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PALYNOLOGY AND PALEOECOLOGY OF UPPER CRETACEOUS - LOWER TERTIARY STRATA, PRICE CANYON, UTAH

Volume I

By

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ABSTRACT

PALYNOLOGY AND PALEOECOLOGY OF UPPER CRETACEOUS - LOWER TERTIARY STRATA, PRICE CANYON, UTAH

By

Myung S. Yi

Forty-five palynologically productive samples from the Price Canyon Section were analyzed. A flora of 246 different palynomorphs (pollen, spores, algae, and fungi) was differentiated. These are reviewed, illustrated, and compared to palynomorphs from other related floras. 1 new genus, 36 new species, 13 new combinations, and 1 emended genus are tentatively designated.

The qualitative and quantitative analyses enabled the establishment of four biostratigraphic zones, i.e. K1, K2, T1, and T2, in ascending order. Relative ages of the strata of the study section were correlated with other sections in western North America.

Paleoenvironments controlling the floras that produced the palynomorph assemblages are considered. The K1 zone, representing the Castlegate Sandstone and the Price River Formation, was interpreted as late Campanian in age (79-73Ma). K2 zone represents the Cretaceous interval of the North Horn Formation, and it is postulated as early Maastrichtian in age (73-69Ma). There is a hiatus, between zones K2 and T1, which includes the Cretaceous - Tertiary boundary. The T1 zone represents the early part of the Paleocene interval present in the North Horn Formation. It is middle Paleocene in age (61.5-60Ma). A minor hiatus is postulated to separate zones T1 and T2. The T2 zone represents the later part of Paleocene interval of North Horn Formation, which is considered here to be the upper Paleocene in age (59.5-56Ma).

Paleoenvironments that produced the palynoflora are analyzed by cluster analysis. The depositional site of the sediments accumulated with the palynoflora of the Castlegate and Price River Formation is interpreted as a floodplain of a large river. A suite of lacustrine, coal swamp or marsh, and lakeside deposits characterize the Cretaceous beds at the base of the North Horn Formation, and the Paleocene section of North Horn is also associated with a large fresh-water lake and associated swamps, and lacustrine deltas.

A significant number of recycled pollen and spores were identified during this study. These are principally Lower Cretaceous and Upper Jurassic with a few older species.

To my parents for their endurance and encouragement.

ACKNOWLEDGMENTS

I am deeply grateful to Professor Aureal T. Cross, Department of Geological Sciences and Department of Botany and Plant Pathology, Michigan State University, who directed this research. Thanks go also to Dr. R. E. Taggart, Department of Botany and Plant Pathology and Department of Geological Sciences, and Drs. C. E. Prouty and R. L. Anstey, Department of Geological Sciences, who served on the advisory committee in addition to Dr. Cross (chairman).

Dr. Cross directed the field study and collected additional samples. Dr. L. R. Parker, California Polytechnic State University encouraged me in the field. Mr. J. K. Balsley, Mitchell Energy Corporation, kindly allowed me to attend the American Association Petroleum Geologists Field Trip conducted in the vicinity of the study area.

Mr. R. C. Brown prepared a part of samples for the SEM study. Dr. D. F. Sibley allowed me to use his SEM facility. Mr. R. E. Carroll shared valuable discussions.

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1. STATEMENT OF PROBLEM

SCOPE

The study area in east-central Utah, U.S.A., lies west of the extensive series of Upper Cretaceous transgressive and regressive shoreline sediments, deposited along the western shore of the epicontinental sea, that occupied the region of the present cetral Rocky Mountains and Great Plains of the United States at that time. Following the retreat of the sea from the area, the zone of coastal deposites were overlain by sediments representing lake or lake margin, or braided stream deposits. Shifts in elevation and areal extent of the mesocordilleran highlands to the west, cyclical tectonic activity in the region, and compaction of sediments resulted in delta progradation and oscillating, eastward-shifting shorelines from the area. Proximity to the sea, and later to large inland lakes, was probably a major factor in amelioration of temperature and consequent uniformity of vegetation in the region studied. Extensive angiosperm diversification during this time span, and the change of plant communities and patterns of succession through Cretaceous - Tertiary boundary time, have been controlled by paleogeography, orogenies, or extraterrestrial events, according to present hypotheses. Palynologists have contributed information that should aid in the resolution of the true history of the Late Cretaceous - early Tertiary events. Palynomorphs extracted from a certain rock sample may be biased by the local environmental conditions that controlled the parent plants or plant community, the conditions of preservation, and other factors such as provincialism, latitudinal positions, etc. Such combinations of factors have obscured the stratigraphic and ecologic value of palynomorphs. In spite of this, much valuable information is available from studies of the stratigraphic and geographic distribution of palynomorphs.

PURPOSE

The goals of this study are to demonstrate the following, on the basis of palynology:

The position of the Cretaceous - Tertiary boundary or hiatus (located somewhere in the North Horn Formation).

The sequence of floras which characterize this important time period (Castlegate Sandstone, Price River Formation, and North Horn Formation). Angiospermous pollen are abundant in these strata. They represent flowering plants that were evolving very rapidly, and were widely distributed during this time span. These evolutionary changes were rapid enough to be differentiated stratigraphically in the Castlegate, Price River, and North Horn sequences.

The types of environments in which the sediments were deposited.

The environmental factors controlled the distribution mosaic of the palynomorphs. The distribution mosaic of palynomorphs produced by the extant floras was largely influenced by environments of living communities and sedimentary basins where palynomorphs were transported and deposited.

The identifiable spatial and temporal relationships in the distribution of the reworked palynomorphs indicate episodic rise and continuous denudation of the mesocordilleran highlands to the west. The concomitant deposition of reworked palynomorphs with indigenous floras provides evidence for the rate and time of erosion of the headlands which were the source of the sediments. As the headward-cutting streams dissected older and older rocks, the successively older palynomorphs freed from those rocks were transported and re-deposited with successively younger indigenous pollen and spores.

2. PREVIOUS STUDIES

GEOLOGY

Numerous studies have been conducted in this area, most of which have dealt with the economic potential of the coal-bearing Upper Cretaceous strata. Earliest papers include the reconnaissance surveys accomplished by Taff (1905, 1906) and Richardson (1909). Spieker and Reeside (1925), Clark (1928), Erdmann (1934), and Fisher (1936) have contributed to broaden the knowledge of the geology and stratigraphy of this area.

The third generation of east-central Utah geological research includes Young (Young, 1955, 1957), who described the facies changes between the Mesaverde Group and the intertonguing Mancos Shale (1955). He suggested the cyclic nature of deposits of Late Cretaceous strata describing marine shales, littoral marine sandstones, lagoonal deposits, and coals in ascending order (1957). Katich (1954), Johnson (1956), and Abbott and Liscomb (1956) are among the individuals who have contributed to the study of the stratigraphic correlation of the Book Cliffs and Wasatch Plateau area. Hale and Van De Graaff (1964) constructed a paleogeographic map based on the interpretation of facies patterns. A stratigraphic study in central Utah by McGookey in 1960 focused on the early Tertiary strata, including the North Horn Formation and the Flagstaff Member of the Green River Formation. Recently several master's thesis studies were conducted on the stratigraphy in the Price Canyon and nearby areas, including Russon (1987) and Carroll (1987). Several field guide books (Rigby, 1968; Cross *et al.*,1975; and Fouch *et al.*,1976) were valuable aids in this study to establish the formational boundaries as well as to study the exposed section.

In the Price Canyon section, paleontological studies are limited in number. La Rocque (1956, 1960) reported on the Tertiary mollusks in the North Horn

Formation and Flagstaff Member of the Green River Formation. Beard(1959) conducted his master's thesis research on the microfossils, including foraminifers, ostracods, and charophytes, in the western Book Cliffs including the Price Canyon section. Fouch *et al.*(1987) reported on the measurement and study of the North Horn Formation and the Flagstaff Member of the Green River Formation in this section, and they also established it as a principal reference section. Their study included not only the stratigraphy and lithology, but also the mineralogic and paleontologic analyses of different types of fossils as well.

PALYNOLOGY

The earliest palynologic study in the Rocky Mountain region was presented by Wodehouse (1933), on the taxonomy and systematics of pollen from the Eocene Green River Formation. Since that time, there has been a great amount of data accumulated on the Late Cretaceous and early Tertiary palynomorphs. Many of these studies have focused on the problem of the Cretaceous - Tertiary boundary. Palynologic studies which are relevant to this study will be discussed here describing the occurrences of palynomorph types through time, especially through the boundaries of stages in different regions.

Campanian Records

Relatively few studies have dealt with the guide palynomorphs that can be used to differentiate Campanian assemblages from Maastrichtian ones. Nichols *et al.* (1982) defined the Upper Cretaceous biostratigraphic zones in Wyoming and Montana, and identified these biozones in Utah and Colorado (Figure 1). The *Siberiapollis montanensis* lower subzone of *Aquilapollenites quadrilobus* Interval Zone contains *Siberiapollis montanensis*, *Montanapollis endannulatus*, and possibly *Umbosporites callosus*, *Kuylisporites scutatus*, and *Pseudoplicapollis newmanii*. The

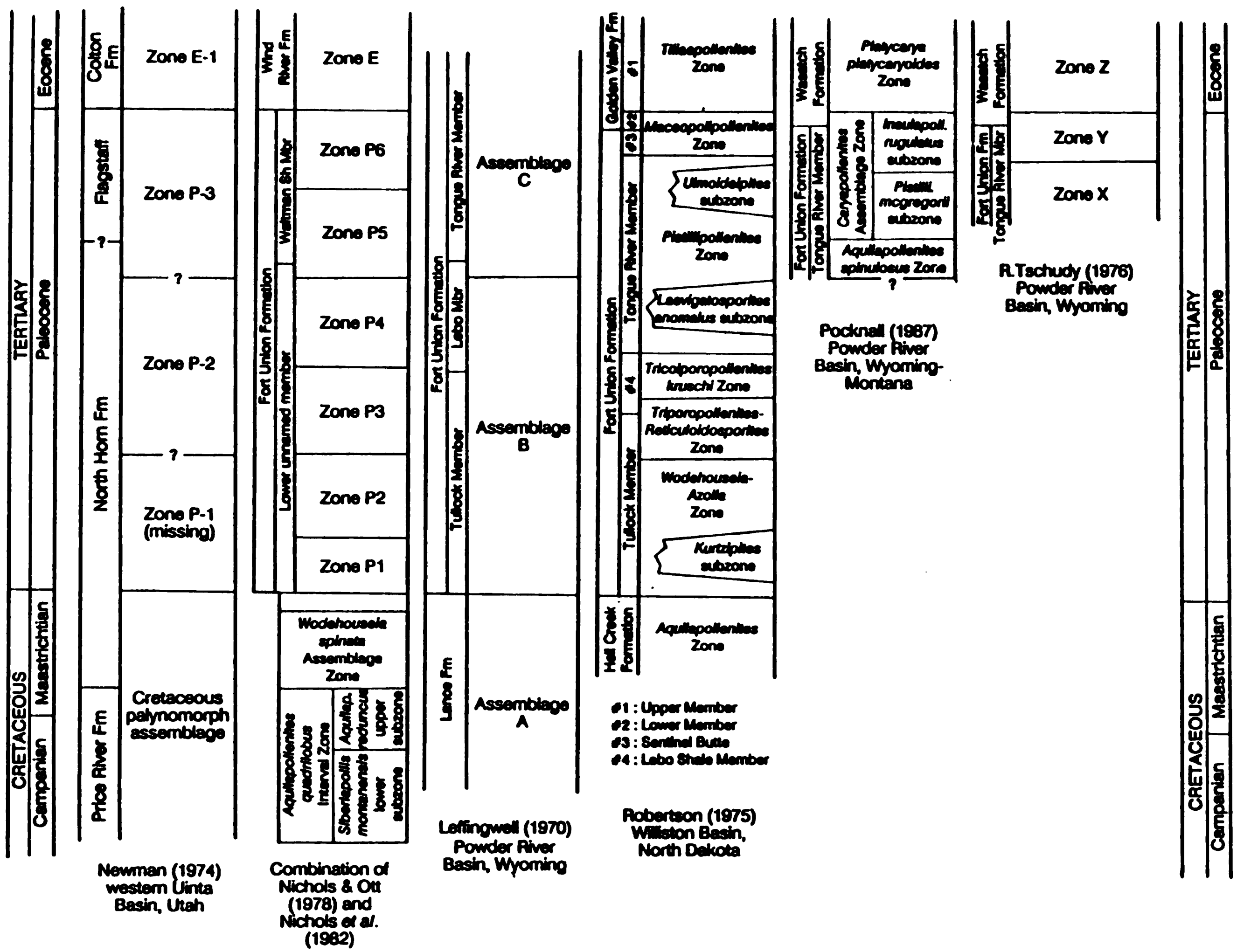

Figure 1. Palynomorph zones of Late Cretaceous and early Tertiary in western North America.

ranges of these species are restricted to this late Campanian lower subzone. *Wodehouseia spinata*, *Pterocarya levis*, and *Aquilapollenites conatus* have ranges restricted to the *Wodehouseia spinata* Assemblage Zone, which is late Maastrichtian in age (Figure 2). In the Alberta region, the *Balmeispoites rarus*, *Aquilapollenites dolium*, *A. trialatus*, and *A. turbidus* assemblage was interpreted as Campanian (Wall and Singh, 1975).

Two extinct angiosperm genera, *Wodehouseia* and *Aquilapollenites*, serve as good stratigraphic markers because of the short duration of ranges, abundant occurrences during this time span, and characteristic forms. In the Rocky Mountain Region, *Aquilapollenites trialatus* var. *uniformis*, *A. tripodiformis*, *A. rigidus*, and *A. trialatus* var. *variabilis* occur only in Campanian strata, while *A. delicatus* var. *collaris*, *A. conatus*, and *A. bertillonites* occur only in Maastrichtian strata. *A. spinulosus*, which makes its earliest known appearance in Maastrichtian, is the only species in this genus which has a Paleocene record (B. Tschudy and Leopold, 1970). Two types of Oculata pollen, *Azonia* and *Wodehouseia*, are used as good stratigraphic markers in the Alaska region. *Azonia recta*, *A. sufflata*, *A. cribrata*, *A. fabacea*, and *A. parva* have only Campanian records, while *Wodehouseia quadrispina*, *W. octospina*, *W. vestivirgata*, *W. edmontonicola*, *W. stanleyi*, *W. campillata*, and *W. avita* have only Maastrichtian records (Wiggins, 1976). In their study of palynomorphs of British Columbia and adjacent Alberta, Rouse *et al.* (1970) reported that *Proteacidites* is a characteristic genus of coastal environments and *Aquilapollenites* is characteristic of more interior locales.

Ranges of some species in the Rocky Mountain Region in the United States are apparently different from those in Alberta, Canada, and the assemblages are not precisely correlated (Norris *et al.*, 1975). It is almost impossible to directly correlate the assemblage of Rocky Mountain taxa with those of eastern North America. These provincial and latitudinal variations may be the result of patterns of the

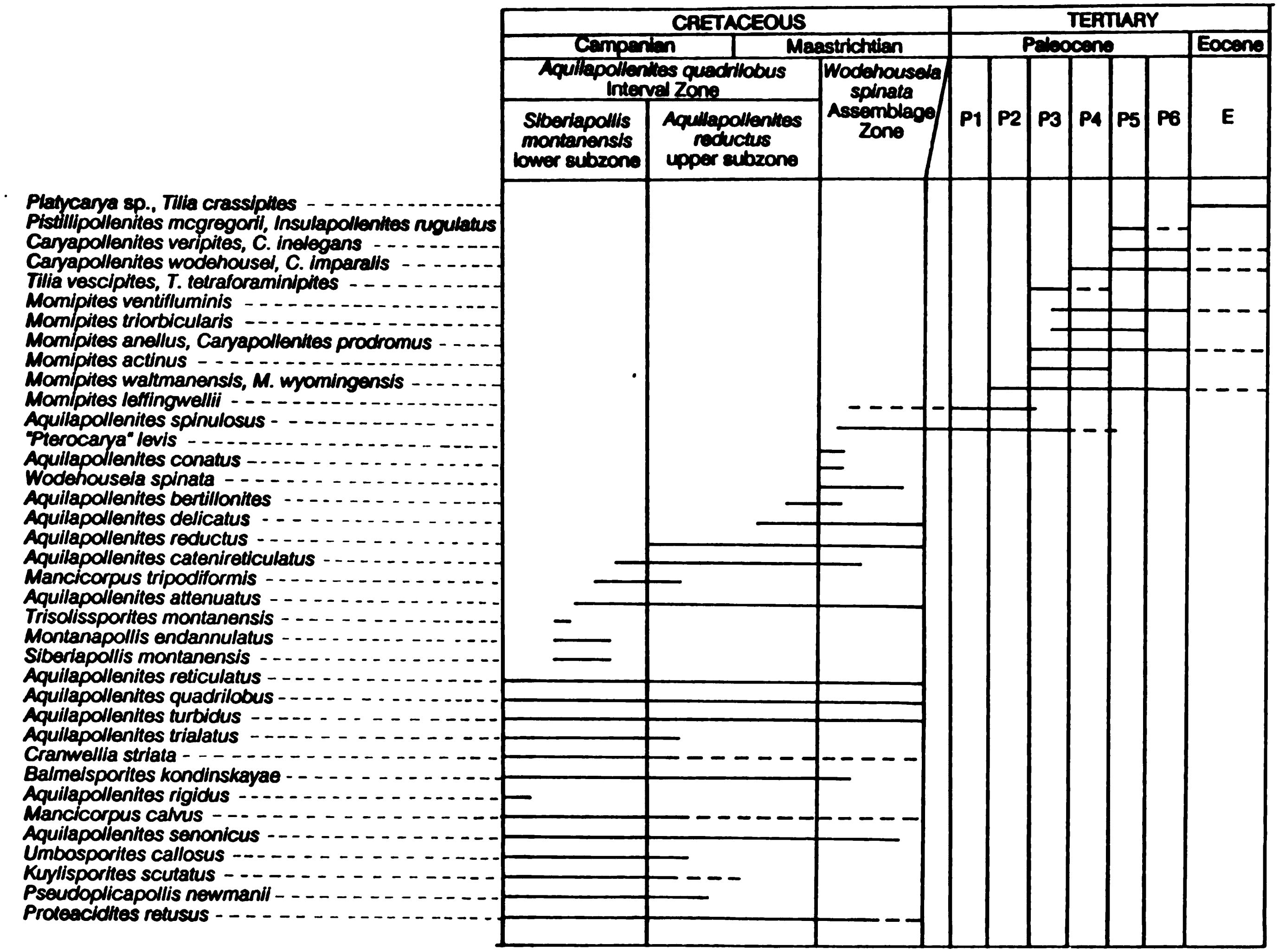

Figure 2. Guide palynomorphs of Late Cretaceous and early Tertiary in the Rocky Mountain Region of the United States. From Nichols *et al.*, 1982 and Nichols and Ott, 1978.

Campanian paleoclimate and the presence of the epicontinental sea during this time. That sea was a more significant barrier than it had been in pre-Campanian time (Nichols *et al.*, 1982).

Maastrichtian Records

The Geological Society of America Special Paper 127 (1970), edited by R. M. Kosanke and A. T. Cross, contributed significantly to broaden the knowledge of Cretaceous - Tertiary Palynology. This includes: Leffingwell's recognition of three palynological zones from upper Lance (Late Cretaceous) to Fort Union (Paleocene) Formations in Powder River Basin, Wyoming; R. Tschudy's Cretaceous - Tertiary index assemblages in Montana and the Mississippi Embayment area; B. Tschudy and Leopold's biostratigraphic as well as taxonomic study of *Aquilapollenites* in the Rocky Mountain Region; Griggs' Late Cretaceous and early Tertiary palynological work in northwestern Washington; study of major differences in floral composition between coast and interior regions in British Columbia and Alberta by Rouse *et al.*; Tappan and Loeblich's discussion of fossil phytoplankton evolution on the basis of distribution in time and space; and Zaitzeff and Cross' demonstration of usefulness of dinoflagellates and acritarchs for zonation and correlation in Texas.

There are widespread tonsteins and an iridium horizon at some outcrops of the Cretaceous - Tertiary boundary in the Western Interior of the United States. Some specialists believe the iridium-rich horizon to have been formed as a result of meteorite impact about 65 Ma. In this region, Cretaceous palynomorph assemblages are confined to the strata below the iridium horizon. Immediately above this zone, at some localities, the palynomorph assemblage shows high proportions of fern spores, the so-called "fern spike", followed by an angiosperm dominated assemblage, possibly indicating the successional recovery by a new plant community sometime after destruction (R. Tschudy and B. Tschudy, 1985).

Provincialism in North America is distinct. In the west, the *Aquilapollenites* province contains characteristic genera such as *Aquilapollenites*, *Cranwellia*, *Scollardia* and *Wodehouseia*. *Aquilapollenites spinulosus* is the only species among *Aquilapollenites* that has a Tertiary record. All the other species of this genus are believed to have become extinct at the end of the Cretaceous. In the east, Normapolles-type pollen are characteristic. Some plants producing this type of pollen evidently crossed the Cretaceous epeiric sea barrier, resulting in scattered Normapolles pollen records in the *Aquilapollenites* province. In the northern part of the Rocky Mountains, there are occasional, isolated Normapolles-type pollen records such as *Interpollis supplingensis*. In the central Rocky Mountains and southward, there is a higher occurrence of Normapolles types in the pollen record such as *Thomsonipollis magnificus* (R. Tschudy, 1980).

The correlation of palynomorph assemblages in the Rocky Mountain Region is complicated by difficulties caused by taxonomic problems in some species and the different stratigraphic ranges of certain species in different localities. R. Tschudy and B. Tschudy (1986) proposed two local provinces in the Western Interior of North America, and set the boundary of these at 40 degrees North latitude. Stratigraphic ranges of guide palynomorphs of the two provinces show the contrast in the palynomorph suites. Though *Gunnera microreticulata* and *Liliacidites complexus* are characteristic Cretaceous palynomorphs in Montana, both species survived into the early Tertiary in Colorado.

Newman (1965, 1974) illustrated guide palynomorphs in the southern Rocky Mountain Region (Colorado and Utah). Characteristic Cretaceous palynomorphs are *Proteacidites* spp. and *Aquilapollenites* spp., whilst *Momipites coryloides*, *Ulmoideipites tricostatus*, *Caryapollenites* spp. and *Pistillipollenites macgregorii* have only Tertiary records. Nichols *et al.* (1982), in their comprehensive study on Cretaceous palynomorph zonation of the central and northern Rocky Mountain Regions, noted that *Mancicorpus tripodiformis*, *Siberiapollis montanensis, Montanapollis endannulatus, Trisolissporites montanensis, Umbosporites callosus, Kuylisporites scutatus, Plicapollis* spp., *Pseudoplicapollis newmanii*, and *P.* spp. have ranges extending up to the *Aquilapollenites quadrilobus* Interval Zone (late Campanian - early Maastrichtian), while *Wodehouseia spinata, Pterocarya levis, Balmeisporites kondinskayae, Cranwellia striata*, and *Aquilapollenites* spp. have ranges up to the *Wodehouseia spinata* Assemblage Zone (late Maastrichtian) (Figures 1 and 2).

In Alberta and the Yukon, ranges of some pollen species show the differences from those of western United States (Table 1). Russell and Singh (1978) determined that floral change in south central Alberta is 0.4 Ma(?) earlier than the extinction of the dinosaurs which is the Cretaceous - Tertiary boundary. In some parts of western United States, strata that includes this interval cannot be found probably due to minor erosion. However, the boundary beds are recognized at several places in the Raton Basin and in the San Juan Basin etc. Sweet reported the angiosperm pollen peak, especially *Syncolporites minimus* and *Triporopollenites plektosus*, immediately above the Cretaceous - Tertiary boundary in Alberta (Jerzykiewicz and Sweet, 1986). Among the species listed in Table 1, *Wodehouseia spinata* and *W. fimbriata* have been recorded both in Cretaceous and Tertiary in Alaska (Wiggins, 1976).

In his pioneer palynological study in the San Juan Basin, Anderson (1960) reported many new forms of palynomorphs. R. Tschudy (1970) reported stratigraphic guide palynomorphs in the Mississippi Embayment regions.

Table 1. Guide palynomorphs of Cretaceous and Tertiary in Alberta and Yukon, Canada (from Russell and Singh, 1978; Snead, 1969; and Rouse and Srivastava, 1972).

CRETACEOUS	TERTIARY
Wodehouseia spinata	*Tricolpites bathyreticulatus*
Cranwellia striata	*T. anguloluminosus*
Tricolpites reticulatus	*Momipites tenuipolus*
Polycolpites granulatus	*Aquilapollenites spinulosus*
Proteacidites spp.	*Momipites inaequalis*
Carpinus subtriangula	*Tilia danei*
Leptolepidites tenuis	*Caryapollenites scabratus*
Schizosporis complexus	*Tilia tetraforaminipites*
Kurtzipites trispissatus	*Vitis* sp. cf. *V.? affluens*
Mancicorpus sp.	*Alnus rubriformis*
Wodehouseia fimbriata	*Ovoidites ligneolus*
Alnus trina	
Aquilapollenites except *A. spinulosus*	

Table 2. Guide palynomorphs on Paleocene - Eocene boundary in Georgia, South Carolina, and Gulf Coast Region (from Frederiksen and Christopher, 1978; Frederiksen, 1980b; and Christopher *et al.*, 1980).

PALEOCENE	EOCENE
Momipites dilatus	*Platycarya platycaryoides*
M. strictus	*Platycaryapollenites swasticoidus*
M. flexus	*Nuxpollenites crockettensis*
M. tenuipolus Group spp.	*N. claibomensis*
Subtriporopollenites anulatus	*Cyrillaceaepollenites megaexactus*
Choanopollenites alabamicus	
Pseudoplicapollis serena	
Retitrescolpites anguloluminosus	
Subtriporopollenites anulatus	
Tricolpites crassus	
Quadrapollenites vagus	
Corollina sp.	

Paleocene Records

There are relatively few studies on palynomorphs from early Tertiary strata in the Rocky Mountain Region. Nichols and Ott (1978) established palynomorph zones in Paleocene and Eocene strata in the Wind River Basin, Wyoming, mainly on the basis of *Momipites* and *Caryapollenites* (Figure 1). In that region, a relatively complete stratigraphic section is present, compared to other areas of western North America. R. Tschudy's western North Dakota study (1976) indicated that the Paleocene - Eocene boundary coincides closely with the boundary between zone Y and zone Z, which coincides with the initial appearance of the *Platycarya* group pollen. Newman (1974), in his study of the palynology of the western Uinta Basin, Utah, suggested 3 Paleocene palynomorph zones (Figure 1). Robertson proposed several palynomorph zones from the uppermost Cretaceous through the Eocene in the Williston Basin, North Dakota (1975). Pocknall (1987) proposed several late Paleocene zones and an early Eocene palynomorph zone in his study of the Powder River Basin, Wyoming and Montana, and compared it with Early Tertiary palynomorph zones proposed earlier (Figure 1). Rouse (1977) suggested four Paleocene palynomorph assemblage zones in western and northern Canada. These zones have not been correlated effectively with other palynomorph zones established in the western United States.

Abundant palynological data of this time span were accumulated by Frederikson and Christopher for the Gulf Coast Region, and they recognized guide palynomorphs useful for distinguishing the Paleocene from Eocene strata (Table 2).

Palynology in the Price Canyon Section

Several earlier preliminary palynological studies in this section are known. Poor palynomorph productivity of samples from this section has probably been caused by rapid deposition of sediments and post-depositional oxidation. Griesbach and MacAlpine (1973) first reported on the palynomorph succession in this section. More than two-thirds of the samples they collected from the North Horn Formation were barren. They reported that representative palynomorphs of the latest Late Cretaceous flora, such as *Proteacidites, Balmeisporites*, and *Aquilapollenites*, are present in strata 60m above the base of the North Horn Formation. However above a 120m barren interval overlying the Cretaceous pollen-bearing stratum, palynomorph succession is interpreted as early Tertiary in age on the basis of the occurrence of *Momipites*. Newman (1974), in his study in the western Uinta Basin at Soldier Summit, reported the earliest Paleocene palynomorph zone to be missing in the North Horn Formation (Figure 1).

Nichols, in conjunction with Fouch *et al.* (1987), also analyzed palynomorphs in samples from the Price Canyon section. He reported that samples from the lowermost 50m of North Horn Formation contain *Tricolpites interangulus, Balmeisporites kondinskayae*, and *Zlivisporis* sp. which are stratigraphically restricted to the Upper Cretaceous strata. The next 275m of strata above in his section constitutes a barren zone, presumably containing the Cretaceous - Tertiary boundary. since a sample from the 330m level yielded middle Paleocene palynomorphs including *Momipites* spp. Samples from the 410m level, and above, yielded late Paleocene palynomorphs including *Caryapollenites* spp. Algal palynomorphs in his samples from the North Horn Formation, such as *Pediastrum paleogeneites, Schizosporis* spp., *Tetraporina* sp. cf. *T. antiqua*, and *Botryococcus* sp. indicate a lacustrine environment. Some samples have a great abundance of *Laevigatosporites haardtii* which indicates a wet environment (Fouch *et al.*, 1987).

II. GEOLOGY

1. GEOGRAPHIC SETTING

LOCATION OF THE STUDY AREA

The study area is located in the Price Canyon, Carbon County, Utah, approximately 20km north of Price, Utah. The studied section extends from SW 1/4, Sec.26, T12S, R9E, following the U.S.highway 6 and 50, to NW 1/4, Sec.5, T12S, R9E, Kyune 7.5 min. Quadrangle. The lower part of the section including the Castlegate Sandstone was measured on the northeast side of Price River. Most of study of rocks above the Castlegate was conducted on the southwest side of highway and along old, abandoned sections of the road (Figure 3).

GENERAL GEOMORPHOLOGY

Price Canyon dissects the east-west trending Cretaceous Book Cliffs and Tertiary Roan Cliffs, which dip gently north and form the southern flank of the Uinta Basin (Figure 3). These sinuous southward-facing cuestaform escarpments extend to Grand Mesa, east of Grand Junction, Colorado, where they form the southern flank of the Piceance Basin. West of the Price Canyon, the escarpment continues to the south and forms the eastern flank of the Wasatch Plateau. The Mancos Shale is exposed south of the Book Cliffs in Castle Valley and Clark Valley. These are broad topographic lowlands developed on the Mancos Shale. This broad lowland is interrupted by San Rafael Swell which was formed during the Tertiary Period. All these features belong to the Colorado Plateau Physiographic Province. Alternating sandstones and shales form the cliff-slope topography over almost all the area. Mirabilite ($Na_2SO_4.10H_2O$) present in the widespread Mancos Shale changes to thenardite (Na_2SO_4) under high summer temperatures, and changes

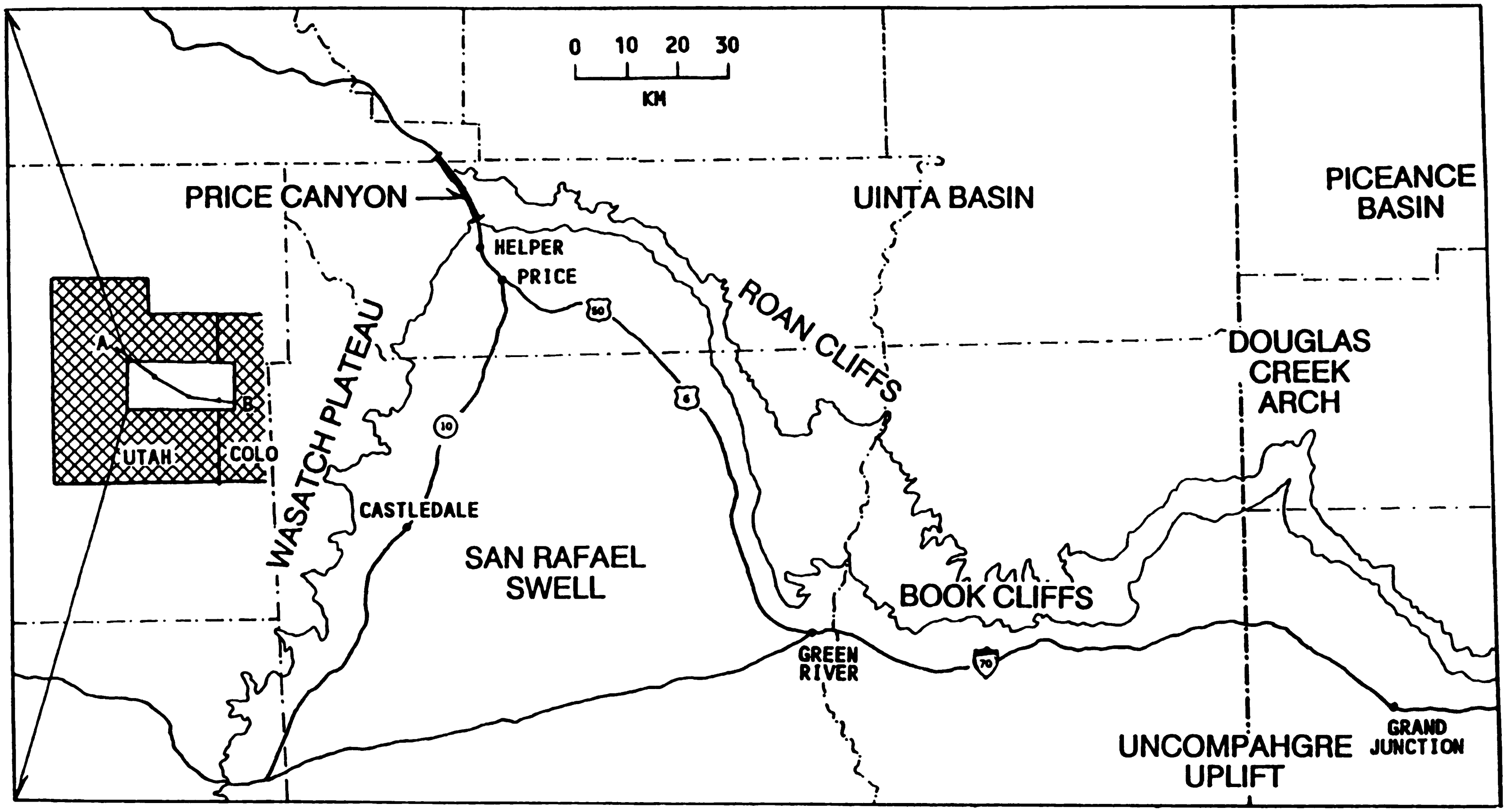

Figure 3. Index map showing the location of study section and surrounding major structural features.

back to mirabilite under decreased temperature. The presence of these salts is hostile to the plant growth, and favorable to the weathering by the continuous expansion and contraction. This caused steep cliff scarps by erosion of the weak Mancos Shale beneath the more resistant sandstone beds which, when undercut, break off to form the steep cliffs (Buss, 1956).

2. GEOLOGIC SETTING

During the Late Cretaceous, periodic tectonism of the mesocordilleran highland to the west and basinal subsidence, as well as compaction of sediments, influenced the sedimentary facies patterns in this area. These tectonic activities include episodes of thrust faulting and local coeval folding in front of the thrusts (Armstrong, 1968; Fouch *et al.*, 1983). These periodic activities of orogeny resulted in the east-west extensive sheet-like sedimentation over the plain that sloped gently eastward to a marine foreland basin with a fluctuating shoreline. During this time, the slow regression was punctuated by pulses of basinal subsidence along with the compaction of sediments which produced transgressions forming marine tongues of the Mancos Shale (Figure 4).

