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PALYNOLOGY OF THE LOWER CRETACEOUS BEAR RIVER FORMATION IN THE OVERTHRUST BELT OF SOUTHWESTERN WYOMING

By

John Craig Tingey

A DISSERTATION

Submitted to
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for the degree of

DOCTOR OF PHILOSOPHY

Department of Geology

1978

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ABSTRACT

PALYNOLOGY OF THE LOWER CRETACEOUS BEAR RIVER FORMATION IN THE OVERTHRUST BELT OF SOUTHWESTERN WYOMING

By

John Craig Tingey

Rock samples from two sections of the Bear River Formation and one section of the Smiths Formation (both Lower Cretaceous) in the Overthrust Belt of southwestern Wyoming were studied for their acid insoluble plant microfossil content. The palynomorphs were isolated using conventional chemical and physical techniques in the laboratory.

113 distinct taxa were differentiated and systematically treated. Tabulation of the stratigraphic ranges of the previously reported taxa indicates a middle (?) to late Albian age for the Bear River Formation and Smiths Formation.

A four part subdivision of the Bear River Formation is suggested from comparison of lithology, relative abundance counts of palynomorphs and terrestrial and marine percentages. These coincide with transgressive and regressive periods.

The Bear River Formation in southwestern Wyoming was apparently deposited in a pronounced embayment of the Cretaceous seaway which contained marine or at least brackish waters during most of Bear River time. Local freshwater environments have also been indicated by other studies treating charophytes, ostracods and molluscs. The overall palynofloral assemblage suggests a subtropical to warm temperate climate existed in southwestern Wyoming during middle (?) to late Albian time.

ACKNOWLEDGMENTS

The author gratefully acknowledges the direction and help of Dr. A. T. Cross of the Department of Geology and the Department of Botany and Plant Pathology, Michigan State University who served as chairman of the doctoral committee and provided guidance during all phases of this dissertation. Appreciation is also extended to Drs. R. L. Anstey, J. H. Fisher and C. E. Prouty of the Department of Geology and Dr. R. E. Taggart of the Department of Botany and Plant Pathology who served on the doctoral committee.

The generosity of Chevron U.S.A., Inc. and particularly H. L. Ott in securing the description, measurements and samples from the Stowe Creek section and financial support for this study was greatly appreciated.

This study was also supported by grants from the Michigan State University Chapter of Sigma Xi, the American Association of Petroleum Geologists and Union Oil Company through the Geological Society of America.

Lastly, I wish to acknowledge the patience and encouragement of my family and particularly my wife, Anne, without whose support the completion of this dissertation would not have been possible.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Objectives of the Study:

1) Identify the terrestrial and marine palynomorphs of the Bear River Formation in southwestern Wyoming.
2) Evaluate the plant microfossil assemblage in terms of age and comparison with other similar palynofloras in western North America.
3) Interpret the probable environments of deposition of sampled sections using relative abundances of environmentally significant plant groups, terrestrially-derived/marine ratios, diversity of plant groups and correlation of occurrences to rock type.
4) Make time correlations of the sampled sections, where possible, based on species ranges and relative abundances.

Previous Studies: Significant Lower Cretaceous and Cenomanian palynofloras have been studied in northern Wyoming (Davis, 1963, unpublished thesis), the Denver Basin of Colorado and Nebraska (Pannella, 1966, unpublished thesis), the southern Black Hills in northwestern South Dakota (Cahoon, 1964, unpublished thesis), Minnesota (Cenomanian; Pierce, 1961), southern Oklahoma (Cenomanian; Hedlund, 1966; Hedlund and Norris, 1968; Srivastava, 1975), southwestern Mississippi and northeastern Louisiana (partly Cenomanian; Phillips and Felix, 1971a, b), southwestern Arkansas (Bond, 1972) and north-central California (Warren, 1967, unpublished thesis).

The western Canadian Lower Cretaceous has also been studied in east-central Alberta (Singh, 1964), central Alberta (Norris, 1967; Brideaux, 1971), northwestern Alberta (Singh, 1971), northeastern Alberta (Vagvolgyi and Hills, 1969), southern Alberta and southern Saskatchewan (Pocock, 1962, 1964), southern Saskatchewan (Steeves and Wilkins, 1967), eastern Saskatchewan and western Manitoba (Playford, 1971), the District of Mackenzie (Brideaux and McIntyre, 1975; Brideaux, 1977), the District of Franklin (Hopkins, 1971; Hopkins and Balkwill, 1973) and the Canadian Arctic Archipelago (Hopkins, 1974).

Numerous studies of Lower Cretaceous palynomorphs and their stratigraphic significance in sediments of the Atlantic Coastal Plain have been carried out in recent years (Wolfe and Pakiser, 1971; Robbins and others, 1975; Doyle and Robbins, 1977) since the earlier work of Groot and Penny (1960), Groot, Penny and Groot (1961) and Brenner (1963).

GEOLOGY

Regional and Structural Setting: Since the first reconnaissance work in the Overthrust Belt of southwestern Wyoming by the Hayden and King surveys (1867 to 1879), a basic understanding of the structural relations has often dictated the nature of geologic interpretations. This is particularly true of the early stratigraphic placement and age determinations of the Bear River Formation. Significant studies dealing at least in part with structural complexities of the southern Overthrust Belt have been published by Veatch (1907), Schultz (1914), Mansfield (1927), Rubey and Hubbert (1959), Eardley (1960), Armstrong and Cressman (1963), Armstrong and Oriel (1965), Armstrong (1968), Oriel (1969), Rubey and others (1975) and Royse and others (1975). Armstrong and Oriel's paper is perhaps the most important contribution to an understanding of the tectonic development of the Idaho-Wyoming thrust belt, including the area where the Bear River Formation was deposited. Another particularly pertinent paper in dealing with "structural geometry and related stratigraphic problems" is Royse and others (1975).

The Overthrust Belt occupies an eastwardly convex belt about 50 to 65 miles wide and 200 miles long. It extends north-south in the area southeast of the Snake River Plain, west of the Green River Basin and southward a short distance into northern Utah. The northern limit is the Teton Range where the thrusts trend northwest-southeast as opposed to the principal trend which is a few degrees east of north as far south as Kemmerer and Evanston.

Armstrong and Oriel (1965) characterize the tectonic development of the thrust belt of southwestern Idaho and western Wyoming by three developmental stages: (1) Thick sedimentary accumulation in Paleozoic miogeosynclinal and shelf environments (50,000 to 6000 feet thicknesses, respectively) with sources to the east and west. Eastern sources would include the stable craton whose contact with the miogeosynclinal shelf fluctuated considerably but generally centered in west-central Wyoming during the Paleozoic. Intermittantly elevated local areas and broad features on the craton such as the Transcontinental Arch and the Ancestral Rockies also contributed sediments to the miogeosyncline.
Source areas to the west would include numerous volcanic "islands" dotting the western part of the eugeosyncline in a north-south belt and the Antler orogenic belt which became a positive area beginning in the Late Devonian. Additional thick basinal accumulations (35,000 feet in the west and 15,000 feet in the east) of marine and increasingly more terrestrial sediments continued through the Mesozoic as the result of an eastward spreading western positive area rising in the central Idaho region in Late Triassic as the miogeosyncline began to break up. By Late Jurassic time intracratonic geosynclinal basins had formed east of these highlands. (2) Crustal instability progressing eastward during latest Jurassic (in the west) to early Eocene (in the east) manifested by an area of folds overturned to the east and gently westward dipping thrust faults forming an arcuate outline convex to the east. (see Figure 1)

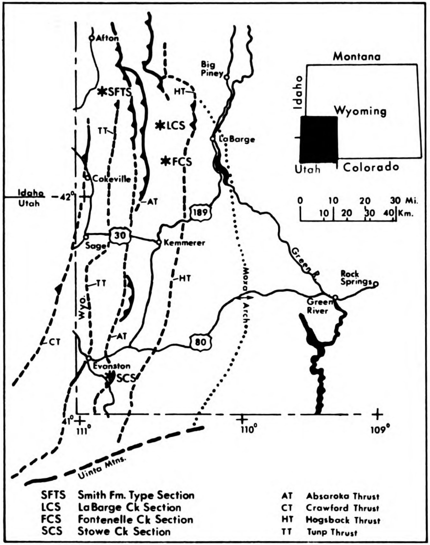


Figure 1 Index map of southern Overthrust Belt (Structure after Royse et al., 1975 and Armstrong and Oriel, 1965)

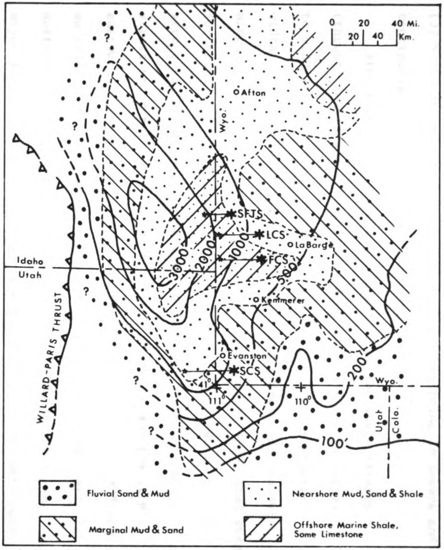


Figure 2 Palinspastic isopach and generalized facies map of the Bear River Formation (Redrafted from Royse et al., 1975)

(3) North and east trending block faulting beginning in Eocene and continuing recurrently to the present.

Armstrong and Oriel discuss eight major low angle reverse (thrust) faults and associated folding which, from Late Jurassic to middle Eocene time, shortened to roughly half, the original width of the westward thickening wedge of Paleozoic and Mesozoic miogeosynclinal sediments. Royse and others (1975) show, that except for broad warping, the crystalline basement is unaffected by the structurally detached sedimentary cover. The fact that younger strata are represented on the upper plate of each successively eastward thrust fault has been pointed out by Armstrong and Oriel as evidence that thrusting started in the west and progressed eastward. They also note the unusual lack of metamorphism and major fault breccia or mylonite associated with the thrust faults. Stratigraphic displacement is on the order of 5000 to 20,000 feet placing Paleozoic rocks in contact with progressively younger Upper Mesozoic and Cenozoic rocks eastward. Horizontal displacement along the major thrusts has been estimated at 10 to 15 miles by Armstrong and Oriel (1965) and to more than twice that amount by others.

Royse and others (1975) discuss the importance of palinspastic isopach and generalized facies maps in creating meaningful stratigraphic interpretations in an area such as the Overthrust Belt where stratigraphic units have been shortened laterally by thrusting. Such maps which show the original isopach and facies pattern at the time of deposition also help to interpret the influence of uplifted and thrusted blocks on sediment source and on facies determinations. Their reconstruction of the Bear River Formation which is based on data from 110 control points (36 surface sections and 74 boreholes) is represented in Figure 2. The approximate pre-thrust (small asterisk) and present location (large asterisk) of the stratigraphic sections used in this study is plotted.

In his treatment of the "Sevier orogenic belt" in Nevada and Utah, R. L. Armstrong (1968) states that "the Sevier belt is a continuous entity from Nevada to Idaho; structural style, age of deformation, magnitude of shortening, and width of the highly deformed zone show no radical changes over a distance exceeding 500 miles." He included the Idaho-Wyoming thrust belt in his newly named orogenic belt but failed to carry his investigation much beyond northern Utah. Except for the earliest thrusting in southern Idaho (Paris thrust) which probably began in latest Jurassic (Armstrong and Cressman, 1963), Armstrong's newly proposed Sevier orogeny could be applicable to the deformation in the Idaho-Wyoming thrust belt which from earliest Cretaceous to Campanian supplied sediments to the Rocky Mountain geosyncline.

Armstrong insists on the term Sevier orogeny in order to emphasize the distinction in position and timing with the earlier "classic" Nevadan orogeny and later Laramide orogeny which have sometimes been vaguely defined.

Stratigraphy

General Remarks: Although this study concentrates on the strata of the Bear River Formation, a brief review of Lower Cretaceous stratigraphy of southwestern Wyoming is necessary in understanding what has been called the classic "Bear River problem" which is discussed later. A correlation chart of the units to be discussed is presented in Figure 3.

Gannett Group: The Gannett Group (maximum thickness about 32,000 feet) was named from the Gannett Hills in Caribou County, Idaho and Lincoln County, Wyoming by Mansfield and Roundy (1916) who divided it into five distinct formations on the basis of its characteristic lithology in western Wyoming and southeastern Idaho: (1) Ephraim Conglomerate - primarily coarse conglomerates of alluvial-fan origin intercalated with fluvial channel fills of finer grained sediments (Eyer, 1969), (2) Peterson Limestone - primarily ostracod and charophyte rich, lacustrine limestones with some interbedded calcareous shale, (3) Bechler Conglomerate - similar in lithology to the Ephraim Conglomerate, (4) Draney Limestone - similar in lithology to the Peterson Limestone, and (5) Tygee "sandstone". The name was originally applied to a 100 feet thick "gray to buff, even grained sandstone" overlying the Draney Limestone at its type locality in Caribou County, Idaho. Since its original description the Tygee "sandstone" and the overlying black shale have been placed at the base of the overlying Bear River Formation (Cobban and Reeside, 1952; Moritz, 1953; Stokes; 1955; Burk, 1957; Eyer, 1969).

Eyer (1969) proposed the name Smoot Formation for the previously unnamed red mudstone and siltstone just below the marine black shale of the Tygee Member. He considers it to span the Aptian-Albian stage boundary because of the apparent Albian age of the overlying Bear River Formation. The lower boundary of the Gannett Group is considered by some to be conformable with the underlying marine Stump Formation of Jurassic age (Eyer, 1969) and unconformable

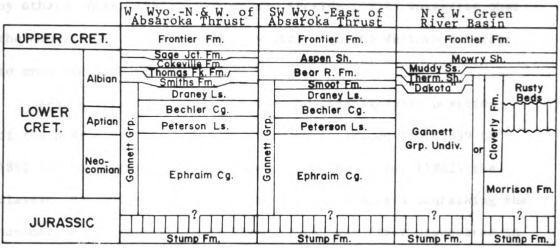


Figure 3 Stratigraphic nomenclature and probable equivalency of Lower Cretaceous strata in western Wyoming.

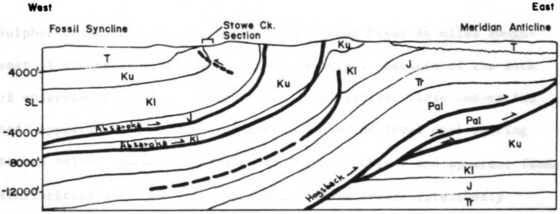


Figure 4 East-west structural cross section near the Stowe Creek section. (After Royse et al., 1975) Pal = Paleozoic strata
Horizontal Scale: 1" = 2.3 miles (3.7 km.)

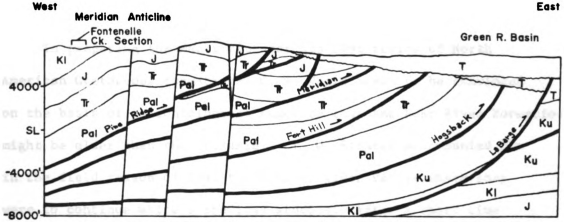


Figure 5 East-west structural cross section near the Fontenelle Creek section. (After Oriel, 1969) Pal = Paleozoic strata
Horizontal Scale: 1" = 1.6 miles (2.6 km.)

by others (Burk, 1957). Cobban and Reeside (1952) suggested that the Gannett Group may be the only strata in the Western Interior to span the Neocomian.

Bear River Formation: The age and stratigraphic position of the Bear River Formation was vehemently argued from 1859 to 1892 and constitutes what has been called by Thomas (1962) the classic "Bear River problem." The series of strata containing the non-marine to brackish "Bear River fauna" was first discovered in 1859 by Henry Engelman, geologist to the United States exploring expedition in the charge of Captain Simpson, along the bank of Sulphur Creek near its junction with the Bear River 8½ miles southeast of the present town of Evanston, Wyoming. Because of the lack of understanding of local structural conplexities, these non-marine beds appeared to be stratigraphically above the local coal-bearing strata called "Laramie." These structural problems and apparent faunal similarities with the "Lignite formation" in France (previously published and referred to the Tertiary) left little doubt that the "Bear River estuary beds," as they were called, were Tertiary in age.

In preparing the manuscript for his 1891 review of North American Cretaceous formations, C. A. White began to be convinced on the basis of paleontological evidence that the Bear River Formation might be older than the "Laramie." T. W. Stanton accompanied him in the field season of 1891 to the Bear River Valley where they were to continue White's previous studies. After a short time White had to leave Stanton to pursue the investigation alone. Stanton, through keen geological observation, was able to prove that the Bear River Formation occupies a stratigraphic position between the Colorado Formation above and the Jurassic marine strata below. The following year Stanton published his results along with a supporting paper by White (Stanton, 1892; White, 1892). In 1895 White published his detailed, "The Bear River Formation and its characteristic fauna," which summarized all studies to that time. Veatch (1907) placed the Bear River Formation "conclusively in the Upper Cretaceous because of the fossil assemblage collected on Little Muddy Creek, 3 miles southeast of Cumberland" (Sec. 3, 4, T. 18 N., R. 116 W.)

More recently, Peck (1956) stated that the Bear River Formation probably contains both Upper and Lower Cretaceous rocks but later (Peck and Craig, 1962) concluded on the basis of its characteristic assemblage of freshwater charophytes and ostracods and its stratigraphic position below the Aspen Shale that it was entirely Lower Cretaceous. In Cobban and Reeside's "Correlation of the Cretaceous formations of the Western Interior of the United States," published in 1952, they placed the Bear River Formation in a position occupying the entire middle third of the Albian stage (pl. 1, col. 35, 62-64 and 66). Their placement was based on the late Albian cephalopods found in the Mowry Shale (Aspen Shale equivalent).

Yen, (1952) presents four reasons, based on comparison of non-marine gastropod faunas (particularly Pyguliféra) of the Bear River Formation with those of Europe, why the Bear River Formation must be Upper Cretaceous (Cenomanian) in age. As Moritz (1958) points out by quoting Reeside, "the difference of opinion as not really great, for the time involved - latest Albian to earliest

Cenomanian - is only a small part of one European stage."

The lithology of the Bear River Formation is heterogeneous and somewhat cyclic. Its spatial relations suggest a complex array of westward thickening and intertonguing marine, brackish and non-marine beds represented by tan to buff sandstones, black to gray shales, siltstones, coquinoid limestones, coals and bentonites. The intertonguing facies relationships are most apparent in the central portions of the thrust belt and have warranted separate terminology east and west of the trace of the Absaroka thrust fault (Rubey, 1973). Rubey named four new formations which occur west and north of the Absaroka thrust fault and defined them as equivalent to the Bear River Formation and Aspen Shale on the east side (see Figure 3). These new formations are, in descending order: (1) the Sage Junction Formation, (2) the Cokeville Formation, (3) the Thomas Fork Formation and (4) the Smiths Formation, of which part of the type section is included in this study. It is time equivalent to roughly the lower third to half of the Bear River Formation.

The Bear River Formation east of the Absaroka thrust attains a thickness of at least 1500 feet (Burk, 1957) and thins northward and eastward where its presumed equivalent, the "Dakota," is about 250 feet thick in the subsurface on the Rock Springs Uplift according to Anderman (1956).

The top of the Bear River Formation is usually placed at the youngest sandstone below the Aspen Shale porcelanites or at the base of these distinctive porcelanites.

Aspen Shale: The Aspen Shale was described by Veatch (1907, p. 64) for 1500 to 2000 feet of black and gray shales near Aspen Station, Uinta County, Wyoming (T. 14 N., R. 118 W.) The Aspen Shale is easily distinguished by its light silvery-gray colored, weathered porcelanites containing fish scales locally. The formation thins locally to less than 1000 feet and also contains darker shales, siltstones and sandstones as well as the porcelanites of quartz latite composition. The Aspen Shale has been placed in the Lower Cretaceous since the work of Cobban and Reeside (1951) who identified Gastropites and Neogastropites collected from both it and the equivalent Mowry Shale.

Time Equivalent Strata in Adjacent Areas: The faunal uniqueness and heterogeneous lithology of the Bear River Formation have compounded the problem of age correlations in other areas. It is widely accepted that the Bear River Formation is time equivalent to the Thermopolis Shale (restricted; Eicher, 1960), Muddy Sandstone and Shell Creek Formation to the east although the absence of foraminifera in the Bear River Formation makes this difficult to demonstrate.

The Wayan Formation's partial time equivalence to the Bear River Formation is summarized by Stokes (1955):

> "The Wayan and Bear River Formations are nearly contemporaneous deposits laid down during the Early (?) and Late Cretaceous in such a manner that they show interfingering facies relationships along the central portions of the thrust belt. Although the lowest part of the Bear River has no equivalent in the Wayan and the highest part of the Wayan has no counterpart in the Bear River, the main bulk of the two formations may be considered as contemporaneous. Tongues of Bear River extend westward into the Wayan and tongues of the Wayan extend eastward into the Bear River."

The Wayan Formation was named by Mansfield and Roundy (1916) for about 11,800 feet of strata in southeastern Idaho (Bannock County) without a defined top or base, which had previously been referred to the Bear River Formation. Rubey (1973) points out that "redefinition of the Wayan Formation is clearly necessary" especially in light of its great thickness and Rubey's new Lower Cretaceous units.

Although parts of the Beckwith Formation as originally defined (Veatch, 1907) and the revised Beckwith Formation (Mansfield and Roundy, 1916) have included strata which are time equivalent to the Bear River Formation, the general abandonment of the term precludes its discussion in this study.

Paleogeography: In order to fully appreciate the problems involved in understanding the Early Cretaceous strata of southwestern Wyoming, it is desirable to envision the broad changes which had taken place since the Paleozoic and early Mesozoic. Thomas (1962) has discussed some of these changes and their related problems.

During the Paleozoic and early Mesozoic southwestern Wyoming had been situated on the eastern shelf of the Cordilleran and Mesocordilleran miogeosynclines, respectively. These epicontinental seas had Pacific connections and although their depth varied through time with each transgression the waters were fairly shallow across Wyoming.

Late Triassic and Early Jurassic time was marked by major paleotectonic change as a north-south trending landmass of folded and faulted Paleozoic sedimentary rocks began emerging west of Wyoming in the old miogeosyncline. This buckling had created a number of small, shallow basins to the east which received marine sediments (Stump Formation) up to Late Jurassic time when the sea (Sundance Sea) began retreating and the area east of the landmass developed into one huge, elongate basin. It was along the prograding shorelines of this sea that the Morrison Formation was being deposited by northeasterly flowing, low gradient streams on the coastal plains (Furer, 1970). Contemporaneous terrestrial deposition of a synorogenic clastic wedge (lower Ephraim Conglomerate) adjacent to the new north-south landmass and the deposition of volcanic ash carried eastward from sources, probably, in west-central Idaho or possibly western Oregon also characterized the latest Jurassic.

The upper Ephraim Conglomerate and Bechler Conglomerate which were deposited in western Wyoming and southeastern Idaho attest to the continued subsidence in this area during the Neocomian. Intervening periods of quiescence are apparent as indicated by the accumulation of freshwater sediments (Draney and Peterson Limestones) rich in charophytes and ostracods which may be of Aptian age (Eyer, 1969).

In early Albian time the Gulf Coast waters were not far from the Mexican border and boreal waters were invading northern Alberta and British Columbia (Lower Mannville Group). This boreal sea (Clearwater Sea) transgressed southward into central Alberta in middle Albian time. It was during this same time from middle Albian to earliest late Albian that the first marine waters since Late Jurassic time invaded the interior of the continent in a narrow north-south trough.

According to Eicher (1962) the boreal sea extended far into the center of the continent but did not connect with the Gulf Coast sea until late Thermopolis time (about middle-early Bear River time) when the Gulf Coast sea advanced northward over the former drainage divide south of Kansas. This seaway which connected the Gulf

Coast and boreal seas has been called the Skull Creek seaway.

It was also during late-middle (?) to middle-late Albian time that the Bear River Formation was being deposited in southwestern Wyoming, southeastern Idaho and northeastern Utah. Royse and others (1975) envision the paleogeography as follows:

> "it is obvious that deposition of the Bear River Formation and equivalent strata centered in a structural downwarp in front of the Willard-Paris fault system. Much of the clastic material was derived from source areas on the hanging wall of this early fault plate. A large part of the deposition took place under marine conditions in an embayment that extended southwest across the Idaho-Wyoming boundary into northern Utah."

Their reconstruction (Figure 2) shows a deep invagination of the sea with an outlet to the northeast and peripheral source areas to the south and southeast besides the Willard-Paris thrust to the west. The freshwater fossils reported in the Bear River Formation (charophytes, ostracods and molluscs) probably lived in local areas bordering the embayment on the landward side where streams draining the western highlands flowed into the embayment. Transgressions and regressions of the sea undoubtedly effected the configuration of the embayment besides controlling the distribution of freshwater and brackish waters throughout Bear River time.

The Bear River Formation does not contain foraminifera, possibly because of eutoxic conditions in the protected areas of the embayment or perhaps because of dilution of seawater by numerous streams flowing off the western highlands. Its coquinoid limestones and some shale units, however, contain a diverse molluscan fauna which has been studied by White (1895) and more recently by Yen (1952). Some faunas observed in soft shale units appear to be dwarfed and further suggest locally adverse bottom conditions characteristic of restricted areas such as lagoons or estuaries.

