thin and membraneous farther above the surface of the spore; wall of the spore characteristically thickened; average wall thickness about 20 microns.

Size range: Equatorial diameter 320 to 375 microns. Holotype 372 microns.

Distribution: Aptian. Rare. Two specimens were recorded from the Ellerslie Member.

Remarks: This species can be distinguished from *Erlansonisporites* reticulatus n. sp. by its smaller size, thicker wall, much longer laesurae which nearly reach the equator, and the shorter membraneous lamellae on the muri.

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 23, fig. 1. Depth 3001 to 3010 feet; Ellerslie Member.

Pl. 23, fig. 2. Depth 3156 to 3165 feet; Ellerslie Member.

Holotype: Pl. 23, fig. 1. Slide No. Mega. 63; co-ord. 12/40.2.

Pl. 23, fig. 2. Slide No. Mega. 92; co-ord. 14/38.5.

ERLANSONISPORITES Sp.

Plate 23, figure 3

Description: equatorial outline of the megaspore circular; trilete mark completely covered by thick reticulation and not visible; coarse network of muri 3 to 4 microns wide outlining circular to four-sided lumina about 10 microns in diameter present all over the spore surface; muri transformed into thin, membraneous lamellae about 20 microns high equally well developed all over the exine, but better preserved around the periphery due to flattening of the spherical body.

Size range: Equatorial diameter of body (including the lamellae) 240 microns.

Equatorial diameter of body (excluding the lamellae) 200 microns.

Length of lamellae about 20 microns.

Thickness of the spore wall about 10 microns.

Distribution: Barremian? Rare. A single specimen was recorded from the Deville Member.

Remarks: Although this species is grossly similar to Tasmanites, the body is distinctly reticulate when examined under high power, and the muri can be seen arising from the body on the margin. However, the surface of the body is strongly convex and only a few lumina come into focus at one time.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 23, fig. 3. Depth 3222 to 3231 feet; Deville Member.

Pl. 23, fig. 3. Slide No. Mega. 106; co-ord. 11/36.5.

Genus Maexisporites Potonié, 1956

1951 Triletes soldanellus Dijkstra, Mededel. Geol. Sticht., n.s., no. 5, p. 10, pl. 2, fig. 17.

1956 Maexisporites soldanellus (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 25-26, pl. 2, figs. 17-19 (type species).

Diagnosis: Trilete megaspores; equatorial contour subtriangular with convex sides; apices more or less rounded, but in some cases acute; triradiate ridges extending up to ¾ of the spore radius and in some species even up to the margin of the spore; contact area perceptible or imperceptible; proximal side raised into a pyramid-shaped structure in some species, sunken in others, with the triradiate ridges on the trilete mark; exine almost smooth, very finely granulate to indistinctly granulate, granules 2 microns in diameter.

Maexisporites soldanellus (Dijkstra) Potonié, 1956

Plate 23, figure 4

(Synonymy as for genus)

Description: Trilete megaspore; equatorial outline subtriangular with convex sides and rounded apices; triradiate ridges on the trilete mark reaching close to the margin of the spore; contact area not visible; proximal side raised into a pyramid-shaped structure, its faces being bound by the triradiate ridges; exine finely granulose with granules of 2 microns or more in diameter; dark brown in color.

Size range: Total equatorial diameter 384 microns.

Height of the triradiate ridges 15 microns.

Width of the triradiate ridges 30 to 40 microns.

Thickness of the spore coat 40 microns.

Distribution: Berriasian to Aptian. Rare. A single specimen was found in the Ellerslie Member. First described from the English Wealden (Berriasian to lower Aptian) by Dijkstra (1951).

Remarks: In the illustrated specimen (Pl. 23, Fig. 4) an air bubble is trapped under the proximal pyramid-shaped structure.

Locality of figured specimen: Fort Augustus No. 1 well
Pl. 23, fig. 4. Depth 3093 to 3102 feet; Ellerslie Member.
Pl. 23, fig. 4. Slide No. Mega. 76; co-ord. 11/35.5.

Maexisporites obolus (Dijkstra) Potonié, 1956

Plate 23, figures 5, 6

1951 Triletes obolus Dijkstra, Mededel. Geol. Sticht., n.s., no. 5, p. 10, pl. 2, fig. 18. 1956 Maexisporites obolus (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 26.

Description: Trilete megaspore; equatorial outline subtriangular with convex sides and rounded apices; triradiate ridges on the trilete mark extending up to the margin of the spore; proximal face sunken with triradiate ridges rising to a considerable height; exine finely granulose; granules about 2 microns in diameter; dark brown in color.

Size range: Total equatorial diameter 224 to 290 microns.

Height of triradiate ridges 20 microns.

Width of triradiate ridges 20 microns.

Thickness of spore coat 30 microns.

Distribution: Hauterivian to Aptian. Rare. A single specimen each was recorded from the Deville and Ellerslie Members. First described from the Hauterivian of the English Wealden (Dijkstra, 1951).

	Locality of	figured specimens: Fort Aug	ustus No. 1 well
Pl.	23, fig. 5.	Depth 3222 to 3231 feet;	Deville Member.
Pl.	23, fig. 6.	Depth 3093 to 3102 feet;	Ellerslie Member.
Pl.	23, fig. 5.	Slide No. Mega. 110;	co-ord. 12/34.5.
Pl.	23, fig. 6.	Slide No. Mega. 77;	co-ord. 11/35.

Genus Thomsonia Mädler, 1954

1954 Thomsonia reticulata Mädler, Geol. Jahrb., vol. 70, p. 150, pl. 5, fig. 15 (type species).

Diagnosis: Trilete megaspores; body of spore almost spherical; outer margin of the arcuate lamellae triangular with convex sides and with well-developed auricles at the apices; triradiate lamellae well developed, flap-like and high with usually waved margin; long and slender, forked or simple appendages arising close to or attached with the triradiate lamellae; contact area reaching up to or close to the equator; exine on the distal surface mostly reticulate, but verrucose or covered with coni in some species.

Remarks: *Thomsonia* is distinguished from *Minerisporites* by the hairy appendages in the apical (proximal) region of the former.

Thomsonia phyllicus (Murray) Potonié, 1956 Plate 23, figure 7

1939 Triletes phyllicus Murray, Geol. Mag., vol. 76, p. 482, text - figs. 7, 8. 1956 Thomsonia phyllicus (Murray) Potonié, Beih. Geol. Jahrb., Heft 23, p. 72.

Description: Trilete megaspore; body spherical, triradiate lamellae leaf-like, one on either side of the triradiate scar, very high; distal surface covered with ridges forming an irregular mesh, ridges prolonged to form short, simple spines at the intersections of the mesh; very long, simple or forked, slender appendages arising near the triradiate lamellae.

Size range: Diameter of the body 200 microns.

Height of the triradiate lamellae 220 microns.

Length of appendages 150 microns.

Diameter of mesh formed by ridges 1 to 2 microns.

Height of the spines 15 microns.

Distribution: Middle Jurassic to Lower Cretaceous. Rare. A single specimen each was recorded from the Ellerslie Member and the top of the Grand Rapids Formation. Middle Jurassic of England (Murray, 1939; Harris, 1961).

Locality of figured specimen: Fort Augustus No. 1 well.

Pl. 23, fig. 7. Depth 3093 to 3102 feet;

Ellerslie Member.

Pl. 23, fig. 7.

Slide No. Mega. 78;

co-ord. 8.8/35.2.

Genus Minerisporites Potonié, 1956

1935 Selaginellites mirabilis Miner, Am. Midland Naturalist, vol. 16, p. 618, pl. 23, fig. 1.
1956 Minerisporites mirabilis (Miner) Potonié, Beih. Geol. Jahrb., Heft 23, p. 67, pl. 9, figs. 87, 88 (type species).

Diagnosis: Trilete megaspores; equatorial outline of the central body subtriangular to almost circular; meridional outline of the central body semi-circular to circular; thin equatorial zona, widest at the apices, resulting in a triangular equatorial outline of the zona; triradiate lamellae (tecta) on the trilete laesurae extending onto the apices, up to the outer margin of the zona and strongly raised into a flap-like structure considerably higher than wide; exine thin, reticulate with vesicular lumina and curved muri.

Remarks: The genus *Minerisporites* can be distinguished from *Henrisporites* by the clearly defined reticulate structure of the exine. *Henrisporites* has an exine ornamented with small conical processes or spines.

Miner (1935a) should not have placed his species *mirabilis* in the genus *Selaginellites*; this genus should be restricted to fossil shoots which show closer similarity to *Selaginella* than to any other genus (Halle, 1907).

Affinity: The probable affinity of *Minerisporites* is with the family Selaginellaceae.

MINERISPORITES MACRORETICULATUS n. sp.

Plate 23, figures 8-11; plate 24, figures 1, 2

Description: Trilete megaspore; equatorial outline of the central body triangular to nearly circular; thin and finely granular equatorial zona widest at the apices, resulting in a triangular equatorial outline of the zona; triradiate lamellae (tecta) on the trilete laesurae extending onto the apices, up to the outer margin of the zona; triradiate lamellae very high; exine thin with very distinct and wide reticulum; muri thin with hair-like or membraneous outgrowths.

Size range: Total equatorial diameter (including zona) 385 (461) 570 microns. Holotype 500 microns.

Width of zona at apices 65 (93) 120 microns. Holotype 75 microns.

Width of zona at sides 30 (40) 50 microns. Holotype 35 microns.

Width of triradiate lamellae (tecta) about 7 microns. Height of triradiate lamellae about 120 microns. Width of lumina 40 microns (average). Width of muri 1 micron.

Distribution: Middle Albian. Abundant in the upper part of the Grand Rapids Formation.

Remarks: This species differs from Minerisporites marginatus (Dijkstra) Potonié, 1956, in being larger, and in having a distinct and wide reticulum and hair-like or membraneous outgrowths on the muri.

The specific name is derived from "macroreticulatus" (with large reticulation) and refers to the wide reticulate pattern on the central body.

Type locality: Fort Augustus No. 1 well Holotype: Pl. 23, fig. 8. Depth 2442 to 2451 feet; Grand Rapids Formation. Pl. 23, fig. 9. Depth 2442 to 2451 feet; Grand Rapids Formation. Pl. 23, figs. 10, 11. Depth 2478 to 2487 feet; Grand Rapids Formation. Pl. 24, figs. 1, 2. Depth 2478 to 2487 feet; Grand Rapids Formation. Holotype: Pl. 23, fig. 8. Slide No. Mega. 4; co-ord. 11.4/37.8. Pl. 23, fig. 9. Slide No. Mega. 3; co-ord. 7.2/49. Pl. 23, fig. 10. Slide No. Mega. 32; co-ord. 17.9/53.1. Pl. 23, fig. 11. Slide No. Mega. 32; co-ord. 8.2/60. Pl. 24, fig. 1. Slide No. Mega. 32; co-ord. 19.5/51. Pl. 24, fig. 2. Slide No. Mega. 33; co-ord. 13.8/45.

Minerisporites marginatus (Dijkstra) Potonié, 1956

Plate 24, figures 3-7

Triletes marginatus Dijkstra, Mededel. Geol. Sticht., n.s., no. 5, p. 13, pl. 3, fig. 11. 1951 1955 Baldurnisporites marginatus (Dijkstra) Delcourt and Sprumont, Mém. Soc. Géol. Belgique, n.s., vol. 4, p. 43, pl. 4, fig. 5.

1956 Minerisporites marginatus (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 68.

Description: Trilete megaspore; equatorial outline of the central body subtriangular to nearly circular; meridional outline almost circular; thin, finely granular equatorial zona widest at the apices onto which the triradiate lamellae (tecta) on the trilete laesurae extend; equatorial outline of the zona triangular; triradiate lamellae extending up to the outer edge of the zona; exine thin, faintly and irregularly reticulate, with rather narrow lumina and arcuate narrow muri.

Size range: Total equatorial diameter (including zona) 282 (301) 350 microns.

Width of zona at apices about 50 microns.

Width of zona on sides about 20 microns. Width of triradiate lamellae (tecta) about 5 microns. Height of triradiate lamellae about 180 microns. Width of lumina 10 to 20 microns. Width of muri 1.5 microns.

Distribution: Lower Cretaceous. Common in the Ellerslie Member and the upper part of the Grand Rapids Formation. Lower Cretaceous (Wealden) of the Netherlands (Dijkstra, 1951), Belgium (Delcourt and Sprumont, 1955), and South Australia (Cookson and Dettmann, 1958b).

Remarks: Recently, Delcourt et al. (1963, p. 289) have agreed to the removal of the megaspore species *Minerisporites marginatus* from the genus *Baldurnisporites*, which has been restricted to microspores only.

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Locality of figured specimens: Fort Augustus No. 1 well
Pl. 24, figs. 3, 4.
                      Depth 3084 to 3093 feet; Ellerslie Member.
Pl. 24, fig. 6.
                      Depth 3093 to 3102 feet; Ellerslie Member.
    Imperial Willingdon No. 1 well
Pl. 24, figs. 5, 7.
                     Depth 1781 to 1791 feet; Grand Rapids Formation.
Pl. 24, fig. 3.
                      Slide No. Mega. 71;
                                                 co-ord. 10/36.5.
Pl. 24, fig. 4.
                      Slide No. Mega. 71;
                                                 co-ord. 10/37.
Pl. 24, fig. 5.
                      Slide No. Mega. 19;
                                                 co-ord. 7/45.
Pl. 24, fig. 6.
                     Slide No. Mega. 78;
                                                co-ord. 9.8/48.2.
Pl. 24, fig. 7.
                     Slide No. Mega. 18;
                                                co-ord. 7/46.
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MINERISPORITES VENUSTUS n. sp.

Plate 24, figures 8, 9; plate 25, figures 1-6

Description: Trilete megaspore; equatorial outline of the central body always circular; arcuate lamellae closer to the proximal side, not positioned at the equator but in the proximal hemisphere; arcuate lamellae widest at the apices; low triradiate lamellae on the trilete laesurae extending onto the apices and also up to the outer edge of the arcuate lamellae; arcuate lamellae thin; exime thin; surface granular, with some indications of a small-meshed reticulation having very low, convolute and narrow muri; no sign of reticulation on most specimens, possibly due to the destruction of the external ornamentation by abrasion or oxidative maceration; color pale yellow, translucent.

Size range: Total equatorial diameter (including arcuate lamellae) 320 (374.6) 410 microns. Holotype 380 microns. Width of arcuate lamellae at apices 20 (33.3) 50 microns. Width of arcuate lamellae at sides 20 to 60 microns. Width of triradiate lamellae (tecta) about 10 microns. Height of triradiate lamellae about 50 microns. Width of lumina about 20 microns. Width of muri 0.2 microns.

Distribution: Middle Albian. Common locally in the Clearwater and upper Grand Rapids Formations.

Remarks: This species differs from other species of Minerisporites in having the arcuate lamellae in the proximal hemisphere rather than on the equator, a small-meshed reticulum with very low, convolute and narrow muri, which may be absent, a thin and fragile wall, and rounded outline. There is some doubt as to whether a form with arcuate lamellae in the proximal hemisphere rather than an equatorial zona should have been placed in the genus Minerisporites. However, the lamellae are not far removed from the equator and the body is faintly reticulate, hence there appears to be no need to erect a new genus.

The specific name is derived from "venustus" (beautiful, graceful).

Type locality: Fort Augustus No. 1 well Holotype: Pl. 24, fig. 8. Depth 2442 to 2451 feet; Grand Rapids

Formation.

Pl. 24, fig. 9. Depth 2442 to 2451 feet;

Grand Rapids Formation.

Pl. 25, figs. 1, 2. Depth 2442 to 2451 feet:

Grand Rapids

Formation.

Imperial Willingdon No. 1 well

Pl. 25, fig. 3. Depth 1891 to 1901 feet; Grand Rapids Formation. Pl. 25, figs. 4, 5. Depth 2045 to 2055 feet; Clearwater Formation,

shale member.

Pl. 25, fig. 6. Depth 1781 to 1791 feet; Grand Rapids Formation.

Holotype: Pl. 24, fig. 8. Slide No. Mega. 8; co-ord. 12/36.8.

Pl. 24, fig. 9. Slide No. Mega. 17; co-ord. 10.6/44.

Pl. 25, fig. 1. Slide No. Mega. 6; co-ord. 14/35.

Pl. 25, fig. 2. Slide No. Mega. 7; co-ord. 13.2/50.8.

Pl. 25, fig. 3. Slide No. Mega. 42; co-ord. 10/44.8.

Pl. 25, fig. 4. Slide No. Mega. 50; co-ord. 12.5/41.

Pl. 25, fig. 5. Slide No. Mega. 50; co-ord. 11/40.5.

Pl. 25, fig. 6. Slide No. Mega. 21; co-ord. 9/43.

Genus Dijkstraisporites Potonié, 1956

Triletes helios Dijkstra, Mededel. Geol. Sticht., n.s., no. 5, p. 11, pl. 3, fig. 17. Dijkstraisporites helios (Dijkstra) Potonié, Beih. Geol. Jahrb., Heft 23, p. 74, pl. 10, figs. 99, 100 (type species).

Diagnosis: Trilete megaspores; zonate to coronate; equatorial outline of the central body circular to subtriangular, outline of the spore always circular; equatorial zona thin, transparent, membraneous and broad and commonly containing a great number of thin rays; margin of the zona continuous or radially ruptured (coronate); triradiate lamellae-thick, flap-like structures, borne on the trilete mark—extending onto the zona, margin of triradiate lamellae continuous or radially ruptured or bearing free hair-like appendages (capilli); exine reticulate or granulose to verrucose.

Dijkstraisporites helios (Dijkstra) Potonié, 1956

Plate 25, figures 7-10

(Synonymy as for genus)

Description: Trilete coronate megaspore; equatorial outline of the central body and of the equatorial corona circular; equatorial corona transparent, membraneous and broad with a great number of thin rays projecting into it from the central body; these rays anastomosing over 2/3 of their length, their free ends entering the radially ruptured branches of the corona; margin of the corona radially ruptured (coronate), the ripped ends commonly fan-shaped or bilobed; triradiate lamellae (tecta) on the trilete mark thick, flap-like structures extending to the margin of the corona, having a radially ruptured margin as in the case of corona; both proximal and distal faces convex, with a reticulate pattern enclosing lumina of somewhat uniform size.