The Cretaceous epicontinental sea withdrew from this region during the latest Campanian or earliest Maastrichtian time. A basin or a series of locally connected basins evolved bounded by such topographically positive features as the San Rafael Swell, Uinta Uplifts, and the Sevier Orogenic Belt which were formed during the Laramide tectonic activity. Diverse interior drainage systems formed other types of sedimentary facies patterns. The North Horn Formation and subsequent strata were deposited in such alluvial or lacustrine environments (Ryder *et al.*, 1976; Fouch *et al.*, 1983)

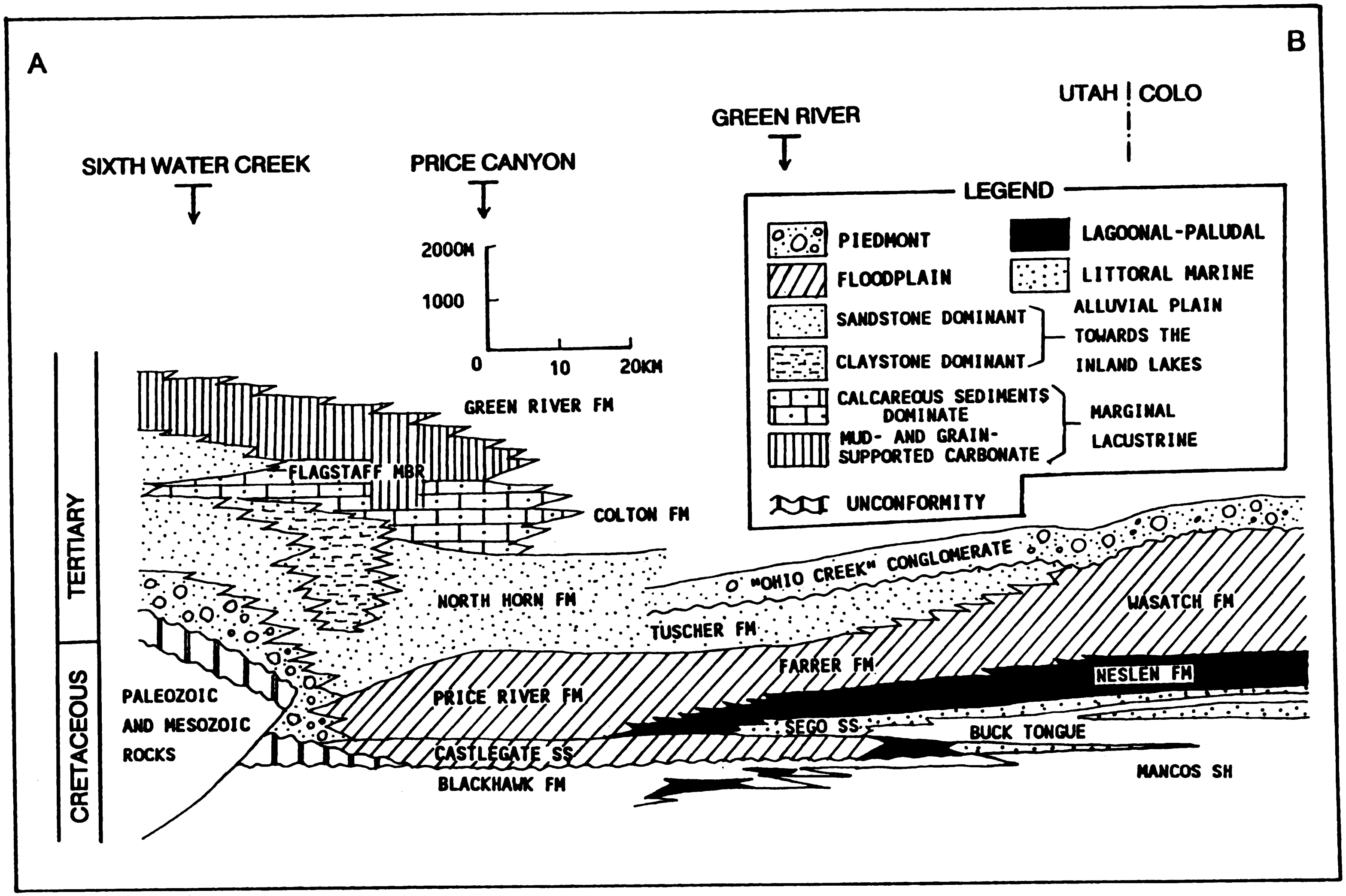

Figure 4. General stratigraphic cross-section of east-central Utah. Combined and modified from Young (1966) and Ryder *et al.* (1976).

3. STRATIGRAPHY

GENERAL STATEMENT

Spieker and Reeside (1925) originally divided the uppermost Cretaceous and lower Tertiary strata in the Wasatch Plateau into the lower and upper members of the Price River Formation, lower member of the Wasatch Formation, and Flagstaff Limestone Member of the Wasatch Formation. Later most of units were elevated to formational status, that is, the Castlegate Sandstone, the Price River Formation, and the North Horn Formation. The Flagstaff Limestone Member of the Wasatch Formation was renamed as the Flagstaff Member of the Green River Formation by Fouch (1976).

The Castlegate Sandstone, disconformably overlying the Blackhawk Formation, forms the most conspicuous cliff in the canyon of the Price River here. The Price River Formation conformably overlies the Castlegate Sandstone. It is comprised of alternating ledges of cliff-forming sandstones and thin zones of slope-forming shales. The contact with the overlying North Horn Formation is gradational and very indefinite in position.

> "It should not be inferred from this that I regard the placement of the boundary, if one exist, as of no importance. Paleontologic studies and petrographic work concentrated on the problem are now in progress. This work is aimed, however, not necessarily at finding the boundary, but rather at finding the facts, and it is recognized that nothing more exact may turn up than a transition zone - which is of course exactly what should turn up if the full geologic record be present. In any event the apparent inconvenience of being unable to map a boundary between the Cretaceous and Tertiary may be set aside as of little real moment in terms of the uniformitarian principle on which modern geologists claim to be working." (Spieker, 1949).

CASTLEGATE SANDSTONE

The Castlegate Sandstone was originally designated by Spieker and Reeside (1925) as the lower member of the Price River Formation. Fisher *et al.* (1960) elevated it to formational status.

At its type locality in Price Canyon, the Castlegate Sandstone consists of white to tan, well-sorted, well-rounded, medium- to fine-grained sandstone intercalated with several very thin zones of carbonaceous materials. This scenic, cliff-forming sandstone formation is 106m thick at its type locality.

During the early Laramide orogeny, a range of mountains formed in central Utah (Spieker, 1949). The thrust-fold activity produced the erosional detritus which formed the extensive complex of sedimentary facies throughout the east-central Utah to western Colorado. The Castlegate Sandstone is comprised of fluvial braided-channel deposits in the Price Canyon area. It merges into conglomeratic, near-source beds to the west. Eastward, the thickness and grain size decrease gradually, merging into nearshore marine, silty mudstones of the Mancos Shale near Grand Junction, Colorado, almost 50km east of its last recognizable position as an offshore marine sandstone, near the Colorado state line (Figure 4 and Figure 5).

PRICE RIVER FORMATION

Spieker and Reeside (1925) applied the name Price River Formation to a series of non-coal-bearing beds above the Blackhawk Formation. Since the Castlegate Sandstone is now considered to be of formational rank, Price River Formation in this study includes the remaining rock sequence overlying the Castlegate Sandstone and underlying the North Horn Formation.

The Price River Formation at its type section, which is the study area is 311m thick, and includes medium- to fine-grained, locally cross-bedded or lenticular sandstones with interbedded siltstones and shales. This formation is distinguished in

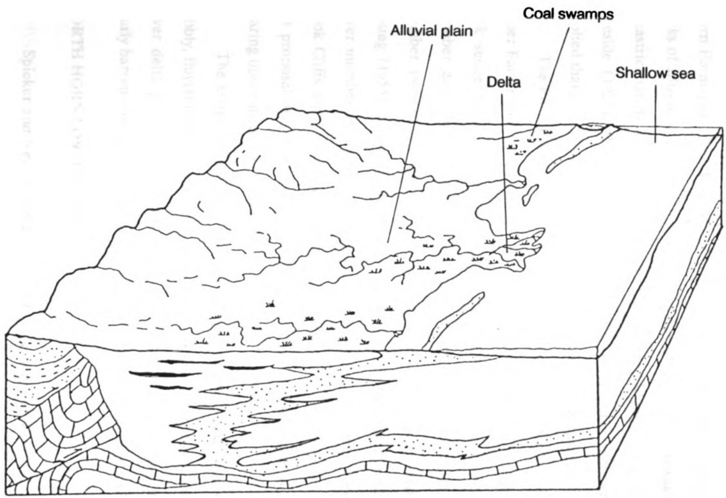

Figure 5. Generalized block diagram showing a wave-dominated deltaic coastal environment. After Hintze (1975).

the field by its slope-forming nature in contrast to the Castlegate Sandstone, and by its more dominant composition of ledge-forming sandstone beds from the North Horn Formation. The Price River Formation is interpreted as being comprised of rocks of alluvial origin (Fouch *et al.*, 1976). Age of the formation was considered as Maastrichtian by Spieker (1946), and Campanian and Maastrichtian by Cobban and Reeside (1925). Fouch *et al.* (1983) in their synorogenic sedimentation study, implied that the age of the Price River Formation is late Campanian.

The Price River Formation was divided into a lower Neslen member and an upper Farrar member by Fisher (1936) in the central Book Cliffs region. The same rock sequences in the eastern Book Cliffs were named as lower Mt.Garfield member and upper Hunter Canyon member by Erdmann (1934). The lower member in both regions contains coal beds, while the upper members do not. Young (1955) proposed that the Neslen Facies be considered equivalent to the lower member of the Castlegate Sandstone and the Price River Formation in the Book Cliffs area, including the Castlegate, Sego, and Neslen - Mt.Garfield units. His proposal also includes that the Farrar Facies be considered as the non-coal-bearing upper member (Figure 4).

The conglomeratic Price River Formation in the west grades eastward to pebbly, fluvial units at its type locality in Price Canyon. It trends eastward from the lower delta plain environments of the coal-bearing Neslen facies into the later nearly barren alluvial plain facies of the Farrar that progrades over it (Figure 6).

NORTH HORN FORMATION

Spieker and Reeside (1925) subdivided the Wasatch Formation into a lower member, Flagstaff Member, and an upper member. In a subsequent study, Spieker (1946) named the lower member the North Horn Formation at its type locality at North Horn Mountain.

Thickness of the formation in Price Canyon Section determined by different geologists are as follows: 597m (Abbott and Liscomb, 1956), 667m (Young, 1955), 727m (Fouch *et al.*, 1987), 730m (Russon, 1987), and 758m (Katich, 1954). The variable thicknesses measured are at least in part due to the uncertainty of the position of the Price River - North Horn boundary, which is transitional. For this study, 704m of North Horn Formation was measured between the Price River Formation and the Flagstaff Member of the Green River Formation.

The formation contains fluvial sandstones interbedded with variegated shales, siltstones, and freshwater limestones, and occasional coal beds which are 10cm to 70cm in thickness. Fossils collected from the North Horn Formation include vertebrates (Gilmore, 1946; Gazin, 1938, 1939, and 1941), mollusks (La Rocque, 1960; Fouch *et al.*, 1987), and such microfossils as palynomorphs, ostracodes, and charophytes (Newman, 1974; Griesbach and MacAlpine, 1973; Beard, 1959). The paleontological evidence indicates the formation was deposited on an alluvial plain with local lacustrine environments that produced a fresh, clear, quiet-water setting with aquatic vegetation (Fouch, 1976; Fouch *et al.*, 1976) (Figure 6).

The North Horn Formation is known to contain both Late Cretaceous and early Tertiary strata. At its type locality in the North Horn Mountain, Spieker interpreted the lower two-thirds of the formation containing a Lance-type ceratopsian fauna to be Late Cretaceous in age, and the upper one-third of it, containing Paleocene mammalian fauna, to be the Paleocene in age (McGookey, 1960). Griesbach and MacAlpine (1973) reported the lower one-third of the formation was Upper Cretaceous and the upper two-thirds was of Paleocene age on the basis of their study of palynomorphs, ostracods, and charophytes. Newman (1974) noted that the lower Paleocene (his palynomorph zone P1) strata in the Price Canyon are missing (Figure 1). In their field guide in this region, Fouch *et al.* (1976)

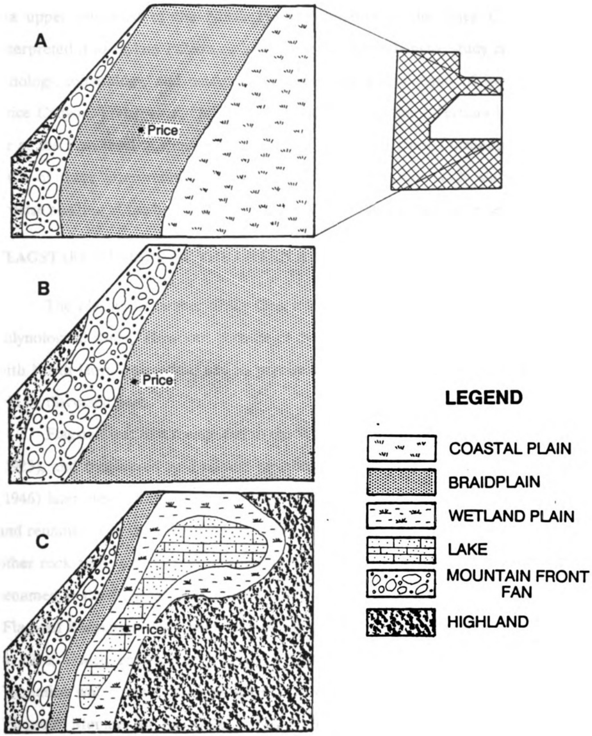

Figure 6. Paleogeographic maps of each time representing Castlegate Sandstone (A), Price River Formation (B), and North Horn Formation (C). After Fouch *et al.* (1983).

recovered a palynomorph assemblage from thin, attrital coal beds at Ford Creek, in the upper one-third of the North Horn Formation in the Price Canyon, and interpreted it as of late Paleocene age. In their comprehensive study chart on the lithology, mineralogy, and paleontology (based on several types of fossils) in the Price Canyon, Fouch *et al.* (1987) indicated the Cretaceous - Tertiary boundary to be at the 52m level in their 727m section of the North Horn Formation. On the basis of these interpretations discussed so far, the present study shows a more precise position of the boundary and the amount of missing Paleocene section.

FLAGSTAFF MEMBER OF THE GREEN RIVER FORMATION

The Flagstaff Member of the Green River Formation is not included in this palynological study. However, because of the nature of the wide distribution along with North Horn Formation, and its precise stratigraphic position in this section, it will be discussed here.

Flagstaff was first recognized in the Wasatch Plateau by Spieker and Reeside (1925), and considered as a middle member of the Wasatch Formation. Spieker (1946) later elevated this member of the Wasatch Formation to formational status, and renamed it as the Flagstaff Limestone. Gilliland (1948) pointed out that many other rock types are present in addition to the large amounts of limestone so he renamed it the Flagstaff Formation. Since then, both "Flagstaff Limestone" and "Flagstaff Formation" have been interchangeably used in the literature. In his paper in 1976, Fouch emphasized that the Flagstaff is a tongue of the Green River Formation which was already considered by Spieker (1946), and proposed the term "Flagstaff Member of the Green River Formation". He also recommended the application of Wasatch Formation, which is widely but not specifically used, for strata equivalent to the North Horn or Colton Formations in the central and western Uinta Basin, where the Flagstaff is not present (Figure 4).

The Flagstaff Member of the Green River Formation is approximately 150m thick in Price Canyon and comprised predominately of shale with lesser amounts of limestone and sandstone (Abbott and Liscomb, 1956). The strata were deposited in a marginal lacustrine facies during the early Tertiary (Ryder *et al.*, 1976). Molluscan fauna from the Flagstaff indicate Paleocene and Eocene age (La Rocque, 1951, and 1960). Newman (1974) reported the Flagstaff is Paleocene in age on the basis of palynomorph study of samples from the southern flank of the Uinta Basin. Fouch *et al.* (1983) studied a sample from the bottommost part of the Flagstaff in Sanpete Valley area which contains Eocene palynomorphs. Flagstaff in study area is believed to be Paleocene in age because of its location in Price Canyon which is at the southern rim of the Uinta Basin.

III. DATA COLLECTION

1. COLLECTION OF SAMPLES

Approximately 1,120 meters of stratigraphic section from the bottom of the Castlegate Sandstone to the top of North Horn Formation was studied. Field descriptions of lithologic characteristics, stratigraphic features, and details of sedimentation were carefully made. Along with the precise measurement of the section, one hundred and thirty composite samples were systematically collected from selected lithologic units of the section.

Samples were placed in cloth collecting bags, and wrapped in newspaper to protect them from contaminating each other. Both cloth bags and wrapping newspaper were labeled with sample numbers including the month, day, year, Roman numeral indicating the stop for the day, and serialized sample number (*e.g.* 8/28/84 II-5). See Appendix 1 for the stratigraphic position and the lithologic description of samples.

2. PREPARATION OF SAMPLES

A small amount of each sample was crushed in a mortar until the largest fragments were approximately 0.5-1.0cm in diameter. Five to twenty gram aliquot, depending on the lithology of sample, was weighed, and put into a polycarbonate (nalgene) tube. The samples were allowed to stand 24-72 hours in the half-full tube of 10% hydrochloric acid (HCl) until all calcium carbonate ($CaCO_3$) was dissolved. After discarding the used hydrochloric acid, samples were placed in 52-55% hydrofluoric acid (HF) (4-5 times the amount of residue) for 24 hours or more, until most of the silica was dissolved. At this step, extreme care was taken using a mask, an apron, and a pair of heavy duty rubber gloves. The samples were then washed twice with 10% hydrochloric acid, and with distilled water to neutrality. After transferring residues to a glass tube, each sample was treated with 40ml of mild Schulze' solution (7parts 69-71% nitric acid to one part 10% solution of potassium chlorate) for 5-20 minutes until effervescence stopped. Coal samples required longer treatment in a hot water bath. The samples were washed twice and then treated with five percent potassium hydroxide solution for 2-5 minutes. Then the samples were washed until the supernatant liquid was clear.

After this, a specific gravity separation of the organic fraction from the remaining, dispersed mineral matter was done using zinc chloride solution ($ZnCl_2$) which had been adjusted to a specific gravity of 1.95. First, the sample was washed with 10% hydrochloric acid, and then approximately the same amount of zinc chloride was added. The homogenized mixture of residue and zinc chloride was centrifuged at lower speed (1400 rpm) for 10 minutes. The float fraction was washed with 10% hydrochloric acid, and then with water to neutrality. After determining that there was no significant amount of palynomorphs in the heavy fraction, it was discarded. The residue was evaluated under the microscope. Unsatisfactory residues were given special treatment. Residue having a significant amount of clay or very minute carbonaceous material, was treated with commercial detergent (*e.g.* Calgon brand) solution followed by a short time, external application of an ultrasonic generator for dispersal of particulate matter in the sample. This was followed by sizing through a 7 micron nylon screen to remove clay size particles. The sample treated in this manner was checked for small pollen grains before discarding the fine fraction. The residue was then stained with 1% solution of Safranin O and stored in solution containing approximately 1.5% of hydroxyethyl cellulose (HEC) and 0.5% of liquified phenol in a one dram, screw top vial.

To prepare slides for microscopic examination, the residue was diluted with water in a 30ml beaker. This mixture was swirled so that heavy non-palynomorphic matter could be concentrated at the center. A few drops of the more concentrated fraction were distributed as evenly as possible on a 22 millimeter square coverslip, and allowed to dry in an oven so that palynomorphs were attached to the coverslip surface. Then the coverslip was inverted and permanently cemented to a regular 2.5cm X 7.5cm slide with HSR (Harleco Synthetic Resin).

3. STUDY OF PALYNOMORPHS

Five productive samples, selected for representative stratigraphical distribution of the whole section, were first examined to establish the palynoflora present during the time span represented by the sedimentary formations in the study area. An adequate familiarization with taxa encountered was sufficiently achieved so that most entities could be identified in a consistent manner. All samples were examined at high-power (1000X) and palynomorphs were photographed. Different types of palynomorphs were categorized using formulae modified from R. H. Tschudy (1957). These formulae are illustrated in Table 3. Each photograph was mounted on 10cm X 15cm card with its sample and coordination numbers and appropriate morphologic formulae.

The sum of 300 palynomorphs was selected for counting from each sample used in this study. This sum was determined after constructing a curve based on the number of palynomorphs counted versus the number of new taxa encountered for several samples which contained diverse palynomorphs. This species-population curve was modelled after species-area curves used in terrestrial plant ecology to determine number and size of sample quadrats. In all of these samples, the sum of 300 fell to the right of the point of sharp change from the steep slope to the flattened curve. Such curves for three samples are shown in Figure 7.

Before commencing the counting, the following guidelines were made: (1) not more than 100 counts per traverse, with the following exception; (2) if 100

Table 3. Artificial formulae for palynomorphs modified from R. H. Tschudy, 1957.

MORPHOLOGIC CODE
Tl : Trilete
M : Monolete
O : Inaperturate
S_1 : Monosulcate
P_1 : Monoporate
P_3 : Triporate
P_∞ : Polyporate
CP_3 : Tricolporate
C_1 : Monocolpate
C_3 : Tricolpate
C_∞ : Polycolpate
V : Vesiculate
Dy : Dyads
Tt : Tetrads
Din : Dinoflagellate
Ac : Acritarch

SCULPTURE CODE
sm : psilate
f : foveolate
p : verrucate, scabrate, gemmate, baculate, and clavate
sp : echinate
st : striate
r : reticulate
cic : cicatricose

e.g. Tlsm-7.

Table 4. Terms and definitions used to describe the abundance of palynomorphs within counted sum. Based on standard counts of 300 grains or other sums noted.

Very rare	:	0 - 2 counts (0 - 0.7 %)
Rare	:	3 - 5 counts (1.0 - 1.7 %)
Few	:	6 - 15 counts (2.0 - 5.0 %)
Common	:	16 - 25 counts (5.3 - 8.3 %)
Abundant	:	> 26 counts (> 8.7 %)

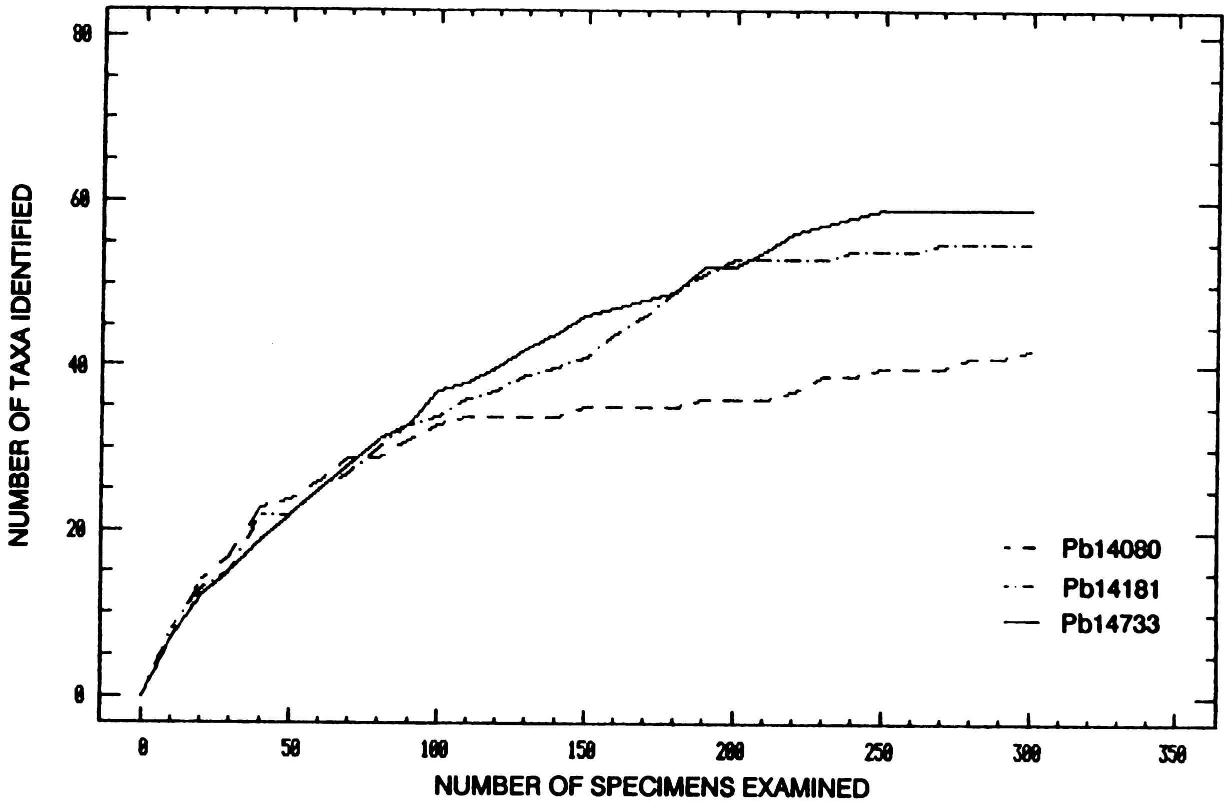

Figure 7. Typical species - population curves showing the points of sharp change from the steep slope to the flattened curve, all of which occur below 300 counted specimens.

palynomorphs are counted before reaching the midway point of the traverse, count to the midpoint or to 150, whichever is attained first; (3) not more than half of the total count (150) is to be made per slide; (4) unidentified (but ultimately possibly identifiable) pollen and spores, dinoflagellates and acritarchs are to be included in the counts; (5) Algae other than dinoflagellates and acritarchs, are not to be included in the counts; (6) Fungal spores and unknown forms of palynomorphs other than pollen and spores are not to be included in the 300 sum. A random order of numbers 1-22 was drawn by lot to determine the order of counting the traverses on a slide, which are 22mm, 5mm, 17mm, 7mm, 4mm, 12mm, 13mm, 9mm, 18mm, 16mm, 21mm, 10mm, 19mm, 3mm, 15mm, 1mm, 8mm, 20mm, 11mm, 2mm, 14mm, and 6mm from the microscope side (top) to the investigator side (bottom). In most samples, rules (1) and (2) did not apply because of sparse distribution of palynomorphs on the slides. In less productive samples, less than 300 palynomorphs were encountered for tabulation in counting. After completion of all sample counts, the first few samples were recounted to check the consistency of previous identifications and relative percentages of palynomorphs.

All microscopic work was carried out with a Leitz Ortholux microscope. The photographs were taken with a Leitz Orthomat automatic camera mounted on the Leitz Ortholux microscope. Kodak Panatomic-X film (ASA 32) was used and developed with Kodak developer D-76. The prints were made on Kodak Polycontrast Rapid II RC paper using Kodak Dektol developer. Most magnifications of the palynomorphs were 1000X.

4. DATA ANALYSES, STATISTICAL PROCEDURES

Forty five productive samples were included in counting procedure for the quantitative analyses. Among these, less than 300 grains were encountered in the counts of only three samples. However, these three were included in the quantitative analyses. Terms used for general description of the relative frequencies of taxa throughout the systematics chapter are defined in Table 4.

In the present study, proprietary SPSS/PC computer software program manufactured for microcomputers by SPSS Inc. was used in statistical calculations for the cluster analyses. Agglomerative hierarchical clustering based on the squared Euclidean distance coefficient was utilized in the present study. In agglomerative hierarchical clustering, clustering starts from grouping of the most similar components until all components are included in one group. Unweighted pair-group method using arithmetic averages was applied for the clustering procedures. Distance coefficient matrix was calculated with the taxa as the variables (R-mode analysis), and the samples as the variables (Q-mode analysis). Each analysis was applied in the ecological interpretation and in the stratigraphic zonation, respectively. Refer to Valentine and Peddicord (1967), Hazel (1970), and the manual of SPSS/PC for the IBM PC/XT (Norusis, 1988) for details.

IV. SYSTEMATICS

1. INTRODUCTION

TAXONOMIC LISTING

Two hundred and forty six separate kinds of palynomorphs, mostly of specific rank, are reported here. Most of these are land-derived palynomorphs such as fern or bryophyte spores, gymnospermous pollen, and angiospermous pollen. Although some marine microplankton were found occasionally, most of them are considered to have been recycled; thus they would not be representatives of the indigenous flora studied here. Therefore, such microplankton as dinoflagellates, acritarchs, diatoms, and silicoflagellates, as well as fungal spores, which do not contribute significantly to the interpretation of the flora, are briefly reported here and compared with the previous records of their occurrence in floras of similar age or geographic distribution, when applicable.

Spores and pollen were categorized into three major groups, *viz*. spores (bryophytes and pteridophytes), gymnospermous pollen, and angiospermous pollen. Under each category, genera are arranged in alphabetical order, and in turn, species are arranged in the same way under the genus to which they belong. Many types of palynomorphs encountered here are of uncertain origin or of debatable affinity. Therefore, each type was assigned to a form-genus in this study to avoid confusion with modern taxa.

METHOD OF DESCRIPTION AND DISCUSSION OF PALYNOMORPHS

The palynomorphs reported herein are described only if they are not definitely referred to a published species or if additional descriptive notes may contribute to a better understanding. Descriptions of all other palynomorphs and synonymies, and supplementary information for all previously described species have been indicated by citation of the original description and synonymy or the most appropriate description for that species given by earlier authors.

The size range, as observed in this study, and the number of specimens measured is reported here for all species included. Most taxa are compared with other pertinent taxa or those with previously reported similar stratigraphic records or distribution patterns. Some botanical affinities are suggested or discussed.

Known stratigraphic and geographic ranges are reported under "occurrence", and distribution of these fossils in the study section are noted. Formation names, or occasionally more generalized portions of time units, such as "Cretaceous interval of North Horn Formation" and "upper interval of Paleocene strata of North Horn Formation", are often used to indicate stratigraphic occurrence. The formations established in the Price Canyon Section and the stratigraphic positions of productive, counted, samples are illustrated in Figures 8 and 9. Abundance is described frequently in terms defined in Table 4, but relative frequencies in percent were given for some species.

For the lithostratigraphic description, see Appendix A. For absolute frequency data for each palynomorph in all samples, see Appendix B.

Table 5 is a list of palynomorphs reported in this study in alphabetical order.

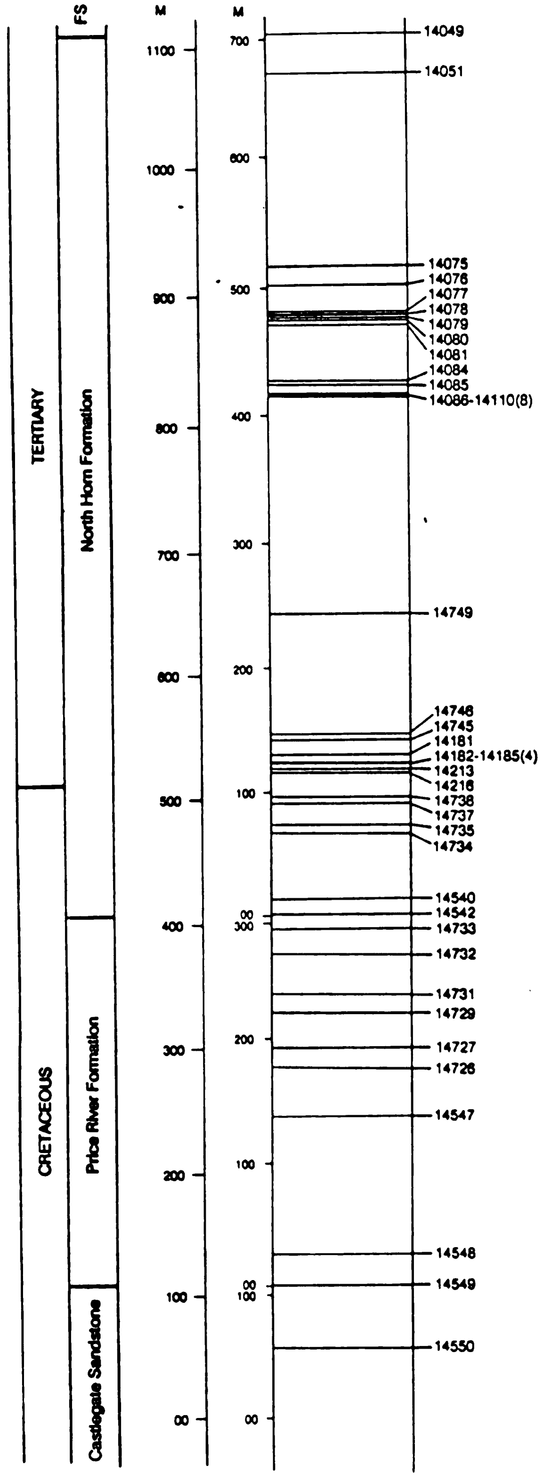

Figure 8. Stratigraphic distribution of productive samples in the Price Canyon Section. FS: Flagstaff Member of the Green River Formation.

Table 5. Alphabetical list of genera and species. SP: spore, GYM: gymnosperm, ANG: angiosperm, FUN: fungal spore, DIN: dinoflagellate, ACR: acritarch, GA: other fresh-water alga, DIA: diatom, and SIL: silicoflagellate.

TAXA	TYPE	PAGE	PL	FIG
Abietineaepollenites microalatus	GYM	84	8	1
cf. *Actinocyclus* sp.	DIA	204	24	4
Actinoptychus senarius	DIA	203	24	3
Aesculiidites circumstriatus	ANG	111	13	1,2
Alabroidaepollenites subtriangulus	ANG	112	16	14,15
Alisporites grandis	GYM	85	8	3
Alisporites aff. *A. rotundus*	GYM	85	8	5
Alisporites thomasii	GYM	86	8	6
Alnipollenites quadrapollenites	ANG	113	13	5,6
Alnipollenites trina	ANG	113	13	7,8
Alnipollenites verus	ANG	114	13	9,10
Annutriporites rotundus	ANG	114	13	11,12
Appendicisporites cristatus	SP	42	1	1
Appendicisporites potomacensis	SP	42	1	2
Aquilapollenites amplus	ANG	116	13	13,14
Aquilapollenites argutus	ANG	116	13	15,16
Aquilapollenites augustus	ANG	117	13	17
Aquilapollenites cf. *A.bertillonites*	ANG	117	13	18
Aquilapollenites regalis	ANG	117	14	1
Aquilapollenites spinulosus	ANG	118	14	2
Araucariacites australis	GYM	86	8	2,4
Arecipites columellus	ANG	118	14	5
Arecipites cf. *A.pseudotranquillus*	ANG	119	14	3
Arecipites tenuiexinous	ANG	119	14	6,7
Arecipites sp.1	ANG	120	14	4,8
Azolla cretacea	SP	43	1	3,4
cf. *Azolla* sp.	SP	44	1	5
Baltisphaeridium multispinosum	ACR	209	25	5
Baltisphaeridium sp.	ACR	209	25	6
Beaupreaidites sp.1	ANG	120	14	9
Biretisporites sp. 1	SP	45	1	6,7
Biretisporites sp. 2	SP	46	1	8,9
Botryococcus sp.	GA	200	23	6
Brevicolporites colpella	ANG	121	14	10,11
Bombacacidites nacimientoensis	ANG	122	14	12
Caryapollenites imparalis	ANG	123	14	15
Caryapollenites inelegans	ANG	124	14	13
Caryapollenites veripites	ANG	124	14	14
Caryapollenites wodehousei	ANG	125	14	16
Caryapollenites sp.1	ANG	126	14	17
Caryophyllidites polyoratus	ANG	127	15	1-3
Cedripites cretaceous	GYM	87	8	7
Cedripites parvus	GYM	87	8	8
Ceratosporites couliensis	SP	46	1	10
Ceratosporites morrinicolus	SP	47	1	11
Cerebropollenites sp. 1	GYM	88	9	1-3

Table 5 (cont'd.).