Thomas (1962) considers the Bear River Formation to be the nearshore, brackish water equivalent of the Thermopolis (restricted, Eicher, 1960), Muddy Sandstone and Shell Creek Shale which were deposited farther to the east in generally more offshore marine conditions as evidenced by their foraminiferal content and general facies relationships.

The seas apparently were again disconnected prior to the deposition of the boreal Shell Creek Shale (Eicher, 1962) which is probably roughly equivalent to the upper part of the Bear River Formation. Eicher suggests that this was the result of renewed warping or tilting during the "Muddy orogeny" perhaps in the area of the old continental divide south of Kansas.

The latest Albian saw the deposition of marine shales (Aspen Shale = Mowry Shale) in a boreal embayment which extended southward only as far as northern Colorado and east into western North Dakota, South Dakota and Nebraska. Distribution of large quantities of volcanic ash from west-central Idaho and perhaps northeastern Oregon extended eastward over an area from western Colorado and north-central Montana across Wyoming and into the Dakotas. This is apparently the main factor responsible for the characteristically siliceous nature of the Aspen Shale and Mowry Shale.

A renewed marine connection of the boreal and Gulf Coast seas was effected in the early Cenomanian which would continue to latest Cretaceous time.

DATA COLLECTION

Localities:

Stowe Creek Section: This section is located about 2 miles (3.2 kilometers) north-northeast of the type section of the Bear River Formation at "Old Bear River City," Uinta County, Wyoming (see Figure 1). The section was measured across steeply dipping overturned beds on the south end of Knight Ridge, northeast of Stowe Creek and the Union Pacific Railroad tracks. (Sec. 21, 22, T. 14 N., R. 119 W.; see Figure 4). The formation is 1299 feet (395.9 meters) thick and well exposed except for some of the softer shale units. This section is located just west of the Absaroka thrust trace and was deposited in a nearshore mud, sand and shale facies according to the reconstruction of Royse and others (see Figure 2).

Fontenelle Creek Section: This section is well exposed in a gap of Oyster Ridge (Frontier Formation) formed by Fontenelle Creek (NE¼ Sec. 6, T. 24 N., R. 115 W.; see Figure 5) about 21 miles (33.8 kilometers) north of Kemmerer in Lincoln County, Wyoming. The Bear River Formation at this locality is 760 feet (231.6 meters) thick and exposed on both sides of Fontenelle Creek. This section is located between the Absaroka and Hogsback thrusts and was deposited in an offshore marine shale facies according to the reconstruction of Royse and others (see Figure 2).

LaBarge Creek Section: This section is exposed under structural conditions similar to the Fontenelle Creek section, located about 16 miles (25.7 kilometers) to the south. It is exposed along LaBarge Creek (SW¼ Sec. 17 and SE¼ Sec. 18, T. 27 N., R. 115 W.) in Lincoln County, Wyoming. During processing, the samples collected from this section were found to contain a residuum of carbonized and corroded palynomorphs of very low diversity. There is no apparent explanation for this phenomenon in terms of increased thermal alteration or depth of burial which would not have also affected the Fontenelle Creek section, a short distance to the south. Both sections are located 5-10 kilometers from major thrust traces and about 8000 feet (2450 meters) stratigraphically above the underlying plane of the Pine Ridge thrust where some thermal alteration should be expected. One possible explanation would be locally increased oxidizing conditions during deposition (perhaps in a semiclosed basin) or after burial. This is, however, very hard to envision having affected the entire Bear River Formation of the area. Because of the extremely poor palynomorph preservation and representation, the LaBarge Creek section is not treated further in this study.

Smiths Formation Type Section: This section is located about 17 miles (27.4 kilometers) south of Afton, Wyoming (NW¼, NE¼ Sec. 27, T. 29 N., R. 118 W.) and 1½ miles (2.4 kilometers) west-northwest of the Smiths Fork Guard Station. According to Rubey (1973) the Smiths Formation is about 700 feet (169.0 meters) thick at this locality and is divided into an upper sandstone member and a lower shale member. The upper sandstone member is only partly exposed as a ledge about 5 feet (1.5 meters) thick at the type locality. It averages 215 feet (65.6 meters) in thickness, however, at two of Rubey's reference sections a short distance away. Only the upper 195 feet (59.4 meters) of the lower shale member is now exposed and was sampled by the author for use in this study. This section is west of the Absaroka thrust and was deposited in an offshore marine facies according to the reconstruction of Royse and others (see Figure 2).

Sample Collecting: The three stratigraphic sections of the Bear River Formation examined in this study were measured, described and sampled systematically in order to obtain the necessary stratigraphic information for later interpretation and comparison. This was achieved by collecting samples at significant lithologic changes and at approximately 15 foot (4.6 meter) intervals within the thick shale units. Each sample represents a 6 to 12 inch (15 to 30 centimeter) interval of relatively unweathered rock collected sometimes as deep as 2½ feet (76 centimeters) below the surface in a pit dug with a mattock. Composite samples were collected from some thinner, resistant units (especially limestones and sandstones) as noted in the sample information in Appendix C.

The Stowe Creek section was measured, described and sampled by Chevron U.S.A., Inc. geologists. The Bear River Formation at the Fontenelle Creek section and LaBarge Creek section were remeasured, redescribed and sampled by the author in the summer, 1977, using the measured sections of Horstman (1966, unpublished thesis) as a guide. The Smiths Formation type section was sampled by the author using the lithologic description given by Rubey (1973).

Those sections sampled by the author were measured using a brunton compass and jacob staff. Complete lithologic descriptions of the three productive sections are included in Appendix B.

Preparation of Samples and Slide Making: Although it is impossible to prepare all samples of a stratigraphic suite identically, it is desirable to be as uniform as possible within practical limits. Samples in this study were processed according to the following schedule with microscopic examination at the conclusion of steps 5, 6, 7, 8 and 9.

1) Crush 50 to 100 grams of sample to 3 to 5 mm size; avoid powdering.

2) Place crushed sample in a pile on a paper towel and roll edges from all sides several times so sample is moved several inches each time. Quarter sample and transfer a representative quarter to balance for weighing (30 grams for limestones and sandstones and 5 to 10 grams for shales).

3) Transfer sample to beaker and cover with HCl (10%) if sample is calcareous; wash three times with distilled water after reaction is complete.

4) Cover sample with concentrated HF (50%) and allow to set with frequent stirring until disaggregated (24 to 96 hours); wash three times with distilled water.

5) Cover sample with warm HCl (10%) and allow to set for 30 minutes with frequent stirring; wash three times with distilled water.

6) Transfer one-third aliquot of sample to 50 ml glass test tube and cover sample with 10 ml Schultz solution (7 parts concentrated

HNO_3 to 1 part saturated $KCLO_3$); the time allowed for this step varied with each sample (1 to 15 minutes) and was determined by the condition of organic material in each sample after step 5. Dilute immediately and wash three times with distilled water.

7) Cover sample with 5 to 10 ml of KOH (5%) and allow to set after initial agitation for 2 minutes; dilute immediately with distilled water and wash three times.

8) For samples with considerable mineral matter proceed with heavy liquid separation. Mix sample with 10 to 15 ml $ZnCl_2$ (sp. gr. 1.95) and centrifuge at 1200 R.P.M. for 30 minutes or until a clear separation is attained. Pour floating fraction into 90 ml test tube and examine sink fraction to assure that it is devoid of palynomorphs. Repeat separation for a second crop of organic material from the sink fraction of the first separation. Transfer the float fraction to a 90 ml test tube and dilute with distilled water in order to lower the specific gravity so the organic material will sink with further centrifuging. Centrifuge initially with twice the usual time and continue washing three additional times.

9) Cover sample with 15 ml of distilled water and add 1 drop NH_4OH (10%) and 2 to 5 drops Safranin O (1% in water). Dilute with distilled water after thirty seconds and wash until clear.

10) Transfer to small vial and cover with enough H.E.C. (Hydroxyethyl Cellulose WP-09, Union Carbide Corp.) so that about one drop of residue will make one slide with the proper density for easy identification and counting of palynomorphs.

11) Mix residue vigorously and transfer one drop to a coverslip

with a Pasteur pipette and distribute as evenly as possible by using a toothpick. Allow to dry to a thin film on the hot plate and mount on microscope slide with 1½ drops of Elvacite (Grade 2044, E. I. DuPont de Nemours & Co., Inc.) Allow to cure in oven at 35° C overnight.

Counting Procedure: Counting of the palynomorphs in productive samples was carried out as described below in order to establish ranges and relative percentages of each taxon for later interpretation. Slides were first examined from representative parts of each section in order to establish the basic floral framework.

The most suitable minimum number of palynomorphs to be counted per sample was determined by plotting the number of palynomorphs counted against the number of taxa encountered. These plots form species-diversity curves similar to those used by ecologists and others dealing with sampling from a population of organisms. With three samples of average diversity the curve leveled off between 125 and 150 palynomorphs counted. A count of 250 was decided upon as it would probably insure an adequate sampling for even any unusually diverse samples. During the counting some samples were found to contain taxa comprising over 40% of all palynomorphs in the sample. Counts on these samples were carried to 300, 400 or 500 to insure an adequate sampling of other palynomorphs.

Every attempt was made in this study to identify palynomorphs to the generic and species level. When this was not possible they were identified at least to some potentially useful group such as unidentified trilete, bisaccate, tricolpate, angiosperm, dinoflagellate, acritarch or simply counted as unidentified palynomorph.

All slides were counted at 500X magnification on a Leitz Ortholux microscope (Michigan State University No. GG2667) in horizontal traverses in a prescribed, random method determined beforehand. In order to partially overcome any bias due to the positioning of residue on slides the first four traverses were made at 5.0, 9.0, 13.0 and 17.0 mm in from the top edge of the slide (farthest from the observer). These four traverses cross the middle of the four horizontal quarters of the slide. No more than 63 palynomorphs were counted in any one of these traverses so all four could be made. The remaining traverses (up to 47) were randomly chosen and recorded before counting began. Any additional slides were treated in the same manner until the sample was adequately counted.

Several hundred additional specimens from each sample were scanned on a slide not used in counting to ensure representation in the record of most of the rarer palynomorphs. These occurrences were not included in counts but are recorded as a "trace" on the range charts (see Table 3).

SYSTEMATICS

Introduction: Several schools of thought exist on the systematic treatment above the generic level of Cretaceous terrestrial palynofloras. Some have followed the totally artificial placement of spores and pollen into morphologically distinct genera and artificial suprageneric taxa (Potonie and Kremp, 1954, 1955, 1956; Potonie, 1956, 1958, 1960). Others (Couper, 1958; Singh, 1964, 1971) have followed a more natural approach and attempted to place these existing morphologically distinct genera in suprageneric taxa based on their resemblance to living families, classes or orders, depending upon the strength of comparison.

The second approach has obvious paleoenvironmental advantages if the relationship to modern taxa can be demonstrated or strongly suggested. This is not possible, however, in many cases and may create misconceptions about affinities which lead to invalid conclusions. In spite of these limitations it is usually possible to speculate broadly about the affinities of certain genera when they are found in association with other genera in numerous floras and under similar paleoenvironmental conditions.

In this study the terrestrially-derived palynomorphs have been listed in alphabetical order in the following categories: TRILETE SPORES, MONOLETE SPORES, SPORES-INCERTAE SEDIS, GYMNOSPERM POLLEN and ANGIOSPERM POLLEN. The angiosperm pollen have been further divided into the subcategories: Monosulcate, Tricolpate, Tricolporate and Incertae Sedis. The artificial classifications of Sarjeant and Downie

(1974) and Downie, Evitt and Sarjeant (1963) have been followed in the treatment of the dinoflagellate cysts and acritarchs, respectively. Because of the poor preservation and paucity of bisaccate pollen, all but several distinct forms were placed in categories based upon their superficial morphological resemblance to modern genera.

The following information is included, as applicable, with each taxon listed:

(1) basionym and currently accepted generic designation for published species.

(2) pertinent synonymy or reference.

(3) description for previously unpublished species or species of uncertain taxonomic placement (designated with cf. or "?").

(4) size range of specimens in this study if pertinent.

(5) stratigraphic range reported from other studies; number of samples in which the species is present, relative abundance of the species in all samples (trace = found only by scanning beyond number counted, rare = <1%, occasional = 1-1.9%, common = 2-4.9%, abundant = 5-9.9%, dominant = 10-40% and flooding = >40%) and stratigraphic occurrence in this study (SCS = Stowe Creek section, FCS = Fontenelle Creek section and SFTS = Smiths Formation type section).

(6) suggested affinity for terrestrially-derived forms.

(7) comments on various topics pertinent to taxonomic placement, affinities, distinguishing characteristics, etc.

(8) slide number and coordinates of a typical specimen for unpublished species and species of uncertain taxonomic placement. A complete listing of the slide numbers and coordinates of all illustrated specimens is found in Appendix A.

Slide numbers are accession numbers of the palynology and paleobotany laboratory at Michigan State University. The horizontal and vertical coordinates, respectively, are taken from a Leitz Ortholux microscope (Michigan State University No. GG2667). Each slide examined is marked with "X" scratched just off the coverslip in the upper left-hand corner of the slide. The coordinates of this "X" are noted on each slide label and provide the possibility to examine reference and illustrated specimens with other microscopes (see Traverse, 1958). Appendix A provides a complete taxonomic listing with: (1) the number assigned to each species in the palynoflora, (2) reference and illustrated specimen coordinates, (3) plate and figure locations for each taxon and (4) the text page number where the systematic treatment is located.

Photomicrographs were taken with a Leitz Orthomat microscope camera mounted on a Leitz Ortholux microscope. Photos were taken with Panatomic-X film developed in Microdol-X and printed on polycontrast paper.

TRILETE SPORES

GENUS Acanthotriletes Naumova, 1939 ex Potonie and Kremp, 1954

Type species: Acanthotriletes ciliatus (Knox) Potonie and Kremp, 1954

Acanthotriletes varispinosus Pocock, 1962

Plate 1, Figure 1

1962 Pocock, p. 36, pl. 1, fig. 18-20.

Occurrence: Early Cretaceous, see Singh (1971, p. 45); 7 samples, trace to rare, found in all three sections.

Suggested affinity: Selaginellaceae.

Comments: Pocock (1962) points out the close resemblance of this species to several modern species of Selaginella.

GENUS Aequitriradites Delcourt and Sprumont, 1955

Type species: Aequitriradites dubius Delcourt and Sprumont, 1955

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

Plate 1, Figure 2

1958 Cirratriradites spinulosus Cookson and Dettmann, p. 113, pl. 18, fig. 9-13; pl. 19, fig. 1-5.

1961 Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, p. 426, pl. 52, fig. 1-12.

Occurrence: Early Cretaceous to Danian, see Singh (1971, p. 34); 3 samples, trace to common, not found in SFTS.

Suggested affinity: Selaginellaceae.

Comments: Brenner (1963) points out the similarity of this species to spore types in the modern Selaginella megastachys group.

GENUS Appendicisporites Weyland and Krieger, 1953

Type species: Appendicisporites tricuspidatus Weyland and Krieger, 1953

Appendicisporites potomacensis Brenner, 1963

Plate 1, Figure 3

1963 Brenner, p. 46, pl. 6, fig. 4, 5.

Occurrence: Barremian to Albian, see Singh (1971, p. 62); 5 samples, rare to common, not found in SFTS.

Suggested affinity: Schizaeaceae.

Comments: This species differs from Appendicisporites problematicus (Burger) Singh which has outer flange-like equatorial ribs.

Appendicisporites problematicus (Burger) Singh, 1971

Plate 1, Figure 4

1966 Plicatella problematica Burger, p. 245, pl. 10, fig. 3.

1971 Appendicisporites problematicus (Burger) Singh, p. 63, pl. 6, fig. 1-6.

Size range: Equatorial diameter (6 specimens): 42(46)53 µm.

Occurrence: Berriasian to Albian, see Srivastava (1975, p. 17); 7 samples, trace to occasional, not found in SFTS.

Suggested affinity: Schizaeaceae.

Appendicisporites sp.

Plate 1, Figure 5

Description: Trilete spore; laesurae extending to equator; commissure raised and becoming wider toward the equator where a 3 to 5 µm projecting appendix is formed. Amb triangular with slightly convex sides. Proximal face canaliculate with 5 to 8 equally spaced ribs running parallel with the side in each interradial area. Ribs on both faces about 2 µm thick and distinctly raised.

Size range: Equatorial diameter (3 specimens): 43(49)53 µm.

Occurrence: 4 samples, trace to rare, found only in the lower 500 feet (150 meters) of SCS and lowermost FCS.

Suggested affinity: Schizaeaceae.

Comments: Specimens assigned to this species superficially resemble Appendicisporites bilateralis Singh but have significantly different canaliculate sculpture.

Reference specimen: slide Pb11602-5, 38.2 X 127.8.

GENUS Biretisporites Delcourt and Sprumont, 1955

Type species: Biretisporites potoniaei Delcourt and Sprumont, 1955

Biretisporites potoniaei Delcourt and Sprumont, 1955

Plate 1, Figure 6

1955 Delcourt and Sprumont, p. 40, fig. 10.

Synonymy and description: see Delcourt, Dettmann and Hughes (1963, p. 284).

Size range: Equatorial diameter (4 specimens): 40(43)47 µm.

Occurrence: Early Cretaceous, see Singh (1971, p. 49); 20 samples, trace to common, found throughout all three sections.

Suggested affinity: Osmundaceae and/or Hymenophyllaceae.

Comments: This species is characterized by its raised commissures and scabrate exine.

GENUS *Camarozonosporites* Pant, 1954 ex Potonie, 1956, emend. Klaus, 1960

Type species: *Camarozonosporites cretaceus* (Weyland and Krieger) Potonie, 1956

Camarozonosporites ambigens (Fradkina) Playford, 1971

Plate 1, Figure 7

1964 *Camptotriletes ambigens* Fradkina *in* Fradkina and Kiseleva, p. 70, pl. 1, fig. 3-5.

1971 *Camarozonosporites ambigens* (Fradkina)Playford, p. 540, pl. 104, fig. 22, 23.

Synonymy: see Playford (1971, p. 540).

Size range: Equatorial diameter (5 specimens): 27(30)36 µm.

Occurrence: Albian to Senonian, see Playford (1971, p. 540);

25 samples, trace to common, not found in SFTS.

Suggested affinity: Lycopodiaceae.

Comments: The average size of specimens in this study approaches the lower limit of ranges quoted by previous authors (Fradkina, 1967, 27(43)60 µm; Norris, 1967, 30 to 55 µm). Brenner (1963, p. 43) points out the resemblance of this species to the modern spores of *Lycopodium cernuum*.

GENUS *Cicatricosisporites* Potonie and Gelletich, 1933

Type species: *Cicatricosisporites dorogensis* Potonie and Gelletich, 1933

Cicatricosisporites hallei Delcourt and Sprumont, 1955

Plate 1, Figure 8

1955 Delcourt and Sprumont, p. 17, pl. 1, fig. 1.

Synonymy: see Norris (1967, p. 92).

Occurrence: Early Cretaceous to Cenomanian, see Singh (1971, p. 71); 8 samples, trace to occasional, not found in SFTS.

Suggested affinity: Schizaeaceae.

Cicatricosisporites minor (Bolkhovitina) Pocock, 1954

Plate 1, Figure 9

1959 Mohria minor Bolkhovitina, p. 93, pl. 2, fig. 31.

1961 Pelletieria minor (Bolkhovitina) Bolkhovitina, p. 68, pl. 19, fig. 8; pl. 22, fig. 3a-c.

1964 Cicatricosisporites minor (Bolkhovitina) Pocock, p. 160, pl. 2, fig. 20-23.

Size range: Equatorial diameter (5 specimens): 22(25)29 µm.

Occurrence: Middle Albian to Late Cretaceous, see Singh (1971, p. 74); 22 samples, trace to dominant, found throughout all three sections.

Suggested affinity: Schizaeaceae.

Cicatricosisporites subrotundus Brenner, 1963

Plate 2, Figure 1

1963 Brenner, p. 51, pl. 10, fig. 1, 2.

Size range: Equatorial diameter (3 specimens): 42(46)51 µm.

Occurrence: Albian, see Singh (1971, p. 79); 4 samples, trace to rare, not found in SFTS.

Suggested affinity: Schizaeaceae.

Cicatricosisporites venustus Deak, 1963

Plate 1, Figures 10, 11

1963 Deak, p. 252, pl. 2, fig. 8-9, 12-13.

Synonymy: see Singh (1971, p. 80).

Occurrence: Barremian to Cenomanian-Turonian, see Singh (1971, p. 80); 17 samples, trace to occasional, not found in SFTS.

Suggested affinity: Schizaeaceae.

Cicatricosisporites sp.

Occurrence: 49 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Schizaeaceae.

Comments: Canaliculate and cicatricose specimens here included were not identified to species level because of mechanical distortions, poor preservation or lack of a complete specimen. These factors are particularly critical in the identification of *Cicatricosisporites*-like spores because the proximal and distal sculpture pattern must be clearly visible for speciation.

GENUS *Cingutriletes* Pierce, 1961, emend. Dettmann, 1963

Type species: *Cingutriletes congruens* Pierce, 1961

Cingutriletes clavus (Balme) Dettmann, 1963

Plate 2, Figure 2

1957 *Sphagnites clavus* Balme, p. 16, pl. 1, fig. 4-6.

1963 *Cingutriletes clavus* (Balme) Dettmann, p. 69, pl. 14, fig. 5-8.

Synonymy: see Dettmann (1963, p. 69) and Norris (1967, p. 97).

Occurrence: Worldwide distribution in Jurassic and Tertiary rocks; 2 samples, rare, found only in SFTS and SCS.

Suggested affinity: Sphagnaceae.

GENUS Concavisporites Pflug in Thomson and Pflug, 1953, emend. Delcourt and Sprumont, 1955

Type species: Concavisporites rugulatus Pflug in Thomson and Pflug, 1953

Concavisporites jurienensis Balme, 1957

Plate 2, Figure 3

1957 Balme, p. 20, pl. 2, fig. 30, 31.

Synonymy and description: see Burger (1966, p. 237).

Size range: Equatorial diameter (5 specimens): 25(28)33 µm.

Occurrence: Worldwide distribution in Late Jurassic and Early Cretaceous rocks; 6 samples, trace to rare, found only in SCS.

Suggested affinity: Pteridophyta.

Comments: Although the illustrated specimens in the literature assigned to this species show considerable morphologic variation, the specimens in this study compare favorably with the holotype of Balme (1957, pl. 2, fig. 30, 31).

GENUS Concavissimisporites Delcourt and Sprumont, 1955, emend. Delcourt, Dettmann and Hughes, 1963

Type species: Concavissimisporites verrucosus Delcourt and Sprumont, 1955, emend. Delcourt, Dettmann and Hughes, 1963

Comments: Dettmann (1963) noted the similarity of spores assigned to this genus with spores of certain living species of Cyathea Smith, Dicksonia L'Herit and Lygodium Swartz.

Concavissimisporites punctatus (Delcourt and Sprumont) Brenner, 1963

Plate 2, Figure 5

1955 Concavisporites punctatus Delcourt and Sprumont, p. 25, pl. 1, fig. 8; pl. 2, fig. 2.

1963 *Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner, p. 59, pl. 14, fig. 6.

Synonymy: see Srivastava (1975, p. 31).

Occurrence: Upper Bathonian to Turonian, see Srivastava (1975, p. 32); 17 samples, trace to occasional, found in all three sections.

Suggested affinity: Pteridophyta.

Concavissimisporites variverrucatus (Couper) Brenner, 1963

Plate 2, Figure 4

1958 *Concavisporites variverrucatus* Couper, p. 142, pl. 22, fig. 4, 5.

1963 *Concavissimisporites variverrucatus* (Couper) Brenner, p. 59, pl. 14, fig. 4.

Synonymy: see Srivastava (1975, p. 32).

Occurrence: Bajocian to Albian, see Srivastava (1975, p. 33); 2 samples, trace, found only in SCS.

Suggested affinity: Pteridophyta.

GENUS *Coronatispora* Dettmann, 1963

Type species: *Coronatispora perforata* Dettmann, 1963

Coronatispora valdensis (Couper)Dettmann, 1963

Plate 2, Figure 7

1958 *Cingulatisporites valdensis* Couper, p. 146, pl. 24, fig. 6, 7.

1963 *Coronatispora valdensis* (Couper) Dettmann, p. 67.

Synonymy: see Srivastava (1975, p. 33, 34).

Occurrence: Late Jurassic to Albian, see Srivastava (1975, p. 34); 2 samples, rare, found only in SCS and FCS.

Suggested affinity: Pteridophyta.

GENUS Costatoperforosporites Deak, 1962

Type species: Costatoperforosporites fistulosus Deak, 1962

Costatoperforosporites fistulosus Deak, 1962

Plate 2, Figure 8

1962 Deak, p. 233, pl. 27, fig. 1-3.

Description: see Singh (1971, p. 86).

Size range: Equatorial diameter (3 specimens): 33(38)47 µm.

Occurrence: Late Aptian to Albian, see Singh (1971, p. 86); 8 samples, trace to common, not found in SFTS.

Suggested affinity: Schizaeaceae.

Comments: The specimens from this study are slightly smaller than the type material of Deak which is 45 to 50 µm.