Size range: Total equatorial diameter (including corona) 450 (540) 615 microns.

Width of corona 128 (152) 192 microns.

Width of triradiate lamellae (teota) about 30 microns.

Width of triradiate lamellae (tecta) about 30 microns. Height of triradiate lamellae (tecta) 50 to 60 microns.

Width of lumina about 19 microns.

Width of muri 2 microns.

Distribution: Upper Barremian to Aptian. Common in the Deville Member, rare in the Ellerslie Member. First described from the upper Barremian-Aptian of England (Dijkstra, 1951).

Locality of figured specimens: Fort Augustus No. 1 well Pl. 25, figs. 7, 8, 10. Depth 3213 to 3222 feet; Deville Member. Pl. 25, fig. 9. Depth 3222 to 3231 feet; Deville Member. Pl. 25, fig. 7. Slide No. Mega. 98; co-ord, 12.2/37. Pl. 25, fig. 8. Slide No. Mega. 101; co-ord. 10.5/35.8. Pl. 25, fig. 9. Slide No. Mega. 107; co-ord, 13/36. Pl. 25, fig. 10. Slide No. Mega. 96; co-ord, 11/38.

DIJKSTRAISPORITES TRIANGULATUS n. sp.

Plate 26, figure 1

Description: Trilete coronate megaspore; equatorial outline of the central body triangular with convex sides, and the equatorial corona surrounding it, giving the spore a more or less circular outline; corona translucent, membraneous, thinning out towards the margin, not very wide

compared to the size of the body; large number of 10-micron thick rays projecting into the corona from the central body, the rays running over 2/3 of their length separately embedded in the continuous membraneous corona, but at their extremities entering the radially ruptured lobes of corona; triradiate lamellae on the trilete mark—thick, high and flap-like structures—extending to the margin of the corona, with a radially ruptured margin as in the case of corona; both the proximal and distal surfaces of the central body convex, with coarsely reticulate pattern enclosing lumina of variable size.

Size range: Total equatorial diameter (including corona) about 737 microns. Holotype 737.2 microns.

Width of corona about 141 microns.

Width of triradiate lamellae about 50 microns.

Height of triradiate lamellae about 192 microns.

Width of lumina 20 to 45 microns.

Width of muri 4 microns.

Distribution: Middle Albian. Very rare. A single specimen was recorded from the Wabiskaw Member.

Remarks: This species is distinguished from *D. helios* by its larger size, triangular central body, and more narrow corona with thick separate rays supporting it. The triradiate lamellae are much higher and the reticulate pattern on the central body is coarser in *D. triangulatus* n. sp. than in *D. helios* (Dijkstra) Potonié, 1956.

Type locality: Fort Augustus No. 1 well Holotype: Pl. 26, fig. 1. Depth 2923 to 2932 feet; Wabiskaw Member. Holotype: Pl. 26, fig. 1. Slide No. Mega. 56; co-ord. 10.5/39.

Genus Arcellites Miner, 1935, emend. Ellis and Tschudy, 1964

1935 Arcellites disciformis Miner, Am. Midland Naturalist, vol. 16, p. 600, pl. 20, figs. 61, 64-66 (type species).

1950 Arcellites crillensis Schemel, Am. J. Botany, vol. 37, p. 751-753, figs. 16-19.

1955 Pyrobolospora Hughes, Geol. Mag., vol. 92, p. 204. 1963 Arcellites cf. A. hexapartitus (Dijkstra) Potter, Oklahoma Geology Notes, vol. 23, p. 230, pl. 1, figs. 1-7.

1964 Arcellites disciformis Miner, emend. Ellis and Tschudy, Micropaleont., vol. 10, p. 75, pl. 1, figs. 1-12, text-fig. 1.

Diagnosis: Trilete spores in the megaspore size-range (150 microns and larger); spore body spherical (and not axially elongated) with a prominent neck composed of (usually) six segments; body of the spore covered uniformly by sculptine detail, varying in different species from small granules to appendages 300 microns long; endexine much thinner and darker colored than ektexine; small triradiate tetrad scar present apically beneath the neck, visible only by dissection.

Remarks: Miner (1935a) described Arcellites disciformis from the Upper Cretaceous coal measures of Greenland. As the neck segments on

his specimens were not preserved, he misunderstood the morphology and described his specimens as: "Body small, circular, with a few to several short tube-like appendages, surface pitted, pits minute". The "tube-like appendages" led him to think that the specimens were possibly fresh-water rhizopods.

Schemel (1950) described Arcellites crillensis from the Dakota Formation of Iowa. Although his specimens were not very well preserved, the neck segments were present. Schemel found A. crillensis to be identical with A. disciformis in ornamentation and tube-like appendages, but different in possessing three "wing-like extensions" (neck segments). He observed, however, that "Miner's illustrated specimens appear to be broken in such a manner that it is possible that they possessed the wing-like extensions also". The holotype of A. crillensis is not well preserved, which accounts for the fact that only three wing-like segments, instead of six, and a very small number of tube-like appendages were reported. Hall (1963) described well-preserved specimens with six neck segments and a large number of evenly spaced body appendages from the same level as A. crillensis and designated them as A. disciformis.

Hughes (1955), obviously unaware of these earlier descriptions based on incompletely preserved specimens, described well-preserved specimens from the Wealden of England as the new genus *Pyrobolospora*. Hughes (pers. comm.) agrees that the genus *Arcellites* has priority, but at the same time feels that, because the genus *Pyrobolospora* is based on *P. vectis* which has coarsely reticulate ridges on its body, the genus *Pyrobolospora* should be restricted to the forms with murornate ornamentation. In the opinion of the writer, murornate ornamentation is of specific value only, and it would not serve any useful purpose to subdivide further this distinctive group of megaspores with a spherical body and a neck composed of six segments.

Ellis and Tschudy (1964) have recently revised the genus Arcellites and designated Arcellites disciformis Miner, 1935, as the type species. They have synonymized A. crillensis Schemel, 1950, with A. disciformis and the genus Pyrobolospora Hughes, 1955, with the genus Arcellites Miner, 1935, rejecting Pyrobolospora as a later synonym.

Affinity: The occurrence of the various species of the genus Arcellites in the deposits of lacustrine, fluvial, or paralic origin, the general morphological pattern of a terminal trilete mark under the neck appendages, and the numerous hollow appendages or bladders which add buoyancy to the spore body, suggest an aquatic habit. The genus has a possible affinity with the water ferns of the orders Salviniales or Marsileales.

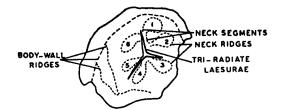


FIGURE 12. Arcellites vectis (Hughes)
Potter. Transverse section at
the spore-apex (after Hughes,
1955) showing the 6 neck
ridges and the 6 leaf-like
neck segments.

ARCELLITES RUGOSUS n. sp.

Plate 26, figures 2-4

Description: Trilete megaspores; spore body approximately spherical, with a neck nearly always longer than the spore-body diameter and composed of six leaf-like segments fused by their margins into six ridges extending upwards, the centre part of each segment being folded inwards; trilete mark probably present apically beneath the neck; thickness of the leaf-like segments decreasing from the base upwards; spore body smooth, covered with broad and high, irregularly arranged ridges with indications of a reticulate arrangement; ridge pattern controlled by a pattern of thickening in the wall; development of the ridges incipient, only faintly indicated, or well marked as on the holotype.

Size range: Total length (including neck) 570 (625) 670 microns. Holotype 670 microns.

Diameter of body 270 (295) 310 microns. Holotype 310 microns.

Length of neck 300 (330) 370 microns. Holotype 370 microns.

Width of ridges on body about 30 microns. Height of ridges on body 20 to 40 microns.

Distribution: Barremian? to Aptian. Rare. Makes its first appearance in the Deville Member, ranging into the Ellerslie Member.

Remarks: Arcellites rugosus can be distinguished from Arcellites nudus (Cookson and Dettmann) Potter by the absence of granular and pitted layers of ektexine. The presence of ridges on the spore body effects a resemblance to Arcellites vectis (Hughes) Potter, but no appendages were seen attached to the ridges on the body, nor any sign of scars left by detached appendages on any of the specimens. A. rugosus is, on the average, 207 microns longer than A. vectis. The neck in A. vectis is always shorter than the diameter of the body, whereas in A. rugosus n. sp. it is always longer than the diameter of the body.

The specific name is derived from "rugosus" (wrinkled, shriveled) and refers to the ridges on the body.

Type locality: Imperial Namao No. 1 well

Holotype: Pl. 26, figs. 2, 4. Depth 3632 to 3642 feet; Ellerslie Member.

Fort Augustus No. 1 well

Pl. 26, fig. 3. Depth 3249 to 3257 feet; Deville Member.

Holotype: Pl. 26, figs. 2, 4. Slide No. Mega. 122; co-ord. 10.2/40.1. Pl. 26, fig. 3. Slide No. Mega. 111; co-ord. 11.8/37.2.

ARCELLITES RETICULATUS (Cookson and Dettmann) Potter, 1963

Plate 26, figures 5-7

1958 Pyrobolospora reticulata Cookson and Dettmann, Micropaleont., vol. 4, p. 40-41, pl. 1, figs. 2-6.

1963 Arcellites reticulatus (Cookson and Dettmann) Potter, Oklahoma Geology Notes, vol. 23, p. 230.

Description: Trilete megaspore; spore body nearly spherical with a reticulate surface; neck usually shorter than the diameter of the spore body, and composed of six leaf-like neck segments, adherent along their margins or free along their entire length; each neck segment folded inwards, and supported by a median rib arising from the ektexine and running forward to taper off behind the apex; outer margin of segments finely and transversely plicate; trilete mark situated apically beneath the neck; spore coat about 15 microns thick, composed of three layers; innermost layer a brown homogeneous endexine, middle layer a dark brown inner ektexine, and the outermost layer a translucent light yellow-brown outer ektexine; reticulate surface developed mainly from the ektexine; lumina polygonal or hexagonal in outline; reticulum wide, the outer ektexine forming short funnel-shaped appendages at the angles of the reticulum, appendages very thin-walled distally and therefore seldom found in a fully expanded condition.

Size range: Total length (including neck) 577 (618.5) 718 microns. Diameter of body 320.5 (342.8) 384.5 microns. Length of neck 256 (275.4) 333.3 microns. Width of reticulum 20 to 35 microns. Width of muri 8 to 10 microns.

Distribution: Albian. Present in the upper part of the Grand Rapids Formation. First described from the Lower Cretaceous (Albian) of South Australia (Cookson and Dettmann, 1958b).

Remarks: Arcellites reticulatus can be distinguished from other species of Arcellites by the clearly defined surface reticulum. The Canadian specimens appear to have a thicker wall than the Australian specimens.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 26, figs. 5-7. Depth 2442 to 2451 feet; Grand Rapids Formation.

Pl. 26, fig. 5. Slide No. Mega. 16; co-ord. 12/51.8.

Pl. 26, figs. 6, 7. Slide No. Mega. 12; co-ord. 11.8/39.5.

ARCELLITES INCIPIENS n. sp.

Plate 27, figures 1, 2

Description: Trilete megaspore; spore body nearly sperical with a reticulate surface; neck about ½ the diameter of the spore body and probably composed of six neck segments folded inwards with a tetrad scar between them; spore coat very thin and fragile; spore body almost transparent; ektexine ornamented by a reticulate pattern; lumina polygonal or pentagonal in outline; reticulum very wide, ektexine forming elongated conical to rounded closed processes at the angles of the reticulum.

Size range: Total length (including neck) 385 to 449 microns. Holotype 385 microns.

Maximum diameter of body 269 to 350 microns. Holotype 350 microns.

Length of neck 128 to 179 microns. Holotype 128 microns.

Width of reticulum 40 to 50 microns.

Width of muri 7 to 10 microns.

Length of appendages 30 to 40 microns.

Distribution: Aptian. Rare. Two specimens were recorded from the Ellerslie Member.

Remarks: This species can be distinguished from Arcellites reticulatus (Cookson and Dettmann) Potter by its much smaller neck relative to the body, over-all smaller size, wider reticulum, thinner spore coat, and elongated conical to rounded closed processes at the junctions of the muri (instead of short funnel-shaped appendages).

Owing to the small number of specimens, none was dissected to determine the number of neck segments or the presence of a tetrad scar.

The specific name is derived from "incipiens" (beginning).

Type locality: Fort Augustus No. 1 well

Holotype: Pl. 27, figs. 1, 2. Depth 3001 to 3010 feet; Ellerslie Member.

Holotype: Pl. 27, figs. 1, 2. Slide No. Mega. 62; co-ord. 9/35.

ARCELLITES NUDUS (Cookson and Dettmann) Potter, 1963

Plate 27, figures 3-8

1958 Pyrobolospora nuda Cookson and Dettmann, Micropaleont., vol. 4, p. 41-42, text-figs. 2a-d.

figs. 2a-d.

1963 Arcellites nuda (Cookson and Dettmann) Potter, Oklahoma Geology Notes, vol. 23, p. 230.

Description: Trilete megaspore; spore body nearly spherical and without appendages; neck nearly as long or slightly longer than the diameter of the spore body, composed of six leaf-like neck segments, probably enclosing a trilete mark and fused by their margins into six ridges running upwards; outer margins of the segments plicate; spore coat composed of four layers, yellow-brown in color and from 15 to 20 microns thick; innermost layer consisting of a homogeneous endexine with a thin inner and a thicker outer endexine; outer layers composed of a double-layered ektexine, inner layer granular and outer layer coarsely pitted.

Size range: Total length (including neck) 448.5 (517) 641 microns. Diameter of body 270 to 372 microns. Length of neck 270 to 320 microns.

Distribution: Albian. Rare. A few specimens were found in the uppermost beds of the Grand Rapids Formation. First described from the Lower Cretaceous (Albian) of South Australia (Cookson and Dettmann, 1958b).

Remarks: Of the nine species of Arcellites that have so far been described from the Lower Cretaceous, A. nudus is the only one in which the exine is devoid of appendages and is pitted. The Canadian specimens appear to have slightly shorter necks than the Australian specimens and a more coarsely pitted outer ektexine.

Locality of figured specimens: Fort Augustus No. 1 well
Pl. 27, figs. 3, 5, 6, 8. Depth 2478 to 2487 feet; Grand Rapids
Formation.
Pl. 27, figs. 4, 7. Depth 2442 to 2451 feet; Grand Rapids
Formation.
Pl. 27, figs. 3, 5, 6, 8. Slide No. Mega. 34; co-ord. 13/42.
Pl. 27, figs. 4, 7. Slide No. Mega. 10; co-ord. 11.5/37.5.

ARCELLITES DISCIFORMIS Miner, emend. Ellis and Tschudy, 1964
Plate 28, figures 1-5

(Synonymy as for genus)

Description: Trilete megaspore; spore body approximately spherical, with a neck nearly always longer than the diameter of the spore body and composed of six leaf-like segments fused by their margins into six ridges running upwards; centre part of each segment folded inwards, neck segments usually twisted anti-clockwise; thickness of the leaf-like neck segments decreasing from the base upwards; spore body showing minutely pitted surface and bearing about fifty translucent cylindrical and hollow appendages; complete appendage bearing a thin translucent disc on the end—possibly a collapsed spherical bladder; spore coat composed of three layers: a thick, light-colored, finely pitted outer ektexine with slight radial thickening, a thin, light-colored, finely granular inner ektexine adhering to the en-

dexine—these two layers of ektexine forming the neck and appendages—an innermost third layer composed of a thin dark-colored endexine.

Size range: Total length (including neck and appendages) 487 (545) 679.5 microns.

Equatorial diameter of body 243.5 (256.5) 269 microns.

Length of neck 224 (271) 346 microns.

Length of appendages 64.1 (73.7) 102.5 microns.

Width of appendages 20 to 30 microns.

Diameter of the terminal disc on appendages 40 to 70 microns.

Distribution: Upper Barremian to Cenomanian. Abundant locally in the Ellerslie Member, rare in the Deville Member and Grand Rapids Formation. Reported from the Upper Cretaceous of Greenland (Miner, 1935a), the Dakota Group (Cenomanian) of Iowa (Schemel, 1950; Hall, 1963), Albian of the western interior United States, and Patuxent Formation of Virginia (Ellis and Tschudy, 1964). "Pyrobolospora" hexapartita, with which A. disciformis may be conspecific, makes its first appearance in the upper Barremian of the English Wealden (Hughes, 1955).

Remarks: Arcellites disciformis Miner, emend. Ellis and Tschudy differs from "Pyrobolospora" hexapartita (Dijkstra) Hughes, in having an outer finely pitted and an inner granular layer of ektexine, visible under high magnification. "P". hexapartita, as described by Hughes (1955), has a smooth spore body on which the outer ektexine layer has radial thickenings. Cookson and Dettmann (1958b), who reported the same species from Australia, describe the surface of the spore body, neck segments, and appendages as finely granular. Hall (1963) describes the outer ektexine layer on A. disciformis as foveolate. He describes the effect of these foveae in a section of the wall as: "The foveae are all about the same radial extent, and seem to create a palisade-like outer layer". Perhaps this "palisade-like" outer layer has been described by Hughes as radial thickenings on the outer ektexine layer. Thus, if there is any difference between A. disciformis and "P". hexapartita, it is in the structure of the ektexine. The ektexine of the specimens so far assigned to "P". hexapartita should be re-examined under high power to determine whether this difference really exists.¹

The Canadian specimens are larger than "P". hexapartita, but the neck is not as long relative to the diameter of the spore body, and in some cases the neck is of the same length or even slightly shorter than the diameter of the spore body. In "P". hexapartita the neck is always much longer than the spore-body diameter.

¹Ellis and Tschudy (1964), after examining some specimens of "P". hexapartita from the Isle of Wight (Wealden), report that the surface of the body is not pitted.

Locality of figured specimens: Fort Augustus No. 1 well

Pl. 28, figs. 1, 3, 4, 5.	Depth 3111 to 3120 feet;	Ellerslie Member.
Pl. 28, fig. 2.	Depth 3019 to 3028 feet;	Ellerslie Member.
Pl. 28, figs. 1, 4, 5.	Slide No. Mega. 85;	co-ord. 10/36.
Pl. 28, fig. 2.	Slide No. Mega. 65;	co-ord. 11/39.5.
Pl. 28, fig. 3.	Slide No. Mega. 85;	co-ord. 10/42.

