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A DISSERTATION

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PALYNOLOGY AND STRATIGRAPHY OF THE LOWER CRETACEOUS ROCKS OF NORTHERN WYOMING

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PALYNOLOGY AND STRATIGRAPHY OF THE LOWER CRETACEOUS ROCKS OF NORTHERN WYOMING

INTRODUCTION

This study was begun in the summer of 1960 with the following objectives:

(1) To describe the palynological assemblages recovered from the Cloverly, Morrison, Lakota, Thermopolis, Fall River, Skull Creek, Muddy, and Newcastle Formations of northern Wyoming.

(2) To attempt a zonation and correlation of the Lower Cretaceous strata of northern Wyoming by the palynological method.

(3) To describe the paleoecology of the microorganisms which existed in the area during Lower Cretaceous time.

(4) To determine the depositional environment of the lithologic units by an analysis of their palynomorph content.

Investigation has not revealed any palynologic fossils in the Morrison, Cloverly, and Lakota Formations of the area with which this report is concerned. This dissertation consequently has been restricted to the rock stratigraphic section consisting of the Rusty beds, Thermopolis Shale, and Muddy Sandstone in western and central Wyoming and the Fall River, Skull Creek, and Newcastle Formations in the Black Hills area of eastern Wyoming.

Published works dealing with Lower Cretaceous palynology are few. Lower Cretaceous deposits in the U. S. S. R. have been investigated by Russian palynologists but little of their work is available. Considerable work has been done in Australia and in Europe. The only published paper dealing with Lower Cretaceous palynology in North America is a study by Pocock (1962) of Upper Jurassic and Lower Cretaceous strata from western Canada. This is a comprehensive paper but it treats with only a limited area and it is evident that much more work remains to be done before a thorough knowledge of the Lower Cretaceous palynology of North America will be available.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the Pure Oil Company for financial support during the course of this investigation.

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STRATIGRAPHY

The nomenclatural history of the formations involved in this study has been summarized by Waage (1959) and by Eicher (1960). The terminology applied to Lower Cretaceous rocks in central and western Wyoming differs somewhat from that used in the Black Hills. The table on page 5 is a summary of the terminology used in this paper.

Shell Creek Shale

In the Big Horn Basin, a well-developed section of soft black shale containing several prominent bentonite beds occurs between the top of the Muddy Sandstone and the base of the typical siliceous Mowry Shale. The U. S. Geological Survey regards this black shale unit as part of the Thermopolis Shale but other workers (Love, 1956) have placed the base of the Mowry at the top of the Muddy Sandstone. Eicher (1960) proposed the name Shell Creek Shale for this black shale interval and recommended that it be raised to formational rank. As defined by Eicher, the Shell Creek Shale

SUMMARY OF STRATIGRAPHIC TERMINOLOGY

Teton County	Big Horn Basin	Black Hills
Mowry Shale	Mowry Shale	Mowry Shale
	Shell Creek Shale	
Muddy Sandstone	Muddy Sandstone	Newcastle Formation
Thermopolis Shale	Thermopolis Shale	Skull Creek Shale
Rusty beds at base	Rusty beds at base	Fall River Formation
Cloverly and Morrison Formations Undivided	Cloverly and Morrison Formations Undivided	Lakota Formation
		Morrison Formation

includes the soft, black, bentonitic shale between the top of the Muddy Sandstone and the base of the hard, siliceous Mowry Shale. Eicher named the unit from exposures along Shell Creek near Greybull, Wyoming. According to Eicher, the Shell Creek Shale ranges from 200 to more than 300 feet in thickness in the Big Horn Basin but thins southeastward. In the Black Hills the Shell Creek Shale is apparently equivalent to a thin black shale unit between the Newcastle Formation and the overlying siliceous Mowry Shale. This thin shale unit was at one time designated as the Nefsy shale but this name has been discarded.

Eicher's recommendation is followed in this paper and the Shell Creek Shale is regarded as a unit of formational rank. The lower 80 feet of the Shell Creek Shale was sampled at the Big Horn County sample locality.

Muddy Sandstone

The Muddy Sandstone is a highly variable unit consisting of sandstone, siltstone, shale, and bentonite. At the Teton County sample locality the Muddy Sandstone is 45 feet thick and consists of two sandstone units separated by 20 feet of siltstone. Approximately one mile to the northwest the Muddy Formation consists of 50 feet of massive sandstone containing a few claystone lenses at the base. In the Big Horn Basin, the Muddy Sandstone is 36 feet thick at the sampled locality and consists predominantly of sandstone. According to Eicher (1960) the Muddy is variable both in thickness and lithology in the southern part of the Big Horn Basin and may lack prominent sandstone beds.

The Muddy Sandstone has never been formally recognized as a formation and a type section has never been designated. The name is firmly established in the literature, however, and the Muddy appears to be persistent over large areas, particularly in the Big Horn Basin. In spite of its lack of formal recognition, the Muddy Sandstone is herein regarded as a unit of formational rank.

Thermopolis Shale

The Thermopolis Shale was originally described by Lupton (1916) from exposures near the town of Thermopolis, Wyoming. As defined in this paper, the Thermopolis Shale includes only the lower part of Lupton's section. Specifically, the Thermopolis is defined as including the strata lying between the base of the Muddy Sandstone and the top of the Cloverly Formation. The Thermopolis consists of a thick sequence of black shale containing occasional thin siltstone beds and grading downward into a sequence of siltstone, sandstone, and shale beds at the base. This basal facies is commonly called the rusty beds and weathers to a rusty brown color, at many places forming prominent cliffs. Some workers have included the rusty beds in the upper part of the Cloverly Formation but they are herein regarded as basal Thermopolis.

The rusty beds are composed of interbedded sandstones, siltstones, and shales. Fucoidal markings are common and the beds are thin and lenticular. At the Hot Springs sample locality the rusty beds are 106 feet thick. In Teton County they form a prominent cliff and were measured as 103 feet thick. The rusty beds grade upward into a black shale sequence 180 feet thick at the Teton County locality and 170 feet thick in Hot Springs County.

Cloverly and Morrison Formations

Underlying the Thermopolis Shale in central and western Wyoming is a thick sequence of non-marine Lower Cretaceous and Upper Jurassic strata consisting of sandstones, variegated claystones, and occasional marls and limestones. No reliable criteria exist for the subdivision of this sequence and it is commonly referred to as the Cloverly and Morrison Formations undivided.

The Cloverly Formation was named by Darton in 1904 from exposures in the northeastern part of the Big Horn Basin but according to Burk (1957) "the typical Cloverly Formation can be recognized with certainty only in a very limited area at the eastern edge of the Big Horn Basin."

The Morrison Formation was named by Eldridge in 1896 from exposures near the town of Morrison, Colorado. In the Black Hills area the Morrison is recognizable as a distinct formation.

No palynological fossils were recovered from Cloverly or Morrison samples.

Newcastle Formation

The Newcastle Formation consists of sandstone, siltstone, shales, and occasional bentonites and lignites. The Newcastle crops out in a belt around the Black Hills and is supposedly correlative with the Muddy Sandstone of central and western Wyoming.

The Newcastle Formation was sampled near Newcastle, Wyoming. At this locality it consists predominantly of sandstones and shales.

Skull Creek Shale

The Skull Creek Shale was named by Collier in 1922 from exposures around Skull Creek southeast of Osage, Wyoming. The Skull Creek underlies the Newcastle Formation and crops out in a belt around the Black Hills. The formation ranges in thickness from approximately 110 feet to nearly 220 feet. The Skull Creek is composed of soft black shale with a few thin sandstone beds in the lower part.

The Skull Creek occupies the same stratigraphic position in the Black Hills area as does the Thermopolis Shale in central and western Wyoming but it is extremely doubtful that the two formations are strict time correlatives. The present study suggests that the Skull Creek in the sampled area around Newcastle, Wyoming, correlates only with the upper part of the Thermopolis in the central part of the State.

Fall River Formation

The Fall River Formation was described by Russell in 1928 from exposures in a quarry on Fall River near Hot Springs, South Dakota. The Fall River forms the upper part of what has been termed the Inyan Kara group in the Black Hills. According to Waage (1959) the basal contact of the Fall River with the underlying Lakota Formation is sharply marked by a transgressive disconformity. The upper contact with the Skull Creek Shale is normally quite gradational.

The Fall River is composed predominantly of sandstone with interbedded siltstones, shales, and occasional lignites. The formation ranges from 110 to 160 feet in thickness. The measured thickness of the Fall River at the sampled locality in Weston County is 142 feet.

Lakota Formation

The Lakota Formation forms the basal unit of the Inyan Kara group in the Black Hills as defined by Waage (1959). The Lakota is somewhat variable in thickness and lithology. Sandstones, siltstones, and variegated claystones are common, and local conglomerates may be present. In the eastern Black Hills, the Lakota contains a coal-bearing sequence.

COLLECTIONS

During the summers of 1960 and 1961 collections were made and sections measured of Lower Cretaceous rocks in Weston, Crook, Hot Springs, Big Horn, and Teton Counties in northern Wyoming. The Muddy Sandstone, Thermopolis Shale, Rusty beds, and Cloverly-Morrison undivided Formations were sampled in Teton County. In Big Horn County, collections were made of the lower Shell Creek Shale, the Muddy Sandstone, and the Thermopolis Shale. The lower Thermopolis Shale, the Rusty beds, and part of the upper Cloverly Formation were sampled in Hot Springs County. In Weston County, collections were made of the Newcastle Formation, the Skull Creek Shale, and the Fall River Formation. The Lakota and Morrison Formations were sampled in Crook County.

The sample localities are shown in Figure 1. Sample intervals and lithology are presented graphically in the columnar sections in Figure 2.

Samples were collected at each locality as segments of a channel. Each group of segment samples in a particular channel was assigned an OPC number (Oklahoma Palynological Collection). Individual segment samples in a channel were designated A, B, C, etc. from the base of the channel upward.

The following pages present a listing of the samples taken at each locality, their thickness, position in the section, and a brief lithological description. Measurements were made with a hand level and Brunton compass. Samples which were barren of palynological fossils are so noted. The residues from processing, as well as the unused portion of the samples are deposited in the palynological collection of the Oklahoma Geological Survey.

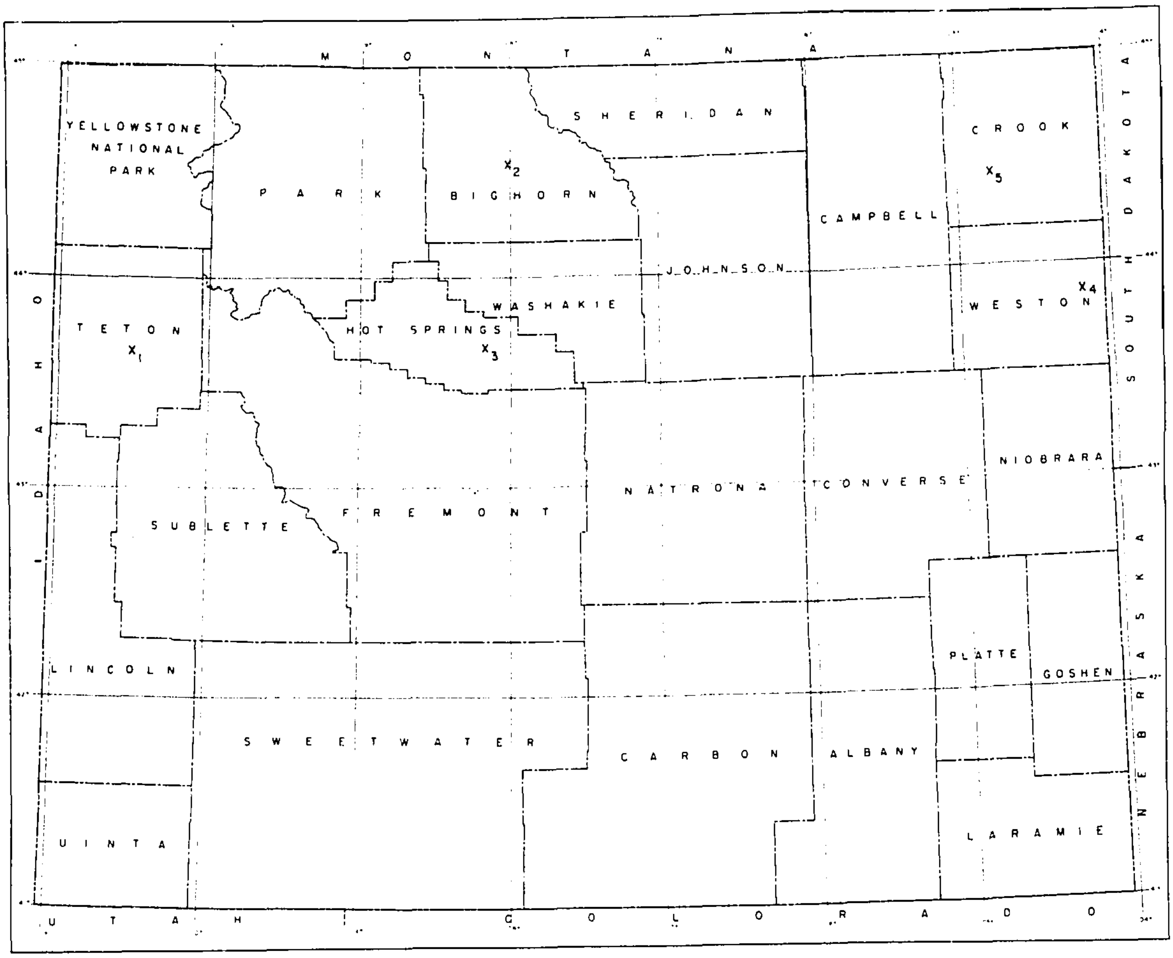

Fig. I INDEX MAP OF WYOMING
SHOWING SAMPLED LOCALITIES

1 Teton County Section

2 Big Horn County Section

3 Hot Springs County Section

4 Weston County Section

5 Crook County Section

Teton County Section

Exposure in a ridge to the west of Horsetail Creek, W½ Sec. 35, T. 43 N., R. 114 W., Teton Co., Wyoming.

Samples		Thickness in feet
Muddy Sandstone		
Sandstone, cross-bedded, fine-grained, massive, salt and pepper type, not collected		10.2
OPC 841B	Siltstone, gray, and shale, gray, sandy, poorly exposed.	15.4
Covered		5.0
OPC 841A	Sandstone, salt and pepper type, cross-bedded, massive at base, becoming thinner-bedded towards top. Sample barren.	14.0
	Total Muddy Sandstone	44.6

Section offset to ridge on north side of west end of Lower Slide Lake, SW¼ Sec. 33, T. 43 N., R. 114 W., Teton Co., Wyoming.

Thermopolis Shale		
Covered		5.0
OPC 840E	Shale, dark-gray to black, blocky.	10.0

Covered		6.0
OPC 840D	Shale, dark gray to black, blocky	10.4
OPC 840C	Shale, gray to black, blocky, grading downward from top of sample into black to gray, sandy, laminated siltstone in lower half of sample interval.	20.8
Covered		3.0
OPC 840B	Siltstone, gray to black, brownish laminae, sandy.	20.8
OPC 840A	Shale, dark gray to black, and siltstone, sandy; rare ironstone beds present.	20.8
Covered		28.8

Section offset approximately one mile east to SW¼ SE¼ sec. 34, T. 43 N , R. 114 W., Teton Co., Wyoming.

OPC 644C	Shale, black, fissile.	15.0
OPC 644B	Shale, black, fissile, siltstone beds present at top and base of sample interval.	26.0
OPC 644A	Shale, black, fissile, and siltstone, dark gray.	13.0
	Total Thermopolis Shale	180.0

Rusty beds		
OPC 643D	Siltstone, light-gray, laminated, and sandstone, light-gray to brown, thin-bedded.	20.0
OPC 643C	Siltstone, light-gray, laminated, and sandstone, light gray to tan, thin-bedded, shale partings present, fucoidal markings common.	22.5
OPC 643B	Shale, black, fissile, and siltstone, dark-gray to tan; three feet thick, cross-bedded sandstone present at top of sample interval.	23.5
OPC 643A	Shale, black, fissile, clayey, and siltstone, light-gray, rare sandstone present.	22.5
Covered		14.5
	Total Rusty beds	103.0

Approximately 600 feet of Cloverly-Morrison undivided was collected at this locality. All samples proved to be barren of fossils, however, and they have not been tabulated.

Big Horn County Section

Exposure in hillside southeast of junction of bentonite roads, about 5 miles northeast of Greybull, Wyoming. NE¼ Sec. 36, T. 53 N., R. 93 W., Big Horn Co., Wyoming.

Samples		Thickness in feet
Shell Creek Shale (lower 80 feet)		
OPC 839E	Shale, dark-gray to black, fissile, two-foot thick bentonite bed present one foot above base of sample.	15.6
Covered		5.2
OPC 839D	Shale, dark-gray to black, fissile	20.8
OPC 839C	Shale, dark-gray, fissile, and siltstone, dark-gray, in upper half of sample interval.	20.8
OPC 839B	Shale, dark-gray to black, fissile, six-inch thick bentonite bed at base of sample interval.	20.8
OPC 839A	Shale, black, lignitic, grades upward from base of sample into gray to black, carbonaceous siltstone, upper part of sample interval is	

	composed of dark gray to black, fissile shale; thin, light gray, laminated bentonite present 5 feet above base of sample interval. Sample barren.	7.2
Muddy Sandstone		
OPC 838E	Sandstone, tan, friable, coarse-grained, sandy lignite present in top half of sample. Sample barren.	0.9
OPC 838D	Lignite, black, sandy, weathers to a powdery dust. Sample barren.	1.2
OPC 838C	Sandstone, light-gray to light-brown, poorly indurated; contorted, lignitic laminae present in top 2 feet. Sample barren.	5.3
Sandstone, salt and pepper type, massive,	poorly indurated. Not collected	17.5
OPC 838B	Half-inch thick lens of black shale 2.8 feet above base of the Muddy.	
OPC 838A	Sandstone, salt and pepper, poorly indurated, massive, bedding irregular. Sample barren.	11.5
	Total Muddy Sandstone	36.4

Section offset about one mile to the north, exposure in a cliff on east side of bentonite road, NE¼ Sec. 24, T. 53 N., R. 93 W., Big Horn Co., Wyoming.

Thermopolis Shale

OPC 837H	Shale, dark-gray, blocky, and siltstone, light-gray to tan, sandy.	16.2
OPC 837G	Shale, dark-gray to black, blocky, deeply weathered.	14.4
OPC 837F	Shale, dark-gray to black, blocky, many laminae stained yellow, gypsum crystals present.	21.0
OPC 837E	Shale, gray to black, fissile, many laminae stained yellow, rare, rust-colored ironstone beds present, lower 6 feet of sample interval deeply weathered	22.6
OPC 837D	Shale, gray to black, fissile, rare brownish sandstone partings present.	25.0
	Shale, dark-gray to black, fissile, deeply-weathered, not collected.	2.0
	Sandstone, fine-grained, dark-gray to brown, well-indurated, iron-impregnated, bench-former, not collected.	3.0

OPC 837C	Shale, black to dark-gray, fissile, deeply weathered, rare stringers of tan sandstone present, thin ironstone bed at base of sample interval.	9.5
	Shale, gray to black, fissile, deeply-weathered; 2-foot thick, bench-forming, tan, very fine-grained, well-indurated sandstone present at base of interval. Not collected.	6.7

Section offset about ½ mile south to S½ Sec. 24, T. 53 N., R. 93 W., Big Horn Co., Wyoming.

	Shale, gray to black, fissile, deeply weathered, not collected.	9.0
OPC 837B	Shale, gray to black, fissile, and siltstone, gray, present in lower third of sample interval.	19.0
OPC 837A	Siltstone, gray to black, laminated, laminae contorted, and shale, gray to black; middle third of sample is predominantly shale, a few one-inch thick beds of brown to yellow sandstone present.	24.8
Covered	(approximately)	50.0
	Total Thermopolis Shale	223.2

Hot Springs County Section

Exposure in roadcut on highway 20 about 4 miles north of Thermopolis, Wyoming. NW¼ Sec. 19, T. 43 N., R. 94 W., Hot Springs Co., Wyoming.

Samples		Thickness in feet
Thermopolis Shale (lower part). The Thermopolis Shale, exclusive of the Rusty beds, was measured at this locality as 170 feet thick; only the lowermost portion was well enough exposed to collect.		
OPC 836C	Shale, black to gray, and siltstone, gray. Deeply weathered, sample barren.	6.0
OPC 836B	Shale, black, and siltstone, gray to black, deeply weathered.	8.7
OPC 836A	Shale, black, fissile, and siltstone, gray, some tan sandstone interbedded with the shale.	6.5
Rusty beds		
OPC 835H	Shale, black, fissile, and siltstone, gray, hard, a four-inch-thick ironstone bed caps this sample interval.	11.6

OPC 835G	Shale, black, and siltstone, gray, seven-inch-thick, gray ironstone bed present at base of sample.	10.0
OPC 835F	Siltstone, gray, and sandstone, tan to gray with considerable interbedded black shale.	14.7
OPC 835E	Siltstone, gray, hard, interbedded with thin sandstones and fissile, gray to black shale.	21.0
OPC 835D	Siltstone, gray, indurated, and shale, gray to black, with thin, interbedded sandstones, fucoidal markings common on bedding surfaces; six-inch-thick ironstone bed forms the top of this sample.	12.2
OPC 835C	Siltstone, gray, indurated, interbedded with thin sandstones, laminae of black shale present.	18.9
OPC 835B	Claystone, blocky, light-green at base, grading into purple and gray at top. Sample barren.	8.5
OPC 835A	Siltstone, gray, hard, and shale, gray. Siltstone and shale	

	lenticular and contorted, some interbedded sandstone present.	9.4
	Total Rusty beds	106.3
Cloverly Formation (in part)		
OPC 834C	Claystone, red, green, and gray, present in upper 2 feet of sample, basal 7 feet of sample interval composed of tan, thick-bedded, cross-bedded, sandstone. Sample barren.	9.0
OPC 834B	Claystone, red, green, gray, and purple, hard, calcareous in zones. Sample barren.	10.1
	Sandstone, tan, thick-bedded at top, becoming less thickly-bedded towards base. Not collected.	6.5
OPC 834A	Claystone, light-gray, calcareous. Sample barren.	5.5

Weston County Section

Exposure in roadcut on highway 85, about ½ mile north of Newcastle, Wyoming. NW¼ Sec. 28, T. 45 N., R. 61 W., Weston Co., Wyoming.

Samples		Thickness in feet
Newcastle Formation		
Sandstone, tan, not collected.		3.0
OPC 637K	Shale, very light-gray, bentonitic, becomes sandy towards top. Sample barren.	9.4
OPC 637J	Shale, gray to black, and sandstone, gray, carbonaceous. Shale is gray and sandy at base of sample, is lignitic in middle and top of sample.	6.4
OPC 637I	Sandstone, brownish yellow at base, gray at top, friable, carbonaceous near base, sample barren.	5.3
OPC 637H	Shale, black, lignitic at base, becoming gray and sandy at top; one-inch-thick bentonite bed present in middle of sample interval.	3.5

OPC 637G	Sandstone, carbonaceous, brown and friable at base, becoming gray and massive at top. Sample barren.	4.3
OPC 637F	Shale, black, blocky, sample barren.	2.5
OPC 637E	Sandstone, yellow brown at base, becoming gray at top, carbonaceous at base, sample barren.	13.0
OPC 637D	Shale, black, blocky, becoming lignitic near top of sample interval, interbedded, yellowish sandstone present near top.	6.4
OPC 637C	Sandstone, gray, carbonaceous.	2.4
OPC 637B	Shale, black, blocky, sandy near middle of sample interval, sample barren.	6.7
OPC 637A	Shale, black, blocky, contains fossil leaves. Sample barren.	5.4
	Total Newcastle	68.3

Section offset to ridge to the north of Newcastle, NW¼ Sec. 19, T. 45 N., R. 61 W., Weston Co., Wyoming.

Skull Creek Shale

OPC 636	Shale, black, fissile, stained brown in zones, occasional thin

	sandy lenses, poorly exposed.	12.0

Section offset to exposure in cliff east of old highway 85, SE¼ SE¼ Sec. 12, T. 43 N., R. 61 W., Weston Co., Wyoming.

Covered		25.0
OPC 847D	Shale, black, fissile, laminae stained yellow, selenite crystals present.	17.0
OPC 847C	Shale, black, fissile, thin ironstone bed near top of sample interval.	8.5

Section offset to exposure in hillside approximately 4.5 miles west of Newcastle, NW¼ Sec. 15, T. 45 N., R. 62 W., Weston Co., Wyoming.

OPC 635C	Shale, dark-gray to black, fissile, occasional brownish laminae, one-foot-thick ironstone bed present 7 feet above base of sample interval.	21.5
Covered		11.5
OPC 635B	Shale, dark-gray to black, fissile, occasional sandy partings.	18.3
OPC 635A	Shale, dark-gray to black, fissile, and sandstone, fine-grained, light-gray, stained reddish brown, iron impregnated. Two thin sandstome	

	beds in this sample, one 7 inches thick at the top of the sample interval and the other 1 foot thick occurring 4.5 feet above the base of the sample.	6.1
Covered		17.6
	Total Skull Creek Shale	137.5

Section offset to exposure in banks of Cambria Creek, just in back of the Newcastle City Maintenance Shop. SE¼ Sec. 20, T. 45 N., R. 61 W., Weston Co., Wyoming.

Fall River Formation

OPC 634R	Sandstone, fine-grained, very thin-bedded, and shale, gray to black.	22.4
OPC 634Q	Sandstone, brown, fine-grained, and shale, dark-gray fissile.	2.5
OPC 634P	Sandstone, very thin-bedded, fine-grained, and shale, black, sandy	17.7
OPC 634O	Sandstone, yellow-brown, fine-grained, friable, half-inch-thick gray shale parting present 8 inches from top of sample.	2.4
OPC 634N	Siltstone, gray, sandy, very thin-bedded, and shale, dark-gray.	10.3

OPC 634M	Lignite.	0.5
OPC 634L	Sandstone, yellow to white, fine-grained, cross-bedded, friable, and siltstone, dark-gray, occurring near base of sample interval and showing flow casts; sample barren.	12.7
OPC 634K	Siltstone, gray, sandy; shale, gray, fissile, and sandstone, brown, ripple-marked.	10.8
OPC 634J	Sandstone, brown, irregularly bedded, cross-bedded, interbedded gray shale and siltstone.	8.4
Covered		5.2
OPC 634I	Sandstone, brown, bedding irregular, ripple-marked, flow casts, cross-bedded, interbedded with gray, sandy siltstone and gray shale.	8.4
OPC 634H	Siltstone, gray to black, laminated; sandstone, yellow-brown, very thin-bedded, and shale, gray to black, sample barren.	18.8
OPC 634G	Sandstone, gray, thin to medium-bedded, and siltstone, gray,	

	laminated, some black shale, sample barren.	17.5
OPC 634B-F	Lignite, 2-foot-thick gray shale parting in middle of sample interval.	4.3
	Total Fall River	141.9

Crook County Section

Exposure in a hillside, NW¼ SE¼ Sec. 14, T. 61 N., R. 66 W., Crook Co., Wyoming.

Sample		Thickness in feet
Lakota Formation		
OPC 633D	Shale, olive at base of sample interval, becoming gray and black upward, and claystone, green to purple, rare sandstone, black shale at top of sample interval.	28.0
OPC 633C	Claystone, gray to olive, and shaly siltstone, gray, containing rounded pebbles, basal one foot of sample interval is composed of light-gray shale. Sample barren.	21.0
OPC 633B	Claystone, gray to gray-green, sandy, slightly conglomeratic, and siltstone, gray, conglomeratic in zones, rare sandstone, sample barren.	17.0
OPC 633A	Claystone, olive-green, sandy, slightly conglomeratic, sample barren.	7.0

Covered		87.0
	Total Lakota Formation	160.0

Section offset to exposure in a hillside near Inyan Kara Creek, SE¼ Sec. 25, T. 52 N., R. 66 W., Crook Co., Wyoming.

Lakota Formation (lower 15 feet)

OPC 632	Sandstone, gray to white, reddish and brown stains, occasional dark laminae, small, rounded chert pebbles in basal portion, upper part of sample is conglomeratic and cross-bedded, sample barren.	15.5

Morrison Formation

Covered		5.0
OPC 631F	Claystone, brownish-gray to dark-gray. Sample barren.	5.3
Covered		19.7
OPC 631E	Claystone, brownish-gray in upper part of sample, gray-green in lower part, sample barren.	10.8
Covered		5.0
OPC 631D	Claystone, gray-green, blocky, and limestone, fine-grained, occurs as thin beds and nodules. Sample barren.	10.8

OPC 631C	Claystone, gray-green, reddish-brown zones, blocky, and limestone, gray, very fine-grained, occurs as lenses and nodules, one-foot-thick limestone bed is present 6 feet below the top of the sample interval. Sample barren.	21.8
OPC 631B	Claystone, gray-green and reddish-brown, slightly calcareous, sample barren.	17.3
Covered		10.8
OPC 631A	Claystone, gray-green, blocky, and limestone, light-gray, very fine-grained. Sample barren.	6.0
	Total Morrison Formation	112.5

LABORATORY AND STUDY TECHNIQUES

The laboratory techniques used in this study were essentially those outlined by Wilson (1959a). Each sample was crushed into fragments approximately one-eighth inch in diameter and thoroughly mixed. Approximately five grams of each sample was placed in a polyethylene beaker and covered with 52 percent hydrofluoric acid for 24 hours with periodic stirring. Samples containing calcareous material were covered with concentrated hydrochloric acid for 8 to 10 hours prior to treatment with the hydrofluoric acid. Following treatment with HF, each sample was thoroughly washed with distilled water and examined with the microscope. Samples containing a high percentage of organic material were treated with Schulze's solution (potassium chlorate and concentrated nitric acid) for five minutes to one hour, depending on the amount of organic material present. During this stage of the treatment, the sample was checked with the microscope to determine the progress of the reaction. The residue from the treatment with Schulze's solution was again thoroughly washed with distilled water and treated with ammonium hydroxide for not longer than five minutes. The residues from hydrofluoric acid and from treatment with Schulze's solution and ammonium hydroxide contained a high percentage of insoluble mineral fragments. The microfossils were separated from the mineral matrix by heavy liquid flotation using a solution of stannic chloride with a specific gravity of approximately 1.85. The procedure used in this step was that outlined by Urban (1961) and Davis (1961). The microfossil residues were thoroughly washed and stored in distilled water to which a few drops of acetic acid were added as a preservative.

Lignite samples were processed by the following methods. They were first treated with hydrofluoric acid for 24 hours and then with Schulze's solution for 6 to 8 hours. The residues from the Schulze's treatment were washed and treated with a 10 percent solution of potassium carbonate for approximately 10 minutes. The residues from this step were washed and stored in distilled water and acetic acid.

Slides were prepared following the methods set forth by Funkhouser and Evitt (1959) and Wilson (1959b). A portion of the residue from each fossiliferous sample was stained with Safranin O, mounted on a cover slip in Clearcol, and dried; the coverslips were then mounted on microslides.

Approximately 10 slides were made from each sample.

The slides were studied with an American Optical compound binocular microscope. Microfossils selected for photographs were ringed with glass-marking ink. The cataloging system used to designate each specimen refers to sample number, slide number, and ring number. For example, slide number OPC 634Q-5-4 refers to ring number 4 on slide number 5 of the series of slides made from sample OPC 634Q. Specimens were photographed with a Zeiss Photomicroscope on Adox KB-14 film.

The fossils present were identified and assemblage counts were made. Two hundred individuals were counted from each fossiliferous sample. Several slides were used per sample to insure random sampling. Relative percentages of species present in each level were computed and the results plotted as histograms. Slides containing figured specimens have been deposited in the palynological collection of the Oklahoma Geological Survey.

PALEONTOLOGY

The total palynological assemblage reported in this paper consists of 58 genera and 122 species of microfossils of which 4 genera and 64 species are regarded as having been previously undescribed. Specifically, the assemblage is composed of 24 genera and 52 species of fossil spores, 11 genera and 20 species of fossil gymnosperm pollen, 4 genera and 9 species of fossil pollen of probable angiosperm affinities, 5 genera and 8 species of fossil dinoflagellates, 8 genera and 26 species of hystrichosphaerids, and 6 genera and 7 species of problematical fossils which are probably planktonic in origin.

Fossil spores and pollen are classified according to the system of Potonié (1956, 1958, and 1960). Although in many respects inadequate, this system is the most comprehensive and up-to-date available and is utilized by most investigators. In questions of synonymy or priority, the International Rules of Botanical Nomenclature have been followed.

Names have not been assigned to the new genera and species described in this study.

Many of the palynological fossil species recognized in this study are represented by only a small number of specimens. In cases where a species was judged to be undescribed but too few specimens were available to adequately describe the range of morphological variation, no typical specimen was chosen.