GENUS Cyathidites Couper, 1953

Type species: Cyathidites australis Couper, 1953

Comments: Balme (1957, p. 21) points out that Cyathidites is basically a morphologic form genus with similar types occurring in the Dicksoniaceae and Polypodiaceae as well as the Cyatheaceae.

Srivastava (1975) has suggested the synonymy of Deltoidospora Miner and Cyathidites Couper. He feels that distinction on the basis of amb shape of exine thickness is hypothetical and thus, meaningless. In this study the two genera were sucessfully differentiated as in other Lower Cretaceous studies in North America.

Cyathidites australis Couper, 1953

Plate 2, Figure 10

1953 Couper, p. 27, pl. 2, fig. 11, 12.

Synonymy: see Dettmann (1963, p. 22).

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 16 samples, trace to common, found in all three sections.

Suggested affinity: Cyatheaceae, Dicksoniaceae and/or Polypodiaceae.

Cyathidites minor Couper, 1953

Plate 2, Figure 9

1953 Couper, p. 28, pl. 2, fig. 13.

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 50 samples, rare to dominant, found throughout all three sections.

Suggested affinity: Cyatheaceae, Dicksoniaceae and/or Polypodiaceae.

GENUS *Deltoidospora* Miner, 1935, emend. Potonie, 1956

Type species: *Deltoidospora hallii* Miner, 1935

Deltoidospora psilostoma Rouse, 1959

Plate 2, Figure 6

1959 Rouse, p. 311, pl. 2, fig. 7, 8.

Occurrence: Late Jurassic to Late Cretaceous of North America; 1 sample, common, found only in Pb11602 at the base of FCS.

Suggested affinity: Cyatheaceae and/or Dicksoniaceae.

Deltoidospora sp. cf. *D. juncta* (Kara-Murza) Singh, 1964

Plate 2, Figure 11

cf. 1956 *Cibotum junctum* Kara-Murza *in* Bolkhovitina, p. 37, pl. 3, fig. 25a-e.

cf. 1964 Deltoidospora junctum (Kara-Murza) Singh, p. 81, pl. 9, fig. 16.

cf. 1967 Deltoidospora juncta (Kara-Murza) Singh: Norris, p. 86, pl. 10, fig. 4, 5.

Description: Trilete; commissures slightly raised and reaching or nearly reaching the equator; equatorial outline deltoid with straight or very slightly concave sides; apices rounded; proximal exine smooth to slightly scabrate; distal exine folded on itself perpendicular to the laesurae between 1/2 and 1/3 the distance to the apices.

Size range: Equatorial diameter (10 specimens): 17(19)22 µm.

Occurrence: 17 samples, trace to abundant, not found in SFTS.

Suggested affinity: Cyatheaceae and/or Dicksoniaceae.

Comments: Part of the Albian material described by Brenner (1963, p. 52, pl. 11, fig. 3a, b) as Gleicheniidites apilobatus appears to be conspecific with Deltoidospora sp. cf. D. juncta.

Reference specimen: slide Pb11621-1, 39.0 X 119.0.

GENUS Foraminisporis Krutzsch, 1959

Type species: Foraminisporis foraminis Krutzsch, 1959

Foraminisporis wonthaggiensis (Cookson and Dettmann) Dettmann, 1963

Plate 2, Figure 13

1958 Apiculatisporis wonthaggiensis Cookson and Dettmann, p. 100, pl. 14, fig. 7-10.

1963 Foraminisporis wonthaggiensis (Cookson and Dettmann) Dettmann, p. 71, pl. 14, fig. 19-23, text-fig. 40.

Occurrence: Valanginian to Turonian, see Singh (1971, p. 36); 2 samples, trace to rare, found only in FCS and the Aspen Shale of SCS.

Suggested affinity: Hepaticae.

Comments: Dettmann (1963) points out the similarity of this species to spores in the modern hepatic species *Nothylas breutelii* Gottsche.

GENUS *Gleicheniidites* Ross, 1949 ex Delcourt and Sprumont, 1955, emend. Dettmann, 1963

Type species: *Gleicheniidites senonicus* Ross, 1949

Gleicheniidites senonicus Ross, 1949

Plate 2, Figure 12

1949 Ross, p. 31, pl. 1, fig. 3, 4.

Occurrence: Worldwide distribution in Jurassic, Cretaceous and Tertiary rocks; 58 samples, rare to dominant, found throughout all three sections.

Suggested affinity: Gleicheniaceae.

Comments: There is a great amount of morphologic diversity and size variability with this species (Srivastava, 1975). The specimens of this study most resemble the illustrated material of various authors from Western and Arctic Canada.

Gleicheniidites sp. cf. *G. circinidites* (Cookson) Dettmann, 1963

Plate 3, Figure 1

cf. 1953 *Gleichenia circinidites* Cookson, p. 464, 465, pl. 1, fig. 5, 6.

1957 *Gleichenia* sp. cf. *G. circinidites* Cookson: Balme, p. 23, pl. 3, fig. 42-44.

1963 *Gleicheniidites* sp. cf. *G. circinidites* (Cookson) Dettmann, p. 65, pl. 13, fig. 6-10.

Occurrence: Late Jurassic and Early Cretaceous, see Singh (1971,

p. 97); 20 samples, trace to common, found in all three sections.

Suggested affinity: Gleicheniaceae.

Comments: This species is differentiated from *Gleicheniidites senonicus* Ross which has more rounded apices and thinner interradial crassitudes. Norris (1967) illustrates specimens similar to *G.* sp. cf. *G. circinidites* of this study but places them in *G. senonicus*. He suggests that *G.* sp. cf. *G. circinidites* may be a distinctive preservational type of *G. senonicus*.

Reference specimen: slide Pb11639-1, 38.0 X 119.3.

GENUS *Klukisporites* Couper, 1958

Type species: *Klukisporites variegatus* Couper, 1958

Klukisporites pseudoreticulatus Couper, 1958

Plate 3, Figure 2

1958 Couper, p. 138, pl. 19, fig. 8-10.

Occurrence: Late Jurassic to early Cenomanian, see Singh (1971, p. 96); 5 samples, trace to common, not found in SFTS.

Suggested affinity: Schizaeaceae (Couper, 1958; Dettmann, 1963).

"*Koilisporis excavatus*" (Brenner) Pannella, 1966
(unpublished manuscript name)

Plate 3, Figures 4, 5

1963 *Matonisporites excavatus* Brenner, p. 54, pl. 12, fig. 2, 3.

1966 "*Koilisporis excavatus*" (Brenner) Pannella (unpublished manuscript name), p. 48, pl. 4, fig. 3.

Description: see Brenner (1963, p. 54) and Pannella (1966, p. 48).

Size range: Equatorial diameter (4 specimens): 39(45)52 µm.

Occurrence: Albian to Cenomanian. Patapsco Formation in Maryland (Brenner, 1963), Dakota Group and Graneros Shale of the Denver Basin (Pannella, 1966); 1 sample, rare, found only in Pb11602 at the base of FCS.

Suggested affinity: Matoniaceae ?

Comments: Pannella (1966, p. 46-48, unpublished thesis) designated a new manuscript genus, "Koilisporis," to accommodate Matonisporites-type spores with a "distal thinning and the absence of true valvae." One of his three manuscript species, "Koilisporis excavatus" (Brenner) Pannella, appears to be conspecific with specimens encountered in this study. Pannella created the new genus because the distinctive distal thinning with a thick ring is present on all three of his proposed new manuscript species and Dettmann (1963) had emended Matonisporites to include only valvate spores.

This is a case in which the erection of a new genus is clearly justified but must be published so as to be valid and useful. The name "Koilisporis excavatus" is used in this study as a convenience pending the publication of a valid name.

GENUS Kuylisporites Potonie, 1956

Type species: Kuylisporites waterbolki Potonie, 1956

Kuylisporites lunaris Cookson and Dettmann, 1958

Plate 3, Figure 3

1958 Cookson and Dettmann, p. 103, pl. 14, fig. 21-23.

Description: see Dettmann (1963, p. 39).

Size range: Equatorial diameter (1 specimen): 31 µm.

Occurrence: Early Cretaceous, see Singh (1971, p. 102); 1 sample, rare, found only in Pb11238 (Aspen Shale) at the top of SCS.

Suggested affinity: Cyatheaceae and/or Dicksoniaceae.

Comments: The only specimen encountered was slightly smaller than the type material. Dettmann (1963) points out the slight resemblance of this species to *Alsophila blechnoides* of the Cyatheaceae.

GENUS *Lycopodiumsporites* Thiergart, 1938 ex Delcourt and Sprumont, 1955

Type species: *Lycopodiumsporites agathoecus* (Potonie) Thiergart, 1938

Lycopodiumsporites austroclavatidites (Cookson) Potonie, 1956

Plate 3, Figure 6

1953 *Lycopodium austroclavatidites* Cookson, p. 469, pl. 2, fig. 35.

1956 *Lycopodiumsporites austroclavatidites* (Cookson) Potonie, p. 46.

Synonymy: see Dettmann (1963, p. 44).

Size range: Equatorial diameter (5 specimens): 36(42)45 µm.

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 4 samples, trace to rare, found only in the lower half of FCS and SCS.

Suggested affinity: Lycopodiaceae.

GENUS *Neoraistrickia Potonie*, 1956

Type species: *Neoraistrickia truncata* (Cookson) Potonie, 1956

Neoraistrickia truncata (Cookson) Potonie, 1956

Plate 3, Figure 7

1953 Triletes truncata Cookson, p. 471, pl. 2, fig. 36.

1956 Neoraistrickia truncata (Cookson) Potonie, p. 34, pl. 3, fig. 32.

Synonymy and description: see Dettmann (1963, p. 36).

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 1 sample, rare, found only in Pb11613 near the top of FCS.

Suggested affinity: Selaginellaceae.

Comments: Only a single specimen of this species was encountered. Dettmann (1963, p. 36) points out the similarity of this species to the spores of Knox's (1950) Selaginella biformis group.

GENUS Ornamentifera Bolkhovitina, 1966

Type species: Ornamentifera echinata (Bolkhovitina) Bolkhovitina, 1966

Ornamentifera echinata (Bolkhovitina) Bolkhovitina, 1966

Plate 3, Figure 8

1953 Gleichenia echinata Bolkhovitina, p. 55, pl. 8, fig. 17.

1966 Ornamentifera echinata (Bolkhovitina) Bolkhovitina, p. 69.

Synonymy and description: see Singh (1971, p. 98).

Occurrence: Hauterivian to Senonian, see Singh (1971, p. 98); 8 samples, trace to occasional, found near the base of FCS and SCS.

Suggested affinity: Gleicheniaceae (Singh, 1971).

GENUS Osmundacidites Couper, 1953

Type species: Osmundacidites wellmanii Couper, 1953

Osmundacidites wellmanii Couper, 1953

Plate 3, Figure 10

1953 Couper, p. 20, pl. 1, fig. 5.

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 1 sample, trace, found only in sample Pb11642 near the top of FCS.

Suggested affinity: Osmundaceae.

GENUS Pilosisporites Delcourt and Sprumont, 1955

Type species: Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

Plate 3, Figure 11

1949 Sporites trichopapillosus Thiergart, p. 22, pl. 4, fig. 18.

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

Occurrence: Purbeckian to Albian, see Singh (1971, p. 129); 3 samples, trace to rare, not found in SFTS.

Suggested affinity: Pteridophyta.

GENUS Psilatriletes van der Hammen, 1954 ex Potonie, 1956

Type species: Psilatriletes detortus (Weyland and Krieger) Potonie, 1956

Psilatriletes radiatus Brenner, 1963

Plate 3, Figure 9

1963 Brenner, p. 63, pl. 20, fig. 6, 7.

Occurrence: Barremian to early Cenomanian, see Singh (1971, p. 133); 2 samples, occasional to common, found in the lower half of SCS.

Suggested affinity: Pteridophyta.

GENUS Stereisporites Pflug in Thomson and Pflug, 1953

Type species: Stereisporites stereoides (Potonie and Venitz) Pflug, 1953

Stereisporites antiquasporites (Wilson and Webster) Dettmann, 1963

Plate 3, Figure 12

1946 Sphagnum antiquasporites Wilson and Webster, p. 273, fig. 2.

1963 Stereisporites antiquasporites (Wilson and Webster) Dettmann, p. 25, pl. 1, fig. 20, 21.

Synonymy: see Dettmann (1963, p. 25).

Occurrence: Worldwide distribution in Jurassic and Tertiary rocks; 33 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Sphagnaceae.

GENUS Todisporites Couper, 1958

Type species: Todisporites major Couper, 1958

Todisporites minor Couper, 1958

Plate 3, Figure 13

1958 Couper, p. 135, pl. 16, fig. 9, 10.

Occurrence: Bajocian to Cenomanian, see Singh (1971, p. 50); 6 samples, trace to rare, found in the Aspen Shale of FCS and throughout SCS.

Suggested affinity: Osmundaceae.

Comments: Couper (1958, p. 135) points out the likelihood of spores in this genus belonging to the fern represented by megafossils identified as *Todites williamsonii* and *Todites princeps*.

GENUS *Trilobosporites* Pant, 1954 ex Potonie, 1956

Type species: *Trilobosporites hannonicus* (Delcourt and Sprumont) Potonie, 1956

Trilobosporites minor Pocock, 1962

Plate 4, Figure 1

1962 Pocock, p. 44, pl. 4, fig. 61, 62.

Occurrence: Aptian to Cenomanian. Quartz Sand Member and Calcareous Member (Lower Mannville Group) of the Western Canada Plains (Pocock, 1962); Mannville Group except the basal Deville Member of east-central Alberta (Singh, 1964); Lower Cretaceous of the Saskatoon area (Steeves and Wilkins, 1967); "Walnut" clay facies of southern Oklahoma (Hedlund and Norris, 1968); Tuscaloosa Formation of the southern U.S.A. (Phillips and Felix, 1971a). This study: 3 samples, rare, not found in SFTS.

Suggested affinity: Pteridophyta.

GENUS *Triporoletes* Mtchedlishvili *in* Mtchedlishvili and Samoilovitch, 1960, emend. Playford, 1971

Type species: *Triporoletes singularis* Mtchedlishvili *in* Mtchedlishvili and Samoilovitch, 1960

Triporoletes reticulatus (Pocock) Playford, 1971

Plate 4, Figure 2

1962 Rouseisporites reticulatus Pocock, p. 53, pl. 7, fig. 101-105.

1971 Triporoletes reticulatus (Pocock) Playford, p. 552, pl. 106, fig. 5.

Synonymy: see Srivastava (1975, p. 72).

Description: see Dettmann (1963, p. 97).

Occurrence: Early Cretaceous, see Srivastava (1975, p. 72);

4 samples, trace, found only in SCS.

Suggested affinity: Hepaticae.

Comments: Dettmann (1963) pointed out the resemblance of this species to spores of the modern hepatic species Riccia beyrichiana Hampe.

GENUS Undulatisporites Pflug in Thomson and Pflug, 1953

Type species: Undulatisporites microcutis Pflug in Thomson and Pflug, 1953

Undulatisporites undulapolus Brenner, 1963

Plate 4, Figure 3

1963 Brenner, p. 72, pl. 24, fig. 1.

Occurrence: Barremian to Albian, see Singh (1971, p. 148); 10 samples, trace to rare, found in all three sections.

Suggested affinity: Pteridophyta.

Comments: Specimens in this study were somewhat variable in the width of the thickened lips bordering the laesurae and the shape of the amb.

GENUS Verrucosisporites Ibrahim, 1933, emend. Potonie and Kremp, 1954

Type species: Verrucosisporites verrucosus Ibrahim, 1933, emend. Potonie and Kremp, 1954

Verrucosisporites rotundus Singh, 1964

Plate 4, Figure 4

1964 Singh, p. 96, pl. 13, fig. 3.

Occurrence: Aptian and Albian, see Singh (1971, p. 149); 4 samples, trace to rare, not found in SFTS.

Suggested affinity: Pteridophyta.

Verrucosisporites sp.

Plate 4, Figure 5

Description: Trilete ? Laesurae, if present, are indistinct. Equatorial outline ovoid. Exine about 1 to 2 µm thick and densely covered with verrucae with diameters from 1 to 5 µm. Central area of one face very thin or missing but with no apparent marginal features.

Size range: Equatorial diameter - long dimension (8 specimens): 36(43)55 µm.

Equatorial diameter - short dimension: 29(37)40 µm.

Occurrence: 12 samples, trace to rare, found in all three sections.

Suggested affinity: Unknown.

Comments: The lack of an observable trilete mark makes the assignment to this genus provisional. Verrucosisporites obscurilaesuratus Pocock is similar to specimens of Verrucosisporites sp. but has very indistinct laesurae and continuous verrucose sculpture on both faces.

Reference specimen: slide Pb11642-6, 37.5 X 116.1.

MONOLETE SPORES

GENUS Laevigatosporites Ibrahim, 1933, emend. Schopf, Wilson and Bentall, 1944

Type species: Laevigatosporites vulgaris (Ibrahim) Ibrahim, 1933

Comments: Singh (1964) remarks that the bean-shaped form of this genus indicates a close affinity with the Polypodiaceae and Dennstaedtiaceae.

Laevigatosporites ovatus Wilson and Webster, 1946

Plate 4, Figure 6

1946 Wilson and Webster, p. 273, fig. 5.

Synonymy: see Dettmann (1963, p. 86).

Description: see Singh (1964, p. 99).

Size range: Length (5 specimens): 32(34)40 µm.

Breadth: 18(25)35 µm.

Occurrence: Worldwide distribution in Jurassic, Cretaceous and Tertiary rocks; 18 samples, trace to occasional, found throughout all three sections.

Suggested affinity: Polypodiaceae and/or Dennstaedtiaceae.

SPORES
(Incertae Sedis)

GENUS Schizosporis Cookson and Dettmann, 1959

Type species: Schizosporis reticulatus Cookson and Dettmann, 1959

Schizosporis parvus Cookson and Dettmann, 1959

Plate 4, Figure 7

1959 Cookson and Dettmann, p. 216, pl. 1, fig. 15-20.

Occurrence: Barremian to Cenomanian, see Singh (1971, p. 151); 2 samples, trace to rare, found only in SCS.

Suggested affinity: Unknown.

Schizosporis reticulatus Cookson and Dettmann, 1959

Plate 4, Figure 9

1959 Cookson and Dettmann, p. 216, pl. 1, fig. 5-9.

Occurrence: Berriasian to Cenomanian, see Singh (1971, p. 151); 1 sample, trace, found only in Pb11212 near the base of SCS.

Suggested affinity: Unknown.

GYMNOSPERM POLLEN

Abies-type pollen

Plate 4, Figure 8

Size range: Total length: 60 to 100 µm.

Occurrence: 34 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Pinaceae.

Comments: Included here are bisaccate pollen grains like those in Abies with comparable size and shape. Some of the larger specimens are probably conspecific with Abiespollenites sp. of Singh (1971).

Reference specimen: slide Pb11602-5, 38.7 X 113.0.

GENUS *Araucariacites* Cookson, 1947 ex Couper, 1953

Type species: *Araucariacites australis* Cookson, 1947

Araucariacites australis Cookson, 1947

Plate 4, Figure 10

1947 Cookson, p. 130, pl. 13, fig. 1-4.

Occurrence: Worldwide distribution in Jurassic, Cretaceous and Tertiary rocks; 30 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Araucariaceae.

Comments: Couper (1958) points out the similarity of this species to the pollen of the Jurassic araucarian *Brachyphyllum mamillare* Brongniart.

Araucariacites limbatus (Balme) Habib, 1969

Plate 4, Figure 11

1957 *Inaperturopollenites limbatus* Balme, p. 31, pl. 7, fig. 83-84.

1969 *Araucariacites limbatus* (Balme) Habib, p. 91, pl. 4, fig. 6.

Occurrence: Cretaceous; 22 samples, trace to occasional, not found in SFTS.

Suggested affinity: Araucariaceae.

GENUS *Callialasporites* Dev, 1961

Type species: *Callialasporites trilobatus* (Balme) Dev, 1961

Callialasporites dampieri (Balme) Dev, 1961

Plate 4, Figure 12

1957 Zonalapollenites dampieri Balme, p. 32, pl. 8, fig. 88-90.

1961 Callialasporites dampieri (Balme) Dev, p. 48, pl. 4, fig. 26, 27.

1961 Applanopsis dampieri (Balme) Doring, p. 113, pl. 16, fig. 11-15.

1962 Pflugipollenites dampieri (Balme) Pocock, p. 72, pl. 12, fig. 183, 184.

1963 Tsugaepollenites dampieri (Balme) Dettmann, p. 100, pl. 24, fig. 1-5.

Occurrence: Worldwide distribution in Jurassic to Eocene rocks; 2 samples, trace, found only in SCS.

Suggested affinity: Gamerro (1965) found pollen similar to Callialasporites dampieri and C. trilobatus in the male podocarpaceous cone Apterocladus lanceolatus Archangelsky, thus suggesting its affinity to the Podocarpaceae.

GENUS Cedripites Wodehouse, 1933

Type species: Cedripites eocenicus Wodehouse, 1933

Cedripites cretaceus Pocock, 1962

Plate 5, Figure 1

1962 Pocock, p. 63, pl. 9, 10, fig. 145-148.

Occurrence: Barremian to Albian, see Singh (1971, p. 171); 11 samples, trace to common, found in all three sections.

Suggested affinity: Pinaceae.

GENUS Classopollis Pflug, 1953, emend. Pocock and Jansonius, 1961

Type species: Classopollis classoides Pflug, 1953

Classopollis classoides Pflug, 1953, emend. Pocock and Jansonius, 1961

Plate 5, Figures 2, 3

1953 Classopollis classoides Pflug, p. 91, pl. 16, fig. 29-31.

1961 Classopollis classoides Pflug, emend. Pocock and Jansonius, p. 443, 444, pl. 1, fig. 1-9.

Occurrence: Worldwide distribution in uppermost Triassic to Eocene rocks; 57 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Pollen of the Classopollis type was probably produced by plants of the extinct conifer family Cheirolepidiaceae, consisting of Brachyphyllum, Cheirolepis, Masculostrobus and Pagiophyllum.

GENUS Cycadopites Wodehouse, 1933

Type species: Cycadopites follicularis Wilson and Webster, 1946

Cycadopites sp.

Plate 5, Figure 4

Description: Monosulcate pollen. Sulcus extending the entire length of the grain and slightly overlapping the entire length on most specimens leaving a uniformly wide sulcus. Exine smooth to very slightly scabrate and about 1 μm thick. Ends of grain pointed; length to width ratio of grains from 2 to 3.

Size range: Total length (8 specimens): 29(36)40 μm.

Total width: 11(14)18 μm.

Occurrence: 41 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Cycadophyta or Ginkgophyta.

Comments: The non-broadening sulcus of this species distinguishes it from most species in the related genera: *Cycadopites*, *Ginkgocycadophytus* and *Monosulcites*. There is some resemblance to *Monosulcites epakros* Brenner but the overall shape is different. *Monosulcites* sp. of Brenner (1963) is also similar but much larger.

Reference specimen: slide Pb11609-5, 36.8 X 117.2.

GENUS *Eucommiidites* Erdtman, 1948, emend. Hughes, 1961

Type species: *Eucommiidites troedssonii* Erdtman, 1948

Eucommiidties minor Groot and Penny, 1960

Plate 5, Figure 5

1960 Groot and Penny, p. 234, pl. 2, fig. 14.

Occurrence: Late Jurassic to Albian, see Singh (1971, p. 177); 20 samples, trace to common, found in all three sections.

Suggested affinity: Unknown gymnosperm.

Comments: Eucommiiditian pollen (*Eucommiidites delcourtii*) was found in the micropylar canal of the Lower Cretaceous gymnospermous seed *Spermatites pettensis* Hughes by Hughes (1961). Brenner (1963, 1967) has reported pollen similar to *E. minor* in the micropylar canal and pollen chamber of over 50% of the Lower Cretaceous gymnospermous seeds, *Spermatites patuxensis* Brenner which he examined from the Patuxent Formation in Virginia.

Eucommiidites troedssonii Erdtman, 1948

Plate 5, Figure 6

1948 Tricolpites (Eucommiidites) troedssonii, p. 267, test-fig. 5-10, 13-15.

Occurrence: Worldwide distribution in Jurassic and Cretaceous rocks; 8 samples, trace to occasional, not found in SFTS.

Suggested affinity: Unknown gymnosperm.

GENUS Equisetosporites Daugherty, 1941

Type species: Equisetosporites chinleana Daugherty, 1941

Equisetosporites multicostatus (Brenner) Norris, 1967

Plate 5, Figures 7, 8

1963 Ephedripites multicostatus Brenner, p. 90, pl. 38, fig. 1-2.

1967 Equisetosporites multicostatus (Brenner) Norris, p. 105, pl. 16, fig. 15.

Occurrence: Late Barremian to Cenomanian, see Norris (1967, p. 103); 1 sample, trace, found only in Pb11642 near the top of FCS.

Suggested affinity: Ephedraceae.

Comments: Although only two specimens from a single sample were encountered, the existence of this family of plants is important in the overall paleofloral picture.

GENUS Exesipollenites Balme, 1957

Type species: Exesipollenites tumulus Balme, 1957

Exesipollenites tumulus Balme, 1957

Plate 5, Figure 9

1957 Balme, p. 39, pl. 11, fig. 123-125.

Occurrence: Jurassic and Cretaceous, see Singh (1971, p. 178); 7 samples, trace to occasional, not found in FCS.