Genus Dictyothylakos Horst, 1954

1954 Dictyothylakos pesslerae Horst, Geologie (Berlin), vol. 3, p. 610-613.

DICTYOTHYLAKOS sp.

Plate 29, figures 1-3

Description: Mesh-like perispore covering the megaspore *Thylako-sporites retiarius* (Hughes, 1955) Potonié, 1956, forming different layers of different mesh-sizes; width of the mesh strands ranging between 15 to 35 microns, strands commonly thick enough to be circular in cross section; mesh usually angular, with variable diameter seldom exceeding 200 microns along its maximum width.

Distribution: Barremian? to middle Albian. Rare throughout the Mannville Group.

Remarks: All mesh-like perispores cannot be included in this species: those specimens with distinctly larger mesh-diameter and which do not show the characteristic layers at different levels interwoven with each other do not belong to this species.

Locality of figured specimens: Imperial Willingdon No. 1 well

Pl. 29, figs. 1, 3. Depth 1791 to 1801 feet; Grand Rapids Formation. Fort Augustus No. 1 well

Pl. 29, fig. 2. Depth 3222 to 3231 feet; Deville Member.

Pl. 29, figs. 1, 3. Slide No. Mega. 22; co-ord. 13/37. Pl. 29, fig. 2. Slide No. Mega. 105; co-ord. 11/36.5.

CAYTONIA seed

Plate 29, figure 4

Description: Seed consisting of a rather thickly cutinized nucellus enclosed in a thinly cutinized integument; orthotropous in nature; nucellus composed of rows of elongated cells, cells becoming convoluted towards the base; integument membraneous with indistinct cell structure.

Size range: Length 705 microns; breadth 435 microns.

Locality of figured specimen: Imperial Willingdon No. 1 well

Pl. 29, fig. 4.

Depth 1846 to 1856 feet; Grand Rapids Formation.

Pl. 29, fig. 4.

Slide No. Mega. 38;

co-ord. 11/42.

Nucellus cuticle of CAYTONIA seed?

Plate 29, figures 5, 6

Description: Surface showing transverse wrinkles continuous around the body; longitudinal wrinkles present laterally; body multicellular and hollow.

Size range: Length 1100 microns; breadth 700 microns.

Locality of figured specimen: Fort Augustus No. 1 well

Pl. 29, figs. 5, 6. Depth 2992 to 3001 feet; Ellerslie Member.

Pl. 29, figs. 5, 6. Slide No. Mega. 59; co-ord. 11.2/67.

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APPENDIX. GLOSSARY OF DESCRIPTIVE TERMS

Acolpate: Pollen without colpi, i.e. equatorial longitudinal furrows or apertures.

Alete: Spores without laesurae, i.e. proximal triradiate or single longitudinal apertures.

Alveolate: Pitted with small cavities.

Apical archeopyle: An opening in fossil dinoflagellates formed by the loss of the entire series of apical plates. Often indicated by a rupture along the line between the apical and precingular series of plates.

Apiculae: Small conical protuberances.

Arcuate lamellae: Membraneous lamellae which run parallel to the equator in an arc joining the outer extremity of the trilete mark.

Arcuate ridges (=curvaturae): Ridges which run parallel to the equator in an arc joining the outer extremity of the trilete mark. Outer limits of the contact faces are usually marked by these ridges.

Auricle: Process shaped like the lower lobe of the ear.

Baculae: Rod-like projections with or without modified tips.

Baculate: Ornamented with baculae.

Bisaccate: Pollen grains with two ektexinous protuberances or bladders on either side of the central body.

Bladders (=sacci or vesicles): Ektexinous protuberances that stand apart from the central body, e.g. gymnospermous pollen grains.

Bosses: Small knob-like protuberances.

Capilli: Free hair-like appendages.

Canaliculate: Ornamented with parallel or concentric narrow grooves.

Central body: Central portion of a cingulate or zonate spore, or saccate pollen.

Cicatricose: Ornamented with arcuate or straight parallel ridges and grooves. Ridges may often branch.

Cingulum: A thickened equatorial rim attached to a central body, the point of attachment being quite narrow, and the rim and central body being in the same equatorial plane.

Cingulate: A spore with a cingulum.

Clavate: Rod-shaped processes with expanded tips.

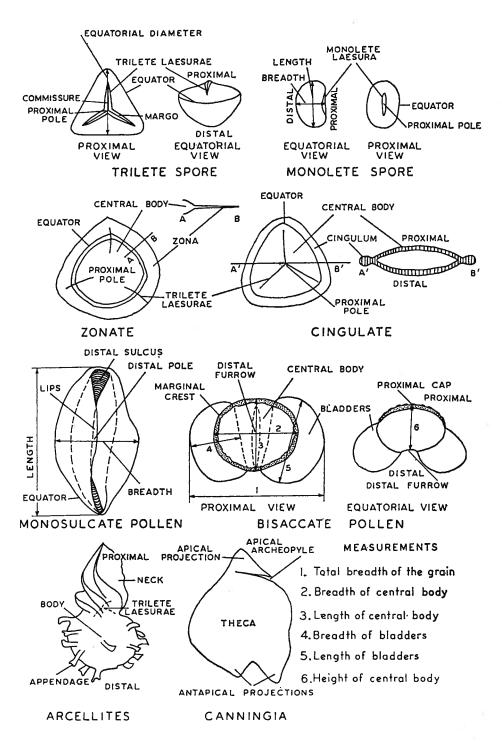


FIGURE 13. Schematic drawings illustrating the morphology of spore and pollen grains.

Colpi: Longitudinal apertures or furrows on the equator of a pollen grain. Germinal furrows serving as a place of emission of the pollen tube among the angiosperms.

Commissure: The line of dehiscence on trilete or monolete rays of spores. It refers only to the trace of the slit and excludes lips, margo, or contact areas.

Coni: Small cone-shaped protuberances.

Contact faces: Following the simultaneous divisions of the nucleus of the spore mother cell, spores are in contact with each other along the contact faces. Each spore has three contact faces. The contact faces meet at the proximal pole of the spore. They are laterally separated by the trilete mark and distally limited by curved lines or ridges called arcuate ridges or curvaturae.

Coronate: A radially ruptured zona margin resembling a corona.

Distal: That part of the pollen grain or spore which faces outwards in the tetrad.

Distal face or surface: All area in the distal hemisphere.

Distal pole: Centre of the distal surface.

Distal sulcus or furrow (=leptoma or tenuitas): Longitudinal furrow on the distal surface of a pollen grain. It is a germinal furrow serving as a place of emission of the pollen tube among gymnosperms and some monocotyledons. It is not a real aperture, but only a thin aperturoid area functioning as a germination area, gradually merging into the surrounding exine.

Echinate: Ornamentation consisting of long spines with pointed tips and broadened base.

Ektexine (=exoexine or sexine): The outer layer of exine.

Endexine (=intexine or nexine): The inner layer of exine.

Equator: A line separating the distal from the proximal hemisphere in spores and pollen.

Equatorial outline: Outline as seen in polar view.

Exine: The main outer resistant layer of sporoderm.

Fimbriae: Hair-like processes.

Foveolate: With pits up to 2 microns in diameter, or, if larger, too widely separated to form a reticulum.

Foveo-reticulate: With pits large enough and close enough to form a reticulum, but with wide intervening walls.

Germinal furrow: See distal sulcus or furrow.

Granulate: Ornamented with circular projections, the height of which is less than their basal diameter; usually less than 1/20 the size of the spore. The terms infra- or sub-granulate are used for comparatively smaller-sized granules.

Interradial (=interapical): The area between the adjacent commissures and the side of a trilete spore.

Kyrtome (=torus): An abruptly convex exine area surrounding the laesurae, which is reduced to three arcuate folds in the proximal interradial regions on compressed spores.

Laesurae: Triradiate (trilete) or single (monolete) tetrad scar. It also includes the commissures, lips, margo, etc. where present.

Laevigate (=psilate): Smooth.

Lumen: Space between the muri of a reticulum.

Marginal crest: Thickened edge of the proximal cap on the central body of coniferous pollen.

Margo: A distinct area surrounding the commissures or apertures, distinguished by the differences in the thickness of endexine or ektexine, or by the absence or reduction of exine sculpture in that area.

Monolete: Spores having a proximal single slit-like laesura.

Monoporate: Having a single germ-pore in the exine.

Monosulcate: Pollen having a single longitudinal distal sulcus or furrow, e.g. cycads.

Muri: Ridges separating the lumina of a reticulum.

Neck segments: Leaf-like segments surrounding the trilete mark and constituting a neck-like projection on the proximal side, e.g. Arcellites, Balmisporites, etc.

Patella: Thickened ektexine layer confined to the equatorial and distal surfaces of the spore body.

Perine (=perispore): The outermost layer, outside the exine, in certain spores.

Pole: The centre of either the distal or proximal surface.

Proximal: Part of the spore facing toward the centre of the tetrad.

Proximal pole: Centre of the proximal surface.

Proximal face or surface: All area in the proximal hemisphere.

Proximal cap: The proximal part of the central body of a coniferous pollen which has thicker exine than the distal part.

Punctate: Omamentation composed of very minute granules.

Raised lips (=labra): Raised exinal margins of trilete or monolete commissures.

Reticulate: Ornamentation consisting of a network of ridges (muri) surrounding regular or irregular depressions (lumina).

Ribs (=ridges): Elongate, more or less parallel-sided, raised ektexinous areas separated by furrows. These include both hollow inflated structures (taeniae) and solid bands (lirae).

Rugulae: Long, narrow, raised wrinkles irregularly distributed on the spore surface.

Rugulate: Ornamented with rugulae.

Scabrate: Flecked by minute pits or elevations less than 1 micron in size.

Sulcus: See distal sulcus or furrow.

Sculptine: That part of the ektexine concerned with ornamentation or appendages; refers to the sculptured ektexine.

Trilete: Refers to the triradiate laesurae which mark a germinal area on the proximal side of spores among the ferns.

Triradiate lamellae (=tecta): Raised membraneous lamellae on the trilete mark.

Triradiate ridges: Raised ridges on which the trilete laesurae are present.

Velum: Membraneous covering.

Verrucose: Ornamented with slightly irregular, flat wart-like protuberances. Coarser than granulate texture.

Zona: A hyaline, thin flange, formed by the extension and fusion of the proximal and distal ektexine around the equator of the spore.

Zonate: A spore with zona.

All specimens are illustrated at a magnification of X500 unless otherwise stated IN=Imperial Namao No. 1 well FA=Fort Augustus No. 1 well IW=Imperial Willingdon No. 1 well	
Figure 1: Sphagnumsporites antiquasporites (Wilson and Webster) Pococl proximal view, 20.4 microns, IW1781-1791 (Grand Rapids Formation); known range: Upper Jurassic to Tertiary (p. 38	
Figure 2: Sphagnumsporites psilatus (Ross) Couper; proximal view, 33 microns, IW1921-1931 (Grand Rapids Formation); known range: Jurassic to Cretaceous	})
Figures 3, 4: Lycopodiumsporites austroclavatidites (Cookson) Pocock; 3— proximal view, 35 microns, IW1781-1791 (Grand Rapids Formation); 4— distal view, 36 microns, IW1791-1801 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous (p. 39)	€)
Figures 5, 6: Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont; 5— proximal view, 50 microns, FA2442-2451 (Grand Rapids Formation); 6—distal view, 46 microns, IW1921-1931 (Grand Rapids Formation); known range: Jurassic to Cretaceous (p. 40)))
Figures 7-10: Lycopodiumsporites marginatus n. sp.; 7—proximal view, 51 microns, FA3028-3037 (Ellerslie Member); 8—(holotype) proximal view, 60 microns, FA3084-3093 (Ellerslie Member); 9—(holotype) X1024 proximal view; 10—(holotype) X1024 distal view; known range: Aptian to middle Albian (p. 41)	L)
Figure 11: Lycopodiumsporites sp. A; distal view, 48 microns, IW1781-1791 (Grand Rapids Formation); known range: Aptian to middle Albian (p. 41	.)
Figures 12-15: Lycospora sp.; 12—mid-focus, 30 microns, FA2923-2932 (Wabiskaw Member); 13—same specimen X1024 proximal view; 14—same specimen X1024 mid-focus; 15—same specimen X1024 distal view; known range: middle Albian	2)
Figure 16: Lycospora cretacea Pocock; proximal view, 59 microns, IW1781-1791 (Grand Rapids Formation); known range: Aptian to middle Albian (p. 42	(د
Figures 17, 18: Acanthotriletes varispinosus Pocock; 17—proximal view, 32 microns (excluding spines), IW1816-1826 (Grand Rapids Formation); 18—distal view, 33 microns (excluding spines), IN3850-3860 (Ellerslie Member); known range: Lower Cretaceous	;)
Figure 19: Acanthotriletes levidensis Balme; proximal view, 38 microns, IN3768-3778 (Ellerslie Member); known range: Lower Cretaceous	.)
Figure 20: Osmundacidites wellmanii Couper; proximal view, 40 microns, IW1826-1836 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous	(
Figure 21: Rugulatisporites sp.; proximal view, 40 microns, FA3075-3084 (Ellerslie Member); known range: Aptian (p. 45	5)
Figure 22: Todisporites minor Couper; proximal view, 40 microns, FA2607-2616 (Grand Rapids Formation); known range: Middle Jurassic to Lower Cretaceous	()

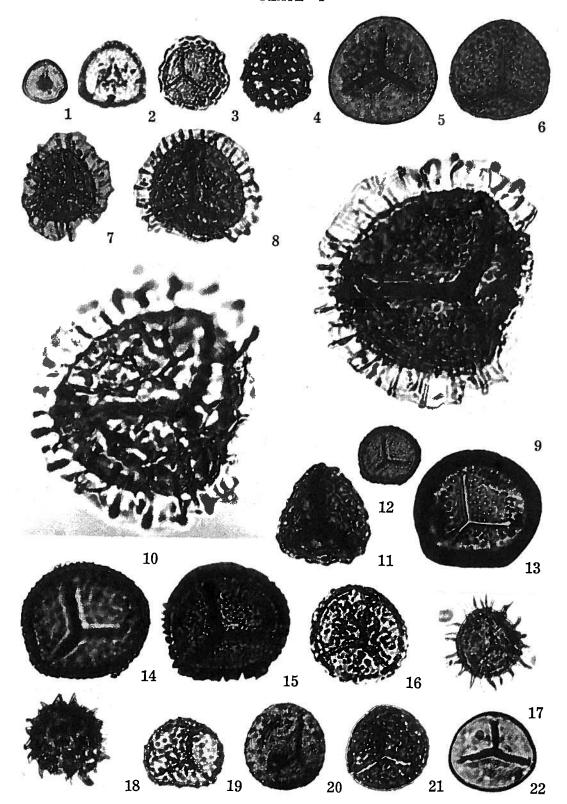
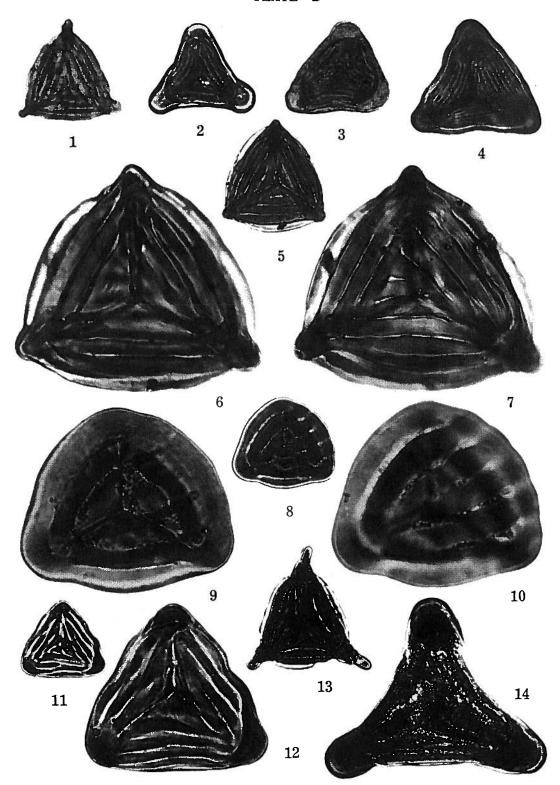


PLATE 2



Explanation of Plate 2

That is
All specimens are illustrated at a magnification of X500 unless otherwise stated
Figure 1: Appendicisporites tricornitatus Weyland and Greifeld; distal view, 47 microns, IN3706-3716 (Ellerslie Member); known range: Cretaceous (p. 46
Figures 2, 3: Appendicisporites crickmayii Pocock; 2—proximal view, 43 microns, IN3850-3860 (Ellerslie Member); 3—distal view, 47 microns, IN3850-3860 (Ellerslie Member); known range: Aptian to middle Albian (p. 47)
Figure 4: Appendicisporites jansonii Pocock; proximal view, 56 microns, FA3213-3222 (Deville Member); known range: Barremian? to middle Albian (p. 47)
Figures 5-7: Appendicisporites erdtmanii Pocock; 5—proximal view, 53 microns, IW1781-1791 (Grand Rapids Formation); 6—same specimen X1024 proximal view; 7—same specimen X1024 distal view; known range: Barremian? to middle Albian
Figures 8-10: Appendicisporites cooksonii (Balme) Pocock; 8—distal view, 48 microns, FA3213-3222 (Deville Member); 9—same specimen X1024 proximal view; 10—same specimen X1024 distal view; known range: Callovian to Albian
Figures 11, 12: Appendicisporites crimensis (Bolkhovitina) Pocock; 11—mid- focus, 39 microns, IW1816-1826 (Grand Rapids Formation); 12—same specimen X1024 proximal view; known range: Hauterivian to Albian (p. 49)
Figure 13: Appendicisporites sp. cf. A. pschekhaensis (Bolkhovitina) Pocock; midfocus, 59 microns, IW1781-1791 (Grand Rapids Formation); known range: Neocomian to middle Albian (p. 50)
Figure 14: Appendicisporites sp.; mid-focus, 84 microns, FA3213-3222 (Deville Member); known range: Barremian? (p. 51)