TAXA	TYPE	PAGE	PL	FIG
Cerebropollenites sp. 2	GYM	88	9	4
Chomotriletes minor	SP	47	1	12
Cibotiumspora juncta	SP	48	2	1,2
Cibotiumspora cf. *C. jurienensis*	SP	49	2	3
Cicatricosisporites dorogensis	SP	50	2	4,5
Cicatricosisporites ornatus	SP	50	2	6
Cicatricosisporites sp. 1	SP	50	2	7
Cicatricososporites norrisii	SP	51	2	8
Cingutriletes congruens	SP	52	2	9
Cirratriradites teter	SP	52	2	10,11
Clavatipollenites hughesii	ANG	128	15	4,5
Concavisporites parkinii	SP	53	2	12
Concavisporites sp. 1	SP	53	2	13
Concavisporites sp. 2	SP	54	2	14
Concavissimisporites cf. *C. michinus*	SP	55	2	15,16
Concavissimisporites punctatus	SP	55	3	1,2
Confertisulcites gracilis	GYM	89	9	5
Corollina parva	GYM	90	9	6
cf. *Coscinodiscus nodulifer*	DIA	204	24	5
Cranwellia cf. *C.rumseyensis*	ANG	129	15	6-8
Cranwellia sp.1	ANG	129	15	9,10
Cupanieidites reticularis	ANG	130	15	11
Cupuliferoidaepollenites mutabilis	ANG	131	15	12,13
Cupuliferoidaepollenites parvulus	ANG	131	15	14,15
Cupuliferoidaepollenites sp.1	ANG	132	15	16,17
Cyathidites australis	SP	55	3	3
Cyathidites cf. *C. concavus*	SP	56	3	4
Cyathidites minor	SP	56	3	5
Cyathidites sp. 1	SP	57	3	6,7
Cycadopites formosus	GYM	91	9	7
Cycadopites giganteus	GYM	92	9	8
Cycadopites scabratus	GYM	92	9	9
Cycadopites sp. 1	GYM	93	9	10,11
cf. *Deflandrea microgranulata*	DIN	206	24	9
cf. *Deflandrea* sp.	DIN	207	24	10
Deltoidospora diaphana	SP	58	3	8
Densoisporites velatus	SP	59	3	9
Dicellate fungal spore 1	FUN	196	22	9
Dicellate fungal spore 2	FUN	196	22	10
Dicellate fungal spore 3	FUN	196	22	6
Dicellate fungal spore 4	FUN	196	22	11
Dictyophyllidites harrisii	SP	59	3	11,12
Dictyotosporites cf. *D. speciosus*	SP	60	3	10
Dinogymnium sp.	DIN	207	24	11
Distephanus crux	SIL	205	24	7,8
Dyadonapites reticulatus	ANG	132	16	1,2
Engelhardtioidites minutus	ANG	133	16	3
Equisetosporites cf. *E. claricristata*	GYM	94	10	1
Equisetosporites cf. *E. concinnus*	GYM	94	9	15

Table 5 (cont'd.).

TAXA	TYPE	PAGE	PL	FIG
Equisetosporites eocenipites	GYM	95	9	13
Equisetosporites cf. *E. ovatus*	GYM	95	9	14
Equisetosporites cf. *E. volutus*	GYM	96	10	2
Erdtmanipollis procumbentiformis	ANG	134	16	5,6
Eucommiidites couperi	GYM	97	10	4,5
cf. *Exesipollenites tumulus*	GYM	97	10	3
Faguspollenites sp.1	ANG	135	16	4
Foveotriletes cf. *F. parviretus*	SP	61	4	1
Fraxinoipollenites artus	ANG	136	16	7,8
Fraxinoipollenites variabilis	ANG	136	16	9
Fungal scar	FUN	198	23	1
Gabonisporis bacaricumulus	SP	61	4	2,3
Ghoshispora bella	SP	62	4	4,5
Ghoshispora major	SP	63	4	6
Ghoshispora scollardiana	SP	64	5	1
Ghoshispora sp. 1	SP	64	5	2
Ginkgocycadophytus nitidus	GYM	98	10	6
Gleicheniidites senonicus	SP	65	5	3
Gleicheniidites simplex	SP	65	5	4
cf. *Grewipollenites* sp.	ANG	137	16	10
Hamulatisporis cf. *H. hamulatis*	SP	66	5	5
Hazaria cf. *H. sheopiarii*	SP	66	5	6
Heliosporites altmarkensis	SP	67	5	7
Heliosporites cf. *H. kemensis*	SP	68	5	8,9
Hyphae	FUN	198	23	2,3
Inaperturopollenites dubius	GYM	98	10	8
Inaperturopollenites rugosus	GYM	99	10	7
Inaperturopollenites rugulatus	GYM	99	10	10
Inaperturopollenites sp. 1	GYM	100	10	9
Inaperturotetradites scabratus	ANG	138	16	11
Kurtzipites annulatus	ANG	139	16	12
Kurtzipites trispissatus	ANG	139	16	13
Labraferoidaepollenites dilatus	ANG	140	13	3,4
Laevigatosporites discordatus	SP	69	5	10
Laevigatosporites haardtii	SP	70	5	11
Laevigatosporites ovatus	SP	70	5	12
Leioaletes calvatus	GYM	100	10	11
Leiofusa jurassica	ACR	211	25	7
Libopollis jarzenii	ANG	141	16	16,17
Liburnisporis cf. *L. adnacus*	SP	70	6	1
Liliacidites cf. *L.complexus*	ANG	142	16	18,19
Liliacidites leei	ANG	142	17	1
Liliacidites variegatus	ANG	143	17	2
Margocolporites puercoensis	ANG	143	17	3
Micrhystridium fragile	ACR	210	25	8
Micrhystridium inconspicuum	ACR	210	25	9
Micrhystridium piliferum	ACR	210	25	10
Momipites actinus	ANG	145	17	4
Momipites anellus	ANG	145	17	5

Table 5 (cont'd.).

TAXA	TYPE	PAGE	PL	FIG
Momipites inaequalis	ANG	146	17	6
Momipites leffingwellii	ANG	147	17	7
Momipites ventifluminis	ANG	147	17	8
Momipites waltmanensis	ANG	148	17	9,11
Momipites wyomingensis	ANG	149	17	10
Monocellate fungal spore 1	FUN	195	22	1
Monocellate fungal spore 2	FUN	195	22	2
Monocellate fungal spore 3	FUN	195	22	3
Monocellate fungal spore 4	FUN	195	22	4
Monocellate fungal spore 5	FUN	195	22	5
Monocellate fungal spore 6	FUN	196	22	7
Monocellate fungal spore 7	FUN	196	22	8
Monocolpopollenites tranquilloides	GYM	101	10	12
Monocolpopollenites sp. 1	GYM	102	10	13
Monosulcites latus	ANG	150	17	12
Monosulcites scabratus	ANG	150	17	14
Monosulcites tectatus	ANG	150	17	15
Monosulcites sp.1	ANG	151	17	13
Monosulcites sp.2	ANG	151	17	16
Multicellate fungal spore 1	FUN	197	22	12
Multicellate fungal spore 2	FUN	197	22	13
Multicellate fungal spore 3	FUN	197	22	14
Multicellate fungal spore 4	FUN	197	22	15,19
Multicellate fungal spore 5	FUN	197	22	16
Multicellate fungal spore 6	FUN	197	22	20
Multicellate fungal spore 7	FUN	198	22	21
Muriform fungal spore 1	FUN	198	22	17,18
Myrtaceidites solidus	ANG	152	17	18,19
Myrtipites laqueaeformis	ANG	153	17	20,21
Myrtipites scabratus	ANG	154	17	17
Myrtipites tectus	ANG	154	17	22
Nyssapollenites minima	ANG	155	18	1,2
Nyssapollenites pseudocruciatus	ANG	155	18	3,4
Osmundacidites wellmanii	SP	71	6	2,3
Ovoidites ligneolus	GA	201	23	7
Palaeohystrichophora infusoriodes	DIN	207	24	12
Pandaniidites typicus	ANG	156	18	5
Paraalnipollenites sp.1	ANG	157	18	6,7
Pediastrum paleogeneites	GA	201	23	9
Peromonolites subengelmanni	SP	72	6	4,5
Peronosporites sp.	FUN	199	23	4,5
Phyllocladidites cf. *P. ruei*	GYM	102	10	14
Pistillipollenites mcgregorii	ANG	158	18	10
Pityosporites constrictus	GYM	103	11	1
Pityosporites elongatus	GYM	103	11	2
Pityosporites grandis	GYM	104	11	3
Podocarpidites biformis	GYM	104	11	6,7
Podocarpidites cf. *P. decorus*	GYM	105	11	4,5
Podocarpidites ornatus	GYM	105	11	8,9

Table 5 (cont'd.).

TAXA	TYPE	PAGE	PL	FIG
Podocarpidites otagoensis	GYM	106	12	1
Polotricolporites cf. *P.rotundus*	ANG	159	18	8,9
Polycingulatisporites reduncus	SP	73	6	6
Polypodiites inangahuensis	SP	74	6	7
cf. *Polysphaeridium* sp.	ACR	212	25	11
Pristinuspollenites microsaccus	GYM	106	12	2
Pristinuspollenites sp. 1	GYM	107	12	3,4
Proteacidites cf. *P.marginus*	ANG	160	18	11
Proteacidites retusus	ANG	161	18	12,13
Proteacidites thalmanii	ANG	161	18	14
Proteacidites sp.1	ANG	162	18	16,17
Proteacidites sp.2	ANG	163	18	15
Pseudotricolpites reticulatus	ANG	163	18	18
Pterospermopsis cf. *P. eurypteris*	ACR	212	25	12
Pterospermopsis sp. 1	ACR	212	25	13
Reticuloidosporites dentatus	SP	74	6	8
Retitrescolpites anguloluminosus	ANG	164	18	19-21
Retitrescolpites sp.1	ANG	165	19	1
Retitriletes nidus	SP	75	6	9
Rousea sp.1	ANG	165	19	6-8
Rousea sp.2	ANG	166	19	2,3
Salixipollenites discoloripites	ANG	167	19	4,5
Schizosporis parva	GA	202	23	8
Sequoiapollenites polyformosus	GYM	108	12	5
Siberiapollis montanensis	ANG	167	19	11
Simpsonipollis mullensis	ANG	168	19	9,10
Smilacipites echinatus	ANG	169	19	12,13
Smilacipites herbaceoides	ANG	169	19	14
Spirally coiled fungal spore 1	FUN	198	22	22
Spirally coiled fungal spore 2	FUN	198	22	23
Stellatopollis barghoornii	ANG	170	19	15,16
Stephanocolpites fredericksburgensis	ANG	171	19	17,18
Stereisporites antiquasporites	SP	75	6	12
Stereisporites stereoides	SP	76	6	10,11
Striatopollis tectatus	ANG	171	20	1,2
Striatopollis trochuensis	ANG	172	20	3,4
Subtriporopollenites alpinus	ANG	172	20	5,6
Taxodiaceaepollenites hiatus	GYM	108	12	6,7
cf. *Thalassiosira* sp.	DIA	204	24	6
Tiliaepollenites tetraforaminipites	ANG	174	20	7,8
Tiliaepollenites vescipites	ANG	175	20	9
Todisporites cf. *T. major*	SP	76	6	14
Todisporites minor	SP	77	6	13
Triangulopsis cf. *T. discoidalis*	GYM	109	12	8,9
Tricolpites hians	ANG	176	20	10,11
Tricolpites cf. *T.parvistriatus*	ANG	177	20	12,13
Tricolpites psilascabratus	ANG	177	20	14,15
Tricolpites reticulatus	ANG	178	20	16,17
Tricolpopollenites cf. *T.levita*	ANG	179	20	18

Table 5 (cont'd.).

TAXA	TYPE	PAGE	PL	FIG
Tricolpopollenites lilliei	ANG	179	20	19,20
Tricolpopollenites microreticulatus	ANG	180	20	21,22
Tricolpopollenites variofoveatus	ANG	181	21	1,2
Tricolpopollenites sp.1	ANG	182	21	3,4
Tricolpopollenites sp.2	ANG	182	21	5,6
Triplanosporites sinuosus	SP	77	6	15
Triporoletes asper	SP	78	7	1
Triporoletes novomexicanus	SP	79	7	2
Triporopollenites plektosus	ANG	183	21	7
Triporopollenites sp.1	ANG	183	21	8,9
Ulmipollenites hebridicus	ANG	186	21	13
Ulmipollenites krempii	ANG	187	21	10,11
Ulmipollenites planeraeformis	ANG	188	21	12
Ulmipollenites tricostatus	ANG	189	21	16
Ulmipollenites undulosus	ANG	190	21	14,15
Ulmipollenites sp.1	ANG	191	21	17,18
Ulmipollenites sp.2	ANG	191	21	19-21
Undulatisporites pflugii	SP	79	7	4
Undulatisporites undulapolus	SP	80	7	3
Utriculites cf. *U.visus*	ANG	192	21	22
Varirugosisporites tolmanensis	SP	80	7	5,6
Vitipites affluens	ANG	193	21	23
Wilsonipites cf. *W.margocolpatus*	ANG	194	21	24
Zonalapollenites cf. *Z. segmentatus*	GYM	110	12	10
Genus et sp. nov. 1.	SP	81	7	7,8
Unidentified dinoflagellate 1	DIN	207	25	1
Unidentified dinoflagellate 2	DIN	208	25	2
Unidentified dinoflagellate 3	DIN	208	25	3
Unidentified dinoflagellate 4	DIN	208	25	4
Unknown alga 1	GA	202	24	1
Unknown alga 2	GA	203	24	2
Unknown fungal spore 1	FUN	196	22	24
Unknown pollen 1	ANG	194	21	25
Unknown spore 1	SP	82	7	9,10
Unknown spore 2	SP	82	7	11

2. SPORES (BRYOPHYTES, PTERIDOPHYTES)

Genus Appendicisporites Weyland and Krieger 1953

TYPE SPECIES: *Appendicisporites tricuspidatus* Weyland and Krieger 1953

SYNONYMY: See Srivastava (1975b, p.10).

DESCRIPTION: See Brenner (1963, pp.45-46).

Appendicisporites cristatus Markova 1961

[Plate 1, Figure 1]

Appendicisporites cristatus Markova; Pocock 1964b, p.164, pl.3, figs.9-10.

Appendicisporites cristatus Markova; Srivastava 1972b, p.5, pl.3, figs.5-6.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Pocock (1964b, p.164).

DISCUSSION: Triangular shape is characteristic of this species. Equatorial diameters are 34-42um (2 specimens measured). Some of Utah specimens show distal protuberances that result in a somewhat tetrahedral shape.

SUGGESTED AFFINITY: Schizaeaceae.

OCCURRENCE: Albian - Senonian of Siberia (Samoilovitch and Mtchedlishvili, 1961), Albian of Saskatchewan (Pocock, 1964b), Maastrichtian of Alberta (Srivastava, 1972b). Uppermost Price River Formation and lower coal (middle Paleocene in age) of North Horn Formation in this study. Very rare.

Appendicisporites potomacensis Brenner 1963

[Plate 1, Figure 2]

Appendicisporites potomacensis Brenner 1963, p.46, pl.6, figs.4-5.

Appendicisporites potomacensis Brenner; Srivastava 1975b, pp.16-17, pl.7, figs.6-8; pl.8, figs.1-6; pl.9, figs.1-2.

ADDITIONAL SYNONYMY: See Srivastava (1975b, p.16).

DESCRIPTION: See Brenner (1963, p.46).

DISCUSSION: Although the single specimen encountered in this study is incomplete in preservation (42um in equatorial diameter), it shows distal rib pattern identical to the SEM photomicrograph by Srivastava (1975b, pl.9, fig.1).

SUGGESTED AFFINITY: Schizaeaceae.

OCCURRENCE: Berriasian - Senonian of U.S.S.R., England, and North America (see Srivastava 1975b, p.17). Found in Castlegate Sandstone (Pb14550) in this study.

Genus Azolla Lamarck 1783

TYPE SPECIES: *Azolla filiculoides* Lamarck 1783

Azolla Lamarck; Stanley 1965, p.256.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Stanley (1965, p.256).

DISCUSSION: This genus was first systematically described in the western North America by Stanley (1965). Since then, this has been studied extensively by Hall and others (Hall, 1969; Hall and Bergad, 1971; Jain and Hall, 1969; and Bergad and Hall, 1971). No whole specimens were found. It is possible that the method of maceration used in this study resulted in breakup of these large massulae. Fragments of massula can easily be overlooked unless glochidia are attached. In some samples, *Azolla*-type microspores were found in abundance, but no fragments of megaspores were identified.

SUGGESTED AFFINITY: Salviniaceae

Azolla cretacea Stanley 1965

[Plate 1, Figures 3,4]

Azolla sp. R. Tschudy 1961, p.54, pl.1, figs.7-8.

Azolla cretacea Stanley 1965, pp.256-257, pl.33, figs.1-5.

Azolla cretacea Stanley; Srivastava 1966, pp.508-510, pl.3, figs.12-15.

Azolla cretacea Stanley; Norton and Hall 1969, p.21, pl.8, fig.6

Azolla cretacea Stanley; Leffingwell 1970, p.21, pl.4, figs.1-2.

DESCRIPTION: See Stanley (1965, pp.256-257), and Srivastava (1966, pp.508-510).

DISCUSSION: Separated glochidia and microspores were found in abundance, but massulae encountered were fragmented. Microspores range 15-24um in equatorial diameter (17 specimens measured). These are smaller than the previous records for this species (Stanley 1965, 30um; Srivastava 1966, 30-32um; and Norton and Hall 1969, 23-30um), except Wyoming record (Leffingwell 1970; illustrated specimen 17um). Usually the microspores show some convexity on both proximal and distal sides, but they are usually somewhat flattened perpendicular to the polar axis.

OCCURRENCE: Maastrichtian - Paleocene of western North America (R. Tschudy, 1961; Stanley, 1965; Srivastava, 1966 and 1967; Norton and Hall, 1969; and Leffingwell, 1970). Very rare to common in the Price River Formation, and very rare to abundant (up to 43%) in Cretaceous interval of the North Horn Formation in this study.

cf. Azolla sp.

[Plate 1, Figure 5]

Azolla barbata Snead 1969, pp.61-62, pl.16, figs.1-3.

Azolla barbata Snead; Hall and Bergad 1971, pp.346-348, pl.1, figs.1-5; pl.2, figs.1-11; pl.3, figs.1-3.

DISCUSSION: Some fragments with hair-like features similar to the perisporial hairs of the megaspore of *Azolla barbata* described and illustrated by Hall and Bergad (1971) were observed in this study. These forms cannot be assigned to this species with certainty because no definitive organ structure was observed.

OCCURRENCE: Maastrichtian of Alberta (Snead, 1969) and Montana (Hall and Bergad, 1971). Occasionally found on slides outside the counted sums from the Cretaceous interval of North Horn Formation.

Genus Biretisporites Delcourt and Sprumont emend. Delcourt et al. **1963**

TYPE SPECIES: *Biretisporites potoniaei* Delcourt and Sprumont emend. Delcourt *et al.* 1963

Biretisporites Delcourt and Sprumont 1955, P.40.

Biretisporites Delcourt and Sprumont emend. Delcourt *et al.* 1963, pp.283-284.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Delcourt *et al.* (1963, pp.283-284).

SUGGESTED AFFINITY: Rouse (1957) compares *Biretisporites deltoidus* (*al. Hymenophyllumsporites deltoidus*) with the extant genus *Hymenophyllum*.

Biretisporites sp.1

[Plate 1, Figures 6,7]

DESCRIPTION: Trilete spore; laesurae extending to the equator; amb triangular with pointed radial extremities; sides straight to slightly convex; commissures raised 5 to 10um, and form dark bands under transmitted light; exine psilate, 1.5-2um thick; size ranges 51-53um in equatorial diameter (4 specimens measured).

DISCUSSION: Extremely well developed membraneous lips are distinct, and can be used to assign this species to the genus *Biretisporites* with certainty. This appears to be distinctive from any previously reported species.

OCCURRENCE: Two specimens from a sample Pb14731 of the Price River Formation, and two specimens were recovered from a sample Pb14185 of the lower interval of Paleocene strata (middle Paleocene in age) of the North Horn Formation.

Biretisporites sp.2

[Plate 1, Figures 8,9]

DESCRIPTION: Trilete spore; laesurae extending to the equator; amb triangular with pointed radial extremities; sides straight to slightly convex; commissures raised 3 to 6um, and form the dark flared bands; exine psilate, 1um thick; size ranges 25-31um in equatorial diameter (3 specimens measured).

DISCUSSION: Lips are flared instead of being stout as in *Biretisporites* sp.1 above. *Biretisporites* sp.1 is larger than this species.

OCCURRENCE: A single specimen was recovered from sample Pb14727 of the Price River Formation, and three samples from the uppermost Cretaceous interval (Maastrichtian in age) and lowermost interval of Paleocene strata (middle Paleocene in age) of the North Horn Formation yielded one to three specimens.

Genus Ceratosporites Cookson and Dettmann 1958

TYPE SPECIES: *Ceratosporites equalis* Cookson and Dettmann 1958

Ceratosporites Cookson and Dettmann 1958, P.101.

Ceratosporites Cookson and Dettmann; Srivastava 1972b, pp.6-7.

DESCRIPTION: See Cookson and Dettmann (1958, p.101).

SUGGESTED AFFINITY: Probably Selaginellaceae.

Ceratosporites couliensis Srivastava 1972b

[Plate 1, Figure 10]

Ceratosporites couliensis Srivastava 1972b, p.7, pl.3, figs.12-13.

DESCRIPTION: See Srivastava (1972b, p.7).

DISCUSSION: In *Ceratosporites couliensis* the sculptural elements are more sparsely distributed than in *Ceratosporites morrinicolus*. Utah specimens range 34-42um in equatorial diameter (8 specimens measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). Very rare to rare (up to 2.3%) in the Castlegate Sandstone, Price River Formation, and Cretaceous interval of North Horn Formation in this study.

Ceratosporites morrinicolus Srivastava 1972b

[Plate 1, Figure 11]

Ceratosporites morrinicolus Srivastava 1972b, p.7, pl.4, figs.2-6.

DESCRIPTION: See Srivastava (1972b, p.7).

DISCUSSION: *Ceratosporites morrinicolus* has denser sculptural elements and thinner exine than *Ceratosporites couliensis*. Specimens assigned to this species range in equatorial diameter 42-46um (3 specimens measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). All three specimens encountered were found on slides outside of the counted sum in samples from the Cretaceous interval of North Horn Formation (Maastrichtian in age) in this study.

Genus Chomotriletes Naumova 1939 ex Naumova 1953

TYPE SPECIES: *Chomotriletes vedugensis* Naumova 1953

Chomotriletes Naumova ex Naumova; Singh 1964, p.61.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Singh (1964, p.61).

DISCUSSION: Singh (1964, p.61) justified the generic assignment of the Canadian material to *Chomotriletes*.

Chomotriletes minor (Kedves) Pocock 1970

[Plate 1, Figure 12]

SYNONYMY: See Singh (1983, pp.34-35).

DESCRIPTION: See Pocock (1970, p.61).

SIZE RANGE: 31-39um in equatorial diameter (8 specimens measured).

OCCURRENCE: Upper Jurassic - Eocene of various parts of the world. Very rare to rare in Cretaceous interval of the North Horn Formation, and one specimen was found in the sample Pb14076 from the upper interval of Paleocene strata (middle/late Paleocene age) of Horn Formation in this study.

Genus Cibotiumspora Chang 1965

TYPE SPECIES: *Cibotiumspora paradoxa* (Malyavkina) Chang 1965; Tripartina paradoxa Malyavkina 1949

Cibotiumspora Chang; Filatoff 1975, p.60.

DESCRIPTION: See Filatoff (1975, p.60).

DISCUSSION: Singh (1971, p.112) mentioned that the kyrtomes, which are characteristic features of this genus, are "formed by an abruptly convex exine area surrounding the laesurae which is reduced to three arcuate folds in the proximal interradial regions on compressed spores".

Cibotiumspora juncta (Kara-Murza) Singh 1983

[Plate 2, Figures 1,2]

Deltoidospora juncta (Kara-Murza) Singh 1964,

Deltoidospora juncta (Kara-Murza) Singh; Norris 1967, p.86, pl.10, figs.4-5.

Deltoidospora juncta (Kara-Murza) Singh; Singh 1971, pp.119-120, pl.16, figs.10-11.

Cibotiumspora juncta (Kara-Murza) Singh; Singh 1983,

ADDITIONAL SYNONYMY: See Norris (1967, p.86).

DESCRIPTION: See Singh (1964, p.81).

SIZE RANGE: 22um in equatorial diameter (1 specimen measured).

OCCURRENCE: Upper Jurassic and Lower Cretaceous of U.S.S.R. (Bolkhovitina, 1956), Albian of Rumania (Baltes, 1967) and Alberta (Norris, 1967; Singh, 1964, 1971) (*fide* Singh, 1971). Two samples of the Price River Formation (upper Campanian in age) yielded one and three specimens, respectively in this study. These are probably reworked from earlier strata.

Cibotiumspora cf. C. jurienensis Balme 1957

[Plate 2, Figure 3]

Concavisporites jurienensis Balme 1957, pp.20-21, pl.2, figs.30-31.

Concavisporites jurienensis Balme; Burger 1966, p.237, pl.4, fig.6.

Concavisporites jurienensis Balme; Singh 1971, pp.112-113, pl.15, figs.16-17.

Cibotiumspora jurienensis (Balme) Filatoff 1975, p.61, pl.10, figs.8-13.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Burger (1966, p.237).

DISCUSSION: Two specimens measured (14-16um in equatorial diameter) are smaller than species previously described (25-36um in Balme, 1957; 20-27um in Burger, 1966; 28um in illustrations of Singh, 1971). Otherwise, the Utah specimens are very similar to the previous descriptions and illustrations, especially it appears to be identical to the form illustrated by Singh (1971, pl.15, figs.16-17). Since only two specimens were encountered in this study, and they are significantly smaller than the other *Cibotiumspora jurienensis* specimens, this species can be hardly assigned to *Cibotiumspora jurienensis* with confidence.

OCCURRENCE: Late Jurassic and Early Cretaceous. Widespread in various parts of the world. Specimens found in the Price River Formation are probably reworked from earlier strata.

Genus Cicatricosisporites Potonie and Gelletich 1933

TYPE SPECIES: *Cicatricosisporites dorogensis* Potonie and Gelletich 1933

SYNONYMY AND DESCRIPTION: See Dettmann (1963, pp.52-53).

SUGGESTED AFFINITY: Schizaeaceae.

Cicatricosisporites dorogensis Potonie and Gelletich 1933

[Plate 2, Figures 4,5]

SYNONYMY AND DESCRIPTION: See Srivastava (1972a, p.227)

SIZE RANGE: 38-43um in equatorial diameter (3 specimens measured).

OCCURRENCE: Upper Mesozoic and Tertiary of various parts of the world. Very rare and scattered throughout the section in this study. Most specimens were found on slides outside the counted sums.

Cicatricosisporites ornatus Srivastava 1972b

[Plate 2, Figure 6]

Cicatricosisporites ornatus Srivastava 1972b, p.9, pl.5, figs.3-11; pl.6, figs.1-4.

DESCRIPTION: See Srivastava (1972b, p.9).

SIZE RANGE: 36um in equatorial diameter, 35um in polar axis (one specimen measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). Very rare to rare in two samples of the Price River Formation in this study.

Cicatricosisporites sp.1

[Plate 2, Figure 7]

DESCRIPTION: Trilete spore, amb triangular with straight sides and rounded corners. Laesurae not clearly defined, approximately 2/3 of spore radius. Proximal surface distinctly foveolate, distal side cicatricose. Ribs parallel to the equator and 2um apart.

SIZE RANGE: 44um in equatorial diameter (1 specimen measured).

DISCUSSION: Only one specimen was found. It is distinctly foveolate on the proximal side, a characteristic feature that distinguishes this species from other similar forms. It is similar to *Microreticulatisporites* Singh, and *Foveosporis triangulis* Stanley, but Utah specimen is pitted rather than reticulate.

OCCURRENCE: Found on a slide outside the counted sum of samples from the Price River Formation.

Genus Cicatricososporites Pflug and Thomson 1953 emend. Krutzsch 1959

TYPE SPECIES: *Cicatricososporites pseudodorogensis* (Potonie 1934) Thomson and Pflug 1953

Cicatricososporites Pflug and Thomson emend. Krutzsch; Srivastava 1971a, p.256.

ADDITIONAL SYNONYMY: See Srivastava (1971a, p.256).

DISCUSSION: Parallel arrangement of ribs of *Cicatricososporites* can be used as a criterion to distinguish this genus from *Schizaeosporites*. Srivastava (1971a, p.256) noted the difficulty in distinguishing these two genera since twisted *Cicatricososporites* may also show rib arrangements similar to those of *Schizaeosporites*.

Cicatricososporites norrisii Srivastava 1971a

[Plate 2, Figure 8]

Cicatricososporites norrisii Srivastava 1971a, p.257, pl.1, figs.5-8.

DESCRIPTION: See Srivastava (1971a, p.257).

SIZE RANGE: 53-56um X 35-47um (4 specimens measured).

SUGGESTED AFFINITY: Srivastava (1971a, p.257) compares this species with spores of the extant species *Schizaea laevigata*.

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1971a). Very rare to rare in the Price River Formation, and one specimen was found on a slide outside the counted sum of the Cretaceous interval of North Horn Formation in this study.

Genus Cingutriletes Pierce 1961 emend. Dettmann 1963

TYPE SPECIES: *Cingutriletes* Pierce 1961 emend. Dettmann 1963

Cingutriletes Pierce 1961, p.20 (*pars*).

Cingutriletes Pierce emend. Dettmann 1963, p.69.

DESCRIPTION: See Pierce (1961, p.20) and Dettmann (1963, p.69).

Cingutriletes congruens Pierce 1961

[Plate 2, Figure 9]

Cingutriletes congruens Pierce 1961, p.25, pl.1, fig.1.

ADDITIONAL SYNONYMY: See Jameossanaie (1987, p.12).

DESCRIPTION: See Pierce (1961, p.25).

SIZE RANGE: 28um in equatorial diameter excluding flange (1 specimen measured).

OCCURRENCE: Cenomanian of Oklahoma (Hedlund, 1966), Campanian of New Mexico (Jameossanaie, 1987), and uppermost Cretaceous of Colorado (Clarke, 1963). Very rare to rare in the uppermost Price River Formation and lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation.

Genus Cirratriradites Wilson and Coe 1940

TYPE SPECIES: *Cirratriradites saturni* (Ibrahim) Schopf, Wilson and Bentall 1944

DESCRIPTION: See Singh (1971, p.111).

Cirratriradites teter Norris 1967

[Plate 2, Figures 10,11]

Cirratriradites teter Norris 1967, pp.98-99, pl.14, figs.6-10.

Cirratriradites teter Norris; Singh 1971, p.112, pl.15, figs.14-15.

DESCRIPTION: See Norris (1967, pp.98-99).

DISCUSSION: Specimens assigned ton this species fall well within the range of morphological variation described by Norris (1967). Spore body ranges 21-24um in equatorial diameter (4 specimens measured).

OCCURRENCE: Middle and late Albian in Alberta (Norris, 1967; Singh, 1971). One specimen was found in the lowermost sample (Pb14549) of the Price River Formation, and ten specimens were recovered from the sample Pb14734 in the Cretaceous interval of North Horn Formation.

Genus Concavisporites Pflug 1953

TYPE SPECIES: *Concavisporites rugulatus* Pflug 1953

DESCRIPTION: See Pocock (1962, p.46).

Concavisporites parkinii Pocock 1962

[Plate 2, Figure 12]

Concavisporites parkinii Pocock 1962, p.46, pl.4, fig.71.

DESCRIPTION: See Pocock (1962, p.46).

DISCUSSION: Specimens encountered here are identical to the original description and illustration given by Pocock (1962) except the outline of the amb. Sides of Utah specimens show less distinct concavity probably caused by the folding. Equatorial diameter is 65um (1 specimen measured).

OCCURRENCE: Neocomian to Aptian? of Alberta (Pocock, 1962). Single specimen seen in Price River Formation and two specimens in the Cretaceous interval of North Horn Formation in this study are probably recycled.

Concavisporites sp. 1

[Plate 2, Figure 13]

DESCRIPTION: Trilete spore; amb. concavely triangular with pointed radial extremities; laesurae undulate, extending to amb. enclosed within membraneous, elevated lips; exine psilate to faintly granulate, 1-1.5um thick; 24um in equatorial diameter (1 specimen measured).

DISCUSSION: Strongly concave sides and undulate laesurae with elevated lips characterize this species.

OCCURRENCE: One specimen found in lowermost stratum of Price River Formation is probably recycled.

Concavisporites sp. 2

[Plate 2, Figure 14]

DESCRIPTION: Trilete spore; amb. concavely triangular with rounded radial extremities; laesurae straight, extending to amb.; exine 1um thick and verrucate; verrucae 2um high, 3um in diameter; 20um in equatorial diameter (1 specimen measured).

DISCUSSION: Strongly concave sides, nature of verrucate exine, and small size characterize this species. Although *Concavisporites* sp. 1 and this species include only one specimen each, the morphological characteristics are distinct and the condition of preservation is relatively good. I have described these species briefly as separate from other previously defined species of the genus for the reference of future study.

OCCURRENCE: One specimen recovered from Price River Formation (Pb14729) is probably recycled.

Genus Concavissimisporites Delcourt and Sprumont emend. Delcourt et al. 1963

TYPE SPECIES: *Concavissimisporites verrucosus* Delcourt and Sprumont 1955

SYNONYMY: See Srivastava (1975b, p.29).

DESCRIPTION: See Singh (1964, p.76).

SUGGESTED AFFINITY: Dettmann (1963, p.30) summarized the studies on the morphological similarity of this genus to various living species of *Cyathea* Smith, *Dicksonia* L'Herit, and *Lygodium* Swartz.

Concavissimisporites cf. C. michinus Srivastava 1975b

[Plate 2, Figures 15,16]

Concavissimisporites michinus Srivastava 1975b, pp.30-31, pl.13, figs.1-7.

DESCRIPTION: See Srivastava (1975b, pp.30-31).

DISCUSSION: Utah specimens (ranges 32-70um in equatorial diameter, 6 specimens measured) contain larger forms than the range of original description (30-38um) in Texas. This species can be differentiated further on the basis of size.

OCCURRENCE: Albian of Texas (Srivastava, 1975b). Price River Formation in this study. Six specimens found (five of these were from outside the counted sum).

Concavissimisporites punctatus (Delcourt and Sprumont) Brenner 1963

[Plate 3, Figures 1,2]

SYNONYMY AND DESCRIPTION: See Srivastava (1975b, p.31).

SIZE RANGE: 32-45um in equatorial diameter (6 specimens measured).

OCCURRENCE: Upper Bathonian - Turonian from many parts of the world. All specimens studied here were found on slides outside the counted sum of samples of the Cretaceous interval of North Horn Formation. Probably recycled.

Genus Cyathidites Couper 1953

TYPE SPECIES: *Cyathidites australis* Couper 1953

DESCRIPTION: See Couper (1953, p.27).

SUGGESTED AFFINITY: Filicales.

Cyathidites australis Couper 1953

[Plate 3, Figure 3]

Cyathidites australis Couper 1953, p.27, pl.2, figs.11-12.

Cyathidites australis Couper; Dettmann 1963, p.22, pl.1, figs.1-3.

ADDITIONAL SYNONYMY: See Dettmann (1963, p.22).

DESCRIPTION: See Couper (1953, p.27).

DISCUSSION: Equatorial diameter ranges 50-56um (5 specimens measured). In this study, the major criterion used to distinguish between *Cyathidites australis* and *Cyathidites minor* is the size range (larger than 50um, smaller than 49um, respectively; see Couper 1958, p.139, Text-fig.9).

OCCURRENCE: Jurassic - Cretaceous strata. Found in various parts of the world. Scattered in the Price River Formation and North Horn Formation in this study. Very rare to few.

<u>Cyathidites</u> cf. <u>C</u>. <u>concavus</u> (Bolkhovitina) Dettmann 1963

[Plate 3, Figure 4]

Stenozonotriletes concavus Bolkhovitina 1953, p.46, pl.6, fig.7.

Cyathidites concavus (Bolkhovitina) Dettmann 1963, p.24, pl.1, figs.17-19.

Cyathidites concavus (Bolkhovitina) Dettmann; Srivastava 1972b, p.11, pl.7, fig.1.

DESCRIPTION: See Dettmann (1963, p.24).

DISCUSSION: Single specimen found (33um in equatorial diameter) is probably an aborted pollen of *Cyathidites*.

OCCURRENCE: Aptian of U.S.S.R. (Bolkhovitina, 1953), Neocomian-Aptian of southeastern Australia (Dettmann, 1963). Maastrichtian of Alberta (Srivastava, 1972b). Single specimen was found on a slide outside the counted sum of the sample Pb14181, which belongs to the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study.

<u>Cyathidites</u> <u>minor</u> Couper 1953

[Plate 3, Figure 5]

SYNONYMY: See M. Wilson (1978, pp.107-108).