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch, 1881 emend. Potonié and Kremp, 1954

Subturma AZONOTRILETES Luber, 1935

Infraturma LAEVIGATI Bennie and Kidston, 1886
emend. Potonié, 1956

Genus CYATHIDITES Couper, 1953

Type species: *Cyathidites australis* Couper, 1953
(p. 27, pl. 2, fig. 11).

CYATHIDITES AUSTRALIS Couper, 1953

Plate 1, fig. 1

Specimens herein assigned to *C. australis* are slightly smaller than those described by Couper but are otherwise similar.

Affinity: Filicinean, probably related to the Cyatheaceae or Dicksoniaceae.

Stratigraphic occurrence: Rare in the Rusty beds, Hot Springs County, and in the Fall River Formation, Weston County.

CYATHIDITES MINOR Couper, 1953

Plate 1, fig. 2

C. minor was originally described by Couper from the Jurassic of New Zealand. In 1958 he recognized similar spores in the Jurassic and Lower Cretaceous of Britain. The thin wall and small size of this species distinguish it from C. australis.

Affinity: Filicinean, probably related to either the Cyatheaceae or the Dicksoniaceae.

Stratigraphic occurrence: Abundant in all formations in all three sections.

Figured specimen: Slide No. OPC 837H-4-5, Thermopolis Shale, Big Horn County.

Genus GLEICHENIIDITES Ross, 1949 emend.
Delcourt and Sprumont, 1955

Type species: Gleicheniidites senonicus Ross, 1949
(p. 31, pl. 1, fig. 3).

GLEICHENIIDITES SP. A

Plate 1, figs. 3 and 4

Spores radial; trilete; outline triangular, corners sharply rounded, sides straight to slightly concave or convex; trilete rays reach to margin of spore, lips slightly raised; wall laevigate, 1-1.5 microns thick at corners, thickens to 3.0-4.0 microns between corners; distal side frequently folded parallel to margins; overall diameter 21.0 -31.0 microns.

Typical specimen: Slide No. OPC 635A-12-2, Skull Creek Shale, Weston County, Wyoming. Dimensions 27.9 x 28.0 x 26.0 microns.

This species resembles Cingutriletes interruptus Pierce, 1961 (p. 26) from the Upper Cretaceous of Minnesota. The species is characterized by the excessive wall thickness between the corners.

Affinity: Spores of this type are comparable with those of the genus Gleichenia, an extant filicinean.

Stratigraphic occurrence: Occurs in minor to major abundance in all formations in all three sections.

Figured specimens: Slides No. OPC 635A-12-2, Skull Creek Shale, Weston County, and OPC 637J-1-11, Newcastle Formation, Weston County.

Genus CONCAVISPORITES Pflug, 1953 emend.
Delcourt and Sprumont, 1955

Type species: Concavisporites rugulatus Pflug in Thomson and Pflug (p. 49, pl. 1, fig. 22).

CONCAVISPORITES VARIVERRUCATUS Couper, 1958

Plate 1, fig. 5

Spores from Wyoming assigned to this species are comparable in every respect with Couper's description and photographs of the species. Couper's specimens are from the Middle Jurassic and Lower Cretaceous of Britain.

Affinity: Filicinean, Couper suggested a cyatheaceous or dicksoniaceous origin for this genus.

Stratigraphic occurrence: Rare in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634I-2-3, Fall River Formation, Weston County.

Genus LYGODIUMSPORITES Potonié, Thomson and Thiergart, 1950
emend. Potonié, 1956

Type species: Lygodiumsporites adriennis (Potonié and Gelletich, 1933) Potonié, Thomson and Thiergart, 1956 (p. 45, pl. C, fig. 2).

1933 Punctatisporites adriennis Potonié and Gelletich (p. 521, pl. 2, figs. 14 and 15).

LYGODIUMSPORITES MINOR (Couper, 1958) n. comb.

Plate 1, fig. 6

1958 Todisporites minor Couper (p. 134, pl. 16, figs. 6-8).

Couper (1958) erected the genus Todisporites to contain spherical, thin-walled, trilete spores which he observed in the Middle Jurassic of Yorkshire. This genus, however, is obviously synonymous with Lygodiumsporites. Specimens from Wyoming which have been assigned to this species appear similar to T. minor as described by Couper.

Affinity: Filicinean, possibly related to the Osmundaceae.

Stratigraphic occurrence: Present as a minor element in all formations in all three sections.

Figured specimen: Slide No. OPC 644A-9-1, Thermopolis Shale, Teton County, Wyoming.

LYGODIUMSPORITES SP. A

Plate 1, fig. 9

Spores radial; trilete; broadly triangular to subspherical; trilete rays distinct, lips thickened and raised, rays extend nearly to margin of spore; exine 2.0-4.0 microns thick, levigate; overall diameter 30.0-51.0 microns.

Typical specimen: Slide No. OPC 635A-7-6, Skull Creek Shale, Weston County, Wyoming. Dimensions 48.3 x 47.0 x 48.3 microns.

This species is distinguished by the raised and thickened areas at the margins of the trilete rays and by its thick wall.

Affinity: Probably filicinean.

Stratigraphic occurrence: Rare in the Rusty beds, Thermopolis Shale, and Muddy Sandstone in Teton County and in the Lakota, Fall River, and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 635A-7-6, Skull Creek Shale, Weston County.

LYGODIUMSPORITES SP. B

Plate 1, figs. 7 and 8

Spores radial; trilete; subspherical, outline roundly triangular; trilete distinct, rays extend nearly to margin, ray margins slightly thickened; wall 1.0-2.0 microns thick, externally smooth, internally densely punctate to micro-reticulate; overall diameter 38.0-56.0 microns.

Typical specimen: Slide No. OPC 634Q-1-6, Fall River Formation, Weston County, Wyoming. Dimensions 53.3 x 53.3 x 54.0 microns.

The distinct infrapunctations and the thickened areas bordering the trilete rays characterize this species. Potonié (1956) stated that this genus may include forms with infrapunctate ornamentation; therefore, the placement of the species in Lygodiumsporites seems justified.

Affinity: Filicinean.

Stratigraphic occurrence: Present as a rare element in the Rusty beds, Teton and Hot Springs Counties, the upper Thermopolis Shale, Big Horn County, and the Fall River Formation, Weston County.

Figured specimens: Slides No. OPC 634Q-1-6, and OPC 634I-4-6, Fall River Formation, Weston County.

Genus AURITULINASPORITES Nilsson, 1958

Type species: Auritulinasporites scanicus Nilsson, 1958 (p. 35, pl 1, fig. 16).

AURITULINASPORITES cf. A. INTRASTRIATUS Nilsson, 1958

Plate 1, fig. 10

Spores radial; outline triangular, sides straight to concave; trilete distinct, lips slightly thickened and raised, rays extend to margin of spore; surface laevigate, proximal surface flat to convex, distal surface with a continuous, thickened ridge, 2.0-4.0 microns wide, parallel to margins of spore and intersecting the corners perpendicular to the trilete rays; overall diameter 16.0-28.0 microns.

This form is similar to A. intrastriatus except that it lacks the striations parallel to the thickened zone which Nilsson described. These markings are not visible on Nilsson's illustrated specimen, however, and because the Wyoming specimens seem to be similar in all other respects to

Nilsson's species they have been referred to it. This form is similar to *Concavisporites montis brassicae* Thiergart, 1953 and to *Concavisporites jurienensis* Balme, 1957. As defined by Delcourt and Sprumont (1955) *Concavisporites* includes only those forms with concave sides and a thickening paralleling the trilete mark. It is obvious that they were discussing a proximal thickened zone. Specimens herein placed in *Auritulinasporites* possess a thickened ridge paralleling the rays of the trilete but this ridge occurs on the distal side of the spore and the specimens are obviously distinct from the type of spores included in the genus *Concavisporites*.

Affinity: Possibly filicinean.

Stratigraphic occurrence: Present as a trace in the Rusty beds and Thermopolis Shale, Teton County, and in the Thermopolis Shale, Big Horn County. Rare in the Lakota, Fall River, Skull Creek, and Newcastle Formations, Weston County.

Figured specimen: Slide No. OPC 643A-3-2, Rusty beds, Teton County.

SPORE TYPE A

Plate 1, fig. 11

Spore radial; trilete; originally probably spherical, badly folded and compressed; trilete rays extend 1/3-1/2 radius of spore, lips slightly raised; exine thin, externally laevigate, internally punctate; diameter 109-114 microns.

Only one specimen of this spore type was observed.

Affinity: Possibly a filicinean megaspore.

Figured specimen: Slide No. OPC 637H-8-1, Newcastle Formation, Weston County.

Infraturma APICULATI Bennie and Kidston, 1886
emend. Potonié, 1956

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

Type species: Granulatisporites granulatus Ibrahim, 1933
(p. 22, pl. 6, fig. 51).

GRANULATISPORITES SP. A

Plate 1, fig. 12

Spores radial; trilete; rounded triangular, corners broadly rounded, sides concave, rarely straight; trilete simple, rays extend 3/4 distance to margin; wall 2.0-2.5 microns thick, ornamented with low, rounded, densely packed granules, maximum diameter of granules 1 micron; overall diameter 50.0-77.0 microns.

Typical specimen: Slide No. OPC 643A-1-5, Rusty beds, Teton County, Wyoming. Dimensions 66.0 x 66.0 x 63.5

microns.

Affinity: Probably filicinean.

Stratigraphic occurrence: Rare in the Rusty beds and lower Thermopolis Shale, Teton County, and in the Rusty beds, Hot Springs County.

Figured specimen: Slide No. OPC 643A-1-5, Rusty beds, Teton County.

GRANULATISPORITES SP. B

Plate 2, fig. 1

Spores radial; trilete; rounded triangular, corners broadly rounded, sides straight to concave; trilete simple, rays extend 1/3-1/2 distance to margin; wall 1 micron thick, ornamented with small, closely spaced granules, all less than 1 micron in diameter; overall diameter 33.0-41.0 microns.

Typical specimen: Slide No. OPC 635B-5-7, Skull Creek Shale, Weston County, Wyoming. Dimensions 33.0 x 33.0 x 33.0 microns.

Affinity: Probably filicinean.

Stratigraphic occurrence: Rare in the Thermopolis Shale, Teton and Big Horn Counties, and in the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 635B-5-7, Skull Creek Shale, Weston County.

Genus LEPTOLEPIDITES Couper, 1953

Type species: Leptolepidites verrucatus Couper, 1953

(p. 28, pl. 2, fig. 14).

LEPTOLEPIDITES VERRUCATUS Couper, 1953

Plate 2, fig. 2

This species was originally described by Couper from the Jurassic of New Zealand. The Wyoming specimens compare closely with Couper's description and illustrations of the type specimen.

Affinity: Filicinean.

Stratigraphic occurrence: Present in the Fall River and Newcastle Formations, Weston County.

Figured specimen: Slide No. OPC 634I-13-1, Fall River Formation, Weston County.

LEPTOLEPIDITES MAJOR Couper, 1958

Plate 2, fig. 3

Couper described this species from the Middle Jurassic of Yorkshire, England. A few spores from the Fall River and Skull Creek Formations were seen which differ from Couper's description of the species only in that the diameter of their verrucose sculpture elements is 2 to 3 microns less than that of the English specimens. This is certainly too minor a character to warrant the erection of a new species and the Wyoming forms have accordingly been equated with Couper's species.

Affinity: Filicinean.

Stratigraphic occurrence: Present in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 634Q-3-2, Fall River Formation, Weston County.

LEPTOLEPIDITES SP. A

Plate 2, figs. 4 and 5

Spores radial; trilete; rounded triangular, sides straight to convex; trilete rays extend 3/4-4/5 distance to margin, lips slightly raised; proximal and distal ornamentation composed of irregular, smooth, lophate to verrucose ridges, 2 to 7 microns wide, 2 to 4 microns high; wall 2-4 microns thick; overall diameter 45.0-64.0 microns.

Typical specimen: Slide No. OPC 634P-11-1, Fall River Formation, Weston County, Wyoming. Dimensions 48.3 x 48.3 x 45.7 microns.

Affinity: Probably filicinean.

Stratigraphic occurrence: Present in the Rusty beds, Teton County, and in the Fall River Formation Weston County. Rare in the upper part of the Thermopolis Shale and in the Muddy Sandstone, Teton County.

Figured specimens: Slides No. OPC 634P-11-1, Fall River Formation, Weston County, and OPC 643D-3-1, Rusty beds, Teton County.

LEPTOLEPIDITES SP. B

Plate 2, fig. 6

Spores radial; trilete; outline rounded triangular; trilete simple, rays extend 4/5 of distance to spore margin; wall 1.5-2.0 microns thick, ornamented with small, rounded, verrucose projections, 1 to 2 microns broad, 1 micron or less high; overall diameter 34.0-66.0 microns.

Description based on only three specimens.

Affinity: Probably filicinean.

Stratigraphic occurrence: Present as a trace in the middle part of the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634K-6-10, Fall River Formation, Weston County.

Genus OSMUNDACIDITES Couper, 1953

Type species: _Osmundacidites_ _wellmanii_ Couper, 1953 (p. 20, pl. 1, fig. 5).

OSMUNDACIDITES WELLMANII Couper, 1953

Plate 2, fig. 7

Spores from Wyoming which have been assigned to this species appear similar to Couper's figured specimens.

Affinity: Couper (1958) referred this species to the Osmundaceae.

Stratigraphic occurrence: Rare in the Rusty beds, Teton County, the upper part of the Thermopolis Shale, Big Horn County, and in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 837H-2-6, Thermopolis Shale, Big Horn County.

OSMUNDACIDITES SP. A

Plate 2, fig. 8

Spores radial; trilete; subspherical; trilete simple, rays extend to margin of spore; wall approximately 1.5 microns thick, ornamented with smooth, slightly irregular verrucae, 1 to 3 microns broad, 2 microns high, smaller verrucae appearing papillate; overall diameter 30.0-38.0 microns.

Typical specimen: Slide No. OPC 635B-1-9, Skull Creek Shale, Weston County, Wyoming. Dimensions 30.5 x 30.5 x 30.5 microns.

Affinity: Filicinean, possibly related to the Osmundaceae.

Stratigraphic occurrence: Present in the Skull

Creek Shale, Weston County, and in the Thermopolis Shale, Teton County.

Figured specimen: Slide No. OPC 635B-1-9, Skull Creek Shale, Weston County.

Genus ANEMIIDITES Ross, 1949

Type species: Anemiidites echinatus Ross, 1949 (p. 32, pl. 1, figs 17 and 18).

ANEMIIDITES ECHINATUS Ross, 1949

Plate 2, fig. 9

Ross described this species from the Cretaceous of Scandia. Only a few specimens of this species were observed in the Wyoming Lower Cretaceous.

Affinity: Probably filicinean.

Stratigraphic occurrence: Present as a trace in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 634I-2-2, Fall River Formation, Weston County.

ANEMIIDITES SP. A

Plate 2, fig. 10

Spores radial; trilete; rounded triangular; trilete rays extend to margin of spore, lips slightly thickened; exine spinose, spines 1.5 microns thick at base, 1.5 to 3.0

microns long, tapering to a point; overall diameter 16.0 to 21.0 microns.

Description based on only three specimens.

Affinity: Probably filicinean.

Stratigraphic occurrence: Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 636-1-2, Skull Creek Shale, Weston County.

Genus PILOSISPORITES Delcourt and Sprumont, 1955

Type species: Pilosisporites trichopapillosus (Thiergart, 1949) Delcourt and Sprumont, 1955 (p. 34, pl. 3, fig. 3).

1949 Sporites trichopapillosus Thiergart (p. 22, pl. IV/V, fig. 18).

PILOSISPORITES TRICHOPAPILLOSUS (Thiergart, 1949)
Delcourt and Sprumont, 1955
Plate 2, fig. 12

This distinctive spore is common in the Rusty beds and in the Fall River Formation. In this species, the long, curved spines are concentrated at the corners of the spore.

Affinity: Unknown.

Stratigraphic occurrence: Present as a minor element in the Rusty beds, Teton County. Rare in the Rusty beds in Hot Springs County and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 643A-4-2, Rusty beds, Teton County.

PILOSISPORITES ERICIUS Delcourt and Sprumont, 1955

Plate 2, fig. 11

In this species, the spinose projections are evenly distributed over the spore coat rather than being concentrated at the corners. A considerable amount of gradation exists between the type of ornamentation shown by *P. trichopapillosus* and this species. As Couper (1958) suggested, the separation of the two species may have little natural validity. However, the two seem to be distinct in the Wyoming samples and are here regarded as separate species.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Rusty beds and lower part of the Thermopolis Shale, Teton County, the Rusty beds, Hot Springs County, and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634Q-5-4, Fall River Formation, Weston County.

Infraturma MURONATI Potonié and Kremp, 1954

Genus LYCOPODIACIDITES Couper, 1953

Type species: *Lycopodiacidites bullerensis* Couper, 1953 (p. 26, pl. 1, fig. 9).

LYCOPODIACIDITES SP. A

Plate 3, fig. 1

Spores radial; trilete; subspherical, outline circular; trilete simple, rays extend to margin of spore; proximal surface laevigate, distal surface with thick outer coat ornamented with short, thick, sinuous ridges and irregular verrucose projections, ridges 3.0 to 3.5 microns wide, 1.5 to 2.0 microns high, verrucae 1.0 to 3.0 microns broad, 1.5 to 2.0 microns high; overall diameter 33.0-41.0 microns.

Too few specimens were seen to warrant the designation of a type. The species is characterized by its circular outline and the thick, verrucose distal ornamentation.

Affinity: Couper (1953) suggested possible lycopodiaceous affinities for this genus.

Stratigraphic occurrence: Present in the spore flora of the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 635A-1-3, Skull Creek Shale, Weston County.

LYCOPODIACIDITES SP. B

Plate 3, figs. 2, 3, and 4

Spores radial; trilete; outline rounded triangular, sides straight to convex, trilete lips slightly raised and thickened, trilete rays extend to margin of spore; proximal surface laevigate, occasionally with low verrucose projections occurring at corners, distal surface covered by a thick outer coat 1.0-2.5 microns thick, ornamented with thin, contorted ridges and verrucose projections, ridges and verrucae 1.0-2.0 microns broad, 1.0-2.0 microns high; overall diameter 26.0-45.0 microns.

Typical specimen: Slide No. OPC 644A-5-1, Thermopolis Shale, Teton County, Wyoming. Dimensions 27.9 x 27.4 x 26.5 microns.

This species is characterized by the thin, subreticulate nature of the distal ornamentation.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Termopolis Shale, Teton County, the Rusty beds, Thermopolis Shale, and Muddy Sandstone, Hot Springs and Big Horn Counties and in the Skull Creek Shale, Weston County.

Figured speciemns: Slides No. OPC 644A-5-1, Thermopolis Shale, Teton County and OPC 635A-10-2, Skull Creek

Shale, Weston County.

Genus CAMAROZONOSPORITES Potonié, 1956 emend. Klaus, 1960

Type species: Camarozonosporites cretaceus (Weyland and Krieger, 1953) Potonié, 1956 (p. 65, pl. 9, fig. 85).

1953, Rotaspora cretaceus Weyland and Krieger (p. 12, pl. 3, fig. 27).

CAMAROZONOSPORITES RUDIS (Leschik, 1955) Klaus, 1960 (p. 136, pl. 29, figs. 12, 14 and 16)

1955, Verrucosisporites rudis Leschik (p. 15, pl. 1, fig. 15).

This species is characterized by a laevigate proximal side and a thickened, strongly rugose to verrucate distal spore coat. The diagnostic feature of the species and also of the genus Camarozonosporites is that the distal spore coat thins markedly in the equatorial region opposite the ends of the trilete rays. The Wyoming specimens agree in all respects with the illustrations and description presented by Klaus (1960).

Affinity: Unknown.

Stratigraphic occurrence: Rare in the upper part of the Thermopolis Shale in Teton and Big Horn Counties, also in the Muddy Sandstone and Shell Creek Shale, Big Horn County, and in the Fall River, Skull Creek, and Newcastle Formations, Weston County.

Figured specimens: Slides No. OPC 838B-9-2, Muddy Sandstone, Big Horn County, and OPC 635A-7-4, Skull Creek Shale, Weston County.

Genus FOVEOTRILETES Potonié, 1956

Type species: Foveotriletes scrobiculatus (Ross, 1949) Potonié, 1956 (p. 43).
1949, Triletes scrobiculatus Ross (p. 32, pl. 1, figs. 5-7).

FOVEOTRILETES SP.

Plate 3, fig. 7

Spores radial; trilete; rounded triangular, sides convex; trilete simple, rays extend to margin of spore; wall thick, ornamentation composed of deep, rounded pits 1 micron or less in diameter, spaced 2.0-3.0 microns apart; overall diameter 46.5-48.3 microns.

Only three specimens of this type were seen.

Affinity: Unknown.

Stratigraphic occurrence: Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 636-4-2, Skull Creek Shale, Weston County.

Genus LYCOPODIUMSPORITES Thiergart, 1938

Type species: Lycopodiumsporites agathoecus (Potonié, 1934)
Thiergart, 1938 (p. 293, pl. 22, figs. 9-10).
1934, Sporites agathoecus Potonié (p. 43,
pl. 1, fig. 25).

LYCOPODIUMSPORITES cf. L. CLAVATOIDES Couper, 1958

Plate 3, fig. 8

Spores radial; trilete; rounded triangular; trilete rays distinct, extending nearly to margin of spore; distal surface reticulate, lumens of reticulum 5.0-10.0 microns wide, muri thin and membranous, 4.0-7.0 microns high, reticulum extends to contact area of proximal surface; spore wall 1.5 microns thick; overall diameter 30.0-40.6 microns.

Spores fitting this description are fairly common in some of the Wyoming samples and compare closely with Lycopodium austroclavatidites Cookson, 1953 from Australia, and with Lycopodiumsporites clavatoides Couper, 1958 from the Jurassic and Lower Cretaceous of Britain. There seems to be no essential difference between Cookson's and Couper's species and the two may be synonymous. Couper's species shows a considerable range of variation and could easily contain the Wyoming specimens; accordingly they have been tentatively assigned to *L. clavatoides*.

Affinity: Possibly related to the genus *Lycopodium*.

Stratigraphic occurrence: Rare in the spore flora of the Rusty beds and Thermopolis Shale in Teton, Hot Springs, and Big Horn Counties, also in the Shell Creek Shale, Big Horn County, and in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 635A-10-8, Skull Creek Shale, Weston County.

Genus CICATRICOSISPORITES Potonié and Gelletich, 1933

Type species: *Cicatricosisporites dorogensis* Potonié and Gelletich, 1933 (p. 522, pl. 1, figs. 1-5).

CICATRICOSISPORITES DOROGENSIS Potonié and Gelletich, 1933

Plate 3, fig. 13

This is the most abundant species of *Cicatricosisporites* in the Wyoming Lower Cretaceous. Spores referred to this species have smooth, straight, rounded ribs about one micron wide and spaced 1.0-1.5 microns apart. The ribs occasionally bifurcate. The low, thin, closely spaced ribs make this species easily recognizable. Average diameter of the Wyoming specimens is about 39.0 microns.

Affinity: Spores of this type resemble those of the modern genus <u>Anemia</u>, a schizaeacean fern.

Stratigraphic occurrence: Rare to abundant in all formations in all three sections. Maximum abundance of this species occurs in the Rusty beds in Teton and Hot Springs Counties, and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 635A-1-1, Skull Creek Shale, Weston County.

CICATRICOSISPORITES SP. A

Plate 3, figs. 10 and 11

Spores radial; trilete; roundly triangular; trilete simple, rays reach nearly to spore margin; proximal contact area laevigate, distal side and peripheral areas of proximal side ornamented by low, fine ribs, less than 1 micron high, less than 1 micron broad, spaced less than 1 micron apart; overall diameter 20.0-26.0 microns.

Typical specimen: Slide No. OPC 636-5-1, Skull Creek Shale, Weston County. Dimensions 25.4 x 25.4 x 25.4 microns.

The small size and fine ribbing of this species distinguish it from previously described forms.

Affinity: Probably related to the Schizaeaceae, possibly to the genera Anemia or Mohria.

Stratigraphic occurrence: Rare in the Rusty beds, Thermopolis Shale, and Muddy Sandstone, Teton County, and in the Fall River and Skull Creek Formations, Weston County.

Figured specimens: Slides No. OPC 636-5-1, Skull Creek Shale, Weston County, and OPC 643A-10-2, Rusty beds, Teton County.

CICATRICOSISPORITES SP. B

Plate 3, fig. 12

Spores radial; trilete; rounded triangular; trilete lips slightly raised and thickened; surface ribbed, ribs smooth, straight, and rounded, some bifurcating, 2.0-4.0 microns thick, spaced 1.0-2.0 microns apart, 1.0 micron or less high; overall diameter 35.0-59.0 microns.

Typical specimen: Slide No. OPC 643A-3-4, Rusty beds, Teton County, Wyoming. Dimensions 50.8 x 53.3 x 58.3 microns.

This species resembles C. sewardi Delcourt and Sprumont, 1955, but is considerably smaller than the size range for that species.

Affinity: Probably a schizaeacean spore; the ornamentation is similar to that of spores of the modern genus Anemia.

Stratigraphic occurrence: Rare in the Rusty beds and Thermopolis Shale, Teton County, the Rusty beds in Hot Springs County, and in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 643A-3-4, Rusty beds, Teton County.

CICATRICOSISPORITES SP. C

Plate 3, fig. 9

Spores radial; trilete; roundly triangular; trilete simple, rays extend to margin of spore; proximal and distal ornamentation composed of ribs parallel to margin of spore, ribs 2.0 microns wide, spaced 3.0-4.0 microns apart; each rib bears a row of blunt, rodlike processes, 2.0-4.5 microns long, 1.0-2.5 microns in diameter; overall diameter 30.5-35.6 microns.

Only one specimen of this spore type was seen. The ornamentation is so striking, however, that its occurrence is here noted. The spores of two modern species of _Anemia_ possess ornamentation of this type; these are _A. laxa_ and _A. phyllitides_.

Affinity: Schizaeacean, resembling spores of the genus _Anemia_.

Stratigraphic occurrence: One specimen was observed in sample 634I, Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634I-4-1, Fall River Formation, Weston County.

CICATRICOSISPORITES cf. C. BREVILAESURATUS Couper, 1958

Plate 3, fig. 14

This spore type is similar to Couper's species except that it is considerably smaller than the lower size range of C. brevilaesuratus. Couper described the species from the Wealden and Aptian of Britain.

Affinity: Probably Schizaeacean.

Stratigraphic occurrence: Present only as a trace in the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 635A-1-23, Skull Creek Shale, Weston County.

Genus TAUROCUSPORITES Stover, 1962

Type species: Taurocusporites segmentatus Stover, 1962 (p. 56, pl. 1, figs. 1-14)

TAUROCUSPORITES SEGMENTATUS Stover, 1962

Plate 4, fig. 3

Stover described this species from the Lower Cretaceous of Maryland. Specimens from Wyoming which have been referred to T. segmentatus are comparable in every respect to the illustrations and description presented by Stover.

Affinity: Unknown.

Stratigraphic occurrence: Present in the lower part of the Thermopolis Shale, Teton County, and in the Fall River and Skull Creek Formations in Weston County.

Figured specimen: Slide No. OPC 634Q-1-4, Fall River Formation, Weston County.

TAUROCUSPORITES REDUNCUS (Bolkhovitina, 1953) Stover, 1962
p. 57, pl. 1, figs. 15-21)
Plate 4, fig. 1

1953, *Chomotriletes reduncus* Bolkhovitina (p. 35, pl. 3, figs. 23-24)

The only essential difference between this species and *T. segmentatus* is that *T. reduncus* is unornamented.

Affinity: Unknown.

Stratigraphic occurrence: Present as a very rare element of the spore flora of the Muddy Sandstone, Teton County and the Fall River and lower Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 6340-1-1, Fall River Formation, Weston County.

Genus KLUKISPORITES Couper, 1958

Type species: *Klukisporites variegatus* Couper, 1958 (p. 137, pl. 19, figs. 6-7).

KLUKISPORITES VARIEGATUS Couper, 1958

Plate 4, fig. 2

Spores from Wyoming which are here designated *K. variegatus* agree in every respect with Couper's description of the species. Couper described this species from the Middle Jurassic of Yorkshire.

Affinity: Couper (1958) stated that this species is similar to spores recovered from the Jurassic schizaeaceous plants *Klukia exilis* and *Stachypteris hallei*.

Stratigraphic occurrence: Present in the Rusty beds, Teton County.

Figured specimen: Slide No. OPC 643A-4-2, Rusty beds, Teton County.

KLUKISPORITES PSEUDORETICULATUS Couper, 1958

Plate 4, fig. 6

This species is easily recognizable by its thick wall and foveoreticulate sculpture on the distal side. The genus *Klukisporites* is rare in the Wyoming Lower Cretaceous and this is the most abundant species present.

Affinity: Probably a schizaeacean spore.

Stratigraphic occurrence: Present as a rare element in the Rusty beds and lower Thermopolis Shale in Teton County, the upper Thermopolis Shale in Big Horn County, and in the Fall River Formation in Weston County.

Figured specimen: Slide No. OPC 840A-2-1, Thermopolis Formation, Teton County.

Turma ZONALES Bennie and Kidston, 1886, emend. Potonié, 1956

Subturma AURITOTRILETES Potonié and Kremp, 1954

Infraturma AURICULATI Schopf, 1938 emend.
Potonié and Kremp, 1954

Genus TRILOBOSPORITES Potonié, 1956

Type species: Trilobosporites hannonicus (Delcourt and Sprumont, 1955) Potonié, 1956 (p. 55).

1955, Concavisporites hannonicus Delcourt and Sprumont (p. 24, pl. 2, fig. 3).

TRILOBOSPORITES cf. T. APIVERRUCATUS Couper, 1958

Plate 4, fig. 5

Spores radial; trilete; outline triangular, corners rounded, sides straight to convave; trilete rays extend about 3/4 spore radius, lips typically thickened; wall 2.0-2.5 microns thick; ornamentation scabrate to verrucose, corners bear strongly developed verrucose projections, 1.5-4.0 microns broad, 1.0-4.0 microns high, proximal and distal polar areas typically scabrate, occasionally granular to verrucose, verrucae occasionally join to form slight lophate structure; overall diameter 40.0-61.0 microns.

This spore type is similar to Couper's species with the exception of the smaller size range (Couper gave the size range of T. apiverrucatus as 60-100 microns) and the development of lophate structures at the corners. Groot and Penny (1955, p. 230) referred a group of spores from the Lower Cretaceous of Maryland to T. apiverrucatus and these fall into the size range of the Wyoming specimens.

Affinity: Resembles spores of the fern genus Cryptogramma of the family Polypodiaceae. Couper (1958) suggested a possible dicksoniaceous affinity.

Stratigraphic occurrence: Rare in the Rusty beds and lower Thermopolis Shale in Teton County. Quite rare in the Rusty beds, Hot Springs County, and in the Thermopolis Shale, Big Horn County. Present in the Lakota, Fall River, lower Skull Creek, and Newcastle Formations in Weston County.

Figured specimen: Slide No. OPC 634I-7-2, Fall River Formation, Weston County.

TRILOBOSPORITES TRIORETICULOSUS Cookson and Dettmann, 1957

Plate 4, fig. 4

Spores radial; trilete; outline triangular, sides straight to convex, corners rounded; trilete rays extend 3/4 spore radius, lips thickened; wall 2.0-3.0 microns thick; proximal and distal polar areas scabrate, corners ornamented by lophate ridges which join to form a shallow reticulate pattern, ridges 3.0-7.0 microns broad, 2.0-4.0 microns high; overall diameter 50-66 microns.

This species is distinguished from _T_. _apiverrucatus_ by the absence of verrucae and the presence of a reticulum at the corners. The size range of the Wyoming specimens is slightly less than that given by Cookson and Dettmann (70-85 microns).

Affinity: Probably filicinean.

Stratigraphic occurrence: Present in the Rusty beds, Teton County, and in the Newcastle Formation, Weston County.

Figured specimen: Slide 637J-2-4, Newcastle Formation, Weston County.

TRILOBOSPORITES SP. A

Plate 4, fig. 7

Spores radial; trilete; outline triquete, sides deeply concave, corners broadly rounded; trilete rays extend

2/3-3/4 radius of spore, lips slightly thickened; spore wall 2.0-2.5 microns thick; ectoexine laevigate, endoexine very minutely reticulate; wall 3.0-3.5 microns thick at corners, corners ornamented by low, lophate ridges and irregular, lophate pits, forming a reticulum; overall diameter 47.0-82.0 microns.

Typical specimen: Slide No. OPC 637J-3-1, Newcastle Formation, Weston County, Wyoming; dimensions: 72.0 x 69.5 x 68.6 microns.

This species is distinguished from previously described forms by the reticulum formed at the corners, by the triquete shape, and by the infrareticulate nature of the spore wall. Under low magnification, the infrareticulum gives the surface a granular to punctate appearance.