All	specimens	are	illustrated	at	a	magnification	of	X500	unless	otherwise	stated
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Figures	1-6: Appendicisporites trichacanthus (Maljavkima) var. dissectus (Mar-
	kova) n. comb.; 1—proximal view, 97 microns, FA2932-2938 (Wabiskaw
	Member); 2—same specimen, distal view; 3—same specimen X1024 distal
	rib pattern; 4-6—same specimen X1024 ornamentation on ribs; known
	range: Albian to Cenomanian (p. 51)

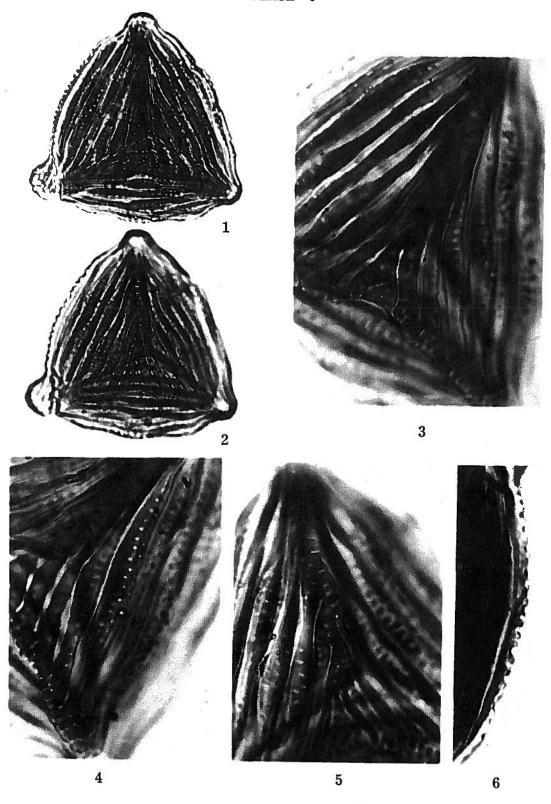
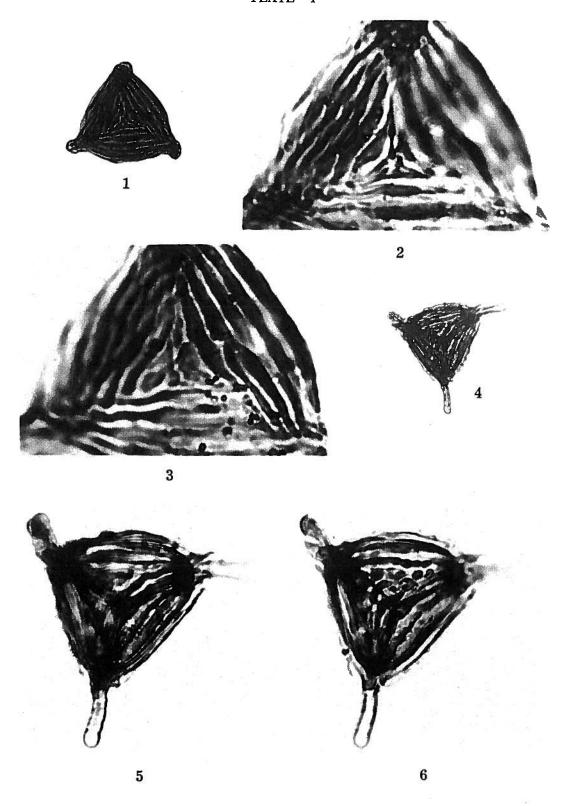
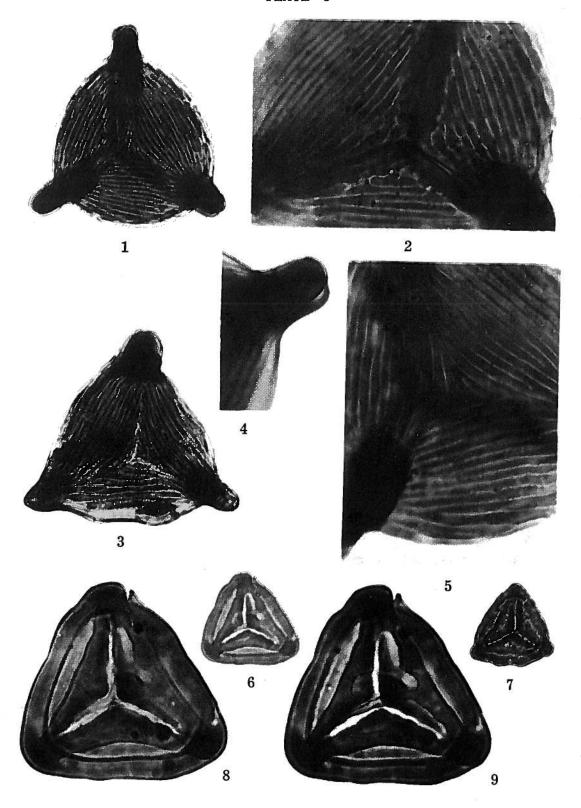


PLATE 4

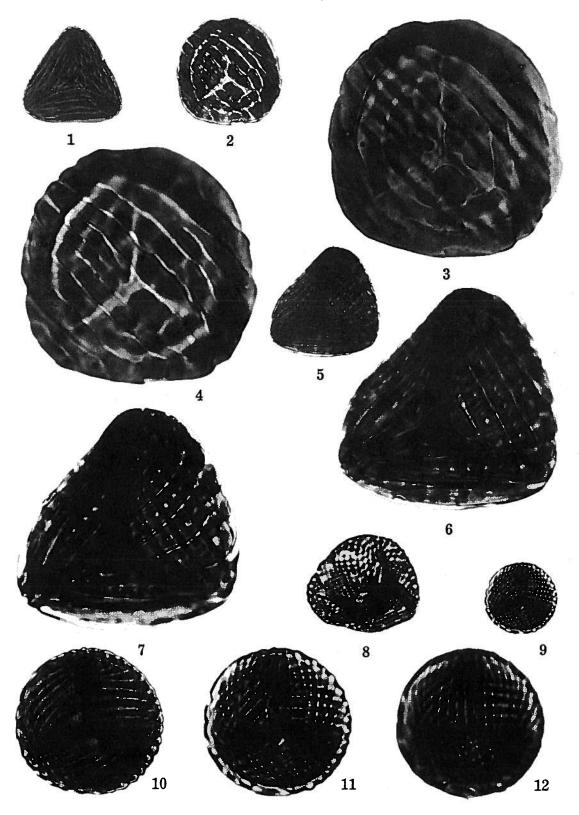


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All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1-3: Appendicisporites sp. cf. Anemia trichacantha (Maljavkina) Markova; 1—mid-focus, 50 microns, FA2905-2914 (Wabiskaw Member); 2—same specimen X1575 proximal view; 3—same specimen X1575 distal rib pattern; known range: Aptian to Cenomanian
Figures 4-6: Appendicisporites unicus (Markova) n. comb.; 4—mid-focus, 38 microns (excluding appendices), FA2607-2616 (Grand Rapids Formation); 5—same specimen X1024 proximal view; 6—same specimen X1024 distal view; known range: Albian to Cenomanian

All spec	imens are illustrated at a magnification of X500 unless otherwise stated
Figures	1-5: Appendicisporites bifurcatus n. sp.; 1—(holotype) mid-focus, 94 microns, FA2842-2851 (Clearwater Formation, shale member); 2— (holotype) X1024 proximal rib pattern; 3—mid-focus, 93 microns, IW1911-1921 (Grand Rapids Formation); 4—(holotype) X1024 bifurcation of appendices; 5—(holotype) X1024 distal rib pattern; known range: middle Albian
Figures	6-9: Appendicisporites perplexus n. sp.; 6—(holotype) distal view, 44.2 microns, FA2496-2505 (Grand Rapids Formation); 7—proximal view, 39 microns, FA2842-2851 (Clearwater Formation, shale member); 8—(holotype) X1024 proximal view; 9—(holotype) X1024 distal view; known range: middle Albian







All specimens are illustrated at a magnification of X500 unless otherwise stated
Figure 1: Cicatricosisporites dorogensis Potonié and Gelletich; distal view, 45 microns, IW2095-2098 (Wabiskaw Member); known range: Purbeck to Tertiary
Figures 2-4: Cicatricosisporites dorsostriatus (Bolkhovitina) n. comb.; 2—distal view, 52 microns, FA2689-2699 (Clearwater Formation, shale member); 3—same specimen X1024 proximal view; 4—same specimen X1024 distal view; known range: Middle Jurassic to Albian (p. 57)
Figures 5-7: Cicatricosisporites perforatus (Baranov, Nemkova and Kondratiev) n. comb.; 5—distal view, 54 microns, IN3860-3870 (Ellerslie Member); 6—same specimen X1024 proximal view; 7—same specimen X1024 distal view; known range: Aptian to Turonian (p. 58)
Figure 8: Cicatricosisporites mediostriatus (Bolkhovitina) Pocock; mid-focus, 50 microns, IN3686-3696 (Ellerslie Member); known range: Hauterivian to Turonian
Figures 9-12: Cicatricosisporites orbiculatus n. sp.; 9—(holotype) mid-focus, 34 microns, IN3860-3870 (Ellerslie Member); 10—(holotype) X1024 proximal view; 11—(holotype) X1024 mid-focus; 12—(holotype) X1024 distal view; known range: Aptian

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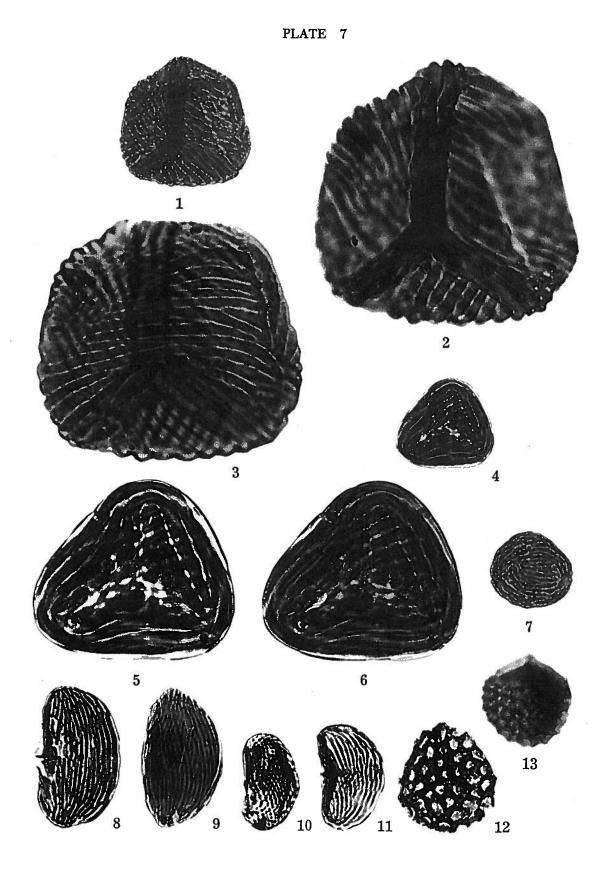
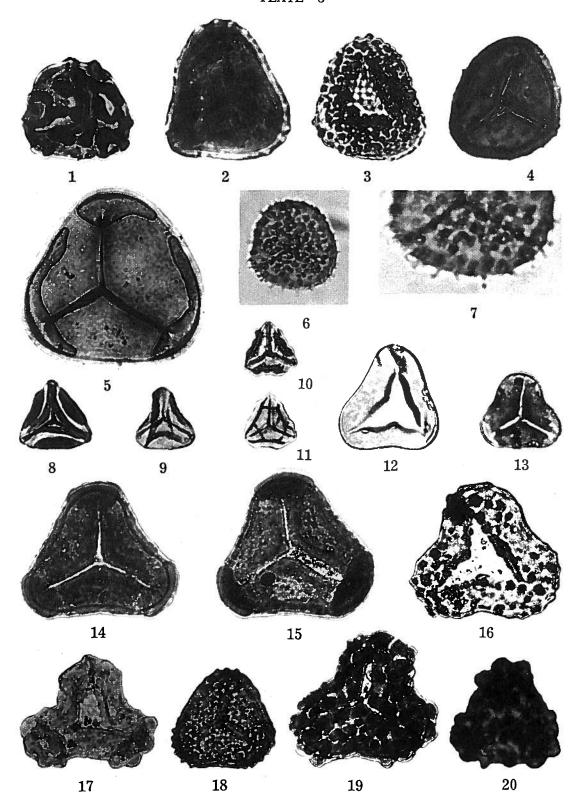
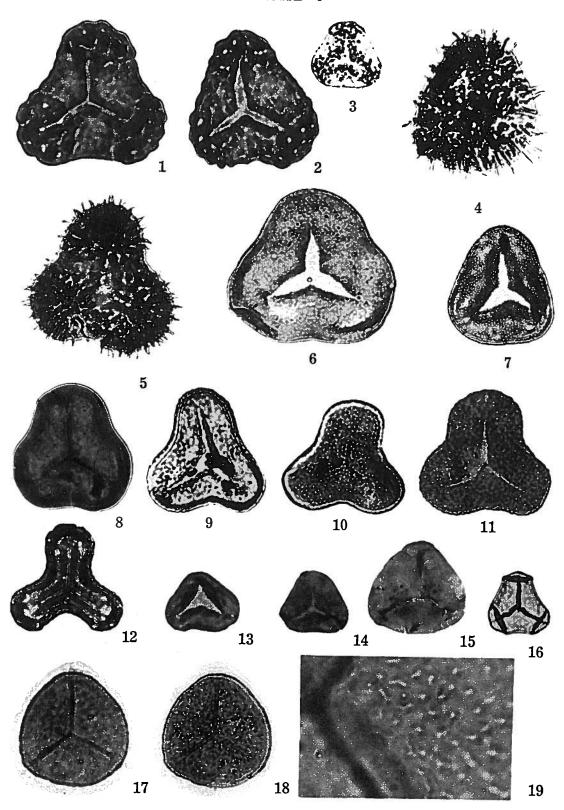


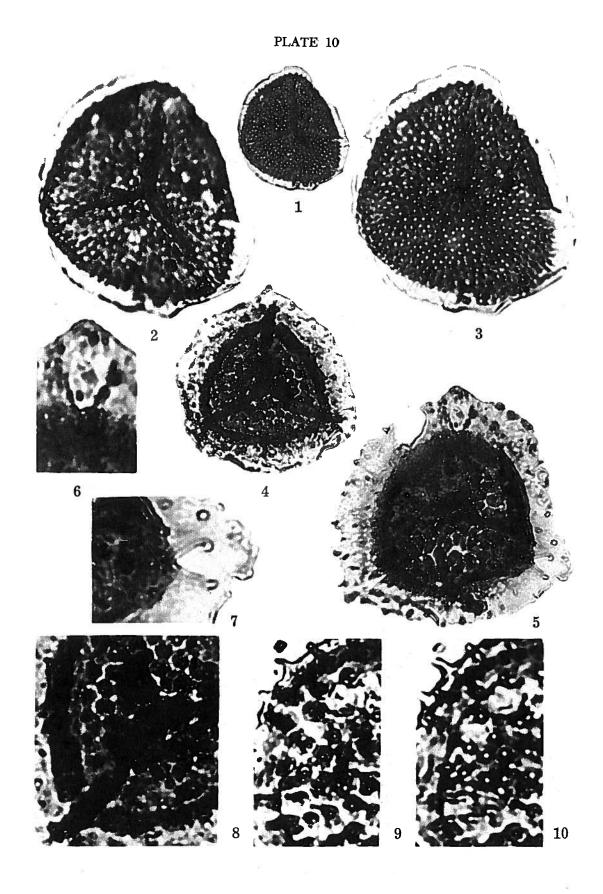
PLATE 8



All specimens are illustrated at a magnification of X500 unless otherwise stated
Figure 1: Klukisporites sp.; distal view, 51 microns, IW1781-1791 (Grand Rapids Formation); known range: middle Albian (p. 65)
Figure 2: Lygodioisporites sp. A; mid-focus, 65 microns, FA2923-2932 (Wabiskaw Member); known range: middle Albian
Figure 3: Lygodioisporites sp. B; proximal view, 58 microns, FA2451-2460 (Grand Rapids Formation); known range: middle Albian
Figure 4: Lygodiumsporites sp. A; proximal view, 60 microns, FA3010-3019 (Ellerslie Member); known range: Aptian to middle Albian (p. 67)
Figure 5: Lygodiumsporites sp. B; proximal view, 85 microns, IW1816-1826 (Grand Rapids Formation); known range: middle Albian (p. 67)
Figures 6, 7: Neoraistrickia? sp.; 6—proximal view, 42 microns, FA3174-3179 (Ellerslie Member); 7—same specimen X1024 clavate spines; known range: Aptian
Figures 8, 9: Gleicheniidites senonicus Ross; 8—proximal view, 32 microns, FA2815-2824 (Clearwater Formation, shale member); 9—proximal view, 29 microns, FA2782-2785 (Clearwater Formation, shale member); known range: Jurassic to Cretaceous
Figures 10, 11: Gleicheniidites sp. cf. G. circinidites (Cookson) n. comb.; 10—mid-focus, 27.5 microns, IW1781-1791 (Grand Rapids Formation); 11—same specimen showing diffraction pattern related with thickened zones; known range: Upper Jurassic to Lower Cretaceous and Eocene (p. 69)
Figure 12: Cyathidites australis Couper; proximal view, 50 microns, IW1791-1801 (Grand Rapids Formation); known range: Jurassic to Lower Cretaceous
Figure 13: Cyathidites minor Couper; mid-focus, 36 microns, IW1816-1826 (Grand Rapids Formation); known range: Jurassic to Cretaceous (p. 71)
Figures 14, 15: Trilobosporites hannonicus (Delcourt and Sprumont) Potonié; 14—proximal view, 64 microns, FA3213-3222 (Deville Member); 15—proximal view, 70 microns, FA3222-3231 (Deville Member); known range: Barremian? to Aptian
Figures 16-18: Trilobosporites apiverrucatus Couper; 16—proximal view, 63 microns, IW2085-2095 (Wabiskaw Member); 17—proximal view, 54 microns, IN3726-3736 (Ellerslie Member); 18—mid-focus, 47 microns, FA2905-2914 (Wabiskaw Member); known range: Berriasian to middle Albian
Figures 19, 20: Trilobosporites canadensis Pocock; 19—proximal view, 64 microns, IN3768-3778 (Ellerslie Member); 20—proximal view, 52 microns, IN3706-3716 (Ellerslie Member); known range: Barrenian? to middle Albian? (p. 73)