DESCRIPTION: See Couper (1953, p.28).

DISCUSSION: M. Wilson (1978, p.108) discussed the differences among form species *Cyathidites minor, Deltoidospora diaphana*, and species of *Triplanosporites*. Forms similar to *Cardioangulina diaphana* described by Stanley (1965, p.248) were included in this species in the present study. Equatorial diameter ranges 19-35um (38 specimens measured), and polar diameter ranges 17-28um (14 specimens measured).

OCCURRENCE: Jurassic - Lower Tertiary of various parts of the world. Throughout entire section in this study. Very rare to abundant (up to 40%).

Cyathidites sp.1

[Plate 3, Figures 6,7]

Concavisporites rugulatus Pflug; Norton and Hall 1969, p.18, pl.1, fig.16.

DESCRIPTION: Trilete, laesurae enclosed by the membrane, extending to the equator; equatorial outline triangular with strongly concave sides; apices pointed; proximal face flat, distal face strongly convex; exine 1um thick; size ranges 25-30um in equatorial diameter (8 specimens measured).

DISCUSSION: Because of the strongly concave nature of its sides, many members of this species were preserved in a laterally compressed way. In such cases, this species is not readily distinguishable from *Cyathidites minor, Deltoidospora diaphana*, or *Triplanosporites sinuosus*. However, *Triplanosporites sinuosus* tends to be bigger and apex of proximal side of it is pointed. *Deltoidospora diaphana* has thicker exine and also tends to be larger in equatorial diameter. Proximal face of *Cyathidites minor* is convex. *Concavisporites rugulatus* described and illustrated by Norton and Hall (1969) seems to be identical to this species, but the present species does not have a torate nature used as a generic, as well as specific, characteristic of *Concavisporites rugulatus* by Pflug (1953).

OCCURRENCE: Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). Price River Formation, and Cretaceous interval and lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study. Very rare to few (up to 4.7%).

Genus Deltoidospora (Miner) Potonie 1956

TYPE SPECIES: *Deltoidospora hallii* Miner 1935

DESCRIPTION: See Singh (1964, p.80).

SUGGESTED AFFINITY: Uncertain.

Deltoidospora diaphana Wilson and Webster 1946

[Plate 3, Figure 8]

SYNONYMY: See Norton and Hall (1969, p.18).

DESCRIPTION: See Wilson and Webster (1946, p.273).

DISCUSSION: This species can be possibly, but not readily, distinguished from *Cyathidites minor* in its thicker exine, slightly shorter laesurae, and less concave sides in amb. Equatorial diameter ranges 31-45um (27 specimens measured), and polar diameter ranges 25-30um (5 specimens measured).

OCCURRENCE: Jurassic - Tertiary of various parts of the world. Throughout entire section in this study with up to 14.3% in relative abundance.

Genus Densoisporites Weyland and Krieger 1953 emend. Dettmann 1963

TYPE SPECIES: *Densoisporites velatus* Weyland and Krieger 1953

SYNONYMY AND DESCRIPTION: See Dettmann (1963, p.83).

SUGGESTED AFFINITY: Balme (1963) compared *Densoisporites playfordi* with the microspores associated with *Selaginellites polaris* Lundblad, and suggested a lycopodiaceous, possibly selaginellid affinity for that species.

Densoisporites velatus Weyland and Krieger emend. Krasnova 1961

[Plate 3, Figure 9]

Densoisporites velatus Weyland and Krieger emend. Krasnova; Dettmann 1963, pp.84-85, pl.19, figs.4-8.

Densoisporites velatus Weyland and Krieger emend. Krasnova; Singh 1971, p.46, pl.3, figs.9-10.

SIZE RANGE: 40um in equatorial diameter (1 specimen measured).

OCCURRENCE: Lias to Danian. Albian of Alberta (Singh, 1971), Barremian to Albian of Maryland (Brenner, 1963), Lias to Aptian of England (Couper, 1958), Senonian of Germany (Weyland and Krieger, 1953), Lower Cretaceous of southeastern Australia (Dettmann, 1963), and Valanginian to Danian of Siberia (Krasnova in Samoilovitch *et al.* 1961; Chlonova, 1961) (*fide* Singh, 1971). Single specimen recovered from the lowermost stratum of the Price River Formation is considered to be recycled.

Genus Dictyophyllidites Couper 1958 emend. Dettmann 1963

TYPE SPECIES: *Dictyophyllidites harrisii* Couper 1958

Dictyophyllidites Couper; Srivastava 1972b, p.11.

ADDITIONAL SYNONYMY: See Srivastava (1972b, p.11).

DESCRIPTION: See Dettmann (1963, p.27).

SUGGESTED AFFINITY: Cheiropleuriaceae? Couper suggested the relationship of this genus with the Jurassic fern *Dictyophyllum rugosum*. See Srivastava (1972b, p.11) for detailed discussion.

Dictyophyllidites harrisii Couper 1958

[Plate 3, Figure 10]

Dictyophyllidites harrisii Couper 1958, p.140, pl.21, figs.5-6.

Dictyophyllidites harrisii Couper; Srivastava 1972b, p.12, pl.7, figs.4-5.

DESCRIPTION: See Couper (1958, p.140).

DISCUSSION: Elevated commissures and margos next to laesurae can differentiate this species from other similar forms. Size ranges 53-57um (3 specimens measured).

OCCURRENCE: Jurassic of England (Couper, 1958) and western Canada (Pocock, 1970), Maastrichtian of Alberta (Srivastava, 1972b). Price River Formation, and Cretaceous interval and lower of two Paleocene intervals (middle Paleocene in age) of North Horn Formation in this study. Very rare to few. Probably recycled.

Genus Dictyotosporites Cookson and Dettmann 1958

TYPE SPECIES: *Dictyotosporites speciosus* Cookson and Dettmann 1958

Dictyotosporites cf. D. speciosus Cookson and Dettmann 1958

[Plate 3, Figures 11,12]

DESCRIPTION: See Singh (1964, p.100).

SIZE RANGE: 33um in equatorial diameter excluding flange (1 specimen measured).

OCCURRENCE: Albian of Alberta (Singh, 1971), and Neocomian to Aptian of eastern Australia (Cookson and Dettmann, 1958). Single specimen found in uppermost stratum of the Price River Formation is probably recycled from the middle Cretaceous strata.

Genus Foveotriletes van der Hammen ex Potonie 1956

TYPE SPECIES: *Foveotriletes scrobiculatus* (Ross) Potonie 1956

Foveotriletes van der Hammen; Dettmann 1963, p.42.

Foveotriletes cf. F. parviretus (Balme) Dettmann 1963

[Plate 4, Figure 1]

Foveotriletes parviretus (Balme) Dettmann 1963, p.42, pl.6, figs.8-13.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Dettmann (1963, p.42).

DISCUSSION: Single specimen (61um in equatorial diameter) found in this study is broken but shows the same morphological characteristic of Australian specimens described by Dettmann (1963). Utah specimen tends to show coarsening of foveolae towards the proximal pole. One illustration of *Matonisporites phlebopteroides* by Srivastava (1972b, pl.22, fig.1) shows very similar foveolate or punctate pattern on its proximal surface. This pattern was interpreted as a corrosion by Srivastava (1972b).

OCCURRENCE: Neocomian - Aptian of western Australia (Balme, 1957), Aptian of southeastern Australia (Dettmann, 1963). Single specimen recovered from Price River Formation in this study is probably recycled.

Genus Gabonisporis Boltenhagen 1967 emend. Srivastava 1972b

TYPE SPECIES: *Gabonisporis vigourouxii* Boltenhagen 1967

Gabonisporis Boltenhagen 1967, p.336.

Gabonisporis Boltenhagen emend. Srivastava 1972b, p.13.

DESCRIPTION: See Srivastava (1972b, p.13).

SUGGESTED AFFINITY: Unknown.

Gabonisporis bacaricumulus Srivastava 1972b

[Plate 4, Figures 2,3]

Gabonisporis bacaricumulus Srivastava 1972b, pp.13-14, pl.7, figs.14-16; pl.8, figs.1-5; pl.9, figs.1-5.

DESCRIPTION: See Srivastava (1972b, p.13).

DISCUSSION: Specimens encountered here correspond closely to the description and illustrations by Srivastava (1972b) including goblet-shaped sculptural elements. 38-40um in equatorial diameter excluding sculptural elements (3 specimens measured). *Gabonisporis vigourouxii* illustrated by Boltenhagen (1967, pl.1, figs.1-3) and *Tsuga viridifluminipites* illustrated by Rouse (1962, pl.1, figs.16-17) could be conspecific as mentioned by Srivastava (1972b, p.14), although these illustrations do not show the detailed shape of sculptural elements. *Peromonolites problematicus* illustrated by Couper (1953) is superficially similar to this form, although it is monolete or alete in nature.

OCCURRENCE: Cretaceous of Gabon (Boltenhagen, 1967), Upper Cretaceous and middle Eocene of western British Columbia (Rouse, 1962), Maastrichtian of Alberta (Srivastava, 1972b). Three specimens were found in two samples of middle Price River Formation in this study.

Genus Ghoshispora Srivastava 1966

TYPE SPECIES: *Ghoshispora scollardiana* Srivastava 1966

Ghoshispora Srivastava 1966, p.511.

Styx Norton and Hall 1967, p.104.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1978a, pp.177-179).

DISCUSSION: Srivastava (1978a, pp.177-179) discussed the nomenclature of the genus at length, and the comparison with other similar forms was clearly reviewed.

Ghoshispora bella (Kondinskaya) Srivastava 1978a

[Plate 4, Figures 4,5]

Ghoshispora bella (Kondinskaya) Srivastava 1978a, pp.181-182, pl.4, figs.3-13.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1971b, pp.306-308).

DISCUSSION: Size ranges 48-130um in equatorial diameter of the spore body (8 specimens measured), but most specimens studied are smaller than 80um. Acrolamellae are frequently removed. Some small specimens show exceptionally long supratectal processes (ratio of process to spore body is 0.5).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973), Maastrichtian of Wyoming (Farabee and Canright, 1986), Montana (Norton and Hall, 1969; Oltz, 1969), Alberta (Srivastava and Binda, 1969). Price River Formation and Cretaceous interval of North Horn Formation in this study. Very rare to abundant (up to 15.3%).

Ghoshispora major (Norton) Srivastava 1978

[Plate 4, Figure 6]

SYNONYMY: See Srivastava (1978a, p.179).

DESCRIPTION: See Norton and Hall (1967, p.105)

DISCUSSION: Size of the species described previously ranges as follows; 130-150um (Norton and Hall, 1967; spore body illustrated in Norton and Hall, 1969 is 102um in equatorial diameter), 110-190um (Oltz, 1969; spore body illustrated in pl.40, fig.58 is 134um in equatorial diameter), 115um for the spore body (Stone, 1973), and 45um and 60um for the spore bodies (Farabee and Canright 1986, pl.3, figs.3,4, respectively, although they mentioned that the size of specimens in their study fell within the above previous ranges). Utah species ranges 45-115um (12 specimens measured) in spore body diameter, and the spore diameter of most specimens studied ranges 50-70um. Other than the size range, this species appears to be identical to species recorded previously. The distinguishing character of this species is its larger size from the other species of the genus (Norton and Hall, 1967, p.105, and Farabee and Canright, 1986, p.18). Since the size variation of this acrolamellate spore is very great, some authors would consider it to be a megaspore

(Norton and Hall, 1967); others a microspore (Srivastava, 1978). Most authors, furthermore, do not indicate whether the given size range is for the spore body alone or the overall size. In such instances, it is presumed to be the overall size. If the caption of pl.3 (Farabee and Canright, 1986) is correct (both figures 3 and 4 are X1000 in magnification), the size range of Wyoming specimens is closer to the Utah specimens than the species recorded from other strata, which are significantly larger (twice or more in lower limit of equatorial diameter). The size range of this species needs to be emended, since the size of the species was the important distinguishing character from other similar forms.

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973), Maastrichtian of Wyoming (Farabee and Canright, 1986), and Montana (Norton and Hall, 1969; Oltz, 1969). Price River Formation and Cretaceous interval of North Horn Formation in this study. Very rare to few.

<u>Ghoshispora scollardiana</u> Srivastava 1966

[Plate 5, Figure 1]

SYNONYMY AND DESCRIPTION: See Srivastava (1978a, pp.179-181).

DISCUSSION: The single specimen encountered is 63um in equatorial diameter. This specimen shows nearly identical features to the revised description and illustrations of Srivastava (1978a).

OCCURRENCE: Upper Maastrichtian of Alberta (Srivastava, 1978a). Castlegate Sandstone in this study. Several specimens were identified outside the counted sum.

<u>Ghoshispora</u> sp. 1

[Plate 5, Figure 2]

DESCRIPTION: Trilete spore; laesurae short, 1/2 of the radius; exine psilate 1.5-2um thick; supratectal processes not conspicuous, 4-13um long; perine thin, punctate, with three leaf-like, proximal extensions of the perine from the acrolamellae. Overall size 38um; spore body 19um in equatorial diameter (1 specimen measured).

DISCUSSION: The single specimen found could be an aborted spore of *Ghoshispora*. Three leaf-like acrolamellae makes it possible to assign this form to the genus. Psilate exine and significantly samll size characterize this form.

OCCURRENCE: Price River Formation.

Genus Gleicheniidites (Ross) Skarby 1964

TYPE SPECIES: Gleicheniidites senonicus Ross 1949

SYNONYMY AND DESCRIPTION: See Skarby (1964, pp.61-62).

SUGGESTED AFFINITY: Gleicheniaceae.

Gleicheniidites senonicus Ross 1949

[Plate 5, Figure 3]

SYNONYMY AND DESCRIPTION: See Skarby (1964, pp.65-67).

OCCURRENCE: Found in most samples in this study. Very rare to common (up to 6.7%).

Gleicheniidites simplex Burger 1966

[Plate 5, Figure 4]

Gleicheniidites simplex Burger 1966, p.239, pl.3, figs.3-4.

DESCRIPTION: See Burger (1966, p.239).

DISCUSSION: 22-30um in equatorial diameter (7 specimens measured). Smaller degree of equatorial thickening of the exine of this species may be used to separate this form from *Gleicheniidites senonicus*.

OCCURRENCE: Lower Cretaceous of Netherlands (Burger, 1966). Found randomly in Price River Formation and the whole interval of North Horn Formation in this study. Very rare to few.

Genus Hamulatisporis Krutzsch 1959 emend. Srivastava 1972b

TYPE SPECIES: *Hamulatisporis hamulatis* Krutzsch 1959

Hamulatisporis Krutzsch emend. Srivastava 1972b, pp.15-16.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1972b, pp.15-16).

SUGGESTED AFFINITY: Lycopodiaceae. Srivastava (1972b, p.16) compares this genus with spores of the extant species *Lycopodium adpressum*.

Hamulatisporis cf. H. hamulatis Krutzsch 1959a

[Plate 5, Figure 5]

Hamulatisporis hamulatis Krutzsch 1959a, p.157, pl.29, figs.326-328.

ADDITIONAL SYNONYMY: See M. Wilson (1978, p.114).

DESCRIPTION: See Stanley (1965, pp.242-243).

DISCUSSION: The only specimen encountered here (29um in equatorial diameter) shows faint, tortuous muri possibly due to the degradation.

OCCURRENCE: Campanian - Paleocene of North America (Stanley 1965; M. Wilson, 1978; Farabee and Canright, 1986), and Eocene of Europe (Krutzsch, 1959a). Lowermost Price River Formation in this study.

Genus Hazaria Srivastava 1971b

TYPE SPECIES: *Hazaria sheopiarii* Srivastava 1971a

Hazaria Srivastava 1971a, p.258.

DESCRIPTION: See Srivastava (1971a, p.258).

Hazaria cf. H. sheopiarii Srivastava 1971a

[Plate 5, Figure 6]

Hazaria sheopiarii Srivastava 1971a, pp.258-260, pl.2, figs.1-4.

DESCRIPTION: See Srivastava (1971a, p.260).

DISCUSSION: The observed aspects of specimens fall well within the range of morphological variation of original description and illustrations. The present author thinks, however, that specimens in greater quantity are required for assignment of this species be made with confidence. Size ranges 40-56um X 24-40um (3 specimens measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1971a). Common in one sample (Pb14727) in the Price River Formation, and seen on slides outside the counted sum of a sample from the Cretaceous interval of North Horn Formation in this study.

Genus Heliosporites Schulz 1962 emend. Srivastava 1972b

TYPE SPECIES: *Heliosporites altmarkensis* Schulz 1962

Heliosporites Schulz 1962, p.311.

Heliosporites Schulz emend. Srivastava 1972b, p.18.

DESCRIPTION: See Srivastava (1972b, p.18).

SUGGESTED AFFINITY: *Selaginella*.

Heliosporites altmarkensis Schulz 1962

[Plate 5, Figure 7]

Heliosporites altmarkensis Schulz; Srivastava 1972b, p.18, pl.13, figs.9-12; pl.14, figs.1-2.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1972b, p.18).

DISCUSSION: Spceimens assigned to this species show punctate nature of sclerine. Equatorial diameter 33um (1 specimen measured).

OCCURRENCE: Uppermost Triassic - lowermost Jurassic of Germany (Schulz, 1962 and 1967), Albian - Senonian of U.S.S.R. (Aristova, 1967; Chlonova, 1960 and 1961; Samoilovitch and Mtchedlishvili, 1961) (*fide* Srivastava, 1972b).

Maastrichtian of Alberta (Srivastava, 1972b). Very rare to common in Price River Formation in this study. One specimen was seen in a sample from the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation.

Heliosporites cf. H. kemensis (Chlonova) Srivastava 1972b

[Plate 5, Figures 8,9]

Heliosporites kemensis (Chlonova) Srivastava; Singh 1983, p.42, pl.15, figs.8-9.

ADDITIONAL SYNONYMY: See Singh (1983, p.42).

DESCRIPTION: See Srivastava (1972b, p.19).

DISCUSSION: Utah specimens do not show the laesurae extending to the equatorial margin. Instead, they extend to the margin of the central body. 34um in equatorial diameter (1 specimen measured).

OCCURRENCE: Uppermost Jurassic of England (Norris, 1969 and 1970), Cenomanian - Maastrichtian of Alberta (Singh, 1983; Srivastava, 1972b), Albian of Louisiana (Phillips and Felix, 1971), Albian of Texas (Srivastava, 1975b), Cenomanian - Turonian of Spain (Van Amerom, 1965) and U.S.S.R. (Chlonova, 1960 and 1976; Chlonova and Krasnova in Samoilovitch *et al.*, 1961) (*fide* Singh, 1983). Two specimens were recovered from one sample (Pb14731) of the Price River Formation in this study.

Genus Laevigatosporites Ibrahim 1933 emend. Schopf et al. **1944**

TYPE SPECIES: *Laevigatosporites vulgaris* (Ibrahim 1932) Ibrahim 1933

SNONYMY: See Srivastava (1971b, pp.252-253).

DESCRIPTION: See Schopf *et al.*(1944, p.36).

DISCUSSION: Variation in outline of spores from oval and broad to narrow and bean-shaped may reflect their degree of expansion, a harmemogathic factor. Since the major differences among *Laevigatosporites ovatus*, *L. hardtii*, and *L. gracilis* are differences in size, these species may be conspecific (Srivastava, 1971a, p.254 and M. Wilson, 1978, p.118), but there is some evidence they are valid morphotypes. In this study, *L. ovatus* represents spores with oval outlines and relatively short laesurae, and *L. haardtii* represents spores with bean-shaped outlines and longer laesurae.

Laevigatosporites discordatus Pflug 1953

[Plate 5, Figure 10]

Laevigatosporites discordatus Pflug 1953, p.59, pl.3, figs.40-43.

Laevigatosporites discordatus Pflug; Norton and Hall 1969, p.20, pl.2, fig.14.

DESCRIPTION: See Norton and Hall (1969, p.20).

DISCUSSION: Size range is 48-67 X 7-50um (9 specimens measured). The only distinction between *Laevigatosporites discordatus* and *Laevigatosporites anomalus* seems to be the presence of foveae on the proximal face, especially near the laesurae, in the latter species. This foveolate nature seems to vary in size and area of distribution in specimens, and is rather gradational among specimens from foveolate to non-foveolate form. There is a suspicion that this foveolate nature might be caused by degradation during process of fossilization. Although the stratigraphical significance of *Laevigatosporites anomalus* (Maastrichtian - Paleocene) was indicated directly by Robertson (1975) and indirectly by Farabee and Canright (1986), forms with foveae-like texture are included with *Laevigatosporites discordatus* in this study.

SUGGESTED AFFINITY: Polypodiaceae.

OCCURRENCE: North American record includes Maastrichtian of Montana (Norton and Hall, 1969). *Laevigatosporites anomalus* was found in Maastrichtian of Wyoming (Farabee and Canright, 1986), Maastrichtian and Paleocene of Montana (Norton and Hall, 1969; Oltz, 1969), and Paleocene of North Dakota (Robertson, 1975). Present in most samples throughout the section in this study. Very rare to common.

Laevigatosporites haardtii (Potonie and Venitz 1934) Thomson and Pflug 1953

[Plate 5, Figure 11]

SYNONYMY: See Stanley (1965, p.252).

DESCRIPTION: See Stanley (1965, p.252).

OCCURRENCE: Paleozoic - present (see M. Wilson, 1978 for further discussion). Present in nearly all samples throughout the section in this study. Lower and upper Paleocene intervals (middle to middle/late Paleocene in age) of North Horn Formation in abundant occurrences (up to 19%).

Laevigatosporites ovatus Wilson and Webster 1946

[Plate 5, Figure 12]

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.253).

OCCURRENCE: Paleozoic - present (see M. Wilson, 1978 for further discussion). Present in nearly all samples throughout the section in this study. Most samples in the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation show abundant occurrences (up to 52.3%).

Genus Liburnisporis Srivastava 1972b

TYPE SPECIES: *Liburnisporis adnacus* Srivastava 1972b

DESCRIPTION: See Srivastava (1972b, p.22).

Liburnisporis cf. L. adnacus Srivastava 1972b

[Plate 6, Figure 1]

Liburnisporis adnacus Srivastava 1972b, p.22, pl.17, figs.1-10; pl.18, figs.1-7; pl.19, figs.1-7; pl.20, figs.1-3.

DESCRIPTION: See Srivastava (1972b, p.22).

DISCUSSION: Single specimen found looks identical to an illustration given by Srivastava (1972b, pl.19, fig.7). Various shape of sculptural elements characterize this form. Size 57um in maximum diameter (probably equatorial diameter).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). Cretaceous interval of North Horn Formation in this study.

Genus Osmundacidites Couper 1953

TYPE SPECIES: *Osmundacidites wellmanii* Couper 1953

SYNONYMY AND DESCRIPTION: See Singh (1964, p.44).

SUGGESTED AFFINITY: Osmundaceae.

Osmundacidites wellmanii Couper 1953

[Plate 6, Figures 2,3]

SYNONYMY AND DESCRIPTION: See Dettmann (1963, p.32).

SIZE RANGE: Five specimens were measured and range 29-44um in equatorial diameter.

OCCURRENCE: Liassic to Maastrichtian. Widespread in various parts of the world. Price River Formation and Cretaceous interval of North Horn Formation in this study. Very rare.

Genus Peromonolites Couper 1953

TYPE SPECIES: *Peromonolites bowenii* Couper 1953

Peromonolites Couper 1953, p.32

DESCRIPTION: See Couper (1953, p.32).

Peromonolites subengelmanni (Elsik) Jameossanaie 1987

[Plate 6, Figures 4,5]

Isoetes subengelmanni Elsik 1968a, p.288,290, pl.5, figs.5-7.

Peromonolites subengelmanni (Elsik) Jameossanaie 1987, pp.14-15, pl.7, figs.15-16.

DESCRIPTION: See Elsik (1968a, pp.288,290).

DISCUSSION: Illustrations of the type species, *Peromonolites bowenii*, (Couper 1953, pl.3, figs.31-32) appear to be closely similar to those of this species. In his description, Couper stated exine of the type species, *P. bowenii*, is "thin, and 1.5-2um". *Peromonolites subengelmanni* has thinner exine (0.5um) than that of *P. bowenii*.

SUGGESTED AFFINITY: Elsik (1968a, p.290) compares this species with extant species *Isoetes engelmanni* which is a common species in North Carolina.

OCCURRENCE: Cenomanian - Paleocene. Cenomanian of Wyoming (Griggs, 1970a), Campanian of New Mexico (Jameossanaie, 1987), Paleocene of Texas (Elsik, 1968a). Paleocene (lower and upper) intervals of North Horn Formation in this study, especially abundant in sample Pb14088 of Ford Creek Coal (15% of the 300 counting sum).

Genus Polycingulatisporites Simoncsics and Kedves emend. Playford and Dettmann 1965

TYPE SPECIES: *Polycingulatisporites circulus* Simoncsics and Kedves 1961

SYNONYMY: See Srivastava (1972b, p.27).

DESCRIPTION: See Playford and Dettmann (1965, p.143).

SUGGESTED AFFINITY: Uncertain.

Polycingulatisporites reduncus (Bolkhovitina) Playford and Dettmann 1965

[Plate 6, Figure 6]

Taurocusporites reduncus (Bolkhovitina) Stover 1962, p.57, pl.1, figs.15-21.

Polycingulatisporites reduncus (Bolkhovitina) Playford and Dettmann; Srivastava 1972b, p.28, pl.23, figs.6-9; pl.24, figs.1-3.

Polycingulatisporites reduncus (Bolkhovitina) Playford and Dettmann; Farabee and Canright 1986, p.27, pl.7, figs.1-3.

ADDITIONAL SYNONYMY: See Srivastava (1972b, p.28).

DESCRIPTION: See Stover (1962, p.57).

SIZE RANGE: Equatorial diameter ranges from 42-49um (2 specimens measured).

OCCURRENCE: Lower Cretaceous of Maryland (Stover, 1962; Brenner, 1963). Aptian to Cenomanian of Colorado and Nebraska (Pannella, 1966). Albian of Oklahoma (Hedlund and Norris, 1968), Wyoming (Davis, 1963), and Alberta (Singh, 1964; Norris, 1967). Cenomanian of Alabama (Leopold and Pakiser, 1964). Maastrichtian and Paleocene of California (Drugg, 1967) (*fide* Srivastava, 1972b). Castlegate Sandstone and Price River Formation yielded one specimen each in this study. This species here is considered to be reworked from the older strata.

Genus Polypodiites Ross ex Couper 1953

TYPE SPECIES: *Polypodiites* Ross ex Couper 1953

SYNONYMY: See Norton and Hall (1969, p.21).

DESCRIPTION: See Couper (1953, p.28).

DISCUSSION: Singh (1983, pp.47-48) discussed the distinctions among sculptured monolete genera.

SUGGESTED AFFINITY: Polypodiaceae. Couper (1953, p.29) noted the similarity between *Polypodiidites inangahuensis* and *Microsorium diversifolium* except the size.

Polypodiites inangahuensis Couper 1953

[Plate 6, Figure 8]

Polypodiites inangahuensis Couper 1953, p.29, pl.2, fig.16.

Polypodiites inangahuensis Couper; Norton and Hall 1969, p.21, pl.2, fig.16.

DESCRIPTION: See Norton and Hall (1969, p.21).

SIZE RANGE: 39 X 31um (1 specimen measured).

OCCURRENCE: Maastrichtian of Montana (Norton and Hall, 1969) and Miocene to Pliocene of New Zealand (Couper, 1953). Single specimen was found in a sample from the Price River Formation in this study.

Genus Reticuloidosporites Pflug 1953

Reticuloidosporites Pflug; Thomson and Pflug 1953, p.60.

SUGGESTED AFFINITY: ?Polypodiaceae.

Reticuloidosporites dentatus Pflug 1953

Reticuloidosporites dentatus Pflug 1953, p.60, pl.4, fig.11.

Reticuloidosporites dentatus Pflug; Norton and Hall 1969, p.21, pl.2, fig.17.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Norton and Hall (1969, p.21).

SIZE RANGE: 39 X 21um (1 specimen measured).

OCCURRENCE: Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). Single specimen was found in outside the counted sum from the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation.

Genus Retitriletes Pierce emend. Doring, Krutzsch, Mai and Schulz in Krutzsch 1963

TYPE SPECIES: *Retitriletes globosus* Pierce 1961

SYNONYMY: See Srivastava (1972b, p.29).

SUGGESTED AFFINITY: Lycopodiaceae.

Retitriletes nidus Srivastava 1972b

[Plate 6, Figure 9]

Retitriletes nidus Srivastava 1972b, p.31, pl.26, figs.17-18; pl.27, figs.1-4.

DESCRIPTION: See Srivastava (1972b, p.31).

DISCUSSION: One specimen encountered in this study (37um in equatorial diameter) is circular in amb. Otherwise it agrees well with description and illustrations of Srivastava (1972b).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). Single specimen was recovered from the Price River Formation in this study.

Genus Stereisporites Pflug 1953

TYPE SPECIES: *Stereisporites stereoides* (Potonie and Venitz) Pflug 1953

Stereisporites antiquasporites (Wilson and Webster) Dettmann 1963

[Plate 6, Figures 12]

Stereisporites antiquasporites (Wilson and Webster) Dettmann; M. Wilson 1978, pp.108-109, pl.1, figs.7,11

SYNONYMY: See M. Wilson (1978, pp.108-109).

DESCRIPTION: See Dettmann (1963, p.25).

SIZE RANGE: 22-36um (2 specimen measured).

OCCURRENCE : Mesozoic - Tertiary. Widespread in the various parts of the world. Seldom found in samples from throughout the section in this study. Very rare to rare.

Stereisporites stereoides (Potonie and Venitz) Pflug 1953

[Plate 6, Figures 10,11]

Stereisporites stereoides (Potonie and Venitz) Pflug; Thomson and Pflug 1953, p.53

SYNONYMY AND DESCRIPTION: See Srivastava (1966, pp.499-501).

SIZE RANGE: 18-25um in equatorial diameter (7 specimens measured).

OCCURRENCE: Mesozoic - Tertiary. Widespread in the various parts of the world. Scattered throughout the section in this study. Very rare to few (up to 1.3%).

Genus Todisporites Couper 1958

TYPE SPECIES: *Todisporites major* Couper 1958

Todisporites Couper 1958, p.134

Todisporites Couper; Singh 1964, p.45.

Todisporites Couper; Singh 1971, p.50.

DESCRIPTION: See Couper (1958, p.134).

SUGGESTED AFFINITY: Couper (1958, p.134) provisionally assigned this genus to Osmundaceae.

Todisporites cf. **T. major** Couper 1958

[Plate 6, Figure 14]

Todisporites major Couper 1958, pp.134-135, pl.16, figs.6-8.

DESCRIPTION: See Couper (1958, p.134).

DISCUSSION: One specimen studied agrees well with the variation of morphology originally described by Couper (1958). The present author, however, hesitates to assign this more or less degraded single specimen to this species. Couper (1958) suggested the different parent plants for *Todisporites major* and *Todisporites minor* by illustrating a bimodal size frequency curve.

OCCURRENCE: Lower Lias to Middle Jurassic of England (Couper, 1958). A single specimen was found on slides outside the counted sum of the Price River Formation in this study is probably recycled.

Todisporites minor Couper 1958

[Plate 6, Figure 13]

Todisporites minor Couper; Singh 1971, pp.50-51, pl.4, fig.2.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Singh (1964, p.45).

DISCUSSION: Exine is thin, but folded nature, which was frequently observed in the previous records, was not seen in this study. 35-40um in equatorial diameter (3 specimens measured).

OCCURRENCE: Middle Jurassic to Cenomanian. Albian of Alberta (Singh, 1964 and 1971; Norris, 1967), Upper Jurassic and Lower Cretaceous of western Canada (Pocock, 1962), Middle Jurassic of England (Couper, 1958), Cenomanian of Oklahoma (Hedlund, 1966). In this study, specimens are seldom found throughout the section, and these are probably recycled from earlier strata. Very rare to rare (up to 1.0%).

Genus Triplanosporites Pflug 1952

TYPE SPECIES: *Triplanosporites sinuosus* Pflug 1952

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.263).

SUGGESTED AFFINITY: Filicineae.

Triplanosporites sinuosus Pflug 1952

[Plate 6, Figure 15]

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.264).

DISCUSSION: Some specimens may belong to *Cyathidites minor* or *Deltoidospora diaphana*. Specimens show some similarity with above two species, but were sufficiently distinctive to be assigned to this species. There is no evidence of elevated commissures or margos as shown in *Dictyophyllidites*. Six specimens measured range 29-37um in equatorial diameter and 29-41um in polar diameter.

OCCURRENCE: Reported in Upper Cretaceous and lower Tertiary of Montana (Norton and Hall, 1969) and lower Tertiary of South Dakota (Stanley, 1965). Present throughout the section in this study. Very rare to abundant (up to 10%).

Genus Triporoletes Mtchedlishvili emend. Playford 1971

TYPE SPECIES: *Triporoletes singularis* Mtchedlishvili in Mtchedlishvili and Samoilovitch 1960

SYNONYMY: See Srivastava (1975b, p.67).

DESCRIPTION: See Playford (1971, p.551).

SUGGESTED AFFINITY: Dettmann (1963, p.96) noted the morphological similarity of this genus to modern hepatic spores belonging to the Ricciaceae and Clavaceae.

Triporoletes asper Srivastava 1972b

[Plate 7, Figure 1]

Triporoletes asper Srivastava 1972b, p.34, pl.27, figs.11-12; pl.28, figs.1-3.

Triporoletes asper Srivastava; Farabee and Canright 1986, pp.28-29, pl.8, fig.1.

DESCRIPTION: See Srivastava (1972b, p.34).

SIZE RANGE: 53um in equatorial diameter of spore body and 7um for the width of zona (1 specimen measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b) and Wyoming (Farabee and Canright, 1986). S single specimen was found on a slide outside the counted sum of the Price River Formation.

Triporoletes novomexicanus (Anderson 1960) Srivastava 1975b

[Plate 7, Figure 2]

SYNONYMY: See Srivastava (1975b, p.69).

DESCRIPTION: See Anderson (1960, p.14).

SIZE RANGE: 37-52um in equatorial diameter (9 specimens measured).

OCCURRENCE: Maastrichtian - Paleocene of New Mexico (Anderson, 1960) and Wyoming (Leffingwell, 1970). Throughout the section except the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation in this study. Very rare to few (up to 4%).

Genus Undulatisporites Pflug 1953

TYPE SPECIES: *Undulatisporites microcutis* Pflug 1953

DESCRIPTION: See Potonie (1956, p.19).

Undulatisporites pflugii Pocock 1970

[Plate 7, Figure 4]

Undulatisporites pflugii Pocock 1970, p.40, pl.7, figs.6-7.

DESCRIPTION: See Pocock (1970, p.40). Description based on the Utah specimens is as follow: Trilete spore; laesurae reaching the margin, commissure bordered by a thick elevated lips which are 2-3um wide; outline in polar view subcircular to subtriangular with convex sides. The laesurae are strongly to moderately undulate for the whole radius; exine smooth, 1-1.5um thick; 16-22um in equatorial diameter (6 specimens measured).

DISCUSSION: Fensome (1983) synonymized this species with the *Undulatisporites undulapolus* Brenner.

OCCURRENCE: Jurassic of western Canada (Pocock, 1970). Scattered throughout the section in this study. Very rare to rare. Probably recycled.

Undulatisporites undulapolus Brenner 1963

[Plate 7, Figure 3]

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

Undulatisporites undulapolus Brenner; Singh 1971, p.148, pl.20, figs.11-12.

DESCRIPTION: See Brenner (1963, p.72).

SIZE RANGE: Utah specimens range 25-33um in equatorial diameter (3 specimens measured).

OCCURRENCE: Barremian - Albian of Alberta (Norris, 1967), Maryland (Brenner, 1963), Oklahoma (Hedlund and Norris, 1968), and Alberta (Singh, 1971). Scattered throughout the section in this study. Very rare to few. This species and *Undulatisporites pflugii* in the present study probably represent recycled palynomorphs from the Early and Middle Cretaceous strata.

Genus Varirugosisporites Doring 1965

TYPE SPECIES: *Varirugosisporites perverrucatus* (Couper) Doring 1965

DESCRIPTION: Jansonius and Hills (1976, p.3161) translated the original description as follow: "azonotrilete microspores; amb. rounded triangular; proximally and distally with relatively large tuberose sculptural elements that may or may not fuse at their bases.