Suggested affinity: Coniferales: possibly Taxaceae, Taxodiaceae or Cupressaceae; Bennettitales (Harris, 1974).

GENUS *Ginkgocycadophytus* Samoilovitch, 1953

Type species: *Ginkgocycadophytus caperatus* (Luber) Samoilovitch, 1953

Ginkgocycadophytus nitidus (Balme) de Jersey, 1962

Plate 5, Figure 10

1957 *Entylissa nitidus* Balme, p. 30, pl. 6, fig. 78-80.

1962 *Ginkgocycadophytus nitidus* (Balme) de Jersey, p. 12, pl. 5, fig. 1-3.

Occurrence: Worldwide distribution in Triassic and Cretaceous rocks; 8 samples, trace to rare, found in all three sections.

Suggested affinity: Cycadophyta or Ginkgophyta.

Comments: This species exhibits some morphological variation but most specimens resemble the holotype (Balme, 1957, pl. 6, fig. 78). Several specimens with slightly expanded ends similar to Brenner's specimens (1963, pl. 25, fig. 3) were encountered.

GENUS *Inaperturopollenites* Pflug, 1952 ex Thomson and Pflug, 1953, emend. Potonie, 1953

Type species: *Inaperturopollenites dubius* (Potonie and Venitz) Thomson and Pflug, 1953

Comments: Potonie (1966, p. 141) emended the generic description to include more or less laevigate or very weakly and more or less loosely granulate forms that may show numerous secondary folds.

This type of pollen grain is abundant in some samples of this study and warranted the counting of additional specimens in these samples to compensate for its "flooding" effect. Initially, an attempt was made to divide the group on the basis of: (1) exine granularity or smoothness, (2) degree of folding and splitting, (3) size and (4) wall thickness. This proved to be totally arbitrary and unsatisfactory except for groupings based on size.

Inaperturopollenites sp. 1

Plate 5, Figure 12

Description: Specimens referred to this species form a gradational series from nearly laevigate to distinctly granular forms. Some have split into two nearly equal halves with long folds as well as secondary folds being common. The exine thickness is less than 1 µm.

Size range: Diameter ranges from 19 µm to about 60 µm with an average of about 20-25 µm.

Occurrence: Similar forms have worldwide distribution in Jurassic, Cretaceous and Tertiary rocks; 62 samples, common to flooding, found in all samples.

Suggested affinity: Taxodiaceae, Cupressaceae and/or Taxaceae; possibly some affinity with Araucariaceae also.

Comments: This species is probably conspecific in part with Inaperturopollenites dubius and Taxodiaceaepollenites hiatus and may include a whole complex of plants belonging to the Taxodiaceae and Cupressaceae (Groot and Penny, 1968). The characteristic splitting of many specimens and overall morphology are very similar to modern *Taxodium*.

Reference specimen: slide Pb11642-6, 37.7 X 127.0.

Inaperturopollenites sp. 2

Plate 5, Figures 13, 14

Description: Specimens referred to this species are identical to *Inaperturopollenites* sp. 1 except that the size range is smaller.

Size range: Diameter ranges from about 10 to 18 µm.

Occurrence: Similar forms have worldwide distribution in Jurassic, Cretaceous and Tertiary rocks; 59 samples, rare to flooding, found in nearly all samples.

Suggested affinity: Taxodiaceae, Cupressaceae and/or Taxaceae.

Reference specimen: slide Pb11642-6, 43.9 X 118.5.

Inaperturopollenites sp. 3

Plate 5, Figure 11

1967 *Inaperturopollenites* sp. Norris, p. 104, pl. 16, fig. 8.

1971 *Inaperturopollenites* sp. of Norris: Singh, p. 150, pl. 21, fig. 1.

Description: see Norris (1967, p. 104).

Occurrence: Triassic and Lower Cretaceous of various parts of the world, see Norris (1967, p. 104); 12 samples, rare to common, not found in SFTS.

Suggested affinity: Unknown gymnosperm ?

Reference specimen: slide Pb11202-1, 44.3 X 122.0.

GENUS Laricoidites Potonie, Thomson and Thiergart, 1950 ex Potonie, 1958

Type species: Laricoidites magnus (Potonie) Potonie, Thomson and Thiergart, 1950

Comments: Laricoidites has been artificially separated from Inaperturopollenites on the basis of its larger size (Brenner, 1963).

Laricoidites gigantus Brenner, 1963

Plate 5, Figure 16

1963 Brenner, p. 88, pl. 36, fig. 1, 2.

Occurrence: 5 samples, trace to rare, not found in FCS.

Suggested affinity: Pinaceae ?

Comments: Pollen here assigned are similar to pollen of modern Larix.

Laricoidites magnus (Potonie) Potonie, Thomson and Thiergart, 1950

Plate 5, Figure 15

1931 Sporites (?) magnus Potonie, p. 566, fig. 6.

1950 Laricoidites magnus (Potonie) Potonie, Thomson and Thiergart, p. 48, pl. C, fig. 9, 10.

Synonymy: see Stanley (1965, p. 278).

Occurrence: Similar forms have worldwide distribution in Cretaceous and Tertiary rocks; 9 samples, trace to occasional, not found in SCS.

Suggested affinity: Pinaceae ?

Comments: Pollen here assigned are similar to pollen of modern Larix. This species is similar to Laricoidites gigantus but has a smaller size of about 60 to 90 μm.

GENUS *Monosulcites* Cookson ex Couper, 1953

Type species: *Monosulcites minima* Cookson, 1947

Monosulcites sp.

Plate 5, Figures 17, 18

Description: Monosulcate pollen. Sulcus 3/4 of total length and bordered by lips less than 1 µm wide; outline oval with broadly rounded ends. Exine less than 1 µm thick and very finely scabrate. Sulcus slightly opened and straight sided.

Size range: Total length (6 specimens): 11(12)14 µm.
Total width: 7(8)10 µm.

Occurrence: 26 samples, rare to common, found in all three sections.

Suggested affinity: Cycadophyta or Ginkgophyta.

Comments: Specimens assigned to this species are smaller than any previously described in the related genera: *Cycadopites*, *Ginkgocycadophytus* and *Monosulcites*.

Reference specimen: slide Pb11642-6, 38.7 X 117.3.

GENUS *Perinopollenites* Couper, 1958

Type species: *Perinopollenites elatoides* Couper, 1958

Perinopollenites sp. cf. *P*. *elatoides* Couper, 1958

Plate 5, Figure 19

cf. 1958 *Perinopollenites elatoides* Couper, p. 152, pl. 27, fig. 9-11.

Description: see Pocock (1962, p. 60); this species differs from *Perinopollenites elatoides* Couper only by its significantly smaller size. The size range of *P*. *elatoides* as reported from previous studies is from 38 to 54 µm.

Size range: Equatorial diameter of perispore (8 specimens): 20(27)37 µm.

Equatorial diameter of central body: 14(21)32 µm.

Occurrence: 33 samples, rare to abundant, found in all three sections.

Suggested affinity: Taxodiaceae.

Comments: This species is undoubtedly closely related or conspecific with *Perinopollenites elatoides*. Couper (1958) concluded that the pollen of this type belongs to *Elatides williamsonii* of the Taxodiaceae.

Reference specimen: slide Pb11216-5, 38.1 X 117.2.

GENUS *Phyllocladidites* Cookson, 1947 ex Couper, 1953

Type species: *Phyllocladidites mawsonii* Cookson, 1947

Phyllocladidites sp.

Plate 5, Figure 20

1964 *Phyllocladidites* sp. Singh, p. 114, pl. 15, fig. 10.

1971 *Phyllocladidites* sp. of Singh: Singh, p. 161, pl. 22, fig. 12.

Description: see Singh (1964, p. 114).

Occurrence: Middle and late Albian of central and northwestern Alberta; 3 samples, trace to rare, found only near the base of FCS.

Suggested affinity: Podocarpaceae.

Comments: Singh (1964) points out the similarity of pollen in *Phyllocladidites* to *Dacrydium*.

Reference specimen: slide Pb11602-1, 44.8 X 118.4.

Pinus - Picea-type pollen

Plate 6, Figure 1

Size range: Total length: about 50 to 110 µm.

Occurrence: 57 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Pinaceae.

Comments: Included here are bisaccate pollen grains similar in size and shape with those in Pinus and Picea. This group also includes several species of pollen assignable to Alisporites which, according to Rouse (1959) has probable affinity with Pinaceae.

Reference specimen: slide Pb11238-1, 46.8 X 118.6.

Large Podocarpus-type pollen

Plate 6, Figure 2

Size range: Total length: 80 to 120 µm.

Occurrence: 21 samples, trace to common, found in all three sections.

Suggested affinity: Podocarpaceae.

Comments: Included here are bisaccate pollen grains similar in shape to those in Podocarpus with the size limitations indicated above.

Reference specimen: slide Pb11609-1, 42.6 X 118.0.

Small Podocarpus-type pollen

Plate 6, Figure 3

Size range: Total length: 45 to 80 µm.

Occurrence: 18 samples, trace to common, found in all three sections.

Suggested affinity: Podocarpaceae.

Comments: Included here are bisaccate pollen grains similar in shape to those in *Podocarpus* with the size limitations indicated above.

Reference specimen: slide Pb11232-5, 32.5 X 121.9.

GENUS *Rugubivesiculites* Pierce, 1961

Type species: *Rugubivesiculites convolutus* Pierce, 1961

Rugubivesiculites rugosus Pierce, 1961

Plate 6, Figure 4, 5

1961 Pierce, p. 40, pl. 2, fig. 59, 60.

Occurrence: Late Albian and Cenomanian, see Singh (1971, p. 167); 6 samples, rare, not found in SFTS.

Suggested affinity: Podocarpaceae.

Comments: Pierce (1961) points out the similarity of some *Dacrydium* pollen to those in *Rugubivesiculites*.

GENUS *Vitreisporites* Leschik, 1955, emend. Jansonius, 1962

Type species: *Vitreisporites signatus* Leschik, 1955

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Plate 6, Figure 6

1938 *Pityosporites pallidus* Reissinger, p. 14 (not figured).

1950 *Pityosporites pallidus* Reissinger, p. 109, pl. 15, fig. 1-5.

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

Synonymy: see Norris (1967, p. 100).

Occurrence: Worldwide distribution in Triassic to Cretaceous rocks; 21 samples, trace to common, found in all three sections.

Suggested affinity: Caytoniaceae.

ANGIOSPERM POLLEN
(Monosulcate)

GENUS *Clavatipollenites* Couper, 1958

Type species: *Clavatipollenites hughesii* Couper, 1958

Clavatipollenites minutus Brenner, 1963

Plate 6, Figure 7

1963 Brenner, p. 95, pl. 41, fig. 8, 9.

Occurrence: Barremian to Albian, see Singh (1971, p. 182); 19 samples, trace to common, found in all three sections.

Suggested affinity: Gymnospermous or angiospermous, see Kemp (1968).

GENUS *Liliacidites* Couper, 1953

Type species: *Liliacidites kaitangataensis* Couper, 1953

Liliacidites dividuus (Pierce) Brenner, 1963

Plate 6, Figure 8

1961 *Retimonocolpites dividuus* Pierce, p. 47, pl. 3, fig. 87.

1963 *Liliacidites dividuus* (Pierce) Brenner, p. 93, pl. 40, fig. 7-10.

Occurrence: Albian and Cenomanian, see Singh (1971, p. 185); 14 samples, trace to common, not found in SFTS.

Suggested affinity: Monocotyledoneae.

Liliacidites peroreticulatus (Brenner) Singh, 1971

Plate 6, Figures 9, 10

1963 Peromonolites peroreticulatus Brenner, p. 94, pl. 41, fig. 1, 2.

1971 Liliacidites peroreticulatus (Brenner) Singh, p. 188, pl. 28, fig. 6-11.

Occurrence: Barremian to early Cenomanian, see Singh (1971, p. 188); 8 samples, rare to common, not found in SFTS.

Suggested affinity: Monocotyledoneae.

Liliacidites textus Norris, 1967

Plate 6, Figures 11, 12

1967 Norris, p. 106, pl. 16, fig. 21-25; pl. 17, fig. 1, 2.

Occurrence: Late Albian of central and northwestern Alberta; 11 samples, trace to occasional, not found in SFTS.

Suggested affinity: Monocotyledoneae.

ANGIOSPERM POLLEN
(Tricolpate)

GENUS Cupuliferoidaepollenites Potonie, Thomson and Thiergart, 1950

Type species: Cupuliferoidaepollenites liblarensis Thomson in Potonie, Thomson and Thiergart, 1950

Cupuliferoidaepollenites minutus (Brenner) Singh, 1971

Plate 6, Figures 13, 14

1963 Tricolpopollenites minutus Brenner, p. 93, pl. 40, fig. 5, 6.

1967 Cornaceoipollenites minutus (Brenner) Norris, p. 107, pl. 17, fig. 7-11.

1971 Cupuliferoidaepollenites minutus (Brenner) Singh, p. 194, pl. 29, fig. 8, 9.

Occurrence: Albian and early Cenomanian, see Singh (1971, p. 194); 15 samples, trace to common, found in all three sections.

Suggested affinity: Dicotyledoneae.

GENUS Psilatricolpites van der Hammen, 1956

Type species: Psilatricolpites incomptus van der Hammen, 1956

Psilatricolpites parvulus (Groot and Penny) Norris, 1967

Plate 6, Figures 15-17

1960 Tricolpopollenites parvulus Groot and Penny, p. 232, pl. 2, fig. 8, 9.

1967 Psilatricolpites parvulus (Groot and Penny) Norris, p. 107, pl. 17, fig. 5, 6.

Occurrence: Late Albian to Danian, see Singh (1971, p. 198); 37 samples, trace to abundant, found in all three sections.

Suggested affinity: Dicotyledoneae.

Psilatricolpites sp.

Plate 6, Figure 18

Description: Tricolpate pollen; ratio of polar to equatorial diameter about 1.5. Colpi closed, slit-like and extending nearly to the poles. Exine smooth or very slightly roughened.

Size range: Polar diameter (8 specimens in equatorial view): 20(23)26 µm.

Equatorial diameter: 10(15)17 µm.

Occurrence: 9 samples, rare to common, found only in SCS.

Suggested affinity: Dicotyledoneae.

Comments: The specimens assigned to this species somewhat resemble Psilatricolpites psilatus Pierce but differ by having closed colpi and slightly more elongate shape.

Reference specimen: slide Pb11212-2, 42.0 X 119.5.

GENUS Retitricolpites van der Hammen, 1956 ex Pierce, 1961

Type species: Retitricolpites ornatus van der Hammen, 1956

Retitricolpites georgensis Brenner, 1963

Plate 6, Figures 20, 21

1963 Brenner, p. 91, pl. 38, fig. 6, 7.

Occurrence: Albian to early Cenomanian, see Singh (1971, p. 200); 11 samples, trace to occasional, found only in SCS.

Suggested affinity: Dicotyledoneae.

Comments: This species is characterized by the reduction in size of the lumina toward the poles.

Retitricolpites prosimilis Norris, 1967

Plate 6, Figure 22, 23

1967 Norris, p. 108, pl. 18, fig. 5-14.

Occurrence: Middle and late Albian, see Singh (1971, p. 202); 13 samples, trace to abundant, found in all three sections.

Suggested affinity: Dicotyledoneae.

Retitricolpites vulgaris Pierce, 1961

Plate 6, Figures 25, 26

1961 Pierce, p. 50, pl. 3, fig. 101, 102.

Occurrence: Middle Albian to Maestrichtian, see Srivastava (1975, p. 103); 47 samples, trace to abundant, found throughout all three sections.

Suggested affinity: Dicotyledoneae.

Comments: Srivastava has placed specimens of this species from the Maestrichtian of Alberta in the genus *Tricolpites* (1969, p. 57). He has concluded from examination by both the optical and scanning electron microscope that the exine is infratectate and not intectate as Pierce (1961), Norris (1967) and Singh (1971) had described. The designation *R. vulgaris* Pierce is used here to conform to nomenclatural practice in other Lower Cretaceous studies.

GENUS *Striatopollis* Krutzsch, 1959

Type species: *Striatopollis sarstedtensis* Krutzsch, 1959

Striatopollis paraneus (Norris) Singh, 1971

Plate 6, Figure 24

1967 *Retitricolpites paraneus* Norris, p. 109, pl. 18, fig. 15-20.

1971 *Striatopollis paraneus* (Norris) Singh, 1971, p. 206, pl. 32, fig. 1-3.

Occurrence: Middle and late Albian, see Singh (1971, p. 206); 3 samples, rare, found only at the base of SCS and the top of FCS.

Suggested affinity: Dicotyledoneae.

GENUS *Tricolpites* Cookson, 1947 ex Couper, 1953, emend. Potonie, 1960

Type species: *Tricolpites reticulatus* Cookson, 1947

Tricolpites crassimurus (Groot and Penny) Singh, 1971

Plate 6, Figure 27

1960 *Tricolpopollenites crassimurus* Groot and Penny, p. 232, pl. 2, fig. 4, 5.

1971 *Tricolpites crassimurus* (Groot and Penny) Singh, p. 207, pl. 32, fig. 4-6.

Occurrence: Albian to Coniacian, see Singh (1971, p. 207); 19 samples, trace to occasional, found throughout all three sections.

Suggested affinity: Dicotyledoneae.

Tricolpites micromunus (Groot and Penny) Singh, 1971

Plate 6, Figure 28

1960 *Tricolpopollenites micromunus* Groot and Penny, p. 232, pl. 2, fig. 6, 7.

1971 *Tricolpites micromunus* (Groot and Penny) Singh, p. 209, pl. 32, fig. 7-11.

Occurrence: Albian to Danian, see Singh (1971, p. 209); 5 samples, trace to common, found near the base of SCS and the top of FCS.

Suggested affinity: Dicotyledoneae.

Tricolpites sp.

Plate 6, Figure 29

Description: Tricolpate pollen; oblate to spherical. Amb trilobate with gaping, V-shaped colpi almost reaching the poles. Exine thin and smooth to very slightly scabrate.

Size range: Equatorial diameter (8 specimens): 11(14)18 µm.

Occurrence: 9 samples, trace to occasional, not found in SFTS.

Suggested affinity: Dicotyledoneae.

Comments: Specimens assigned to this species somewhat resemble *Tricolpites* sp. B of Hopkins (1974, p. 24) from the Christopher

Formation (Albian) of the Canadian Arctic Archipelago.

Reference specimen: slide Pb11205-1, 33.9 X 117.9.

ANGIOSPERM POLLEN
(Tricolporate)

GENUS Nyssapollenites Thiergart, 1937

Type species: Nyssapollenites pseudocruciatus (Potonie) Thiergart, 1937

Nyssapollenites albertensis Singh, 1971

Plate 6, Figure 19

1971 Singh, p. 213, pl. 32, fig. 20, 21.

Occurrence: Late Albian and early Cenomanian, see Singh (1971, p. 213); 11 samples, trace to common, not found in SFTS.

Suggested affinity: Dicotyledoneae.

Comments: Singh accepts the genus Nyssapollenites as a form genus only, with no botanical affinities implied.

ANGIOSPERM POLLEN
(Incertae Sedis)

GENUS Asteropollis Hedlund and Norris, 1968

Type species: Asteropollis asteroides Hedlund and Norris, 1968

Asteropollis asteroides Hedlund and Norris, 1968

Plate 7, Figures 1-3

1968 Hedlund and Norris, p. 153, pl. 6, fig. 18-20; pl. 7, fig. 1-5.

Occurrence: ? Middle Albian to Turonian, see Srivastava (1975,

p. 86); 22 samples, trace to abundant, not found in SFTS.

Suggested affinity: Unknown angiosperm.

Comments: Specimens assigned by Davis (1963, p. 123, unpublished thesis) to "Genus A, sp. A" are probably conspecific with *Asteropollis asteroides*.

Class DINOPHYCEAE Pascher

Family APTEODINIACEAE Eisenack, 1961, emend. Sarjeant and Downie, 1974

GENUS *Spinidinium* Cookson and Eisenack, 1962

Type species: *Spinidinium styloniferum* Cookson and Eisenack, 1962

Spinidinium vestitum Brideaux, 1971

Plate 7, Figure 4

1970 *Deflandrea* cf. *echinoidea* Cookson and Eisenack: Davey, p. 339, pl. 1, fig. 6; pl. 2, fig. 2.

1971 *Spinidinium vestitum* Brideaux, p. 99, pl. 29, fig. 99-103, text-fig. 10a, d.

1971 *Deflandrea limpida* Singh, p. 359, pl. 61, fig. 1, 2.

1974 *Deflandrea echinoidea* Cookson and Eisenack, 1960, emend. Sverdlove and Habib, p. 58, pl. 1, fig. 1-6, text-fig. 2a, b.

Occurrence: Late Albian to early Cenomanian, see Brideaux (1971, p. 101); 12 samples, trace to flooding, not found in SFTS.

Comments: This species is quite variable in size and reaches prolific abundance near the base of the FCS. The attempt to transfer this species to *Deflandrea* by Sverdlove and Habib (1974) was rejected by Lentin and Williams (1975).

Family CTENIDODINIACEAE Sarjeant and Downie, 1966, emend. Sarjeant and Downie, 1974

GENUS *Dinopterygium* Deflandre, 1935

Type species: *Dinopterygium cladoides* Deflandre, 1935

Dinopterygium sp. A

Plate 7, Figure 5

1971 *Dinopterygium* sp. A Brideaux, p. 97, pl. 28, fig. 89-92.

Description: see Brideaux (1971, p. 97).

Size range: Equatorial width including equatorial ledges (3 specimens): 60(65)70 µm.

Occurrence: Late Albian of central Alberta; 2 samples, trace to rare, found only in FCS.

Comments: The several specimens observed appear to be conspecific with Brideaux's species. The apical horn and sulcal area are visible on the illustrated specimen. No recognizable archeopyle structure was observed.

Reference specimen: slide Pb11642-6, 34.6 X 123.8.

Family SPINIFERITACEAE Sarjeant, 1970, emend. Sarjeant and Downie, 1974

GENUS *Spiniferites* Mantell, 1850, emend. Sarjeant, 1970

Type species: *Spiniferites ramosus* Ehrenberg, 1838

Spiniferites sp. cf. *S*. *cingulatus* (O. Wetzel) Sarjeant, 1970

Plate 7, Figure 6

cf. 1933 Cymatiosphaera cingulata O. Wetzel, p. 28, pl. 4, fig. 10.

cf. 1955 Hystrichosphaera cingulata (O. Wetzel) Deflandre and Cookson, p. 267, pl. 6, fig. 4, 5.

cf. 1970 Spiniferites cingulatus (O. Wetzel) Sarjeant, p. 76.

Description: Central body not always distinct but ovoid to spherical when visible. Tabulation superficially resembling S. cingulatus but no clear cingulum observed. Crests dentate and supported by gonal processes not extending beyond crests. Wall of central body smooth to very finely granulate.

Size range: Maximum dimension of cyst including crests (3 specimens): 45(54)59 µm.

Height of crests: 2 to 7 µm.

Occurrence: 3 samples, rare, found only near the base of FCS.

Comments: The small number of specimens encountered allow only a tentative assignment of this species. This species differs from S. cingulatus in Singh (1971, p. 351) by having more highly dentate crests between processes. S. cingulatus has been subdivided by some authors into a number of varieties having some stratigraphic significance.

Reference specimen: slide Pb11607-1, 35.2 X 120.6.

Family PAREODINIACEAE Gocht, 1957, emend. Sarjeant and Downie, 1974

GENUS Pareodinia Deflandre, 1947, emend. Wiggins, 1975

Type species: Pareodinia ceratophora Deflandre, 1947, emend. Gocht, 1970

Pareodinia sp. cf. P. ceratophora Deflandre, 1947, emend. Gocht, 1970

Plate 7, Figure 7

cf. 1947 Pareodinia ceratophora Deflandre, p. 4, text-fig. 1-3.

Description: see Singh (1971, p. 313).

Size range: Total length of cyst (3 specimens): 68(70)71 µm.

Total width of cyst: 34(37)40 µm.

Occurrence: 1 sample, rare, found near the base of FCS.

Comments: Only three specimens of this species were encountered making its taxonomic assignment tentative although it closely resembles Pareodinia ceratophora. The illustrated specimen shows a hint of breakage suggesting an intercalary archeopyle.

Reference specimen: slide Pb11610-1, 35.0 X 122.1.

Family DEFLANDREACEAE Eisenack, 1954, emend. Sarjeant and Downie, 1974

GENUS Deflandrea Eisenack, 1938, emend. Lentin and Williams, 1977

Type species: Deflandrea phosphoritica Eisenack, 1938

Deflandrea sp. 1

Plate 7, Figure 8

Description: Epicyst roughly triangular with apical horn having straight or concave sides and forming a slender point; hypocyst roughly symmetrical with one antapical horn centrally placed or less commonly slightly to one side, apex of antapical horn blunt or rounded. Endophragm spherical or ovoid and usually slightly off center in the periphragm.

Size range: Total length of cyst (8 specimens): 70(80)90 µm.

Total width of cyst: 35(40)49 µm.

Occurrence: 5 samples, rare to common, found only near the base of FCS.

Comments: One of the specimens illustrated by Davis (1963, pl. 10, fig. 7) as *Deflandrea* sp. B may be conspecific with *D.* sp. 1 of this study if it were rotated 180° .

Reference specimen: slide Pb11618-1, 32.1 X 122.8.