All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1, 2: Trilobosporites trioreticulosus Cookson and Dettmann; 1—proximal view, 64 microns, FA2983-2992 ("calcareous" member); 2—proximal view, 60 microns, FA2932-2938 (Wabiskaw Member); known range: Aptian to Albian
Figure 3: Trilobosporites minor Pocock; proximal view, 32 microns, IW1816-1826
(Grand Rapids Formation); known range: Aptian to middle Albian (p. 74
Figure 4: Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont; distal view, 62 microns (excluding spines), IN3850-3860 (Ellerslie Member); known range: Purbeck to middle Albian
Figure 5: Pilosisporites verus Delcourt and Sprumont; proximal view, 63 microns (excluding spines), IN3768-3778 (Ellerslie Member); known range: Barremian? to middle Albian?
Figures 6, 7: Concavissimisporites punctatus (Delcourt and Sprumont) n. comb.; 6—proximal view, 74 microns, FA2815-2824 (Clearwater Formation, shale member); 7—proximal view, 56 microns, IW1781-1791 (Grand Rapids Formation); known range: Berriasian to Aptian
Figure 8: Concavissimisporites parkinii (Pocock) n. comb.; proximal view, 59 microns, IN3850-3860 (Ellerslie Member); known range: Barremian? to Aptian (p. 78
Figures 9-11: Concavissimisporites variverrucatus (Couper) n. comb.; 9—proximal view, 56 microns, FA3093-3102 (Ellerslie Member); 10—distal view, 50 microns, IN3686-3696 (Ellerslie Member); 11—proximal view, 56 microns, FA3093-3102 (Ellerslie Member); known range: Bajocian to middle Albian
Figure 12: Concavissimisporites sp.; mid-focus, 44 microns, FA3010-3019 (Ellerslie Member); known range: Aptian
Figures 13, 14: Deltoidospora hallii Miner; 13—proximal view, 32 microns, IN3768-3778 (Ellerslie Member); 14—distal view, 30 microns, IN3726-3736 (Ellerslie Member); known range: Mesozoic
Figure 15: Deltoidospora psilostoma Rouse; mid-focus, 46 microns, IN3716-3726 (Ellerslie Member); known range: Upper Jurassic to Upper Cretaceous
Figure 16: Deltoidospora junctum (Kara-Murza) n. comb.; proximal view, 30 microns, FA2496-2505 (Grand Rapids Formation); known range: Upper Jurassic to Lower Cretaceous
Figures 17-19: Hymenozonotriletes mesozoicus Pocock; 17—proximal view, 62 microns, FA3093-3102 (Ellerslie Member); 18—distal view of same specimen; 19—same specimen X2500 distal spines; known range: Aptian to lower Albian?

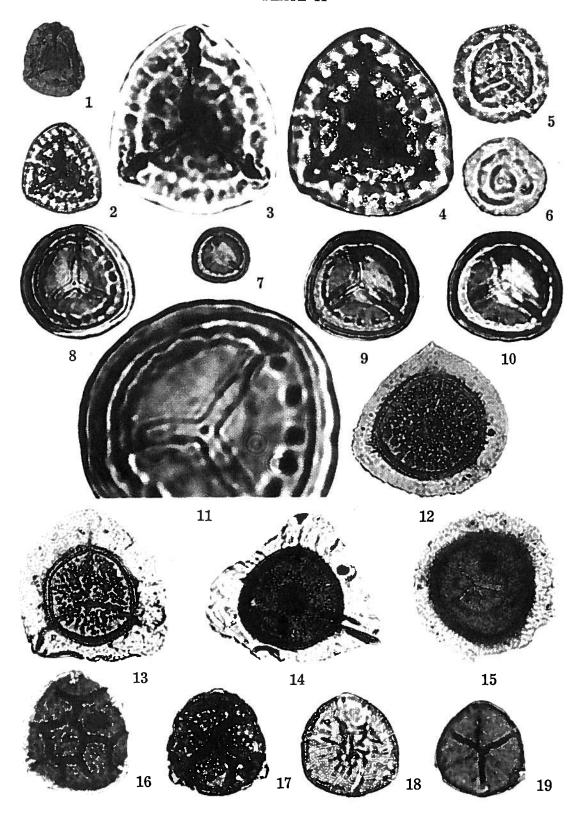


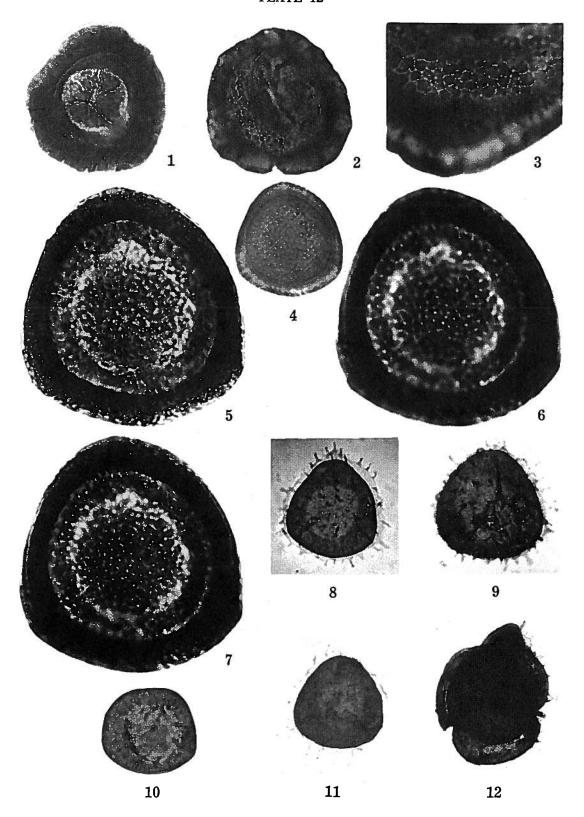


All specimens are illustrated at a magnification of X500 unless otherwise stated	
Figures 1-3: Hymenozonotriletes pseudoalveolatus (Couper) n. comb.; 1—proximal view, 58 microns, IW1921-1931 (Grand Rapids Formation); 2—same specimen X1024 proximal view; 3—same specimen X1024 distal view; known range: Bajocian to middle Albian	83
Figures 4-10: Couperisporites complexus (Couper) Pocock; 4—proximal view, 88 microns, IW1781-1791 (Grand Rapids Formation); 5—distal view, 112 microns, IW1911-1921 (Grand Rapids Formation); 6, 7—X1024 bifurcation of the commissures, IW1911-1921 (Grand Rapids Formation); 8, 9, 10—X1024 distal ornamentation at low, mid, and high focus, respectively; 8—IW1781-1791 (Grand Rapids Formation); 9, 10—IN3850-3860 (Ellerslie Member); known range: Barrenian to middle Albien	0.43

All specimens are illustrated at a magnification of X500 unless otherwise stated	
Figures 1-4: Staplinisporites caminus (Balme) Pocock; 1—mid-focus, 36 microns, IN3742-3743 (Ellerslie Member); 2—distal view, 44 microns, FA3213-3222 (Deville Member); 3—same specimen X1024 proximal view; 4—same specimen X1024 distal view; known range: Upper Jurassic to Lower Cretaceous	š)
Figure 5: Taurocusporites segmentatus Stover; mid-focus, 46 microns, IW1816-1826 (Grand Rapids Formation); known range: Lower Oretaceous (p. 86	3)
Figure 6: Taurocusporites reduncus (Bolkhovitina) Stover; mid-focus, 37 microns, IW1816-1826 (Grand Rapids Formation); known range: Middle Jurassic to Upper Cretaceous	3)
Figures 7-11: Taurocusporites minor n. sp.; 7—(holotype) distal view, 27 microns, FA2923-2932 (Wabiskaw Member); 8—(holotype) X1024 proximal view; 9—(holotype) X1024 mid-focus; 10—(holotype) X1024 distal view; 11—(holotype) X2500 proximal view showing the extension of laesurae; known range: Aptian to middle Albian	′)
Figures 12, 13: Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann; 12—distal view, 74 microns, FA3093-3102 (Ellerslie Member); 13—proximal view, 78 microns, IW1931-1941 (Grand Rapids Formation); known range: Cretaceous	3)
Figures 14, 15: Aequitriradites variabilis Pocock; 14—distal view showing exinous breakdown about the distal pole, 76 microns, FA2896-2905 (Wabiskaw Member); 15—distal view showing exinous breakdown about the distal pole, 72 microns, IN3716-3726 (Ellerslie Member); known range: Barremian? to middle Albian	1)
Figures 16, 17: Rouseisporites reticulatus Pocock; 16—distal view, 58 microns, FA3037-3046 (Ellerslie Member); 17—distal view, 51 microns, IW1781-1791 (Grand Rapids Formation); known range: Barremian? to Albian (p. 90)
Figure 18: Rouseisporites laevigatus Pocock; distal view, 50 microns, IW1781-1791 (Grand Rapids Formation); known range: Aptian to Albian (p. 91)
Figure 19: Rouseisporites triangularis Pocook; distal view, 46 microns, FA3174-3179 (Ellerskie Member); known range: Aptian to Albian)

PLATE 11





All specimens are illustrated at a magnification of X500 unless otherwise stated	
Figures 1-3: Cooksonites variabilis Pocock; 1—proximal view showing trilete laesurae, 70 microns, FA3174-3179 (Ellerslie Member); 2—distal view, 72 microns, IW1911-1921 (Grand Rapids Formation); 3—same specimen X1024 meshwork of polygonal plates on distal pole; known range: Barremian? to middle Albian	2)
Figures 4-7: Cooksonites reticulatus Pocock; 4—mid-focus, 55 microns, FA3010-3019 (Ellerslie Member); 5—same specimen X1024 proximal view; 6—same specimen X1024 mid-focus; 7—same specimen X1024 distal view; known range: Barremian? to middle Albian	3)
Figures 8-12: Januasporites spiniferus n. sp.; 8—(holotype) proximal view, 57.4 microns, FA2496-2505 (Grand Rapids Formation); 9—proximal view, 62 microns, FA2496-2505 (Grand Rapids Formation); 10—distal view of a spore without marginal ektexine, 45 microns, FA2496-2505 (Grand Rapids Formation); 11—proximal view, 58 microns, FA2496-2505 (Grand Rapids Formation); 12—a tetrad, 70 microns, FA2496-2505 (Grand Rapids Formation); 12—b tetrad, 70 microns, FA2496-2505 (Grand Rapids Formation); 12—a tetrad, 70 microns, FA2496-2505 (Grand Rapids Formation); 12—b tetrad, 70 microns, FA2496-2505 (Grand	
mation); known range: middle Albian (p. 94)

All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1, 2: Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock; 1—proximal view, 53 microns, IW1781-1791 (Grand Rapids Formation); 2—proximal view, 43 microns, FA3093-3102 (Ellerslie Member); known range: Aptian to Albian (p. 95)
Figure 3: Verrucosisporites rotundus n. sp.; (holotype) proximal view, 46 microns, IN3742-3743 (Ellerslie Member); known range: Aptian (p. 96)
Figure 4: Verrucosisporites sp.; proximal view, 54 microns, FA2860-2869 (Clearwater Formation, shale member); known range: middle Albian (p. 96)
Figures 5-7: Microreticulatisporites uniformis n. sp.; 5—(holotype) proximal view, 47 microns, IW1781-1791 (Grand Rapids Formation); 6—proximal view, 45 microns, IW1791-1801 (Grand Rapids Formation); 7—mid-focus, 45 microns, IW1826-1836 (Grand Rapids Formation); known range: Aptian to middle Albian
Figure 8: Granulatisporites sp.; mid-focus, 30 microns, FA2782-2785 (Clearwater Formation, shale member); known range: Barremian? to middle Albian
Figures 9-11: Laevigatosporites ovatus Wilson and Webster; 9—proximal view, 34 × 22 microns, IN3768-3778 (Ellerslie Member); 10—equatorial view, 34 × 22 microns, IW1781-1791 (Grand Rapids Formation); 11—sporangial mass, IN3768-3778 (Ellerslie Member); known range: Upper Jurassic to Cretaceous
Figures 12, 13: Dictyotosporites sp. cf. D. speciosus Cookson and Dettmann; 12—mid-focus, 36 microns, FA2938-2947 (Wabiskaw Member); 13—same specimen X1024 proximal view; known range: Neocomian to middle Albian
Figure 14: Schizosporis reticulatus Cookson and Dettmann; mid-focus, 105 microns, FA2442-2451 (Grand Rapids Formation); known range: Neocomian to Albian and Cenomanian?
Figure 15: Schizosporis parvus Cookson and Dettmann; mid-focus, 90 × 60 microns, FA2505-2514 (Grand Rapids Formation); known range: Barremian? to Albian and Cenomanian?
Figure 16: Schizosporis rugulatus Cookson and Dettmann; mid-focus, 78 microns, IW1781-1791 (Grand Rapids Formation); known range: Aptian to Albian and Cenomanian? (p. 101)

PLATE 13

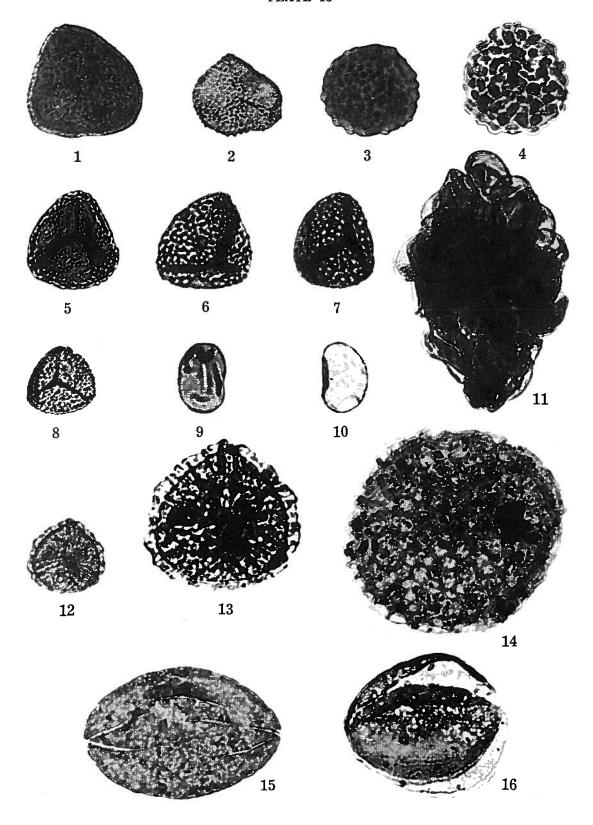
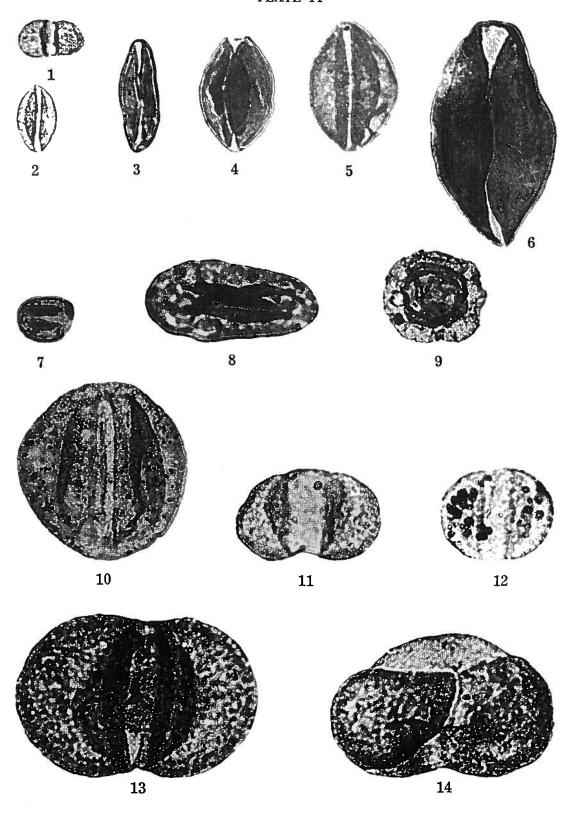


PLATE 14



Explanation of Plate 15

All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1, 2: Alisporites rotundus Rouse; 1—proximal view, 82 × 58 microns, IW1816-1826 (Grand Rapids Formation); 2—distal view, 102 × 90 microns, FA2860-2869 (Clearwater Formation, shale member); known range: Upper Jurassic? to Lower Cretaceous
Figures 3-5: Cedripites cretaceus Pocock; 3—equatorial view, 78 × 48 microns, FA3084-3093 (Ellerslie Member); 4—equatorial view, 78 × 48 microns, FA2514-2523 (Grand Rapids Formation); 5—equatorial view, 86 × 54 microns, FA2782-2785 (Clearwater Formation, shale member); known range: Barremian? to middle Albian (p. 111)
Figure 6: Cedripites canadensis Pocock; equatorial view, 60×37 microns, FA3174-3179 (Ellerslie Member); known range: Barremian? to middle Albian
Figure 7: Parvisaccites radiatus Couper; equatorial view, 52×38 microns, FA3010-3019 (Ellerslie Member); known range: Berriasian to middle Albian
Figures 8, 9: Phyllocladidites mawsonii form verrucosus (Cookson) n. comb.; 8—equatorial view, 50 × 28 microns, FA2896-2905 (Wabiskaw Member); 9—equatorial view, 56 × 32 microns, FA3075-3084 (Ellerslie Member); known range: Lower Cretaceous to Lower Eocene
Figure 10: Phyllocladidites sp.; distal view, 62×60 microns, FA2932-2938 (Wabiskaw Member); known range: middle Albian
Figure 11: Podocarpidites sp. cf. P. ellipticus Cookson; distal view, 70 × 43 microns, IW1781-1791 (Grand Rapids Formation); known range: Jurassic to Tertiary
Figures 12, 13: Podocarpidites multesimus (Bolkhovitina) Pocock; 12—proximal view, 70 × 36 microns, IN3582-3592 ("calcareous" member); 13—distal view, 68 × 28 microns, IN3696-3706 (Ellerslie Member); known range: Jurassic to Cretaceous
Figure 14: Podocarpidites ornatus Pocock; proximal view, 94 × 61 microns, FA3165-3174 (Ellerslie Member); known range: Aptian (p. 117)
Figures 15, 16: Podocarpidites minisculus n. sp.; 15—(holotype) distal view, 51 × 40.8 microns, FA2689-2699 (Clearwater Formation, shale member); 16—equatorial view, 60 × 32 microns, FA2598-2607 (Grand Rapids Formation); known range: Aptian to middle Albian