DISCUSSION: *Varirugosisporites* includes spores having verrucate exine on both proximal and distal surfaces, whereas *Leptolepidites* includes spores having verrucate exine on proximal face only.

SUGGESTED AFFINITY: Uncertain.

Varirugosisporites tolmanensis Srivastava 1972b

[Plate 7, Figures 5,6]

Varirugosisporites tolmanensis Srivastava 1972b, p.37, pl.35, figs.10-12.

DESCRIPTION: See Srivastava (1972b, p.37).

DISCUSSION: Size of Utah specimens (26-43um, 5 specimens measured) is smaller than that of Alberta specimens (37-50um).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1972b). Several specimens were found on slides outside the counted sum from the youngest part of the Cretaceous interval (Maastrichtian) and lower interval of Paleocene strata (middle Paleocene in age) of the North Horn Formation.

Genus nov. 1

DESCRIPTION: Trilete spore; amb circular to rounded triangular; laesurae reaching the amb, segmented most of the length, enclosed within membraneous, elevated lips; exine psilate, covered with moderately spaced gemmae.

DISCUSSION: This genus is different from *Taurocusporites* Stover 1962, in that the distal face is not trizonate. *Baculatisporites* Pflug and Thomson 1953 has baculate surface, and laesurae are not segmented by thickenings perpendicular to the raised lips.

Genus et sp. nov. 1

[Plate 7, Figures 7,8]

DESCRIPTION: Trilete spore; amb circular to rounded triangular; laesurae reaching the amb, enclosed within membraneous, elevated lips, 1um high, 1um wide; laesurae segmented by closely spaced transverse sculptural elements, 1.5-2um long, 1um wide, less significant towards the margin; exine psilate, covered with moderately spaced gemmae; gemmae, 0.5-1um high, 0.5-1um in diameter; gemmae distributed over both proximal and distal surfaces except the equatorial area; equatorial diameter ranges 35-45um (3 specimens measured).

DISCUSSION: This species is similar to *Taurocusporites* cf. *T. segmentatus* Stover reported by Drugg (1967), but different in not being trizonate on the distal surface.

OCCURRENCE: Three specimens were recovered from one sample (Pb14726) of the Price River Formation.

Unknown spore 1.

[Plate 7, Figures 9,10]

DESCRIPTION: Alete spore; amb. triangular with more or less straight sides; on one side, wall has band parallel to the side, three bands are frequently separated and overlapped each other; bands have inwardly-folded wall extension(?) which yvaries in size and shape, width of band 6-11um; exine psilate to faintly granulate, 1-2um thick; 27-42um in maximum diameter (7 specimens measured).

DISCUSSION: This species may appear to be incomplete or degraded. However, palynomorphs present with this species tend to be relatively well-preserved. This form has a morphology similar to that of *Callialasporites trilobatus* (Balme) Sukh Dev described by Pocock (1970) from the Jurassic strata of western Canada, except that the latter has a very thin-walled transparent saccus which envelopes the central body distalo-equatorially. If the present specimens have been reworked, they may be referable to *Callialasporites trilobatus*.

OCCURRENCE: Lower and upper intervals of Paleocene strata (middle to middle/late Paleocene in age) of North Horn Formation in this study. Very rare to common.

Unknown spore 2

[Plate 7, Figure 11]

DESCRIPTION: Trilete spore; spheroidal, the distal surface strongly arched, contact area occupies most of proximal hemisphere (approximately 76um in diameter); amb. circular; exine psilate and 2um thick; laesurae straight, extending to the equator; equatorial diameter 97um.

DISCUSSION: Although this spore belongs to the size range of microspore, it has the characteristics of a megaspore. This form may be related to *Azolla* which is an abundant megaspore in the Late Cretaceous and early Tertiary strata of mid-continent North America (Hall and Bergad, 1971).

OCCURRENCE: One specimen was found in this study on a slide in an area outside the counted sum; Cretaceous interval of North Horn Formation.

3. GYMNOSPERMOUS POLLEN

Genus Abietineaepollenites Potonie ex Delcourt and Sprumont 1955

TYPE SPECIES: *Abietineaepollenites microalatus* (Potonie) Delcourt and Sprumont 1955

SYNONYMY: See B. Tschudy (1973, p.14).

DESCRIPTION: See Delcourt and Sprumont (1955, p.51).

SUGGESTED AFFINITY: Pinaceae.

Abietineaepollenites microalatus (Potonie) Delcourt and Sprumont 1955

[Plate 8, Figure 1]

Abietineaepollenites microalatus microalatus Potonie 1958, p.61, pl.7, figs.73-74.

Abietineaepollenites microalatus microalatus Potonie; Norton and Hall 1969, p.28, pl.4, fig.3.

DESCRIPTION: See Norton and Hall (1969, p.28).

DISCUSSION: 55-65um in overall length (4 specimens measured). In the present study, morphological variation within the species is not considered to be divisible to the subspecies level

OCCURRENCE: Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). Scattered in the Price River Formation, and very rare to few throughout the North Horn Formation in this study.

Genus Alisporites Daugherty 1941

TYPE SPECIES: *Alisporites opii* Daugherty 1941

SYNONYMY: See B. Tschudy (1973, p.14).

DESCRIPTION: See Singh (1964, p.108).

SUGGESTED AFFINITY: Probably Pinaceae (Rouse, 1959).

Alisporites grandis (Cookson) Dettmann 1963

[Plate 8, Figure 3]

SYNONYMY: See B. Tschudy (1973, p.14).

DESCRIPTION: See Dettmann (1963, p.102).

SIZE RANGE: 73-90um in overall length (2 specimens measured).

OCCURRENCE: Late Jurassic - Maastrichtian of Australia and North America including Campanian of Montana (B. Tschudy, 1973) and Maastrichtian of Alberta (Srivastava, 1966). One specimen was found in the lower interval of Paleocene strata (middle Paleocene in age), very rare to rare in the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation, and one specimen was recovered from the lowermost stratum of Flagstaff Member of Green River Formation.

Alisporites aff. A. rotundus Rouse 1959

[Plate 8, Figure 5]

Alisporites rotundus Rouse 1959, p.316, pl.1, figs.15-16.

Alisporites rotundus Rouse; Singh 1964, p.110, pl.14, figs.13-14, pl.15, figs.1-2.

DESCRIPTION: See Singh (1964, p.110).

DISCUSSION: This species agrees nearly exactly with *Alisporites rotundus* of Singh (1964) which is much larger (75-120um in overall length). Utah species ranges 64-75um in overall length.

OCCURRENCE: Upper Jurassic? of western Canada (Rouse, 1959) and Lower Cretaceous of Alberta (Singh, 1964). Very rare to rare in the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation and lowermost Flagstaff Member of Green River Formation (outside the counted sum).

Alisporites thomasii (Couper) Nilsson 1958

SYNONYMY: See B. Tschudy (1973, p.14).

DESCRIPTION: See Singh (1964, p.109).

SIZE RANGE: 54-62um in overall length (5 specimens measured).

OCCURRENCE: Jurassic of Scotland (Couper, 1958) and Sweden (Nilsson, 1958); Early Cretaceous of British Columbia (Rouse, 1959), and Alberta (Pocock, 1962; Singh, 1964); Albian of Alberta (Norris, 1967); Cenomanian of Oklahoma (Hedlund, 1966); Campanian of Montana (B. Tschudy, 1973). Throughout the section except the Castlegate Sandstone in this study. Mostly very rare to few, but one sample (Pb14746) yielded 18.6% of the total count.

Genus Araucariacites (Cookson 1947) Couper 1953

TYPE SPECIES: *Araucariacites australis* Cookson 1947

DESCRIPTION: See Couper (1953, p.39).

SUGGESTED AFFINITY: Araucariaceae.

Araucariacites australis Cookson 1947

[Plate 8, Figures 2,4]

SYNONYMY: See Brenner (1963, p.76).

DESCRIPTION: See Couper (1958, p.151).

SIZE RANGE: 35-70um in maximum diameter (5 specimens measured).

OCCURRENCE: Jurassic to Tertiary of various parts of the world. Price River Formation, and Cretaceous interval and lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study. Very rare to rare.

Genus Cedripites Wodehouse 1933

TYPE SPECIES: *Cedripites eocenicus* Wodehouse 1933

SYNONYMY: See B. Tschudy (1973, p.15).

DESCRIPTION: See Wodehouse (1933, p.490).

SUGGESTED AFFINITY: Pinaceae. Singh (1964) compares this genus to the extant genus *Cedrus*.

Cedripites cretaceous Pocock 1962

[Plate 8, Figure 7]

Cedripites cretaceous Pocock 1962, p.63, pl.9, figs.145-146, pl.10, figs.147-148.

SYNONYMY: See B. Tschudy (1973, p.15).

DESCRIPTION: See Pocock (1962, p.63).

SIZE RANGE: 59-80um in overall length (4 specimens measured).

OCCURRENCE: Neocomian (Pocock, 1962) and Aptian (Singh, 1964; Norris, 1967) of Alberta. Campanian of Montana (B. Tschudy, 1973). Very rare to rare in the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation, and lowermost Flagstaff member of Green River Formation in this study. One specimen was seen from outside the counted sum of Castlegate Sandstone sample.

Cedripites parvus Norton 1969

[Plate 8, Figure 8]

Cedripites parvus Norton; Norton and Hall 1969, p.29, pl.4, fig.7.

Cedripites parvus Norton; B. Tschudy 1973, p.15, pl.5, fig.7.

DESCRIPTION: See Norton and Hall (1969, p.29).

SIZE RANGE: 55um in overall length (1 specimen measured).

OCCURRENCE: Campanian (B. Tschudy, 1973) and Paleocene (Norton and Hall, 1969) of Montana. Two specimens were recovered from upper interval of

Paleocene strata (middle/late Paleocene in age) of North Horn Formation in this study.

Genus Cerebropollenites Nilsson 1958

TYPE SPECIES: *Cerebropollenites mesozoicus* (Couper) Nilsson 1958

SYNONYMY AND DESCRIPTION: See Pocock (1970, p.97).

Cerebropollenites sp.1.

[Plate 9, Figures 1-3]

DESCRIPTION: Multisaccate pollen; oval shaped central body is smooth and relatively thin, 27-34um in maximum diameter (5 specimens measured); sacci distinct, strongly convoluted, spherical in shape, sacci are not widest at base; sacci smooth, sparsely distributed over the whole surface of central body, 3-6um in diameter; some specimens show leptoma on the distal pole.

DISCUSSION: Spherical sacci with thick wall and their sparse distribution differentiate this species from the previously recorded forms.

OCCURRENCE: Lower and upper intervals of Paleocene strata (middle to middle/late Paleocene in age) of North Horn Formation. Very rare to rare.

Cerebropollenites sp.2.

[Plate 9, Figure 4]

DESCRIPTION: Multisaccate pollen; oval shaped central body is smooth and relatively thin, 38um in maximum diameter (1 specimen measured); sacci distinct and strongly convoluted, the bases of sacci are always the widest part of these; sacci surface smooth and distributed irregularly and sparsely over the whole surface of the central body, 8-13um in diameter; leptoma-like structure was observed on its distal pole.

DISCUSSION: Overall size and the size of sacci are much larger than those of *Cerebropollenites* sp.1. Also the shape and the thickness of sacci may be significant in differentiating this species from the latter.

OCCURRENCE: A single specimen was recovered from outside the counted sum of upper interval of Paleocene strata (middle/late Paleocene in age) of the North Horn Formation.

Genus Confertisulcites Anderson 1960

TYPE SPECIES: *Conferticulcites knowltonii* Anderson 1960

DESCRIPTION: See Anderson (1960, p.27).

Confertisulcites gracilis (Krutzsch 1970) Frederiksen 1983

[Plate 9, Figure 5]

Monosulcites sp. Brenner 1963, p.76, pl.25, fig.8.

Confertisulcites gracilis (Krutzsch) Frederiksen *et al.* 1983, p.45, pl.13, figs.18-20.

DESCRIPTION: See Frederiksen *et al.*(1983, p.45).

DISCUSSION: Frederiksen *et al.*(1983, p.45) noted that one of their illustrated specimens shows the expanded end at one side and interpreted it as the result of damage. Some of Utah specimens have damaged ends. The other specimens do not seem to be damaged but they also show one expanded end. It may be the result of preservational condition caused by its nature of slender and elongate form. Size ranges 36-53um (5 specimens measured).

OCCURRENCE: Eocene of California (Frederiksen *et al*, 1983). Cretaceous interval and lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in this study. Very rare to few.

Genus Corollina Maliavkina emend. Cornet and Traverse 1975

TYPE SPECIES: *Corollina compacta* Maliavkina 1949

SYNONYMY AND DESCRIPTION: See Cornet and Traverse (1975, pp.16-17).

DISCUSSION: *Circulina* and *Corollina* were published by Maliavkina (1949), and Pflug (Thomson and Pflug, 1953) described the genus *Classopollis*. Although both genera were described validly by Maliavkina, inadequacy of illustrations of these caused the confusion and disagreement in application of generic names and synonymizing *Classopollis* to either genus. Boltenhagen (1973) believed that *Circulina*, *Corollina* and *Classopollis* should be in one genus after studying pollen extracted directly from Liassic *Brachyphyllum* cones (Boltenhagen and Doubinger, 1973) (*fide*. Srivastava, 1976). Traverse *et al.* (1974) suggested that it would be better to use either *Circulina* or *Corollina*, because both genera were validly published and have priority over *Classopollis*. Cornet and Traverse (1975, pp.15-16; later corrected by Travèrse and Cornet, 1976, p.141) suppressed the name *Circulina* in favor of *Corollina* because the latter was monotypic when published. Van Erve (1977, pp.72-74 and 117) shares this idea, although he had favored *Circulina* over *Corollina* at the beginning. Srivastava (1976, pp.438-439) suggested not to use the names *Circulina* and *Corollina* to avoid confusion and misinterpretation due to non-availability of the type specimens and inadequate illustration of these. He contributed to broaden the knowledge of the form that was studied under the name *Classopollis* through the detailed study of different types.

SUGGESTED AFFINITY: Cheirolepidiaceae, extinct family which has an affinity with Araucariaceae, Voltziaceae and Gnetaceae.

Corollina parva (Brenner) comb. nov.

[Plate 9, Figure 6]

Circulina parva Brenner 1963, p.84, pl.34, figs.2-3.

Exesipollenites tumulus Balme; Pocock 1970, pl.23, fig.8 only.

Classopollis cf. *Circulina parva* Brenner; Jameossanaie 1987, p.21, pl.12, fig.8.

DESCRIPTION: See Brenner (1963, p.84).

DISCUSSION: This species could be conspecific with *Corollina meyeriana* (Klaus 1960) Venkatachala and Goczan 1964, described and discussed by Cornet and Traverse (1975, p.19). Specimens encountered in this study, however, show the faint equatorial striations as present in Brenner's specimens. This striation is significant in degraded specimens. The Utah specimens (21-25um in equatorial diameter, 9 specimens measured) is larger than the New Mexico specimens of the species described by Jameossanaie (1987) from Campanian strata (16-21um), and those from Maryland described by Brenner (1963) from Lower Cretaceous strata (13-23um).

OCCURRENCE: Jurassic of western Canada (Pocock, 1970), Lower Cretaceous of Maryland (Brenner, 1963), and Campanian of New Mexico (Jameossanaie, 1987). Throughout the North Horn Formation including Cretaceous and Paleocene intervals in this study.

Genus Cycadopites Wodehouse ex Wilson and Webster 1946

TYPE SPECIES: *Cycadopites follicularis* Wilson and Webster 1946

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.270).

SUGGESTED AFFINITY: Cycadaceae.

Cycadopites formosus Singh 1964

[Plate 9, Figure 7]

Cycadopites formosus Singh 1964, p.105, pl.14, figs.4-5.

DESCRIPTION: See Singh (1964, p.1105).

SIZE RANGE: 55-57um X 27-30um (2 specimens measured).

OCCURRENCE: Aptian - Albian of Alberta (Singh, 1964). Castlegate Sandstone, Price River Formation, and Cretaceous interval of North Horn Formation (very rare to rare). Upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation (1 specimen, probably recycled).

Cycadopites giganteus Stanley 1965

[Plate 9, Figure 8]

Cycadopites giganteus Stanley 1965, pp.270-271, pl.37, figs.6-9.

DESCRIPTION: See Stanley (1965, pp.270-271).

DISCUSSION: 15-19um X 80-88um (2 specimens measured). Length:breadth ratio of Utah specimens is higher than that of Stanley's specimens from South Dakota.

OCCURRENCE: Paleocene of South Dakota (Stanley, 1965). Cretaceous interval (very rare) and one specimen from upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study.

Cycadopites scabratus Stanley 1965

[Plate 9, Figure 9]

Cycadopites scabratus Stanley 1965, p.271, pl.37, figs.10-15.

ADDITIONAL SYNONYMY: See M. Wilson (1978, p.129).

DESCRIPTION: See Stanley (1965, p.271).

SIZE RANGE: 30-36um in length (5 specimens measured).

OCCURRENCE: Albian to Paleocene of the various parts of the world. Throughout the section in this study. Very rare to few.

Cycadopites sp.1.

[Plate 9, Figures 10,11]

DESCRIPTION: Monosulcate pollen; amb. elongate oval; sulcus extending the full length of grain, flared at ends, constricted at the center but edges not touching; exine 0.5um thick, psilate to faintly scabrate; size range 6-10umX11-15um (8 specimens measured).

DISCUSSION: This species is characterized by its small size. It is smaller than the most of previously reported Cycadopites species. *Cycadopites minimus* (Cookson) Pocock 1970 is similar to this species but much larger (average 14X29.5um).

OCCURRENCE: Castlegate Sandstone, Price River Formation, and Cretaceous interval of North Horn Formation. Very rare to common (up to 8%).

Genus Equisetosporites Daugherty emend. Pocock and Jansonius 1964

TYPE SPECIES: *Equisetosporites chinleana* Daugherty 1941

SYNONYMY AND DESCRIPTION: See Pocock (1964b, pp.143-144).

DISCUSSION: There have been various opinions on the taxonomy of fossil ephedralean pollen including *Equisetosporites*, *Ephedripites*, and *Gnetaceaepollenites*. *Ephedripites* Bolkhovitina is regarded as being invalid (Singh 1964, p.131; Pocock 1964b, p.145). Steeves and Barghoorn (1959) studied the pollen of *Ephedra* in detail. They grouped the pollen of various species of *Ephedra* into four major morphological groups, *viz*. Types A, B, C, and D. However, two major contrasting opinions on systematic relationship of ephedralean pollen are: to include all four types of Steeves and Barghoorn in the genus *Equisetosporites* (Pocock, 1964); or include only Type A of Steeves and Barghoorn in this genus, and assign the other three types to the genus *Gnetaceaepollenites* (Singh, 1964; Srivastava, 1968c). In the present study, Pocock's opinion is favored, and all the ephedralean pollen types are described under the genus *Equisetosporites* without further splitting. Occurrences of these ephedralean pollen are well-documented in Srivastava (1968c).

SUGGESTED AFFINITY: Ephedraceae, *Ephedra*.

Equisetosporites cf. E. claricristata (Shakhmundes) comb nov.

[Plate 10, Figure 1]

Ephedra claricristata Shakhmundes; Frederiksen *et al.*1983, pp.29-30, pl.7, figs.12-13.

SYNONYMY: See Frederiksen (1980a, p.36).

DESCRIPTION: See Frederiksen *et al.* (1983, p.29 under *Ephedra exiguua* Frederiksen).

SIZE RANGE: Two specimens measured are 15 X 25um and 15 X 27um.

OCCURRENCE: Two specimens were found on slides outside the counted sums from the Cretaceous interval of North Horn Formation.

Equisetosporites cf. E. concinnus Singh 1964

[Plate 9, Figure 15]

Equisetosporites concinnus Singh 1964, p.132, pl.17, figs.10-15.

DESCRIPTION: See Singh (1964, p.132).

DISCUSSION: 49-55um X 18-21um (3 specimens measured). This species is comparable to *Equisetosporites concinnus* described by Singh (1964). However, Utah specimens are significantly smaller (Alberta specimens average 83X35um). Length:breadth ratio of this species is higher (2.6) than that of *Equisetosporites ovatus* (2.1).

OCCURRENCE: Aptian of Alberta (Singh, 1964). Price River Formation and Cretaceous interval of North Horn Formation in this study. Very rare. Probably recycled.

<u>Equisetosporites</u> <u>eocenipites</u> Wodehouse 1933

[Plate 9, Figure 13]

Ephedra eocenipites Wodehouse 1933, p.495, fig.16 (should read fig.16 in the legend on page 499).

Gnetaceaepollenites eocenipites (Wodehouse) Potonie 1958, p.88.

Ephedripites eocenipites Wodehouse; Krutzsch 1961b, p.20.

Gnetaceaepollenites eocenipites Wodehouse; Norton and Hall, p.33, pl.3, fig.17.

Gnetaceaepollenites eocenipites (Wodehouse) Potonie; Farabee and Canright, 1986, pp.32-33, pl.9, figs.8-10.

DESCRIPTION: See Norton and Hall (1969, p.33).

DISCUSSION: Size ranges 34-57um X 12-18um (7 specimens measured). *Ephedra fusiformis* Shakhmundes, described from Eocene of California (Frederiksen *et al.*, 1983, p.30, pl.7, figs.15-16), is probably conspecific.

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986) and Montana (Norton and Hall, 1969). Eocene of Colorado and Utah (Wodehouse, 1933) and California (Frederiksen *et al.*1983). Two samples (Pb14734 and Pb14542) from the Cretaceous interval of North Horn Formation yielded 9 specimens each in this study.

<u>Equisetosporites</u> cf. <u>E</u>. <u>ovatus</u> (Pierce) Singh 1964

[Plate 9, Figure 14]

Strianinaperturites ovatus Pierce 1961, p.45, pl.3, fig.80.

DESCRIPTION: See Pierce (1961, p.45).

SIZE RANGE: 15 X 31um (1 specimen measured).

OCCURRENCE: Aptian of Alberta (Singh, 1964), Cenomanian of Minnesota (Pierce, 1961). Campanian (Stone, 1973) and Maastrichtian (Farabee and Canright,

1986) of Wyoming. Maastrichtian of Montana (Norton and Hall, 1969). Single specimen was recovered from the Price River Formation (Pb14727) in this study.

Equisetosporites cf. E. volutus (Stanley) Farabee and Canright 1986

[Plate 10, Figure 2]

DESCRIPTION: See Stanley (1965, p.284).

DISCUSSION: Size of the species ranges 48X24um (South Dakota; Stanley, 1965) and 33-44um X 13-19.3um (Wyoming; Farabee and Canright, 1986). Two specimens recovered are 27 X 18um and 58 X 29um in overall size in the present study. These could well be different species. Except the size, these are comparable to *Equisetosporites volutus*.

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986) and South Dakota (Stanley, 1965). Cretaceous interval of North Horn Formation in this study.

Genus Eucommiidites Erdtman emend. Hughes 1961

TYPE SPECIES: *Eucommiidites troedssonii* Erdtman 1948

SYNONYMY AND DESCRIPTION: See Hughes (1961, p.292).

DISCUSSION: Hughes conducted a research on this genus from the material recovered from the micropyle and pollen chamber of a Lower Cretaceous seed. Orientation of this genus which will determine whether the furrow of this form is on the distal or proximal side of the grain, still remains in question. Hughes noted the co-occurrences of this form with *Classopollis* Pflug (also zonisulcate) and cycad pollen (monosulcate).

SUGGESTED AFFINITY: Gymnospermae.

Eucommiidites couperi Anderson 1960

[Plate 10, Figures 4,5]

Eucommiidites couperi Anderson 1960, p.21, pl.11, figs.7-8.

DESCRIPTION: This is not tricolpate pollen as described by Anderson (1960). Hughes (1961) illustrated the nature of the genus which includes one aperture on one side and a ring furrow on opposite side. See Anderson (1960, p.21) for the description of other features.

DISCUSSION: 23-27um X 17-19um (2 specimens measured). Srivastava (1978b) regards the occurrence of this form in younger strata than Turonian as being reworked (*fide*. Jameossanaie, 1987).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973) and Maastrichtian of New Mexico (Anderson, 1960). Castlegate Sandstone and Price River Formation in this study. Very rare to few.

Genus Exesipollenites Balme 1957

TYPE SPECIES: *Exesipollenites tumulus* Balme 1957

SYNONYMY AND DESCRIPTION: See Singh (1964, p.126).

SUGGESTED AFFINITY: Uncertain. Probably a gymnosperm.

cf. Exesipollenites tumulus Balme 1957

[Plate 10, Figure 3]

SYNONYMY AND DESCRIPTION: See Singh (1964, p.126).

DISCUSSION: 19-23um in maximum diameter (3 specimens measured). This species closely resembles *Exesipollenites tumulus* Balme. Three specimens found were in poor condition.

OCCURRENCE: Lower Jurassic of western Australia (Balme, 1957). Barremian to Albian of Maryland (Brenner, 1963), Alberta (Singh, 1964,1971; Norris, 1967), and Oklahoma (Hedlund and Norris, 1968). Cenomanian and Turonian of Malaysia (Muller, 1968). Three specimens were found on slides outside the counted sum from the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study. Probably recycled.

Genus Ginkgocycadophytus Samoilovitch 1953

TYPE SPECIES: *Ginkgocycadophytus* (Luber) Samoilovitch 1953

DESCRIPTION: See Singh (1971, p.155).

SUGGESTED AFFINITY: Cycadales or Bennettitales or Ginkgoales.

Ginkgocycadophytus nitidus (Balme 1957) de Jersey 1962

[Plate 10, Figure 6]

Entylissa nitidus Balme; Brenner 1963, pp.74-75, pl.25, figs.3-4.

Ginkgocycadophytus nitidus (Balme) de Jersey; Singh 1971, pp.155-156, pl.22, fig.3.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Dettmann (1963, p.104).

OCCURRENCE: Triassic to Cretaceous from the various parts of the world. As far as my knowledge goes, this species has never been reported from the Tertiary strata. Scattered throughout the section in this study. Very rare to few.

Genus Inaperturopollenites Pflug and Thomson 1953

TYPE SPECIES: *Inaperturopollenites dubius* (Potonie and Venitz 1934) Pflug and Thomson 1953

DESCRIPTION: See Potonie (1958, p.77).

SUGGESTED AFFINITY: Taxodiaceae - Cupressaceae.

Inaperturopollenites dubius (Potonie and Venitz) Pflug and Thomson 1953

[Plate 10, Figure 8]

Pollenites magnus dubius Potonie and Venitz 1934, p.17, pl.2, fig.21.

DESCRIPTION: See Groot *et al.* (1961, p.130).

DISCUSSION: 44-55um in maximum diameter (10 specimens measured). Groot *et al.*(1961) compares this species with Cupressaceae.

OCCURRENCE: Albian - Turonian of eastern U.S.A. (Groot and Penny, 1960; Groot *et al.*1961). Maastrichtian of Alberta (Srivastava, 1966). Tertiary of Europe (Thomson and Pflug, 1953). Throughout the section in this study. Very rare to abundant (up to 21%).

Inaperturopollenites rugosus Groot *et al.* 1961

[Plate 10, Figure 7]

Inaperturopollenites rugosus Groot *et al.* 1961, p.130, pl.24, fig.17.

DESCRIPTION: See Groot *et al.* (1961, p.130).

DISCUSSION: This species could have been derived from the same or closely related species of parent plant as the one that produced *Taxodiaceaepollenites hiatus*, studied herein. The distinctly scabrate nature of the wall and folding due to the thinness of the exine differentiate this species from other similar forms. Utah specimens (20-30um in diameter, 8 specimens measured) is smaller than the species of the eastern United States described by Groot *et al.* (1961).

OCCURRENCE: Similar inaperturate grains have been reported from the various parts of the world. Throughout the section in this study. Very rare to abundant (up to 23%).

Inaperturopollenites rugulatus Norton 1969

[Plate 10, Figure 10]

Inaperturopollenites rugulatus Norton; Norton and Hall 1969, p.30, pl.3, fig.12.

DESCRIPTION: See Norton and Hall (1969, p.30).

SIZE RANGE: 47-59um in maximum diameter (4 specimens measured).

OCCURRENCE: Maastrichtian of Montana (Norton and Hall, 1969). Castlegate Sandstone and Price River Formation in this study. Very rare.

Inaperturopollenites sp.1.

[Plate 10, Figure 9]

DESCRIPTION: Grains inaperturate; amb. elongate spheroidal; exine psilate to faintly foveolate, irregularly folded.

DISCUSSION: Except the size (81-89um in maximum diameter, 3 specimens measured), this species is very close, if not the same, to *Inaperturopollenites rugulatus* Norton. Most specimens of this species were found in a sample (Pb14738, uppermost sample of Cretaceous interval of the study section) which contains such lacustrine palynomorphs as *Azolla*, *Ghoshispora*, and *Pediastrum*. Although the botanical affinity is not determinable, this species could well be a paleoecological index palynomorph.

OCCURRENCE: Uppermost sample (Pb14738) from the Cretaceous interval of North Horn Formation yielded 52 specimens. Only one other specimen was found (Castlegate Sandstone sample, Pb14550).

Genus Leioaletes Staplin 1960

TYPE SPECIES: *Leioaletes aliquandostriatus* Staplin 1960

DESCRIPTION: See Singh (1964, p.125).

SUGGESTED AFFINITY: *Podozamites*.

Leioaletes calvatus Singh 1964

[Plate 10, Figure 11]

Leioaletes calvatus Singh 1964, p.126, pl.17, fig.3,

DESCRIPTION: See Singh (1964, p.126).

DISCUSSION: Specimens encountered here were not well stained, and show light yellow color as noticed in Alberta species. This species is similar to *Schizosporis laevigatus* described by Stanley (1965), but the fine line indicating a division of the pollen grain, or separation into two parts, was not observed here. 45-58um X 27-32um (4 specimens measured). Utah specimens are smaller than the Alberta specimens (67um X 28um). Separation of Utah specimens from those recorded in Alberta on the basis of the size is regarded as being unnecessary.

OCCURRENCE: Albian of Alberta (Singh, 1964). Lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study.

Genus Monocolpopollenites Pflug and Thomson emend. Nichols et al. **1973**

TYPE SPECIES: *Monocolpopollenites tranquillus* (Potonie) Thomson and Pflug 1953

SYNONYMY AND DESCRIPTION: See Nichols *et al.* (1973, p.251).

SUGGESTED AFFINITY: Uncertain. Probably *Palmae* or Cycadales for the smooth members and Monocotyledonae for the reticulated members.

Monocolpopollenites tranquilloides Nichols *et al.* 1973

[Plate 10, Figure 12]

Monocolpopollenites tranquilloides Nichols *et al.* 1973, pp.252,254, pl.2, figs.2-5.

DESCRIPTION: See Nichols *et al.* (1973, p.252).

DISCUSSION: 32X30um (1 specimen measured). Length:breadth ratio of Utah specimens are lower than that of Texas specimens (23-30um X 29-37um).

OCCURRENCE: Late Paleocene of Texas (Nichols *et al.*,1973). Sample Pb14729 of the Price River Formation yielded two specimens in this study. It was also identified occasionally on slides outside the counted sum.

Monocolpopollenites sp.1.

[Plate 10, Figure 13]

DESCRIPTION: Monocolpate pollen; amb. elongate oval; colpus flared at ends, colpus shorter than length of grain (not extending to the grain margin), constricted at the center; exine 1-1.5um thick, psilate; size 13-16um X 20-22um.

DESCUSSION: This species is much smaller and more slender, and has a slightly thicker exine than *Monocolpopollenites tranquilloides* Nichols *et al.* It has longer colpus than that of *M. tranquillus* (Potonie) Thomson and Pflug.

OCCURRENCE: One specimen from the uppermost Price River Formation, and one specimen from the lowermost sample of the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation.

Genus Phyllocladidites Cookson ex Couper 1953

TYPE SPECIES: *Phyllocladidites mawsonii* Cookson ex Couper 1953

Phyllocladidites Cookson 1947, p.132.

Phyllocladidites Cookson ex Couper 1953, p.38.

Phyllocladidites Cookson ex Couper; Norton and Hall 1969, p.30.

DESCRIPTION: See Couper (1953, p.38).

SUGGESTED AFFINITY: *Phyllocladus* (Norton and Hall, 1969).

Phyllocladidites cf. P. ruei Cookson 1947

[Plate 10, Figure 14]

Phyllocladidites ruei Cookson 1947, p.133, pl.14, figs.31-37.

Phyllocladidites ruei Cookson; Couper 1953, pp.38-39, pl.9, fig.136.

Phyllocladidites ruei Cookson; Norton and Hall 1969, p.30, pl.4, fig.10.

DESCRIPTION: See Norton and Hall (1969, p.30).

SIZE RANGE: 42um in overall length (1 specimen measured).

OCCURRENCE: Lower Cretaceous to lower Oligocene. Very abundant in Cretaceous, rare in lower Tertiary (*fide* Couper, 1953, p.39). Maastrichtian of Montana (Norton and Hall, 1969). One specimen was recovered from the Castlegate Sandstone in this study.

Genus Pityosporites Seward emend. Manum 1960

TYPE SPECIES: *Pityosporites antarcticus* Seward 1914

SYNONYMY AND DESCRIPTION: See Singh (1964, pp.121-122).

SUGGESTED AFFINITY: Probably Pinaceae.

Pityosporites constrictus Singh 1964

[Plate 11, Figure 1]

SYNONYMY: See B. Tschudy (1973, p.15).

DESCRIPTION: See Singh (1964, pp.122-123).

SIZE RANGE: 66-82um in overall length (2 specimens measured).

OCCURRENCE: Aptian to middle Albian (Singh, 1964), and Maastrichtian (Srivastava, 1966) of Alberta. Campanian of Montana (B. Tschudy, 1973). One specimen was recovered from the Price River Formation (Pb14729), and two specimens were found in the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation (Pb14746) in this study.

Pityosporites elongatus (Norton) B. Tschudy 1973

[Plate 11, Figure 2]

Pinuspollenites elongatus Norton: Norton and Hall 1969, p.27, pl.4, fig.1.

Pityosporites elongatus var. *elongatus* B. Tschudy 1973, p.15, pl.6, figs.2-4.

DESCRIPTION: See Norton and Hall (1969, p.27).

DISCUSSION: 54-63um (6 specimens measured). Two variations described by B. Tschudy (1973), *viz. Pityosporites elongatus* var. *elongatus* and *P. elongatus* var. *grandis*, are considered as two separate species in this study.

OCCURRENCE: Campanian (B. Tschudy, 1973) and Paleocene (Norton and Hall, 1969) of Montana. Lower and upper Paleocene intervals (middle to middle/late Paleocene age) of the North Horn Formation in this study. Rare to few.

Pityosporites grandis (B. Tschudy) comb nov.

[Plate 11, Figure 3]

Pityosporites elongatus var. grandis B. Tschudy 1973, p.15, pl.6, figs.5-6.

DESCRIPTION: See B. Tschudy (1973, pp.14-15).

DISCUSSION: 90-150um in overall length (3 specimens measured). See the discussion under *Pityosporites elongatus.*

OCCURRENCE: Campanian of Montana (B. Tschudy, 1973). Castlegate Sandstone and Price River Formation yielded one specimen each, and several specimens were seen on slides outside the counted sums from the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study.

Genus Podocarpidites Cookson ex Couper 1953

TYPE SPECIES: *Podocarpidites ellipticus* Cookson ex Couper 1953

SYNONYMY AND DESCRIPTION: See Singh (1964, p.115).

SUGGESTED AFFINITY: Podocarpaceae

Podocarpidites biformis Rouse 1957

[Plate 11, Figures 6,7]

Podocarpidites biformis Rouse 1957, p.367, pl.2, fig.13.

SYNONYMY: See M. Wilson (1978, p.23).

DESCRIPTION: See Norton and Hall (1969, p.31).

SIZE RANGE: 45-60um in overall length (8 specimens measured).

OCCURRENCE: Aptian of Alberta (Singh, 1964). Upper Cretaceous of western Canada (Rouse, 1957) and Northwestern Territory (McIntyre, 1974). Maastrichtian of Wyoming (Farabee and Canright, 1986) and Paleocene of Montana (Norton and Hall, 1969). Throughout the North Horn Formation in this study. Very rare to rare.