Deflandrea sp. 2

Plate 7, Figures 9, 10

Description: Epicyst roughly triangular with apical horn having straight sides and coming to a sharp point when not broken; hypocyst strongly asymmetrical with one longer horn coming to a rounded point while the shorter horn is little more than a slight protuberance on the opposite side. Endophragm slightly ovoid with its long diameter parallel to the cingulum and slightly off center in the periphragm.

Size range: Total length of cyst (7 specimens): 60(66)75 µm.

Total width of cyst: 38(40)43 µm.

Occurrence: 2 samples, occasional to common, found only near the base of FCS.

Comments: The asymmetrical nature of the hypocyst of this species makes it easily identifiable and differentiatable from *Deflandrea* sp. 1.

Reference specimen: slide Pb11618-1, 40.0 X 125.8.

Family PALAEOPERIDINIACEAE Vozzhennikova, 1961, emend. Sarjeant, 1967

GENUS *Palaeoperidinium* Deflandre, 1934, emend. Sarjeant, 1967

Type species: *Palaeoperidinium pyrophorum* (Ehrenberg) Sarjeant, 1967

Palaeoperidinium cretaceum Pocock, 1962

Plate 8, Figures 1, 2

1962 Pocock, p. 80, pl. 14, fig. 219-221.

Size range: Total length of cyst (5 specimens): 64(75)86 µm.

Total width of cyst: 49(57)60 µm.

Occurrence: Cretaceous, see Singh (1971, p. 385); 6 samples, rare to abundant, found only near the base of FCS.

Comments: This species has been treated differently by various authors. *P*. *cretaceum* is the type of the genus *Astrocysta* Davey, 1970, which is considered to be a junior synonym of *Palaeoperidinium* Deflandre, emend. Sarjeant by Lentin and Williams (1975, p. 110). It has also been placed in *Lejeunia* by Brideaux (1971, p. 86).

Family HEXAGONIFERACEAE Sarjeant and Downie, 1966, emend. Sarjeant and Downie, 1974

GENUS *Hexagonifera* Cookson and Eisenack, 1961, emend. Cookson and Eisenack, 1962

Type species: *Hexagonifera glabra* Cookson and Eisenack, 1961

Hexagonifera sp. cf. *H*. *chlamydata* Cookson and Eisenack, 1962

Plate 8, Figure 3

cf. 1962 *Hexagonifera chlamydata* Cookson and Eisenack, p. 496, pl. 7, fig. 1-3, 5-8.

Description: see Cookson and Eisenack (1962, p. 496).

Occurrence: 2 samples, trace, found only near the base of FCS.

Comments: Only three specimens of this species were encountered allowing only a tentative taxonomic placement. The only well-preserved specimen lacked the archeopyle and had the characteristic size, outer membrane and verrucose inner body surface sculpture of Hexagonifera chlamydata. Lentin and Williams (1976, p. 84) questionably retained H. chlamydata in Hexagonifera in spite of its apparent apical archeopyle, pending reexamination of the type material.

Reference specimen: slide Pb11642-6, 33.4 X 127.4.

Family PSEUDOCERATIACEAE Eisenack, 1961, emend. Sarjeant and Downie, 1966

GENUS Odontochitina Deflandre, 1935, emend. Davey, 1970

Type species: Odontochitina operculata (O. Wetzel) Deflandre and Cookson, 1955

Odontochitina costata Alberti, 1961, emend. Clarke and Verdier, 1967

Plate 8, Figure 4

1961 Odontochitina costata Alberti, p. 31, pl. 6, fig. 10-13.

Synonymy: see Clarke and Verdier (1967, p. 58).

Occurrence: Albian to Cenomanian, see Davey and Verdier (1973, p. 198); 3 samples, trace, found only near the base and middle of FCS.

Comments: Singh (1971, p. 372) considers O. costata Alberti and

O. striatoperforata Cookson and Eisenack as distinct species contrary to the emendation of Clarke and Verdier (1967). Only one complete specimen was encountered in this study along with several apical and antapical halves.

GENUS Pseudoceratium Gocht, 1957

Type species: Pseudoceratium pelliferum Gocht, 1957

Pseudoceratium ? sp.

Plate 8, Figures 5, 6

Description: Cyst flattened; asymmetrical outline with two prominent horns. Apical horn with rounded or blunt point and slightly convex or straight sides. Antapical horn drawn to a long slender point and set to extreme side of hypocyst. Second antapical horn not developed but suggested by broad bulge on opposite side of hypocyst. Archeopyle apical; paratabulation absent. The cyst wall is patterned with an irregular reticulum having no apparent relief.

Size range: Total length of cyst (4 specimens): 103(111)126 µm.
Total width of cyst: 41(43)47 µm.

Occurrence: 3 samples, trace to rare, found only in SFTS.

Comments: This species was tentatively placed in the genus Pseudoceratium because it lacks a distinct second antapical horn. Only several complete specimens were encountered in the study allowing little chance for comparison.

Reference specimen: slide Pb11681-1, 37.1 X 119.8.

Family MUDERONGIACEAE Neale and Sarjeant, 1962, emend. Sarjeant and Downie, 1966

GENUS *Muderongia* Cookson and Eisenack, 1958

Type species: *Muderongia mcwhaei* Cookson and Eisenack, 1958

Muderongia sp. 1

Plate 8, Figures 7, 10

Description: Cyst flattened; roughly bilaterally symmetrical with one apical, two lateral and two antapical horns. Apical horn slightly longer and broader than the other four. Two lateral horns about equal in length and postcingular in position. Antapical horns equal in length or only slightly unequal and within the same length and width range as the lateral horns. Endocyst not clearly defined. Periphragm surface smooth or faintly roughened. Paratabulation and paracingulum faintly suggested on some specimens. Archeopyle apical.

Size range: Total length of cyst (6 specimens): 119(130)144 µm.

Total width of cyst: 83(98)110 µm.

Length of apical horn: 43(48)50 µm.

Length of lateral and antapical horns: 29(34)50 µm.

Occurrence: 7 samples, rare to dominant, found only in SFTS and uppermost Bear River Formation in FCS.

Comments: This species is distinguished from *Muderongia asymmetrica* Brideaux, 1977, which exhibits the pairing of long left antapical and short right postcingular horns and short right antapical and long left postcingular horns. "*Pseudoceratium* sp A" of Davis (1963, unpublished thesis) is distinguished by its shorter and broader horns and appears to be conspecific with *Muderongia* sp. 2 of this study.

Reference specimen: slide Pb11681-1, 37.8 X 124.4.

Muderongia sp. 2

Plate 8, Figures 8, 9

1963 "*Pseudoceratium* sp. A", Davis, p. 130, pl. 10, fig. 9-12 (unpublished thesis).

Description: Cyst flattened; roughly bilaterally symmetrical with one apical, two lateral and two antapical horns. Apical horn broadly triangular and sharply pointed with a slightly longer length than the other four horns. Two lateral and two antapical horns broadly based and about equal in size and shape with sharp points. Endocyst not clearly defined. Periphragm surface smooth or faintly roughened. Paratabulation, paracingulum and archeopyle not observed.

Size range: Total length of cyst (8 specimens): 75(87)100 µm.
Total width of cyst: 61(69)75 µm.
Length of apical horn: 25(27)31 µm.
Length of lateral and antapical horns: 16(21)25 µm.

Occurrence: Middle to late Albian of northern Wyoming (Davis, 1963); 2 samples, rare to dominant, found only in the uppermost SFTS.

Comments: This species appears to be conspecific with "*Pseudoceratium* sp. A" of Davis (1963, unpublished thesis) differing only by having a slightly smaller overall size. It differs from *Muderongia asymmetrica* Brideaux which does not have lateral and antapical horns of equal length. This species is usually folded or broken with the horns folded over the body.

Reference specimen: slide Pb11687-5, 29.3 X 125.5.

Family MEMBRANILARNACIACEAE Eisenack, 1963, emend. Sarjeant and Downie, 1966

GENUS Chlamydophorella Cookson and Eisenack, 1958

Type species: Chlamydophorella nyei Cookson and Eisenack, 1958

Chlamydophorella nyei Cookson and Eisenack, 1958

Plate 9, Figure 1

1958 Cookson and Eisenack, p. 56, pl. 11, fig. 1-3.

Occurrence: Aptian to early Turonian, see Singh (1971, p. 377); 2 samples, rare to occasional, found only in FCS.

Family HYSTRICHOSPHAERIDIACEAE Evitt, 1963, emend. Sarjeant and Downie, 1974

GENUS Oligosphaeridium Davey and Williams, 1966

Type species: Oligosphaeridium complex (White) Davey and Williams, 1966

Oligosphaeridium anthophorum (Cookson and Eisenack) Davey, 1966

Plate 9, Figure 2

1958 Hystrichosphaeridium anthophorum Cookson and Eisenack, p. 43, pl. 11, fig. 12, 13.

1969 Oligosphaeridium anthophorum (Cookson and Eisenack) Davey, p. 147, pl. 5, fig. 1-3.

Occurrence: Late Jurassic to Albian, see Singh (1971, p. 336); 2 samples, trace to rare, found only near the base of FCS.

Oligosphaeridium complex (White) Davey and Williams, 1966

Plate 9, Figures 3, 4

1842 Xanthidium tubiferum complex White, p. 39, pl. 4, div. 3, fig. 11.

1946 Hystrichosphaeridium complex (White) Deflandre, p. 111.

1966 Oligosphaeridium complex (White) Davey and Williams, p. 71, pl. 7, fig. 1, 2; pl. 10, fig. 3, text-fig. 14.

Occurrence: Valanginian to early Eocene, see Singh (1971, p. 334); 12 samples, rare to common, not found in SFTS.

GENUS Tanyosphaeridium Davey and Williams, 1966

Type species: Tanyosphaeridium variecalamum Davey and Williams, 1966

Tanyosphaeridium sp. A

Plate 9, Figure 5

1971 Tanyosphaeridium sp. A Brideaux, p. 93, pl. 26, fig. 71.

1971 Tanyosphaeridium sp. Singh, p. 344, pl. 57, fig. 7.

1975 Tanyosphaeridium sp. A of Brideaux: Brideaux, p. 31, pl. 9, fig. 11.

Description: see Brideaux (1971, p. 93) and Brideaux (1975, p. 31).

Occurrence: Middle and late Albian of central and west-central Alberta and Horton River area (Brideaux, 1971; Singh, 1971; Brideaux and McIntyre, 1975); 4 samples, rare to occasional, not found in SFTS.

Comments: This species is distinguished by processes with open and flared ends. Norvick (1975, p. 63) describes a new species, Tanyosphaeridium salpinx, with similar processes which he considers as conspecific with *T.* sp. of Singh, 1971. The specimens illustrated by Singh and Brideaux and those encountered in this study show little variation in number of processes and have a more elongate cyst outline than Norvick's illustrated specimen (he does not include length to width ratios for comparison). For these reasons *Tanyosphaeridium* sp. A is not considered conspecific with *T. salpinx* Norvick pending further study.

Reference specimen: slide Pb11618-1, 39.0 X 126.2.

Family CLEISTOSPHAERIDIACEAE Sarjeant and Downie, 1974

GENUS *Cleistosphaeridium* Davey and others, 1966

Type species: *Cleistosphaeridium diversispinosus* Davey and others, 1966

Cleistosphaeridium multispinosus (Singh) Brideaux, 1971

Plate 9, Figure 6

1964 *Baltisphaeridium multispinosus* Singh, p. 141, pl. 20, fig. 1, 2.

1971 *Cleistosphaeridium multispinosus* (Singh) Brideaux, p. 93, pl. 27, fig. 77-79.

Occurrence: Middle Albian to early Cenomanian, see Brideaux (1971, p. 94); 25 samples, trace to dominant, found throughout all three sections.

Family AREOLIGERACEAE Evitt, 1963, emend. Sarjeant and Downie, 1966

GENUS *Cyclonephelium* Deflandre and Cookson, 1955, emend. Ioannides and others, 1977

Type species: Cyclonephelium compactum Deflandre and Cookson, 1955

Cyclonephelium sp. A

Plate 9, Figure 7

1971 Cyclonephelium sp. A Brideaux, p. 97, pl. 28, fig. 88.

Occurrence: Late Albian of central Alberta, see Brideaux (1971, p. 97); 7 samples, trace to abundant, found only near the base of FCS.

Comments: Complete specimens were not observed but the remaining cyst falls within the circumscription of this genus and the description of Cyclonephelium sp. A of Brideaux.

Reference specimen: slide Pb11618-1, 42.8 X 115.7.

Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant, 1963

GENUS Baltisphaeridium Eisenack, 1958, emend. Downie and Sarjeant, 1963

Type species: Baltisphaeridium longispinosum (Eisenack) Eisenack, 1958

Baltisphaeridium sp.

Plate 9, Figures 8, 9

Description: Body spherical to ovoid, thin walled and densely covered with short spines distributed over the entire surface; processes of approximately equal length, never longer than 1.5 µm and with pointed, blunt or less commonly capitate tips.

Spines spaced about 1 to 1.5 µm apart. Body not uncommonly slightly folded and/or broken.

Size range: Total diameter of test with spines (15 specimens):
18(23)26 µm.

Occurrence: 9 samples, trace to dominant, not found in SFTS.

Comments: This species falls within the circumscription of Downie and Sarjeant's emendation of the genus *Baltisphaeridium* Eisenack. Although a few specimens are smaller than their arbitrary 20 µm limit the mean diameter is 23 µm.

Reference specimen: slide Pb11210-2, 40.5 X 119.3.

GENUS *Micrhystridium* Deflandre, 1937, emend. Downie and Sarjeant, 1963

Type species: *Micrhystridium inconspicuum* (Deflandre) Deflandre, 1937

Micrhystridium bifidum Davey, 1970

Plate 9, Figures 10, 11

1970 Davey, p. 368, pl. 7, fig. 10, 11, text-fig. 2L.

Occurrence: Cenomanian of England; 11 samples, rare to dominant, found in all three sections.

Comments: Specimens assigned to this species compare favorably in all aspects with those of Davey.

Micrhystridium fragile Deflandre, 1947

Plate 9, Figure 12

1947 Deflandre, p. 8, fig. 13-18.

Description: see Singh (1971, p. 399).

Occurrence: Jurassic to Oligocene in various parts of the world, see Drugg (1967, p. 34); 2 samples, rare, found only near the base of FCS.

Comments: The few specimens assigned to this species fall well within the variable size range and spine number of this species reported in the literature.

Micrhystridium inconspicuum (Deflandre) Deflandre, 1937

Plate 10, Figures 1, 2

1935 *Hystrichosphaera inconspicua* Deflandre, p. 233, pl. 9, fig. 11, 12.

1937 *Micrhystridium inconspicuum* (Deflandre) Deflandre, p. 32, pl. 12, fig. 11-13.

Occurrence: Oxfordian to Senonian, western Europe and northern Wyoming (Davis, 1963, unpublished thesis); 39 samples, rare to flooding, found throughout all three sections.

Comments: Specimens assigned to this species are comparable to those illustrated in drawings by Davis (1963, pl. 13, fig. 3, 8) in the upper Albian of northern Wyoming.

Micrhystridium sp. cf. *M*. *densispinium* Valensi, 1953

Plate 10, Figures 3, 4

cf. 1953 *Micrhystridium densispinium* Valensi, vol 32, no. 68.

Description: Radially symmetrical test; spherical to ovate. Wall less than 1 µm thick and evenly covered with closely spaced spines. Spines no longer than about 2 µm high and with slightly expanded bases.

Size range: Total diameter of test with spines (10 specimens):
8(11)17 µm.

Occurrence: 47 samples; rare to dominant, found throughout all three sections.

Comments: Specimens assigned to this species are similar to those described and illustrated in drawings by Davis (1963, fig. 7, 9, unpublished thesis) as *Micrhystridium densispinium* Valensi.

Reference specimen: slide Pb11232-5, 32.2 X 118.8.

Micrhystridium sp. cf. *M. piliferum* Deflandre, 1937

Plate 10, Figure 5

cf. 1937 *Micrhystridium piliferum* Deflandre, p. 80, pl. 15, fig. 11.

1971 *Micrhystridium* sp. cf. *M. piliferum* Deflandre: Brideaux, p. 73, pl. 21, fig. 7.

Description: Test spherical; wall thin and covered with short, slightly tapered spines. Spines evenly distributed and about 3 to 4 μm apart and 3 to 6 μm long.

Size range: Total diameter of test with spines (4 specimens): 13(18)25 μm.

Occurrence: 2 samples; trace to occasional, found only in the basal Aspen Shale of FCS and near the base of SCS.

Comments: Specimens of *Micrhystridium* sp. cf. *M. piliferum* Deflandre reported by Brideaux (1971) are slightly smaller than those found in this study but otherwise appear to be conspecific. This species differs from *M. piliferum* Deflandre by having fewer spines and spines with broad bases rather than being rod-like.

Reference specimen: slide Pb11653-1, 35.9 X 121.1.

Subgroup POLYGONOMORPHITAE Downie, Evitt and Sarjeant, 1963

GENUS Veryhachium Deunff, (1954) 1958, emend. Downie and Sarjeant, 1963

Type species: Veryhachium trisulcum (Denuff) Deunff, 1958

Veryhachium sp. cf. V. europaeum Stockmans and Williere, 1960, forma 1 Wall and Downie, 1962

Plate 10, Figures 6, 7

cf. 1962 Veryhachium europaeum Stockmans and Williere forma 1 Wall and Downie, p. 782, pl. 114, fig. 4, 5.

Description: Body tetrahedral with a triangular outline and bearing 4 hollow spines of equal length. Sides of the body nearly straight and extending to form apices of the triangular outline. Fourth spine vertical and usually flattened against body. Spine length up to ½ diameter of body.

Size range: Total diameter of test with spines (5 specimens): 7(9)11 µm.

Occurrence: 7 samples, trace to dominant, found in the basal Aspen Shale of SCS and throughout FCS.

Comments: Specimens here assigned were considerably smaller than those described in the literature but morphologically similar to Veryhachium europaeum forma 1.

Referance specimen: slide Pb11642-1, 42.3 X 120.0.

Subgroup NETROMORPHITAE Downie, Evitt and Sarjeant, 1963

GENUS Leiofusa Eisenack, 1938

Type species: Leiofusa fusiformis (Eisenack) Eisenack, 1938

Leiofusa jurassica Cookson and Eisenack, 1958

Plate 10, Figure 8

1958 Cookson and Eisenack, p. 51, pl. 10, fig. 3, 4.

Occurrence: Permian to Oligocene of various parts of the world, see Brideaux and McIntyre (1975, p. 39); 6 samples, trace to occasional, found in the basal Aspen Shale of SCS and throughout FCS.

Subgroup PTEROMORPHITAE Downie, Evitt and Sarjeant, 1963

GENUS Pterospermopsis W. Wetzel, 1952

Type species: Pterospermopsis danica W. Wetzel, 1952

Pterospermopsis australiensis Deflandre and Cookson, 1955

Plate 10, Figure 9

1955 Deflandre and Cookson, p. 286, pl. 3, fig. 4, text-fig. 52, 53.

Occurrence: Early Cretaceous to Paleocene of various parts of the world, see Brideaux and McIntyre (1975, p. 39); 12 samples, rare to common, found in all three sections.

Group ACRITARCHA
(Incertae Sedis)

GENUS Palaeostomocystis Deflandre, 1935

Type species: Palaeostomocystis reticulata Deflandre, 1935

Palaeostomocystis fragilis Cookson and Eisenack, 1962

Plate 10, Figure 10

1962 Cookson and Eisenack. p. 496, pl. 7, fig. 10, 11.

Occurrence: Aptian to Late Cretaceous, see Brideaux and McIntyre (1975, p. 26); 4 samples, trace to rare, not found in SFTS.

ANALYSIS OF DATA

Age of the Bear River Formation: Table 1 presents an abbreviated listing of significant palynomorphs found in samples from two sections of the Bear River Formation in southwestern Wyoming and from the upper part of the type section of the Smiths Formation with previously reported stratigraphic occurrences of these fossils in North America and other parts of the world. Those species with stratigraphic ranges too extended to be useful are not included. However, all previously reported species which have also been identified in this study of these strata include some part of the Albian Stage in their stratigraphic range.

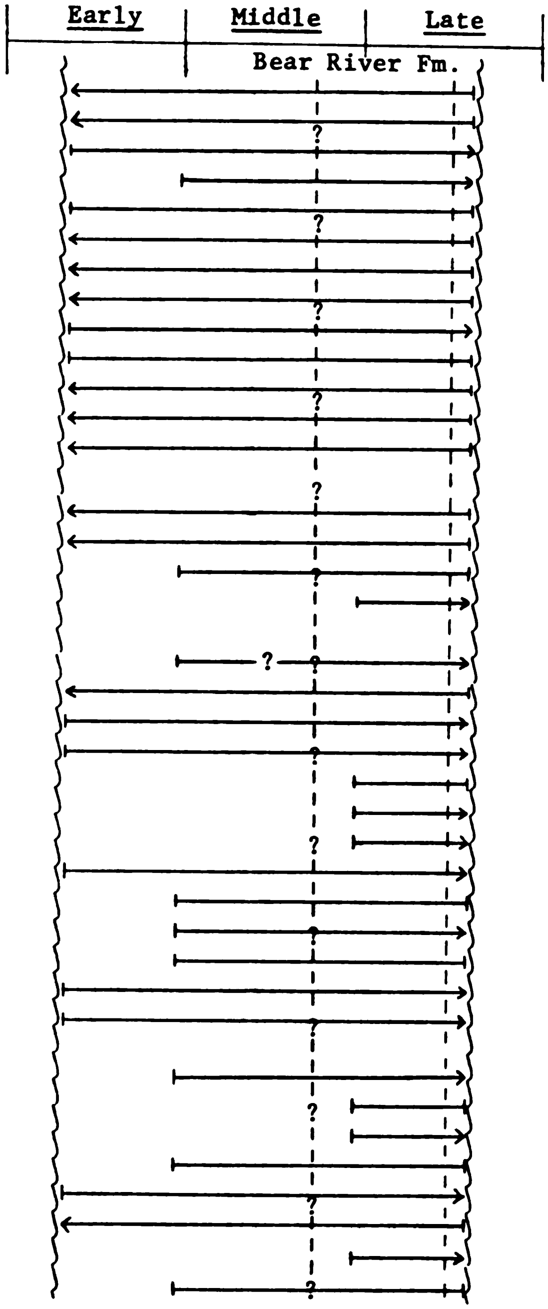
The data from overlapping ranges points to a late Albian age for the Bear River Formation at the two sections studied and that part of the Smiths Formation studied at its type locality.

Brenner (1976, Figure 1) has reviewed the data on first occurrences of tricolpate pollen in various latitudes of the Western Hemisphere. Their first appearance in the middle latitudes is in middle Albian sediments. The diverse angiosperm flora of tricolpate pollen and one tricolporate (*Nyssapollenites*) in the Bear River Formation at the Stowe Creek section and to a lesser extent at the other two sections studied suggests a possible age of late-middle Albian for the oldest of these sediments. The overlying Aspen Shale contains late Albian cephalopods and

Table 1 Stratigraphic occurrences as previously reported for some of the plant microfossils found in the Bear River Formation and Smiths Formation.

Species Whose Previously Reported Stratigraphic Range Has a Top, Base or both Top and Base Within the Albian Stage

Part of Previously Reported Stratigraphic Range in the Albian Stage



Appendicisporites potomacensis
A. problematicus
Camarozonosporites ambigens
Cicatricosisporites minor *
C. subrotundus
Concavissimisporites variverrucatus
Coronatispora valdensis
Costatoperforosporites fistulosus
Deltoidospora sp. cf. D. juncta
"Koilisporis excavatus"
Pilosisporites trichopapillosus
Undulatisporites undulapolus *
Verrucosisporites rotundus

Cedripites cretaceus *
Eucommiidites minor *
Phyllocladidites sp.
Rugubivesiculites rugosus

Asteropollis asteroides
Clavatipollenites minutus
Cupuliferoidaepollenites minutus
Liliacidites dividuus
L. textus
Nyssapollenites albertensis
Psilatricolpites parvulus *
Retitricolpites georgensis
R. prosimilis *
R. vulgaris *
Striatopollis paraneus
Tricolpites crassimurus *
T. micromunus

Cleistosphaeridium multispinosus *
Cyclonephelium sp. A
Dinopterygium sp. A
Muderongia sp. 2 **
Odontochitina costata
Oligosphaeridium anthophorum
Spinidinium vestitum
Tanyosphaeridium sp. A

* Species found in sediments of the type section of the Smiths Formation as well as the Bear River Formation.

** Species found only in sediments of the type section of the Smiths Formation.

provides an upper limit for the age of the Bear River Formation. According to the recent Cretaceous time scale published by van Hinte (1976), the stratigraphic range of the Bear River Formation in southwestern Wyoming would occupy a time period of about 2 to 4 million years duration.

Comparison with Other Palynofloras of Comparable Age: A comparison of plant microfossil taxa with other similar studies in North America is presented in Table 2. Not only is there an obviously greater similarity with palynomorphs attributed to the middle and late Albian; but a marked similarity exists between this flora and others reported in Western Canadian strata. This should be expected because of the numerous terrestrial plants which would accompany the southern push of the boreal sea during late-middle Albian and late Albian time. This should also be true with phytoplankton living in those Cretaceous seas which have been so clearly shown to be alternately transgressive and regressive. Floras from areas to the south and on the east side of the seaway (Hedlund, 1966; Phillips and Felix, 1971a, b; Bond, 1972) with the exception of Hedlund and Norris's study (1968) show somewhat less similarity and probably represent a more Gulf Coast type flora with slightly different ecological and climatic requirements.