Affinity: Probably filicinean.

Stratigraphic occurrence: Present only in sample 637J of the Newcastle Formation, Weston County.

Figured specimen: Slide No. OPC 637J-3-1, Newcastle Formation, Weston County.

Infraturma APPENDICIFER Potonié, 1956

Genus APPENDICISPORITES Weyland and Kreiger, 1953

Type species: Appendicisporites tricuspidatus Weyland and

Kreiger, 1953 (p. 42, pl. 11, fig. 54).

APPENDICISPORITES TRICORNITATUS Weyland and Greifeld, 1953

Plate 4, fig. 10

This species is characterized by apical processes which the authors have described as thimblelike (fingerhutartig). A description of spores from the Lower Cretaceous of Wyoming which have been referred to this species follows:

Spores radial; trilete; rounded triangular, sides straight to convex; trilete simple, rays extend nearly to margin of spore, lips slightly thickened; ornamentation consists of ribs parallel to sides, ribs smooth and rounded, 2.0-5.0 microns broad, spaced 2.0-5.0 microns apart; contact area of proximal side smooth; apical processes 5.0-10.0 microns long, processes blunt and rounded; overall diameter 40.0-59.0 microns.

Affinity: Probably a schizaeaceous fern spore.

Stratigraphic occurrence: Rare in the Rusty beds, Teton and Hot Springs Counties, and in the Thermopolis Shale, Teton County, also in the Fall River Formation and lower part of the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 635B-5-1, Skull Creek Shale, Weston County.

APPENDICISPORITES cf. A. TRICEPS

Weyland and Krieger, 1953

Plate 4, fig. 9

Spores radial; trilete; rounded triangular, sides straight to convex; trilete simple, rays extend nearly to margin; proximal contact area laevigate, distal ornamentation composed of smooth, rounded ribs arranged parallel to the sides, ribs 2.0-4.0 microns broad, spaced 1.0-2.0 microns apart; corners thickened, thickenings 5-6 microns broad, 5-6 microns high, typically not projecting far beyond equatorial contour of spore and merging with the equatorial contour at a low angle; overall diameter 30.0-59.0 microns.

This species differs from *A. tricornitatus* in the nature of the apical thickenings and in the fact that the ribs are more closely spaced.

Affinity: Schizaeacean. This species resembles spores of some species of the genus *Anemia*.

Stratigraphic occurrence: Present as a trace in the Rusty beds, Teton and Hot Springs Counties, and in the Thermopolis Shale, Big Horn County. Rare in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 643B-9-7, Rusty beds, Teton County.

APPENDICISPORITES SP.

Plate 4, fig. 11

Spores radial; trilete; rounded triangular, sides straight to convex; trilete rays extend nearly to margin, lips slightly thickened; contact area of proximal side laevigate, distal side ornamented with ribs parallel to the sides, ribs 2-3 microns broad, spaced 2-4 microns apart, apical projections rodlike, rounded at tips, diameter 3-4 microns, length 7-20 microns; overall diameter 3-4 microns.

Two few specimens of this spore type were seen to warrant the erection of a new species. The apical processes are somewhat longer than those of _A_. _tricornitatus_, averaging 1/3-1/2 the diameter of the spore.

Affinity: Probably a schizaeaceous fern spore.

Stratigraphic occurrence: Rare in the Rusty beds, upper Thermopolis Shale, and Muddy Sandstone, Teton County. Present as a trace in the lower part of the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 840D-3-6, Thermopolis Shale, Teton County.

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié and Klaus, 1954

Genus CINGULATISPORITES Thomson, 1953

Type species: Cingulatisporites levispeciosus Pflug in Thomson and Pflug, 1953 (p. 58, pl. 1, fig. 6).

CINGULATISPORITES LEVISPECIOSUS Pflug, 1953

Plate 4, fig. 8

This spore type is comparable to C. levispeciosus except that it is 4 or 5 microns smaller than the lowest size range of the species.

Affinity: C. levispeciosus resembles spores of the bryophyte genus Sphagnum.

Stratigraphic occurrence: Rare in the Thermopolis Shale and Muddy Sandstone, Teton County, the Rusty beds and Thermopolis Shale in Hot Springs and Big Horn Counties, and in the Fall River, Skull Creek, and Newcastle Formations in Weston County.

Figured specimen: Slide No. OPC 840D-3-4, Thermopolis Shale, Teton County.

CINGULATISPORITES cf. C. PSEUDOALVEOLATUS Couper, 1958

Plate 5, fig. 1

Spores radial; trilete; rounded triangular; trilete rays extend to margin of spore, lips thickened; spore wall ornamented with deep pits, pits less than one micron in diameter, spaced 2-3 microns apart; cingulum 3-4 microns wide, laevigate and membranous; diameter exclusive of cingulum 38-46 microns, diameter including cingulum 45-51 microns.

In describing the surface ornamenation of _C_. _pseudoalveolatus_ Couper (1958) mentioned the presence of short, thick, truncated papillae which appear as small pits in surface view. The Wyoming specimens are definitely punctate, the margins of the spore body appear serrate, however, and the area between the pits, seen in section, may be what Couper referred to as papillae. Because the spores described above agree with Couper's species in all other respects, they have been tentatively assigned to _C_. _pseudoalveolatus_.

Affinity: Unknown, probably filicinean.

Stratigraphic occurrence: Rare in the Thermopolis Shale, Teton and Big Horn Counties, and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 6340-1-2, Fall River Formation, Weston County.

CINGULATISPORITES PROBLEMATICUS Couper, 1958

Plate 5, fig. 2

Couper described this species from the Middle and Upper Jurassic and Lower Cretaceous of Yorkshire. His illustrations and description of the species indicate a considerable variation in ornamentation. The ornamentation of specimens from Wyoming which have been assigned to this species is composed of low, lophate ridges on the distal side. The proximal side is essentially laevigate but some specimens slow a slight development of proximal lophate sculpture.

Affinity: Unknown, probably filicinean.

Stratigraphic occurrence: Present in the Thermopolis Shale, Teton County and in the Fall River and Skull Creek Formations, Weston County.

Figured specimen: Slide No. OPC 840C-1-3, Thermopolis Shale, Teton County.

CINGULATISPORITES SP. A

Plate 5, fig. 3

Spores radial; trilete; rounded triangular, sides concave; trilete distinct, rays extend to inner margin of cingulum; low, irregular, thickenings present bordering trilete rays, spore coat otherwise laevigate; cingulum laevigate, 3.0-4.5 microns wide; diameter including cingulum 33.0-30.0 microns.

This spore type resembles Cingulatisporites cavus

Delcourt and Sprumont, 1955, except that it is about 20 microns smaller than the lowest size range of the species and the exine is not granular. Too few specimens of this spore type were seen to warrant the designation of a type.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634P-1-4, Fall River Formation, Weston County.

CINGULATISPORITES SP. B

Plate 5, fig. 4

Spores radial; trilete; outline triangular; trilete distinct, rays reach to inner margin of cingulum; spore coat laevigate; cingulum laevigate, invaginated at corners, width of cingulum irregular, 3.5-7.5 microns; diameter including cingulum 43.0-48.5 microns.

Affinity: Unknown.

Stratigraphic occurrence: Only three specimens of this spore type were seen, all from the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634I-13-5, Fall River Formation, Weston County.

Infraturma ZONATI Potonie and Kremp, 1954

SPORE TYPE B

Plate 5, fig. 5

Spores radial; outline rounded triangular with a membranous equatorial flange; surface of central body ornamented with distinct, closely spaced, vermiculate ridges and large granules; surface of flange coarsely granular, flange bears thickened ridges extending radially outward from corners of central body, one at each corner, and which resemble the rays of a tetrad scar, ridges not traceable onto central body; body wall 2-4 microns thick; diameter of central body 40-61 microns; width of flange 7-20 microns.

Only three specimens of this form were seen, all from the Rusty beds in Teton County. Cookson and Dettmann (1958) described a group of spores from the Cretaceous of Australia under the generic name Cirratriradites Wilson and Coe, 1940, which resemble the Wyoming specimens. Cirratriradites verrucosus Cookson and Dettmann, 1958, in particular, seems similar to the forms reported in this paper. The Wyoming specimens, however, have a more conspicuous type of ornamentation and lack the fovea described by Cookson and Dettmann. The Wyoming specimens are probably spores of some type despite the lack of a tetrad scar on the central body but it is doubtful if they can be assigned to the genus Cirratriradites. Because only three specimens were observed, no attempt has been made to erect a new genus to contain them.

Affinity: Unknown.

Stratigraphic occurrence: Present only in the Rusty beds, Teton County.

Figured specimen: Slide No. OPC 643B-3-1, Rusty beds, Teton County.

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma LAEVIGATO-MONOLETI Dybová and Jachowicz, 1957

Genus LAEVIGATOSPORITES Ibrahim, 1933 emend. Schopf, Wilson, and Bentall, 1944

Type species: Laevitagosporites vulgaris (Ibrahim, 1932) Ibrahim, 1933 (p. 39-40, pl. 2, fig. 16, pl. 5, figs. 37-39).

1932, Sporonites vulgaris Ibrahim in Potonié, Ibrahim, and Loose (p. 448, pl. 15, fig. 16).

LAEVIGATOSPORITES SP. A

Plate 5, fig. 6

Spores bilateral; monolete; ovate; monolete suture fairly short and simple, extends 1/2-2/3 length of spore; exine approximately 1 micron thick, laevigate; total length 31-40 microns, width 21-30 microns.

Typical specimen: Slide No. OPC 635A-5-5, Skull Creek Shale, Weston County, Wyoming. Length 39.5 microns, width 30.5 microns.

This species falls into the same size range as Monoletes minor Cookson, 1947, but seems to be of a more ovate shape than Cookson's species.

Affinity: Probably filicinean.

Stratigraphic occurrence: Present in minor abundance in the Rusty beds, Thermopolis Shale, and Muddy Sandstone in Teton County. Rare in the Thermopolis Shale in Big Horn County. Rare in the Lakota, Fall River, and Skull Creek Formations, Crook and Weston Counties.

Figured specimen: Slide No. OPC 635A-5-5, Skull Creek Shale, Weston County.

Infraturma SCULPTATOMONOLETI
Dybová and Jachowicz, 1957

Genus MARATTISPORITES Couper, 1958

Type species: Marattisporites scabratus Couper, 1958 (p.

133, pl. 15, figs. 20-23).

MARATTISPORITES SCABRATUS Couper, 1953

Plate 5, fig. 7

This small, subgranulose species of monolete spore is very rare in the Wyoming samples. Couper described the species from the Jurassic and Lower Cretaceous of Britain.

Affinity: Couper (1958) related this genus to the fern family Marattiaceae.

Stratigraphic occurrence: Present in the Thermopolis Shale, Big Horn County, and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634I-2-6, Fall River Formation, Weston County.

SPORAE INCERTAE SEDIS

Genus SCHIZOSPORIS Cookson and Dettmann, 1959

Type species: Schizosporis reticulatus Cookson and Dettmann, 1959 (p. 213, pl. 1, figs. 1-4).

Cookson and Dettmann erected this genus to include problematical microfossils from the Cretaceous of eastern Australia. The diagnostic feature of the genus is that the forms included therein separate along an equatorial line into approximately two halves. Five species of Schizosporis are recognized in this paper, one of which has not been previously reported.

SCHIZOSPORIS RETICULATUS Cookson and Dettmann, 1959

Plate 5, fig. 8

S. reticulatus is most common in the Wyoming sediments in samples of lignite from the Fall River and Newcastle Formations.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Fall River and Newcastle Formations, Weston County.

Figured specimen: Slide No. OPC 637H-7-1, Newcastle Formation, Weston County.

SCHIZOSPORIS PARVUS Cookson and Dettmann, 1959

Plate 5, fig. 9

This smooth, elongated species of *Schizosporis* is a fairly common component of the spore flora of the Fall River lignites. It may occur with the two halves joined as shown in the illustrated specimen, or when fission is complete, the separate halves appear as elongated, boat-shaped objects.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the middle part of the Thermopolis Shale in Teton and Big Horn Counties. Fairly common in the Fall River Formation lignite samples from Weston County.

Figured specimen: Slide No. OPC 837D-17-6, Thermopolis Shale, Big Horn County.

SCHIZOSPORIS cf. S. RUGULATUS Cookson and Dettmann, 1959

Plate 5, fig. 13

Large, hemispherical, hollow structures bearing slightly rugose ornamentation are common in sample M of the Fall River Formation. The ornamentation consists of sinuous, closely spaced, anastomosing ridges approximately 1.5 microns broad. These forms appear quite similar to Cookson and Dettmann's illustrations and description of *S. rugulatus* and are probably the separated halves of specimens of that species. No complete specimens were seen.

Affinity: Unknown.

Stratigraphic occurrence: Abundant in sample M of the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 634M-9-1, Fall River Formation, Weston County.

SCHIZOSPORIS SPRIGGI Cookson and Dettmann, 1959

Plate 5, figs. 10 and 11

This large, subspherical, laevigate form splits unevenly along a median line into two subhemispherical halves. The species is common in sample M of the Fall River Formation where it typically occurs as separate halves, occasional specimens are seen with the halves still joined.

Affinity: Unknown.

Stratigraphic occurrence: Common in the two samples of lignite from the Fall River Formation, Weston County.

Figured specimens: Slides No. OPC 634M-7-1, and OPC 634M-7-2, Fall River Formation, Weston County.

SCHIZOSPORIS SP. A

Plate 5, figs. 12 and 14

Spores (?) bilateral; biconvex; circular in polar view; typically split into saucer-shaped halves along a median line or furrow; exine 1.5-2.0 microns thick, ornamentation composed of low, irregular anostomosing ridges forming an obscure vermiculate to rugose pattern, ridges 1.5-2.0 microns broad; largest diameter 40-63 microns.

Typical specimen: Slide No. OPC 634BF-1-3, Fall River Formation, Weston County, Wyoming. Diameter 60.9 microns.

This species occurs as isolated halves; complete specimens are rare and are almost invariably folded and compressed. The species differs from S. rugulatus in that the size range is smaller and the ornamentation is more obscure, more closely resembling irregular exinal thickenings than true ridges.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Shell Creek Shale, Big Horn County, and in the Skull Creek Shale, Weston County. Abundant in sample OPC 634BF of the Fall River Formation, Weston County.

Figured specimens: Slides No. OPC 634BF-1-3, and OPC 634BF-3-1, Fall River Formation, Weston County.

Genus SCHIZOCYSTIA Cookson and Eisenack, 1962

Type species: Schizocysta rugosa Cookson and Eisenack, 1962 (p. 270, pl. 37, figs. 11-12).

SCHIZOCYSTIA SP. A

Plate 6, figs. 1 and 2

Symmetry bilateral; biconvex in end view; shape roughly square to rectangular in side view with two opposite straight to slightly concave or convex sides and two opposite sides produced into broad humps at either end; these humps are more than half as wide as the width of the grain and overlap slightly; grain splits into halves along a median line perpendicular to the two straight sides; wall 1.5-2.0 microns thick with irregular, uneven thickenings, giving surface of grain an obscure vermiculate to scabrate appearance;

length 43.0-55.0 microns, width 40.0-50.0 microns.

Typical specimen. Slide No. OPC 634BF-2-2, Fall River Formation, Weston County, Wyoming. Length 50.8 microns, width 45.7 microns.

Affinity: Unknown.

Stratigraphic occurrence: Abundant in sample OPC 634BF of the Fall River Formation, Weston County.

Figured specimens: Slides No. OPC 634BF-2-2, and OPC 634BF-1-6, Fall River Formation, Weston County.

SPORE TYPE X

Plate 6. fig. 3

Spore radial; trilete; roundly triangular; trilete rays narrow, slightly elevated, extend to margin of spore; proximal surface convex and covered with shallow punctate depressions spaced less than one micron apart; distal surface bears a shallow groove encircling the spore 7-8 microns from the margin, inside this grove, the exine bears shallow, punctate ornamentation, outside the groove the ornamentation consists of closely spaced, radially arranged ribs or corrugations about one micron wide, the ends of which extend 1-2 microns beyond the equatorial margin of the spore, giving the margins a serrate appearance; overall diameter 45-49 microns.

Only one specimen of this distinctive type of spore was observed: Slide No. OPC 634Q-3-1, Fall River Formation, Weston County.

Anteturma POLLENITES R. Potonié, 1931

Turma EUPOLLENITES Klaus, 1960

Subturma OPERCULATI Venkatachala and Góczán, 1962

Genus CLASSOPOLLIS Pflug, 1953 emend.
Pocock and Jansonius, 1961

Type species: *Classopollis classoides* Pflug, 1953 emend.
Pocock and Jansonius, 1961 (p. 443, pl. 1, figs. 1-9)
1953, *Classopollis classoides* Pflug (p. 91, pl. 16, figs. 29-31).

CLASSOPOLLIS CLASSOIDES Pflug, 1953 emend.
Pocock and Jansonius, 1961
Plate 6, fig. 4

Grains from Wyoming which have been referred to this species agree closely with the description presented by Pocock and Jansonius, 1961. Most of the Wyoming specimens are compressed through the polar axis and the equatorial striations are usually not visible. Ornamentation consists of small, radially disposed pits within the exine, giving the surface a pitted or subreticulate appearance.

Affinity: Probably related to the Cheirolepidaceae, a Mesozoic conifer family related to the Araucariaceae.

Stratigraphic occurrence: The genus _Classopollis_ is fairly abundant in all formations in all three sections studied. In most cases, preservation was such that a specific identification could not be made and in the assemblage counts, the two species of _Classopollis_ which are recognized in this paper were lumbed together. Well preserved grains which are undoubtedly relatable to _C_. _classoides_ are present in the Fall River and Lakota Formations in Weston County, however.

Figured specimen: Slide No. OPC 634N-14-4, Fall River Formation, Weston County.

CLASSOPOLLIS SP. A

Plate 6, figs. 5 and 6

Grains radial; distally operculate; irregularly shaped pore at distal pole; faint trilete mark visible at proximal pole on some specimens; shape spherical, usually secondarily compressed along polar axis; equatorial region surrounded by a band of 8-10 low, thin, parallel ridges; furrow completely surrounds grain immediately distal to this set of ridges; exine spinose to finely granular, granules or spines very closely spaced, less than one micron broad, spines, when present, one micron or less high, hirsute; overall diameter 20-31 microns.

Typical specimen: Slide No. OPC 635A-1-25, Skull Creek Shale, Weston County, Wyoming. Dimensions 25.0-30.5 microns.

Specimens possessing hirsute spines form a gradational series with the finely granular type and the designation of two separate species based on this character would seem to be unjustified.

Affinity: Probably related to the extinct conifer family Cheirolepidaceae.

Stratigraphic occurrence: Well-preserved specimens of _Classopollis_ _sp_. _A_ are common in the Skull Creek Shale, Weston County.

Figured specimens: Slides No. OPC 635A-1-25, and OPC 635A-1-26, Skull Creek Shale, Weston County.

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES (Chitaley, 1951)
Potonié and Kremp, 1954

MONOSACCATE POLLENS

Two specimens of monosaccate pollen grains were observed during the course of this investigation, one from the Fall River Formation and one from the Skull Creek Shale. The occurrence of monosaccate grains is common in samples of Paleozoic age but only a few have been reported from the Upper Mesozoic. No attempt was made to relate the two Wyoming specimens to genus or species, but their occurrence is here noted. A description of the two specimens follows:

MONOSACCATE TYPE A

Plate 6, fig. 7

Grain radial; monosaccate; trilete, rays extend to margin of central body; shape elliptical; saccus completely surrounds central body except on proximal side; saccus internally punctate to microreticulate; central body rounded triangular, secondary folds occur at margin; central body finely punctate; overall diameter 50-56 microns; central body 33-38 microns.

Specimen: Slide No. OPC 6340-2-2, Fall River Formation, Weston County.

MONOSACCATE TYPE B

Plate 6, fig. 8

Grain radial; monosaccate; no germinal aperture visible; shape ovate; saccus completely surrounds central body except on one side, saccus internally reticulate, muri 1-2 microns wide, lumens uneven, 1-2 microns broad; central body indistinct, ovate, ornamentation not visible due to poor preservation; overall diameter 78-53 microns; central body 35-40 microns.

Specimen: Slide No. OPC 635B-1-10, Skull Creek Shale, Weston County.

Subturma DISACCITES Cookson, 1947

Infraturma DISACCITRILETI Leschik, 1955

Genus VITREISPORITES Leschik, 1955

Type species: *Vitreisporites signatus* Leschik, 1955 (p. 53, pl. 8, fig. 10).

VITREISPORITES PALLIDUS (Reissinger, 1938) Nilsson, 1958

Plate 6, fig. 11

1938 *Pityosporites pallidus* Reissinger (p. 14).

1950 *Pityopollenites pallidus* (Reissinger, 1938) Reissinger (p. 109, pl. 15, figs. 1-5).

1958 *Caytonipollenites pallidus* (Reissinger, 1938) Couper (p. 150, pl. 26, figs. 7-8).

1958 *Vitreisporites pallidus* (Reissinger, 1938) Nilsson (p. 78, pl. 7, figs. 12-14).

Reissinger proposed the generic name Pityopollenites in 1950 for small bisaccate pollens of the type illustrated in this paper. However, he failed to give a generic diagnosis and therefore did not validate the name. Couper (1958) proposed the name Caytonipollenites for pollens of this type and designated Caytonipollenites pallidus (Reissinger) Couper as the type species. However, Leschik, in 1955, had proposed the name Vitreisporites for small, bisaccate pollen grains from the Upper Triassic of Switzerland and it is obvious that Caytonipollenites is a synonym of Vitreisporites. The grains here designated as V. pallidus are bilaterally symmetrical, oval in polar view and bisaccate. The sacci are laevigate externally, internally they are finely granular to subreticulate. The wall is less than one micron thick. Preservation of the Wyoming specimens is poor and no germinal aperture is visible.

Affinity: Couper (1958) has established that pollens of this type are related to the Caytoniaceae, a Jurassic pteridosperm family.

Stratigraphic occurrence: Rare in the Thermopolis Shale and Muddy Sandstone in Teton County, in the Rusty beds and Thermopolis Shale in Hot Springs and Big Horn Counties, and in the Fall River and Skull Creek Formations in Weston

County.

Figured specimens: Slides No. OPC 635A-1-12, Skull Creek Shale, Weston County.

Infraturma PINOSACCTI (Erdtman, 1945) Potonié, 1958

Genus PINUSPOLLENITES Raatz, 1937

Type species: Pinuspollenites labdacus (Potonié, 1931) Raatz, 1937 (p. 16).

1931, Pollenites labdacus Potonié (p. 5, fig. 32).

PINUSPOLLENITES ? SP.

Plate 6, fig. 9

Grains bilateral; bisaccate; tube cell ovate to subspherical, finely granular; exine 1.5-2.5 microns thick; sacci subcircular with obscure internal reticulum; proximal attachment of sacci slightly proximal to equator, distal attachment inserted over approximately 1/3 radius of tube cell, sacci join with tube cell proximally at an angle approaching 90 degrees; length of tube cell 28-50 microns, height (measured along polar axis) 30-46 microns; diameter of sacci 17-38 microns.

This pollen type is characterized by the sharp angle formed by the proximal junction of the sacci with the tube cell. Too few specimens were seen to warrant the designation of a type specimen.

Affinity: Probably related to the Pinaceae.

Stratigraphic occurrence: Present in the Rusty beds, Teton County and in the Fall River Formation, Weston County.

Figured specimen: Slide No. OPC 643A-2-12, Rusty beds, Teton County.

Infraturma ABIETOSACCITI (Erdtman, 1945) Potonié, 1958

Genus PICEAEPOLLENITES Potonié, 1931

Type species: _Piceaepollenites_ _alatus_ Potonié, 1931 (p. 28, pl. 2, fig. V 70a).

The central body of this genus is slightly more elongate and joins with the sacci at a lower angle than in the case of _Abietineaepollenites_ or _Abiespollenites_. Potonié (1958) states that a strong crest (optical section of the proximal cap) is present. No feature of this type is visible on the Wyoming specimens. In this paper, the relation of sacci to tube cell and the nature of attachment of the sacci is regarded as the major criteria for separating the various genera of fossil bisaccate pollen. Specimens from Wyoming which have been referred to this genus have a relatively large tube cell, the sacci are attached distally from the equator, and sacci and tube cell join at a low angle.

PICEAEPOLLENITES SP. A

Plate 6, figs. 10 and 12

Grains bilateral: bisaccate; elliptical in polar view; sacci attached distally from the equator, sacci typically slightly tapered and joining with tube cell at a low angle when seen in side view, sacci half circular in polar view, merging smoothly with equatorial outline of tube cell; sacci overlap tube cell by about one-third its radius; sacci internally reticulate, muri wide, lumens small and irregular, reticulum is quite obscure in poorly preserved specimens; tube cell circular to oval in polar view, longer than broad in side view; proximal exine 1-2 microns thick; tube cell internally microreticulate; overall width including sacci 48-79 microns; diameter of tube cell 25-48 microns.

typical specimen: Slide No. OPC 635A-7-9, Skull Creek Shale, Weston County, Wyoming. Overall width 68.6 microns, dimensions of tube cell 45.7-40.6 microns.

Affinity: Possibly referable to the Pinaceae.

Stratigraphic occurrence: Although two species of <u>Piceaepollenites</u> are recognized in this paper, poor preservation in many samples made it necessary to group the two when the assemblage counts were made. The genus

Piceaepollenites is present in minor to major abundance in all formations in all three sections.

Figured specimens: Slide No. OPC 635A-7-9, and OPC 635A-7-8, Skull Creek Shale, Weston County.

PICEAEPOLLENITES SP. B

Plate 7, figs. 1 and 2

Grains bilateral; elliptical in polar view, sacci attached distally from equator, typically inflated and subspherical in shape, sacci join with tube cell at a low angle, sacci bear obscure, internal reticulum, muri wide, lumens small and irregular; sacci overlap tube cell by approximately 1/3 its radius; tube cell circular to slightly ovate in polar section, internally microreticulate; proximal exine 1.5-2.5 microns thick; overall width including sacci 71-110 microns; tube cell 54-82 microns.

Typical specimen: Slide No. OPC 635A-3-2, Skull Creek Shale, Weston County, Wyoming. Overall width 81.3 microns, dimensions of tube cell 63.5-66.0 microns.

This species differs from Piceaepollenites sp. A in that the size is larger, the sacci are more inflated, more nearly spherical, and do not merge with the margin of the tube cell in polar view. The species resembles Pityosporites neomundanus Leschik, 1955, but differs from it in that the exine is thinner and not granular and the size range is somewhat smaller.

Affinity: Possibly related to the Pinaceae.

Stratigraphic occurrence: The typical specimen is from the Skull Creek Shale, Weston County, where well-preserved specimens of this species are common.

Figured specimens: Slides No. OPC 635A-3-2, and OPC 635A-3-17, Skull Creek Shale, Weston County.

Infraturma PODOCARPOIDITI

Potonié, Thomson, and Theirgart, 1950

Genus PLATYSACCUS Potonié and Klaus, 1954

Type species: *Platysaccus papilionis* Potonié and Klaus, 1954 (p. 540-541, pl. 10, figs. 11-12).

PLATYSACCUS SP. A

Plate 7, fig. 3

Grains bisaccate, sacci inflated and broadly reniform in shape, 1½ to 2 times larger than tube cell, sacci with internal reticulum, muri narrow and closely spaced, lumens small and irregular; tube cell spherical to ovate in polar view, prominent, irregularly thickened equatorial ridge present; sacci overlap tube cell by approximately half its diameter; ornamentation of tube cell rugose; overall length 53-77 microns; diameter of tube cell 25-38 microns; sacci 41-54 microns long, 28-36 microns broad.

Two few specimens of this pollen type were seen to warrant the erection of a type.

Affinity: Possibly related to the Podocarpaceae.

Stratigraphic occurrence: Rare in the Thermopolis and Shell Creek Shales in Big Horn County. Present as a trace in the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 635A-7-10, Skull Creek Shale, Weston County.

Genus PODOCARPIDITES Cookson, 1947 emend. Potonié, 1958

Type species: _Podocarpidites_ _ellipticus_ (Cookson, 1947)
Couper, 1953 (p. 36).
1947, _Disaccites_ (_Podocarpidites_) _elliptica_
Cookson (p. 131, pl. 13, figs. 5-7).

Cookson (1947) erected this genus to include fossil bisaccate pollens of the _Podocarpus_ type but she failed to establish a type specimen. In 1953 Couper designated Cookson's _P_. _elliptica_ as the type and emended the genus to include tri-saccate forms. Potonié (1958) published the first detailed description of _Podocarpidites_ and suggested that the genus be restricted to include only bisaccate forms. A free translation of Potonié's emendation follows:

Equatorial contour of central body oval to polygonal, crest recognizable, sulcus area without thickened rim. Both sacci extend at least to equatorial circumference as in *Pinuspollenites* or even more, over both poles. Longest diameter of sacci is longer than central body, moreover, they reach distally farther than in the case of *Pinuspollenites*. The fine mesh of the infrareticulum of the sacci is essentially finer than in *Pinuspollenites* or *Platysaccus*.

As defined in this paper, the genus *Podocarpidites* consists of bisaccate pollens with a thickened tube cell wall. The tube cell is circular to elliptical in polar view, the sacci are large and inflated, reniform in equatorial section, with an obscure internal reticulum, and a long diameter greater than the diameter of the tube cell.

PODOCARPIDITES cf. P. BIFORMIS Rouse, 1957

Plate 7, figs. 4 and 5

Grains bilateral; bisaccate; tube cell circular to elliptical in polar view; tube cell wall 2.5-4.0 microns thick; tube cell coarsely granular to verrucose; sulcus normally narrow; sacci large, inflated, longest diameter longer than diameter of tube cell, typically reniform in equatorial section; internal ornamentation of sacci composed of obscure, poorly defined reticulum, muri thick and irregular, lumens small; diameter of central body 22-51 microns, average 37 microns; width of sacci 20-43 microns, average 31 microns.

Rouse's description of P. biformis is quite brief and he does not mention a thick tube cell wall; however, his photograph of the type specimen seems to show the presence of a thickened rim surrounding the tube cell. Because the size range and ornamentation of P. biformis appear similar to the Wyoming specimens they have been referred to that species. Rouse described P. biformis from the Oldman Formation (Upper Cretaceous) of Alberta. He later (1959) recognized the same species in the Kootenai Formation (Lower Cretaceous) of British Columbia.

Affinity: As the name implies, this genus is probably related to the Podocarpaceae.

Stratigraphic occurrence: Present in minor abundance in all formations studied with the exception of the Shell Creek Shale, Big Horn County, and the Lakota and Newcastle Formations in Crook and Weston Counties.

Figured specimens: Slides No. OPC 636-3-4, and OPC 635A-14-2, Skull Creek Shale, Weston County.

Genus RUGUBIVESICULITES (Pierce, 1961) emend.

Grains bisaccate, tube cell subspherical to ovate with rugose proximal ornamentation; sacci smaller than central body, attached distally, many with thickened folds radiating outward from tube cell.

Type species: Rugubivesiculites convolutus Pierce, 1961 (p. 39, pl. 2, fig. 57).

Pierce erected this genus to contain "two winged pollen with rugulate design on cap." Pierce's diagnosis is too incomplete to define clearly the limits of the genus. Grains included in this genus are quite similar to pollen of the modern conifer genus Dacrydium.

RUGUBIVESICULITES SP. A

Plate 7, fig. 7

Symmetry bilateral; bisaccate; tube cell ovate in polar view, subcircular in side view; proximal surface covered by coarse, closely spaced, convoluted, smooth, rugose ridges, 2-4 microns high; distal furrow broad; sacci smaller than tube cell, thickened proximal roots present, sacci infrareticulate, subspherical in side view, reniform in polar view, overlapping tube cell approximately 1/3 to 1/2 saccus diameter, often with folds radiating outward from tube cell; overall length (including sacci) 58-72 microns; diameter of tube cell 33-50 microns.

Typical specimen: Slide No. OPC 839B-4-2, Shell Creek Shale, Big Horn County, Wyoming. Overall length 66 microns; tube cell 40.6-43.2 microns (including ornamentation).

Affinity: Genus Dacrydium, family Podocarpaceae.

Stratigraphic occurrence: Present in minor abundance only in the Newcastle Formation, Weston County, and in the Shell Creek Shale, Big Horn County.

Figured specimen: Slide No. OPC 839B-4-2, Shell Creek Shale, Big Horn County.

Genus PARVISACCITES Couper, 1958

Type species: Parvisaccites radiatus Couper, 1958 (p. 154, pl. 29, figs. 5-8, pl. 30, figs. 1-2).