Podocarpidites cf. P. decorus (Bolkhovitina) Pocock 1962

[Plate 11, Figures 4,5]

Podocarpidites decorus (Bolkhovitina) Pocock 1962, pp.66-67, pl.10, figs.159-160.

DESCRIPTION: See Pocock (1962, p.66).

SIZE RANGE: 45-52um in overall length (3 specimens measured).

OCCURRENCE: Neocomian of western Canada (Pocock, 1962). One sample (Pb14547) of the Price River Formation yielded two specimens, and one specimen was seen on a slide outside the counted sum from the lower interval of Paleocene strata (middle Paleocene in age) of North Horn Formation in this study.

Podocarpidites ornatus Pocock 1962

[Plate 11, Figures 8,9]

Podocarpidites ornatus Pocock 1962, pp.67-68, pl.11, figs.164-166.

DESCRIPTION: See Pocock (1962, pp.67-68).

DISCUSSION: Crenulate margin of central body is distinct. 53-65um in overall length (6 specimens measured).

OCCURRENCE: Barremian of western Canada (Pocock, 1962). Very rare in the lower and upper intervals of Paleocene strata (middle to middle/late Paleocene in age) of North Horn Formation in this study. Several specimens were seen on slides outside the counted sums in the same interval.

Podocarpidites otagoensis Couper 1953

[Plate 12, Figure 1]

Podocarpidites otagoensis Couper 1953, p.37, pl.4, fig.41.

Podocarpidites otagoensis Couper; Norton and Hall 1969, p.32, pl.5, fig.1.

DESCRIPTION: See Couper (1953, p.37).

DISCUSSION: 45-66um in overall length (6 specimens measured). This species is the only species which has large elongate body and small sacci relative to their central body among *Podocarpidites* species encountered in this study.

OCCURRENCE: Upper Cretaceous of New Zealand (Couper, 1953) and Maastrichtian of Montana (Norton and Hall, 1969). One specimen was included in the counted sum of the uppermost North Horn Formation sample (Pb14051) in this study. This species was identified on slides outside the counted sums from throughout the North Horn Formation.

Genus Pristinuspollenites B. Tschudy 1973

TYPE SPECIES *Pristinuspollenites microsaccus* (Couper) B. Tschudy 1973

Pteruchipollenites Couper 1958, p.151 (*pars.*).

Alisporites Daugherty restrict. Potonie and Kremp; Pocock 1962, pp.60-61 (*pars.*).

DESCRIPTION: See B. Tschudy (1973, p.16).

DISCUSSION: B. Tschudy defined the new genus *Pristinuspollenites* on the basis of the distinctive morphology of sacci which are greatly reduced. She then combined 7 species under this genus.

Pristinuspollenites microsaccus (Couper) B. Tschudy 1973

[Plate 12, Figures 2]

SYNONYMY AND DESCRIPTION: See B. Tschudy (1973, pp.17-18).

SIZE RANGE: 27-33um in overall length (2 specimens measured).

OCCURRENCE: Uppermost Jurassic and lowermost Cretaceous Canada (Pocock, 1962), and Netherlands (Burger, 1966). Lower Jurassic to Aptian of Britain (Couper, 1958). Campanian of Montana (B. Tschudy, 1973). Castlegate Sandstone, Price River Formation, and Cretaceous interval of North Horn Formation in this study. Very rare.

Pristinuspollenites sp.1.

[Plate 12, Figure 3,4]

DESCRIPTION: Bisaccate pollen; rounded-quadrangular to subrounded in polar view; length of body equal to, or slightly greater than its breadth; sacci distally attached, clearly set off from body, much smaller than body, maximum length of sacci at their base, length of sacci greater than their breadth, sacci inwardly inclined; both body and sacci finely reticulate; sizes on the bases of 6 specimens measured are as follows:

36-44um in length of central body

31-40um in breadth of central body

34-39um in length of sacci

7-11um in breadth of sacci

Total breadth is same as the breadth of central body

DISCUSSION: This species is similar to *Pristinuspollenites microsaccus* (Couper) B. Tschudy. Larger size and sacci always inwardly inclined can be sufficient to differentiate the two types.

OCCURRENCE: Price River Formation and lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation. Very rare.

Genus Sequoiapollenites Thiergart 1938

TYPE SPECIES: *Sequoiapollenites polyformosus* Thiergart 1938

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.281).

SUGGESTED AFFINITY: Taxodiaceae. Possibly *Sequoia*.

Sequoiapollenites polyformosus Thiergart 1938

[Plate 12, Figure 5]

Sequoiapollenites polyformosus Thiergart 1938, p.301, pl.23, fig.6.

DESCRIPTION: See Norton and Hall (1969, p.33).

SIZE RANGE: 24-27um in maximum diameter (2 specimens measured). Ligula 3um in length.

OCCURRENCE: Maastrichtian and Paleocene of Montana (Farabee and Canright, 1986; Oltz, 1969; and Norton and Hall, 1969). Miocene of Germany (Thiergart, 1938). Also upper Tertiary strata of various parts of western United States under different names, *viz*. *Sequoia*, *Sequoiadendron*, or TCT. Two specimens were found on slides outside the counted sums from the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study.

Genus Taxodiaceaepollenites Kremp ex Potonie 1958

TYPE SPECIES: *Taxodiaceaepollenites hiatus* (Potonie) Kremp 1949

SYNONYMY AND DESCRIPTION: See Stanley (1965, pp.271-272).

SUGGESTED AFFINITY: Taxodiaceae - Cupressaceae.

Taxodiaceaepollenites hiatus (Potonie) Kremp ex Potonie 1958

[Plate 12, Figures 6,7]

SYNONYMY AND DESCRIPTION: See Stanley (1965, pp.273-274).

DISCUSSION: It is almost impossible to distinguish pollen grains derived from parent plants belonging to the Taxodiaceae, Cupressaceae, and Taxaceae. In this study, thin-walled, inaperturate pollen grains with psilate to scabrate sculpture and a rupture were assigned to this species. It is more than likely that the specimens of this species were shed from more than one type of parent plant. Some specimens similar to *Monosulcites crescentus*, described by Norton (Norton and Hall, 1969, p.26, pl.3, fig.5), were included in this species. Maximum diameter ranges 19-36um (36 specimens measured).

OCCURRENCE: Middle Albian to Miocene of various parts of the world. Very rare to abundant throughout the section in this study. Some samples show very high proportions of this species, such as Pb14745 (68.0%), Pb14110 (50.0%), and Pb14731 (35.0%).

Genus Triangulopsis Doring emend. Pocock 1970

TYPE SPECIES: *Triangulopsis discoidalis* Doring 1961

DESCRIPTION: See Pocock (1970, pp.73-74).

SUGGESTED AFFINITY: Possibly araucariacian affinity.

Triangulopsis cf. T. discoidalis Doring

[Plate 12, Figures 8,9]

Triangulopsis discoidalis Doring; Pocock 1970, p.74, pl.7, figs.1-3.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Pocock (1970, p.74).

DISCUSSION: Morphology of this species falls well within the description of the species from western Canada by Pocock (1970). The Utah specimens do not show a triangular amb. However, the outline could be distorted or obscured if specimens have several folds in their walls as they do here in this study (pl.12, figs.8-9). The two specimens measured were 41-42um in equatorial diameter.

OCCURRENCE: Jurassic of western Canada (Pocock, 1970). Two specimens were found on slides outside the counted sums from the Price River Formation sample and uppermost Cretaceous interval of North Horn Formation in this study. Probably recycled.

Genus Zonalapollenites Pflug 1953

TYPE SPECIES: *Zonalapollenites igniculus* (Potonie) Pflug 1953

Tsugae-pollenites Potonie and Venitz 1934, p.17.

Zonalapollenites Pflug; Thomson and Pflug 1953, p.66.

ADDITIONAL SYNONYMY: See B. Tschudy (1973, p.13).

Zonalapollenites cf. Z. segmentatus Balme 1957

[Plate 12, Figure 10]

Zonalapollenites segmentatus Balme 1957, p.33.

DESCRIPTION: See Balme (1957, p.33).

DISCUSSION: Single specimen found in this study (62um in maximum diameter) is comparable to *Zonalapollenites segmentatus* Balme. Germinal aperture and spurious cingulum were observed.

OCCURRENCE: Mesozoic of western Australia (Balme, 1957). One specimen was found on a slide outside the counted sum of the upper interval of Paleocene strata (middle/late Paleocene in age) of North Horn Formation in this study.

4. ANGIOSPERMOUS POLLEN

Genus Aesculiidites Elsik 1968b

TYPE SPECIES: *Aesculiidites circumstriatus* (Fairchild) Elsik 1968b; *Tricolpites circumstriatus* Fairchild 1966

DESCRIPTION: See Elsik (1968b, p.632).

Aesculiidites circumstriatus (Fairchild) Elsik 1968b

[Plate 13, Figures 1,2]

Aesculiidites circumstriatus (Fairchild) Elsik 1968b, pp.632,634, pl.27, figs.10-18; pl.28, figs.1-7.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Elsik (1968b, pp.632,634).

SIZE RANGE: 19-28um X 11-18um (7 specimens measured).

SUGGESTED AFFINITY: Elsik (1968b) compares this species with extant *Aesculus*, especially *A. hippocastanum*.

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986). Paleocene (Elsik, 1968b) and lower Eocene (Stover *et al.*, 1966) of Texas. Price River Formation, and Cretaceous interval and lower interval of Paleocene strata (middle Paleocene age) of the North Horn Formation in this study. Rare to few.

Genus Alabroidaepollenites Kedves 1982

TYPE SPECIES: *Alabroidaepollenites maculatus* (Pflug) Kedves 1982; *Triatriopollenites maculatus* Pflug 1953

Triatriopollenites sect. *Alabroidae* Pflug 1953, p.79.

Alabroidaepollenites Kedves 1982, p.109.

DISCUSSION: The simple germinal exine region differentiates this genus from *Labraferoidaepollenites* and *Triatriopollenites*.

Alabroidaepollenites subtriangulus (Stanley) comb. nov.

[Plate 16, Figures 14,15]

Carpinus subtriangula Stanley 1965, p.291, pl.43, figs.12-16.

Triatriopollenites subtriangulus (Stanley) Frederiksen 1979, p.149, pl.2, figs.19-22.

DESCRIPTION: See Stanley (1965, p.292).

DISCUSSION: 34-38um in equatorial diameter (5 specimens measured). Utah specimens are larger than the South Dakota specimens (27-33um). Otherwise these are very closely similar including the circumpolar thickening in some specimens (Stanley, 1965, pl.43, fig.16). This species is similar to *Alabroidaepollenites myricoides* reported by Kedves (1982) from Paleocene strata of Germany, and may be conspecific.

OCCURRENCE: Upper Cretaceous and Paleocene of South Dakota (Stanley, 1965). One specimen was recovered from the sample Pb14746 of the lower interval of Paleocene section (middle Paleocene age), and up to 7.3% in five samples of the upper interval of Paleocene strata (middle/late Paleocene age) of the North Horn Formation in this study.

Genus Alnipollenites Potonie 1931b

TYPE SPECIES: *Alnipollenites verus* (Potonie) ex Potonie 1931b

SYNONYMY: See Farabee and Canright (1986, p.36).

DISCUSSION: Frederiksen and Ames (1979) discussed the status of the genus *Pollenites* Potonie 1931a. They concluded the genus *Pollenites* Potonie 1931a including *Pollenites verus* was not validly published. Consequently the publication of *Alnipollenites* 1931b is valid, and *Polyvestibulopollenites* is a junior synonym of this genus.

SUGGESTED AFFINITY: Betulaceae. *Alnus*.

Alnipollenites quadrapollenites (Rouse) Srivastava 1966

[Plate 13, Figures 5,6]

Alnus quadrapollenites Rouse 1962, p.202, pl.2, figs.9,36.

Alnus quaternaria Stanley 1965, pp.288-289, pl.43, figs.1-3.

Alnipollenites quadrapollenites (Rouse) Srivastava 1966, pp.530,532, pl.7, fig.3.

DESCRIPTION: See Rouse (1962, p.202).

SIZE RANGE: 13-19um (4 specimens measured).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973). Maastrichtian of South Dakota (Stanley, 1965) and Alberta (Srivastava, 1966). Eocene of British Columbia (Rouse, 1962). Cretaceous and upper interval of Paleocene strata (middle/late Paleocene) of the North Horn Formation with up to 1.0% in this study.

Alnipollenites trina (Stanley) Norton 1969

[Plate 13, Figures 7,8]

Alnus trina Stanley 1965, p.289, pl.43, figs.4-6.

Alnipollenites trina (Stanley) Norton; Norton and Hall 1969, p.42, pl.5, fig.20.

Syncolporate sp.; M. Wilson 1978, p.141, pl.11, fig.6.

DESCRIPTION: See Stanley (1965, p.289).

DISCUSSION: This species and *Ulmipollenites tricostatus* are not readily differentiated. Arci connect the shoulders of pores. Size ranges 19-21um (2 specimens measured).

OCCURRENCE: Paleocene of South Dakota (Stanley, 1965) and Montana (Norton and Hall, 1969). Maastrichtian and Paleocene in western Canada (M. Wilson, 1978). Uppermost Price River Formation, and throughout the North Horn Formation in this study with up to 8.3% abundance.

Alnipollenites verus Potonie 1931b

[Plate 13, Figures 9,10]

SYNONYMY: See Martin and Rouse (1966, pp.196-197) and Srivastava (1975a, p.141).

DESCRIPTION: See Martin and Rouse (1966, p.197).

DISCUSSION: Equatorial diameter of Utah species (30-35um, 3 specimens measured) is larger than most other specimens recorded from North America. One specimen shows the circumpolar thickening in one pole. Diameter of this ring is 12um and the width is 2um. *Alnus speciipites* Wodehouse 1933 from the Green River Formation of Colorado and Utah may be conspecific.

OCCURRENCE: Uppermost Cretaceous and Tertiary of various parts of the world. Restricted to the upper interval of the Paleocene section (middle/late Paleocene) of the North Horn Formation with up to 1.0% in this study.

SUGGESTED AFFINITY: Betulaceae. *Alnus*.

Genus Annutriporites Gonzalez Guzman 1967

TYPE SPECIES: *Annutriporites iversenii* (Van der Hammen) Gonzalez Guzman 1967

Annutriporites Gonzalez Guzman 1967, p.54.

DESCRIPTION: See Jansonius and Hills (1976, p.122).

DISCUSSION: Frederiksen (1983, p.37) gives a comprehensive discussion of this genus.

Annutriporites rotundus Frederiksen 1983

[Plate 13, Figures 11,12]

Annutripotites rotundus Frederiksen 1983, pp.37-38, pl.9, figs.24-28.

DESCRIPTION: See Frederiksen (1983, p.37).

SIZE RANGE: 33-36um (4 specimens measured). California specimens (23-33um).

OCCURRENCE: Middle Eocene of California (Frederiksen, 1983). Rare to few in three samples from the upper interval of Paleocene strata (middle/late Paleocene) of the North Horn Formation in this study.

Genus Aquilapollenites Rouse emend. Funkhouser 1961

TYPE SPECIES: *Aquilapollenites quadrilobus* Rouse 1957

SYNONYMY AND DESCRIPTION: See B. Tschudy and Leopold (1970, pp.120-121)

HISTORICAL BACKGROUND OF GENUS: See Farabee and Canright (1986, p.37).

SUGGESTED AFFINITY: Extinct genus *Aquilapollenites* still of uncertain relationship with extant taxa, has been a subject of different opinions about its botanical affinity. Affinities suggested by different authors include Loranthaceae (Erdtman, 1971) and Santalaceae (Jarzen, 1977). Muller (1981, pp.84,89) suggested the third and last family of Santalales, the Olacaceae, to be the most closely related family to the extinct *Aquilapollenites*. Through the study of tetrad arrangement, Catteral and Srivastava (1985) favored the Proteaceae to be of closer affinity to the *Aquilapollenites* than any families of the Santalales. Among the species studied here *Aquilapollenites amplus*, *A. augustus*, *A. regalis* were synonymized under *A. attenuatus* by B. Tschudy (1973). The large number of specimens encountered in the study of Judith River Formation by B. Tschudy demonstrates the gradational changes in the morphology of groups within the species. In the present study, however, probably because of the paucity of occurrence of specimens, such gradational changes were not evident.

Aquilapollenites amplus Stanley 1961b.

[Plate 13, Figures 13,14]

Aquilapollenites amplus Stanley 1961b, pp.342,344, pl.1, figs.1-6, pl.2, figs.1-4, pl.3, figs.1-5.

Aquilapollenites amplus Stanley; Stanley 1965, pp.313-314, pl.48, figs.1-6.

Aquilapollenites amplus Stanley; Norton and Hall 1969, p.57, pl.6, fig.11.

Aquilapollenites amplus Stanley; Farabee and Canright 1986, pp.38-39, pl.11, figs.1-2.

DESCRIPTION: See Stanley (1961b, pp.342,344).

SIZE RANGE: 41-49um in the length of polar axis (4 specimens measured).

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986), South Dakota (Stanley, 1965), and Montana (Norton and Hall, 1969). Upper part of the Price River Formation (outside the counted sums) and the Cretaceous interval of North Horn Formation; rare in this study.

Aquilapollenites argutus Srivastava 1969c

[Plate 13, Figures 15,16]

Aquilapollenites argutus Srivastava 1969c, p.135, pl.2, fig.11.

DESCRIPTION: See Srivastava (1969c, p.135).

DISCUSSION: 25-28um in the length of polar axis (5 specimens measured). In some specimens of this species, equatorial projections arise as flanges from near the ends of opposite points. One polar projection is very short so the equatorial projections are asymmetrically placed towards one end (the longer polar axis). Therefore, the distinction between this species and *Aquilapollenites aptus* should be focused on the degree one polar projection protrudes which affect the overall shape.

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1969c). Two samples of lower part of the Price River Formation yielded 2 and 4 specimens, respectively.

Aquilapollenites augustus Srivastava 1969c

[Plate 13, Figure 17]

Aquilapollenites augustus Srivastava 1969c, p.137, pl.3, figs.18-21, pl.4, figs.22-25.

Aquilapollenites attenuatus Funkhouser; B. Tschudy 1973, pl.10, figs.3,6 only.

Aquilapollenites augustus Srivastava; Farabee and Canright 1986, p.39, pl.11, figs.3-8.

DESCRIPTION: See Srivastava (1969c, p.137).

SIZE RANGE: 38-39um in the length of polar axis (2 specimen measured).

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986) and Alberta (Srivastava, 1969c). Castlegate Sandstone sample (Pb14550, outside the counted sum), and the lowermost sample (Pb14549) of the Price River Formation (2 specimens) in this study.

Aquilapollenites cf. **A. bertillonites** Funkhouser 1961

[Plate 13, Figure 18]

Aquilapollenites bertillonites Funkhouser 1961, p.196, pl.2, figs.5.

ADDITIONAL SYNONYMY: See Farabee and Canright (1986, p.39).

DESCRIPTION: See Funkhouser (1961, p.196).

DISCUSSION: 30-32um in the length of polar axis (2 specimens measured). The two specimens observed in this study are not adequately preserved to make more precise specific determination possible.

OCCURRENCE: Lower or middle Maastrichtian of Montana (B. Tschudy and Leopold, 1970) and Wyoming (Farabee and Canright, 1986). Two specimens were seen outside the counted sums of one sample of the Price River Formation and one sample of the Cretaceous interval of North Horn Formation, respectively.

Aquilapollenites regalis Srivastava 1969c

[Plate 14, Figure 1]

Aquilapollenites regalis Srivastava 1969c, p.142, pl.6, figs.42-43.

Aquilapollenites attenuatus Funkhouser; B. Tschudy 1973, pl.10, figs.4,5 only.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1969c, p.142).

SIZE RANGE: 30-39um in the distance from the center of the polar axis to the tips of equatorial projections (3 projections of the single specimen measured).

OCCURRENCE: Maastrichtian of Alberta (Srivastava, 1969c). One specimen was found in the lowermost sample (Pb14549) of Price River Formation in this study.

Aquilapollenites spinulosus Funkhouser 1961

[Plate 14, Figure 2]

Aquilapollenites spinulosus Funkhouser 1961, p.194, pl.1, figs.4-6.

DESCRIPTION: See Funkhouser (1961, p.194).

SIZE RANGE: 41-45um in the length of polar axis (2 specimens measured).

OCCURRENCE: Middle Maastrichtian of Montana, Paleocene of Colorado and North Dakota (B. Tschudy and Leopold, 1970). Middle Paleocene of Wyoming (Nichols and Ott, 1978), and Wyoming and Montana (Pocknall, 1987). Ford Creek Coal, upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation in this study. Rare.

Genus **Arecipites** **Wodehouse 1933 emend. Nichols** et al. **1973**

TYPE SPECIES: *Arecipites punctatus* Wodehouse 1933

SYNONYMY AND DESCRIPTION: See Nichols *et al.* (1973, pp.248-249).

Arecipites columellus Leffingwell 1970

[Plate 14, Figure 5]

Arecipites columellus Leffingwell 1970, pp.40-41, pl.7, figs.1-2.

Arecipites columellus Leffingwell; Farabee and Canright 1986, p.43, pl.15, figs.10-13.

DESCRIPTION: See Leffingwell (1970, pp.40-41).

SIZE RANGE: 15 X 23um (1 specimen measured).

OCCURRENCE: Maastrichtian and Paleocene of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986). Two specimens were recovered from the Price River Formation, and several specimens were seen outside the counted sums of samples of the lower interval of Paleocene strata (middle Paleocene age) of the North Horn Formation in this study.

Arecipites cf. A. pseudotranquillus Nichols *et al.* 1973

[Plate 14, Figure 3]

SYNONYMY : See Nichols *et al.* (1973, p.249).

DESCRIPTION: Monocolpate pollen; colpus long, extending to the tapered ends of the grain, usually obscure, but not flared or gaping; oval in polar view; exine 1um, faintly scabrate; size ranges 11-17um X 22-26um (8 specimens measured).

DISCUSSION: The Utah specimens appear to be identical to the specimens originally described and illustrated by Nichols *et al.* (1973, pp.249-250, pl.1, figs.9-12) except the much smaller size (23-29um X 35-41um for the Texas specimens).

SUGGESTED AFFINITY: Palmae (*Phoenix*?).

OCCURRENCE: Seldom found outside the counted sums of Castlegate Sandstone, Price River Formation, and upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study.

Arecipites tenuiexinous Leffingwell 1970

[Plate 14, Figures 6,7]

Arecipites tenuiexinous Leffingwell 1970, p.41, pl.5, figs.8-9.

DESCRIPTION: See Leffingwell (1970, p.40).

SIZE RANGE: 26-35um X 19-29um (8 specimens measured).

OCCURRENCE: Maastrichtian and Paleocene of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986). Price River Formation, and Cretaceous interval and lower interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study. Very rare to common (up to 7.0%).

Arecipites sp.1.

[Plate 14, Figures 4,8]

DESCRIPTION: Monocolpate pollen; amb. oval, colpus short, approximately two thirds of the length of grain, always closed; exine psilate, 1-2um thick; size 16-21um X 11-18um (6 specimens measured).

DISCUSSION: Psilate exine and short colpi of this species are distinct.

OCCURRENCE: Many samples throughout the section with up to 5.3% in relative abundance.

Genus Beaupreaidites Cookson emend. Srivastava 1969b

TYPE SPECIES: *Beaupreaidites elegansiformis* Cookson 1950

SYNONYMY AND DESCRIPTION: See Srivastava (1969b, p.1572).

DISCUSSION: B. Tschudy (1971) regarded Srivastava's emendation (1969d) of this genus invalid because his emendation does not include the type species of the genus. See the discussion under *Proteacidites* cf. *P. marginus* in this study for detail.

SUGGESTED AFFINITY: Pollen of extant genus *Beauprea* which is the only genus of Proteaceae family having tricolpoid pollen.

Beaupreaidites sp.1

[Plate 14, Figure 9]

DESCRIPTION: Triaperturate pollen, amb. triangular with more or less straight sides; angulaperturate, aperture large, colpoid, colpi meridional, short, wedge-shaped, extending meridionally beyond apertural zone. Exine 2um thick, finely reticulate. 27um in equatorial diameter (1 specimen measured).

DISCUSSION: The single specimen found is similar to *Beaupreaidites angulatus* (Samoilovitch) Srivastava 1969b. That species is significantly larger (50-80um), and has verrucate surface. This specimen superficially looks like a smooth circular inner body enclosed with reticulate triangular perine-like structure which has three ruptures at the corners.

OCCURRENCE: Cretaceous interval (Pb14731) of North Horn Formation.

Genus Brevicolporites Anderson 1960

TYPE SPECIES: *Brevicolporites colpella* Anderson 1960

Brevicolporites colpella Anderson 1960, p.24.

DESCRIPTION: See Anderson (1960, p.24).

Brevicolporites colpella Anderson 1960

[Plate 14, Figures 10,11]

Brevicolporites colpella Anderson 1960, p.24, pl.6, figs.11-14.

DESCRIPTION: See Anderson (1960, p.24).

SIZE RANGE: 19-23um in equatorial diameter (15 specimens measured).

OCCURRENCE: Lowermost Paleocene of New Mexico (Anderson, 1960). Stratigraphically restricted, but with high in frequencies, in the lower coal of the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation) in this study. This species can serve as a stratigraphic index palynomorph for the lower to middle Paleocene strata in the southern province of the western United States, since it shows stratigraphic restriction and relatively high frequency. It may also be of environmental significance.

Genus Bombacacidites Couper 1960

TYPE SPECIES: *Bombacacidites bombaxoides* Couper 1960

Bombacacidites Couper 1960, p.53.

Bombacacipites Anderson 1960, p.23.

DESCRIPTION: See Couper (1960, p.53).

DISCUSSION: Couper established the genus *Bombacacidites* in September, 1960 to indicate Bombacaceae-type pollen . In December of the same year, Anderson defined the genus *Bombacacipites* to include the same type of pollen taxa.

SUGGESTED AFFINITY: BST (Bombacaceae - Sterculiaceae - Tiliaceae) complex. Most species were probably produced by Bombacaceae. (See Frederiksen, 1983, p.75 for more detail).

Bombacacidites nacimientoensis (Anderson) Elsik 1968b

[Plate 14, Figure 12]

Bombacacipites nacimientoensis Anderson 1960, p.23, pl.8, fig.13.

Bombacacidites nacimientoensis (Anderson) Elsik 1968b, p.620, pl.22, figs.1-2,4.

DESCRIPTION: See Anderson (1960, p.23).

DISCUSSION: Frederiksen (1983) discussed the morphological variation within this species especially the sizes of brochi (lumina and half of muri) at poles and corners. Utah specimen 35um in maximum diameter (1 specimen measured).

OCCURRENCE: Lower Paleocene of New Mexico (Anderson, 1960) and California (Drugg, 1967). Upper Paleocene of Texas (Elsik, 1968b). Middle Eocene to early Oligocene of Mississippi and Alabama (Frederiksen, 1980b). Middle Eocene of California (Frederiksen, 1983). One specimen was found in the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in the Price Canyon Section (Pb14181).

Genus Caryapollenites Raatz ex Potonie emend. Krutzsch 1961a

TYPE SPECIES: *Caryapollenites simplex* (Potonie) Raatz 1938

SYNONYMY AND DESCRIPTION: See Nichols and Ott (1978, pp.104-105).

DISCUSSION: The definition of the genus, *Caryapollenites* by Nichols and Ott (1978) as well as that of *Momipites*, is accepted. Key for the species based on the Utah specimens is as follow.

1.a. Circumpolar ring present -------------------- go to 2

b. Circumpolar ring absent ---------------------- go to 3

2.a. Margin entire ---------------------------------- *C.veripites*

b. Two or more pores notched ---------------- *C.wodehousei*

3.a. Margin entire ---------------------------------- *C.inelegans*

b. All three pores notched --------------------- *C.imparalis*

c. Only one pore notched ----------------------- *C.*sp.1

SUGGESTED AFFINITY: Juglandaceae.

Caryapollenites imparalis Nichols and Ott 1978

[Plate 14, Figure 15]

Caryapollenites imparalis Nichols and Ott 1978, p.105, pl.2, figs.4-6.

DESCRIPTION: See Nichols and Ott (1978, p.105).

DISCUSSION: The specimens studied here share all characteristics in common with the Wyoming specimens assigned to this species (Nichols and Ott, 1978, p.105) except the size. The Utah specimens range 32-38um in size (2 specimens measured) as compared with 29-35um for Wyoming specimens.

OCCURRENCE: Middle to upper Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P4-P6), Wyoming (Nichols and Ott, 1978; zones P4-P6), and Alberta (Demchuk, 1987; zones P4-P6). Upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation with up to 7.7% in relative abundance in the present study.

SUGGESTED AFFINITY: Juglandaceae.

Caryapollenites inelegans Nichols and Ott 1978

[Plate 14, Figure 13]

Caryapollenites inelegans Nichols and Ott 1978, p.105, pl.2, figs.7-8.

DESCRIPTION: See Nichols and Ott (1978, p.105).

DISCUSSION: Specimens encountered in this study are specifically similar to the ones illustrated and described by Nichols and Ott(1978).

OCCURRENCE: Upper Paleocene and lower Eocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P5-E), Wyoming (Nichols and Ott, 1978; zones P5-E(?)), and Alberta (Demchuk, 1987; zones P4-P6). Uppermost four samples of upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation and lowermost sample of Flagstaff Member of Green River Formation with up to 8.3% in relative abundance in this study.

SUGGESTED AFFINITY: Juglandaceae.

Caryapollenites veripites (Wilson and Webster) Nichols and Ott 1978

[Plate 14, Figure 14]

Carya veripites Wilson and Webster 1946, p.276.

Carya veripites Wilson and Webster; Leffingwell 1970, p.28, pl.6, fig.3.

Caryapollenites veripites (Wilson and Webster) Nichols and Ott 1978. p.106, pl.2, figs.12-13.

DESCRIPTION: See Nichols and Ott (1978, pp.106-107).

DISCUSSION: Specimens studied here are specifically identical to those included in the original description and illustration.

OCCURRENCE: Upper Paleocene - lower Eocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P5-E) and Wyoming (Nichols and Ott, 1978; zones P5-E(?)). Two specimens were found in the lower part of the upper interval of Paleocene strata (middle/late Paleocene age) of the North Horn Formation; and five specimens were counted from the uppermost sample (Pb14051) of the same interval; and sixteen specimens from the lowermost sample (Pb14049) of Flagstaff Member of Green River Formation.

SUGGESTED AFFINITY: Juglandaceae.

<u>**Caryapollenites wodehousei**</u> Nichols and Ott 1978

[Plate 14, Figure 16]

Caryapollenites wodehousei Nichols and Ott 1978; p.106, pl.2, figs.9-11.

DESCRIPTION: See Nichols and Ott (1978, p.106).

DISCUSSION: The width of circumpolar ring of most of the Utah specimens is much narrower (1um) than that given in the original description (2-4um) by Nichols and Ott (1978, p.106). This difference might be caused by the differential degradation of exine in the process of preservation.

OCCURRENCE: Upper Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P4-P6), Wyoming (Nichols and Ott, 1978; zones P4-P6), and Alberta (Demchuk, 1987; zones P4-P6). One specimen was recovered from the sample Pb14091 of the upper interval of Paleocene rocks (middle/late Paleocene age) of North Horn Formation, and one specimen was found in lowermost stratum of Flagstaff Member of Green River Formation in the Price Canyon Section.

SUGGESTED AFFINITY: Juglandaceae.

__Caryapollenites__ sp.1

[Plate 14, Figure 17]

DESCRIPTION: Triporate pollen, amb well-rounded, triangular to almost circular. Two or more pores located off the equator. Outline not entire, one pore equatorial or subequatorial, indents the equatorial margin. Other two pores are far off the equator and located in one hemisphere. Pores atriate although atria may be obscure; exopores 2-3um in diameter, endopores about 10um in diameter. Exine 1um thick at equator, endexine not extending to apertures but ending at the endopores to form the atria. Surface faintly scabrate. Exine is essentially uniform in thickness at both poles. Size ranges 26-32um (8 specimens measured).

DISCUSSION: *Caryapollenites* sp. 1 differs from *C. imparalis* in that only one pore indents the margin and the outline is less triangular. It also differs from *C.inelegans* in the indention of one pore and less circular in the former. In fact, it fits well in between the *C.imparalis* and *C.inelegans* lineage of the phylogenetic diagram (Nichols and Ott, 1978, p.108). *C.paleocenicus* (Stanley) Srivastava 1969a is similar to this species. However the species illustrated by Stanley (1965, pl.45, figs.3-7) has an entire margin and has larger pores and rough, almost verrucate exine. Although there is a strong suspicion that part of these belong to the genus Ulmipollenites, it is not possible to determine that until such illustrated specimens are checked. Felix and Burbridge's specimens from Arctic Canada (1973, p.15, pl.3, fig.19) could be the same as the species described here except the specimens they illustrated are circular in shape.

OCCURRENCE: Present in most samples of upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation with 0.3 to 1.7% in relative abundance.

SUGGESTED AFFINITY: Juglandaceae.

Genus Caryophyllidites Couper 1960

TYPE SPECIES: *Caryophyllidites polyoratus* Couper 1960

DESCRIPTION: See Couper (1960, p.68).

SUGGESTED AFFINITY: Possibly Caryophyllaceae.

Caryophyllidites polyoratus Couper 1960

[Plate 15, Figures 1-3]

Caryophyllidites polyoratus Couper 1960, p.68, pl.10, fig.14.

DESCRIPTION: See Couper (1960, p.68).

DISCUSSION: 30-36um in maximum diameter (5 specimens measured). There is concern that this anemophilous pollen could possibly be the contamination of modern taxa, but in the present study, caution was taken to distinguish fossil forms from the modern contamination. Specimens encountered here show significant differences from the obvious modern taxa in the degree of degradation and flattened condition of the fossils.

OCCURRENCE: Maastrichtian to Danian of New Zealand (Couper, 1960). Throughout the North Horn Formation in this study. Very rare to common (up to 6.3%).

Genus Clavatipollenites Couper 1958

TYPE SPECIES: *Clavatipollenites hughesii* 1958

Clavatipollenites Couper 1958, p.159.

DESCRIPTION: See Coouper (1958, p.159).

DISCUSSION: Doyle *et al.*(1975) emphasized the importance of this species as being an example of Lower Cretaceous monosulcate pollen with angiospermous exine structure, and being the oldest pollen record of angiosperms.

SUGGESTED AFFINITY: Doyle *et al.*(1975) consider some forms of *Clavatipollenites* described from the Jurassic strata by various authors to be gymnospermous. While other forms of this genus including *Clavatipollenites* cf *C. hughesii* from Potomac Group are compared with modern monocotyledons and magnoliid dicotyledons.

Clavatipollenites hughesii Couper 1958

[Plate 15, Figures 4,5]

Clavatipollenites hughesii Couper 1958, p.159, pl.31, figs.19-22.

Clavatipollenites cf. *C. hughesii* Couper; Doyle *et al.*1975, pp.450-454, pl.3, figs.1-13; pl.4, figs.1-3.

DESCRIPTION: See Doyle *et al.* (1975, pp.450-454).

DISCUSSION: 25-33um X 20-28um (2 specimens measured). It is probable that these oldest angiospermous monosulcate pollen grains were reworked since this form has never been reported from strata younger than Cenomanian.

SUGGESTED AFFINITY: Monocotyledons or magnoliid dicotyledons (Doyle *et al.*1975).

OCCURRENCE: Barremian - Cenomanian. England, eastern United States, Louisiana and Australia (see Doyle *et al.* 1975, p.452). Two samples from the Price River Formation yielded one specimen each in this study. Considered to be recycled.

Genus Cranwellia Srivastava 1966

TYPE SPECIES: *Cranwellia striata* (Couper) Srivastava 1966

SYNONYMY AND DESCRIPTION: See Srivastava (1966, p.537).

SUGGESTED AFFINITY: Srivastava suggested *Elytranthe*, Loranthaceae. Farabee and Canright (1986) do not share this idea through their SEM study. Thus, the affinity of this taxon remains uncertain.