Four of the palynofloras listed in Table 2 reported no angiosperms (Singh, 1964; Vagvolgyi and Hills, 1969; Hopkins, 1971; Bond, 1972) and appear to be older on this basis unless the very small angiosperm pollen were lost in preparation or overlooked during microscopic examination. According to Brenner (1976) the appearance of tricolpate pollen in the higher latitudes

Table 2 Comparison of Bear River and Smiths Formation taxa with those of similar studies in other areas of North America.

Author - Age - Location	Comparable Taxa					
	Spores	Gymnosperms	Angiosperms	Marine	Total	TOTAL%
This study - - - - - - - - - - -	(44)	(25)	(16)	(28)	(113)	
Norris (1967) - M.-L. Albian - Central Alberta, Canada	23(52)	13(23)	9(11)	*	45(86)	52%
Hopkins (1971) - L. Valanginian-Aptian - District of Franklin, Canada	13(37)	10(11)	0(0)	*	23(48)	48%
Hedlund and Norris (1968) - M.? Albian - S. Oklahoma	14(47)	6(15)	7(14)	*	27(76)	36%
Playford (1971) - M.-L. Albian - E. Saskatchewan and W. Manitoba, Canada	21(74)	11(18)	4(9)	*	36(101)	36%
Hopkins and Balkwill (1973) - L. Albian-E. Cenomanian - District of Franklin, Canada	10(31)	6(14)	2(5)	*	18(50)	36%
Brenner (1963) - Barremian-Albian - Maryland	21(79)	12(28)	8(14)	*	41(121)	34%
Vagvolgyi and Hills (1969) - E.-M. Albian - NE. Alberta, Canada	20(69)	7(16)	0(0)	2(8)	29(93)	31%
Hopkins (1974) - M.-L. Albian - Canadian Arctic Archipelago	17(60)	5(11)	0(2)	*	22(73)	30%
Davis (1963) - E.-L. Albian - N. Wyoming	17(55)	8(18)	5(9)	6(41)	36(123)	29%
Singh (1964) - Barremian-M. Albian - E. Central Alberta	23(86)	11(21)	0(0)	2(16)	36(123)	29%
Cahoon (1964) - Neocomian-Albian - S. Black Hills of NW. S. Dakota	11(54)	8(22)	3(5)	*	22(81)	27%
Brideaux and McIntyre (1975) - Aptian-M. Albian - District of Mackenzie, Canada	27(76)	14(17)	2(4)	5(64)	43(161)	27%
Singh (1971) - M.-L. Albian - NW. Alberta, Canada	39(133)	18(23)	13(25)	6(114)	76(295)	26%
Pocock (1962) - L. Jurassic-Albian - S. Alberta and S. Saskatchewan, Canada	18(63)	6(20)	0(1)	1(13)	25(97)	26%
Pannella (1966) - M. Albian-Cenomanian - Denver Basin of W. Nebraska and E. Colorado	19(100)	9(29)	7(11)	1(18)	36(158)	23%
Bond (1972) - Aptian-Albian - SW. Arkansas	3(16)	3(6)	0(0)	0(4)	6(26)	23%
Hedlund (1966) - Cenomanian - S. Oklahoma	7(35)	6(20)	1(10)	*	14(65)	22%
Phillips and Felix (1971a, b) - Albian-Cenomanian - SW. Mississippi and NE. Louisiana	13(74)	6(19)	1(10)	*	20(103)	19%

* Studies reporting no marine palynomorphs or not treating them.

Notes: (1) Numbers in parentheses are the total taxa reported in each group.

(2) The conspecificity of certain taxa with those in other studies was interpreted by this author. This required reevaluation and reassignment of some taxa, particularly those in the earlier studies.

(3) E. = Early, M. = Middle and L. = Late

of Western Canada would be slightly later than in areas to the south and might explain their absence in all but Bond's palynoflora.

A particularly significant comparability exists between gymnosperm taxa (at the species and group level defined in this study) found in this study and those of Hopkins (1971), Brideaux and McIntyre (1975) and Singh (1971). All are from Western Canada and show over 75% comparability with taxa found in this study. This further demonstrates the close affinity of Bear River and Smiths Formation taxa with boreal palynofloras.

The similarity of the palynoflora studied in southwestern Wyoming with that reported by Brenner (1963) is not easily explained except in light of the generally cosmopolitan nature of pre-Turonian pollen assemblages (Doyle, 1969) and any, yet unknown, boreal connection with the present Atlantic Coastal Plain.

If the Skull Creek seaway did indeed split in late Bear River time prior to the spread of the boreal Shell Creek seaway, as Eicher (1962) has suggested on foraminiferal evidence, there may have been a short interval of time when plant migration could have taken place between the east and west side of the Western Interior seaway. Such a land connection is not suggested by the comparability of palynomorphs found in this study with the palynofloras of Hedlund (1966), Phillips and Felix, (1971a, b) or Bond (1972), all located considerably south and east of southwestern Wyoming, however, and undoubtedly representing somewhat more tropical floras, lessening their potential for comparability. The comparability with palynomorphs found by Hedlund and Norris (1968) from southern Oklahoma is 36% but still far from conclusive.

The taxonomic treatment of bisaccate pollen resorted to in this study, as discussed earlier, somewhat reduced the diversity of this group. Comparisons are based mainly upon similarity to modern genera. Thus, the potential for comparison of bisaccate taxa with those of other studies is reduced and limited to these "generic groupings" except for several bisaccate pollen which could be identified to the species level.

Paleoenvironments of Deposition:

Introduction: In attempting to determine the probable depositional regime, climatic conditions and paleoecology during Early Cretaceous time, strong comparison must be made with modern analogs tempered with common sense and imagination. The approach of this study is to present information from several lines of evidence which together give a generalized picture of the environmental conditions existing in southwestern Wyoming during the deposition of the Bear River Formation.

The fact that most samples in this study contain marine palynomorphs is significant and interpreted to mean that the Bear River Formation was predominantly deposited in marine or at least brackish-marine conditions. As already discussed, however, the degree of invagination of the embayment probably allowed for local freshwater environments on the landward side near the point of debouchment of rivers draining the highlands to the west. The numerous interrelated factors governing the distribution of plant entities in marine environments are still little understood but warrant brief review here because they form the basis for interpretation of the Bear River Formation.

A number of major studies have been undertaken in recent marine sedimentary environments around the world in order to shed light on this subject: Koreneva (1957) in the Sea of Okhotsk, Muller (1959) in the Gulf of Paria and the Orinoco delta, Rossignol (1961) on the Israeli continental shelf, Koreneva (1964) in the western Pacific Ocean, Cross and others (1966) in the Gulf of California, Traverse and Ginsburg (1966) on the Grand Bahama Banks, Williams (in Williams and Sarjeant, 1967) in the Niger delta region and the North Atlantic Ocean and Davey (1971) on the southwest coast of South Africa. Although each study has presented some results unique to its own conditions, the following general trends and facts have been noted from these and related studies:

1) Most pollen and spores fall within the size range of very fine sand (125 μm) to very fine silt (8 μm) but because of their lighter specific gravity than comparable sized rock particles they act as particles of the finer silt sizes and should ideally occur in greatest abundance in sediments of this size. Some grains with odd shapes or protruding bladders are even further retarded in settling and may occur in even finer sediments.

2) The very light density of pollen and spores, dinoflagellate cysts and acritarchs precludes their deposition in regions of high turbulence because of winnowing-type size sorting.

3) The general trend for pollen and spores is to increase in frequency toward the shoreline (Woods, 1955). Hoffmeister

(1954) first recognized the importance of this relationship in determining the position of ancient shorelines. The reverse trend is usually true with microplankton although not always (Davey, 1971; Williams and Sarjeant, 1967).

4) Numerous factors affecting the distribution of plant microfossils such as longshore currents, wind and sedimentation patterns, rates of sedimentation, bottom conditions, ecological barriers for marine microplankton (salinity and temperature), etc. do not act uniformly and create distribution patterns with frequency contours deviating from the coastal outline.

5) Wind-borne pollen and spores which are actually transported to the sea by wind represent only a minute part of the plant entities found in marine environments. The majority of these and other terrestrial forms are transported to the sea by rivers and their vast tributaries draining the land surface.

6) Microplankton distribution tends to be environmentally controlled and roughly related to sedimentary facies.

The results of relative abundance counts in this study are presented in columns 1 through 4 of Table 3 (in pocket). The relative abundance percentages of spores, bisaccate pollen, inaperturate pollen, other gymnosperms (excluding inaperturates and bisaccates), angiosperm pollen, dinoflagellate cysts and acritarchs are presented in column 1. Column 2 shows the relative percent of terrestrial and marine forms as well as the total diversity (number of distinct taxa) of terrestrial and marine forms. Terrestrial diversity is further split into diversity of pollen and spores in column 3. Column 4 simply serves as a rough index of preservational quality based upon the relative percentage of unidentified palynomorphs. This graphic information is combined with the sediment type shown on the stratigraphic column to provide a basis for interpretation.

The influence of reworking of older palynomorphs in the Bear River Formation sediments appears to be minor. A few highly corroded spores such as those found in the cicatricose and canaliculate genera of the Schizaeaceae may have been reworked from older Mesozoic strata along with some of the bisaccate pollen which are poorly preserved as a rule. The latter could, however, be a result of long distance transport rather than reworking.

Comparison of the Stowe Creek and Fontenelle Creek Sections: These two sections are roughly correlative and lend themselves well to an analysis of their environments of deposition. They have been divided into four zones or periods of distinct depositional history based upon the integration of available stratigraphic and biostratigraphic data. A brief treatment of these zones follows (see Figure 6).

ZONE I: Both sections have a thick sequence of sandstone with interbedded shale at their base. This stratigraphic unit has been called the Tygee Member of the Bear River Formation in northern portions of the Idaho-Wyoming thrust belt and has been interpreted recently as a fluvial sandstone (Kamis, 1977) on the basis of sedimentary structures, stratigraphic position and grain size plots. His results are inconclusive but suggest nearshore processes have modified at least part of the Tygee Member in some areas and may, therefore, be interpreted as partly marine. Eyer (1969) has suggested a shallow, brackish water

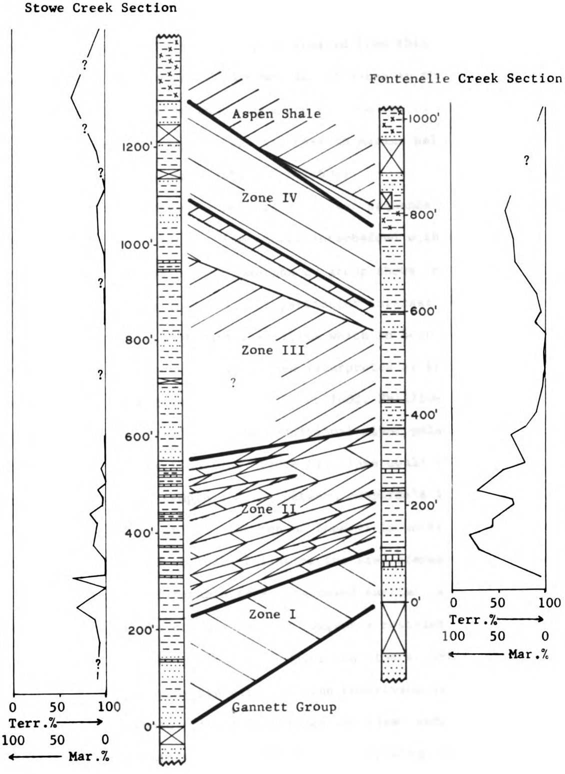


Figure 6 Zonation of the Bear River Formation at the Stowe Creek and Fontenelle Creek sections. Vertical Scale: 1" = 200 ' (61.0 m)

▧ Transgressive Phase ▨ Regressive Phase or marine environment for some portions of the Tygee Member based on fossil evidence. The three samples studied from this thick sandstone sequence indicate at least some marine influence in the basin at the time of accumulation of the palynomorphs. The top of this zone is marked by the first significant increase in marine palynomorphs above the thick sandstone units (Pb11207-Pb11607).

ZONE II: Overlying zone I is a thicker sequence of dark shales with thin, dark, coquinoid limestones interbedded with them. The relative percentages of palynomorphs by group shows considerable fluctuation in this interval. Of particular interest is the relative abundance percentage of marine entities which in both sections makes several distinct, correlative pulses interpreted as transgressions with sequential regressions (Pb11208-Pb11608, Pb11210-Pb11610, Pb11214-Pb11614 and Pb11219-11621). Two additional minor pulses at the Fontenelle Creek section (see Figure 6). This could be simply the result of too wide sample spacing between comparable intervals at the Fontenelle Creek section. The top of Zone II is marked by the final regression (Pb11222-Pb11622) following the last transgressive pulse.

The absence of foraminifera, discussed earlier, and the dark, organic rich nature of these shales suggest a restricted basin or embayment similar to the model of Royse and others (1975). As the sea transgressed following deposition of the underlying sandstones a period of relative tectonic quiescence existed and finer sediments settled into this shallow, possibly restricted basin or embayment in southwestern Wyoming. The thin coquinoid limestones may represent relatively stable periods when rate and volume of sedimentation were reduced allowing a temporary domination of shallower shelf environments by bivalves and gastropods. Some mudstones in this sequence from the Stowe Creek section also contain a fauna of abundant small gastropods and bivalves which may possibly be dwarfed because of adverse bottom conditions in what seem to be lagoonal muds.

Although the overall abundance of inaperturate pollen in this shale sequence is less than in overlying parts of the Bear River Formation, if their affinity to Taxodiaceae-type plants is correct, their abundance may indicate that poorly drained, swampy areas existed on or near the shores of the embayment. The presence of thin coals in the Bear River Formation at various localities in southwestern Wyoming (Glass, 1977) would support this idea; however, any interpretations made on the basis of inaperturate pollen must be considered tenuous because of the uncertainity involving their parent plants. Plants in genera of the modern Cupressaceae and Taxaceae, as well as the Taxodiaceae, produce inaperturate pollen similar to pollen found in this study and represent quite variable ecological and climatic conditions. The unusual abundance of inaperturate pollen is difficult to explain but similar high relative abundances were reported by Davis (1963) for strata of comparable age in northern Wyoming.

Angiosperm pollen are much more abundant in this interval of the Stowe Creek section than in the Fontenelle Creek section. This may reflect in a general way the existence of more favorable sites to the south for these plants to grow, but there are several other possible explanations. The greater abundance at the Stowe Creek section may, for example, be a function of sedimentological factors such as longshore currents concentrating these very small pollen grains locally at the southern end of the embayment or a local concentration due to nearness to a river mouth carrying them from more upland areas where some authors have postulated the angiosperms to have first become diversified. Too little is known about their origin and early competitive strategy to interpret their distribution or abundance in marine sediments except where distribution patterns can be partly inferred from sedimentological factors. They do, however, form part of the general paleofloral framework of the region and aid in age determinations as discussed earlier.

The nature of the phytoplankton also appears to be characteristic in this lower shale sequence. It is readily evident that the transgressions at the Stowe Creek section are marked by increases in relative abundance of acritarchs. Those at the Fontenelle Creek section, however, are marked by generally larger abundances of acritarchs coupled with large abundances of dinoflagellate cysts, especially during the maximum development of the lower three transgressive pulses. The overall indication of environment is that deposition at the Fontenelle Creek section was under more normal marine conditions than at the Stowe Creek section as evidenced by (1) larger relative abundances, (2) greater diversity and (3) a different type of phytoplankton community.

Wall (1965), in studying the paleoecological relationships of acritarchs in the Lias of England and South Wales, found them to have an environmentally controlled distribution. He noted a low phytoplankton diversity and domination of "inshore, partly enclosed" environments by members of the Acanthomorphitae (*Micrhystridium* and *Baltisphaeridium*). These findings have been backed up by other similar studies which together help to explain the differences in phytoplankton at the Stowe Creek and Fontenelle Creek sections and further support the restricted embayment postulated by Royse and others (1975). The boreal sea which had pushed southward and expanded laterally into the region of the Stowe Creek section was relatively shallow and its restricted nature probably precluded the spread of anything but a limited Micrhystridium community. Only to the north and northwest toward the deeper, open sea could a varied dinoflagellate community flourish with a slightly more varied acritarch flora during transgressive pulses into the embayed area.

ZONE III: Overlying zone II is an interval represented by 550 feet (167.6 meters) of interbedded siltstone and shale at the Stowe Creek section. This zone is reduced to about 230 feet (70.0 meters) of predominantly shale at the Fontenelle Creek section. Figure 6 illustrates the reduction of section in this interval based on the correlation of transgressive and regressive pulses below and above. Few samples from this interval of the Stowe Creek section proved productive. There, the coarser sediments suggest a regressive period of increased tectonic activity in the southernmost part of the Idaho-Wyoming Thrust Belt in middle Bear River time which apparently did not affect the Fontenelle Creek section until late Bear River time. Terrestrial percentages are high during this time in the Fontenelle Creek section suggesting a similar regressive phase with a dominance of shoreline, swampy (?) inaperturates but much less clastic sediments than to the south. Units 13 and 14 at the Fontenelle Creek section are part of this regressive phase and contain sediments locally containing burrowing, plant roots and some small, delicate gymnosperm-like cones.

A period of non-deposition cannot be ruled out as a possible factor in shortening this stratigraphic interval at the Fontenelle Creek section but no biostratigraphic data collected seems to justify the existence of such an hiatus.

ZONE IV: The last nearly complete regression of the sea (Pb11234-Pb11637) marks the beginning of latest Bear River time. and zone IV (see Figure 6). The relative abundance of marine microfossils increases to a maximum in each section (Pb11238-Pb11644) just below the Bear River Formation-Aspen Shale contact. Productivity of samples in this interval and into the base of the Aspen Shale is low and precludes a more complete understanding of the transition into the presumably more offshore environment of the Aspen Shale.

Smiths Formation Type Section: The abbreviated nature of this section lends itself only to a very generalized interpretation of its environment of deposition. The sediments are entirely dark shale with no interbeds of limestone or coarser clastics. Relative marine abundances are rather low with gymnosperms as a whole generally more abundant and spores and angiosperms less abundant than at the two sections to the south. The combination of these trends for terrestrial species suggests a closer proximity to true uplands or elevated, drier sites supporting species with bisaccate pollen and less favoring more poorly drained sites where certain spore producing plants lived. The great relative abundance of inaperturate pollen is striking and suggests extensive swampy (?) areas bordering the embayment or restricted basin possibly dominated by Taxodiaceae-type plants with a relative reduction in the kinds of plants living to the south. Again, however, these trends may be more apparent than real if longshore currents, proximity to river mouths and/or high energy environments have been factors affecting the depositional regime.

Paleoclimate and Paleoecology of the Bear River Formation: Attempts to postulate paleoclimates existing during the Early Cretaceous are at best educated guesses based upon ecological requirements of modern plant family counterparts. As seen from Table 4 this is very generalized with many families being presently found in all three latitudinal belts. The two basic unproven and tenuous assumptions which must be made in these types of interpretations are: (1) fossil pollen and spores can be related to modern families on the basis of morphologic similarity and (2) the basic climatic requirements of plant families in the past are analogous to their modern plant counterparts.

The association of families present in the Bear River Formation and shown in Table 4 suggests a subtropical to warm temperate climate for southwestern Wyoming during the middle (?) to late Albian. Quite variable microenvironments for plant growth probably existed in this tectonically active area depending upon local edaphic conditions, nearness to the restricted boreal sea, proximity to the western highlands or rivers draining them, local topography, etc. Slightly elevated sites near the sea with adequate drainage could well have supported many of the gymnosperms such as cycads, ginkgophytes and *Classopollis*-bearing plants as well as some of the bisaccate producing conifers. Some of the bisaccates, however,

Table 4 Climatic distribution of probable modern counterparts of plant families identified in the Bear River Formation and Smiths Formation. (P = present but not commonest occurrence, C = commonest occurrence; WT = warm temperate)

Family	Climatic Distribution			Comments
	Tropical	Subtropical	Temperate	
Sphagnaceae	P	P	C	bogs and ponds with low pH
Lycopodiaceae	C	C	P	moist environments
Selaginellaceae	C	C	C	moist environments
Cyatheaceae	C	C	P, WT	montane forests
Dicksoniaceae	C	C	P	
Gleicheniaceae	C	C	P, WT	drier sites
Osmundaceae	C	C	C	swampy or damp
Polypodiaceae	C	C	P	forests and humid areas
Schizaeaceae	C	P	P	
Ginkgoaceae			C, WT	
Cycadophyta		C	P, WT	
Araucariaceae		C	C	southern hemisphere
Cupressaceae		C	C, WT	
Pinaceae		P	C	northern hemisphere
Podocarpaceae		C	P	southern hemisphere
Taxaceae		C	C	
Taxodiaceae		C	C, WT	
Ephedraceae	C	C	C	arid sites

probably represent the small air-borne fraction brought from the tectonically active uplands in central Idaho.

The exact habitat of Classopollis-bearing plants has been widely discussed and disputed. Most authors have considered them to have inhabited coastlines (Wall, 1965; Hughes and Moody-Stuart, 1967; Hughes, 1973) or floodplain and true uplands (Medus and Pons, 1967; Vakhrameev, 1970). Batten (1975) in recently restudying the paleoecology of Wealden (Neocomian) plant communities in England, believes that Classopollis-bearing plants occupied mangrove-type or sandy beaches, bars and barrier islands during transgressive stages. During periods of regression, however, they occupied "upland" sites consisting of slightly elevated sites on the floodplain whose edaphic conditions differed greatly from adjacent soils. Srivastava (1976) also suggests that Classopollis-bearing plants "occupied well-drained soils of upland slopes as well as lowlands near coastal areas preferring the warm climates of transgressive seas." In both these cases the pollen of Classopollis-bearing plants would reflect relatively local vegetation when compared with the pollen from true uplands in montane regions.

The abundance, relatively good preservation and widespread stratigraphic and geographic distribution of Classopollis in samples of this study would indicate the local nature of its parent plant(s) distribution near the sea and in association with a variety of other gymnosperms as Batten's flexible model suggests.

The bryophytic spore genera suggest the existence of continually wet sites possibly in the uplands where extensive communities of these small plants could grow in close proximity to streams and poorly drained slopes. In such environments their spores could easily be carried to the sea. Some of the bryophytic spores could also be representative of local bogs and ponds of low pH. The pteridosperm genus Vitreisporites (Caytoniaceae) is also a significant element of the flora (especially in the Smiths Formation type section) but very little is presently known about its paleoecological requirements. Even xerophytic plants such as those producing Ephedroid pollen (Equisetosporites) are represented in the palynoflora of the region, however, they may have been carried from great distances.

A discussion of the paleoenvironmental significance of select plant groups as the angiosperms, inaperturates and microplankton has been included in the previous section in relationship to their vertical distributions.

The significance of microfloral diversity in paleoecological interpretations has been treated by Cousminer (1961). Information on total marine and terrestrial diversity and pollen and spore diversity was tabulated in this study in hopes of supplementing relative abundance percentages of palynomorph groups. Diversity information, for example, helps to indicate whether abundance increases are the result of a sudden "bloom" of one or several taxa or an adaptive peak for a more diverse and stable group of plants. The latter appears to have occurred in the following samples: Pb11642 and Pb11618 for marine forms, pollen and spores; Pb11221 and Pb11212 for pollen and spores; and Pb11231 and Pb11105 for pollen. These could be interpreted as particularly favorable adaptive periods for the floras involved; however, some of the abrupt changes in diversity just noted can be explained in part by sedimentological factors causing a distinct lithologic change from sediments below and/or above. Other samples such as Pb11234, Pb11628 and Pb11633 show little diversity change but abrupt changes in the relative abundances and nature of palynomorph groups, especially spores. These samples are all from zone III and occur in thick shale units. The relative enrichment of spores in these thick shales during short intervals suggests a temporary change in sediment source to areas occupied by a greater abundance of these plants, probably more poorly drained sites on the coastal plain.

Zonation of the Bear River Formation: The four part division of the Stowe Creek and Fontenelle Creek sections already outlined provides the best means for zonation of the Bear River Formation (see Figure 6). These four zones are admittedly not time equivalent, being based on lithologic facies and terrestrial-marine percentages, but they are useful in understanding the depositional history and associated environments of the Bear River Formation.

Attempts to create a zonation based on first and/or last occurrences of index species and key assemblages failed because of the facies differences controlling key groups at the Stowe Creek and Fontenelle Creek sections. These facies differences have already been discussed in relationship to the distribution of dinoflagellates and angiosperms, these two groups being the most useful for time correlations and zonation. Additional studies of stratigraphic sections exhibiting intermediate environments of deposition are needed to carry time lines between these two sections and discover which species were responding to evolutionary rather than paleoenvironmental changes.

Sufficient similarity between the exposed part of the Smiths Formation type section and the Stowe Creek and Fontenelle Creek sections does not exist in order to make correlations or determine to which zone(s) the Smiths Formation might belong. According to the relative stratigraphic placement of Rubey (1975), however, that part of the type section studied would fit in the lower middle part of the Bear River Formation.