PARVISACCITES SP. A

Plate 7, fig. 6

Grains bilateral; bisaccate; body of grain spherical to ovate; exine 2.5-3.5 microns thick in proximal and equitorial regions, thinner distally; tube cell coarsely granulose to verrucose; sacci quite small in relation to tube cell, attached distally, surface of sacci laevigate to slightly granular; sacci possess internal thickenings. One micron or less broad arranged radially with respect to central body; maximum diameter of tube cell 35-54 microns; sacci 20-33 microns long, 7-11 microns wide.

Description based on only four specimens.

This species resembles the genotype except that the ornamentation of the tube cell is somewhat different and the size range is smaller.

Affinity: Possibly related to the genus *Dacrydium*, family Podocarpaceae.

Stratigraphic occurrence: This genus is quite rare and the two species recognized in this paper were grouped together in the assemblage counts. The genus *Parvisaccites* occurs as a rare element of the spore flora of the Rusty beds and Thermopolis Shale in Teton County and of the Lakota, Fall River, and Skull Creek Formations in Crook and Weston Counties.

Figured specimen: Slide No. OPC 634R-1-1, Fall River Formation, Weston County.

PARVISACCITES SP. B

Plate 7, fig. 8

Grains bilateral; bisaccate; tube cell oval; exine punctate to microreticulate, exine 3.0-4.5 microns thick proximally and equatorially, thinner distally; sacci attached distally, small in relation to tube cell, sacci ornamented with thin, internal thickenings radially disposed from tube cell; when seen in polar view sacci show obscure interval reticulate thickenings in addition to radial structure; length of tube cell 25-58 microns, width 27-53 microns; sacci 18-39 microns long.

Description based on only five specimens.

Affinity: Possibly related to the Podocarpaceae.

Stratigraphic occurrence: Specimens assigned to this species are present in the Lakota Formation, Crook County.

Figured specimen: Slide No. OPC 633D-2-1, Lakota Formation, Crook County.

Turma ALETES Ibrahim, 1933

Subturma AZONOALETES Luber, 1935 emend.
Potonié and Kremp, 1954

Infraturma GRANULONAPITI Cookson, 1947

Genus INAPERTUROPOLLENITES Pflug in Thomson and Pflug, 1953

Type species: _Inaperturopollenites dubius_ (Potonié and Venitz, 1934) Thomson and Pflug, 1953 (p. 65, pl. 4, fig. 89, pl. 5, figs. 1-13).

1934, _Pollenites magnus dubius_ Potonié and

Venitz (p. 17, pl. 2, figs. 20-21).

Palynological literature is burdened with a complex of generic names used to describe fossil inaperturate pollen grains. Of the available described genera, however, *Araucariacites* and *Inaperturopollenites* seem to be the most widely accepted. According to Potonié (1958) *Araucariacites* contains only granular forms and the genus *Inaperturopollenites* is reserved for smooth or infrapunctate grains. The grains described in this paper exhibit every gradation from nearly smooth forms to distinctly granular specimens. To attempt to make a generic split on the basis of exine ornamentation would, in this case, be entirely arbitrary and totally without validity. Accordingly, *Araucariacites* is herein regarded as a synonym of *Inaperturopollenites* and Potonié's 1958 emendation of the genus is not recognized. As here defined, the genus *Inaperturopollenites* consists of granular to laevigate, thin-walled radially symmetrical, spherical to ovate, inaperturate grains, some of which may be split open as in modern specimens of *Taxodium*. Secondary folds are present on most specimens.

INAPERTUROPOLLENITES SP. A

Plate 8, figs. 1, 2, 5, and 9

Specimens referred to this species form a gradational series from finely granular to distinctly granular forms. They are frequently found split open, indicating that germination of the grains was of the same type as in the modern genus Taxodium. Exine thickness is less than one micron and secondary folds are quite common. Diameter of the specimens ranges from 18-55 microns with an average of 24 microns.

Typical specimen: Slide No. OPC 635A-3-6, Skull Creek Shale, Weston County, Wyoming. Diameter 34.0-35.6 microns.

Affinity: Probably related to the Taxodiaceae and in part to the Araucariaceae.

Stratigraphic occurrence: Inaperturopollenites sp. A is abundant in all formations in all three sections.

Figured specimens: Slides No. OPC 635A-3-6 and OPC 636-4-5, Skull Creek Shale, Weston County, OPC 643A-8-1, Rusty beds, Teton County, and OPC 847D-4-8, Thermopolis Shale, Big Horn County.

INAPERTUROPOLLENITES cf. I. MAGNUS (Potonié, 1931)
Thomson and Pflug, 1953

Plate 8, fig. 3

1931, Sporonites magnus Potonié (p. 556, fig. 1).

1934, Pollenites magnus (Potonié, 1931) Potonié (p. 48, pl. 6, fig. 5).

Grains radial; inaperturate; spherical to subspherical; all specimens with numerous secondary folds; exine less than one micron thick, laevigate to finely granular; diameter 63-104 microns.

The size range of the Wyoming specimens is slightly smaller than the range of the species as given by Potonié in 1934 (80-100 microns) but they seem to be otherwise comparable.

Affinity: This species is probably related to the Araucariaceae.

Stratigraphic occurrence: Present as a minor element in the Thermopolis Shale, Teton County, the Thermopolis Shale and Muddy Sandstone, Big Horn County, and in the Skull Creek and Newcastle Formations in Weston County.

Figured specimen: Slide No. OPC 635A-1-19, Skull Creek Shale, Weston County.

INAPERTUROPOLLENITES cf. I PATELLAEFORMIS

Weyland and Greifeld, 1953

Plate 8, fig. 7

Grains radial; inaperturate; outline circular, shape probably originally spherical; exine about one micron thick, laevigate to slightly roughened; secondary folds common; diameter 27-51 microns.

This featureless, rather nondescript species is fairly common in the Fall River and Skull Creek Formations. It closely resembles I. patellaeformis which Weyland and Greifeld described from the Upper Cretaceous of Germany.

Affinity: Probably related to the Arauceriaceae.

Stratigraphic occurrence: Present in minor abundance in the upper part of the Thermopolis Shale and in the Shell Creek Shale in Big Horn County. Fairly common in the Fall River and Skull Creek Formations in Weston County.

Figured specimen: Slide No. OPC 635A-7-5, Skull Creek Shale, Weston County.

INAPERTUROPOLLENITES SP. B

Plate 8, figs. 4 and 6

Grains radial; inaperturate; occasionally split open as in grains of Taxodium; shape spherical to subspherical, often folded and compressed; exine less than one micron thick, faintly to distinctly granular; diameter 7-19 microns.

Typical specimen: Slide No. OPC 837D-12-2, Thermopolis Shale, Big Horn County, Wyoming. Diameter 18.5 microns.

This species is similar to I sp. A except that the size range is smaller. A size frequency study of 400 granular, inaperturate grains from the Wyoming samples gives a slightly bimodal curve, indicating that, in this case, a species split on the basis of size may be valid.

Affinity: Like *I.* sp. *A*, this species is probably referable to the Taxodiaceae or the Araucariaceae.

Stratigraphic occurrence: Present in the Thermopolis Shale in Teton County. Fairly abundant in the Rusty beds and Thermopolis Shale in Hot Springs County and in the Thermopolis Shale, Muddy Sandstone, and Shell Creek Shale in Big Horn County. Present in minor abundance in the Fall River and Skull Creek Formations in Weston County.

Figured specimens: Slides No. OPC 837D-12-2, and OPC 837D-12-4, Thermopolis Shale, Big Horn County.

INAPERTUROPOLLENITES SP. C

Plate 8, fig. 8

Grains radial; inaperturate; subspherical to ovate, frequently folded and compressed; exine one micron or less thick, ornamented with closely spaced, rounded granules and verrucate projections approximately one micron wide and one micron high, many granules appearing gemmate; diameter 21-61 microns.

Typical specimen: Slide No. OPC 635B-4-1, Skull Creek Shale, Weston County, Wyoming. Dimensions 60.9-41.0 microns.

This species is distinguished by the thick, granular to gemmate ornamentation. The Wyoming specimens are rather similar to Araucaricites australis Cookson, 1947.

Affinity: The most likely affinity for this species is with the Araucariaceae.

Stratigraphic occurrence: Present in minor abundance in the Thermopolis Shale in Teton County, in the Rusty beds in Hot Springs County and in the Thermopolis Shale in Big Horn County. Also in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 635B-4-1, Skull Creek Shale, Weston County.

INAPERTUROPOLLENITES SP. D

Plate 8, fig. 10

Grains radial; inaperturate; spherical to ovate, secondary folds usually present; exine 1.0-1.5 microns thick, very finely punctate, pits shallow, less than one micron in diameter and spaced less than one micron apart; diameter 25-66 microns.

Typical specimen: Slide No. OPC 635A-1-2, Skull Creek Shale, Weston County, Wyoming. Diameter 50.8 microns.

The relatively thick wall and punctate ornamentation characterize this species.

Affinity: Probably an araucariacean grain.

Stratigraphic occurrence: Present in minor abundance in the Muddy Sandstone, Teton County, in the upper part of the Thermopolis Shale and in the Muddy Sandstone in Big Horn County. Present as a trace in the Skull Creek Shale in Weston County

Figured specimen: Slide No. OPC 635A-1-2, Skull Creek Shale, Weston County.

INAPERTUROPOLLENITES SP. E

Plate 8, fig. 11

Grains radial; inaperturate; subspherical; exine 1.0 -1.5 microns thick and thrown into folds 3-5 microns wide, 5-10 microns high, which inclose polygonal lumens 10-18 microns broad, exine otherwise laevigate; overall diameter 63-99 microns.

Typical specimen: Slide No. OPC 634M-5-1, Fall River Formation, Weston County, Wyoming. Dimensions 71.1-73.7 microns.

The reticulate nature of the ornamentation of this species seems to be due to folding of the exine rather than due to ridges occurring on the surface of the grain.

Affinity: Unknown.

Stratigraphic occurrence: Present only in samples OPC 634BF and OPC 634M of the Fall River Formation, Weston

County.

Figured specimen: Slide No. OPC 634M-5-1, Fall River Formation, Weston County.

Turma PLICATES (Plicata Naumova, 1937, 1939) Potonié, 1960

Subturma PRAECOLPATES Potonié and Kremp, 1954

Genus EUCOMMIIDITES Erdtman, 1948 emend. Couper, 1958

Type species: *Eucommiidites troedssonii* (Erdtmann, 1948) Couper (p. 160-165, pl. 31, figs. 23-27, text fig. 11).

1948, *Tricolpites* (*Eucommiidites*) *troedssonii* Erdtman (p. 267, figs. 5-10, 13-15).

EUCOMMIIDITES MINOR Groot and Penny, 1960

Plate 8, figs. 12 and 13

This is a rare species in the Wyoming Lower Cretaceous but its relatively thick exine and asymmetrical development of the colpae make it easily recognizable. Except for its smaller size, this species is similar to *E. troedssonii*. Figure 14 of Erdtman (1948, p. 267) in particular is similar to some of the Wyoming specimens. Groot and Penny described *E. minor* from the Patapsco Formation (Lower Cretaceous) of Maryland.

Affinity: Probably a gymnospermous grain of unknown affinity.

Stratigraphic occurrence: Occurs as a rare element of the spore flora of the Rusty beds and Muddy Sandstone in Teton County. Present as a trace in the Thermopolis Shale and Muddy Sandstone in Big Horn County and in the Fall River Formation in Weston County.

Figured specimens: Slides No OPC 838B-9-1, Muddy Sandstone, Big Horn County, and OPC 634K-6-2, Fall River Formation, Weston County.

Subturma POLYPLICATES Erdtman, 1952

Genus EPHEDRIPITES Bolchovitina, 1953

Type species: *Ephedripites mediolobatus* Bolchovitina, 1953
(p. 60, pl. 9, fig. 15, pl. 11, fig. 120).

EPHEDRIPITES SP.

Plate 8, fig. 14

Two grains assignable to the genus *Ephedripites* were observed in the Fall River Formation. A description of these specimens follows:

Grains bilateral; fusiform; polycolpate; approximately 14 furrows separated by ridges visible on one surface; ridges laevigate, 1.5-3.0 microns wide and merging at poles; polar area thickened; wall 1.5-2.0 microns thick; length 74 and 84 microns, maximum equatorial diameter 43.2 and 43.2 microns (two specimens).

Affinity: Probably related to the Ephedraceae.

Stratigraphic occurrence: Sample OPC 634N and sample OPC 634Q of the Fall River Formation.

Figured specimen: Slide No. OPC 634Q-1-7, Fall River Formation, Weston County.

Subturma MONOCOLPATES

Iversen and Troëls-Smith, 1950

Genus CLAVATIPOLLENITES Couper, 1958

Type species: Clavatipollenites hughesii Couper, 1958 (p. 159, pl. 31, figs. 19-22).

CLAVATIPOLLENITES cf. C. HUGHESII Couper, 1958

Plate 9, fig. 1

Grains bilateral; monosulcate; ovate to subspherical; sulcus distinct, long, extends nearly entire length of grain; sexine tectate, forming a fine reticulum in surface view; lumens of reticulum polygonal, 1.5 microns or less in diameter, reticulum 1.0-1.5 microns high; exine exclusive of sexine, 1.0-1.5 microns thick, overall diameter 22-31 microns.

Pollens of this type are quite similar to the illustrations and description of the genotype from the Wealden and Aptian of Britain. They also resemble Liliacidites variegatus Couper, 1953, from the Upper Cretaceous of New Zealand.

Affinity: Probably an angiospermous grain of unknown affinity.

Stratigraphic occurrence: Occurs in minor abundance in the Thermopolis Shale in Teton County, in the Shell Creek Shale in Big Horn County, and in the Lakota, Fall River, Skull Creek and Newcastle Formations in Crook and Weston Counties.

Figured specimen: Slide No. OPC 634I-3-5, Fall River Formation, Weston County.

CLAVATIPOLLENITES SP. A

Plate 9, figs. 2 and 3

Grains bilateral; monosulcate; oblate, rarely subspherical; sulcus long, narrow, poorly visible, sexine tectate, forming a reticulate pattern in surface view, lumens of reticulum polygonal, unequal in size, 1.0-2.0 microns broad, muri 1.0-1.5 microns high; sexine often torn away revealing laevigate nexine layer; overall length 15-31 microns; overall width 10-18 microns.

Typical specimen: Slide No. OPC 637J-2-3, Newcastle Formation, Weston County, Wyoming. Dimensions 29.0-17.8

microns.

This species is more elongate and has somewhat coarser ornamentation than does C. hughesii.

Affinity: Probably related to the angiosperms.

Stratigraphic occurrence: Present in the Thermopolis Shale, Teton and Big Horn Counties, and in the Fall River, Skull Creek, and Newcastle Formations in Weston County.

Figured specimens: Slides No. OPC 637J-2-3, and OPC 637J-1-7, Newcastle Formation, Weston County.

CLAVATIPOLLENITES SP. B

Plate 9, fig. 4

Grains bilateral; monosulcate; spherical to subovate; sulcus generally narrow, extends 2/3-3/4 diameter of grain; exine thin, sexine tectate giving grain a minutely punctate to irregular microreticulate appearance in surface view, tectum less than one micron high; diameter 17-31 microns.

Too few specimens of this type of pollen grain were seen to warrant the designation of a typical specimen.

Affinity: This species is probably related to the angiosperms.

Stratigraphic occurrence: Rare in the Thermopolis Shale in Teton and Big Horn Counties. Present as a trace in the spore floras of the Skull Creek Shale and Newcastle Formation in Weston County.

Figured specimen: Slide No. OPC 635A-5-9, Skull Creek Shale, Weston County.

Infraturma MONOPTYCHES (Naumova, 1937) Potonié, 1958

Genus PALMAEPOLLENITES Potonié, 1951

Type species: Palmaepollenites tranquillus (Potonié, 1934) Potonié, 1951 (pl. 20, figs. 30 and 31a).
1934 Pollenites tranquillus Potonié (p. 51, pl. 1, figs. 3 and 8).

PALMAEPOLLENITES SP. A

Plate 9, fig. 5

Grains bilateral; monocolpate; spherical to subovate; colpus fairly narrow, ends blunt, 3/4-4/5 diameter of grain in length; exine 1.0-2.0 microns thick; sexine granular, granules subspherical to irregular in shape, closely packed, 1.0-3.0 microns broad, less than one micron high; overall diameter 33-44 microns.

Typical specimen: Slide No. OPC 637C-2-4, Newcastle Formation, Weston County, Wyoming. Dimensions 43.2-40.6 microns.

Affinity: Possibly an angiospermous grain. In spite of the name, it is doubtful that this genus is related to the monocotyledons.

Stratigraphic occurrence: Present in minor abundance in the Newcastle Formation, Weston County.

Figured specimen: Slide No. OPC 637C-2-4, Newcastle Formation, Weston County.

Subturma TRIPTYCHES Potonié, 1960

Genus TRICOLPITES Couper, 1953

Type species: Tricolpites reticulatus Cookson, 1947 (p. 134, pl. 15, fig. 45).

TRICOLPITES cf. T. RETICULATUS Cookson, 1947

Plate 9, figs. 6, 7, and 8

Grains radial; tricolpate; subspherical to subprolate; colpae long; exine 1.0-1.5 microns thick, tectate, forming a fine reticulum in surface view, lumens of reticulum irregular in size and shape, maximum diameter 1.5 microns, usually less than one micron, reticulum low, usually less than one micron high; polar diameter 17-24 microns, average 20 microns; equatorial diameter 12-22 microns, average 17 microns.

This species is similar to the genotype of Tricolpites except that the size range is slightly smaller and the reticulate pattern of the ornamentation seems to be more distinct.

Affinity: Tricolpites is a form genus for angiospermous pollens of probable dicotyledonous affinities.

Stratigraphic occurrence: Present in the Rusty beds and Thermopolis Shale in Teton County, in the Thermopolis, Muddy and Shell Creek Formations in Big Horn County, and in the Fall River, Skull Creek, and Newcastle Formations in Weston County.

Figured specimens: Slides No. OPC 636-4-4 and OPC 847D-8-5, Skull Creek Shale, Weston County, OPC 837E-4-2, Thermopolis Shale, Big Horn County.

TRICOLPITES SP. A

Plate 9, figs. 9 and 10

Symmetry radial; tricolpate; prolate to subspherical; colpae long and tapering; exine 1.0-1.5 microns thick, structure tectate, sexine clavate to gemmate (as defined by Faegri and Iversen, 1950) appearing microreticulate in surface view, lumens circular to subcircular, closely spaced, less than one micron in diameter; overall diameter 13-36 microns.

Typical specimen: Slide No. OPC 644C-3-4, Thermopolis Shale, Teton County, Wyoming. Dimensions 22.8 x 22.8 x 22.8 microns.

This species is distinguished by the uniform size and subcircular shape of the lumens of the pseudoreticulum.

Affinity: Unknown, probably angiospermous.

Stratigraphic occurrence: Present as a minor element of the spore flora of the Rusty beds and Thermopolis Shale in Teton County. Present in the Thermopolis and Shell Creek Shales in Big Horn County, and in the Fall River, Skull Creek, and Newcastle Formations in Weston County.

Figured specimens: Slides No. OPC 644C-3-4, Thermopolis Shale, Teton County, and OPC 634R-6-9, Fall River Formation, Weston County.

TRICOLPITES SP. B

Plate 9, figs. 11 and 12

Grains radial; tricolpate; subprolate, frequently secondarily compressed along polar axis; colpae long and usually narrow, extend approximately two-thirds the length of the grain; exine 1.0-1.5 microns thick ornamentation granular to psilate (granules embedded within sexine) optical section of wall shows small, low granules protruding above surface; polar diameter 13-22 microns, equatorial diameter 12-18 microns; overall diameter of polar compressed specimens 12-23 microns.

Typical specimen: Slide No. OPC 637J-8-1, Newcastle

Formation, Weston County, Wyoming. Dimensions 16.5 x 17.8 x 17.8 microns.

Affinity: Unknown, probably angiospermous.

Stratigraphic occurrence: Present in the Thermopolis Shale, Teton County, the Rusty beds, Hot Springs County, the Thermopolis and Shell Creek Shales, Big Horn County, and in the Fall River, Skull Creek, and Newcastle Formations in Weston County.

Figured specimens: Slides No. OPC 637J-8-1, Newcastle Formation, Weston County, and OPC 644C-4-5, Thermopolis Shale, Teton County.

TRICOLPITES SP. C

Plate 9, fig. 13

Grains radial; tricolpate; subspherical (?); exine 1.0-1.5 microns thick; sexine very finely granular, granules seem to be composed of small rods buried in the wall and protruding slightly above the surface; all grains observed were compressed along the polar axis so that separate length and breadth measurements could not be taken; diameter of compressed specimens 33-44 microns.

Too few specimens of this species were seen to select a typical specimen.

Affinity: Although the exact affinities are unknown, this species is probably angiospermous in origin.

Stratigraphic occurrence: Rare in the Thermopolis Shale, Teton County, and in the Fall River and Skull Creek Formations in Weston County.

Figured specimen: Slide No. OPC 634I-5-9, Fall River Formation, Weston County.

Turma POROSES Naumova, 1937, 1939 emend. Potonié, 1960

Subturma POLYPORINES Naumova, 1937, 1939 emend. Potonié, 1960

GENUS A

Symmetry radial; shape spherical; five porate; pores concentrated in one hemisphere; pores connected by lines of exinal thinning which converge at one pole; ornamentation piliferous.

GENUS A SP. A

Plate 9, figs. 14, 15, and 16

Symmetry radial; spherical; five porate, pores confined to one hemisphere, evenly distributed equidistant from one pole; lines of exinal weakness extend from each pore and converge at pole, forming a star shaped zone of exinal thinning with a pore at each point of the star; exine less than one micron thick, piliferous, pila joined to form a tectate structure, pila less than one micron high; exine appears punctate in surface view, punctae very small and closely spaced; overall diameter 23.5-33.0 microns.

Typical specimen: Slide No. OPC 643B-1-20, Rusty beds, Teton County, Wyoming. Diameter 25.4 microns.

All grains observed exhibit a star-shaped area from which the exine is absent to a greater or lesser degree. The position of the pores is marked by the five points of the star and the center is located at one pole. This stellate area probably represents a zone of exinal thinning and germination may have been achieved by rupture of the exine in this zone.

The ornamentation elements are so small as to be nearly indistinguishable. On some grains, however, individual pila may be distinguished. The heads of the pila appear to be joined, forming a tectum.

Affinity: The ornamentation and type of germinal aperture suggest that this grain is related to the angiosperms.

Stratigraphic occurrence: This species occurs only in the Rusty beds in Teton County where it is present in minor abundance.

Figured specimens: Slides No. OPC 643B-1-18, OPC 643B-1-19, and OPC 643B-1-20, Rusty beds, Teton County.

Class DINOFLAGELLATA

Family DELEFANDREIDAE Eisenack, 1954

Genus DEFLANDREA Eisenack, 1938

Type species: *Deflandrea phosphoritica* Eisenack, 1938 (p. 187, fig. 6)

DEFLANDREA cf. D. MINOR Cookson and Eisenack, 1960

Plate 10, figs. 1 and 3

Symmetry bilateral; test elongate with strongly convex sides; test produced apically into a short, wide, blunt, or pointed horn; two unequal antapical projections present, one on each side, one short and pointed, the other shorter and rounded; distinct equatorial girdle and ventral longitudinal furrow present; a few specimens show some indication of plates but exact tabulation is impossible to determine; membrane less than one micron thick, covered with widely spaced, pointed apiculae; apiculae 1-2 microns high, often showing linear arrangement, particularly along margin of girdle; internal body thin walled, laevigate, spherical to ovate; diameter of internal body 23-43 microns; overall length of test 38-61 microns; overall width 33-45 microns.

This species is easily recognized by the well developed girdle and by the apiculate ornamentation of the test. The internal body is often rather indistinct and sometimes bears secondary folds. The Wyoming specimens lack the well developed pylome described by Cookson and Eisenack and appear to be slightly more apiculate but are otherwise similar.

Affinity: This genus probably represents a motile dinoflagellate stage with a cyst inside.

Stratigraphic occurrence: Fairly common in the upper part of the Thermopolis Shale in Teton and Big Horn Counties and in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 837H-4-3, Thermopolis Shale, Big Horn County, and OPC 635C-2-1, Skull Creek Shale, Weston County.

DEFLANDREA SP. A

Plate 10, fig. 2

Symmetry bilateral; test elongate, sides strongly convex, tapering apically to a blunt cone, produced antapically into two short wide lateral horns, generally unequal in length; distinct equatorial girdle present, some specimens show indications of a lateral furrow; pylome or plates not indicated; membrane thin and finely granular; internal body spherical; laevigate, frequently secondarily folded;

diameter of internal body 35-49 microns; overall length of test 63-84 microns; overall width 36-56 microns.

Typical specimen: Slide No. OPC 847D-8-6, Skull Creek Shale, Weston County, Wyoming. Length 73.7 microns, width 53.3 microns, diameter of internal body 44 microns.

The low rounded nature of the epitheca, the well defined girdle, and the granular surface ornamentation characterize this species.

Affinity: Motile dinoflagellate with an inner cyst.

Stratigraphic occurrence: Present as a minor element in the Thermopolis Shale in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 847D-8-6, Skull Creek Shale, Weston County.

DEFLANDREA SP. B

Plate 10, figs. 4, 5, and 7

Symmetry bilateral; test elongate with convex sides; epitheca elongated into a long, fingerlike, blunt or pointed horn; hypotheca strongly asymmetric, posteriorly elongated on one side into a long, fingerlike horn and on the other side into a very low, rounded knob which is frequently poorly developed, giving many specimens a distinctly fusiform appearance; epitheca slightly longer than hypotheca; girdle slightly helicoid and poorly defined; plates and furrow not observable; external membrane finely granular; capsule subspherical to ovate, laevigate, often secondarily folded; capsule 30.5-43.2 microns broad, 33.0-48.3 microns long; overall length of test 68-102 microns; overall breadth 38-59 microns.

Typical specimen: Slide No. OPC 838B-8-5, Muddy Sandstone, Big Horn County, Wyoming. Length 89 microns, width 43.2 microns, capsule 33.6 x 40.6 microns.

The elongated apical horn and the asymmetric hypotheca with one long lateral horn make this species easily recognizable.

Affinity: This species is probably a motile dinoflagellate with an inner cyst.

Stratigraphic occurrence: Present only in the Muddy Sandstone and Shell Creek Shale, Big Horn County.

Figured specimens: Slides No. OPC 838B-8-5, OPC 838B-8-9, and OPC 838B-8-10, Muddy Sandstone, Big Horn County.

Family GONYAULACIDAE Lindemann

Genus GONYAULAX Diesing, 1866

GONYAULAX SP. A

Plate 10, fig. 8

Test ovate to subspherical with a straight, rigid apical horn; distinct helicoid girdle present; margins of girdle and plate sutures thickened and raised; surface of test granular to echinate, giving surface a roughened or ragged appearance; breadth of test 66-84 microns; length (including horn) 69-89 microns.

Specimens placed in this group almost certainly belong to the genus Gonyaulax but their preservation is too poor to give an accurate plate tabulation or to place them in a distinct species.

Affinity: This genus is present in recent plankton assemblages.

Stratigraphic occurrence: Two species of Gonyaulax were recognized but were lumped together in the assemblage counts. The genus occurs in the upper part of the Thermopolis Shale in Teton and Big Horn Counties, and in the upper part of the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 636-3-10, Skull Creek Shale, Weston County.

GONYAULAX SP. B

Plate 10, fig. 6

Test subspherical with a short, rigid apical horn; distinct helicoid girdle present, girdle and plates with thickened and raised margins; surface of test smooth with scattered granules and blunt spinose projections 2 microns or less high; width of test 43-76 microns; length (including horn) 61-101 microns.

The specimens are too poorly preserved to provide a complete plate tabulation or to be assigned to a definite species.

Affinity: Probably an ancestral form of the modern genus Gonyaulax.

Figured specimen: Slide No. OPC 837G-4-3, Thermopolis Shale, Big Horn County.

Family PAREODINIDAE Gocht, 1957

Genus PSEUDOCERATIUM Gocht, 1957

Type species: Pseudoceratium pelliferum Gocht, 1957 (p. 166-168, pl. 18, figs. 1-2, text figs. 1-3).

PSEUDOCERATIUM SP. A

Plate 10, figs. 9, 10, 11, and 12

Symmetry bilateral; test irregularly rounded to somewhat angular, prolonged apically into one long, pointed horn; two separate, divergent antapical horns present, two median horns present, one on either side of body, pointing antapically, one or both often bifurcated; surface of test laevigate to very finely granular; wall less than one micron thick; girdle, furrow, or plate sutures not present; secondary folds and breaks common; horns of variable length, apical horn usually longer than the other four; body (excluding horns) 38-51 microns wide; 43-60 microns long; horns approximately 15-40 microns long.

Typical specimen: Slide No. OPC 644C-11-5, Thermopolis Shale, Teton County, Wyoming. Body 106.7 microns long (including horns), 76.2 microns wide.

Due to the flexible nature of the tests, this form is frequently folded and broken with the horns folded in over the body. In undeformed specimens in which the median horns bifurcate, one point of the bifurcation points apically and the other antapically.

Affinity: This form represents a motile dinoflagellate stage.

Stratigraphic occurrence: Thermopolis Shale, Teton County, Rusty beds and Thermopolis Shale in Hot Springs and Big Horn Counties and the Fall River and Skull Creek Formations in Weston County.

Figured specimens: Slides No. OPC 644C-11-2, OPC 644C-11-5, OPC 644C-11-6, and OPC 644C-12-1, Thermopolis Shale, Teton County.

Genus ODONTOCHITINA Deflandre, 1935

Type species: Odontochitina operculata (O. Wetzel, 1933) Deflandre, 1958 in Deflandre and Cookson (p. 291, pl. 3, figs. 5-6).

1933 Ceratium operculatum O. Wetzel (p. 170, pl. 2, figs. 8-10).

1935 Odontochitina silicornum Deflandre (p. 234, pl. 9, figs. 8-10).

ODONTOCHITINA OPERCULATA (O. Wetzel, 1933) Deflandre, 1958

Plate 11, figs. 4 and 5

These large, problematical fossils are well known from the Cretaceous of Europe and Australia. Their occurrence in the Wyoming samples is fairly rare. A description of forms herein assigned to O. operculata follows:

Globular to ovate body with two long, tapering spines, one attached in an apical position and the other attached in an equatorial position; body operculate, operculum provided with a long, tapering apical spine; operculum, spines, and body laevigate; body 40-60 microns wide; length 53.3 microns (one specimen); opercular spine approximately 170 microns long; apical body spine 94-115 microns long; equatorial spine 60- 70 microns long.

Affinity: Evitt (1961) believed that this genus may represent a dinoflagellate cyst.

Stratigraphic occurrence: Rare in the upper Thermopolis Shale in Teton and Big Horn Counties, also in the Muddy Sandstone in Big Horn County and in the upper part of the Skull Creek Shale in Weston County.

Figured specimens. Slides No. OPC 847C-2-3, and OPC 636-4-3, Skull Creek Shale, Weston County.

Family PERIDINIIDAE Kent

Genus PALAEOPERIDINIUM Deflandre, 1934

Type species: Palaeoperidinium pyrophorum (Ehrenberg, 1838) (p. 967, fig. 1).

1838 Peridinium pyrophorum Ehrenberg (p. 110, figs. 2 and 4).

PALAEOPERIDINIUM cf. P. CAULLERYI Deflandre, 1936

Plate 11, figs 1 and 6

Test elongate; epitheca longer than hypotheca; epitheca tapers to a narrow, rounded or pointed cone; hypotheca asymmetric, right side (in ventral view) produced posteriorly into a short, wide, pointed horn; left side low and rounded, broad lateral furrow present, restricted to hypotheca; girdle slightly helicoid, distinct; surface covered with closely spaced echinate spines, 1-3 microns long, occasionally joined at bases and often arranged linearly; girdle typically with a row of spines along margin; overall width 37-48 microns; overall length 45-66 microns.

Specimens here assigned to *P. caulleryi* are quite similar to the illustrations and description published by Deflandre in 1936. The Wyoming specimens frequently exhibit polygonal ruptures in the epitheca, marking the former position of plates. Deflandre published an illustration of *P. caulleryi* in 1934 but did not validate the species with a description until 1936.

Affinity: This form is a fossil of a motile dinoflagellate.

Stratigraphic occurrence: Present only in the Muddy Sandstone, Big Horn County.

Figured specimens: Slides No. OPC 838B-13-1, and OPC 838B-16-1, Muddy Sandstone, Big Horn County.

Order HYSTRICHOSPHAERIDIA

Family HYSTRICHOSPHAERIDAE Deflandre, 1937

Genus HYSTRICHOSPHAERIDIUM Deflandre, 1937 emend. Eisenack, 1958

Type species: *Hystrichosphaeridium tubiferum* (Ehrenberg,

1838) Deflandre, 1937 (p. 69, pl. 13, figs. 2, 4, and 5).