<u>Cranwellia rumseyensis</u> Srivastava 1966

[Plate 15, Figure 6-8]

Cranwellia rumseyensis Srivastava 1966, p.538, pl.11, figs.3,7.

DESCRIPTION: See Srivastava (1966, p.538).

DISCUSSION: Although only a single specimen was found in this study, and it was compressed obliquely, it shows clearly structure of the colpi and exine sculpture of *Cranwellia rumseyensis*. 30um diameter between two corners of the illustrated specimen. SEM pictures of another specimen found show more detailed structures of features mentioned above.

OCCURRENCE: Upper Campanian of Montana (B. Tschudy, 1973) and Wyoming (Stone, 1973). Upper Campanian to Maastrichtian of Yukon (M. Wilson, 1978). Maastrichtian of Wyoming (Farabee and Canright, 1986) and Alberta (Srivastava, 1966; Snead, 1969). Two specimens were found in Price River Formation (Pb14726 and Pb14733) in this study.

<u>Cranwellia</u> sp.1.

[Plate 15, Figures 9,10]

DESCRIPTION: Tricolporate pollen; isopolar, anguloaperturate; amb triangular with straight sides and rounded corners, equatorial view rhombic with broadly rounded corners, to elliptic in outline; pores round, large, 3-4um in diameter, crosscut by short colpi; colpi reaching one-fourth to one-fifth of the radius of the grain; exine thin, striate, striae parallel to the polar axis; 17-19um in equatorial diameter (4 specimens measured), 14-15um in polar axis (3 specimens measured).

DISCUSSION: Distinct tricolporate nature and small size distinguish this species from other similar forms. This species is very similar to, or possibly conspecific with, *Cranwellia rumseyensis*. The latter species has an inconspicuous or no pore chamber, longer colpi, and generally larger in size.

OCCURRENCE: Six specimens were recovered from the Uppermost sample (Pb14733) from the Price River Formation in this study.

Genus Cupanieidites Cookson and Pike 1954

TYPE SPECIES: *Cupanieidites major* Cookson and Pike 1954

Cupanieidites Cookson and Pike 1954, p.210.

ADDITIONAL SYNONYMY: See Farabee and Canright (1986, p.45).

DESCRIPTION: See Cookson and Pike (1954, p.210).

SUGGESTED AFFINITY: Chmura (1973) suggested that the affinity of this genus might be in the Sapindaceae, tribe Cupanieae.

Cupanieidites reticularis Cookson and Pike 1954

[Plate 15, Figure 11]

Cupanieidites reticularis Cookson and Pike 1954, p.214, pl.2, figs.87-89.

DESCRIPTION: See Cookson and Pike (1954, p.214).

SIZE RANGE: 21-25um in equatorial diameter (2 specimens measured).

OCCURRENCE: Campanian - Maastrichtian of Gabon (Belsky *et al.*, 1965), Maastrichtian of Wyoming (Farabee and Canright, 1986) and California (Drugg, 1967), and Eocene of Australia (Cookson and Pike, 1954). Two specimens were found outside the counted sums of the Castlegate Sandstone sample and a sample from Price River Formation in this study.

Genus Cupuliferoidaepollenites Potonie, Thomson, and Thiergart ex. Potonie 1960

TYPE SPECIES: *Cupuliferoidaepollenites liblarensis* Potonie, Thomson, and Thiergart ex Potonie 1960

DESCRIPTION: See Potonie (1960, p.92).

Cupuliferoideapollenites mutabilis (Leffingwell) Jameossanaie 1987

[Plate 15, Figures 12,13]

Tricolpites mutabilis Leffingwell 1970, p.44, pl.8, figs.1-3.

Cupuliferoideapollenites mutabilis (Leffingwell) Jameossanaie 1987, p.25, figs.14/42-44.

DESCRIPTION: See Leffingwell (1970, p.44).

DISCUSSION: Transferring of this species to *Cupuliferoideapollenites* seems to be appropriate. Some specimens show the foldings in polar region. 14-23um in equatorial diameter (5 specimens measured).

OCCURRENCE: Campanian of New Mexico (Jameossanaie, 1987). Maastrichtian and Paleocene of Wyoming (Leffingwell, 1970). Rare to few in most samples of Cretaceous interval of the section, and very rare and scattered in Paleocene interval of the section.

Cupuliferoidaepollenites parvulus (Groot and Penny) Dettmann 1973

[Plate 15, Figures 14,15]

Cupuliferoidaepollenites parvulus (Groot and Penny) Dettmann; Farabee and Canright 1986, pp.46-47, pl.17, figs.5,6.

ADDITIONAL SYNONYMY: See Farabee and Canright (1986, p.46).

DESCRIPTION: See Groot and Penny (1960, p.232).

DISCUSSION: 12-16um in equatorial diameter (8 specimens measured). The specimens assigned to this species have very little anatomy or morphology for distinctive recognition to species level. It is possible that specimens found in different stratigraphic position of different areas represent more than one species.

OCCURRENCE: Albian - Turonian of various parts of the world (see Dettmann, 1973), Campanian (Stone, 1973) and Maastrichtian (Farabee and Canright, 1986), and Paleocene of California (Drugg, 1967). Most samples of Castlegate Sandstone and Price River Formation (up to 10.0%), and scattered occurrences in the upper interval of Paleocene rocks (middle/late Paleocene age) of the North Horn Formation (0.3 to 1.3%) in this study.

Cupuliferoidaepollenites sp.1.

[Plate 15, Figures 16,17]

DESCRIPTION: Tricolpate pollen; prolate, amb cylindrical with rounded poles, the ratio between polar axis and equatorial axis 2.7; colpi long, reaching almost the margin of grain; exine psilate, 1um thick; size 13-15um X 5-8um (4 specimens measured).

DISCUSSION: Small size and slender outline distinguish this species from other similar forms. Specimens assigned to this species could be shrunken or collapsed forms of *Cupuliforidaepollenites parvulus* described earlier.

OCCURRENCE: Price River Formation (1.0 to 2.0%) in this study. Pattern of occurrences of this species supports the idea discussed above.

Genus Dyadonapites Erdtman ex B. Tschudy 1973

TYPE SPECIES: *Dyadonapites reticulatus* B. Tschudy 1973

SYNONYMY AND DESCRIPTION: See B. Tschudy (1973, p.32).

Dyadonapites reticulatus B. Tschudy 1973

[Plate 16, Figures 1,2]

Dyadonapites reticulatus B. Tschudy 1973, p.32, pl.11, figs.15-17.

DESCRIPTION: See B. Tschudy (1973, p.32).

DISCUSSION: Individual grains were found in some samples in this study as was the case noticed in the Montana samples studied by B. Tschudy (1973). 27-36um in overall length, 16-24um in the diameter of individual grain (5 specimens measured).

OCCURRENCE: Campanian of Montana (B. Tschudy, 1973). Price River Formation and lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in this study. Very rare to few.

Genus Engelhardtioidites Potonie, Thomson & Thiergart ex. Potonie 1960

TYPE SPECIES: *Engelhardtioidites microcoryphaeus* (Potonie) Potonie, Thomson & Thiergart ex Potonie 1960

Engelhardtioidites Potonie, Thomson & Thiergart ex. Potonie 1960

DISCUSSION: Manning (1966) demonstrated the correct original spelling for the extant genus (thought by some to be related to these dispersed pollen) is *Engelhardia*, having precedence over *Engelhardtia*. However, the original generic spelling for this genus of dispersed pollen correctly reflects the name of Engelhardt for whom the extant, possibly related genus of plants in the Juglandaceae is related.

Engelhardtioidites minutus Newman 1965

[Plate 16, Figure 3]

Engelhardtioidites minutus Newman 1965, p.12, pl.1, fig.8.

Engelhardtioidites minutus Newman; Stone 1973, p.93, pl.20, fig.133.

DESCRIPTION: See Newman (1965, p.13).

SIZE RANGE: 12-13um in equatorial diameter (2 specimens measured).

OCCURRENCE: Campanian - Maastrichtian of Colorado (Newman, 1965) and Campanian of Wyoming (Stone, 1973). Two specimens were seen outside the counted sums of uppermost Price River Formation in this study.

Genus Erdtmanipollis Krutzsch 1962

TYPE SPECIES: Erdtmanipollis pachysandroides Krutzsch 1962

DISCUSSION: Srivastava (1969a, p.978) made additional description and distinction among species.

SUGGESTED AFFINITY: Buxaceae. *Pachysandra-Sarcococca.* See Stanley (1965, p.294) and Srivastava (1969a, p.977).

Erdtmanipollis procumbentiformis (Samoilovitch) Krutzsch 1966

[Plate 16, Figures 5,6]

SYNONYMY: See Srivastava (1969a, p.978).

DESCRIPTION: See Stanley (1965, p.294).

DISCUSSION: Size of the Utah specimens ranges 25-30um in diameter (3 specimens measured).

OCCURRENCE: Present in four samples in the North Horn Formation. Very rare to rare (up to 1.7%).

SUGGESTED AFFINITY: Buxaceae. *Pachysandra - Sarcococca.*

Genus Faguspollenites (Raatz) Nagy 1969

TYPE SPECIES: *Faguspollenites verus* Raatz 1937

DESCRIPTION: Given by Nagy (1969) ; "Roundish, tricolporate pollen of 30 to 58u size: exine intra-baculate, baculate or granulate, resulting in a more or less coarse granulation of the surface. Exocolpi of various length, splitting open in some instances. The round or oval endopore invariably overreaches the colpus." (from Jansonius and Hills, 1976, p.999).

Faguspollenites sp.1

[Plate 16, Figure 4]

DESCRIPTION: Tetracolporate to tetraporate pollen, circular in plan view, usually folded and forms an irregular shape; aperture shows irregular positions, unfolded specimens show two apertures at equator, and the other two are 1/2 radius of pollen from the equatorial margin; ora mostly elongate, some round, 2-5um in diameter; colpi when present (or visible?) short slit-like, cutting across the endannulus; endannulus 5-8um in diameter; exine 1um, distinctly scabrate; 27-41um in maximum diameter (10 specimens measured).

DISCUSSION: It is difficult to make the generic assignment of this species. *Porocolpopollenites* Pflug, in Thomson and Pflug 1953, has a wide range of morphological variation within the genus. This species, however, has neither a large postvestibulum, nor belongs to any group of given descriptions for the genus. This species might be assigned to the genus *Annutriporites* Gonzalez Guzman 1967. But that genus only includes triporate-type of pollen. *Annutriporites rotundus*, originally described and illustrated by Frederiksen (1983, pp.37-38, pl.9, figs.24-28) appears to be similar to the present Utah specimens, especially one of his illustrated specimens (pl.9, fig.25), which shows a distinct colpus cross-cutting the endannulus. Although, description of *Faguspollenites* includes only tricolporate pollen, the present author thinks it is the most suitable category for the present species, since all of the other morphological characteristics of this genus are shared by the Utah specimens. *Faguspollenites* sp. described by Frederiksen (1980b, p.165, pl.2, fig.38, pl.3, figs.1-5) may be conspecific, but it is smaller (21-27um) and tricolporate.

OCCURRENCE: Present in the upper interval of Paleocene strata (middle/upper Paleocene age) of North Horn Formation in this study.

Genus Fraxinoipollenites Potonie 1951 (Wien) ex Potonie 1960

TYPE SPECIES: *Fraxinoipollenites pudicus* (Potonie 1934) Potonie 1951 ex Potonie 1960

DESCRIPTION: Potonie's generic description (1960, p.94) translated by Jansonius and Hills (1976, p.1059) is as follows; "Shape elongated ovoid to fusiform; with 3 long colpi that show neither a geniculus nor a pore; exine granulate to reticulate; outline crenate".

SUGGESTED AFFINITY: Frederiksen (1983, p.57) noted the resemblance between this form and pollen of Bignoniaceae.

Fraxinoipollenites artus Frederiksen 1983

[Plate 16, Figures 7,8]

Fraxinoipollenites cf. *F.scoticus* (Simpson) Frederiksen 1980b, p.48, pl.17, figs.1-4.

Fraxinoipollenites artus Frederiksen 1983, pp.56-57, pl.16, figs.13-15.

DESCRIPTION: See Frederiksen (1983, pp.56-57).

DISCUSSION: This species is bigger and greater in length/width ratio than *Fraxinoipollenites variabilis* Stanley 1965. The Utah specimens are smaller (23-28um X 13-22um, 9 specimens measured) than specimens of the California and the Gulf Coast (25-37um in length), both of which were described by Frederiksen. *Tricolpites* sp. A illustrated by Pocknall (1987, pl.1, fig.8) could be synonymous.

OCCURRENCE: Middle Eocene of California (Frederiksen, 1983, p.56) and upper part of the middle Eocene through lower Oligocene of Gulf Coast (Frederiksen, 1980a, p.48). Pocknall's *Tricolpites* sp. A from Wyoming and Montana is restricted to the upper Paleocene. Very rare to few in many samples of Paleocene interval of North Horn Formation in this study.

Fraxinoipollenites variabilis Stanley 1965

[Plate 16, Figure 9]

Fraxinoipollenites variabilis Stanley 1965, p.306, pl.45, figs.29-35.

DESCRIPTION: See Stanley (1965, p.306).

SIZE RANGE: 21-24um X 19-21um (4 specimens measured).

OCCURRENCE: Upper Campanian (Stone, 1973), Maastrichtian (Farabee and Canright, 1986) and Paleocene (Leffingwell, 1970) of Wyoming, Paleocene of South Dakota (Stanley, 1965). Price River Formation, and Paleocene interval of North Horn Formation in this study. Very rare to rare.

Genus Grewipollenites (Srivastava) Srivastava 1984

TYPE SPECIES: *Grewipollenites canadensis* Srivastava 1969d

DESCRIPTION: Emended description of the genus by Srivastava (1984) is as follows: "Pollen grain, tricolpate or tricolporoidate, angulaperturate; oblate; colpi wedge-shaped in polar view, area and the centre of the polar area; amb subtriangular or subcircular, sides convex; sexine rugulose, rugulae aligned to form striate sculpture on the outer exine surface; supratectal sculpture none." (from Jansonius and Hills, 1985, p.4256).

cf. Grewipollenites sp.

[Plate 16, Figure 10]

DESCRIPTION: Probably tricolporate; amb oval, 31um in diameter; pores round, 2um in diameter, crosscut by colpi; colpi 7um long, 1um wide near the pores; exine rugulate - striate, muri 1um wide, closely spaced.

DISCUSSION: This form is similar to *Grewipollenites* (Srivastava) Srivastava 1984 which is tricolpate or tricolporoidate, and angulaperturate.

OCCURRENCE: One specimen was found in Price River Formation (Pb14726) in this study.

Genus Inaperturotetradites van Hoeken-Klinkenberg 1964

TYPE SPECIES: *Inaperturotetradites lacunosus* van Hoeken-Klinkenberg 1964

Inaperturotetradites scabratus B. Tschudy 1973

[Plate 16, Figure 11]

Inaperturotetradites scabratus B. Tschudy 1973, pp.32-33, pl.11, figs.18-19.

DESCRIPTION: See B. Tschudy (1973, p.33).

DISCUSSION: Individual grains 26um in diameter, 38um in diameter of tetrad (1 specimen measured). One grain of tetrad shows a depression which looks superficially like a pore, and similar to *Dicotetradites granulatus* Norton 1969. I consider that this species and Stanley's *Ericaceoipollenites rallus* may be conspecific. The individual Utah specimens do not show colpi.

SUGGESTED AFFINITY: Ericaceae.

OCCURRENCE: Campanian - Maastrichtian of Wyoming and Montana (*fide*. B. Tschudy, 1973). Paleocene of South Dakota (Stanley, 1965). Castlegate Sandstone in this study.

Genus Kurtzipites (Anderson 1960) Leffingwell 1970

TYPE SPECIES: *Kurtzipites trispissatus* Anderson 1960

SYNONYMY AND DESCRIPTION: See Srivastava (1981, pp.868-869).

DISCUSSION: *Kurtzipites*, oblate tricolporate or tricolporoidate(?) pollen with aspidote and atriate apertures, is stratigraphically restricted to the Campanian - early Paleocene. Although the *Kurtzipites*-producing plant shares the *Aquilapollenites* phytogeoprovince with the *Aquilapollenites*-producing plant, it has been suggested that this plant favored inland areas compared to coastal environment favored by *Aquilapollenites* (Srivastava, 1981). It has also been suggested that parent plants of *Kurtzipites* survived the temperate climate of early Paleocene, which most of *Aquilapollenites*-producing plants could not.

SUGGESTED AFFINITY: Betulaceae, Carpinaceae, or Corylaceae. Srivastava (1981, p.872) noted the possible relationship between elongated pores and sexinal thickenings (arci) of *Alnus* and *Betula* and the elongated apertures and exinal folds of *Kurtzipites*.

Kurtzipites annulatus Norton 1969

[Plate 16, Figure 12]

SYNONYMY: See Srivastava (1981, p.874).

DESCRIPTION: See Norton and Hall (1969, p.52).

DISCUSSION: Nexinous thickening completely around the pore areas is characteristic of this species only. Size ranges 21-24um in equatorial diameter (3 specimens measured).

OCCURRENCE: Maastrichtian - Paleocene of Montana (Norton and Hall, 1969; Oltz, 1969; Penny, 1969; and R. Tschudy, 1970), Wyoming (Leffingwell, 1970); Alberta (Snead, 1969; Srivastava, 1981) and Saskatchewan (Jarzen, 1977) (*fide* Srivastava, 1981). Two samples of lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation yielded this species with 1.0 and 4.0% in relative abundance.

SUGGESTED AFFINITY: Betulaceae, Carpinaceae, or Corylaceae.

Kurtzipites trispissatus Anderson 1960

[Plate 16, Figure 13]

SYNONYMY AND DESCRIPTION: See Srivastava (1981, pp.876-877).

DISCUSSION: Roughly circular thickening (3-4um) of nexine at the polar ends of colpi distinguish this species from similar forms. Size ranges 22-29um in equatorial diameter (6 specimens measured).

OCCURRENCE: Campanian - Paleocene of North America (Anderson, 1960; Evitt, 1973; Felix and Burbridge, 1973; Jarzen, 1977; Norris *et al*, 1975, Leffingwell, 1970; Norton and Hall, 1969; Oltz, 1969; Snead, 1969; Srivastava, 1967, 1969d, 1970, and 1981; Stanley, 1965; and R. Tschudy, 1970 and 1973) (*fide* Srivastava, 1981). One specimen was recovered from sample Pb14548, and three specimens from sample Pb14731 of the Price River Formation in this study.

SUGGESTED AFFINITY: Betulaceae, Carpinaceae, or Corylaceae.

Genus Labraferoidaepollenites Kedves 1982

TYPE SPECIES: *Labraferoidaepollenites pseudorurensis* (Pflug) Kedves 1982;

Triatriopollenites pseudorerensis Pflug 1953

Triatriopollenites sect. *Labraferoidae* Pflug; Thomson and Pflug 1953, p.78.

Labraferoidaepollenites Kedves 1982, p.108.

DISCUSSION: This genus include the pollen without annulus, but tumescens or labrum, compared to annulate *Triatriopollenites*.

Labraferoidaepollenites dilatus (Fairchild) Kedves 1982

[Plate 13, Figures 3,4]

Triatriopollenites dilatus Fairchild; Stover *et al.* 1966, p.4, pl.1, figs.9-10.

Labraferoidaepollenites dilatus (Fairchild) Kedves 1982, p.109, pl.10, figs.17-18.

DESCRIPTION: See Stover *et al.* (1966, p.4).

SIZE RANGE: 16-19um in equatorial diameter (2 specimens measured).

OCCURRENCE: Paleocene of Alabama (Stover *et al.*, 1966). Paleocene of Germany (Kedves, 1982). Castlegate Sandstone sample (Pb14550) and uppermost sample of Price River Formation (Pb14733) yielded one specimen each in this study.

Genus Libopollis Farabee et al. 1984

TYPE SPECIES: *Libopollis jarzenii* Farabee *et al.* 1984

Libopollis Farabee *et al.* 1984, pp.151-152.

DESCRIPTION: See Farabee *et al.* (1984, p.151).

DISCUSSION: Farabee *et al.* (1984, pp.158,160) contend that palynomorphs assigned to this genus are useful stratigraphic index markers because of the distinctive morphology, the limited stratigraphic range (confined to the Maastrichtian), and being relatively widespread in both the Normapolles and the *Aquilapollenites* phytogeoprovinces.

SUGGESTED AFFINITY: Uncertain. Farabee and Canright (1986, p.73) noted the dicotyledonous appearance of its type species, *Libopollis jarzenii.*

Libopollis jarzenii Farabee *et al.* 1984

[Plate 16, Figures 16,17]

Libopollis jarzenii Farabee *et al.*; Farabee and Canright, 1986, p.10, pl.26, figs.1-12.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Farabee *et al.* (1984, pp.152,154).

DISCUSSION: Single specimen (26um in equatorial diameter) found appears to be identical to the original description and illustrations given by Farabee *et al.* (1984). Apertural preservation is missing in this specimen, which is a common phenomenon in the specimens of this species from Wyoming (Farabee *et al.* 1984).

OCCURRENCE: Maastrichtian of the United States. One specimen was found in the uppermost sample (Pb14733) of Price River Formation in this study.

Genus Liliacidites Couper 1953

TYPE SPECIES: *Liliacidites kaitangatensis* Couper 1953

DESCRIPTION: See Couper (1953, p.56).

SUGGESTED AFFINITY: Monocotyledonous, Liliales.

Liliacidites cf. L. complexus (Stanley) Leffingwell 1970

[Plate 16, Figures 18,19]

Liliacidites *complexus* (Stanley) Leffingwell; Farabee and Canright 1986, p.52, pl.18, figs.10-15.

ADDITIONAL SYNONYMY: See Farabee and Canright (1986, p.52).

DESCRIPTION: See Stanley (1965, pp.267-268).

DISCUSSION: Specimens encountered here are elongate rather than spherical to subspherical. This could possibly be due to the preservational control. 33-40um X 19-22um (4 specimens measured).

OCCURRENCE: Campanian of Wyoming (Stone, 1973). Maastrichtian of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986) and Montana (Norton and Hall, 1969). Maastrichtian - Paleocene of Montana (Oltz, 1969). Castlegate Sandstone, Price River Formation, and Cretaceous interval of North Horn Formation (0.7 to 2.3% of the total counted). Three specimens were recovered from one coal sample (Pb14088) of the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation.

Liliacidites leei Anderson 1960

[Plate 17, Figure 1]

Liliacidites leei Anderson 1960, pp.18-19, pl.1, figs.9-11; pl.5, fig.10; pl.7; fig.7; pl.8, figs.4-5.

DESCRIPTION: See Anderson (1960, pp.18-19).

SIZE RANGE: 21-27um X 13-17um.

OCCURRENCE: Campanian (Stone, 1973). Maastrichtian (Farabee and Canright, 1986). Uppermost Cretaceous - Paleocene (Anderson, 1960). Castlegate Sandstone and the lowermost sample (Pb14549) of Price River Formation in this study. Total of three specimens were studied here.

Liliacidites variegatus Couper 1953

[Plate 17, Figure 2]

Liliacidites variegatus Couper 1953, p.56, pl.7, figs.98-99.

DESCRIPTION: See Couper (1953, p.56).

SIZE RANGE: 22-37um X 12-23um (7 specimens measured).

OCCURRENCE: Upper Cretaceous - lower Oligocene of the various parts of the world. Two samples from the Price River Formation yielded one and three specimens, respectively.

Genus Margocolporites Ramanujam 1966 ex Srivastava 1969

TYPE SPECIES: *Margocolporites tsukadae* Ramanujam 1966 ex Srivastava 1969

DESCRIPTION: See Ramanujam (1966, p.173).

Margocolporites puercoensis (Anderson) comb. nov.

[Plate 17, Figure 3]

Nyssa puercoensis Anderson 1960, p.23, pl.7, fig.12.

Nyssapollenites puercoensis (Anderson) Drugg 1967, p.52, pl.8, fig.4.

Tricolporopollenites kruschii (Potonie) Thomson and Pflug; Elsik 1968b, p.628 (*pars*).

DESCRIPTION: See Anderson (1960, p.23).

DISCUSSION: 35um in equatorial diameter (1 specimen measured). "Reticulum fining towards the poles as well as towards the colpi margin", should be added to the previous description, on the basis of the Utah specimens and the illustrations of previous reports. *Margocolporites varireticulatus* Jameossanaie 1987 may be conspecific. It has same size of lumina at poles. *Margocolporites cribellatus* Srivastava 1972a has finer lumina and uniform size. *Margocolporites lihokus* Srivastava 1972a is coarser in sculpture and has convex sides.

OCCURRENCE: Lowermost Paleocene of New Mexico (Anderson, 1960). Paleocene of Texas (Elsik, 1968b). Maastrichtian and Danian of California (Drugg, 1967). Two specimens were recovered from the Castlegate Sandstone sample (Pb14550), and a sample (Pb14729) of Price River Formation in this study.

Genus Momipites Wodehouse emend. Nichols 1973

TYPE SPECIES: *Momipites coryloides* Wodehouse 1933

SYNONYMY AND DESCRIPTION: See Nichols (1973, p.106)

DISCUSSION: Frederiksen and Christopher(1978) emended the genus by transferring the triorbiculate and triradiate members of the genus to genus *Plicatopollis*. However, Nichols and Ott (1978) argue that there is a morphologic continuum in the phylogenetic relationships of *Momipites* with *Caryapollenites*. In this study, Nichols' (1973) definition of the genus is accepted. *Momipites* emended by Nichols include pollen with or without various structural modifications in exine. A simplified key for the species, based on the Utah specimens, is as follows:

1.a. Simple polar region -------------------------- go to 2
b. Three circular thin spots in one pole -------- go to 3
c. Triradiate thin area in one pole -------------- *M. actinus*
d. Thinned circumpolar ring in one pole ------- go to 4
2.a. Interporia convex ------------------------------ *M. wyomingensis*
b. Interporia concave ------------------------------ *M. waltmanensis*
c. Interporia of unequal length ------------------ *M. inaequalis*
3.a. Interporia convex ------------------------------ *M. ventifluminis*
b. Interporia concave ------------------------------ *M. triorbicularis*
4.a. Interporia convex ------------------------------ *M. anellus*
b. Interporia concave ------------------------------ *M. leffingwellii*

SUGGESTED AFFINITY: Juglandaceae. Similar to modern *Engelhardia* - *Alfaroa* group and, in part, to *Carya*.

Momipites actinus Nichols and Ott 1978

[Plate 17, Figure 4]

Momipites actinus Nichols and Ott 1978, p.103, pl.1, figs.18-21.

DESCRIPTION: See Nichols and Ott (1978, p.103).

DISCUSSION: It is likely that the triradiate thinning of pole (trilete mark) is the relict structure on the proximal side resulting from the contact of the three other pollen grains of the tetrad following two successive divisions of the spore mother cell that resulted in four equal spores. If this is the case, this is the same form as *Momipites waltmanensis*. This also could be used to support the argument for the heteropolarity of juglandaceous pollen by Nichols and Ott (1978, p.98).

OCCURRENCE: Middle - upper Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P3-P4), Wyoming (Nichols and Ott, 1978; zones P3-P4), and Alberta (Demchuk, 1987; zones P3-P5). One specimen was found on a slide from a coaly shale in the upper interval of Paleocene strata (middle/late Paleocene age) outside the counted sum (Pb14092), and one specimen was recovered from the lowermost Flagstaff Member of the Green River Formation.

SUGGESTED AFFINITY: Juglandaceae.

Momipites anellus Nichols and Ott 1978

[Plate 17, Figure 5]

Momipites anellus Nichols and Ott 1978, p.103, pl.1, figs.22-25.

DESCRIPTION: See Nichols and Ott (1978, p.103).

DISCUSSION: Specimens studied here appear to be identical to those defined by Nichols and Ott (1978) in every aspect including size range (22-28um, 6 specimens measured). An interesting question has arisen as to why *Momipites anellus*, reported in this study, is present both in east-central Utah and the Wind River Basin, Wyoming (400km distant) (Nichols and Ott, 1978), but *M.amplus* was not found in the Price Canyon Section, whereas in the Powder River Basin, 150km from from the Wind River Basin, *M.amplus* was reported (Leffingwell, 1970), but *M.anellus* was not. Although all the other characteristics used to define these two species are almost identical, there is no overlapping in size range (18-27um and 28-37um, respectively, for *M.anellus* and *M.amplus*). Another question that concerns me is the possible relationship of *M.amplus*, *M.anellus*, and *M.marylandicus*. Each has its own local occurrence during the same time span (in this case Paleocene). Size of these are 28-37um, 18-27um, and 19-22um, respectively. There seems to be a possibility of latitudinal size variation, that the smaller form is near the equator and getting larger towards the pole, as in many organisms, though such characterization is less applicable to various organs (seeds, leaves, etc.).

OCCURRENCE: Middle Paleocene - lower Eocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P3-E), Wyoming (Nichols and Ott, 1978; zones P3-E), and Alberta (Demchuk, 1987; zones P3-P6). Throughout entire Paleocene interval of North Horn Formation with up to 3.3% in this study.

SUGGESTED AFFINITY: Juglandaceae.

<u>Momipites inaequalis</u> Anderson 1960

[Plate 17, Figure 6]

Momipites inaequalis Anderson 1960, p.25, pl.6,figs.7-10; pl.7, fig.13.

DESCRIPTION: See Anderson (1960, p.25).

DISCUSSION: It is possible that the characteristic of unequal length of sides of this species is a variable artifact of preservation rather than the original nature of the pollen. It is likely that some specimens of this species were included with either

Momipites wyomingensis or *M.waltmanensis* in the counting process. Demchuk (1987) synonymized this species with *Momipites wyomingensis*.

OCCURRENCE: Maastrichtian and Paleocene of various parts of North America. One specimen was included in counting from the upper interval of Paleocene strata (middle/late Paleocene age, Pb14079) of North Horn Formation in this study.

SUGGESTED AFFINITY: Juglandaceae.

Momipites leffingwellii Nichols and Ott 1978

[Plate 17, Figure 7]

Maceopolipollenites tenuipolus (Anderson) Leffingwell 1970, p.31, pl.6, fig.4.

Momipites leffingwellii Nichols and Ott 1978, p.103, pl.1, figs.27-30.

DESCRIPTION: See Nichols and Ott (1978, pp.103-104).

DISCUSSION: Three specimens measured in this study range in size between 24-27um. Nichols and Ott (1978) gave 16-25um as the size range for this species. Although grains encountered here are somewhat larger in size, they are specifically identical in other respects to *Momipites leffingwellii* as described by Nichols and Ott (1978, p.104), and are therefore considered to be conspecific.

OCCURRENCE: Lower - middle Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P1-P3), Wind River Basin, Wyoming (Nichols and Ott, 1978; zones P1-P3), Powder River Basin, Wyoming (Leffingwell, 1970; Assemblage B), and Alberta (Demchuk, 1987; zones P2-P4). Lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in the Price Canyon Section. Very rare to few.

SUGGESTED AFFINITY: Juglandaceae.

Momipites ventifluminis Nichols and Ott 1978

[Plate 17, Figure 8]

Momipites ventifluminis Nichols and Ott 1978, p.102, pl.1, figs.9-14.

DESCRIPTION: See Nichols and Ott (1978, p.102).

DISCUSSION: Frederiksen and Christopher(1978) recommended the transfer of "forms with only thin spots, or with only the triradiate structure, or both" to *Plicatopollis*. As mentioned in Nichols and Ott (1978, p.102), the morphologic continuity of phylogenetic pattern and the morphologic uncertainty of the holotype of *Plicatopollis*, Nichols'(1973) definition of *Momipites ventifluminis* along with *Momipites* is accepted. Morphotypes similar to *Plicatopollis* spp. of the *P.triorbicularis*-type of Frederiksen and Christopher (1978, pl.2, figs.1-4, *non* fig.3) are included in this species.

OCCURRENCE: Middle - upper Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; middle of zones P3 - P6), Wyoming (Nichols and Ott, 1978; zones P3-P6), and western and arctic Canada (Jerzykiewicz and Sweet, 1986; and McIntyre, 1974). Scattered throughout entire Paleocene interval of North Horn Formation with up to 2.0% in this study.

SUGGESTED AFFINITY: Juglandaceae.

Momipites waltmanensis Nichols and Ott 1978

[Plate 17, Figures 9,11]

Momipites waltmanensis Nichols and Ott 1978, p.102, pl.1, figs.5-8.

DESCRIPTION: See Nichols and Ott (1978, p.102).

DISCUSSION: Most specimens encountered in this study show straight to only slightly concave interporia outlines. Thus, specimens with convex equatorial profile between pores similar to Pocknall's (1987) illustration of *Momipites wyomingensis*, pl.1, fig.3, are considered to be *Momipites waltmanensis*.

OCCURRENCE: Lower - upper Paleocene of Utah-Wyoming thrust belt (Jacobson and Nichols, 1982; zones P2-P6), Wyoming (Nichols and Ott, 1978; zones P2-P6), Alberta (Demchuk, 1987; zones P2-P5), and other part of western and arctic

Canada (Jerzykiewicz and Sweet, 1986; and McIntyre, 1974). Throughout the lower interval of Paleocene section (middle Paleocene age) and occasional in upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation with up to 9.7% in sample Pb14213 of this study.

SUGGESTED AFFINITY: Juglandaceae.

Momipites wyomingensis Nichols and Ott 1978

[Plate 17, Figure 10]

Momipites wyomingensis Nichols and Ott 1978,p.100, pl.1, figs.1-4.

DESCRIPTION: See Nichols and Ott (1978, p.100).

DISCUSSION: Size of the species encountered in this study is slightly larger (20-28um, 10 specimens measured) than that given in the original description. Even though the polar region is simple and the exine shows relatively uniform thickness, some degraded specimens show a tendency to be thinner in polar region.

OCCURRENCE: Lower - upper Paleocene of Utah-Wyoming (Jacobson and Nichols, 1982; zones P2-E), Wyoming (Nichols and Ott, 1978; zones P2-E(?)), and Alberta (Demchuk, 1987; zones P2-P6). Throughout entire Paleocene interval of North Horn Formation with up to 16.3% in this study.

SUGGESTED AFFINITY: Juglandaceae.

Genus Monosulcites Cookson ex Couper 1953

TYPE SPECIES: *Monosulcites minimus* Cookson ex Couper 1953

SYNONYMY AND DESCRIPTION: See Couper (1953, p.65).

SUGGESTED AFFINITY: As suggested by Stone (1973), one species of this genus (*Monosulcites scabratus*) is gymnospermous, however most others appear to be angiospermous. This genus is tentatively described under the "angiospermous pollen" in this study.

Monosulcites latus Norton 1969

[Plate 17, Figure 12]

Monosulcites latus Norton; Norton and Hall 1969, p.27, pl.3, fig.6.

DESCRIPTION: See Norton and Hall (1969, p.27).

SIZE RANGE: 24-30um (1 specimen measured).

OCCURRENCE: Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). A single specimen was found on a slide outside the counted sum; lower interval of Paleocene section (middle Paleocene age) of the North Horn Formation in this study.

Monosulcites scabratus (Stanley) Stone 1973

[Plate 17, Figure 14]

Schizosporis scabratus Stanley 1965, p.269, pl.35, figs.10-17.

Monosulcites scabratus (Stanley) Stone 1973, p.77, pl.15, figs.80-81.

DESCRIPTION: Monosulcate pollen. See Stanley (1965, p.269) for the other features.

SIZE RANGE: 14-21um X 21-24um.

SUGGESTED AFFINITY: Gymnospermae (Stone, 1973).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973). Maastrichtion of South Dakota (Stanley, 1965). Scattered throughout the section in this study. Very rare to few except one sample of coal (Pb14183) in lower interval of Paleocene strata (middle Paleocene age) of the North Horn Formation (27 grains).

Monosulcites tectatus Norton 1969

[Plate 17, Figure 15]

Monosulcites tectatus Norton; Norton and Hall 1969, pp.34-35, pl.3, fig.4.

Monosulcites tectatus Norton; Farabee and Canright 1986, p.56, pl.19, fig.16.

SIZE RANGE: 22-29um X 14-18um (7 specimens measured).

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986). Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). Throughout the section except the upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation in this study. Very rare to few (up to 2.3%).