CONCLUSIONS

1) The analysis of palynomorphs in two sections of the Bear River Formation and one of the upper part of the Smiths Formation at its type locality has resulted in the differentiation of 113 distinct entities assignable to 30 genera of trilete spores, 1 genus of monolete spores, 1 genus of spores-incertae sedis, 16 genera and 4 groups of gymnosperm pollen, 9 genera of angiosperm pollen, 15 genera of dinoflagellate cysts and 6 genera of acritarchs.

2) The Bear River Formation at the sections studied and the upper part of the Smiths Formation studied at its type locality are middle (?) to late Albian in age.

3) The palynoflora of the Bear River Formation compares most favorably with palynofloras of similar age in Western Canada and the Western Interior of the United States as previously reported by others.

4) The Bear River Formation exposed at the Stowe Creek and at the Fontenelle Creek sections are correlated and can be divided into four zones on the basis of lithologic facies, fluctuations in the relative abundance of select plant groups and transgressive and regressive cycles.

5) The palynofloral assemblage suggests that the paleoclimate in southwestern Wyoming during the deposition of the Bear River Formation was probably subtropical to warm temperate with quite

variable local environments controlled by factors such as nearness to the sea, edaphic conditions, topography, microclimate, etc.

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APPENDICES

APPENDIX A

Taxonomic Listing
(Alphabetical by Group)

No.		Slide No.	Coordinates	Plate	Figure	Page
	TRILETE SPORES					
1	*Acanthotriletes varispinosus* Pocock	Pb11642-6	30.6 X 109.8	1	1	29
2	*Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann	Pb11602-5	35.5 X 115.4	1	2	29
3	*Appendicisporites potomacensis* Brenner	Pb11220-4	43.6 X 114.3	1	3	30
4	*A. problematicus* (Burger) Singh	Pb11602-2	38.3 X 113.8	1	4	30
5	*A.* sp.	Pb11602-5	38.2 X 127.8	1	5	30
6	*Biretisporites potoniaei* Delcourt and Sprumont	Pb11205-3	34.2 X 117.1	1	6	31
7	*Camarozonosporites ambigens* (Fradkina) Playford	Pb11642-5	34.7 X 114.9	1	7	32
8	*Cicatricosisporites hallei* Delcourt and Sprumont	Pb11602-5	33.8 X 118.4	1	8	32
9	*C. minor* (Bolkhovitina) Pocock	Pb11607-4	41.7 X 124.9	1	9	33
10	*C. subrotundus* Brenner	Pb11618-1	39.5 X 126.1	2	1	33
11	*C. venustus* Deak	Pb11602-5	47.7 X 112.3	1	10, 11	33
12	*C.* sp.	---------	------------	-	-	34
13	*Cingutriletes clavus* (Balme) Dettmann	Pb11642-6	39.0 X 116.8	2	2	34
14	*Concavisporites jurienensis* Balme	Pb11241-3	29.3 X 116.2	2	3	35

No.		Slide No.	Coordinates	Plate	Figure	Page
15	*Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner	Pb11207-1	47.1 X 114.5	2	5	35
16	*C. variverrucatus* (Couper) Brenner	Pb11618-1	37.5 X 123.9	2	4	36
17	*Coronatispora valdensis* (Couper) Dettmann	Pb11616-3	43.7 X 119.3	2	7	36
18	*Costatoperforosporites fistulosus* Deak	Pb11235-4	33.7 X 116.4	2	8	37
19	*Cyathidites australis* Couper	Pb11208-1	40.6 X 115.7	2	10	37
20	*C. minor* Couper	Pb11681-1	40.0 X 112.7	2	9	38
21	*Deltoidospora psilostoma* Rouse	Pb11602-6	43.3 X 124.2	2	6	38
22	*D.* sp. cf. *D. juncta* (Kara-Murza) Singh	Pb11621-1	39.0 X 119.0	2	11	38
23	*Foraminisporis wonthaggiensis* (Cookson and Dettmann) Dettmann	Pb11241-1	35.1 X 122.2	2	13	39
24	*Gleicheniidites senonicus* Ross	Pb11221-1	45.9 X 118.1	2	12	40
25	*G.* sp. cf. *G. circinidites* (Cookson) Dettmann	Pb11639-1	38.0 X 119.3	3	1	40
26	*Klukisporites pseudoreticulatus* Couper	Pb11613-4	35.3 X 117.0	3	2	41
27	"*Koilisporis excavatus*" (Brenner) Pannella (manuscript name)	Pb11602-2	46.0 X 120.4	3	4	41
		Pb11602-1	30.4 X 114.8	3	5	
28	*Kuylisporites lunaris* Cookson and Dettmann	Pb11238-1	37.0 X 116.1	3	3	42
29	*Lycopodiumsporites austroclavatidites* (Cookson) Potonie	Pb11642-6	32.4 X 128.8	3	6	43
30	*Neoraistrickia truncata* (Cookson) Potonie	Pb11613-1	40.6 X 115.5	3	7	44
31	*Ornamentifera echinata* (Bolkhovitina) Bolkhovitina	Pb11607-4	42.6 X 112.1	3	8	44
32	*Osmundacidites wellmanii* Couper	Pb11642-6	37.2 X 116.4	3	10	45
33	*Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont	Pb11602-4	39.7 X 117.5	3	11	45
34	*Psilatriletes radiatus* Brenner	Pb11211-4	46.9 X 113.8	3	9	46
35	*Stereisporites antiquasporites* (Wilson and Webster) Dettmann	Pb11218-1	33.0 X 122.0	3	12	46
36	*Todisporites minor* Couper	Pb11232-2	30.8 X 122.9	3	13	46
37	*Trilobosporites minor* Pocock	Pb11215-2	48.4 X 109.7	4	1	47
38	Triporoletes reticulatus (Pocock) Playford	Pb11602-5	38.9 X 125.7	4	2	48

No.		Slide No.	Coordinates	Plate	Figure	Page
39	*Undulatisporites* *undulapolus* Brenner	Pb11237-4	34.6 X 116.4	4	3	48
40	*Verrucosisporites* *rotundus* Singh	Pb11618-1	26.2 X 115.7	4	4	49
41	*V*. sp.	Pb11642-6	37.5 X 116.1	4	5	49
	MONOLETE SPORES					
42	*Laevigatosporites* *ovatus* Wilson and Webster	Pb11208-4	33.3 X 122.9	4	6	50
	SPORES-INCERTAE SEDIS					
43	*Schizosporis* *parvus* Cookson and Dettmann	Pb11208-1	42.1 X 113.2	4	7	51
44	*S*. *reticulatus* Cookson and Dettmann	Pb11212-2	44.8 X 118.2	4	9	51
	GYMNOSPERM POLLEN					
45	*Abies*-type pollen	Pb11602-5	38.7 X 113.0	4	8	51
46	*Araucariacites* *australis* Cookson	Pb11229-4	33.4 X 118.7	4	10	52
47	*A*. *limbatus* (Balme) Habib	Pb11229-2	40.4 X 123.9	4	11	52
48	*Callialasporites* *dampieri* (Balme) Dev	Pb11213-1	44.1 X 119.2	4	12	52
49	*Cedripites* *cretaceus* Pocock	Pb11212-2	35.0 X 116.6	5	1	53
50	*Classopollis* *classoides* Pflug, emend. Pocock and Jansonius	Pb11237-1	36.5 X 115.8	5	2	54
		Pb11681-1	33.3 X 118.7	5	3	
51	*Cycadopites* sp.	Pb11609-5	36.8 X 117.2	5	4	54
52	*Eucommiidites* *minor* Groot and Penny	Pb11208-1	34.0 X 116.4	5	5	55
53	*E*. *troedssonii* Erdtman	Pb11229-4	38.1 X 113.0	5	6	55
54	*Equisetosporites* *multicostatus* (Brenner) Norris	Pb11642-6	40.8 X 116.8	5	7	56
		Pb11642-6	31.0 X 127.3	5	8	
55	*Exesipollenites* *tumulus* Balme	Pb11639-1	38.8 X 120.5	5	9	56
56	*Ginkgocycadophytus* *nitidus* (Balme) de Jersey	Pb11216-1	30.5 X 119.2	5	10	57

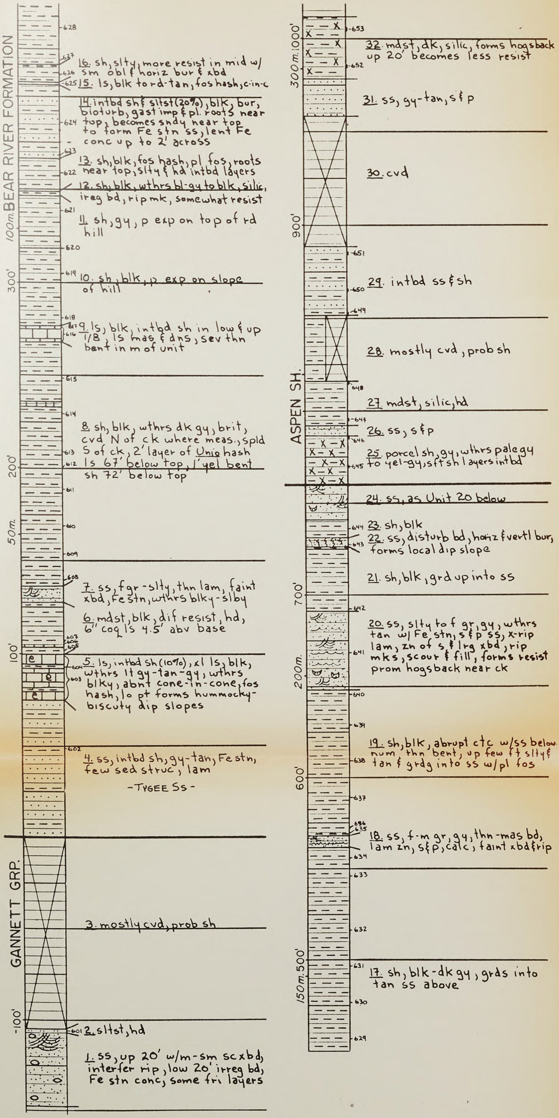
No.		Slide No.	Coordinates	Plate	Figure	Page
57	*Inaperturopollenites* sp. 1	Pb11642-6	37.7 X 127.0	5	12	58
58	*I.* sp. 2	Pb11642-6	43.9 X 118.5	5	13	59
		Pb11642-6	40.7 X 117.1	5	14	
59	*I.* sp. 3	Pb11202-1	44.3 X 122.0	5	11	59
60	*Laricoidites* *gigantus*	Pb11231-1	32.7 X 112.0	5	16	60
61	*L.* *magnus* (Potonie) Potonie, Thomson and Thiergart	Pb11635-1	28.1 X 117.6	5	15	60
62	*Monosulcites* sp.	Pb11642-6	38.7 X 117.3	5	17	61
		Pb11220-1	39.3 X 117.6	5	18	
63	*Perinopollenites* sp. cf. *P.* *elatoides* Couper	Pb11216-5	38.1 X 117.2	5	19	61
64	*Phyllocladidites* sp.	Pb11602-1	44.8 X 118.4	5	20	62
65	*Pinus* - *Picea*-type pollen	Pb11238-1	46.8 X 118.6	6	1	63
66	Large *Podocarpus*-type pollen	Pb11609-1	42.6 X 118.0	6	6	63
67	Small *Podocarpus*-type pollen	Pb11232-5	32.5 X 121.9	6	3	63
68	*Rugubivesiculites* *rugosus* Pierce	Pb11640-1	34.8 X 124.3	6	4	64
		Pb11610-2	44.7 X 121.6	6	5	
69	*Vitreisporites* *pallidus* (Reissinger) Nilsson	Pb11642-6	35.0 X 127.1	6	6	64
	ANGIOSPERM POLLEN - MONOSULCATE					
70	*Clavatipollenites* *minutus* Brenner	Pb11642-5	42.1 X 110.9	6	7	65
71	*Liliacidites* *dividuus* (Pierec) Brenner	Pb11208-1	26.0 X 126.7	6	8	65
72	*L.* *peroreticulatus* (Brenner) Singh	Pb11642-5	40.3 X 115.2	6	9	66
		Pb11642-5	42.2 X 117.8	6	10	
73	*L.* *textus* Norris	Pb11208-1	28.7 X 128.7	6	11	66
		Pb11642-6	42.4 X 116.3	6	12	
	ANGIOSPERM POLLEN - TRICOLPATE					
74	*Cupuliferoidaepollenites* *minutus* (Brenner) Singh	Pb11642-5	42.8 X 115.5	6	13	66
		Pb11684-6	37.4 X 115.5	6	14	

No.		Slide No.	Coordinates	Plate	Figure	Page
75	*Psilatricolpites parvulus* (Groot and Penny) Norris	Pb11217-4	26.0 X 118.0	6	15	67
		Pb11642-5	33.7 X 114.9	6	16	
		Pb11217-4	29.0 X 112.7	6	17	
76	*P.* sp.	Pb11212-2	42.0 X 119.5	6	18	67
77	*Retitricolpites georgensis* Brenner	Pb11642-5	45.8 X 115.0	6	20	68
		Pb11205-2	41.3 X 121.5	6	21	
78	*R. prosimilis* Norris	Pb11208-1	37.4 X 116.7	6	22	68
		Pb11231-4	39.1 X 115.6	6	23	
79	*R. vulgaris* Pierce	Pb11208-4	37.7 X 110.2	6	25	68
		Pb11228-2	35.0 X 122.5	6	26	
80	*Striatopollis paraneus* (Norris) Singh	Pb11642-6	33.6 X 128.4	6	24	69
81	*Tricolpites crassimurus* (Groot and Penny) Singh	Pb11687-1	30.6 X 122.0	6	27	70
82	*T. micromumus* (Groot and Penny) Singh	Pb11219-1	31.9 X 111.7	6	28	70
83	*T.* sp.	Pb11205-1	33.9 X 117.9	6	29	70
	ANGIOSPERM POLLEN - TRICOLPORATE					
84	*Nyssapollenites albertensis* Singh	Pb11642-6	37.6 X 129.4	6	19	71
	ANGIOSPERM POLLEN - INCERTAE SEDIS					
85	*Asteropollis asteroides* Hedlund and Norris	Pb11205-3	36.7 X 114.6	7	1	71
		Pb11227-4	34.4 X 117.4	7	2	
		Pb11211-4	31.7 X 115.2	7	3	
	DINOFLAGELLATES					
86	*Chlamydophorella nyei* Cookson and Eisenack	Pb11647-1	35.5 X 112.8	9	1	82
87	*Cleistosphaeridium multispinosus* (Singh) Brideaux	Pb11215-1	34.4 X 126.6	9	6	84
88	*Cyclonephelium* sp. A	Pb11618-1	42.8 X 115.7	9	7	85

No.		Slide No.	Coordinates	Plate	Figure	Page
89	Deflandrea sp. 1	Pb11618-1	32.1 X 122.8	7	8	75
90	D. sp. 2	Pb11618-1	40.0 X 125.8	7	9	76
		Pb11618-2	36.8 X 116.6	7	10	
91	Dinopterygium sp. A	Pb11642-6	34.6 X 123.8	7	5	73
92	Hexagonifera sp. cf. H. chlamydata Cookson and Eisenack	Pb11642-6	33.4 X 127.4	8	3	77
93	Muderongia sp. 1	Pb11681-1	37.8 X 124.4	8	10	80
		Pb11681-1	36.5 X 112.4	8	7	
94	M. sp. 2	Pb11687-1	46.4 X 119.2	8	8	81
		Pb11687-5	29.3 X 125.5	8	9	
95	Odontochitina costata Alberti, emend. Clarke and Verdier	Pb11607-4	31.3 X 117.1	8	4	78
96	Oligosphaeridium anthophorum (Cookson and Eisenack) Davey	Pb11613-1	39.8 X 112.4	9	2	82
97	O. complex (White) Davey and Williams	Pb11607-4	39.5 X 123.4	9	3	83
		Pb11607-4	37.3 X 115.9	9	4	
98	Palaeoperidinium cretaceum Pocock	Pb11613-2	43.9 X 127.0	8	1	77
		Pb11613-1	33.5 X 108.2	8	2	
99	Pareodinia sp. cf. P. ceratophora Deflandre, emend. Gocht	Pb11610-1	35.0 X 122.1	7	7	75
100	Pseudoceratium ? sp.	Pb11681-1	37.1 X 119.8	8	5	79
		Pb11687-1	47.2 X 116.9	8	6	
101	Spinidinium vestitum Brideaux	Pb11613-2	37.2 X 118.5	7	4	72
102	Spiniferites sp. cf. S. cingulatus (O. Wetzel) Sarjeant	Pb11607-1	35.2 X 120.6	7	6	73
103	Tanyosphaeridium sp. A	Pb11618-1	39.0 X 126.2	9	5	83
	ACRITARCHS					
104	Baltisphaeridium sp.	Pb11210-2	40.5 X 119.3	9	8	85
		Pb11210-1	34.8 X 117.2	9	9	
105	Leiofusa jurassica Cookson and Eisenack	Pb11610-1	27.8 X 125.9	10	8	90

No.		Slide No.	Coordinates	Plate	Figure	Page
106	*Micrhystridium bifidum* Davey	Pb11642-5	45.5 X 128.8	9	10	86
		Pb11642-5	27.2 X 117.2	9	11	
107	*M. fragile* Deflandre	Pb11654-1	37.4 X 119.1	9	12	86
108	*M. inconspicuum* (Deflandre) Deflandre	Pb11208-1	46.4 X 111.0	10	1	87
		Pb11653-1	29.8 X 116.9	10	2	
109	*M.* sp. cf. *M. densispinium* Valensi	Pb11607-4	41.4 X 122.9	10	3	87
		Pb11232-5	32.2 X 118.8	10	4	
110	*M.* sp. cf. *M. piliferum* Deflandre	Pb11653-1	35.9 X 121.1	10	5	88
111	*Palaeostomocystis fragilis* Cookson and Eisenack	Pb11208-1	31.6 X 128.7	10	10	90
112	*Pterospermopsis australiensis* Deflandre and Cookson	Pb11642-5	40.1 X 116.6	10	9	90
113	*Veryhachium* sp. cf. *V. europaeum* Stockmans and Williere forma 1 Wall and Downie	Pb11642-1	42.3 X 120.0	10	6	89
		Pb11642-1	45.1 X 123.3	10	7	

APPENDIX B-2 Fontenelle Creek Section: NE¼ Sec. 5, T. 24 N., R. 115 W., Lincoln County, Wyoming. Vertical Scale: 1" = 50' (15.2 m) Sample numbers noted at right of diagrammatic lithologic column, e.g., 601, 602, etc. These numbers are preceded by Pb11___, e.g., Pb11601, Pb11602, etc. Section described, measured and sampled by the author.



16. sh, slty, more resist in mid w/ sm obl & horiz bur & xbd

15. ls, blk to rd-tan, fos hash, c-in-c

14. intbd sh & sltst (20%), blk, bur, bioturb, gast imp & pl. roots near top, becomes sndy near top to form Fe stn ss, lent Fe conc up to 2' across

13. sh, blk, fos hash, pl fos, roots near top, slty & hd intbd layers

12. sh, blk, wthrs bl-gy to blk, silic, ireg bd, rip mk, somewhat resist

11. sh, gy, p exp on top of rd hill

10. sh, blk, p exp on slope of hill

9. ls, blk, intbd sh in low & up 1/8, ls mas & dns, sev thn bent in m of unit

8. sh, blk, wthrs dk gy, brit, cvd N of ck where meas., spld S of ck, 2' layer of *Unio* hash ls 67' below top, 1' yel bent sh 72' below top

7. ss, f gr-slty, thn lam, faint xbd, Fe stn, wthrs blky-slby

6. mdst, blk, dif resist, hd, 6" coq ls 4.5' abv base

5. ls, intbd sh (10%), xl ls, blk, wthrs lt gy-tan-gy, wthrs blky, abnt cone-in-cone, fos hash, lo pt forms hummocky-biscuty dip slopes

4. ss, intbd sh, gy-tan, Fe stn, few sed struc, lam

-TYGEE Ss-

3. mostly cvd, prob sh

2. sltst, hd

1. ss, up 20' w/m-sm sc xbd, interfer rip, low 20' irreg bd, Fe stn conc, some fri layers

32. mdst, dk, silic, forms hogsback up 20' becomes less resist

31. ss, gy-tan, s & p

30. cvd

29. intbd ss & sh

28. mostly cvd, prob sh

27. mdst, silic, hd

26. ss, s & p

25. porcel sh, gy, wthrs pale gy to yel-gy, sft sh layers intbd

24. ss, as Unit 20 below

23. sh, blk

22. ss, disturb bd, horiz & vertl bur, forms local dip slope

21. sh, blk, grd up into ss

20. ss, slty to f gr, gy, wthrs tan w/ Fe stn, s & p ss, x-rip lam, zn of s & lrg xbd, rip mks, scour & fill, forms resist prom hogsback near ck

19. sh, blk, abrupt ctc w/ss below. num thn bent, up few ft slty & tan & grdg into ss w/pl fos

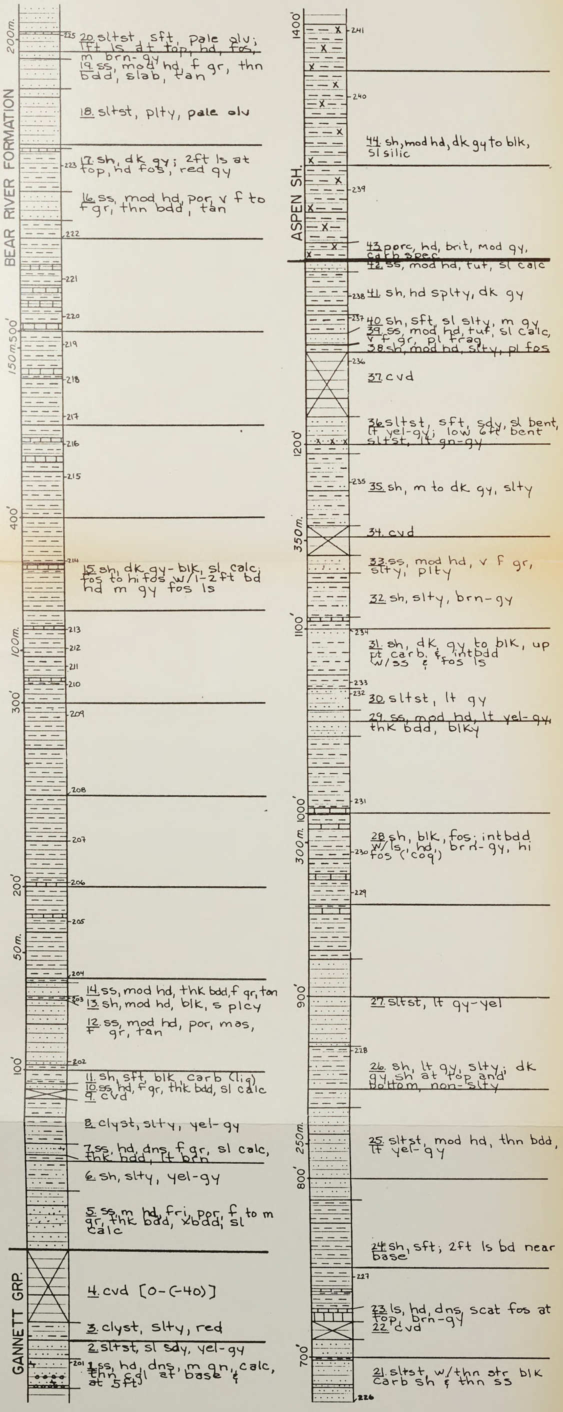
18. ss, f-m gr, gy, thn-mas bd, lam zn, s & p, calc, faint xbd & rip

17. sh, blk-dk gy, grds into tan ss above

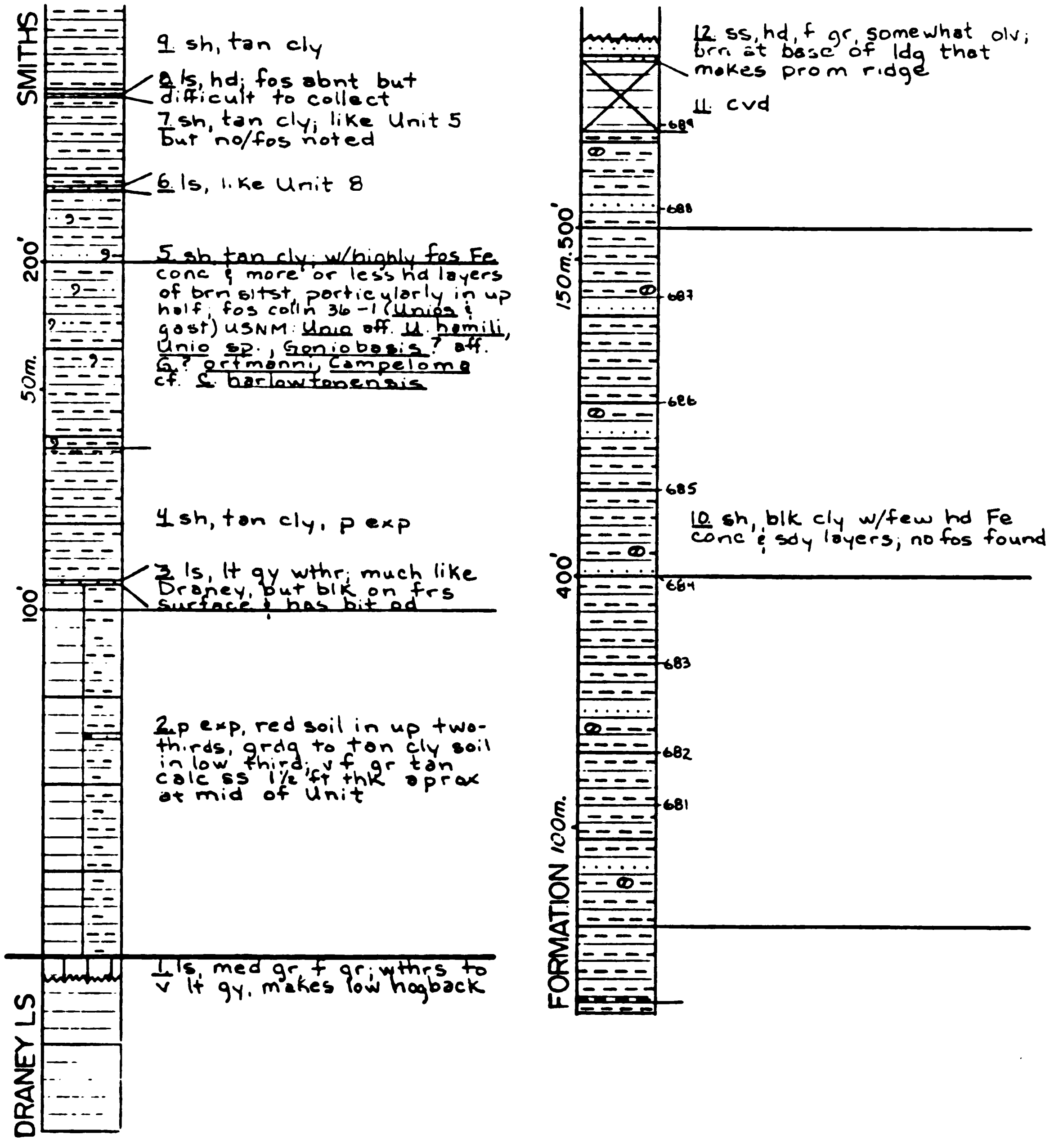
APPENDIX B

Stratigraphic Sections

APPENDIX B-1 Stowe Creek Section: Sec. 21, 22, T. 14 N., R. 119 W., Uinta County, Wyoming. Vertical Scale: 1" = 50' (15.2 m) Sample numbers noted at right of diagrammatic lithologic column, e.g., 201, 202, etc. These numbers are preceded by Pb11___, e.g., Pb11201, Pb11202, etc. Section described, measured and sampled by geologists of Chevron U.S.A., Inc.