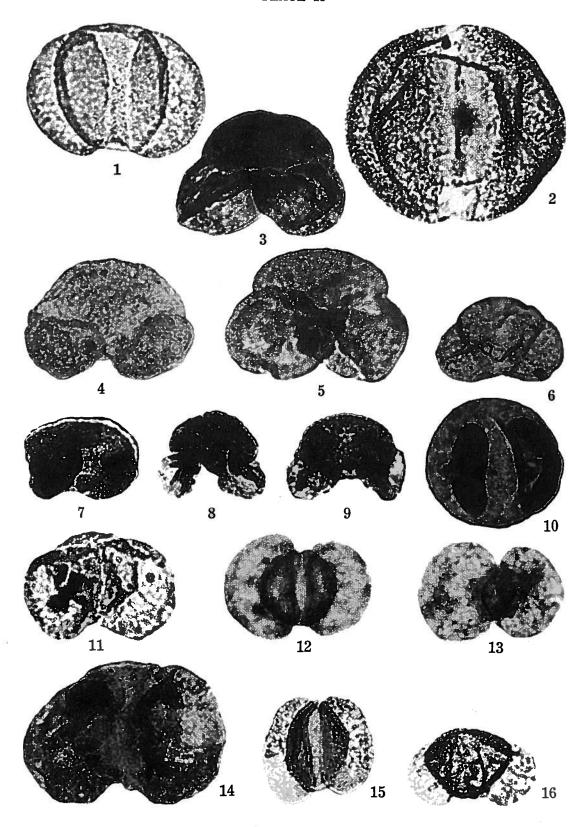
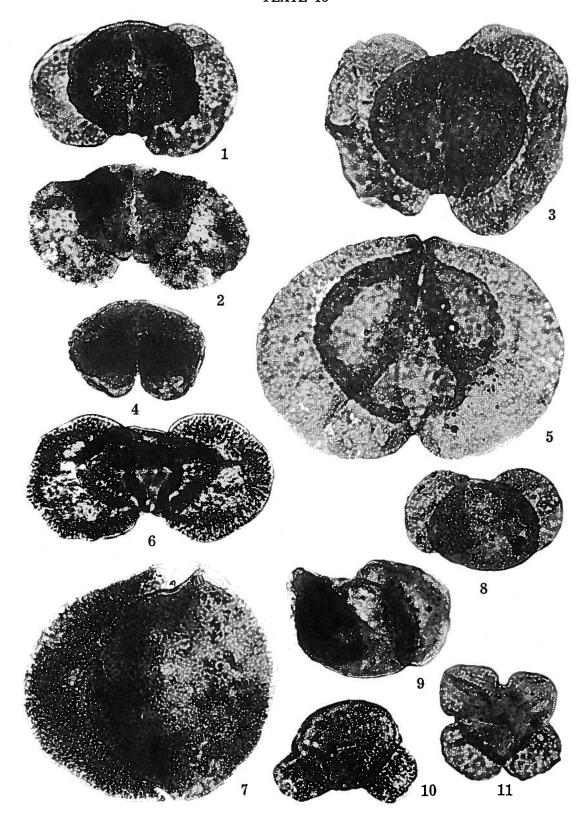


PLATE 16



All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1-3: Podocarpidites canadensis Pocock; 1—proximal view, 98 × 54 microns, FA3174-3179 (Ellerslie Member); 2—proximal view, 104 × 46 microns, IN3582-3592 ("calcareous" member); 3—proximal view, 112 × 68 microns, FA3093-3102 (Ellerslie Member); known range: Barremian? to middle Albian
Figure 4: Aberrant <i>Podocarpidites</i> pollen; equatorial view, 63×36 microns, FA2932-2938 (Wabiskaw Member)
Figure 5: Podocarpidites sp.; proximal view, 142×92 microns, FA3174-3179 (Ellerslie Member); known range: Aptian
Figure 6: Podocarpidites naumovai n. name; distal view, 116×66 microns, FA2782-2785 (Clearwater Formation, shale member); known range: Albian to Cenomanian
Figure 7: Piceaepollenites sp.; equatorial end view, 120×112 microns, FA2905-2914 (Wabiskaw Member); known range: middle Albian (p. 121)
Figures 8, 9: Pityosporites constrictus n. sp.; 8—(holotype) distal view, 74×42 microns, FA3010-3019 (Ellerslie Member); 9—distal view, 76×47 microns, IN3778-3784 (Ellerslie Member); known range: Aptian to middle Albian
Figure 10: Pityosporites alatipollenites (Rouse) n. comb.; equatorial view, 66 × 42 microns, IW1826-1836 (Grand Rapids Formation); known range: Upper Jurassic? to Upper Cretaceous
Figure 11: Aberrant <i>Pityosporites</i> pollen, equatorial view, 56 microns, FA3174-

All specimens are illustrated at a magnification of X500 unless otherwise stated
Figure 1: Tsugaepollenites mesozoicus Couper; distal view, 59 microns, IN3748-3758 (Ellerslie Member); known range: Jurassic to Cretaceous
Figure 2: Classopollis classoides Pflug, emend. Pocock and Jansonius; a tetrad, 28 × 23 microns (size of single pollen), IN3726-3736 (Ellerslie Member); known range: Jurassic to Cretaceous
Figure 3: Leioaletes calvatus n. sp.; (holotype), 67×28 microns, FA2478-2487 (Grand Rapids Formation); known range: middle Albian (p. 126)
Figures 4, 5: Exesipollenites tumulus Balme; 4—30 microns, FA2782-2785 (Clearwater Formation, shale member); 5—28 microns, IW2095-2098 (Wabiskaw Member); known range: Lower Jurassic to middle Albian (p. 126)
Figures 6-9: Eucommidites troedssonii Erdtman, emend. Hughes; 6—23 × 24 microns, IW2095-2098 (Wabiskaw Member); 7—24 × 23 microns, FA2607-2616 (Grand Rapids Formation); 8—same specimen X1024 showing the median furrow; 9—same specimen X1024 showing the ring-furrow on the opposite face; known range: Jurassic to Lower Cretaceous (p. 128)
Figures 10-15: Equisetosporites concinnus n. sp.; 10—75 × 40 microns, IN3850-3860 (Ellerslie Member); 11—78 × 34 microns, IN3850-3860 (Ellerslie Member); 12—90 × 36 microns, IN3850-3860 (Ellerslie Member); 13— (holotype) mid-focus, 92 × 32 microns, IN3850-3860 (Ellerslie Member); 14—(holotype) X1024 focussed on upper surface to show the width of ridges and furrows; 15—(holotype) X1967 showing coalescing ridges before reaching the longitudinal ends; known range: Barremian? to Aptian (p. 132)
Figure 16: Equisetosporites sp. cf. E. ovatus (Pierce) n. comb.; 54 × 28 microns, FA3046-3054 (Ellerslie Member); known range: Aptian to Cenomanian
Figures 17, 18: Equisetosporites albertensis n. sp.; 17—(holotype) mid-focus, 104 × 34 microns, IN3850-3860 (Ellerslie Member); 18—(holotype) X1024 mid-focus; known range: Aptian

PLATE 17

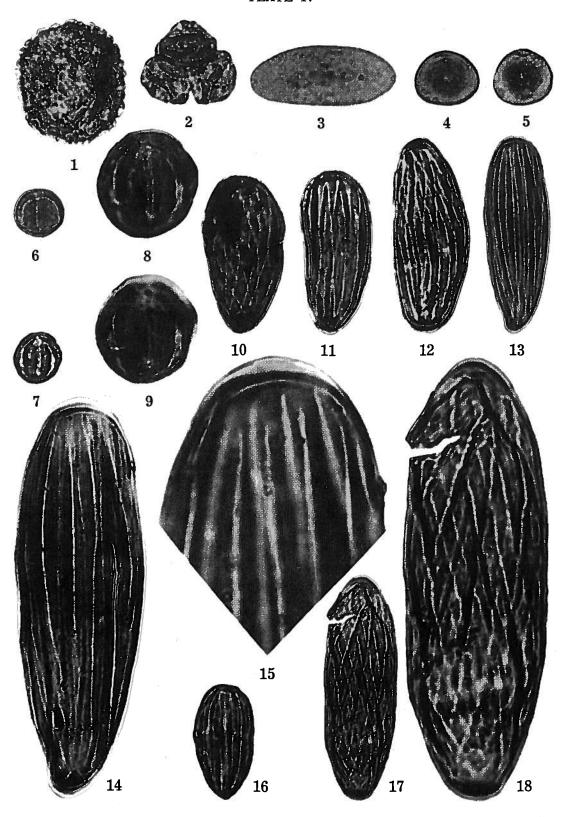
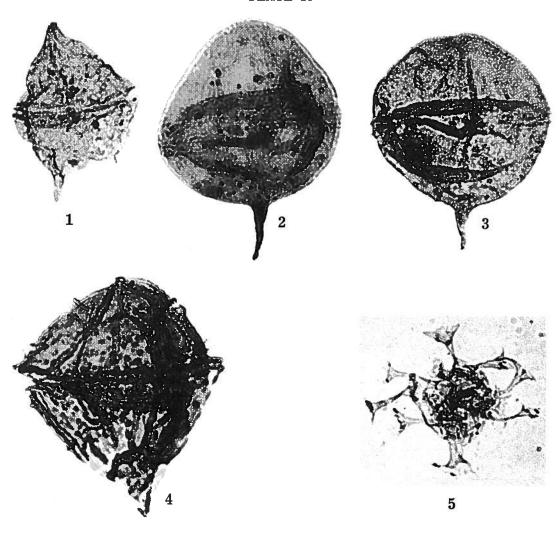
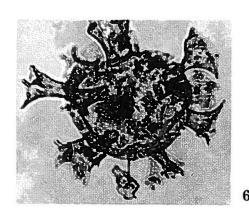
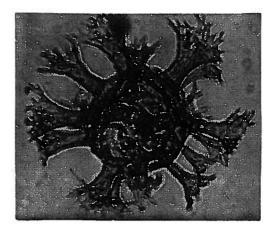


PLATE 18







1

All specimens are illustrated at a magnification of X500 unless otherwise stated	
Figure 1: Palaeoperidinium cretaceum Pocock; 84×58 microns, FA2598-2607 (Grand Rapids Formation); known range: Cretaceous (p. 1	134)
Figures 2, 3: Palaeoperidinium granulatum n. sp.; 2—110 × 85 microns, FA2598-2607 (Grand Rapids Formation); 3—(holotype) 100 × 83 microns, FA2598-2607 (Grand Rapids Formation); known range: middle Albian	135)
Figure 4: Gonyaulax sp. cf. G. jurassica Deflandre; 112 × 98 microns, FA2607-2616 (Grand Rapids Formation); known range: Oxfordian to middle Albian? (p. 1	136)
Figure 5: Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; 80 microns (including processes), IW2095-2098 (Wabiskaw Member); known range: Aptian to Senonian	137)
Figures 6, 7: Hystrichosphaeridium albertense Pocock; 6—94 microns (including processes), IW2095-2098 (Wabiskaw Member); 7—108 microns (including processes), IW2098-2101 (Wabiskaw Member); known range: lower? to middle Albian (p. 1)	138)

All specimens are illustrated at a magnification of X500 unless otherwise stated
Figures 1-4: Hystrichosphaeridium irregulare Pocock; 1—124 microns (including processes), IW2055-2065 (Wabiskaw Member); 2, 3, 4—same specimen X1024 showing irregular nature of processes; known range: lower? to middle Albian
Figure 5: Baltisphaeridium longispinosum (Eisenack) Eisenack; 100 microns (including processes), IW1816-1826 (Grand Rapids Formation); known range: Reworked from Ordovician
Figures 6, 7: Baltisphaeridium sp. cf. B. neptuni Eisenack; 6—60 microns (including processes), FA2717-2725 (Clearwater Formation, shale member); 7—same specimen X1024 showing nature of processes; known range: Aptian to middle Albian
Figure 8: Baltisphaeridium sp.; 37 microns (including processes), FA2717-2725

(Clearwater Formation, shale member); known range: middle Albian (p. 141)

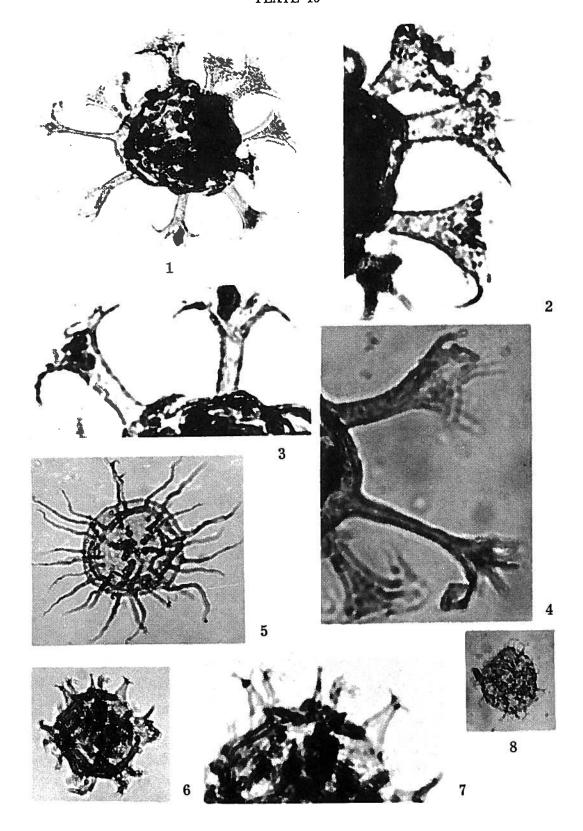
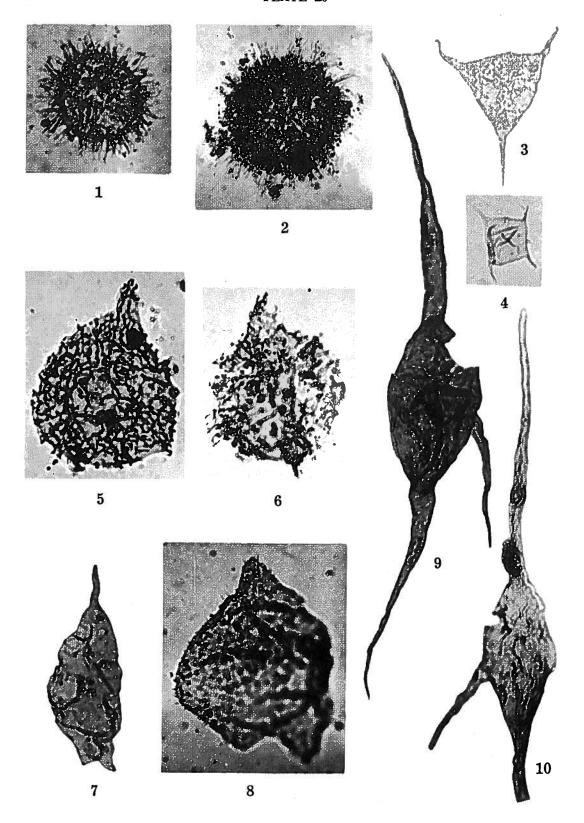


PLATE 20



All specimens are illustrated at a magnification of X500 unless otherwise stated

Figures 1, 2: Baltisphaeridium multispinosum n. sp.; 1—(holotype) 62 microns
(including processes), IW2098-2101 (Wabiskaw Member); 2—74 microns
(including processes), IW2098-2101 (Wabiskaw Member); known range:
middle Albian (p. 141)
Figure 3: Veryhachium reductum (Deunff) Jekhowsky; 62 microns (diameter
including processes), IW1816-1826 (Grand Rapids Formation); known
range: Ordovician to Cenomanian
Figure 4: Veryhachium irregulare form subhexahedron Jekhowsky; diameter of

- Figure 7: Pseudoceratium gochtii Pocock; 93.5×34 microns, FA2782-2785 (Clearwater Formation, shale member); known range: Cretaceous (p. 145)
- Figure 8: Canningia colliveri Cookson and Eisenack; 102×70 microns, IW2085-2095 (Wabiskaw Member); known range: Aptian to middle Albian (p. 145)

All specimens are illustrated at a magnification of X100 unless otherwise stated
Figure 1: Triletes persimilis Harris; proximal view, 510 microns, IW1816-1826 (Grand Rapids Formation); known range: Rhaetic-Liassic to Senonian (p. 149)
Figure 2: Triletes sp. A; proximal view, 641 microns, FA3111-3120 (Ellerslie Member); known range: Aptian
Figure 3: Triletes sp. B; proximal view, 397 microns, FA3111-3120 (Ellerslie Member); known range: Aptian (p. 150)
Figures 4, 5: Horstisporites reticuliferus (Dijkstra) Potonié; 4—proximal view, 470 microns, FA3188-3197 (Ellerslie Member); 5—proximal view, 840 microns, FA3188-3197 (Ellerslie Member); known range: Neocomian to Aptian
Figure 6: Verrutriletes sp. cf. V. compositipunctatus (Dijkstra) Potonié; proximal view, 330 microns, IN3572-3582 (Wabiskaw Member); known range: Aptian to Senonian