1838 Xanthidium tubiferum Ehrenberg (p. 109-136, pl. 1, fig. 16).

1904 Ovum hispidium (Xanthidium) tubiferum Ehrenberg) Lohmann (p. 21-25).

1933 Hystrichosphaera tubifera (Ehrenberg) O. Wetzel (p. 40-41, pl. 4, figs. 16).

Eisenack (1958) restricted this genus to include only forms possessing open-ended appendages which are usually expanded into a funnel shape. Eisenack's recommendation is followed in this paper.

HYSTRICHOSPHAERIDIUM cf. H. TUBIFERUM

(Ehrenberg, 1838) Deflandre, 1937

Plate 11, fig. 3

A few crushed specimens were observed which seem to be similar to H. tubiferum as described by Deflandre. No well-preserved specimens were seen and a positive identification is impossible.

Affinity: Evitt (1961) regards this species as a dinoflagellate cyst.

Stratigraphic occurrence: Present in the upper part of the Thermopolis Shale in Teton and Big Horn Counties, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 847C-9-1, Skull Creek Shale, Weston County.

HYSTRICHOSPHAERIDIUM cf. H. CHOANOPHORUM

Deflandre and Cookson, 1955

Plate 11, fig. 2

Body spherical, minutely and densely granular; projections laevigate, tubular, hollow, apparently do not communicate with interior of body, ends abruptly flared into a small funnel with slightly serrate margins; diameter of body 18.5-33.0 microns; projections 6.5-12.0 microns long, 1.0-4.0 microns in diameter.

Specimens which are here referred to *H. choanophorum* differ from that species in that they are slightly smaller, the projections are a little shorter, and the surface of the central body is more distinctly granular.

Affinity: Possibly an encysted dinoflagellate.

Stratigraphic occurrence: Present in minor abundance in the upper part of the Thermopolis Shale in Teton and Big Horn Counties and in the upper part of the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837G-5-1, Thermopolis Shale, Big Horn County.

HYSTRICHOSPHAERIDIUM cf. H. EOINODES Eisenack, 1958

Plate 11, fig. 11

Body spherical to subspherical, laevigate to very slightly granular; appendages hollow, tubular, flared at the ends into a funnel like shape with highly serrate margins; surface of appendages laevigate to very slightly granular; diameter of body 44-54 microns; length of appendages 11-24 microns.

Forms here designated as *H. eoinodes* are a little larger and have slightly shorter appendages than the specimens described by Eisenack but appear to be otherwise similar.

Affinity: Possibly this species represents a dinoflagellate cyst.

Stratigraphic occurrence: Fairly common in the Thermopolis Shale and Muddy Sandstone in Teton County. Present in the upper part of the Thermopolis Shale in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 635C-7-1, Skull Creek Shale, Weston County.

HYSTRICHOSPHAERIDIUM SP. A

Plate 11, fig. 8

Body spherical to subspherical; wall thin, laevigate to very finely granular; large, hollow, open tubular process present at one pole of body, 17-22 microns long, 5-12 microns in diameter, margin of large process simple to slightly dentate; low, rounded knob, 3-5 microns high often present at opposite pole; other processes numerous, hollow, tubular, straight, usually considerably smaller in diameter than polar process, ends simple to multi-partate, bases usually widened, length 8-19 microns, diameter usually 2-3 microns, rarely 5-8 microns; diameter of body 35-46 microns.

Typical specimen: Slide No. OPC 847D-1-5, Skull Creek Shale, Weston County, Wyoming. Diameter of body 43.2 microns, polar process 20 microns long, 10 microns wide; other processes 13-15 microns long.

This species is similar to _H_. _colligerum_ Deflandre and Cookson, 1955. However, the large polar process of that species has a closed apex and no knob is present at the opposite pole. The size ranges are also slightly different.

Affinity: Possibly a dinoflagellate cyst.

Stratigraphic occurrence: Present in the upper part of the Thermopolis Shale in Teton and Big Horn Counties, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 847D-1-5, Skull Creek Shale, Weston County.

HYSTRICHOSPHAERIDIUM SP. B

Plate 11, fig. 10

Symmetry radial; body spherical; surface very finely granular; provided with numerous, radially arranged, smooth, tubular processes slightly flared at the distal ends, flared portions with highly serrate margins; processes 8-20 microns long, 1-2 microns wide, approximately the same length on individual specimens, 30-40 processes visible extending beyond the margin of the body; diameter of body 38-53 microns.

Too few specimens were seen to warrant the designation of a type specimen.

This species resembles _H_. _tubiferum_ but has more numerous and shorter processes.

Affinity: This species may represent a dinoflagellate cyst.

Stratigraphic occurrence: Thermopolis Shale, Big Horn County.

Figured specimen: Slide No. OPC 837F-5-1, Thermopolis Shale, Big Horn County.

Genus HYSTRICHOSPHAERA O. Wetzel, 1933
emend. Deflandre, 1937

Type species: Hystrichosphaera furcata (Ehrenberg, 1838) O. Wetzel, 1933 (p. 34-35, pl. 2, fig. 35a-b, pl. 5, figs. 1, 9, 15, and 16).

1838 Xanthidium furcatum Ehrenberg (pl. 1, fig. 14).

1885 Xanthidium delitziense (Ehrenberg) Rüst, (pl. 19, fig. 21).

1904 Ovum hispidium (Xanthidium) furcatum (Ehrenberg) Lohmann (p. 21 and 25).

HYSTRICHOSPHAERA cf. H. FURCATA (Ehrenberg, 1838)
O. Wetzel, 1933
Plate 12, figs. 1 and 2

Specimens herein assigned to H. furcata are ovate with a laevigate to faintly granular surface. A well defined girdle is present and the body plates are polygonal in outline, definite tabulation could not be established. Numerous flexible processes arise from the sutures, the processes are 5 to 10 microns long and typically multipartate at the ends. The body is 35 to 44 microns wide and 35 to 51 microns long.

Forms of this type are fairly common in the Thermopolis and Skull Creek Formations. They compare closely with the specimens discussed by Deflandre (1937) and those illustrated by Eisenack (1958). Unfortunately no specimens were observed in which preservation was such that an exact plate tabulation could be made.

Affinity: Evitt (1961) believes this form represents a dinoflagellate cyst.

Stratigraphic occurrence: Present in the upper part of the Thermopolis Shale in Teton and Big Horn Counties and in the upper part of the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 636-3-7, and OPC 847D-2-1, Skull Creek Shale, Weston County.

HYSTRICHOSPHAERA cf. H. WETZELI Deflandre, 1937

Plate 12, fig. 3

This form is similar to _H_. _furcata_ except that the projections which arise from the sutures are connected by distinct, slightly granular membranes. In compressed specimens, this membrane is normally folded over the surface of the body, making an interpretation of the plates even more difficult than in the case of _H_. _furcata_.

Affinity: Possibly a dinoflagellate cyst.

Stratigraphic occurrence: Rare in the upper part of the Thermopolis Shale in Teton and Big Horn Counties.

Figured specimen: Slide No. OPC 837H-1-3, Thermopolis Shale, Big Horn County.

Genus BALTISPHAERIDIUM Eisenack, 1958

Type species: Baltisphaeridium longispinosum (Eisenack, 1931) Eisenack, 1958 (p. 398).

1931 Ovum hispidium longispinosum Eisenack (p. 110, pl. 5, figs. 6-17).

1938 Hystrichosphaeridium longispinosum (Eisenack) Eisenack (p. 12-14, pl. 1, figs. 1-9).

Eisenack (1958) erected this genus to contain specimens formerly referred to Hystrichosphaeridium but having appendages with closed ends not flared into a funnel shape. As Eisenack pointed out, it is extremely difficult to determine if the processes of some species of hystrichosphaerids are closed or not, especially those species with thin, pointed processes.

BALTISPHAERIDIUM PARVISPINUM (Deflandre, 1937) n. comb.

Plate 12, fig. 4

1937 Hystrichosphaeridium xanthiopyxides O. Wetzel, 1933 var. parvispinum Deflandre (p. 77, pl. 16, fig. 5).

1958 Hystrichosphaeridium parvispinum (Deflandre, 1937) Cookson and Eisenack (p. 45, pl. 8, figs. 10-12).

Body ovate, longer than broad, surface finely granular; spines fairly widely spaced, short, smooth and tapering to a point, frequently recurved at tips; body 30 x 52 microns, spines 6-8 microns long.

The specimens herein assigned to B. parvispinum are slightly smaller than the Australian specimens described by Cookson and Eisenack.

Affinity: Unknown.

Stratigraphic occurrence: Present in the upper part of the Thermopolis Shale in Big Horn County.

Figured specimen: Slide No. OPC 837G-3-2, Thermopolis Shale, Big Horn County.

BALTISPHAERIDIUM MACHAEROPHORUM
(Deflandre and Cookson, 1955) Gerlach, 1961
Plate 13, fig. 2

1955 Hystrichosphaeridium machaerophorum Deflandre and Cookson (p. 274, pl. 9, figs. 4 and 8).

1961 Baltisphaeridium machaerophorum (Deflandre and Cookson) Gerlach (p. 191, pl. 28, fig. 11).

Specimens herein assigned to B. machaerophorum seem to be comparable with those described by Deflandre and Cookson except that the size range is a little smaller. A description follows:

Body spherical, finely granular; spinose, spines smooth, tapering, and pointed, 7-19 microns long; body diameter 35-56 microns.

Affinity: Unknown.

Stratigraphic occurrence: Present in rare amounts in the upper part of the Thermopolis Shale in Teton and Big Horn Counties, and in the upper part of the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 840C-2-2, Thermopolis Shale, Teton County.

BALTISPHAERIDIUM cf. B. LUMECTUM Sarjeant, 1960

Plate 13, fig. 4

Body spherical, thin walled, laevigate, often secondarily folded; numerous radially disposed processes present, processes smooth and tapering, less than one micron wide at base, may be pointed, bifurcate, or multipartate at tips, processes 5-12 microns long; overall diameter (excluding processes) 30-33 microns.

Sarjeant (1960) described the processes of _B_. _lumectum_ as being greater than two-thirds the shell diameter. The processes of the Wyoming specimens are somewhat shorter but this seems to be the only difference between them and the specimens described by Sarjeant.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Thermopolis

Shale in Teton and Big Horn Counties, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 847D-9-1, Skull Creek Shale, Weston County.

BALTISPHAERIDIUM EHRENBERGI (Deflandre, 1947)
var. BREVISPINOSUM Sarjeant, 1961

Plate 13, fig. 1

Body spherical, laevigate; ornamented with tapering, pointed. smooth spines, one micron or less wide at base, 3-9 microns long; spines rigid or flexed, often recurved; diameter of body (excluding spines) 18-33 microns.

Specimens herein assigned to this variety seem to be similar to Sarjeant's description of the single specimen which he used to erect the group.

Affinity: Unknown.

Stratigraphic occurrence: Rare in the Thermopolis Shale and Muddy Sandstone in Teton County.

Figured specimen: Slide No. OPC 841B-3-2, Muddy Sandstone, Teton County.

BALTISPHAERIDIUM SP. A

Plate 13, fig. 6

Body spherical; wall thin; surface finely granular, covered with numerous, radially disposed, pointed spines

4-11 microns long, one micron or less wide at base; spines usually erect, often slightly flexed or recurved; diameter of body (excluding spines) 24-38 microns.

Typical specimen: Slide No. OPC 837H-2-18, Thermopolis Shale, Big Horn County, Wyoming. Diameter 35.6-30.5 microns.

This species is characterized by the numerous, pointed spines and the granular surface of the body.

Affinity: Unknown.

Stratigraphic occurrence: Fairly common in the Thermopolis Shale in Teton and Big Horn Counties. Also present in the Rusty beds in Hot Springs County and in the Muddy Sandstone and Shell Creek Shale in Big Horn County. Common in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837H-2-18, Thermopolis Shale, Big Horn County.

BALTISPHAERIDIUM SP. B

Plate 13, fig. 5

Body spherical; laevigate; ornamented with pointed, hirsute, densely spaced spinose projections; projections less than one micron in diameter, frequently recurved and tangled together, length 5-8 microns; diameter of body (exclusive of spines) 23-53 microns.

Typical specimen: Slide No. OPC 837G-4-4, Thermopolis Shale, Big Horn County, Wyoming. Diameter 23.5 microns.

This species is similar to Hystrichosphaeridium whitei Deflandre and Courteville, 1939, but the size range is considerably smaller and the spines are apparently not as closely packed.

Affinity: Unknown.

Stratigraphic occurrence: Present in minor abundance in the Thermopolis Shale in Teton and Big Horn Counties. Present in the lower part of the Thermopolis Shale in Hot Springs County, and in the Fall River and Skull Creek Formations in Weston County.

Figured specimen: Slide No. OPC 837G-4-4, Thermopolis Shale, Big Horn County.

BALTISPHAERIDIUM SP. C

Plate 12, fig. 5

Body spherical; laevigate; spinose, spines short, smooth, widely spaced and conical, usually rigid, occasionally slightly recurved at tips, one micron wide at base, 2.0-4.5 microns long, apparently solid; diameter of body (excluding spines) 23-31 microns.

Typical specimen: Slide No. OPC 840D-3-3, Thermopolis Shale, Teton County. Diameter 23.0 microns.

This form is quite rare but is easily recognizable by the short, widely spaced, apiculate projections and the laevigate surface.

Affinity: Unknown.

Stratigraphic occurrence: Present as a trace in the Thermopolis Shale in Teton County and in the Fall River and Skull Creek Formations in Weston County.

Figured specimen: Slide No. OPC 840D-3-3, Thermopolis Shale, Teton County.

Genus MICRHYSTRIDIUM Deflandre, 1937

Type species: Micrhystridium inconspicuum (Deflandre, 1935) Deflandre, 1937 (p. 80, pl. 12, figs. 11-13).
1935 Hystrichosphaera inconspicua Deflandre (p. 233, pl. 9, figs. 4, 7, 11, and 12).

MICRHYSTRIDIUM INCONSPICUUM (Deflandre, 1935) Deflandre, 1937

Plate 13, figs. 3 and 8

The extremely small size, laevigate surface, and long, thin spines of this species make it easily recognizable. It occurs in the Thermopolis Shale and Muddy Sandstone in Big Horn County in fair abundance.

Affinity: Unknown.

Stratigraphic occurrence: Present in small numbers in the Thermopolis Shale in Teton County. Common in the Thermopolis Shale, Muddy Sandstone, and Shell Creek Shale in Hot Springs and Big Horn Counties. Fairly common in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 836B-1-1, Thermopolis Shale, Hot Springs County, and OPC 838B-2-3, Muddy Sandstone, Big Horn County.

MICRHYSTRIDIUM cf. M. FRAGILE Deflandre, 1947

Plate 12, fig. 6

Body spherical; surface laevigate; 5-10 needlelike processes present, 9-18 microns long, hollow, tapering, pointed and rigid; diameter of body 12-18 microns.

The specimens here referred to *M. fragile* have fewer processes and they seem to be more rigid than the forms described by Deflandre.

Affinity: Unknown.

Stratigraphic occurrence: Present in small numbers in the upper part of the Thermopolis Shale and Muddy Sandstone in Teton County, in the upper part of the Thermopolis Shale in Big Horn County, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837H-1-17, Thermopolis Shale, Big Horn County.

MICRHYSTRIDIUM DENSISPINUM Valensi, 1953

Plate 13, figs. 7 and 9

This is a common species in the lower part of the Thermopolis Shale in Big Horn County. A description of the forms herein assigned to M. densispinum follows:

Symmetry radial; shape spherical to ovate; wall less than one micron thick, covered with closely spaced, evenly arranged, pointed, apiculate to hirsute spines, 1.5 microns or less high, spines may have slightly expanded bases; diameter exclusive of spines 4-19 microns, average 11 microns.

The Wyoming forms differ from the specimens described by Valensi only in that the size range is somewhat larger. The species is characterized by the short, pointed, very closely spaced spines.

Affinity: Unknown.

Stratigraphic occurrence: Present in the Thermopolis Shale and Muddy Sandstone in Teton County. Very abundant in the lower Thermopolis Shale in Hot Springs and Big Horn Counties. Present in the Muddy Sandstone and Shell Creek Shale in Big Horn County. Fairly common in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 635C-7-4, Skull

Creek Shale, Weston County, and OPC 836B-1-2, Thermopolis Shale, Hot Springs County.

MICRHYSTRIDIUM SP. A

Plate 13, fig. 10

Symmetry radial; spherical; widely spaced, pointed, spinose projections present, slightly wider at base than at tip, generally rigid, occasionally recurved, 1-2 microns long; surface otherwise laevigate; diameter exclusive of spines 5.5-13.5 microns.

Type specimen: Slide No. OPC 837F-9-1, Thermopolis Shale, Big Horn County, Wyoming. Diameter 7.7-8.8 microns.

Affinity: Unknown.

Stratigraphic occurrence: Present in the Thermopolis Shale in Teton County. Fairly common in the Thermopolis, Muddy, and Shell Creek Formations in Big Horn County. Present in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837F-9-1, Thermopolis Shale, Big Horn County.

Genus VERYHACHIUM Deunff, 1954

Type species: *Veryhachium trisulcum* (Deunff, 1951) Deunff, 1954 (p. 1064).

1951 *Hystrichosphaeridium trisulcum* Deunff

(p. 322, fig. 3).

VERYHACHIUM SP. A

Plate 12, figs. 7 and 8

Outline triangular; flattened, probably originally biconvex in side view; surface laevigate; sides straight to slightly concave or convex; each corner produced in a tapering, pointed process; wall thin, less than one micron thick; dimensions (from tip of one corner process to middle of opposite side) 29-36 microns.

Typical specimen: Slide No. OPC 837G-4-2, Thermopolis Shale, Big Horn County, Wyoming. Dimensions 29.5 x 33.0 x 33.0 microns.

Palaeotetradinium hyalodermum Cookson, 1956 resembles this species except that it bears four spines and is tetrahedral in shape.

Affinity: This species resembles some modern genera of desmids. It is probably related to the algae.

Stratigraphic occurrence: Present in small numbers in the Thermopolis Shale and Muddy Sandstone in Teton County, the Thermopolis Shale in Big Horn County, and the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 837G-4-2, and OPC 837H-10-1, Thermopolis Shale, Big Horn County.

VERYHACHIUM SP. B

Plate 12, figs. 9 and 10

Shape angular; flattened; roughly triangular, each apex prolonged into a tapering, pointed projection; two pairs of flattened, tapering, pointed processes typically project from the central body, one pair occurs near the center of the body, one process on either side of the plane of the central body, the other pair occurs near one margin of the body, one process extending outward on either side of the body; body and processes laevigate; diameter of body 12-21 microns, projections 7-15 microns long.

Typical specimen: Slide No. OPC 837H-10-11, Thermopolis Shale, Big Horn County, Wyoming. Overall diameter (from tip of corner process to middle of opposite side) 28 x 27 x 27 microns, accessory projections 11.5 microns long.

This species bears a total of seven processes, three at the corners of the triangular body and four projecting from the body. Occasionally one of the apical processes will bifurcate slightly. The body processes are often folded back against the surface of the body.

Affinity: Probably related to the algae, possibly to the desmids.

Stratigraphic occurrence: Rare in the Thermopolis

Shale in Teton and Big Horn Counties.

Figured specimens: Slides No. OPC 837H-10-11, Thermopolis Shale, Big Horn County, and OPC 840C-2-1, Thermopolis Shale, Teton County.

VERYHACHIUM SP. C

Plate 12, fig. 11

Symmetry radial; body angular, bears 7-8 long, hollow processes, 19-22 microns long; processes broad at base and taper to a point, processes connect with interior of body, usually rigid, occasionally slightly flexed; 1-2 short, needle like, hollow processes, 8-12 microns long occasionally present; wall less than one micron thick; surface laevigate to very finely granular; diameter of body 17-28 microns.

Too few specimens of this form were seen to warrant the erection of a species.

Affinity: Unknown.

Stratigraphic occurrence: Present only as a trace in the Thermopolis Shale in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837F-1-13, Thermopolis Shale, Big Horn County.

Genus CHLAMYDOPHORELLA Cookson and Eisenack, 1958

Type species: Chlamydophorella nyei Cookson and Eisenack, 1958 (p. 56-57, pl. 11, figs. 1-3).

CHLAMYDOPHORELLA cf. NYEI Cookson and Eisenack, 1958

Plate 11, fig. 7

Body approximately spherical with an apical projection about 15 microns long and 13 microns wide; body covered with thin, smooth, closely spaced spines which bifurcate at tips, 3-6 microns long; spines support a delicate veil or membrane which encircles the whole body and which is drawn out into a tube surrounding the apical projection and extending beyond it a short distance; diameter of body exclusive of spines 31-43 microns.

Specimens here referred to C. nyei lack the girdle-like appearance described by Cookson and Eisenack but are otherwise similar to the Australian specimens.

Affinity: Possibly related to the dinoflagellates.

Stratigraphic occurrence: Present in small numbers in the upper part of the Thermopolis Shale and in the Muddy Sandstone in Teton County, in the Thermopolis Shale in Big Horn County, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 837G-3-6, Thermopolis Shale, Big Horn County.

Family PTEROSPERMOPSIDAE Eisenack, 1954

Genus PTEROSPERMOPSIS W. Wetzel, 1952

Type species: *Pterospermopsis danica* W. Wetzel, 1952 (p. 412, pl. 6, fig. 16, text fig. 34).

PTEROSPERMOPSIS EURYPTERIS

Cookson and Eisenack, 1958

Plate 12, fig. 14

This species was originally described from the Lower Cretaceous of Australia. There are no observable differences between the Wyoming specimens and those described by Cookson and Eisenack.

Affinity: According to Deflandre and Cookson (1955), forms of this type resemble specimens of the genus *Pterosperma* Pouchet, a problematical component of living plankton.

Stratigraphic occurrence: Present as a rare element in the Rusty beds in Hot Springs County, in the Muddy Sandstone in Big Horn County, and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 838B-4-1, Muddy Sandstone, Big Horn County.

PTEROSPERMOPSIS cf. P. AUSTRALIENSIS

Deflandre and Cookson, 1955

Plate 12, fig. 12

Circular in polar view; central body and surrounding "flange" laevigate; wall of central body less than one micron thick; diameter of central body 12-18 microns; overall diameter 35-51 microns.

P. australiensis is essentially similar to P. eurypteris except for its smaller size. The Wyoming specimens differ from the original description of the species in that the ratio of the central body to the flange is slightly higher and the flange frequently lacks well developed radial folds.

Affinity: See discussion for P. eurypteris.

Stratigraphic occurrence: Present in very minor abundance in the upper part of the Thermopolis Shale and in the Muddy Sandstone in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 636-10-8, Skull Creek Shale, Weston County.

PTEROSPERMOPSIS SP. A

Plate 12, fig. 13

Oval to circular in polar view; central body oval to circular, laevigate, fairly thick walled; flange narrow, laevigate; diameter of central body 20-43 microns; overall diameter 28-57 microns; ratio of central body to flange about 1.4.

This form resembles *Pterospermopsis ginginensis* Deflandre and Cookson, 1955 except that the ratio of body to flange is a little smaller and the central body is laevigate rather than punctate. Description based on only four specimens.

Affinity: Probably a planktonic organism similar to other species of *Pterospermopsis*.

Stratigraphic occurrence: Present in the Thermopolis Shale in Teton County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 840D-8-1, Thermopolis Shale, Teton County.

Genus CYMATIOSPHAERA O. Wetzel, 1932 emend. Deflandre, 1954

Type species: *Cymatiosphaera radiata* (O. Wetzel, 1933) Deflandre, 1954 (p. 257-258).

1933 *Cymatiosphaera radiata* O. Wetzel (p. 27, pl. 4, fig. 8).

CYMATIOSPHAERA SP. A

Plate 14, fig. 11

Shell radial; spherical; surface reticulate, otherwise laevigate; intersections of muri slightly thickened, 1.0-1.5 microns high, muri lower between intersections and membranous, defining polygonal lumens with straight to irregularly "crinkled" walls; lumens generally five sided, occasionally 4 or 6 sided, 4-9 microns wide; body wall 2.0-5.5 microns thick; overall diameter 17-53 microns.

Typical specimen: Slide No. OPC 636-4-11, Skull Creek Shale, Weston County, Wyoming. Diameter 35.6 microns.

This species is similar to C. pachytheca Eisenack, 1957 but differs from it in that the wall is thinner and has no pores and the size range is considerably smaller. C. parva Sarjeant, 1959, is considerably smaller and has a thinner wall than the Wyoming specimens.

Affinity: Unknown.

Stratigraphic occurrence: Present in the upper part of the Thermopolis Shale in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 636-4-11, Skull Creek Shale, Weston County.

ANIMALIA INCERTAE SEDIS

Genus CRASSOSPHAERA Cookson and Manum, 1960

Type species: Crassosphaera concinna Cookson and Manum, 1960 (p. 6-7, text fig. 1, pl. 1, figs. 1-3 and 7-10).

CRASSOSPHAERA SP.

Plate 11, fig. 9

Symmetry radial; shape spherical; surface covered with evenly spaced, smooth, rounded projections less than one micron high, 1.0-1.5 microns in diameter, spaced approximately two microns apart; each projection bears a minute pit which apparently does not pierce the body wall; overall diameter 41.5 microns; wall 4 microns thick.

This form is rare in the Wyoming samples and too few specimens were seen to erect a type.

Affinity: Unknown.

Stratigraphic occurrence: Present in the Shell Creek Shale in Big Horn County and in the Skull Creek Shale in Weston County.

Figured specimen: Slide No. OPC 635C-3-3, Skull Creek Shale, Weston County.

Genus DIPLOTESTA Cookson and Eisenack, 1960

Type species: Diplotesta glaessneri Cookson and Eisenack, 1960 (p. 256, pl. 39, figs. 4-6).

DIPLOTESTA GLAESSNERI

Cookson and Eisenack, 1960

Plate 14, fig. 1

This species is rare in the Wyoming Lower Cretaceous but the specimens which were seen differ from D. glaessneri only in that the internal capsule is slightly shorter.

Affinity: Unknown.

Stratigraphic occurrence: Present in minor numbers in the upper part of the Thermopolis Shale and in the Muddy Sandstone in Big Horn County. Also in the Skull Creek Shale, Weston County.

Figured specimen: Slide No. OPC 837G-6-1, Thermopolis Shale, Big Horn County.

Genus DIOXYA Cookson and Eisenack, 1958

Type species: Dioxya armata Cookson and Eisenack, 1958 (p. 59, pl. 11, fig. 11).

DIOXYA ? SP.

Plate 14, fig. 10

Body subspherical; slightly elongate, short, blunt apical process present; antapical end broad, low, and rounded, surface finely granular and covered with closely spaced spines approximately one micron in diameter, 3-5 microns long, with blunt, bifurcate, or rarely multipartate ends; breadth 48-51 microns; length 64 microns.

Description based on several fragmentary specimens and two complete ones. This form resembles Dioxya villosa Cookson and Eisenack, 1960 but seems to have a slightly different shape and a different type of spine.

Affinity: Unknown.

Stratigraphic occurrence: Present only in the Muddy Sandstone in Big Horn County.

Figured specimen: Slide No. OPC 838B-6-1, Muddy Sandstone, Big Horn County.

GENUS B

Symmetry bilateral; body wall less than one micron thick; shape of body subrectangular; four pores present, one at each corner of body; pores may be sessile or the corners may be produced into hollow tubes of variable length with a pore at the end.

GENUS B SP. A

Plate 14, figs. 2, 3, and 6

Symmetry bilateral; body angular; outline rectangular; sides straight to slightly concave or convex; wall less than one micron thick; levigate, secondary folds common; four pores present, one at each corner of body; pores 3-5 microns in diameter, sessile or carried at the ends of hollow tubes 5-26 microns long, 3-5 microns in diameter; length of body 20-38 microns; width of body 12.7-25.4 microns.

Typical specimen: Slide No. OPC 837C-4-2, Thermopolis Shale, Big Horn County, Wyoming. Body 22.8 microns long, 15.2 microns wide; corner projections 7.7-11.1 microns long.

Forms assigned to this species form a gradational series from specimens in which the pores are flush with the surface of the body at each of the four corners to specimens in which each corner is produced in a long, hollow tube with an open pore at the end. Although the length of the corner projections vary greatly from specimen to specimen, they are approximately the same length on an individual. A few specimens show what may be an operculum folded down inside the pore.

Affinity: Unknown.

Stratigraphic occurrence: Present as a rare form in the Thermopolis Shale in Teton, Hot Springs, and Big Horn Counties, and in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 837C-4-2, OPC 837D-3-1, and OPC 837B-5-1, Thermopolis Shale, Big Horn County.

GENUS C

Symmetry bilateral; body wall less than one micron thick; secondary folds common; shape rectangular or subspherical; one pore present at one end of body, pore sessile or with slightly raised margins.

GENUS C SP. A

Plate 14, figs. 4, 5, and 7

Symmetry bilateral; outline normally rectangular, rarely subspherical; wall less than one micron thick; laevigate; secondarily folded; one pore 7-19 microns in diameter present at one end of body; pore sessile or with raised and slightly thickened margins; overall length 40-61 microns; overall width 33-61 microns.

Typical specimen: Slide No. OPC 635A-6-4, Skull Creek Shale, Weston County, Wyoming. Dimensions 50.8 x 48.3 microns, diameter of pore 12 microns.

Due to the delicate nature of the wall, all specimens assigned to this species are found in a compressed state and with numerous secondary folds. The outline is normally rectangular or square but may be rounded. When expanded, these forms may have formed a boxlike or saclike structure with a large pore in one side.

Affinity: Unknown.

Stratigraphic occurrence: Present in the Thermopolis Shale in Teton, Hot Springs, and Big Horn Counties and in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 635A-6-4, OPC 635A-1-13, and OPC 635A-7-16, Skull Creek Shale, Weston County.

GENUS D

Body biconvex, circular to ovate in polar view; roughly circular opening present in center of one side; body variously ornamented; equator may bear spinose projections or a membranous flange.

GENUS D SP. A

Plate 14, figs. 8 and 9

Body circular to oval in polar view; biconvex in equatorial view; roughly circular opening present in center of one side, radius of opening about half that of body as a whole; other side of body entire with a small number of widely spaced apiculate projections 2-4 microns long arising from a zone approximately opposite the opening on the other side; wall 1.0-1.5 microns thick; membranous flange attached equatorially, flange bears widely spaced, outward pointing, apiculae 1.0-1.5 microns long; flange 5-10 microns wide;

diameter of body 44-64 microns.

Typical specimen: Slide No. OPC 643B-9-8, Rusty beds, Teton County, Wyoming. Diameter of body 54.0-59.0 microns, flange 5-6 microns wide.

Specimens assigned to this species are abundant but preservation is uniformly poor, in most specimens only a few remnants of the flange still cling to the central body. All specimens observed possess a circular opening on one side.

Affinity: Unknown.

Stratigraphic occurrence: Present in the Rusty beds and lower Thermopolis Shale in Teton County, present but rare in the Rusty beds in Hot Springs County, the Shell Creek Shale in Big Horn County, and in the Skull Creek Shale in Weston County.

Figured specimens: Slides No. OPC 643B-9-8, OPC 643B-10-3, Rusty beds, Teton County.

GENUS D SP. B

Plate 14, fig. 12

Body circular to oval in polar view, strongly biconvex in equatorial view; roughly circular opening with somewhat ragged edges present in center of one side; other side entire and laevigate; radius of opening one-half to two-thirds radius of body as a whole; obscure, discontinuous reticulum developed on same side of body as opening; lumens polygonal, 5-10 microns in diameter, muri consist of low thickenings approximately one micron wide and less than one micron high; widely spaced spinose projections protrude from equatorial region, spines 5-10 microns long, pointed or with slightly bulbous tips, thin and often recurved; body wall 1.5-2.0 microns thick; overall diameter of body (spines excluded) 40-64 microns.

Typical specimen: Slide No. OPC 835D-1-1, Rusty beds, Hot Springs County, Wyoming. Dimensions 50.8-63.5 microns.

Although abundant, all specimens observed were poorly preserved.

Affinity: Unknown.

Stratigraphic occurrence: Present in the lower part of the Thermopolis Shale in Teton County. Abundant in the Rusty beds in Hot Springs County.

Figured specimens: Slides No. OPC 835D-1-1, Rusty beds, Hot Springs County.

ZONATION AND CORRELATION

Palynological fossils, both marine and non-marine, are present in nearly all sedimentary rock types. Many rocks which are barren of megafossils will yield an abundance of palynomorphs. Palynological fossils are therefore of greater aid in correlation studies than perhaps any other type of fossil.

Two biostratigraphic zones can be recognized with marine planktonic fossils and these divide the Thermopolis and Skull Creek Shales into an upper and a lower zone. The lower zone is characterized by the dinoflagellate species *Pseudoceratium* sp. A and is here termed the *Pseudoceratium* sp. A assemblage zone. In Teton County this zone consists of the Rusty beds and approximately the lower half of the Thermopolis Shale. In Hot Springs and Big Horn Counties, the *Pseudoceratium* sp. A zone consists of the Rusty beds and approximately the lower two thirds of the Thermopolis Shale. In Weston County, the zone extends from slightly below the middle of the Fall River Formation through the lower third of the Skull Creek Shale. In addition to *Pseudoceratium* sp. A, this zone also contains the following problematical fossil species: Genus D sp. A and Sp. B, and Genus B sp. A.