APPENDIX B-3 Smiths Formation Type Section: NW¼, NE¼ Sec. 27, T. 29 N., R. 118 W., Lincoln County, Wyoming. Vertical Scale: 1" = 50' (15.2 m) Sample numbers noted at right of diagrammatic lithologic column, e.g., 681, 682, etc. These numbers are preceded by Pb11___, e.g., Pb11681, Pb11682, etc. Section described and measured by W. W. Rubey and sampled by the author.



Note: Units 1 to 11 constitute the "lower shale member" of Rubey (1973). Unit 12 is the lower 5 feet of Rubey's "upper sandstone member" which forms a ledge that makes a prominent ridge at the type locality.

APPENDIX C

Sample Information

Stowe Creek Section

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
Gannett Grp.				
ss	spot [1]	-62 (-18.9)	Chev.-SC-1	Pb11201
Bear River Fm.				
sh	"	105 (32.0)	" 2	Pb11202 *
"	"	139 (42.4)	" 3	Pb11203
lignite	"	150 (45.7)	" 4	Pb11204
marl	"	181 (55.2)	" 5	Pb11205 *
sh	"	202 (61.6)	" 6	Pb11206
"	"	225 (68.6)	" 7	Pb11207 *
"	"	250 (76.2)	" 8	Pb11208 *
"	"	293 (89.3)	" 9	Pb11209 *
marl	"	310 (94.5)	" 10	Pb11210 *
sh	"	320 (97.5)	" 11	Pb11211 *

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[1] 6 to 12 inch (15 to 30 centimeter) interval collected in a pit up to 2½ feet (76 centimeters) below the surface.

* Productive samples which were used as the data base in this study.

Note: Samples 6/22/77 I-1 to 6/22/77 I-6 were collected on the north side of Fontenelle Creek; all other samples in this section (6/22/77 I-7 to 6/22/77 I-34, 6/23/77 I-1 to 6/23/77 I-10 and 9/17/77 I-1 to 9/17/77 I-9) were collected south of the creek.

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
sh	spot	330 (100.6)	Chev.-SC-12	Pb11212 *
"	"	340 (103.6)	" 13	Pb11213 *
"	"	377 (114.9)	" 14	Pb11214 *
"	"	422 (128.6)	" 15	Pb11215 *
"	"	441 (134.4)	" 16	Pb11216 *
"	"	455 (138.7)	" 17	Pb11217 *
"	"	474 (144.5)	" 18	Pb11218 *
"	"	493 (150.3)	" 19	Pb11219 *
"	"	508 (154.8)	" 20	Pb11220 *
sh-marl	"	528 (160.9)	" 21	Pb11221 *
sh	"	550 (167.6)	" 22	Pb11222 *
"	"	588 (179.2)	" 23	Pb11223
sltst	"	658 (200.6)	" 25	Pb11225
"	"	675 (205.7)	" 26	Pb11226
sh	"	745 (227.1)	" 27	Pb11227
sltst	"	871 (265.5)	" 28	Pb11228 *
sh	"	957 (291.7)	" 29	Pb11229 *
"	"	978 (298.1)	" 30	Pb11230 *
"	"	1007 (306.9)	" 31	Pb11231 *
"	"	1065 (324.6)	" 32	Pb11232 *
"	"	1071 (326.4)	" 33	Pb11233
"	"	1099 (335.0)	" 34	Pb11234 *
"	"	1179 (359.4)	" 35	Pb11235 *
"	"	1245 (379.5)	" 36	Pb11236
"	"	1268 (386.5)	" 37	Pb11237

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
sh	spot	1280 (390.1)	Chev.-SC-38	Pb11238 *
Aspen Shale				
sh	"	1337 (407.5)	" 39	Pb11239
"	"	1378 (420.0)	" 40	Pb11240
"	"	1422 (433.4)	" 41	Pb11241 *
Fontenelle Creek Section				
Gannett Grp.				
sltst	spot	-106 (-32.3)	6/22/77 I-1	Pb11601
Bear River Fm.				
mdst	"	48 (14.6)	" 2	Pb11602 *
ls	composite	75-100 (22.9-30.5)	6/22/77 I- 3	Pb11603
sh & ls	spot	93 (28.3)	" 4	Pb11604
mdst	"	102 (33.1)	" 5	Pb11605
ls	"	105 (32.0)	" 6	Pb11606
mdst	"	106 (32.3)	" 7	Pb11607 *
bent. & sh	"	139 (42.4)	" 8	Pb11608 *
sh	"	153 (46.6)	" 9	Pb11609 *
"	"	168 (51.2)	" 10	Pb11610 *
"	"	188 (57.3)	" 11	Pb11611
ls	"	200 (61.0)	" 12	Pb11612 *
sh	"	208 (63.4)	" 13	Pb11613 *
"	"	228 (69.5)	" 14	Pb11614 *
bent.	"	248 (75.6)	" 15	Pb11615
sh & ls	composite	268-274 (81.7-83.5)	" 16	Pb11616 *

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
ls	spot	276 (84.1)	6/22/77 I-17	Pb11617
sh	"	282 (86.0)	" 18	Pb11618 *
"	"	305 (93.0)	" 19	Pb11619
"	"	318 (96.9)	" 20	Pb11620
"	"	338 (103.0)	" 21	Pb11621 *
"	"	358 (109.1)	" 22	Pb11622 *
"	"	366 (111.6)	" 23	Pb11623
"	"	386 (117.7)	" 24	Pb11624 *
"	"	407 (124.1)	" 25	Pb11625
"	"	412 (125.6)	" 26	Pb11626
"	"	418 (127.4)	" 27	Pb11627
"	"	437 (133.2)	" 28	Pb11628 *
"	"	457 (139.3)	" 29	Pb11629 *
"	"	477 (145.4)	" 30	Pb11630 *
"	"	497 (151.5)	" 31	Pb11631 *
"	"	517 (157.6)	" 32	Pb11632 *
"	"	547 (166.7)	" 33	Pb11633 *
"	"	557 (169.8)	" 34	Pb11634
"	"	569 (173.4)	6/23/77 I- 1	Pb11635 *
bent.	"	572 (174.3)	" 2	Pb11636
sh	"	589 (179.5)	" 3	Pb11637 *
"	"	609 (185.6)	" 4	Pb11638
"	"	629 (191.7)	" 5	Pb11639 *
"	"	646 (196.9)	" 6	Pb11640
ss	"	668 (203.6)	" 7	Pb11641

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
sh	spot	692 (210.9)	6/23/77 I- 8	Pb11642 *
"	"	727 (221.6)	" 9	Pb11643
"	"	736 (224.3)	" 10	Pb11644 *
Aspen Shale				
porcel.	2 ft. chan.	769-771 (234.4-235.0)	9/17/77 I- 1	Pb11645
"	"	784-786 (239.0-239.6)	" 2	Pb11646
"	"	794-796 (242.0-242.6)	" 3	Pb11647 *
"	"	814-816 (248.1-248.7)	" 4	Pb11648
sh & sltst	"	852-854 (259.7-260.3)	" 5	Pb11649
ss	"	864-866 (263.3-264.0)	" 6	Pb11650
porcel.	"	884-886 (269.4-270.1)	" 7	Pb11651
sltst	"	984-986 (299.9-300.5)	" 8	Pb11652
sh	"	1004-1006 (306.0-306.6)	" 9	Pb11653 *
Smiths Formation Type Section				
sh	spot	335 (102.1)	6/15/77 I- 1	Pb11681 *
"	"	350 (106.7)	" 2	Pb11682 *
"	"	375 (114.3)	" 3	Pb11683 *
"	"	400 (121.9)	" 4	Pb11684 *
"	"	425 (129.5)	" 5	Pb11685 *
"	"	450 (137.2)	" 6	Pb11686 *
"	"	480 (146.3)	" 7	Pb11687 *

Lithology	Sample Type	Feet (Meters) Above Base	Collection No.	Accession No.
sh	spot	505 (153.9)	6/15/77 I- 8	Pb11688 *
"	"	530 (161.5)	" 9	Pb11689 *

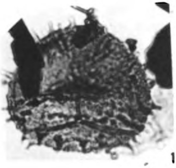
PLATES

PLATE 1

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Acanthotriletes varispinosus* Pocock	29
2	*Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann; X500	29
3	*Appendicisporites potomacensis* Brenner	30
4	*Appendicisporites problematicus* (Burger) Singh	30
5	*Appendicisporites* sp	30
6	*Biretisporites potoniaei* Delcourt and Sprumont	31
7	*Camarozonosporites ambigens* (Fradkina) Playford	32
8	*Cicatricosisporites hallei* Delcourt and Sprumont	32
9	*Cicatricosisporites minor* (Bolkhovitina) Pocock	33
10, 11	*Cicatricosisporites venustus* Deak; proximal view (Figure 10) and distal view (Figure 11)	33

PLATE I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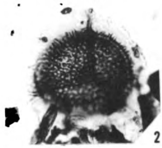
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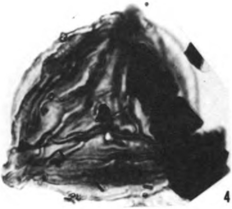
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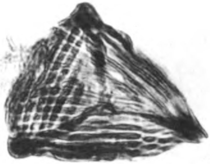
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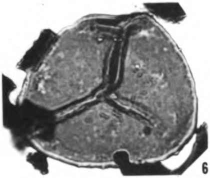
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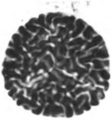
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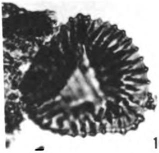
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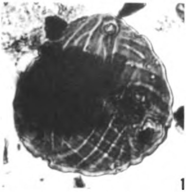
PLATE 2

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Cicatricosisporites subrotundus* Brenner	33
2	*Cingutriletes clavus* (Balme) Dettmann	34
3	*Concavisporites jurienensis* Balme	35
4	*Concavissimisporites variverrucatus* (Couper) Brenner	36
5	*Concavissimisporites punctatus* (Delcourt and Sprumont) Brenner	35
6	*Deltoidospora psilostoma* Rouse; X500	38
7	*Coronatispora valdensis* (Couper) Dettmann	36
8	*Costatoperforosporites fistulosus* Deak	37
9	*Cyathidites minor* Couper	38
10	*Cyathidites australis* Couper	37
11	*Deltoidospora* sp. cf. *D. juncta* (Kara-Murza) Singh	38
12	*Gleicheniidites senonicus* Ross	40
13	*Foraminisporis wonthaggiensis* (Cookson and Dettmann) Dettmann	39

PLATE 2



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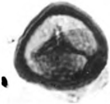

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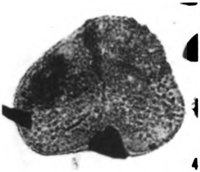

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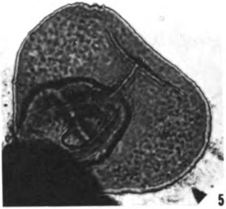

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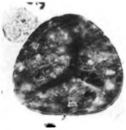

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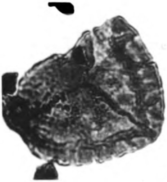

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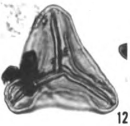

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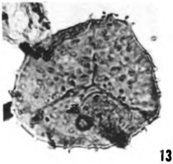

13

PLATE 3

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Gleicheniidites* sp. cf. *G. circinidites* (Cookson) Dettmann	40
2	*Klukisporites pseudoreticulatus* Couper	41
3	*Kuylisporites lunaris* Cookson and Dettmann	42
4, 5	"*Koilisporis excavatus*" (Brenner) Pannella; manuscript name in Pannella (1966, p. 48, pl. 4, fig. 3)	41
6	*Lycopodiumsporites austroclavatidites* (Cookson) Potonie	43
7	*Neoraistrickia truncata* (Cookson) Potonie	44
8	*Ornamentifera echinata* (Bolkhovitina) Bolkhovitina	44
9	*Psilatriletes radiatus* Brenner	46
10	*Osmundacidites wellmanii* Couper	45
11	*Pilosisporites trichopapillosus* (Thiergart) Delcourt and Sprumont	45
12	*Stereisporites antiquasporites* (Wilson and Webster) Dettmann	46
13	*Todisporites minor* Couper	46

PLATE 3

1

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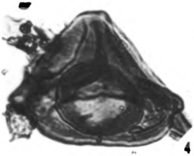

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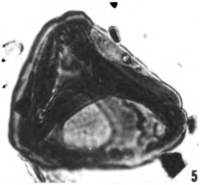

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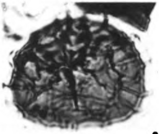

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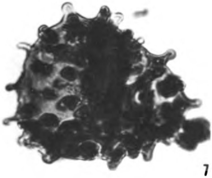

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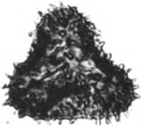

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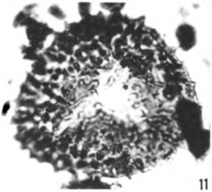


11

12

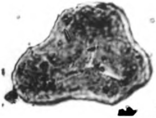
13

PLATE 4

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Trilobosporites minor* Pocock	47
2	*Triporoletes reticulatus* (Pocock) Playford; X500	48
3	*Undulatisporites undulapolus* Brenner	48
4	*Verrucosisporites rotundus* Singh	49
5	*Verrucosisporites* sp	49
6	*Laevigatosporites ovatus* Wilson and Webster	50
7	*Schizosporis parvus* Cookson and Dettmann; X500	51
8	*Abies*-type pollen; X500	51
9	*Schizosporis reticulatus* Cookson and Dettmann; X500	51
10	*Araucariacites australis* Cookson; X500	52
11	*Araucariacites limbatus* (Balme) Habib; X500	52
12	*Callialasporites dampieri* (Balme) Dev	52

PLATE 4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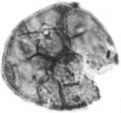
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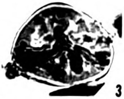
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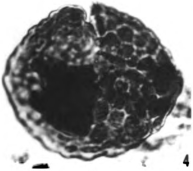
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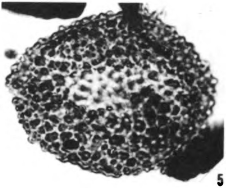
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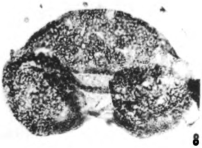
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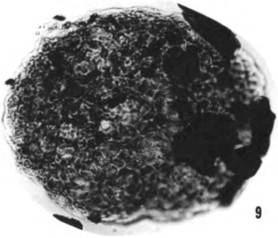
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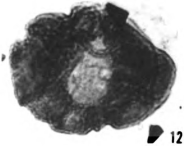
12

PLATE 5

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Cedripites cretaceus* Pocock; X500	53
2, 3	*Classopollis classoides* Pflug, emend., Pocock and Jansonius; single grain (Figure 2) and tetrad (Figure 3)	54
4	*Cycadopites* sp	54
5	*Eucommiidites minor* Groot and Penny	55
6	*Eucommiidites troedssonii* Erdtman	55
7, 8	*Equisetosporites multicostatus* (Brenner) Norris	56
9	*Exesisporites tumulus* Balme	56
10	*Ginkgocycadophytus nitidus* (Balme) de Jersey	57
11	*Inaperturopollenites* sp. 3	59
12	*Inaperturopollenites* sp. 1	58
13, 14	*Inaperturopollenites* sp. 2	59
15	*Laricoidites magnus* (Potonie) Potonie, Thomson and Thiergart; X500	60
16	*Laricoidites gigantus* Brenner; X500	60
17, 18	*Monosulcites* sp	61
19	*Perinopollenites* sp. cf. *P. elatoides* Couper	61
20	*Phyllocladidites* sp.; X500	62

PLATE 5


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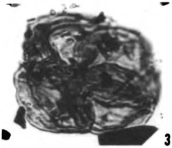
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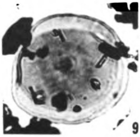
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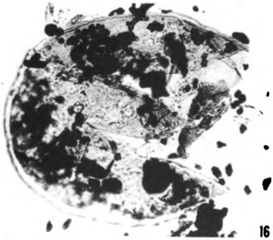
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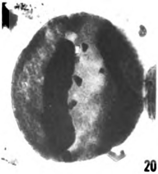
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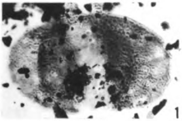
PLATE 6

(All figures X1000 unless otherwise stated)

Figure		Page
1	*Pinus* - *Picea*-type pollen; X500	63
2	Large *Podocarpus*-type pollen; X500	63
3	Small *Podocarpus*-type pollen; X500	63
4, 5	*Rugubivesiculites rugosus* Pierce; X500	64
6	*Vitreisporites pallidus* (Reissinger) Nilsson	64
7	*Clavatipollenites minutus* Brenner	65
8	*Liliacidites dividuus* (Pierce) Brenner	65
9, 10	*Liliacidites peroreticulatus* (Brenner) Singh	66
11, 12	*Liliacidites textus* Norris	66
13, 14	*Cupuliferoidaepollenites minutus* (Brenner) Singh	66
15-17	*Psilatricolpites parvulus* (Groot and Penny) Norris; single grains (Figures 15, 16) and tetrad (Figure 17)	67
18	*Psilatricolpites* sp	67
19	*Nyssapollenites albertensis* Singh	71
20, 21	*Retitricolpites georgensis* Brenner	68
22, 23	*Retitricolpites prosimilis* Norris	68
24	*Striatopollis paraneus* (Norris) Singh	69
25, 26	*Retitricolpites vulgaris* Pierce	68
27	*Tricolpites crassimurus* (Groot and Penny) Singh	70
28	*Tricolpites micromunus* (Groot and Penny) Singh	70
29	*Tricolpites* sp	70

PLATE 6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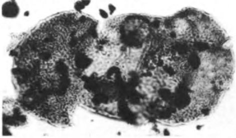
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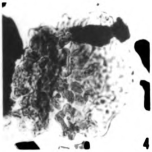
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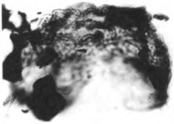
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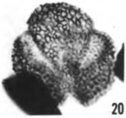
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PLATE 7

(All figures X750 unless otherwise stated)

Figure		Page
1-3	*Asteropollis asteroides* Hedlund and Norris; single grains (Figures 1, 2) and cluster of grains (Figure 3); X1000	71
4	*Spinidinium vestitum* Brideaux	72
5	*Dinopterygium* sp. A	73
6	*Spiniferites* sp. cf. *S. cingulatus* (O. Wetzel) Sarjeant	73
7	*Pareodinia* sp. cf. *P. ceratophora* Deflandre	75
8	*Deflandrea* sp. 1	75
9, 10	*Deflandrea* sp. 2	76

PLATE 7


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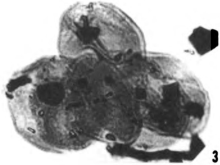
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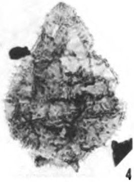
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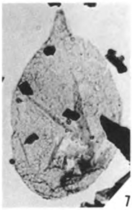
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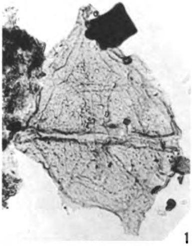
PLATE 8

(All figures X750 unless otherwise stated)

Figure		Page
1, 2	*Palaeoperidinium cretaceum* Pocock	77
3	*Hexagonifera* sp. cf. *H. chlamydata* Cookson and Eisenack	77
4	*Odontochitina costata* Alberti, emend. Clarke and Verdier	78
5, 6	*Pseudoceratium* ? sp.; X500	79
7, 10	*Muderongia* sp. 1; X500	80
8, 9	*Muderongia* sp. 2; X500	81

PLATE 8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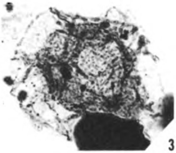
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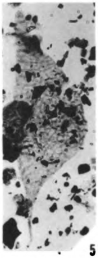
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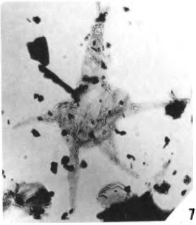
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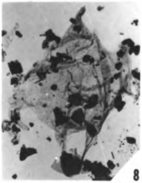
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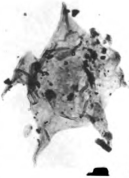
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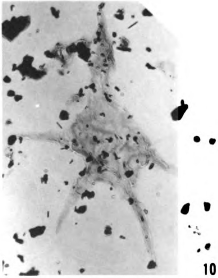
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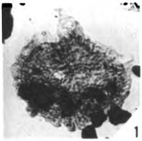
PLATE 9

(All figures X750 unless otherwise stated)

Figure		Page
1	*Chlamydophorella nyei* Cookson and Eisenack	82
2	*Oligosphaeridium anthophorum* (Cookson and Eisenack) Davey	82
3, 4	*Oligosphaeridium complex* (White) Davey and Williams; single specimen (Figure 3) and detached operculum composed of 4 plates (Figure 4)	83
5	*Tanyosphaeridium* sp. A	83
6	*Cleistosphaeridium multispinosus* (Singh) Brideaux	84
7	*Cyclonephelium* sp. A	85
8, 9	*Baltisphaeridium* sp.; X1000	85
10, 11	*Micrhystridium bifidum* Davey; X1000	86
12	*Micrhystridium fragile* Deflandre; X1000	86

PLATE 9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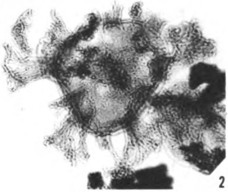
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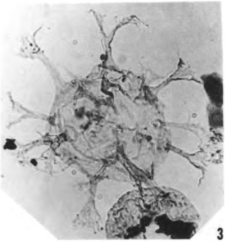
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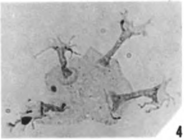
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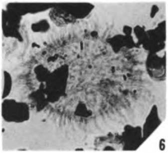
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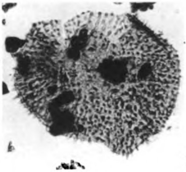
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12

PLATE 10

(All figures X1000 unless otherwise stated)

Figure		Page
1, 2	*Micrhystridium inconspicuum* (Deflandre) Deflandre	87
3, 4	*Micrhystridium* sp. cf. *M. densispinium* Valensi	87
5	*Micrhystridium* sp. cf. *M. piliferum* Deflandre	88
6, 7	*Veryhachium* sp. cf. *V. europaeum* Stockmans and Williere forma 1 Wall and Downie	89
8	*Leiofusa jurassica* Cookson and Eisenack	90
9	*Pterospermopsis australiensis* Deflandre and Cookson	90
10	*Palaeostomocystis fragilis* Cookson and Eisenack; X500	90

PLATE 10


1


3


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6


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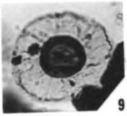
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