PLATE 21

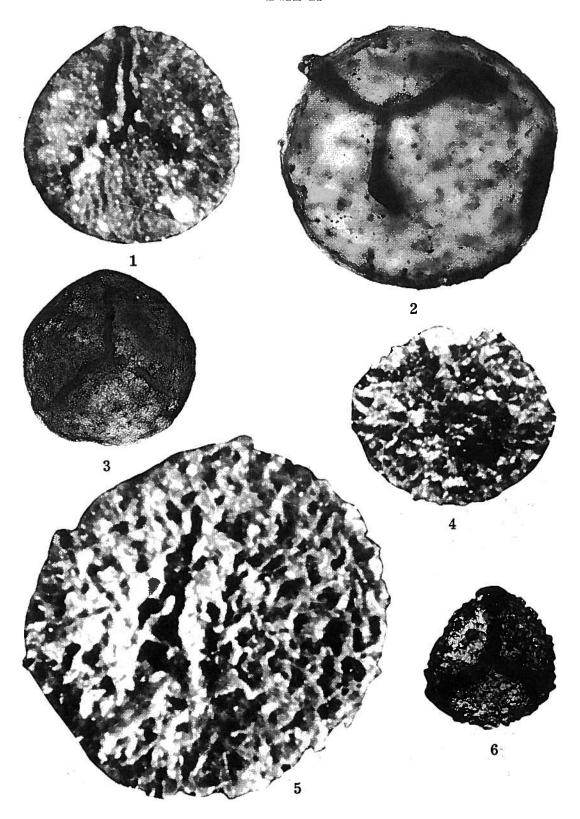
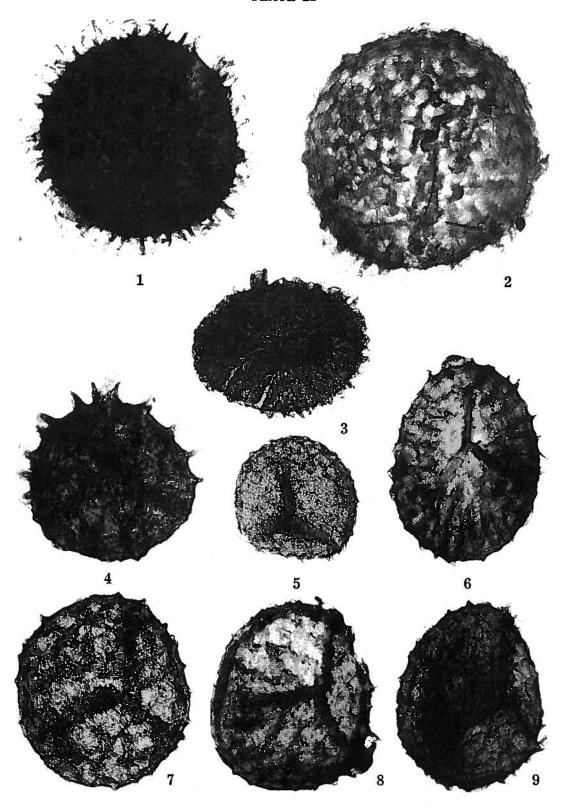
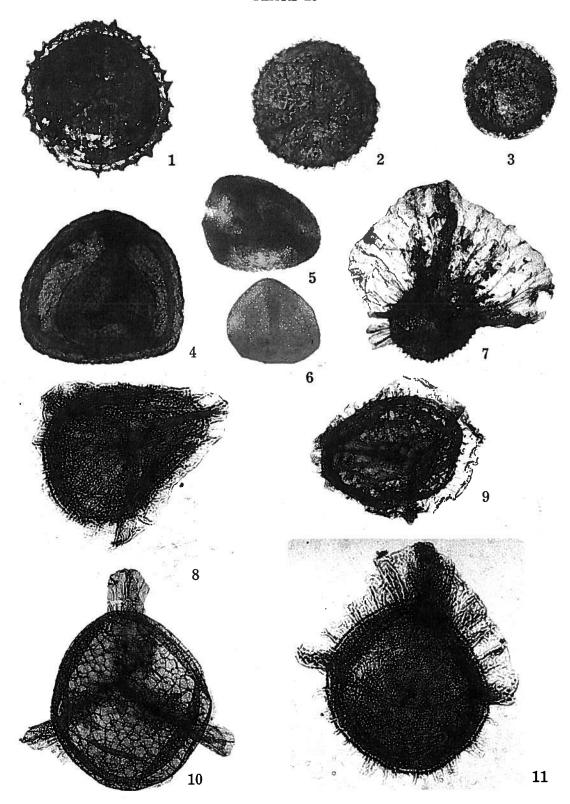


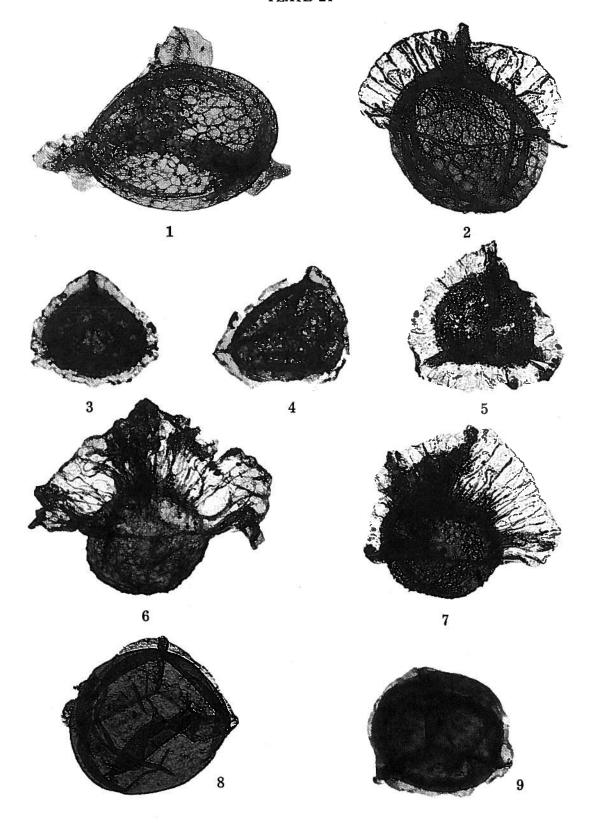
PLATE 22



- All specimens are illustrated at a magnification of X100 unless otherwise stated

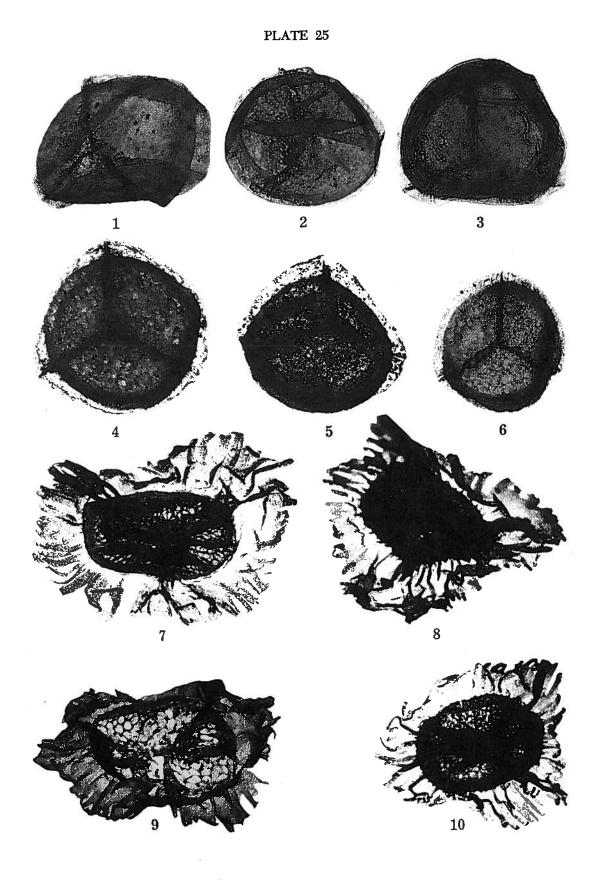
All specimens are illustrated at a magnification of X100 unless otherwise stated
Figures 1, 2: Erlansonisporites globosus n. sp.; 1—(holotype) proximal view, 372 microns, FA3001-3010 (Ellerslie Member); 2—proximal view, 320 microns, FA3156-3165 (Ellerslie Member); known range: Aptian (p. 153)
Figure 3: Erlansonisporites sp.; 230 microns, FA3222-3231 (Deville Member); known range: Barremian?
Figure 4: Maexisporites soldanellus (Dijkstra) Potonié; proximal view, 384 microns, FA3093-3102 (Ellerslie Member); known range: Berriasian to Aptian
Figures 5, 6: Maexisporites obolus (Dijkstra) Potonié; 5—proximal view, 280 microns, FA3222-3231 (Deville Member); 6—proximal view, 224 microns, FA3093-3102 (Ellerslie Member); known range: Hauterivian to Aptian ————————————————————————————————————
Figure 7: Thomsonia phyllicus (Murray) Potonié; equatorial view, 420 microns (diameter of body and height of triradiate lamellae), FA3093-3102 (Ellerslie Member); known range: Middle Jurassic to Lower Cretaceous (p. 156)
Figures 8-11: Minerisporites macroreticulatus n. sp.; 8—(holotype) proximal view, 500 microns, FA2442-2451 (Grand Rapids Formation); 9—proximal view, 390 microns, FA2442-2451 (Grand Rapids Formation); 10—proximal view, equatorial zona mostly lost, present only at apices where it is strengthened by triradiate lamellae, 520 microns, FA2478-2487 (Grand Rapids Formation); 11—equatorial view, 580 microns (diameter of body and height of triradiate lamellae), FA2478-2487 (Grand Rapids Formation); known range: middle Albian

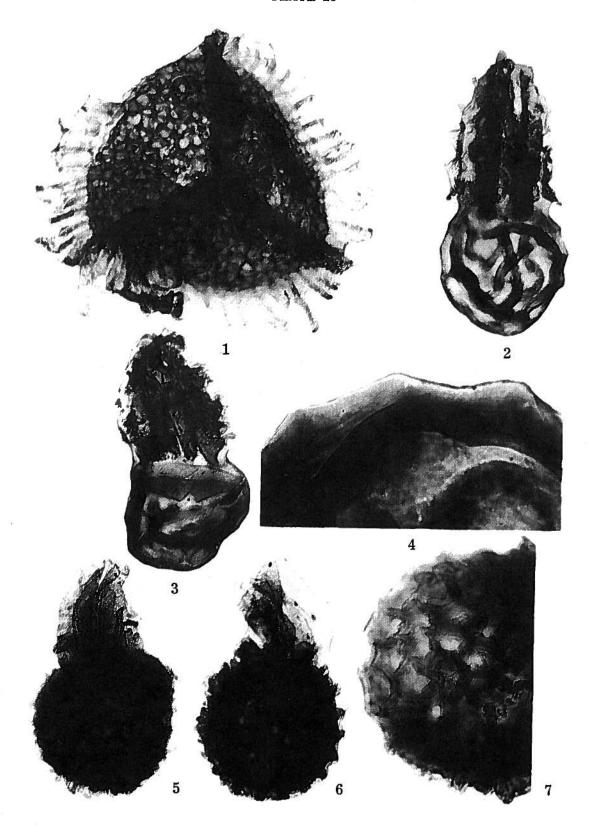




- All specimens are illustrated at a magnification of X100 unless otherwise stated
- Figures 1, 2: Minerisporites macroreticulatus n. sp.; 1—proximal view, equatorial zona mostly lost, present only at apices where it is strengthened by triradiate lamellae, 570 microns, FA2478-2487 (Grand Rapids Formation); 2—equatorial view, 450 microns (diameter of body and height of triradiate lamellae), FA2478-2487 (Grand Rapids Formation); known range: middle Albian _______ (p. 157)

- All specimens are illustrated at a magnification of X100 unless otherwise stated

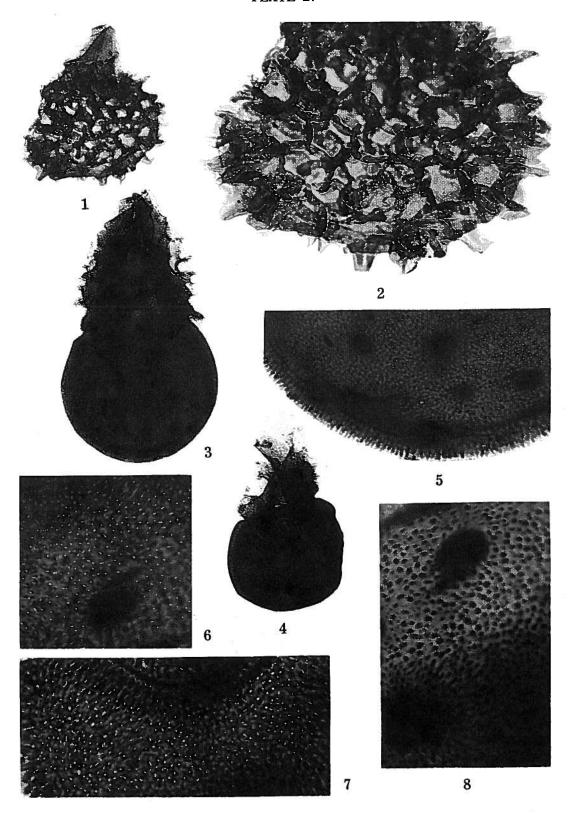


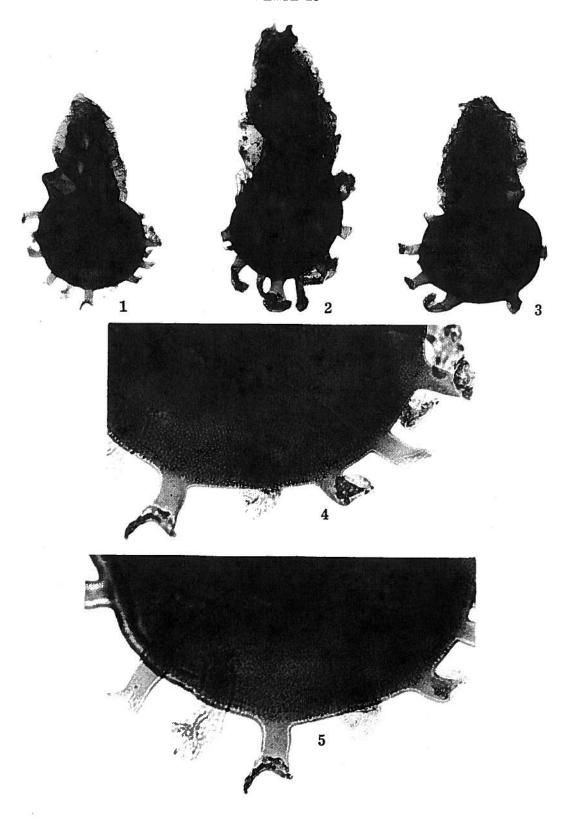


Explanation of Plate 26

All specimens are illustrated at a magnification of X100 unless otherwise stated
Figure 1: Dijkstraisporites triangulatus n. sp.; (holotype) proximal view, 737.2 microns, FA2923-2932 (Wabiskaw Member); known range: middle Albian (p. 161)
Figures 2-4: Arcellites rugosus n. sp.; 2—(holotype) equatorial view, 670 microns, IN3632-3642 (Ellerslie Member); 3—equatorial view, 560 microns, FA3249-3257 (Deville Member); 4—X400 part of ridge pattern enlarged from figure 2; known range: Barremian? to Aptian (p. 164)
Figures 5-7: Arcellites reticulatus (Cookson and Dettmann) Potter; 5—equatorial view, 577 microns, FA2442-2451 (Grand Rapids Formation); 6—equatorial view, 577 microns, FA2442-2451 (Grand Rapids Formation); 7—same specimen X200 part of reticulate pattern on the body; known range:

All	specimens	are	illustrated	at	a	magnification	of	X100	unless	otherwise	stated
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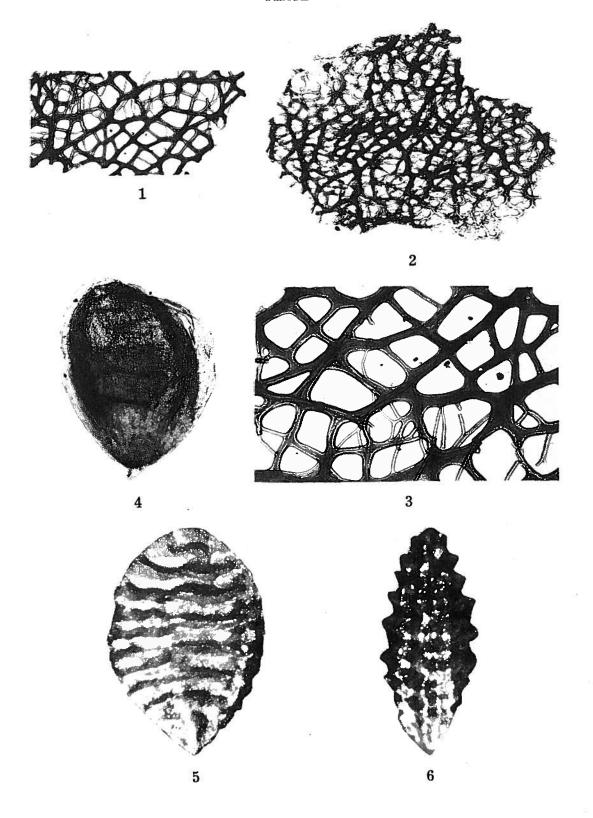




All specimens are illustrated at a magnification of X100 unless otherwise stated

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1.2
Figures 1-3: Dictyothylakos sp.; 1—X50.4, IW1791-1801 (Grand Rapids Formation); 2—X63, FA3222-3231 (Deville Member); 3—X127, IW1791-1801 (Grand Rapids Formation); known range: Barremian? to middle Albian
Figure 4: Caytonia seed; X64.5; length 705 microns, breadth 435 microns, IW1846-
1856 (Grand Rapids Formation); known range: middle Albian (p. 169)
Figures 5, 6: Nucellus cuticle of Caytonia seed?; 5—X50 front view, length 1100
microns, breadth 700 microns, FA2992-3001 (Ellerslie Member); 6—same
specimen X50 lateral view; known range: Aptian (p. 170)



			WEALD	LINCOLNSHIRE	E. HOLLAND	N. GERMANY	BELGIUM	PALYNOLOG	ICAL ZONES
		<u> </u>	OUTCROP	12			J.L.O.O.M	MICROSPORES	MEGASPORES
	ALBIAN MIDDLE ALBIAN		GAULT	6			000000000000000000000000000000000000000	ENTRANCE	
	LOWER		LOWER				'WEALDEN'		
	APTIAN*	GREENSAND		ARINE)	MARINE	CLAYS (MARINE)	? ?	50	
ER CRETACEOUS	BARRENHAM	***	WEALD CLAY	SPEETON CLAYS (MARINE)	W	HILS CLAY		92 70	ARCELLITES (HPYROBOLOSPORA) FLORA
LOWER	HAUTERIVIAN	DEN		88					
	VALANGINIAN	WEALDEN	HASTINGS SANDS		90900000 D000000000000	W6		21 37	THOMSONIA FLORA
	BERRIA SIAM		HAS		=	DEISTER SANDSTONE		36, 37, 46	VERRUTRILETES FLORA
U	UPPER		UPPER		CONTINENTAL	′w³			
UPPER JURASSIC	TITHONIAN		PURBECK MIDDLE PURBECK		5	14/2 1√41		17, 22 35, 41	

			PALYNOLOG	MARINE				
		CENTRAL ALBERTA	MICROSPORES	MEGASPORES	MICROPLANKTON			
ROUP		JOLI FOU GRAND RAFIDS FM, CLEARWATER FM. CALCAREOUS MEMBER	1	ARCELLITES NUDUS	2			
MANNVILLE GROUP	MEMURRAY FM.	-???? ELLERSLIE MEMBER		ARCELLITES (=PYROBOLOSPORA)				
		DEVILLE MEMBER 2 2 2 2 2 2 2 2 2		FLORA				

LEGEND

- Appendicisporites perplexus n.sp.
 Cenningla colliveri Cookson and Elsenock.
 Appendicisporites tricomitatus Weyland and Greifeld.
- 17. Cicatricosisporites daragensis Potonie and Gelletich.
- 21. C. brevilaesuratus Couper.
- Dictyotriletes (Klukisporites) pseudoreticulatus (Couper) Pocock.
 Trilobosporites bemissartensis Delcourt and Sprumont.
- 36. T. apiverrucatus Couper.
- 37. Concerts indigential points (Concerts principle to the Concert and Sprumont) n., comb.
 41. Pilasisporites trichopopiillous (Thiergart) Delocurt and Sprumont.
 44. Cingulatisporites valdensis Couper.