The upper zone is here termed the *Deflandrea* cf. *D. minor* assemblage zone and is characterized by the following species of fossils: *Deflandrea* cf. *D. minor*, *Hystrichosphaera* cf. *H. furcata*, *Gonyaulax* spp., *Hystrichosphaeridium* cf. *H. tubiferum*, *H.* cf. *H. choanophorum*, *H.* sp. A, *Chlamydophorella nyei*, *Baltisphaeridium machaerophorum*, *B. lumectum*, and *Veryhachium* sp. A. In Teton County this zone comprises the upper half of the Thermopolis Shale and includes the Muddy Sandstone. In the Big Horn County section it consists of the upper third of the Thermopolis Shale and in Weston County of approximately the top two thirds of the Skull Creek Shale.

Most of the above fossils are related to the dinoflagellates, either as motile or as incysted forms. Genus B, Genus D, and *Veryhachium* sp. A, however, show no indication of dinoflagellate affinities although they are almost certainly marine planktonic organisms.

Plant microfossils consisting of spores, pollen, cuticles, and wood fragments, derived from land floras are independent of marine ecological conditions and where mixed with marine fossils, they provide one of the surer means for the correlation of strata. Spores and pollen derived from arborescent species which depend upon wind for dissemination are likely to best reflect the composition of the regional vegetation. Changes in the composition of this type of palynological assemblage through the stratigraphic section will tend to be due to plant migration or regional plant succession in response to climatic or major physiographic change rather than to minor local environmental factors. Plant evolution is also a stratigraphic aid if the rocks in question are of considerable difference in age. The following genera have been selected as being the more likely to have been derived from a regional arborescent flora: *Piceaepollenites*, *Classopollis*, *Vitreisporites*, *Rugubivesiculites*, *Podocarpidites* and possibly *Tricolpites*. The first two genera and the last occur in varying abundances throughout the stratigraphic section under study and seem to have little correlation value. *Vitreisporites*, *Podocarpidites*, and *Rugubivesiculites*, however, have somewhat limited ranges in the Wyoming Lower Cretaceous and their stratigraphic occurrence appears significant. In general, they range higher in the section from east to west. This is particularly true of

Rugubivesiculites and Vitreisporites.

The genus Rugubivesiculites, of which only one species was recognized, occurs only in the lower part of the Newcastle Formation in Weston County and in the lower part of the Shell Creek Shale in Big Horn County. Podocarpidites and Vitreisporites are present in the Fall River and Skull Creek Formations in Weston County but not in the Newcastle Formation. In Hot Springs and Big Horn Counties these two genera are restricted to the Rusty beds and Thermopolis Shale and do not occur in the Muddy Sandstone or the Shell Creek Shale. In Teton County both genera range throughout the Thermopolis Shale and into the Muddy. In Weston County Vitreisporites occurs as low as the lower middle of the Fall River Formation (sample OPC 634J). In Hot Springs County it was not observed below sample OPC 835E, approximately the middle of the Rusty beds. In Teton County, the first appearance of Vitreisporites is in the lowermost Thermopolis Shale.

The progressively higher stratigraphic occurrence of the above genera from east to west suggests a progressively older age for similar lithofacies from east to west. The Rusty beds in Teton County, for example, are possibly older than the Rusty facies in Hot Springs County and the Fall River Formation is possibly younger still. Here the assumption is being made that biofacies more closely approximate time lines than do lithofacies boundaries. The inherent danger in utilizing fossils for time correlation lies in the possibility that they represent migrating facies rather than contemporaneous deposition. Wind-borne pollen derived from land floras, however, is independent of marine ecological conditions and may be expected to have a wide aerial distribution. The composition of regional arborescent floras is controlled predominantly by climatic factors and in an area the size of that covered in this study the regional arborescent flora may be assumed to have been relatively constant. Therefore, the distribution of wind-borne pollen may be assumed to represent nearly contemporaneous deposition. The factor of plant migration, however, should not be ignored. The parent plant of Vitreisporites, for example, may have existed in the Black Hills region at an earlier time than in the Teton County area and the rise in the section of this genus from east to west may represent a westward migration of the parent plant. In this study, the conclusion is made that there is a biofacies rise in the section from east to west and that this may be considered a time correlation line. This conclusion is drawn not only from the distribution of wind-borne pollen but also from the distribution of marine planktonic fossils. Marine plankton are much less susceptible to ecological factors which may drastically affect the distribution of benthonic and even neritic megafossils. In any given area the distribution of plankton is more likely to be relatively uniform and widespread than that of the benthonic or neritic faunas.

Pseudoceratium and Genus D are abundant only in the Rusty beds and lowermost Thermopolis Shale in Hot Springs County but occur up into the lower fourth of the Thermopolis section in Teton County. The distribution of Pseudoceratium and Genus D suggests that Rusty deposition had ceased and Thermopolis Shale was being deposited in Teton County while Rusty deposition was still taking place in Hot Springs County. Probably the lower fourth of the Thermopolis shale facies in the Teton County section had been laid down by the time Thermopolis Shale deposition started in the eastern Big Horn Basin. Relationships with the Fall River and lower Skull Creek Formations of the southern Black Hills area are obscure. Pseudoceratium is present, although rare, in the lower third of the Skull Creek Shale and occurs only in samples OPC 634R and OPC 634J of the Fall River Formation. Actually no criteria are available to make any other than generalized postulates regarding the age relationships of the Fall River

Formation and the lower part of the Skull Creek Shale to the Big Horn and Teton County sections. The marine fossil content of the lower third of the Skull Creek section is similar to that of approximately the lower one half to two thirds of the Thermopolis in Big Horn County and approximately the lower one half of the Thermopolis in Teton County.

Possibly the lower third of the Skull Creek Shale in Weston County is equivalent to the interval of the Thermopolis covered by samples OPC 837A, OPC 837B, and OPC 837C in Big Horn County, an interval of about 70 feet (100-170 feet below the base of the Muddy). If this is true then the upper Fall River Formation in Weston County is obviously equivalent to the lowermost Thermopolis in the Big Horn Basin section. The only support for this view is the fact that Genus B and Genus C are either confined to, or are most abundant in the lower Skull Creek in Weston County and the OPC 837A through OPC 837C sample interval in Big Horn County.

The upper two thirds of the Skull Creek Shale in Weston County seems to correlate with the top 50 to 75 feet of the Thermopolis Shale in Big Horn County and with the top half of the Thermopolis Shale and possibly the Muddy Sandstone, in Teton County. This conclusion is based on the following facts:

The following fossil species are restricted, in Big Horn County, to an interval comprising approximately the top third of the Thermopolis Shale: *Hystrichosphaera* cf. *H. furcata*, *Hystrichosphaeridium* cf. *H. tubiferum*, *H.* cf. *H. choanophorum*, *H.* cf. *H. eoinodes*, *H.* sp. A, *Chlamydophorella nyei*, *Veryhachium* sp. A, *Diplotesta glaessneri*, *Deflandrea* cf. *D. minor*, and *Gonyaulax* spp. The same group of fossils is present predominantly in the middle third of the Skull Creek Shale in Weston County. *Veryhachium* sp. A and *Hystrichosphaera* cf. *H. furcata*, however, range up into the top of the Skull Creek, being present in sample OPC 636. *Hystrichosphaeridium* cf. *H. eoinodes* is present in the top of the lower third of the Skull Creek in sample OPC 635B. In Teton County the same assemblage is present predominantly in the top half of the Thermopolis Shale. Only *Hystrichosphaeridium* cf. *H. eoinodes* and *Chlamydophorella nyei* occur up into the Muddy Sandstone in abundance. *Veryhachium* sp. A and *Hystrichosphaeridium* cf. *H. tubiform* are present in the Muddy but are not abundant. *Deflandrea* cf. *D. minor* is present only in samples OPC 840A and OPC 840B, approximately the upper middle of the Thermopolis. *Hystrichosphaeridium* cf. *H. eoinodes* occurs throughout the whole top half of the Thermopolis Shale in Teton County.

Eicher (1960, p. 36) in a study of the Foraminifera of the Thermopolis Shale, concluded that the entire Skull Creek Shale in the southern Black Hills correlates with the upper Thermopolis Shale in the area around Thermopolis, Wyoming. The results of the present investigation suggest that only the upper two thirds of the Skull Creek Shale, at least in the Newcastle Wyoming area, is correlative with the upper Thermopolis in the Big Horn Basin.

EXPLANATION OF FIGURES

Figures 3 and 4 illustrate the distribution and relative percentages of palynological genera and species in the stratigraphic sections studied in this paper. Sample thicknesses are drawn to scale. Each of the three major groups of palynomorphs (trilete spores, pollen, and fossil microplankton) is grouped exclusive of the other two groups. For example, the total of the percentages of trilete spores in any one sample will equal 100 percent. The total of the percentage of pollen in the same sample will also equal 100 percent, as will the total of the fossil microplankton.

The relative abundance of each fossil species in each sample is shown in Table I. Relative abundances are expressed as a percentage of the total assemblage present in each sample.

PALEOECOLOGY AND DEPOSITIONAL ENVIRONMENTS

Time limitations in the field made it impossible to sample the studied formations at more than one, or in some cases two, localities. It must be pointed out that the following conclusions are limited to the areas in which collections were made.

Fall River Formation

The Fall River assemblage indicates deposition in a predominantly continental or slightly brackish environment such as a low-lying coastal area characterized by predominantly fresh-water deposits, but subject to intermittent inwash of marine waters. The palynological assemblage consists essentially of spores and pollen, but a few dinoflagellates and hystrichosphaerids occur in some samples. Sporadic appearance of marine microfossils in a predominantly continental assemblage indicates a fluctuation between fresh and brackish water conditions during deposition of the Fall River

Formation. Fresh-water conditions predominated during this time. The spore flora is large and varied with numerous large, ornate spores of possible schizacaean affinity. Gymnosperm pollen, predominantly coniferalian, is present in abundance and a few angiosperm pollen grains are present.

The plant spores might have been derived from a coastal swamp lying adjacent to the depositional area. The pollen grains may represent swamp vegetation but are also partly derived from upland vegetation. Most of the fossils are rather poorly preserved; apparently the Fall River depositional environment did not favor preservation of organic material. This type of preservation may also be indicative of shallow, well aerated waters, although local lagoonal or swampy areas must have been intermittently present.

Skull Creek Shale

The Skull Creek Shale, in the area around Newcastle, Wyoming, contains the best preserved and most varied assemblage of palynological fossils seen in the course of this investigation. A well-developed marine fauna of dinoflagellates and hystrichosphaerids is present as well as a large spore and pollen assemblage. Gymnosperm pollen grains, particularly <u>Inaperturopollenites</u> sp. A and <u>Piceapollenites</u>

compose the bulk of the assemblage. The marine fauna is dominated by the hystrichosphaerids.

The spore and pollen assemblage is of continental origin and is more diversified in the lower portions of the Skull Creek section. The marine elements become more numerous and more diversified in the upper part of the section. Although the whole of the Skull Creek Shale was undoubtedly deposited in a marine environment, it would seem that the upper part of the formation (samples OPC 837C through OPC 636) was deposited farther from shore, possibly in deeper water than the lower portions of the section (samples OPC 635A through OPC 635C). This is suggested because of the increasing importance upward in the section of marine forms and the corresponding decrease in the number of land-derived fossils. The arborescent land flora appears to have been composed predominantly of conifers. Spore producing plants, probably mostly relatable to the Filicineae (true ferms) were present in abundance.

Newcastle Formation

Grace (1952) has pointed out that the Newcastle Formation is variable both in thickness and character all along its outcrop. The section studied consists predominantly of sandstone interbedded with siltstone, shale, and rare bentonites. Only samples OPC 637C, OPC 637D, OPC 637H, and OPC 637J were fossiliferous. The Newcastle, at the sampled locality, contains a fossil assemblage entirely of continental origin, the bulk of which is made up of plant spores. Gymnosperm pollen is present in abundance only in the lower part of the section in samples OPC 637C and OPC 637D and becomes increasingly rare toward the top of the formation. From the standpoint of bulk composition, angiosperm pollen is not important in the Newcastle assemblage; however, seven different species of angiosperm grains are found in the Newcastle samples, a greater number than is present in any of the other formations studied.

Carbonized leaf remains and thin lignitic zones are present in the lower samples of the Newcastle.

Newcastle deposition, at the locality studied in this paper, was probably in a low-lying, continental, fluvial or swampy environment. The spore flora is dominated by small, smooth fern spores such as *Cyathidites* and *Gleicheniidites* and a number of spores of schizacean affinity. These ferns are characteristic of modern tropical and subtropical swamps. Gymnosperm pollen is present but not abundant. This indicates that the gymnosperm trees were either not abundant in the depositional area or their contribution to the fossil assemblage was from some distant source. Possibly both factors were in operation. A relatively large number of angiosperm pollen species are present in the sediments but these plants were not important elements of the regional flora.

Rusty beds

Deposition of the Rusty beds in both Teton and Hot Springs Counties is interpreted as having been in a shallow-water, near-shore, brackish-water environment. In Hot Springs County, dinoflagellates and problematical marine fossils are present in greater abundance in the upper Rusty samples than in the lower samples, indicating that the upper beds of the Rusty may have been deposited under slightly deeper waters and more marine conditions than the lower part of the formation.

In Teton County, the Rusty beds contain only one fossil species of probable marine origin but this species is present in fair abundance. Plant spores and pollen are present in slightly greater numbers than in Hot Springs County and the assemblage is more varied. The Rusty beds appear to have been laid down nearer to the shore at the Teton County locality than in the Hot Springs County locality.

Preservation at both localities is poor, possibly due to the bottom sediments being aerated and perhaps re-worked to a certain extent by marine organisms.

Thermopolis Shale

The distribution of marine and continental fossils in the Thermopolis Shale, both in Teton and Big Horn Counties, is similar to the pattern shown by the Skull Creek Shale. The occurrence of marine forms is predominantly in the upper part of the section.

A well-developed marine assemblage is present in Big Horn County only in samples OPC 837E through OPC 837H. The lower part of the section (samples OPC 836A through OPC 837D) is characterized by an abundance of Micrhystridium but other marine fossils are rare. In Teton County marine fossils are common only in samples OPC 840B through OPC 840E. Deposition of the lower part of the Thermopolis Shale may have been in a nearer shore, shallower water environment than the upper part in both Teton and Big Horn Counties. The lower Thermopolis in Teton County (samples OPC 644A through OPC 644C) may even have been deposited in brackish waters.

The spore and pollen content of Thermopolis samples is considerably greater in Teton County than in Big Horn

County. This suggests that the entire Thermopolis section in Teton County may have been deposited in a more near-shore environment than the Big Horn County section.

Muddy Sandstone

The Muddy Sandstone, at the two studied localities, was laid down in a marine depositional environment, possibly as a bar sand. A marine fauna is present in the Muddy Formation in both Big Horn and Teton Counties but the marine forms are more abundant and the assemblage is more diversified in Big Horn County. In Teton County, the spore and pollen assemblage is a larger part of the total than in Big Horn County. Possibly the Teton County section was deposited closer to shore than the Big Horn County section.

PALEONTOLOGICAL COMPARISON WITH OTHER AREAS

Evidence from invertebrate stratigraphic ranges indicates that the rock stratigraphic section discussed in this paper belongs to the Albian stage of the Lower Cretaceous (Cobban and Reeside, 1952). This age assignment is supported by Skolnick's Foraminifera study of the Skull Creek and Newcastle Formations in the Black Hills. Skolnick concluded that the lower Mowry Shale, the Newcastle Formation and the Skull Creek Shale are early and middle Albian in age.

The assemblage of palynological fossils reported here compares well with Lower Cretaceous assemblages reported from other areas. The spore and pollen assemblages support an Albian age for the sediments. The palynology of other areas in which detailed palynological studies have been made are reviewed below.

U.S.S.R.

Russian palynologists have published extensively on spore and pollen assemblages recovered from Lower Cretaceous rocks in the U.S.S.R. Unfortunately, the Russians use an entirely different system of nomenclaure for palynological fossils from that used in this country and most of their studies are not available in translation. Nevertheless, it is possible to make a generalized comparison of the Wyoming assemblage with some of the Russian work.

Zaklinskaya (1960, in translation) has summarized the spore and pollen assemblages recovered from the Cretaceous sediments in the Asiatic part of the U.S.S.R. The Wyoming assemblage seems to compare rather closely with the Albian stage as described by Zaklinskaya. In both areas, the Gleicheniaceae and Schizaeaceae are common elements of the spore flora and the pollen is predominantly gymnospermous. Angiosperm pollen is rare and tricolpate forms predominate.

England

The Wyoming assemblage has a general similarity to the spore and pollen association described by Couper (1958) from the Purbeckian and Wealdian beds of England. Couper reported no angiosperm pollen with the possible exception of _Clavatipollenites_ and _Spheripollenites_. It is possible that the Wyoming sediments are younger than the English Wealdian, even though the spore floras are remarkably similar.

New Zealand

Couper (1953) has described spore and pollen assemblages recovered from New Zealand fresh-water sediments ranging in age from Jurassic to Pleistocene. The Wyoming assemblage compares nearest to the spore-pollen assemblage which Couper recovered from the Paparoa beds (Lower Cretaceous) of New Zealand.

Canada

Pocock (1962) described the palynological content of the Upper Jurassic-Lower Cretaceous strata in western Canada. Twenty-nine of the species recognized by Pocock also occur in the rock sections studied from Wyoming. Nine of these species occur throughout Pocock's section, 15 species are restricted to the Mannville Formation of Canada, three species are restricted to strata below the Mannville and two species occur in the lower Mannville and in the underlying strata. Of all the formations included in Pocock's paper, the Wyoming section obviously correlates best with the Mannville Formation. The Mannville Formation is the highest stratigraphic unit with which Pocock's study was concerned and he has assigned a Neocomian-Aptian age to it. Pocock's study is quite detailed and it is possible that even better correlation would have been obtained had he worked with rocks stratigraphically higher than the Mannville Formation.

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APPENDIX

PLATE I

Figure

1. Cyathidites australis Couper, 1953
   58.3 x 60.9 x 55.9 microns; Slide No. OPC 634N-1-1. Page 39.

2. Cyathidites minor Couper, 1953
   33.0 x 30.5 x 30.5 microns; Slide No. OPC 837H-4-5. Page 39.

3-4. Gleicheniidites sp. A
   (3) 26.0 x 28.0 x 27.5 microns; Slide No. OPC 637J-1-11.
   (4) 27.9 x 28.0 x 26.0 microns (holotype); Slide No. OPC 635A-12-2. Page 40

5. Concavisporites variverrucatus Couper, 1958
   63.5 x 66.0 x 64.0 microns; Slide No OPC 634I-2-3. Page 41.

6. Lygodiumsporites minor (Couper, 1958) n. comb.
   48.3 x 48.3 x 48.3 microns; Slide No. OPC 644A-9-1. Page 42.

7-8. Lygodiumsporites sp. B
   (7) 48.3 x 55.9 x 53.3 microns; Slide No. OPC 634I-4-6.
   (8) 53.3 x 53.3 x 54.0 microns (holotype); Slide No. OPC 634Q-1-6. Page 44.

9. Lygodiumsporites sp. A
   48.3 x 47.0 x 48.3 microns (holotype); Slide No. OPC 635A-7-6. Page 43.

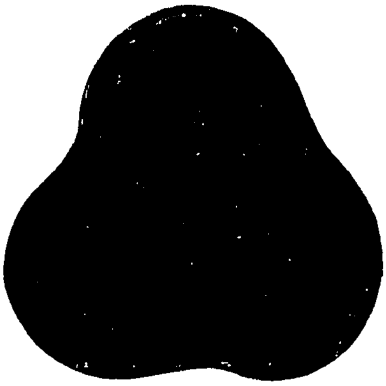
10. Auritulinasporites cf. A. intrastriatus Nilsson, 1958
    22.8 x 25.4 x 26.5 microns; Slide No. OPC 643A-3-2. Page 45.

Figure

11. Spore type A
    109.0 x 114.0 microns; Slide No. OPC 637H-8-1.
    Page 46.

12. <u>Granulatisporites</u> sp. A
    66.0 x 66.0 x 63.5 microns (holotype); Slide No.
    OPC 643A-1-5. Page 47.

PLATE I



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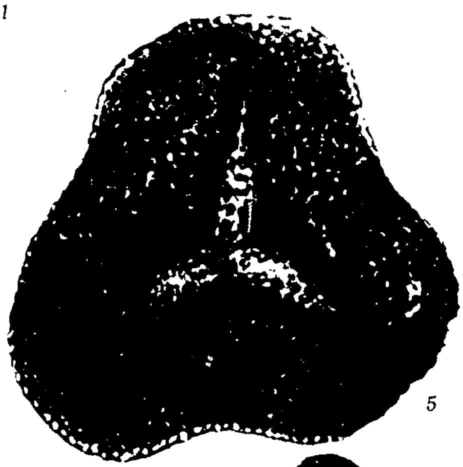

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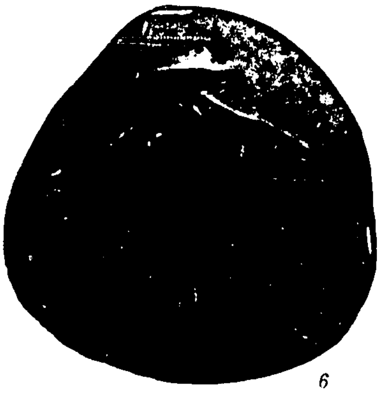

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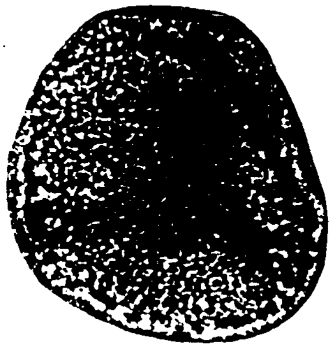

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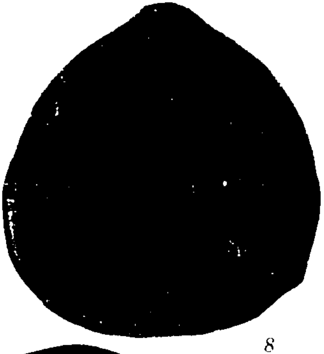

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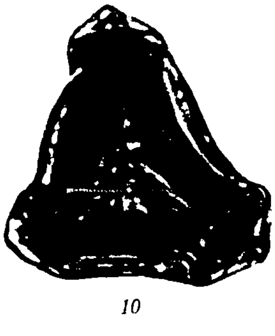

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PLATE II

Figure

1. *Granulatisporites* sp. B
   33.0 x 33.0 x 33.0 microns (holotype); Slide No. OPC 635B-5-7. Page 48.

2. *Leptolepidites verrucatus* Couper, 1953
   40.6 x 40.6 x 43.2 microns; Slide No. OPC 634I-13-1. Page 49.

3. *Leptolepidites major* Couper, 1958
   38.0 x 38.0 x 38.0 microns; Slide No. OPC 634Q-3-2. Page 49.

4-5. *Leptolepidites* sp. A
   (4) 50.8 x 50.8 x 48.3 microns; Slide No. OPC 643D-3-1.
   (5) 48.3 x 48.3 x 45.7 microns (holotype); Slide No. OPC 634P-11-1. Page 50.

6. *Leptolepidites* sp. B
   36.5 x 34.0 x 35.6 microns; Slide No. OPC 634K-6-10. Page 51.

7. *Osmundacidites wellmanii* Couper, 1953
   35.6 x 38.1 microns; Slide No. OPC 837H-2-6. Page 51.

8. *Osmundacidites* sp. A
   30.5 x 30.5 x 30.5 microns (holotype); Slide No. OPC 635B-1-9. Page 52.

9. *Anemiidites echinatus* Ross, 1949
   22.8 x 22.8 x 25.7 microns; Slide No. OPC 634I-2-2. Page 53.

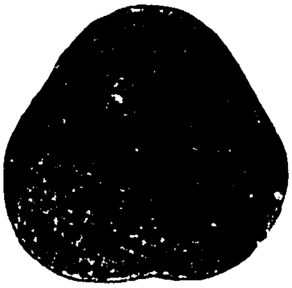
Figure

10. Anemiidites sp. A
    20.3 x 18.5 x 19.5 microns; Slide No. OPC 636-1-2. Page 53.

11. Pilosisporites ericius Delcourt and Sprumont, 1955
    58.3 x 53.3 x 53.3 microns; Slide No. OPC 634Q-5-4. Page 55.

12. Pilosisporites trichopapillosus (Thiergart, 1949) Delcourt and Sprumont, 1955.
    58.3 x 56.5 x 59.0 microns; Slide No. OPC 643A-4-2. Page 54.

PLATE 2



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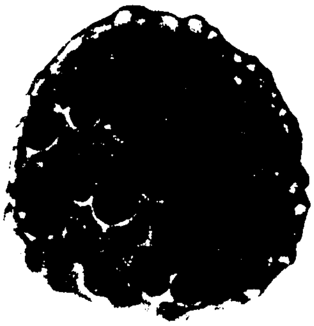

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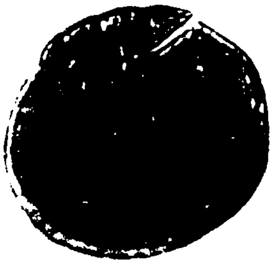

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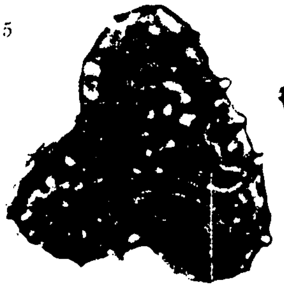

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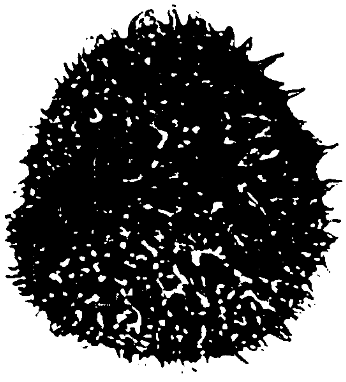

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PLATE III

Figure

1. *Lycopodiacidites* sp. A
   33.0 x 38.1 microns; Slide No. OPC 625A-1-3.
   Page 56.

2-4. *Lycopodiacidites* sp. B
   (2) 43.2 x 45.7 x 50.8 microns (proximal view);
   Slide No. OPC 635A-10-2.
   (3) Same specimen, distal view.
   (4) 27.9 x 27.4 x 26.5 microns (holotype);
   Slide No. OPC 644A-5-1. Page 57.

5-6. *Camarozonosporites rudis* (Leschick, 1955) Klaus, 1960
   (5) 40.6 x 40.6 x 40.6 microns; Slide No. OPC 838B-9-2.
   (6) 45.7 x 45.7 x 45.7 microns; Slide No. OPC 635A-7-4. Page 58.

7. *Foveotriletes* sp.
   45.7 x 46.5 x 48.3 microns; Slide No. OPC 636-4-2. Page 59.

8. *Lycopodiumsporites* cf. *L. clavatsides* Couper, 1958
   38.1 x 38.1 x 40.6 microns; Slide No. OPC 635A-10-8. Page 60.

9. *Cicatricosisporites* sp. C
   30.5 x 33.0 x 35.6 microns; Slide No. OPC 634I-4-1. Page 64.

10-11. *Cicatricosisporites* sp. A
   (10) 25.4 x 25.4 x 25.4 microns (holotype);
   Slide No. OPC 636-5-1.
   (11) 20.3 x 20.3 x 22.0 microns; Slide No.
   OPC 643A-10-2. Page 62.

Figure

12. *Cicatricosisporites* sp. B
    50.8 x 53.3 x 58.3 microns (holotype);
    Slide No OPC 643A-3-4. Page 63.

13. *Cicatricosisporites* *dorogensis* Potonié and Gelletich, 1933
    34.0 x 33.0 x 34.0 microns; Slide No. OPC 635A-1-1. Page 61.

14. *Cicatricosisporites* cf. *C*. *brevilaesuratus* Couper, 1958
    50.8 x 50.8 x 53.3 microns; Slide No. OPC 635A-1-23. Page 65.

PLATE 3


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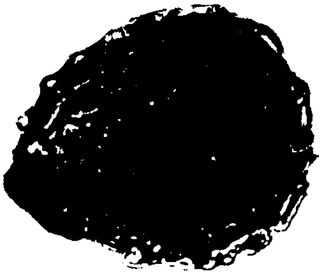
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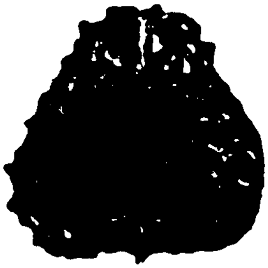
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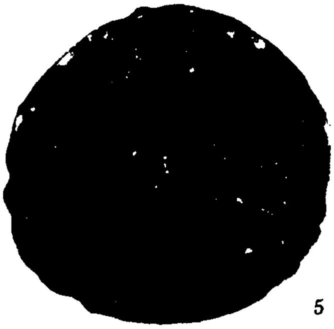
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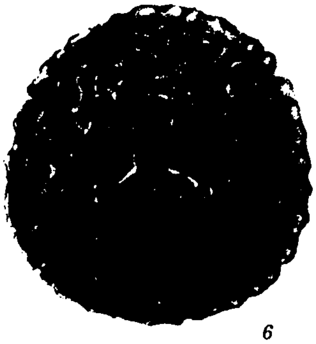
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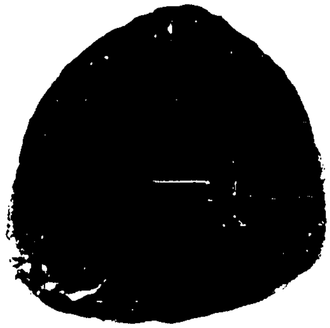
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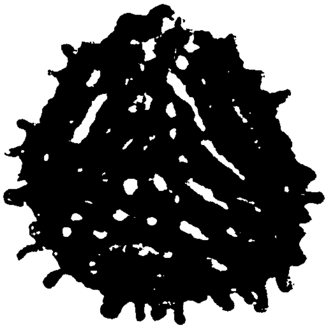
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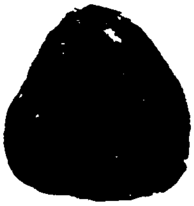
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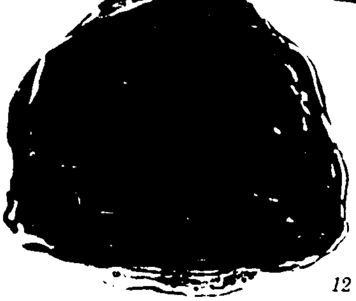
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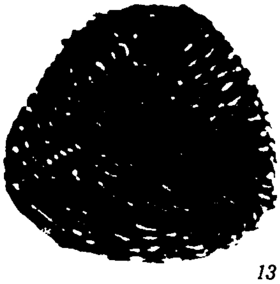
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PLATE IV

Figure

1. *Taurocusporites reduncus* (Bolkhovitina, 1953) Stover, 1962
   43.2 x 43.2 x 38.1 microns; Slide No. OPC 6340-1-1. Page 66.

2. *Klukisporites variegatus* Couper, 1958
   53.3 x 59.0 x 61.0 microns; Slide No. OPC 643A-4-2. Page 67.

3. *Taurocusporites segmentatus* Stover, 1962
   48.3 x 50.8 x 50.8 microns; Slide No. OPC 634Q-1-4. Page 65.

4. *Trilobosporites trioreticulosus* Cookson and Dettmann, 1957
   53.3 x 53.3 x 55.9 microns; Slide No. OPC 637J-2-4. Page 70.

5. *Trilobosporites* cf. *T. apiverrucatus* Couper, 1958
   60.9 x 60.9 x 61.0 microns; Slide No. OPC 634I-7-2. Page 68.

6. *Klukisporites pseudoreticulatus* Couper, 1958
   35.6 x 35.0 x 38.0 microns; Slide No. OPC 840A-2-1. Page 67.

7. *Trilobosporites* sp. A
   72.0 x 69.5 x 68.6 microns (holotype); Slide No. OPC 637J-3-1. Page 70.

8. *Cingulatisporites levispeciosus* Pflug, 1953
   20.3 x 20.3 x 23.5 microns; Slide No. OPC 840D-3-4. Page 75.

Figure

9. Appendicisporites cf. A. triceps Weyland and Krieger, 1953
   40.6 x 43.2 x 45.0 microns; Slide No. OPC 643B-9-7. Page 73.

10. Appendicisporites tricornitatus Weyland and Krieger, 1953
    40.6 x 40.6 x 43.2 microns; Slide No. OPC 635B-5-1. Page 72.

11. Appendicisporites sp.
    38.1 x 45.7 x 45.7 microns; Slide No. OPC 840D-3-6. Page 74.

PLATE 4


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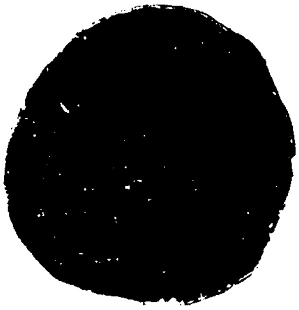
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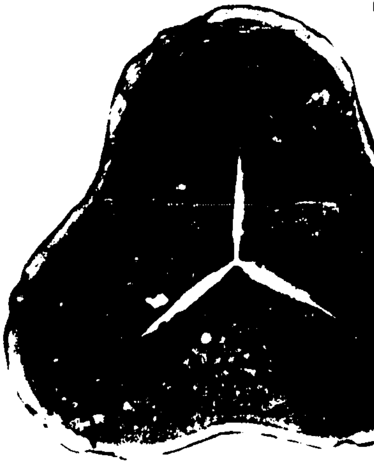
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PLATE V

Figure

1. <u>Cingulatisporites</u> cf. <u>C</u>. <u>pseudoalveolatus</u> Couper, 1958
   50.8 x 50.8 x 45.7 microns; Slide No. OPC 6340-1-2. Page 75.

2. <u>Cingulatisporites</u> <u>problematicus</u> Couper, 1958
   30.5 x 33.0 x 33.0 microns; Slide No. OPC 840C-1-3. Page 76.

3. <u>Cingulatisporites</u> sp. A
   33.0 x 33.0 x 33.0 microns; Slide No. OPC 634P-1-4. Page 77.

4. <u>Cingulatisporites</u> sp. B
   45.7 x 46.0 x 48.3 microns; Slide No. OPC 634I-13-5. Page 78.

5. Spore type B
   94.0 x 83.8 x 92.0 microns; Slide No. OPC 643B-3-1, Page 79.

6. <u>Laevigatosporites</u> sp. A
   39.5 x 30.5 microns (holotype); Slide No. OPC 635A-5-5. Page 80.

7. <u>Marattisporites</u> <u>scabratus</u> Couper, 1958
   17.8 x 12.7 microns; Slide No. OPC 634I-2-6. Page 82.

8. <u>Schizosporis</u> <u>reticulatus</u> Cookson and Dettmann, 1959
   152.4 microns; Slide No. OPC 634H-7-1. Page 83.

Figure

9. Schizosporis parvus Cookson and Dettmann, 1959
   60.9 x 33.0 microns; Slide No. OPC 837D-17-6. Page 83.

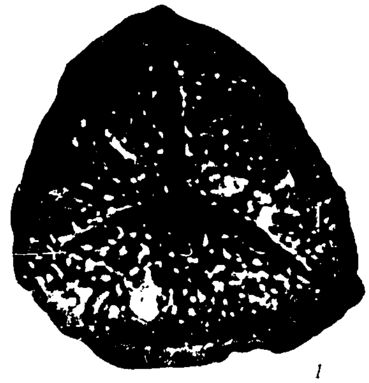
10-11. Schizosporis spriggi Cookson and Dettmann, 1959
   (10) 94.0 x 48.3 microns; Slide No. OPC 634M-7-1.
   (11) 88.9 x 66.0 microns: Slide No. OPC 634M-7-2. Page 84.

12. Schizosporis sp. A
   60.9 microns (holotype); Slide No. OPC 634BF-1-3. Page 85.

13. Schizosporis cf. S. rugulatus Cookson and Dettmann, 1959
   55.9 x 127.0 microns; Slide No. OPC 634M-9-1. Page 84.

14. Schizosporis sp. A
   50.8 x 68.6 microns; Slide No. OPC 634BF-3-1. Page 85.

PLATE 5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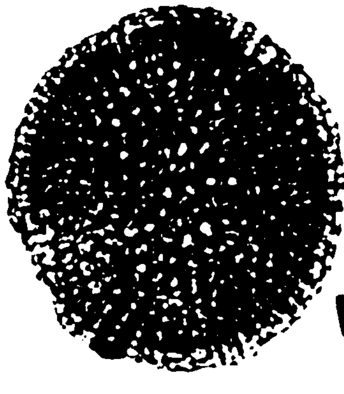
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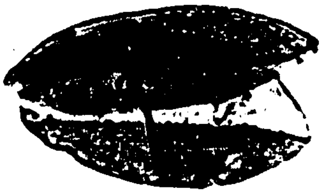
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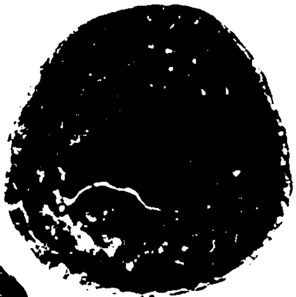
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PLATE VI

Figure

1-2. Schizocysta sp. A
(1) 50.8 x 45.7 microns (holotype); Slide No. OPC 634BF-2-2.
(2) 48.3 x 30.5 microns; Slide No. OPC 634BF-1-6. Page 86.

3. Spore type X
45.7 x 48.3 x 49.5 microns; Slide No. OPC 634Q-3-1. Page 87.

4. Classopollis classoides Pflug, 1953 emend Pocock and Jansonius, 1961
31.5 x 30.5 microns; Slide No. OPC 634N-14-4. Page 88.

5-6. Classopollis sp. A
(5) 27.9 x 30.5 microns; Slide No. OPC 635A-1-26.
(6) 25.0 x 30.5 microns (holotype); Slide No. OPC 635A-1-25. Page 89.

7. Monosaccate pollen type A
50.8 x 55.9 microns; Slide No. OPC 6340-2-2. Page 91.

8. Monosaccate pollen type B
78.0 x 53.0 microns; Slide No. OPC 635B-1-10. Page 91.

9. Pinuspollenites ? sp.
tube cell 33.0 x 31.0 microns, overall dimensions 48.3 x 35.6 microns; Slide No. OPC 643A-2-12. Page 94.

Figure

10. <u>Piceaepollenites</u> sp. A
    45.7 x 68.6 microns (holotype); Slide No. OPC 635A-7-9. Page 96.

11. <u>Vitreisporites</u> <u>pallidus</u> (Reissinger, 1938) Nilsson, 1958
    33.0 x 17.8 microns; Slide No. OPC 635A-1-12. Page 92.

12. <u>Piceaepollenites</u> sp. A
    53.3 x 30.5 microns; Slide No. OPC 635A-7-8. Page 96.

PLATE 6


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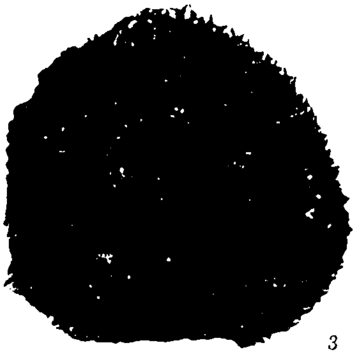
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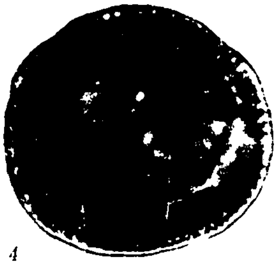
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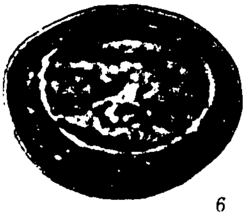
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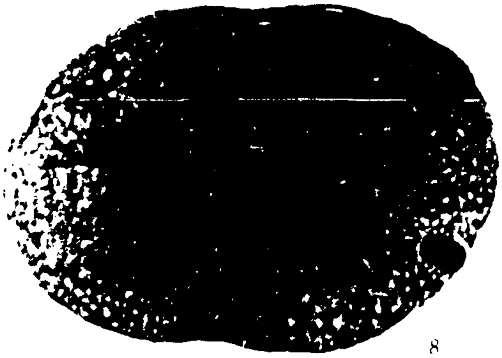
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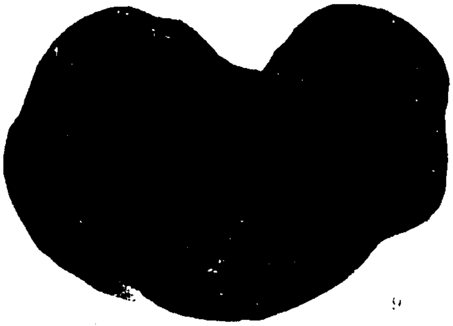
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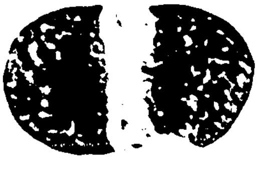
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PLATE VII

Figure

1-2. *Piceaepollenites* sp. B
  (1) 119.4 x 81.3 microns (holotype); Slide No. OPC 635A-3-2.
  (2) 110.0 x 71.0 microns; Slide No. OPC 635A-3-17. Page 97.

3. *Platysaccus* sp. A
  tube cell 28.0 x 40.6 microns, overall dimensions 76.2 x 38.1 microns; Slide No. OPC 635A-7-10. Page 98.

4-5. *Podocarpidites* cf. *P. biformis* Rouse, 1957
  (4) overall length 69.5 microns, tube cell 40.6 microns; Slide No. OPC 635A-14-2.
  (5) overall length 76.2 microns, tube cell 38.0 microns; Slide No. OPC 636-3-4. Page 100.

6. *Parvisaccites* sp. A
  tube cell 50.8 x 48.3 microns; Slide No. OPC 634R-1-1. Page 103.

7. *Rugubivesiculites* sp. A
  overall length 66.0 microns, tube cell 40.6 x 43.2 microns (holotype); Slide No. OPC 839B-4-2. Page 102.

8. *Parvisaccites* sp. B
  overall dimensions 27.9 x 35.6 microns; Slide No. OPC 633D-2-1. Page 104.

PLATE 7


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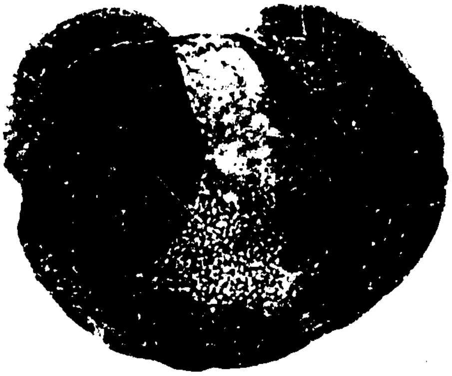
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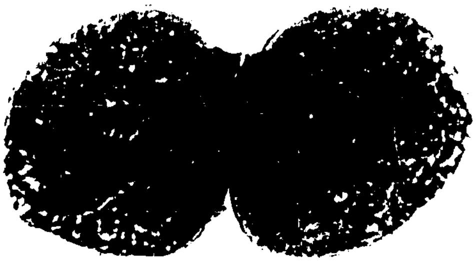
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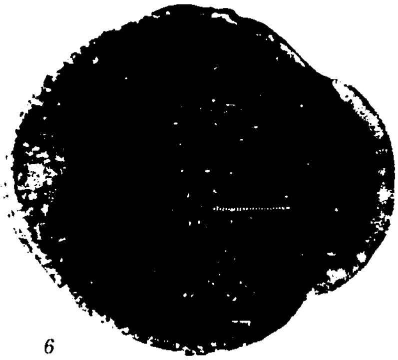
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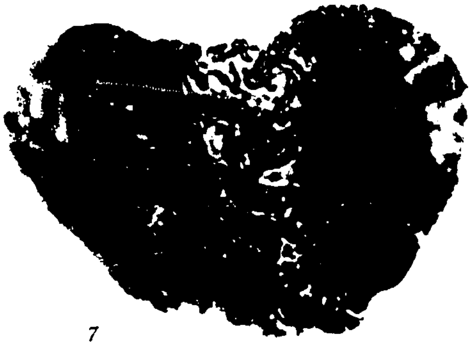
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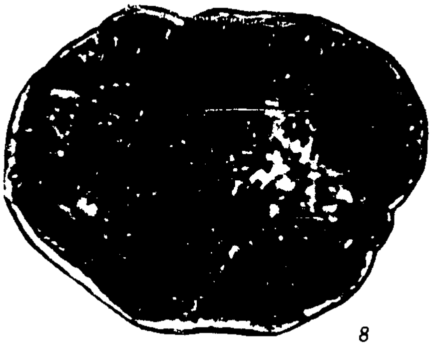
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PLATE VIII

Figure

1-2. *Inaperturopollenites* sp. A
(1) 50.8 x 43.2 microns; Slide No. OPC 636-4-5.
(2) 34.0 x 35.6 microns (holotype); Slide No. OPC 635A-3-6. Page 106.

3. *Inaperturopollenites* cf. *I. magnus* (Potonié, 1931) Thomson and Pflug, 1953
63.5 x 68.0 microns; Slide No. OPC 635A-1-19. Page 107.

4. *Inaperturopollenites* sp. B
18.5 x 18.5 microns (holotype); Slide No. OPC 837D-12-2. Page 109.

5. *Inaperturopollenites* sp. A
30.5 x 25.4 microns: Slide No. OPC 847D-4-8. Page 106.

6. *Inaperturopollenites* sp. B
15.2 x 15.2 microns; Slide No. OPC 837D-12-4. Page 109.

7. *Inaperturopollenites* cf. *I. patellaeformis* Weyland and Greifeld
39.0 x 36.0 microns; Slide No. OPC 635A-7-5. Page 108.

8. *Inaperturopollenites* sp C
60.9 x 41.0 microns (holotype); Slide No. OPC 635B-4-1. Page 110.

9. *Inaperturopollenites* sp. A
27.9 x 35.6 microns; Slide No. OPC 643A-8-1. Page 106.

Figure

10. Inaperturopollenites sp. D
    50.8 x 50.8 microns (holotype); Slide No. OPC 635A-1-2. Page 111.

11. Inaperturopollenites sp. E
    71.1 x 73.7 microns (holotype); Slide No. OPC 634M-5-1. Page 112.

12-13. Eucommiidites minor Groot and Penny, 1960
    (12) 33.0 x 22.8 microns; Slide No. OPC 634K-6-2.
    (13) 27.9 x 26.5 microns; Slide No. OPC 838B-9-1. Page 113.

14. Ephedripites sp.
    42.2 x 89.0 microns; Slide No. OPC 634Q-1-7. Page 114.

PLATE 8


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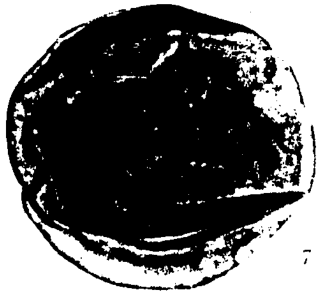
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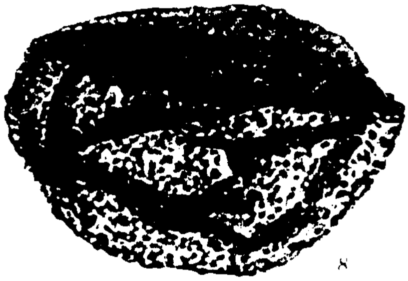
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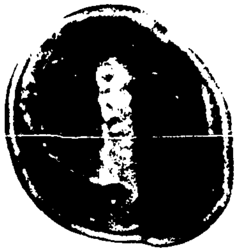
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PLATE IX

Figure

1. *Clavatipollenites* cf. *C. hughesii* Couper, 1958
   27.9 x 22.8 microns; Slide No. OPC 634I-3-5.
   Page 115.

2-3. *Clavatipollenites* sp. A
   (2) 29.0 x 17.0 microns (holotype); Slide No. OPC 637J-2-3.
   (3) 20.3 x 15.2 microns; Slide No. OPC 637J-1-7. Page 116.

4. *Clavatipollenites* sp. B
   30.5 x 23.5 microns; Slide No. OPC 635A-5-9.
   Page 117.

5. *Palmaepollenites* sp. A
   43.2 x 40.6 microns (holotype); Slide No. OPC 637C-2-4. Page 118.

6-8. *Tricolpites* cf. *T. reticulatus* Cookson, 1947
   (6) 25.4 x 25.4 x 27.9 microns; Slide No. OPC 636-4-4.
   (7) 23.5 x 16.5 microns; Slide No. OPC 837E-4-2.
   (8) 17.8 x 20.3 microns; Slide No. OPC 847D-8-5. Page 119.

9-10. *Tricolpites* sp. A
   (9) 22.8 x 22.8 x 22.8 microns (holotype); Slide No. OPC 644C-3-4.
   (10) 25.4 x 25.4 x 27.0 microns; Slide No. OPC 634R-6-9. Page 120.

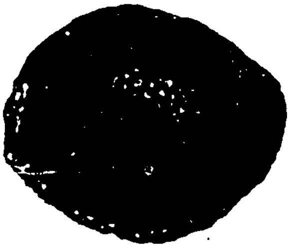
11-12. *Tricolpites* sp. B
   (11) 17.8 x 21.5 microns; Slide No. OPC 644C-4-5.
   (12) 17.8 x 17.8 x 16.5 microns (holotype); Slide No. OPC 637J-8-1. Page 121.

Figure

13. <u>Tricolpites</u> sp. C
    38.1 x 43.2 x 43.2 microns; Slide No. OPC 634I-5-9. Page 122.

14-16. Genus A, sp. A
    (14) 25.4 microns; Slide No. OPC 643B-1-18.
    (15) 25.4 microns; Slide No. OPC 643B-1-19.
    (16) 25.4 microns (holotype); Slide No. OPC 643B-1-20. Page 123.

PLATE 9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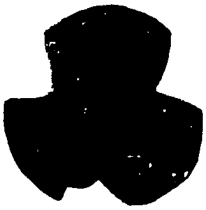
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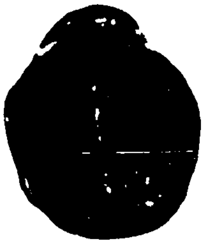
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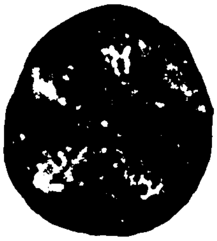
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PLATE X

Figure

1. Deflandrea cf. D. minor Cookson and Eisenack, 1960
   50.8 x 45.7 microns; Slide No. OPC 837H-4-3.
   Page 125.

2. Deflandrea sp. A
   73.7 x 53.3 microns (holotype); Slide No. OPC
   847D-8-6. Page 126.

3. Deflandrea cf. D. minor Cookson and Eisenack, 1960
   38.1 x 43.2 microns; Slide No. OPC 635C-2-1.
   Page 125.

4-5. Deflandrea sp. B
   (4) 43.2 x 89.0 microns (holotype); Slide No.
   OPC 838B-8-5.
   (5) 40.6 x 84.5 microns; Slide No. OPC
   838B-8-9. Page 127.

6. Gonyaulax sp. B
   76.2 x 101.6 microns; Slide No. OPC 837G-4-3.
   Page 129.

7. Deflandrea sp. B
   40.6 x 94.0 microns; Slide No. OPC 838B-8-10.
   Page 127.

8. Gonyaulax sp. A
   78.7 x 89.9 microns; Slide No. OPC 636-3-10.
   Page 128.

9-12. Pseudoceratium sp. A
   (9) 76.2 x 106.7 microns (holotype); Slide No.
   OPC 644C-11-5.
   (10) 63.5 x 76.2 microns; Slide No. OPC 644C-11-6.
   (11) 55.9 x 96.5 microns; Slide No. OPC 644C-11-2.
   (12) 73.7 x 97.5 microns; Slide No. OPC 644C-12-1.
   Page 130.

PLATE 10


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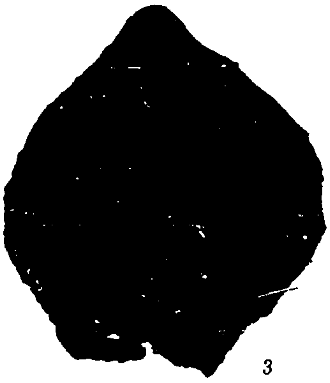
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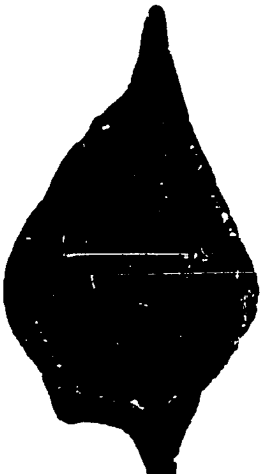
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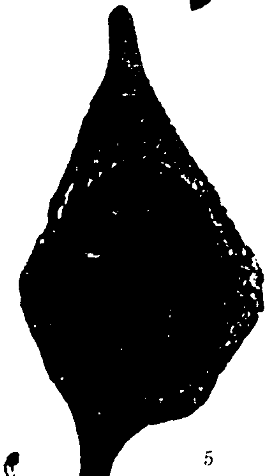
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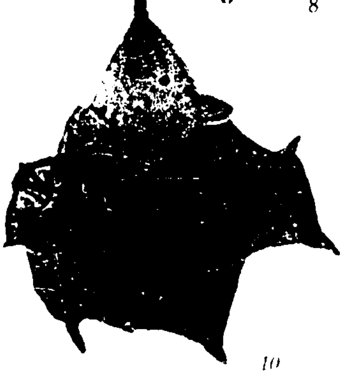
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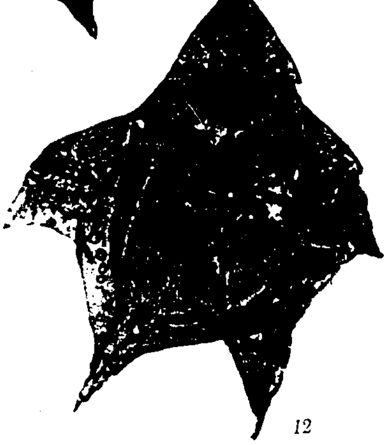
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PLATE XI

Figure

1. Palaeoperidinium cf. P. caulleryi Deflandre, 1936
43.2 x 65.0 microns; Slide No. OPC 838B-16-1.
Page 133.

2. Hystrichosphaeridium cf. H. choanophorum Deflandre and Cookson, 1955
Body 23.0 microns; projections 9.0-12.0 microns;
Slide No. OPC 837G-5-1. Page 136.

3. Hystrichosphaeridium cf. H. tubiferum (Ehrenberg, 1838) Deflandre, 1937
Body 45.7 microns; projections 20.3-27.9 microns;
Slide No. OPC 847C-9-1. Page 135.

4-5. Odontochitina operculata (O. Wetzel) Deflandre, 1958
(4) 53.3 x 142.2 microns; Slide No. OPC 847C-2-3.
(5) 15.2 x 200.7 microns; Slide No. OPC 636-4-3.
Page 132.

6. Palaeoperidinium cf. P. caulleryi Deflandre, 1936
47.5 x 48.3 microns; Slide No. OPC 838B-13-1.
Page 133.

7. Chlamydophorella cf. C. myei Cookson and Eisenack, 1958
45.7 x 48.3 microns; Slide No. OPC 837G-3-6.
Page 155.

8. Hystrichosphaeridium sp. A
Body 43.2 microns; projections 13.0-20.0 microns (holotype); Slide No. OPC 847D-1-5.
Page 137.

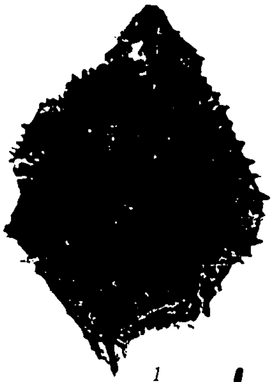
9. Crassosphaera sp.
41.5 microns; Slide No. OPC 635C-3-3. Page 160.

Figure

10. Hystrichosphaeridium sp. B
    Body 38.1 x 48.3 microns; projections 15.0-20.0 microns; Slide No. OPC 837F-5-1. Page 139.

11. Hystrichosphaeridium cf. H. eoinodes Eisenack, 1958
    Body 53.3 microns; projections 20.3-23.0 microns; Slide No. OPC 635C-7-1. Page 137.

PLATE II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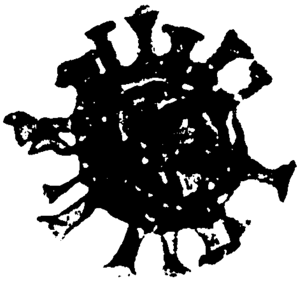
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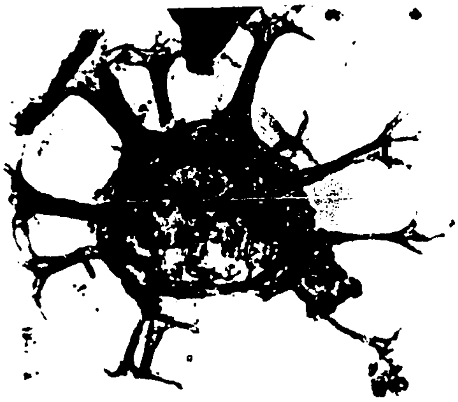
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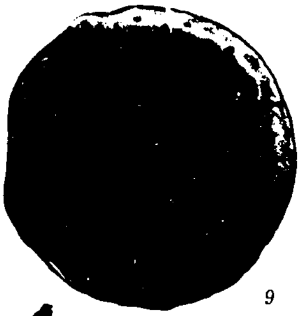
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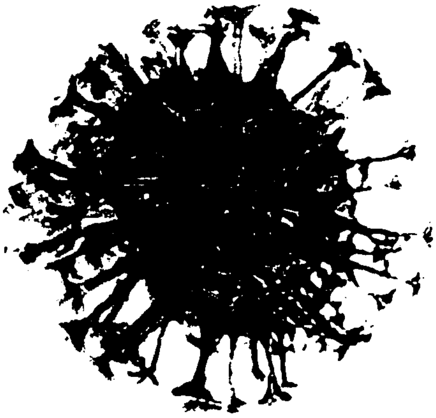
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PLATE XII

Figure

1-2. Hystrichosphaera cf. H. furcata (Ehrenberg, 1838) O. Wetzel, 1933.
  (1) Body 43.2 x 50.8 microns; Projections 5.0-10.0 microns; Slide No. OPC 847D-2-1.
  (2) Body 35.6 x 35.6 microns; projections 6.0-9.0 microns: Slide No. OPC 636-3-7. Page 140.

3. Hystrichosphaera cf. H. wetzeli Deflandre, 1937
  Body 53.3 x 40.6 microns; projections 10.0 microns; Slide No. OPC 837H-1-3. Page 141.

4. Baltisphaeridium parvispinum (Deflandre, 1937) n. comb.
  Body 30.5 x 51.5 microns; projections 6.0-8.0 microns; Slide No. OPC 837G-3-2. Page 142.

5. Baltisphaeridium sp. C
  Body 23.0 microns; projections 2.0-3.5 microns (holotype)
  Slide No. OPC 840D-3-3. Page 147.

6. Micrhystridium cf. M. fragile Deflandre, 1947
  Body 16.5 microns; projections 11.0 microns; Slide No. OPC 837H-1-17. Page 149.

7-8. Veryhachium sp. A
  (7) 29.5 x 33.0 microns (holotype); Slide No. OPC 837G-4-2.
  (8) 33.0 x 33.0 x 33.0 microns; Slide No. OPC 837H-10-1. Page 152.

9-10. Veryhachium sp. B
  (9) Body 20.0 x 21.0 microns; projections 15.0 microns; Slide No. OPC 840C-2-1.
  (10) 28.0 x 27.0 x 27.0 microns (holotype); Slide No. OPC 837H-10-11. Page 153.

Figure

11. Veryhachium sp. C
    Body 17.8 x 27.9 microns; projections 12.0-19.0 microns; Slide No. OPC 837F-1-13. Page 154.

12. Pterospermopsis cf. P. australiensis Deflandre and Cookson, 1955
    35.6 microns; Slide No. OPC 636-10-8. Page 156.

13. Pterospermopsis sp. A
    20.3 x 25.4 microns; Slide No. OPC 840D-8-1. Page 157.

14. Pterospermopsis eurypteris Cookson and Eisenack, 1958
    111.8 microns; Slide No. OPC 838B-4-1. Page 156.

PLATE 12


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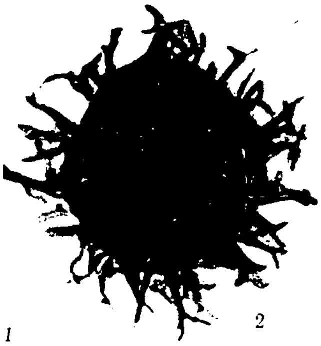
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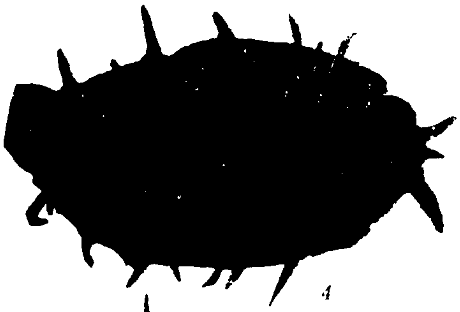
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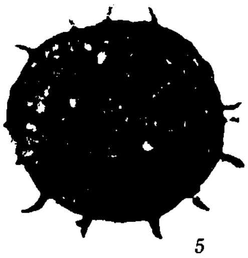
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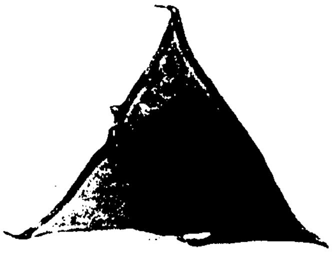
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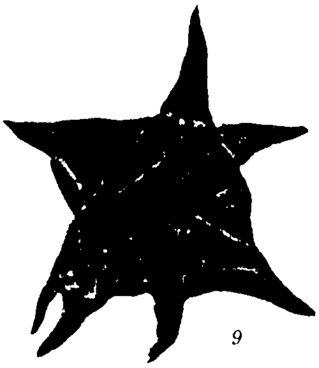
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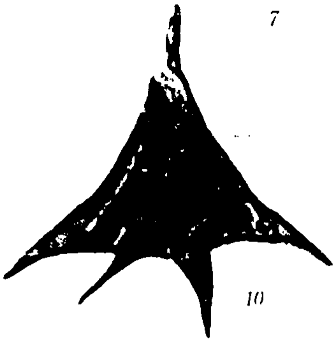
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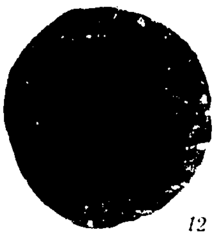
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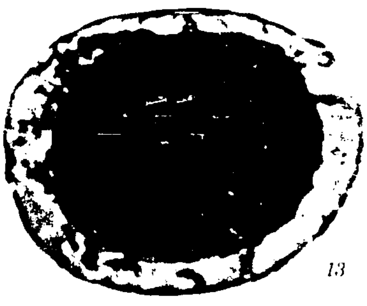
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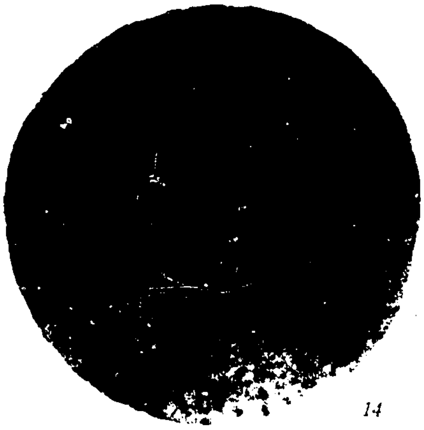

14

PLATE XIII

Figure

1. Baltisphaeridium ehrenbergi (Deflandre, 1947) var. brevispinosum Sarjeant, 1961
   Body 18.0 microns; projections 4.0-7.0 microns; Slide No. OPC 841B-3-2. Page 145.

2. Baltisphaeridium machaerophorum (Deflandre and Cookson, 1955) Gerlach, 1961
   Body 48.3 x 55.9 microns; projections 14.0-19.0 microns; Slide No. OPC 840C-2-2. Page 143.

3. Micrhystridium inconspicuum (Deflandre, 1935) Deflandre, 1937
   Body 11.1 microns; processes 1.0-3.0 microns; Slide No. OPC 836B-1-1. Page 148.

4. Baltisphaeridium cf. B. lumectum Sarjeant, 1960
   Body 33.0 microns; projections 5.0-6.0 microns; Slide No. OPC 847D-9-1. Page 144.

5. Baltisphaeridium sp. B
   Body 23.5 microns; projections 5.0-6.0 microns (holotype); Slide No. OPC 837G-4-4. Page 146.

6. Baltisphaeridium sp. A
   Body 30.5 x 35.6 microns; projections 6.0-9.0 microns (holotype); Slide No. OPC 837H-2-18. Page 145.

7. Micrhystridium densispinum Valensi, 1953
   Body 8.8 microns; projections 1.0-1.5 microns; Slide No. OPC 836B-1-2. Page 150.