- 48. Couperisporites (Cingulatisporites) complexus (Couper) Pocock.
- 49. Cingulatisporites sp.
- 50. C. foveolatus Couper.
- 70. Classopoliis torosus (Raissinger) Couper.
- 92. Clavatipollenites sp.

ooooo Marine transgression.

* The recticostatus Zone is included in Aption Stage in Spath's sense.

FIGURE 6. Microfloral correlation of Lower Cretaceous strata of northwestern Europe and east-central Alberta.

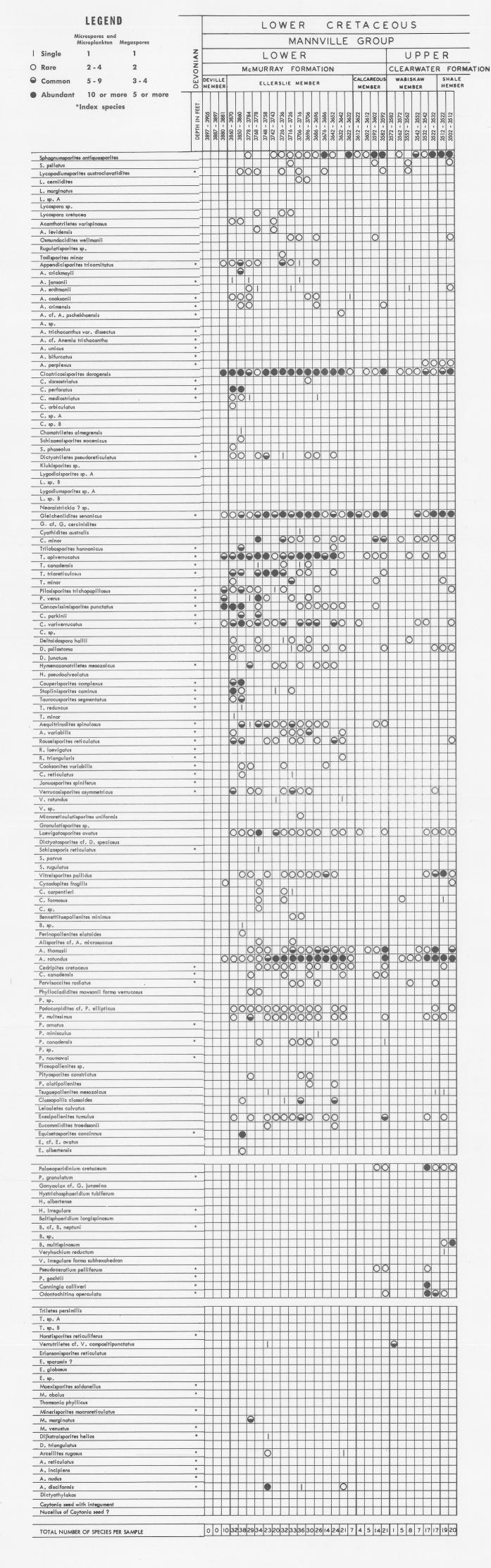


TABLE 2. RANGE CHART SHOWING THE DISTRIBUTION AND RELATIVE ABUNDANCES OF MANNVILLE MICRO-

FLORAL SPECIES IN IMPERIAL NAMAO NO. 1 WELL.

LEGEND	LOWER CRETACEOUS
Microspores and Z Microplankton Megaspores	MANNVILLE GROUP
Single	LOWER
 Common 5-9 3-4 □ Abundant 10 or more 5 or more 	McMURRAY FORMATION CALCAREOUS WABISKAW CALCAREOUS WABISKAW CALCAREOUS WABISKAW CALCAREOUS WABISKAW CALCAREOUS WABISKAW
*Index species	DEVILLE MEMBER MEMBER MEMBER
DEPTH IN	3275 - 3281 3266 - 3275 3266 - 3275 3266 - 3275 3276 - 3286 3277 - 3266 3277 - 3267 3270 - 3277 3270 - 3277 3271 - 3279 3271 - 3273 3272 - 3231 3272 - 3241 3272 - 3273 3273 - 3273 3274 - 2756 2272 - 2770 2272 - 2770 2273 - 2770 2272 - 2770 2273 - 2770 2273 - 2770 2273 - 2770 2274 - 2770 2274 - 2770 2275 - 2770 2277 - 2770 2277 - 2750 2277 - 2750 2277 - 2750 2277 - 2750 2277
Sphagnumsporites antiquasporites	
S. psilatus Lycopodiumsporites austroclavatidites * L. cerniidites	
L. marginatus L. sp. A Lycospora sp.	
Lycospora cretacea Acanthotriletes varispinosus A. levidensis	
Osmundacidites wellmanii Rugulatisporites sp. Todisporites minor	
Appendicisporites tricomitatus * A. crickmayii A. jansonii *	
A. erdtmanii A. cooksonii # A. crimensis #	
A. cf. A. pschekhaensis * A. sp. * A. trichacanthus var. dissectus *	
A. cf. Anemia trichacantha * A. unicus * A. bifurcatus *	
A. perplexus * Cicatricosisporites dorogensis C. dorsostriatus *	
C. perforatus * C. mediostriatus * C. orbiculatus	
C. sp. A C. sp. B Chomotriletes almegrensis	
Schizaeoisporites eocenicus S. phaseolus Dictyotri letes pseudoreti culatus *	
Klukisporites sp. Lygodioisporites sp. A L. sp. B	
Lygodiumsporites sp. A L. sp. B Neoraistrickia ? sp.	
Gleicheniidites senonicus * G. cf. G. cercinidites Cyathidites australis	
C. minor Trilobosporites hannonicus * T. apiverrucatus *	
T. canadensis * T. trioreticulosus * T. minor	
Pilosisporites trichopapillosus * P. verus * Concavissimisporites punctatus *	
C. parkinii * C. variverrucatus * C. sp.	
Deltoidospora hallii D. psilostoma D. junctum	
Hymenozonotriletes mesozoicus	
Staplinisporites caminus * Taurocusporites segmentatus * T. reduncus *	
T. minor Aequitriradites spinulosus * A. variabilis *	
Rouseisporites reticulatus * R. laevigatus * R. triangularis *	
Cooksonites variabilis * C. reticulatus * Januasporites spiniferus *	
Verrucosisporites asymmetricus * V. rotundus V. sp.	
Microreticulatisporites uniformis Granulatisporites sp. Laevigatosporites ovatus	
Dictyotosporites cf. D. speciosus Schizosporis reticulatus * S. parvus	
S. rugulatus Vitreisporites pallidus Cycadopites fragilis	
C. carpentieri C. formosus C. sp.	
Bennettitaepollenites minimus B. sp. Perinopollenites elatoides	
Alisporites cf. A. microsaccus A. thomasii A. rotundus	
Cedripites cretaceus * C. canadensis * Parvisaccites radiatus *	
Phyllocladidites mawsonii forma verrucosus P. sp. Podocarpidites cf. P. ellipticus	
P. multesimus P. ornatus * P. minisculus	
P. canadensis * P. sp. P. naumovai *	
Piceapollenites sp. Pityosporites constrictus P. alatipollenites	
Tsugaepollenites mesozoicus Classopollis classoides Leioaletes calvatus	
Exesipollenites tumulus Eucommiidites troedssonii Equisetosporites concinnus *	
E. cf. E. ovatus E. albertensis	
Palaeoperidinium cretaceum P. granulatum * Gonyaulax cf. G. jurassica	
Hystrichosphaeri dium tubiferum H. albertense H. irregulare *	
Baltisphaeridium longispinosum B. cf. B. neptuni * B. sp.	
B, multispinosum Veryhachium reductum V, irregulare forma subhexahedron	
Pseudoceratium pelliferum * P. gochtii * Canningia colliveri *	
Odontochitina operculata * Triletes persimilis	
T. sp. A T. sp. B Horstisporites reticuliferus *	
Horstisporites reticuliterus Verrutriletes cf. V. compositipunctatus Erlansonisporites reticulatus E. sparassis ?	
E. sparassis ? E. globosus E. sp. Maexisporites soldanellus *	
M. obolus * Thomsonia phyllicus	
M. marginatus M. venustus *	
D. triangulatus Arcellites rugosus *	
A. incipiens * A. nudus *	
Dictyothylakos Caytonia seed with integument	
Nucellus of Caytonia seed ? TOTAL NUMBER OF SPECIES PER SAMPLE	0 0 15 25 8 19 18 21 2 13 14 28 34 19 9 22 36 37 33 22 26 17 24 25 30 10 45 16 32 13 14 12 0 7 30 41 32 4 33 30 6 9 32 17 24 19 14 31 3 16 0 22 0 0 5 7 2 20 1 2 19 0 9 1 2 15 9 3 1 1 23 20 10 3 13 21 3 8 3 8 0 10 14 35 2 25 10 9 36 33 3 1



TABLE 4. RANGE CHART SHOWING THE DISTRIBUTION AND

RELATIVE ABUNDANCES OF MANNVILLE MICRO-

FLORAL SPECIES IN IMPERIAL WILLINGDON NO. 1 WELL.

TABLE 5. CHART	ž.				_							/ILI	EC	GRO	UP	-								1	N	MN				OUP		[INV	'ILLE	 E GF	ROUP
SHOWING THE		<u> </u>							(LO	WE	R)				┵		_			(U	IPPE	R)	_				(UI	PPER)]		(LO				PER)
STRATIGRAPHIC DISTRIBUTION OF MEGASPORES IN THE MANNVILLE GROUP OF EAST-CENTRAL ALBERTA.	ne-C.and E.Fort Augustus I (Lsd.7, Sec.29, Tp.55, th Mer.)	_	DEVILLE MEMBER		•	-			ELLERSLIE MEMBER						CALCAREOUS MEMBER	WARICKAW AKEAABED	TABLES AT WEIGHER			GRAND RAPIDS	FORMATION		-	Sec. 14, Tp.55, R. 15, W.4th Mer.)	CLEARWATER FORMATION	(SHALE MEMBER)				FORMATION	جُ ا	.54, R.24, W.4th Mer.)		ELLERSLIE MEMBER		WABISKAW MEMBER	
ALDENIA.	Anglo-Home-C.and E No. 1 well (Lsd.7, S R.21, W.4th Mer.)	3249-3257	3222-3231	3213-3222	3156-3165	3111-3120	3093-3102	3084-3093	3066-3075	3054-3062	3037-3046	3019-3028	3001-3010	2992-3001	2003-2032	2905-2914	2580-2508	2496-2505	2487-2496	2478-2487	2460-2469	2442-2451	2427-2433	Sec. 14, Tp	2045-2055	2013-2023	1931-1941	1846-1856	1816-1826	1791-1801	Imperial Namao	Sec. 22, 1p	3778-3784	3706-3716	3632-3642	3572-3582	i İ
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E. sp.			1	1	T	T	Г	\Box	1	_	7	\dashv	$^{+}$	\top	十	\top	T	† -			_	+	\dashv		\dashv	\pm	+	╁	H		┪	\vdash	+	+	╁	\dashv	
Maexisporites soldanellus		1	\dashv		\top	T	1	\Box		+	\dashv	十	十	+	+	+	╁╌	╁		\dashv	+	+	┪		\dashv	+	+	+		+-	┪	\vdash	+	+	╁	\dashv	
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Thomsonia phyllicus				\top	✝	1	1	Ħ	T	寸	\top	\dashv		\top	\top	╁	T	\dagger	Н	\dashv	\dashv	\top	┪		+	_	+	╆	H	1	-	┝	+	+	H	\dashv	
Minerisporites macroreticulatus		\dashv	\forall	+	\top		ΙĖ	H	7	\dagger	\dashv	\dagger	$^{+}$	+	+	╁╴	\dagger	†	H	37	2	4	\dashv		+	+		+	╁┤	⊹	\exists	+	+	+	$\vdash \vdash$	\dashv	
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Dijkstraisporites helios			ī	6	1	1	T	\Box	_	\top	\dashv	\dashv	\dashv	\dashv	T	\dagger	۲	\top	H	ᅥ	\dashv	-	\dashv	}	-	+	' '	+	╁┤	1	\exists	-	+-	+	╁	\dashv	
D. triangulatus		7	\top	+	†	<u> </u>		\vdash	\dashv	\dashv	+	\dashv	\forall	+-	+		+	+	+	\dashv	\dashv	\dashv	\dashv	ł	+	+		+		+	1	-	+	+-	₩	\dashv	
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A. nudus		_	\top	\top	\dagger	+	\vdash	\vdash	7	╧┼	+	\dagger	╫	+	\dagger	+	\dagger	†	H	$\overrightarrow{1}$	\dashv	2	\dashv	ł	+	+	+	+-	$\vdash \vdash$	+	-	+	+	+-	$\vdash \vdash$	\dashv	
A. disciformis		\dashv	\dashv	1	\top	4	-	\vdash	ī	+	2	\dagger	+	+	+	+	╁	+	H	┧	\dashv	-	\dashv	ł	+	٠,	-	+-	$\vdash \vdash$	+	-	\vdash	+-	╁	┧	\dashv	
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Caytonia seed ? with integument		\dashv	•	+	+	†	Н	\vdash	+	\dashv	+	+	\dagger	+'	十	+-	+-	+	╁┼	\dashv	\dashv		\dashv	ł	+	+	+'	+	<u> </u>	+	90	\vdash	+	+	$\vdash \vdash$	\dashv	
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		LOWER CRETACEOUS													
			MANNV	ILLE GROUP											
		LOWER		UPPER											
INDEX SPECIES		MURRAY F	м.	CLEARW	ATER FM.	GR. RPS. FM.									
	DEVILLE MEMBER	ELLERSLIE MEM8ER	CALCARE OUS MEMBER	WABISKAW MEMBER	SHALE MEMBER	LOWER	UPPER								
Lycopodiumsporites austroclavatidites Appendicisporites tricornitatus															
A. jansonii															
A. cooksonii															
A. crimensis A. cf. A. pschekhaensis															
A. trichacanthus var. dissectus		 	-												
A. cf. Anemia trichacantha			<u> </u>			1									
A. unicus															
A. bifurcatus															
A. perplexus	 					.	1								
Cicatricosisporites dorsostriatus C. perforatus	 						 								
C. mediostriatus							12								
Dictyotriletes pseudoreticulatus															
Gleichenfidites senonicus															
Trilobosporites hannonicus															
T. apiverrucatus T. canadensis							F								
T. trioreticulosus	† -														
Pilosisporites trichopapillosus	— —														
P. verus															
Concavissimisporites punctatus															
C. parkinii C. variverrucatus		<u> </u>													
Hymenozonotriletes mesozoicus						F									
Couperisporites complexus	—	ļ													
Staplinisporites caminus															
Taurocusporites segmentatus	ļ														
T. reduncus Aequitriradites spinulosus	ļ														
A. variabilis	 														
Rouseisporites reticulatus															
R. laevigatus															
R. triangularis															
Cooksonites variabilis C. reticulatus	====														
Januasporites spiniferus															
Verrucosisporites asymmetricus	1		1.0												
Schizosporis reticulatus															
Cedripites cretaceus															
C. canadensis Parvisaccites radiatus					,										
Podocarpidites ornatus					-										
P. canadensis	İ														
P. naumovai															
Equisetosporites concinnus															
Balana and district and distric															
Palaeoperidinium granulatum Hystrichosphaeridium irregulare															
Baltisphaeridium cf. B. neptuni							····								
Pseudoceratium pelliferum															
P. gochtii															
Canningia colliveri															
Odontochitina operculata															
Horstisporites reticuliferus						····									
Maexisporites soldanellus							—·								
M. obolus															
Minerisporites macroreticulatus															
M. venustus															
Dijkstraisporites helios Arcellites rugosus															
A. reticulatus	- 														
A. incipiens															
A. nudus															
A. disciformis															
					•										

LEGEND

Microspores and Microplankton Megaspores

---- 1 - 4 1 - 2

---- 5 or more 3 or more

TABLE 6. CHART SHOWING THE STRATI-GRAPHIC DISTRIBUTION OF MICRO-FLORAL INDEX SPECIES IN THE MANNVILLE GROUP OF EAST-CENTRAL ALBERTA.