8. Micrhystridium inconspicuum (Deflandre, 1935) Deflandre, 1937
   Body 9.9 microns; projections 3.0-4.0 microns; Slide No. OPC 838B-2-3. Page 148.

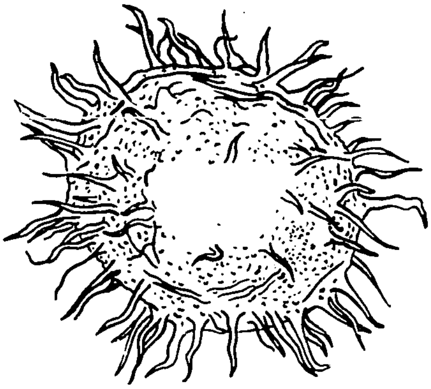
Figure

9. Micrhystridium densispinum Vanensi, 1953
   Body 14.0 microns; projections 1.0 microns;
   Slide No. OPC 635C-7-4. Page 150.

10. Micrhystridium sp. A
    Body 7.7 x 8.8 microns; projections 1.5 microns
    (holotype); Slide No. OPC 837F-9-1. Page 151.

PLATE 13

1



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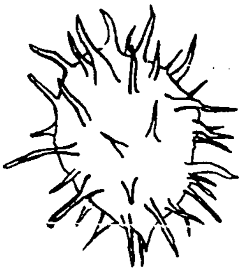

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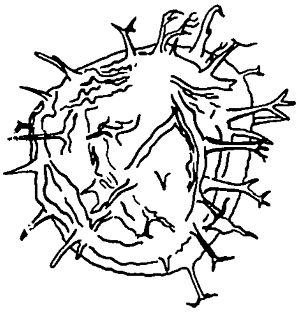

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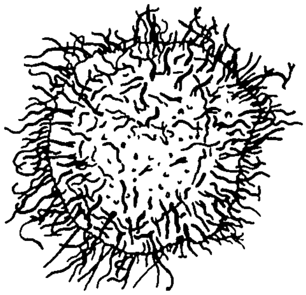

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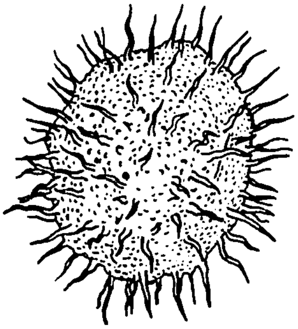

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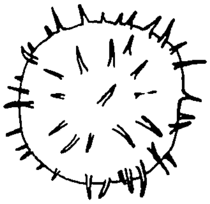

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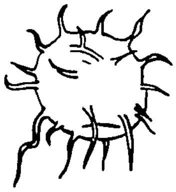

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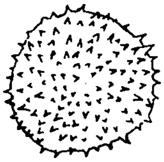

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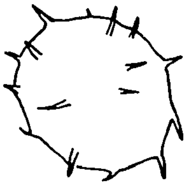

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PLATE XIV

Figure

1. Diplotesta glaessneri Cookson and Eisenack, 1960
   32.0 x 81.3 microns; Slide No. OPC 837G-6-1.
   Page 161.

2-3. Genus B sp. A
   (2) Body 15.2 x 25.4 microns; projections 13.0, 17.0, 11.0 and 11.0 microns; Slide No. OPC 837B-5-1.
   (3) Body 17.8 x 25.4 microns; projections 20.3, 25.4, 20.3, and 26.0 microns; Slide No. OPC 837D-3-1. Page 162.

4-5. Genus C sp. A
   (4) 48.3 x 50.8 microns (holotype); Slide No. OPC 635A-6-4.
   (5) 48.3 x 60.9 microns; Slide No. OPC 635A-7-16. Page 164.

6. Genus B sp. A
   Body 15.2 x 22.8 microns; projections 8.8, 8.8, 7.7, and 11.1 microns (holotype); Slide No. OPC 837C-4-2. Page 162.

7. Genus C sp. A
   43.2 x 48.3 microns; Slide No. OPC 635A-1-13.
   Page 164.

8-9. Genus D sp. A
   (8) 68.6 x 68.6 x 71.7 microns; Slide No. OPC 643B-10-3.
   (9) 63.5 x 68.6 x 68.3 microns (holotype); Slide No. OPC 643B-9-8. Page 165.

Figure

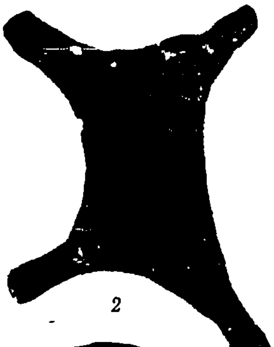
10. *Dioxya* ? sp.
    50.8 x 63.5 microns; Slide No. OPC 838B-6-1.
    Page 161.

11. *Cymatiosphaera* sp. A
    35.6 microns (holotype); Slide No. OPC 636-4-11.
    Page 158.

12. Genus D sp. B
    50.8 x 63.5 microns (holotype); Slide No. OPC
    835D-1-1. Page 166.

PLATE 14

1



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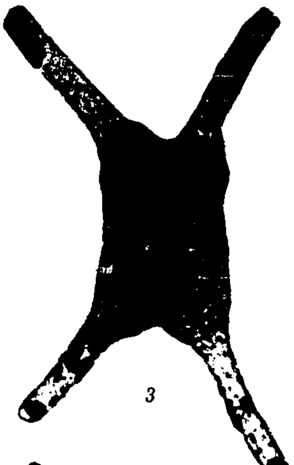

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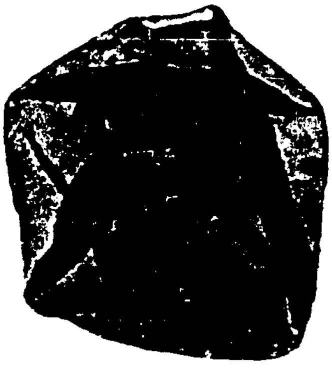

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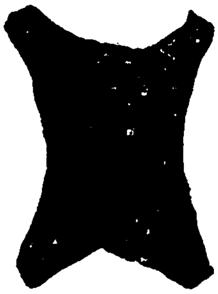

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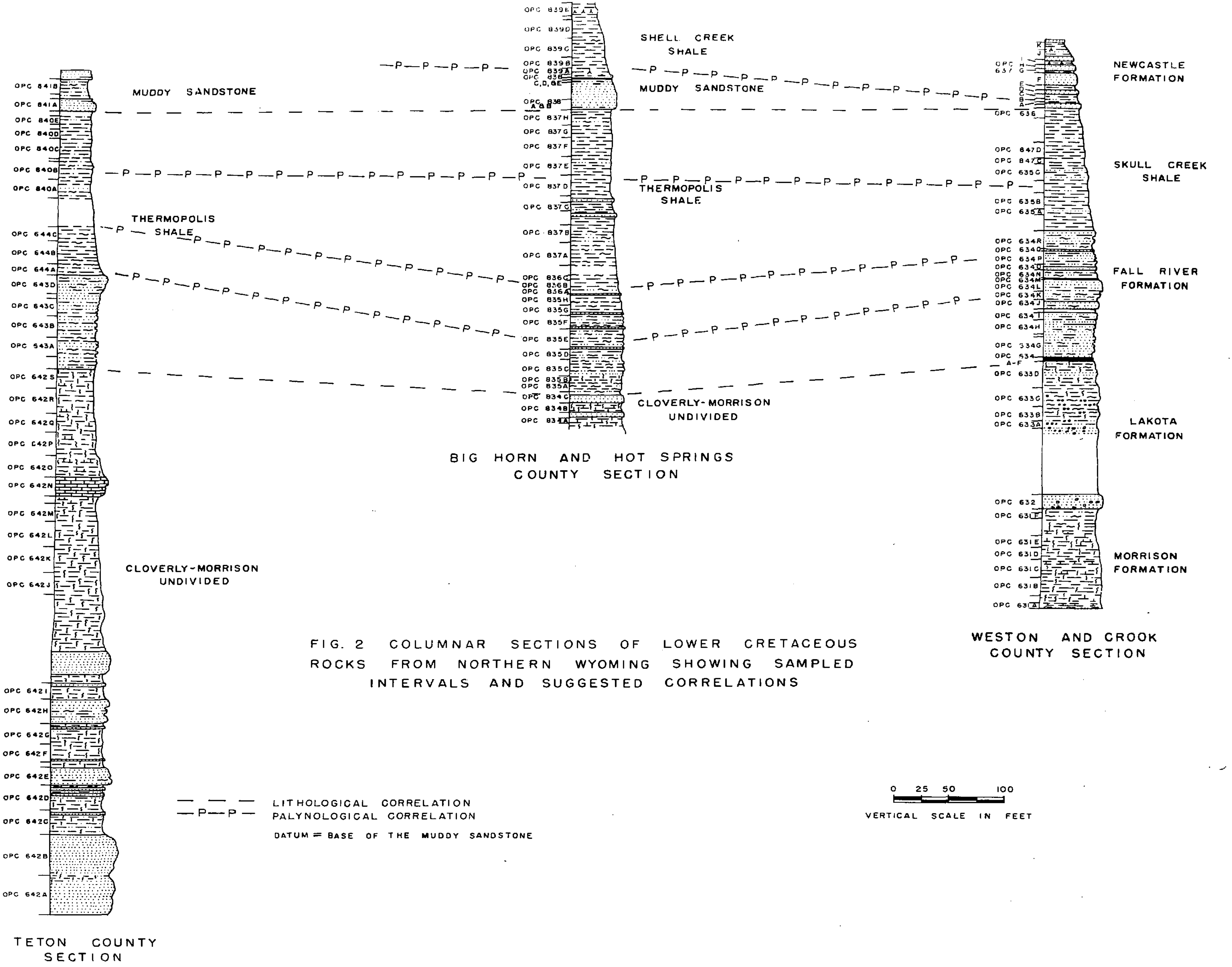


FIG. 2 COLUMNAR SECTIONS OF LOWER CRETACEOUS ROCKS FROM NORTHERN WYOMING SHOWING SAMPLED INTERVALS AND SUGGESTED CORRELATIONS

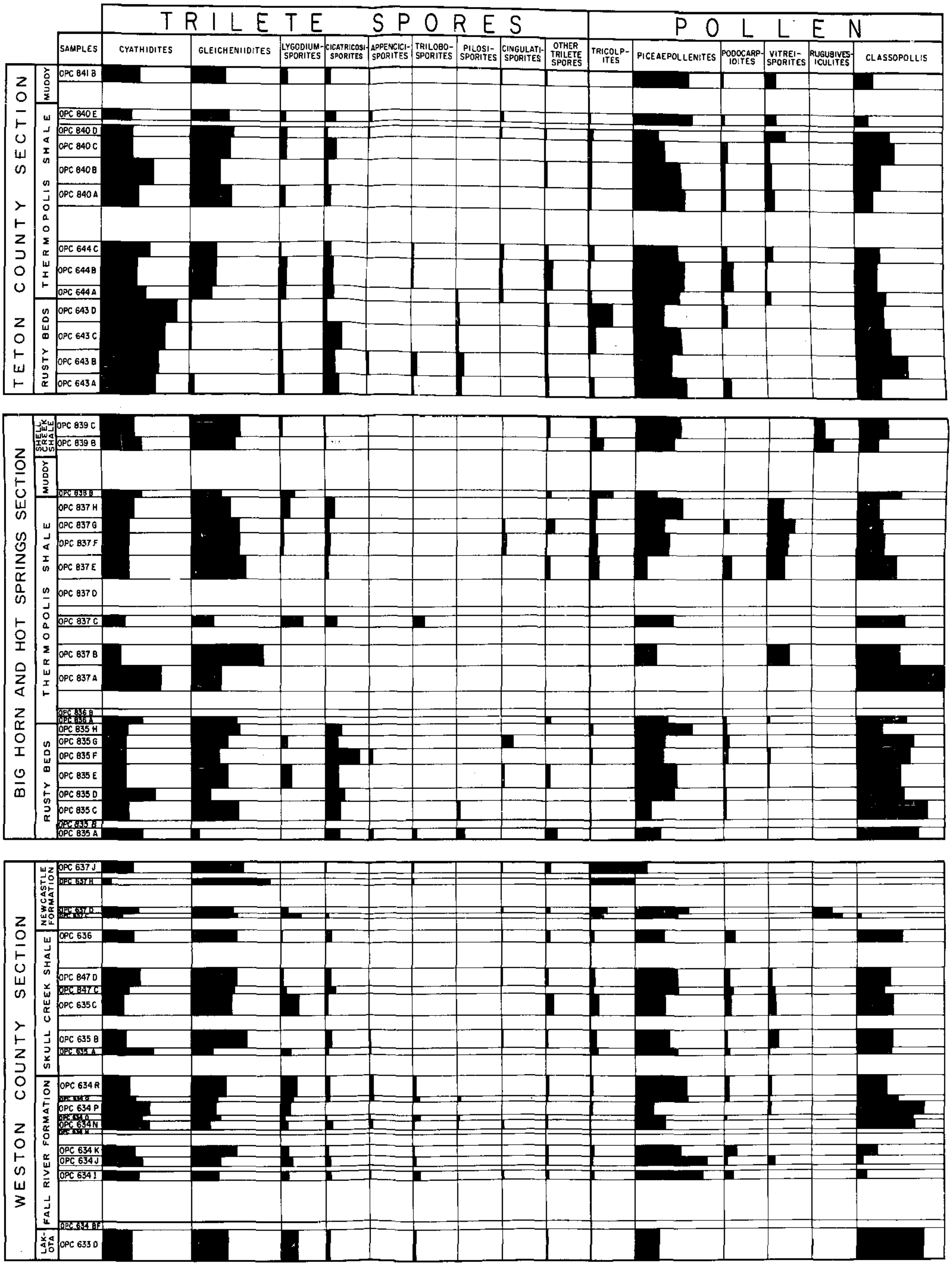
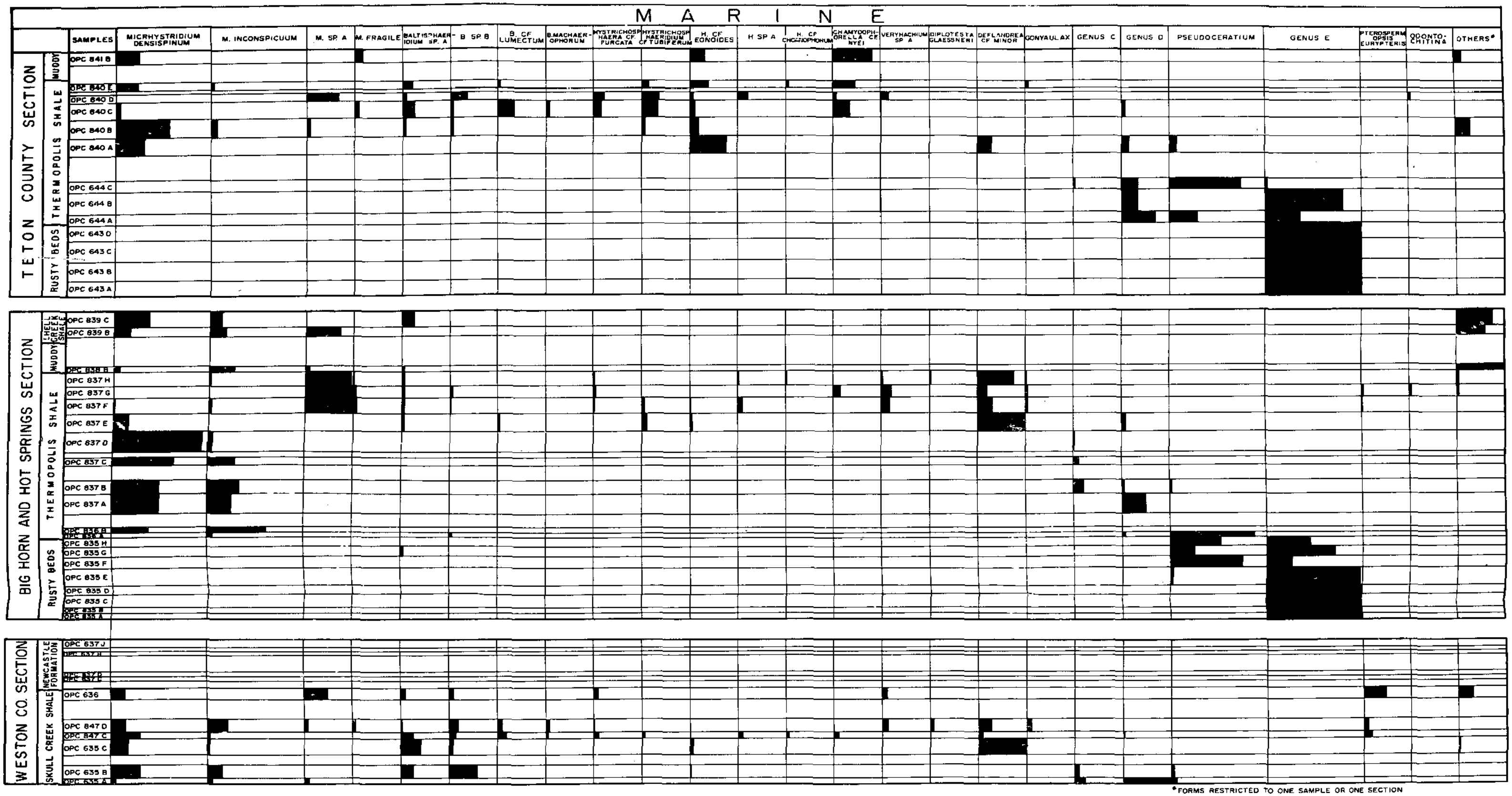


Fig. 3 HISTOGRAMS ILLUSTRATING RELATIVE ABUNDANCES OF TRILETE SPORE GENERA AND SELECTED POLLEN GENERA IN WYOMING LOWER CRETACEOUS SAMPLES

Vertical scale: 0 25 50 100 FEET

Horizontal scale: 0 50 100 PERCENT



*FORMS RESTRICTED TO ONE SAMPLE OR ONE SECTION

Fig. 4 HISTOGRAMS ILLUSTRATING RELATIVE ABUNDANCES OF FOSSIL MICROPLANKTON GENERA AND SPECIES IN WYOMING LOWER CRETACEOUS SAMPLES

Vertical scale: 0 25 50 100 FEET

Horizontal scale: 0 50 100 PERCENT

Table 1. Relative Abundances in Percents of Palynomorphs in Wyoming Lower Cretaceous Samples

ORIGIN	PALYNOMORPHS	TETON CO.													HOT SPRINGS CO. AND BIG HORN CO.																				CROOK CO. AND WESTON CO.																				
		RUSTY BEDS				THERMOPOLIS SHALE								Muddy	RUSTY BEDS							THERMOPOLIS SHALE										Muddy	SHELL CREEK SHALE		LAKOTA	FALL RIVER FM.										SKULL CREEK SH.						NEWCASTLE FM			
		OPC 643 A	OPC 643 B	OPC 643 C	OPC 643 D	OPC 644 A	OPC 644 B	OPC 644 C	OPC 840 A	OPC 840 B	OPC 840 C	OPC 840 D	OPC 840 E	OPC 841 B	OPC 835 A	OPC 835 C	OPC 835 D	OPC 835 E	OPC 835 F	OPC 835 G	OPC 835 H	OPC 836 A	OPC 836 B	OPC 837 A	OPC 837 B	OPC 837 C	OPC 837 D	OPC 837 E	OPC 837 F	OPC 837 G	OPC 837 H	OPC 838 B	OPC 839 B	OPC 839 C	OPC 633 D	OPC 634 B-F	OPC 634 I	OPC 634 J	OPC 634 K	OPC 634 M	OPC 634 N	OPC 634 O	OPC 634 P	OPC 634 Q	OPC 634 R	OPC 635 A	OPC 635 B	OPC 635 C	OPC 647 C	OPC 647 D	OPC 636	OPC 637 C	OPC 637 D	OPC 637 H	OPC 637 J
TERRESTRIAL	SPORES																																																						
	TRILETE																																																						
	CYATHIDITES MINOR	240	240	125	289	81	66	127	125	160	125	180	135	222	35	45	50	17	26	40	40	4.0		10	05	10		35	51	65	65	56	150	200	240	1.1	165	225	260		186	145	150	120	11.5	60	28	5.5	65	68	12.0	7.0	210	6.7	33.5
	C. AUSTRALIS									03							05																								05	0.5													
	GLEICHENIIDITES SP. A	20	05		05	34	52	69	135	90	155	245	170	208	10	80	20	27	29	60	75	45	05	05	25	10		70	92	11.5	80	28	16.0	305	285	1.1	14.5	170	355		78	110	60	95	145	25	65	100	105	116	16.5	16.0	32.5	79.7	54.3
	CONCAVISPORITES VARIVERRUCATUS																																				05	05																	
	LYGODIUMSPORITES MINOR	20	10	05	05	09	14	03	15	T	25	40	20	36				08		10						10			07	05	15	14		15	12.5	6.6	7.5	45	40	10	21	15	30	45	5.5	1.2	T	4.5	2.5	05		7.0	55		2.8
	L. SP. A					04							05	05																					1.0									T		T					0.5				
	L. SP. B	05																T													05						1.0	1.5	2.0		0.5			T	1.0										
	AURITULINASPORITES CF. INTRASTRIATUS	T				T				0.3																			T						1.0				T								T	0.5					0.5		0.3
	GRANULATISPORITES SP. A	1.5	05	0.5	05		02								0.3																																								
	G. SP. B							05			05																		0.2	05																T	0.2								
	LEPTOLEPIDITES VERRUCATUS																																				T																		0.3
	L. MAJOR																																											T		T		T							
	L. SP. A	T	T		T							05		05																							T						T	T											
	OSMUNDACIDITES WELLMANII		05																												T								05				T	05	05		T								
	PILOSISPORITES TRICHOPAPILLOSUS	20	25	05												05																												1.0											
	P. ERICIUS	T	05		14	02									1.0																										05	1.0		T											
	LYCOPODIACIDITES SP. A																																													T				T					
	L. SP. B					T	0.6								0.5			03										0.5		05		T														T	T	1.0							
	CAMAROZONOSPORITES RUDIS											0.5																		05		0.5	05	2.0			0.5									T		1.0			1.5		2.0		2.0
	LYCOPODIUMSPORITES CF. CLAVATOIDES	T				0.2		0.5		0.7		0.5			0.5							0.5								05				0.5				0.5				0.5			0.5	T		T		0.5					
	CICATRICOSISPORITES DOROGENSIS	6.0	3.0	3.0	0.9	1.6	1.0	1.8	2.0	1.4	2.5	1.0	2.0	3.0	2.0	1.5	1.5	1.0	3.7	2.0	2.5					0.5		0.5	1.1	1.0	2.0		0.5	0.5	2.5		2.5	2.9	1.5		2.6	0.8		1.5	1.5	0.4	0.7	0.5	2.0	1.3	1.0	1.0			0.3
	C. SP. A	T	15				0.4				1.5	1.0	2.0	05																					0.5												T				1.0				
	C. SP. B	05		06	0.5	0.2	02				10		05			10	0.5																										T		T				0.5	T					
	C. SP. C																																				T																		
	TAUROCUSPORITES SEGMENTUS					T																															T					T		T		T									
	T. REDUNCUS													05																									0.5			T				T									
	KLUKISPORITES VARIEGATUS	T																																																					
	K. PSEUDORETICULATUS				0.9		T	T	T	0.5																				T											05														
	TRILOBOSPORITES CF. APIVERRUCATUS	05	20				02	03							03											05									1.5		3.5	1.0	0.5		0.5	2.5		2.0	1.0	T								0.7	0.3
	T. TRIONETICULATUS	T																																																					T
	T. SP. A																																																						T
	APPENDICISPORITES TRICORNITATUS	T	05									0.5	1.0		0.5																						0.5				T	T		1.0	T		T								
	A. CF. TRICEPS	T	T																0.4					T															T		1.5	05		0.5	1.5	0.2	0.2								
	A. SP. A	T										T	0.5	05																																T									
	CINGULATISPORITES LEVISPECIOSUS					04	04	08		T		0.5	10	05				0.2		20									09	05							0.5				0.5						0.2			0.3	0.5		0.5		0.5
	C. PSEUDOALVEOLATUS					02																		T						T												T													
	C. PROBLEMATICUS										T																																		T		T								
	MONOLETE AND OTHERS																																																						
	LAEVIGATOSPORITES SP. A	05				0.2	02		05					05															T						0.5		1.0	1.0		1.0		0.5	2.0	T		0.2				T					
	MARATTISPORITES SCABRATUS																														T						T																		
	SCHIZOSPORIS RETICULATUS																																			1.1	0.5							0.5										2.7	
	S. PARVIS							1.3																			05	05								3.4				4.0															
	S. CF. RUGULATUS																																							9.0														0.3	
	S SPRIGGI																																			6.8				34.0															
	S. SP. A																																0.5			37.7												0.5							
	SCHIZOCYSTA SP. A																																			15.9																			
	POLLEN																																																						
	GYMNOSPERM																																																						
	ALETE																																																						
	INAPERTUROPOLLENITES CF. MAGNUS								10	18															03							0.3														1.0	0.4	0.5			T			0.7	0.3
	I. CF PATELLAFORMIS																													35	10		4.0			25.0				55.0		5.0		1.5		T					13.0				
	I. SP. A	380	285	710	535	640	588	488	225	235	265	160	150	150	650	600	635	761	590	440	465	528	95	842	350	430	180	475	560	355	265	233	405	270	60		16.5	15.0	8.5	10.0	34.5	13.5	25.5	18.5	27.5	60.0	65.0	28.5	32.5	48.0	20.5	36.0	16.5	2.3	2.7
	I. SP. B					02		T	2.5	T	10							T				55	19.5	6.7	16.0	7.0	240	9.5	0.4		05	28	2.0	45						4.0					0.5	0.2	0.4	4.5	2.0	0.8	2.0				
	I. SP. C					02		T	10	17					05	15	10	T	T	30	25							1.5		10																1.2	0.8	0.5	3.0	T	1.5				
	I. SP. D													20																	05	10														T									
	I. SP. E																																			1.1				2.0														0.3	
	SACCATE																																																						
	VITREISPORITES PALLIDUS					1.1	0.4	13	40	23	15	45	40	3.0				02	0.8			05			05			2.0	2.2	5.0	1.5							2.5					1.5	0.5	1.0	1.0	1.0	0.5	1.5	0.5	T				
	PINUSPOLLENITES SP. A	T																																			T	0.5							0.5										
	PICEAPOLLENITES SP. A AND SP. B	65	35	40	23	88	121	76	215	183	90	55	215	153	50	40	80	52	94	40	16.0	64			05	20		1.5	37	55	45	1.0	5.0	45	5.0		25.0	25.0	8.0		10.5	16.5	9.0	26.5	18.5	10.6	3.5	2.0	9.5	5.9	6.5	13.0	7.0		0.3
	PLATYSACCUS SP. A																											0.5					1.0													T									
	PODOCARPIDITES CF. BIOFORMIS	10			05	05	31	10	20	1.7	2.0		1.0	05		05	05	0.2	1.6	1.0	1.0	05						1.0	T	1.0	T	T					3.5	1.0	2.0			1.0		2.5	1.5	1.4	0.4	0.5	2.0	0.8	2.5				
	RUGUBIVESICULITES SP. A																																2.5	1.0																		9.0	2.5		
	PARVISACCITES SP.	T						05																											0.5										0.5	T				0.3					
	POLYCOLPATE AND TRICOLPATE																																																						
	EPHEDRIPITES SP.																																								T			T											
	EUCOMMIIDITES MINOR		0.5	05						03				05													T					T							T																
	OPERCULATE																																																						
	CLASSOPOLLIS CLASSOIDES AND SP. A	3.0	5.0	3.0	23	59	53	43	8.0	104	115	75	30	46	120	180	95	56	180	90	70	90		5.6	1.0	2.3		4.5	2.9	4.5	2.0	1.9	2.3	3.0	14.5		5.5	2.0	5.0		19.6	51.0	35.0	17.0	11.0	6.8	3.7	2.5	6.0	4.6	10.0	1.0			
	ANGIOSPERM																																																						
	MONOCOLPATE																																																						
	CLAVATIPOLLENITES CF. HUGHESII							03																										05	2.0		2.5	2.0	6.5						T					0.5			0.5		
	C. SP. A											1.5																			T								1.0				0.5								0.5	1.0		1.6	0.8
	C. SP B							1.0																						05																T						T			
	PALMAEPOLLENITES SP. A																																																			5.0	1.5		0.3
	TRICOLPATE																																																						
	TRICOLPITES CF. RETICULATUS	0.5		05									0.5											T				T	0.4	05	05	1.0	05				0.5									0.6			0.5	0.5	0.5		2.0	2.5	0.7
	T. SP. A				18	T	T	10		14	1.0	1.0																1.0	0.2	T				0.5									0.5		0.5	0.8	T	T							T
	T. SP. B					04		T	10										0.4		0.5										T		1.0					0.5	0.5								0.2	0.5				4.0		0.7	1.0
	T. SP. C						05																														0.5										T								
	PORATE																																																						
	GENUS A SP. A	2.5	6.0	05	1.4																																																		
MARINE	DINOFLAGELLATES																																																						
	DEFLANDREA CF. MINOR								1.0	T																		12.5	2.6	2.0	17.0																	17.5	1.0	2.2					
	D. SP. A																										0.5	T	T																					T	0.5				
	D. SP. B																															26.6	0.5																						
	GONYAULAX SP. A AND SP. B												05																04	05	05																			0.8	T				
	PSEUDOCERATIUM SP. A				T	09	T	71	05									T	0.8	6.0	6.5	14.3			1.0		T											0.5							0.5	0.2	0.4								
	PALAEOPERIDINIUM CF. CAULLERYI																															11.0																							
	ODONTOCHITINA OPERCULATA											05																		0.5		T																	T		T				
	HYSTRICHOSPHAERIDS																																																						
	HYSTRICHOSPHAERIDIUM CF. TUBIFERUM									03	2.0	25	1.0	T														1.0	04	T																			0.5						
	H. CF. CHOANOPHORUM												05																T	T	05																		0.5	T	T				
	H. CF. ECINODES								25	1.0	05	05	52	1.0														05	02																		0.2	1.0			T				
	H. SP. A											1.0																	0.9	T	05																		1.0	1.0	T				
	HYSTRICHOSPHAERA CF. FURCATA											1.5																	02	0.5	0.5																		1.0	0.3	0.5				
	H. CF. WETZELI										1.0																				T																								
	BALTISPHAERIDIUM PARVISPINUM																													T																									
	B. MACHAEROPHORUM										05																			T	T																		0.5	0.5					
	B. CF. LUMECTUM										2.0		05															0.5																					2.0	0.8					
	B. EHRENBERGI VAR. BREVISPINOSUM									T				05																																									
	B. SP. A									0.5	1.5	05	15							1.0								0.5	04	05	1.0	0.5		0.5													1.9	8.0	3.0	0.3	0.5				
	B. SP. B									0.3	0.5											05					T		0.2	1.0	T												0.5				4.2	1.5	1.5	1.6	0.5				
	B. SP. C									17		T																																	T			0.5							
	MICRHYSTRIDIUM INCONSPICUUM									07			05									1.0	430	0.5	14.5	12.0	2.5		04		05	15.2	1.5	0.5												0.2	2.3	1.0	0.5	3.5					
	M. CF. FRAGILE										05	0.5		05															0.4	05	0.5																T			0.5					
	M. DENSISPINIUM								20	60	03		30	1.5									275	1.0	21.5	27.0	54.0	3.0	02			4.3	15	15												0.2	4.4	6.5	6.5	2.7	1.5				
	M. SP. A									05		4.5																	9.0	11.0	21.0	19	5.0													0.2					2.5				
	VERYNACHIUM SP. A											1.0		T															1.5	2.0	0.5																			1.1	0.5				
	V. SP. B										T																			05	1.5																								
	V. SP. C																												T																					T					
	CHLAMYDOPHORELLA CF. NYEI										20	05	30	25																1.5																			1.0	0.5	T				
	PTEROSPERMOPSIS EURYPTERIS																				05											T																			T				
	P. AUSTRALIENSIS																												02	05		0.5																T	1.5	1.0	2.5				
	CYMATOSPHAERA SP. A																														T																				1.0				
	ANIMALIA INCERTAE SEDIS																																																						
	CRASSOSPHAERA SP.																																15	15														0.5							
	DIPLOTESTA GLAESSNERI																												T	T	05																			0.5					
	GENUS B SP. A							03															T		30	25	05																			0.4	0.7								
	GENUS C SP. A					11	06	1.8	05		05											05		0.5	15			1.0																		2.5	0.2		0.5						
	GENUS D SP. A	95	195	30	41	11	14									05		T															05												0.5										
	GENUS D SP. B						12	03							55		8.0	6.0	0.4	17.0	5.5																																		

T: Trace, indicating that species is present in sample but did not occur in assemblage counts.