Monosulcites sp.1.

[Plate 17, Figure 13]

DESCRIPTION: Monosulcate pollen; amb. elongate oval, sulcus has same width throughout the length and extends to the terminal margins of grain; exine baculate-finely reticulate, 0.5um thick; size 12-22um X 9-14um (11 spceimens measured).

DISCUSSION: This species has morphological characteristics which fall within the generic diagnosis of the genus *Monosulcites*. Small size and baculate-finely reticulate exine distinguish this species from other similar forms. *Clavatipollenites minutus* Brenner is very similar to the present species, although the present species tends not to show the clavate nature of pila.

OCCURRENCE: Scattered throughout the section in this study. Most were found outside the counted sums. Very rare.

Monosulcites sp.2

[Plate 17, Figure 16]

DESCRIPTION: Monosulcate pollen; elliptical with pointed ends; sulcus extending to the terminal ends (margin) of the grain, tapering to the ends; exine 1um thick, covered by moderately spaced echinae; echinae sharply pointed, sometimes gently bent, 2-3um high; 26um X 15um (1 spcimen measured).

DISCUSSION: Long, distinct sulcus and echinate surface are characteristic.

OCCURRENCE: One specimen found in this study in the upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation.

Genus Myrtaceidites Cookson and Pike 1954

TYPE SPECIES: *Myrtaceidites mesonesus* Cookson and Pike 1954

SYNONYMY AND DESCRIPTION: See Krutzsch (1969, p.405).

DISCUSSION: Krutzsch (1969) added explanations to the original description including pore structures to the diagnosis of the genus as follows: "Pores are partly thickened to strongly annulate". He used this feature along with the presence of arci as distinguishing features from the genus *Cupanieidites*. The translation presented in Jansonius and Hills (1976) probably should be revised. This form is characterized by its arci, and can be distinguished from *Myrtipites* Norton and Hall by the presence of vestibulum in the latter.

Myrtaceidites solidus Sweet 1986

[Plate 17, Figures 18,19]

Myrtaceidites solidus Sweet 1986, pp.1379-1380, pl.1, figs.14-15.

ADDITIONAL SYNONYMY: See Sweet (1986, p.1379).

DESCRIPTION: Supplementary descriptive notes based on the specimens studied here are as follows: Tricolporate pollen; amb triangular with straight, slightly concave, or slightly convex sides, and rounded corners; pores small, 1um in diameter, equatorial, moderately to strongly annulate; colpi bordered by prominent thickening or ridge; exine scabrate to finely granulate; 17-21um in equatorial diameter (5 specimens measured).

DISCUSSION: *Myrtaceidites* sp. B. and *Myrtaceidites* sp. C. reported by Snead (1969, pp.35-36, pl.6, figs.7 and 10, respectively) are very similar to the present species. Also *Mytaceidites* sp.A reported by Jarzen (1982, pp.140-141, pl.1, figs.8-9) is probably conspecific.

OCCURRENCE: Uppermost Maastrichtian of Alberta (Sweet, 1986); Maastrichtian and Paleocene of Alberta (Snead, 1969); Paleocene of Saskatchewan

(Jarzen, 1982). Present in two samples; Price River Formation (Pb14732), and Cretaceous interval of North Horn Formation (Pb14542), two specimens each. One specimen recovered from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation was probably recycled from Cretaceous strata.

Genus Myrtipites Norton and Hall 1969

TYPE SPECIES: *Myrtipites granulatus* Norton 1969

DESCRIPTION: See Norton and Hall (1969, p.54).

DISCUSSION: Short colpi, the presence of vestibulum, and slightly elongated pores are distinctive features.

Myrtipites laqueaeformis (Weyland and Greifeld) comb. nov.

[Plate 17, Figures 20,21]

Sporopollis laqueaeformis Weyland and Greifeld 1953; Newman 1965, p.16, pl.1, fig.13.

Sporopollis cf. S. *laqueaeformis* Weyland and Greifeld; Stone 1973, p.94, pl.20, fig.137.

DESCRIPTION: Tricolporate pollen, oblate; amb triangular with more or less straight sides and sharply defined corners; pores round, 1-2um in diameter, vestibulum shallow, indistinctly annulate; colpi short, indistinct; arci well-developed, converging at poles forming Y-mark rays; exine thin, psilate to faintly scabrate; 13-19um in equatorial diameter (8 specimens measured).

DISCUSSION: The type specimen of *Sporopollis* is missing, and, therefore, the genus is considered to be *nomen ambiguum*. *Myrtaceidites* sp. B reported by Jarzen (1982, p.141, pl.1, fig.15) is similar to this species.

OCCURRENCE: Campanian of northwestern Colorado (Newman, 1965) and Wyoming (Stone, 1973). Castlegate Sandstone sample and most samples of the Price River Formation with up to 3.7% relative abundance.

Myrtipites scabratus Norton 1969

[Plate 17, Figure 17]

Myrtipites scabratus Norton; Norton and Hall 1969, p.55, pl.8, fig.2.

DESCRIPTION: See Norton and Hall (1969, p.55).

DISCUSSION: Arci present in Utah specimens as in Montana specimens, although not completely developed. Utah specimen has bigger pores (4um in diameter). The single specimen measured is 21um in equatorial diameter.

OCCURRENCE: Maastrichtian and Paleocene of Montana (Norton and Hall, 1969). One specimen was recovered from outside the counted sum; the uppermost sample (Pb14733) of Price River Formation in this study.

Myrtipites tectus (Newman) comb nov.

[Plate 17, Figure 22]

Triporopollenites tectus Newman 1965, p.12, pl.1, fig.6.

DESCRIPTION: Tricolporate pollen, oblate; amb circular to rounded-triangular with convex sides; pore not well-developed, vestibulum weakly present, annulate; colpi short reaching two-thirds of the radius; exine thin, faintly scabrate; 11um in equatorial diameter (1 specimen measured).

DISCUSSION: Specimens found show the structure of aperture relatively clearly. It is smaller than the Colorado specimens of Newman (14-16um).

OCCURRENCE: Maastrichtian of northwestern Colorado (Newman, 1965). Uppermost samples from Price River Formation with 1.0 to 1.3% in relative abundance.

Genus Nyssapollenites Thiergart ex Potonie 1960

TYPE SPECIES: *Nyssapollenites pseudocruciatus* (Potonie) Thiergart 1938

Nyssapollenites Thiergart 1938, p.322.

Nyssapollenites Thiergart ex Potonie 1960, p.103.

DESCRIPTION: See Jansonius and Hills (1976, p.1794).

Nyssapollenites minima (Anderson) comb. nov.

[Plate 18, Figure 1,2]

Cyrilla minima Anderson 1960, pl.10, figs.14-15.

DESCRIPTION: See Anderson (1960, p.22). Additional description based on the specimens encountered here are as follows: Tricolporate pollen; oblate, amb circular to rounded-triangular; colpi long, extending to the pole, 3/4 to 4/5 of the radius in equatorial view; colpi slightly open; pores not distinct; exine 1um thick, psilate to finely scabrate, thinner towards the margins of the colpi; 14-18um in equatorial diameter (6 specimens measured).

DISCUSSION: Small size and psilate to finely-scabrate surface distinguish this species from other similar forms. Utah specimens tend to have longer and less widely opened colpi.

OCCURRENCE: Uppermost Cretaceous of New Mexico (Anderson, 1960). Present in Castlegate Sandstone through the lower interval of Paleocene section (middle Paleocene age) interval of North Horn Formation in this study. Very rare and occasionally found outside the counted sums.

Nyssapollenites pseudocruciatus (Potonie) Thiergart 1938

[Plate 18, Figures 3,4]

SYNONYMY AND DESCRIPTION: Drugg (1967, p.52).

SIZE RANGE: 13-19um in diameter (6 specimens measured).

OCCURRENCE: Maastrichtian - Danian of California (Drugg, 1967). Occasionally found outside the counted sums from the lower interval of Paleocene strata (middle Paleocene age), and from two samples (middle/late Paleocene age) (1 and 7 specimens, a dark gray shale, Pb14084, and a coal, Pb14088, respectively) of North Horn Formation in this study.

Genus Pandaniidites Elsik 1968

TYPE SPECIES: *Pandaniidites texus* Elsik 1968

SYNONYMY: See Sweet (1986, p.1380).

DESCRIPTION: See Elsik (1968b, p.314).

SUGGESTED AFFINITY: *Pandanus* (Pandanaceae) or *Lemna* (Lemnaceae). See Sweet (1986, p.1382) for detail.

Pandaniidites typicus (Norton) Sweet 1986

[Plate 18, Figure 5]

SYNONYMY AND DESCRIPTION: See Sweet (1986, p.1382).

DISCUSSION: Distinctions among species belonging to the genus Pandaniidites are relatively subtle. The only difference between *Pandaniidites texus* and *P. radicus* appears to be the thickness of the wall. Because of the broader circumscription of *P. typicus* (see Sweet 1986, p.1382; exine 0.5-1.0um thick, and pore annulate and nonannulate), this species could include the characteristics of both *P. texus* and *P. radicus*. In this study, *Pandaniidites* specimens were assigned to *P. typicus*.

OCCURRENCE: Maastrichtian - Paleocene of various parts of North America. Most samples of the Price River Formation, and Cretaceous interval and lower interval of Paleocene strata (middle Paleocene age) of the North Horn Formation in this study, with up to 15.0% in a dark gray shale (Pb14737) associated with a sequence of lake beds.

SUGGESTED AFFINITY: Pandanaceae or Lemnaceae. see Sweet (1986, p.1382).

Genus Paraalnipollenites Hills and Wallace 1969

TYPE SPECIES: *Paraalnipollenites confusus* (Zaklinskaya) Hills and Wallace

DESCRIPTION: See Hills and Wallace (1969, p.141).

DISCUSSION: Kedves (1982, p.107) noted that this genus appeared in Late Cretaceous and became a plant assemblages of the *Aquilapollenites* province.

Paraalnipollenites sp.1.

[Plate 18, Figures 6,7]

DESCRIPTION: Triporate pollen; amb. polygonal ; arci extend from one point to another, often from pore to pore; midway between pores, the arci characteristically arch out and form the pore-like structure (false pores); pore equatorial, often labrum is present, no vestibulum identifiable; exine psilate, 1um thick; 23-32um in equatorial diameter (5 specimens measured).

DISCUSSION: This species is similar to *Paraalnipollenites confusus* described by Hills and Wallace (1969). However, that species is larger, and has a circumpolar thickening.

OCCURRENCE: Three samples from the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation (0.7 to 3.3%) in this study.

Genus Pistillipollenites Rouse 1962

TYPE SPECIES: Pistillipollenites macgregorii Rouse 1962

DESCRIPTION: See Rouse and Srivastava (1970, p.287).

DISCUSSION: Rouse and Srivastava(1970) did not accept Elsik's emendation for the genus(1968b). Recent studies of pollen grains extracted from anthers of

Pistillipollenites-bearing flowers show the triporate nature of pollen (Crepet and Daghlian, 1981 and Stockey and Manchester, 1988).

SUGGESTED AFFINITY: *Pistillipollenites*-bearing flowers discovered in the Wilcox Formation (lower Eocene) of northeastern Texas were interpreted to be allied with the Gentianaceae by Crepet and Daghlian (1981, pp.75-76). *Pistillipollianthus wilsonii*, a *Pistillipollenites*-bearing flower described by Stockey and Manchester (1988), found in the Eocene of British Columbia, shows some similarities to the Euphorbiaceae. Stockey and Manchester noted the distinct difference in flowers found in Texas and British Columbia. They suggested that *Pistillipollenites*-type, gemmate pollen grains probably represent different angiosperm families, and that such pollen may have evolved several times through convergent or parallel evolution.

<u>Pistillipollenites</u> <u>macgregorii</u> Rouse 1962

[Plate 18, Figure 10]

SYNONYMY AND DESCRIPTION: See Rouse and Srivastava (1970, pp.288-290).

SIZE RANGE: 21-30um (10 specimens measured).

OCCURRENCE: Lower Tertiary of various parts of the world. Common to abundant in many samples of upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation, with up to 36.7% in one coal sample (Pb14088) and 30.3% in a coaly shale sample (Pb14085) in this study.

SUGGESTED AFFINITY: Uncertain.

Genus Polotricolporites Gonzalez Guzman 1967

TYPE SPECIES: *Polotricolporites mocinnii* Gonzalez Guzman 1967

DESCRIPTION: "Pollen grains with three furrows and three pores. The furrows are 'connected' by thickenings (ridges) of the exine in the polar areas. Sculpture types; foveolate - reticulate- fossulate." (*fide*. Jansonius and Hills, 1976).

DISCUSSION: Sweet (1986, p.1383) suggests that the thickenings are the result of folding of the polar areas.

Polotricolporites cf. P. rotundus Sweet 1986

[Plate 18, Figures 8,9]

Polotricolporites rotundus Sweet 1986, p.1383, pl.1, figs.20-21.; pl.2, figs.1-8.

DESCRIPTION: See Sweet (1986, p.1383, and p.1384 under *Polotricolporites rotundus* var. *pumilus*).

DISCUSSION: Utah specimens seem to be identical to the specimens assigned to the Alberta species, *Polotricolporites rotundus* var. *pumilus*, originally described by Sweet (1986). The two specimens encountered here are more or less degraded. Muri tend to be aligned and show rugulate pattern in parts of surface of Utah specimens.

OCCURRENCE: Latest Maastrichtian and earliest Paleocene of Saskatchewan (Sweet, 1986). Upper coal sample (Pb14078) of the upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation yielded two specimens in this study.

Genus Proteacidites Cookson ex Couper 1953

TYPE SPECIES *Proteacidites adenanthoides* Cookson 1950

Proteacidites Cookson ex Couper 1953, p.42.

DESCRIPTION: See Couper (1953, p.42).

SUGGESTED AFFINITY: Martin and Harris (1974) doubted that Upper Cretaceous species of *Proteacidites*, including *P. thalmanni* and *P. retusus*, may have extant proteaceous affinity, and proposed two new genera *Prophlipollis* and *Cranwellipollis*. Until the further study for the botanical affinity of the genus, or part of genus, is done, this genus should be remain to be uncertain or partly proteaceous affinity.

DISCUSSION: Srivastava (1969b, pp.1576-1577) noted that this genus became extinct at the end of Cretaceous in the Northern Hemisphere (Paleocene records were reported later, such as Drugg,1967 and Oltz,1969), whereas it continued to exist until the early Pleistocene in the Southern Hemisphere. Through the study of the Edmonton Formation, Alberta, Srivastava (1969b) postulated that the environment for *Proteacidites* is a "subtropical climate supporting a rain-forest type of vegetation". He also indicated that this plant was of entomophilous nature similar to extant species of proteaceous plants.

Proteacidites cf. P. marginus Rouse 1962

[Plate 18, Figure 11]

Proteacidites marginus Rouse 1962, p.205, pl.2, fig.26.

Proteacidites marginus Rouse; Norton and Hall 1969, p.38, pl.5, fig.11.

Proteacidites marginus Rouse; Farabee and Canright 1986, p.57, pl.20, fig.1.

DESCRIPTION: See Rouse (1962, p.205).

DISCUSSION: The three specimens observed in this study range from 19um to 24um in equatorial diameter, and have similar polar view and exine structure to those of previously described specimens of this species. However, this species can be transferred to the genus *Beaupreaidites* Cookson, which was emended by Srivastava (1969b) to accomodate colpoid proteaceous pollen. If the strict assignment is accepted, i.e. *Beaupreaidites* for tricolpate pollen and *Proteacidites* for triporate pollen (Martin, 1973; Martin and Harris, 1974), this species should be transferred to genus *Retibrevitricolporites* Legoux 1978 as pointed out by Sweet (1986). It is not clear whether the apertural structure is tricolporate or tricolpoid as illustrated by Srivastava (1969b, fig.2). In the present study, this species is tentatively retained in the genus *Proteacidites*.

OCCURRENCE: Upper Cretaceous of British Columbia (Rouse, 1962). Maastrichtian of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986), Montana (Norton and Hall, 1969), and Alberta (Sweet, 1986). Castlegate Sandstone and Price River Formation yielded one specimen each from outside the counted sums in this study. One degraded specimen, probably reworked, was recovered outside the counted sum from a sample of the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Proteacidites retusus Anderson 1960

[Plate 18, Figures 12,13]

Proteacidites retusus Anderson, 1960, p.21, pl.2, figs.5-7.

DESCRIPTION: See Anderson (1960, p.21).

DISCUSSION: The exine has a finer reticulation than that of *P. thalmanni*. Utah specimens (16-28um in equatorial diameter, 9 specimens measured) are somewhat more sharply angular in polar view.

OCCURRENCE: Uppermost Cretaceous of New Mexico (Anderson, 1960), Maastrichtian of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986), Montana (Norton and Hall, 1969) and South Dakota (Stanley, 1965). Castlegate Sandstone, Price River Formation (1.3 to 8.0%, Pb14733), and one sample from the Cretaceous interval of North Horn Formation (0.7%, Pb14734) in this study.

Proteacidites thalmanni Anderson 1960

[Plate 18, Figure 14]

SYNONYMY: See Srivastava (1969b, p.1575) and Stone (1973, p.96).

DESCRIPTION: See Anderson (1960, p.21).

DISCUSSION: Coarse reticulation is distinctive for this species of *Proteacidites*.

SIZE RANGE: Three specimens measured range 24-29um in equatorial view.

OCCURRENCE: Upper Campanian (Stone, 1973) and Maastrichtian (Farabee and Canright, 1986) of Wyoming, and uppermost Cretaceous of New Mexico (Anderson, 1960). Maastrichtian and Paleocene of California (Drugg, 1967) and Montana (Oltz, 1969). See Stone (1973, p.96) for more detail. Present in Castlegate Sandstone sample and the most samples of Price River Formation with up to 3.3% (Pb14727) in this study.

Proteacidites sp.1

[Plate 18, Figure 16,17]

DESCRIPTION: Triporate pollen, triangular with more or less straight sides; pores large, circular, with annulus, and equatorially located; endopore 11-12um in diameter, exopore 5-6um in diameter; exine 1um thick, reticulate, 20-27um in equatorial diameter (4 specimens measured).

DISCUSSION: This species is very similar to *Proteacidites auratus* Srivastava (1969b) described from Maastrichtian of Edmonton Formation, Alberta. *P. auratus* is significantly bigger in equatorial (50-60um) and pore diameters (16-20um). *Proteacidites parvus* Cookson 1950, described by Drugg (1967, p.58), has thicker exine and the pores do not appear to be annulate. *Proteacidites tenuiexinus* Stover 1973, described from southeastern Australia, is similar to this species, but the Australian species is larger (33um) and the pores are not annulate.

OCCURRENCE: The uppermost sample of the Price River Formation (Pb14733) yielded eight specimens in this study.

Proteacidites sp.2

[Plate 18, Figure 15]

Proteacidites sp. a.; Drugg 1967, p.59, pl.8, fig.33.

DESCRIPTION: Tricolporate pollen; amb triangular with more or less straight sides; exine thickens to form annuli at the pores, annuli 3-4um in width, pore 2um in diameter, short colpi cut across the pores; surface reticulate, reticulation coarsening towards the equator. 16-23um in equatorial diameter (2 specimens measured).

DISCUSSION: This species is identical to the California species described by Drugg (1967) except Utah specimens are smaller (31-41um for California species). This type of pollen may be found to be within the circumscription of the genus *Beaupreaidites* Cookson emend. Srivastava 1969b.

OCCURRENCE: Maastrichtian - Danian of California (Drugg, 1967). In the present study, one sample from the Castlegate Sandstone and three from the Price River Formation yielded a single specimen each.

Genus Pseudotricolpites Stanley 1965

TYPE SPECIES: *Pseudotricolpites reticulatus* Stanley 1965

SUGGESTED AFFINITY: unknown.

Pseudotricolpites reticulatus Stanley 1965

[Plate 18, Figure 18]

Pseudotricolpites reticulatus Stanley 1965, p.317, pl.46, figs.26-33.

DESCRIPTION: See Stanley (1965, p.317).

DISCUSSION: Morphology of the species fits well with Stanley's description and illustrations. This morphotype could probably be an aborted form of a certain type of tricolpate pollen. Size ranges 11-17um X 17-24um.

OCCURRENCE: Upper Cretaceous and lower Tertiary of South Dakota (Stanley, 1965). Very rare to rare in the Price River Formation and one specimen from a sample of the lower interval of Paleocene rocks (middle Paleocene age) of the North Horn Formation in this study.

Genus Retitrescolpites Sah 1967

TYPE SPECIES: *Retitrescolpites typicus* Sah 1967

SYNONYMY: See Frederiksen (1979, p.139).

Retitrescolpites anguloluminosus (Anderson) Frederiksen 1979

[Plate 18, Figures 19-21]

Retitrescolpites anguloluminosus (Anderson) Frederiksen 1979, p.139, pl.1, fig.13.

ADDITIONAL SYNONYMY: See Elsik (1968b, p.624) and Frederiksen (1979, p.139).

DESCRIPTION: See Anderson (1960, p.26).

DISCUSSION: Some specimens found here are more strongly retipilate than others, and the heights of pila reach 2um. Size ranges 22-31um in equatorial diameter (15 specimens measured). Most specimens belong to 27-28um range.

OCCURRENCE: Different types of palynomorphs have been assigned to this species by different authors. Utah specimens are distributed throughout the Price Canyon Section. They include palynomorphs similar to those from New Mexico (Anderson, 1960), South Dakota (Stanley, 1965, pl.47, figs.20-23 only), and Virginia (Frederiksen, 1979). Palynomorphs similar to *Tricolpites bathyreticulatus* from Montana (Norton and Hall, 1969, pl.7, fig.11), and *Tricolpites anguloluminosus* and *T. bathyreticulatus* from Wyoming (Leffingwell, 1970, pl.8, figs.11 and 12, respectively), were not found in the Price River Section.

Retitrescolpites sp. 1

[Plate 19, Figure 1]

Tricolpites bathyreticulatus Stanley 1965, pp.320-321, pl.47, figs.18-19 only.

DESCRIPTION: See Stanley (1965, pp.320-321).

DISCUSSION: Two specimens found are virtually identical to the holotype specimen (Stanley, 1965, pl.47, figs.18-19), and 20um in equatorial diameter. When Stanley instituted *Tricolpites bathyreticulatus*, he apparently included this type of palynomorph which does not seem to have distinct pila, along with palynomorphs assignable to *Retitrescolpites anguloluminosus*. This species tends to have wider and stouter muri and proportionally wider lumina to the grain size than those of *Retitrescolpites anguloluminosus*.

OCCURRENCE: Two specimens were recovered from the lower interval of Paleocene section (middle Paleocene age) of the North Horn Formation in this study.

Genus Rousea Srivastava 1969d

TYPE SPECIES: *Rousea subtilis* Srivastava 1969d

DISCUSSION: This form genus includes tricolpate pollen with lumina that are larger in the mesocolpia and gradationally smaller towards the margins of the colpi.

Rousea sp. 1.

[Plate 19, Figures 6-8]

Rousea sp. 1.; Jameossanaie 1987, p.26, figs.15/7-8.

DESCRIPTION: Tricolpate pollen; spherical, circular in polar view; in equatorial view, one pole is slightly extended, so the equatorial outline is as asymmetrical tear-drop-shape, somewhat like that of *Carex* pollen; colpi simple, long, extending to the poles, gaping; margo distinct; exine 1um thick, reticulate; muri irregularly polygonal, 1.5um wide in mesocolpia areas, abruptly smaller towards the colpi margins and polar areas, and turns to be scabrate; 23-27um in equatorial diameter (5 specimens measured), 23um in polar axis (1 specimen measured).

DISCUSSION: Equatorial outline and nature of the sculpture are distinct.

OCCURRENCE: Campanian of New Mexico (Jameossanaie, 1987). One sample from the Price River Formation and one sample from the Cretaceous interval of the North Horn Formation yielded two specimens each.

Rousea sp.2.

[Plate 19, Figures 2,3]

DESCRIPTION: Tricolpate pollen; oblate to spherical; amb circular; colpi long, extend 3/5 of radius in polar view; margo distinct, 1um wide, separated from the colpi margins; the margo is missing in many specimens, and show ragged colpi margins; exine 1um thick, reticulate; muri irregularly polygonal, 1-1.5um in diameter in mesocolpia areas, 0.5um in diameter near the colpi margins and polar areas; size 24-32um in diameter (6 specimens measured).

DISCUSSION: Surface pattern shows typical *Rousea*-type structure. *Platanus occidentaloides*, established by Frederiksen (1980b), and species assigned as synonymous, show a similar pattern, but the exine of this species appears to be thicker than the species described here. Specimens after losing margos show ragged colpi margins as shown in *Platanus occidentaloides*.

OCCURRENCE: Three samples from the upper interval of Paleocene strata (middle/late Paleocene age) of the North Horn Formation in this study. Very rare.

Genus Salixipollenites Srivastava 1966

TYPE SPECIES: *Salixipollenites discoloripites* (Wodehouse) Srivastava 1966

SYNONYMY AND DESCRIPTION: See Srivastava (1972a, p.272).

DISCUSSION: This genus shares an important feature with *Rousea*, that is, the lumina are reduced in size towards the colpi. *Salixipollenites* is smaller and more finely sculptured than *Rousea*.

SUGGESTED AFFINITY: *Salix*.

Salixipollenites discoloripites (Wodehouse) Srivastava 1966

[Plate 19, Figure 4,5]

Salixipollenites discoloripites (Wodehouse) Srivastava; Srivastava, 1972a, pp.272-273, pl.22, figs.17-18; pl.23, figs.1-2.

SYNONYMY AND DESCRIPTION: See Srivastava (1972a, pp.272-273).

SIZE RANGE: 12-14um in equatorial diameter (3 specimens measured).

OCCURRENCE: Paleocene of Alabama (Srivastava, 1972a). Eocene of Colorado and Utah (Wodehouse, 1933). Present in six samples; one in Castlegate Sandstone, three in Price River Formation; and two in lower interval of Paleocene rocks (middle Paleocene age) of the North Horn Formation in this study.

Genus Siberiapollis B. Tschudy 1971

TYPE SPECIES: *Siberiapollis montanensis* B. Tschudy 1971

DESCRIPTION: See B. Tschudy (1971, p.B54).

DISCUSSION: This genus can be distinguished from other similar forms by its tricolporate nature. *Proteacidites* and *Beaupreaidites* include triporate and tricolpate pollen, respectively. *Siberiapollis* has longer colpi and simpler pore structure than *Montanapollis*.

Siberiapollis montanensis B. Tschudy 1971

[Plate 19, Figure 11]

Siberiapollis montanensis B. Tschudy 1971, p.B55, figs.1-2.

DESCRIPTION: See B. Tschudy (1971, pp.B55,B57).

SIZE RANGE: 53um in equatorial diameter (1 specimen measured). 42-84um for the Montana specimens of this species originally described by B.Tschudy.

OCCURRENCE: Upper Campanian of Montana (B. Tschudy, 1971 and 1973). The range of this species has been reported as being restricted to the *Siberiapollis montanensis* lower subzone of *Aquilapollenites quadrilobus* Interval Zone by Nichols *et al*. (1982) in the western United States, which is upper Campanian in age. A single specimen was recovered from the lowermost sample (Pb14549, a dark gray shale) of the Price River Formation in this study.

Genus Simpsonipollis Srivastava 1975

TYPE SPECIES: *Simpsonipollis mullensis* (Simpson) Srivastava 1975a

SYNONYMY AND DESCRIPTION: Srivastava (1975a, p.142).

Simpsonipollis mullensis (Simpson) Srivastava 1975a

[Plate 19, Figures 9,10]

Simpsonipollis mullensis Srivastava 1975a, p.142, pl.10, figs.5-14; pl.10, figs.1-11.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Srivastava (1975a, p.142).

DISCUSSION: This species is superficially similar to *Horniella genuina* (Potonie) Frederiksen 1980a. However, the latter species has a reticulate surface as compared with striate surface on the Utah specimens.

SIZE RANGE: 25-32um X 20-22um (4 specimens measured).

OCCURRENCE: Maastrichtian of Scotland (Srivastava, 1975a) and Wyoming (Farabee and Canright, 1986). Four samples of the upper interval of Paleocene section (middle/late Paleocene age) of the North Horn Formation with up to 1.7% in this study.

Genus Smilacipites Wodehouse ex Potonie 1960

TYPE SPECIES: *Smilacipites echinatus* Wodehouse 1933

DESCRIPTION: See Wodehouse (1933, p.499).

SUGGESTED AFFINITY: *Smilax* (Liliaceae). Data combined by Frederiksen (1985) indicate that the Eocene and Oligocene records of *Smilax* (Liliaceae) "may have been represented in part by lianas".

Smilacipites echinatus Wodehouse 1933

[Plate 19, Figures 12,13]

Smilacipites echinatus Wodehouse 1933, pp.500-501, fig.27.

DESCRIPTION: See Wodehouse (1933, pp.500-501).

DISCUSSION: 22-33um in maximum diameter (4 specimens measured). Some specimens show the finely granulate surface with irregularly distributed spines.

OCCURRENCE: Eocene of Colorado and Utah (Wodehouse, 1933). Occurs randomly throughout the North Horn Formation; up to 2.0% in relative abundance.

Smilacipites herbaceoides Wodehouse 1933

[Plate 19, Figure 14]

Smilacipites herbaceoides Wodehouse 1933, p.500, fig.26.

DESCRIPTION: See Wodehouse (1933, p.500).

DISCUSSION: Wrinkled nature recorded in Eocene species was not observed in the present study, thus the grain shows a nearly circular outline.

OCCURRENCE: Eocene of Colorado and Utah (Wodehouse, 1933). One specimen was found in the lower interval of Paleocene strata (middle Paleocene age), and three specimens were found in the lowermost sample of the upper interval of Paleocene strata (middle/late Paleocene age) of the North Horn Formation in this study.

Genus Stellatopollis Doyle 1975

TYPE SPECIES: *Stellatopollis barghoornii* Doyle 1975

Stellatopollis Doyle; Doyle *et al.*1975, p.462.

Stellatopollis Doyle; Singh 1983, p.69.

DESCRIPTION: See Doyle *et al.* (1975, p.462).

Stellatopollis barghoornii Doyle 1975

[Plate 19, Figures 15,16]

Stellatopollis barghoornii Doyle; Doyle *et al.*1975, pp.462-470, pl.7, figs.1-8; pl.8, figs.1-5; pl.9, figs.1-4.

DESCRIPTION: See Doyle *et al.* (1975, pp.462-470).

DISCUSSION: Utah specimens are smaller (34-38um X 17-28um) than the Potomac specimens (36-73um in largest dimension with length:breadth ratio 1.9-1.0) originally described by Doyle *et al.* (1975). I am not aware of any record of this primitive angiospermous species having been found in the strata younger than Cenomanian. It is probable that the specimens identified in this study were recycled from older strata.

SUGGESTED AFFINITY: Uncertain.

OCCURRENCE: Middle Albian - lower Cenomanian of Potomac Group of eastern United States, and middle Albian of Oklahoma (Doyle *et al.*, 1975). Three samples, one each of the Castlegate Sandstone, Price River Formation and Cretaceous interval of North Horn Formation yielded 1, 1, and 9 specimens, respectively. Probably recycled.

Genus Stephanocolpites van der Hammen emend. Potonie 1960

TYPE SPECIES: *Stephanocolpites costatus* van der Hammen 1954

SYNONYMY: See Hedlund and Norris (1968, p.150).

DISCUSSION: Jansonius and Hills (1976, p.2698) question the validity of this genus, because the holotype of the species, *Stephanocolpites communis*, originally designated by van der Hammen, is a recent pollen grain of *Lycopus europaeus* (Labiatae).

Stephanocolpites fredericksburgensis Hedlund and Norris 1968

[Plate 19, Figures 17,18]

Stephanocolpites fredericksburgensis Hedlund and Norris 1968, p.152, pl.8, figs.1-12.

Stephanocolpites fredericksburgensis Hedlund and Norris; Wingate 1980, p.47, pl.17, fig.17.

DESCRIPTION: See Hedlund and Norris (1968, p.152).

SIZE RANGE: 19-27um in equatorial diameter (5 specimens measured).

OCCURRENCE: Albian of Oklahoma (Hedlund and Norris, 1968; Wingate, 1980). Ten specimens were found in a sample of dark gray, calcareous shale (Pb14540) from the Cretaceous interval of North Horn Formation in this study.

Genus Striatopollis Krutzsch 1959

TYPE SPECIES: *Striatopollis sarstedtensis* Krutzsch 1959

DESCRIPTION: See Krutzsch (1959b, p.142).

Striatopollis tectatus Leffingwell 1970

[Plate 20, Figures 1,2]

Striatopollis tectatus Leffingwell 1970, p.48, pl.9, figs.3-4.

DESCRIPTION: See Leffingwell (1970, p.48).

SIZE RANGE: 15-19um X 26-29um (8 specimens measured).

OCCURRENCE: Maastrichtian of Wyoming (Leffingwell, 1970; Farabee and Canright, 1986). Two samples from the Cretaceous interval of North Horn Formation yielded 2 and 13 specimens, respectively.

Striatopollis trochuensis (Srivastava) Farabee and Canright 1986

[Plate 20, Figures 3,4]

Salixipollenites trochuensis Srivastava 1966, p.529, pl.7, figs.13,15.

Rutihesperipites trochuensis (Srivastava) Srivastava 1977, pp.536-540, pl.1, figs.1-8; pl.2, figs.1-3; pl.3, figs.1-6; pl.4, figs.1-4.

Rutihesperipites trochuensis (Srivastava) Srivastava; Sweet, 1986, pl.4, fig.10.

Striatopollis trochuensis (Srivastava) Farabee and Canright 1986, pp.64-65, pl.22, fig.7.

DESCRIPTION: See Srivastava (1977, pp.536-540).

DISCUSSION: 25-26um X 19-20um (2 specimens measured). The Utah specimens are nearly identical to the specimens of this species previously reported in western North America, and falls well within the morphological variation of the species described by Srivastava (1977).

SUGGESTED AFFINITY: Srivastava (1977, p.540) noted the morphological similarity of this species to extant *Dipteronia sinensis* and *Acer rubrum*, both of which belong to the family Aceraceae.

OCCURRENCE: Maastrichtian of Wyoming (Farabee and Canright, 1986) and Alberta (Srivastava, 1966, 1977; Sweet, 1986). Occurrences of three specimens are distributed in three samples of the Paleocene interval of the North Horn Formation.

Genus Subtriporopollenites Pflug and Thomson 1953

TYPE SPECIES: *Subtriporopollenites anulatus* subsp. *anulatus* Pflug and Thomson 1953

SYNONYMY: See B. Tschudy (1973, p.31).

Subtriporopollenites alpinus (Wolf) B. Tschudy 1973

[Plate 20, Figures 5,6]

Triporopollenites alpinus Wolf 1964, pp.114-115, pl.1, figs.8-19.

Subtriporopollenites alpinus (Wolf) B. Tschudy 1973, p.31, pl.11, figs.6-8.

DESCRIPTION: See B. Tschudy (1973, p.31).

SIZE RANGE: 21-22um in equatorial diameter (5 specimens measured).

OCCURRENCE: Campanian of Montana and Germany (*fide*. B. Tschudy, 1973). Three samples from the Castlegate Sandstone and Price River Formation yielded this species up to 2.3% of the counted sums.

Genus Tiliaepollenites Potonie 1931a

TYPE SPECIES: *Tiliaepollenites indubitabilis* Potonie 1931

Tiliaepollenites Potonie 1931a, p.556.

Tiliaepollenites (Potonie) ex Potonie and Venitz 1934, p.37.

Tiliapollenites Raatz 1937, p.27.

Intratriporopollenites Pflug and Thomson; Thomson and Pflug 1953, p.70.

Tiliaepollenites (Potonie) ex Potonie and Venitz; Potonie 1960, p.120.

Intratriporopollenites Pflug and Thomson emend. Mai 1961, p.64.

DESCRIPTION: Potonie's (1960) diagnosis is as follows: "Lenticular pollen, amb circular to rounded triangular; the germinals not in the corners, but in the middle of the sides; they may protrude somewhat, vestibulum distinct, exine more or less thickened around exopore; exine on outline smooth to roughened, the columellae so arranged that in top view they produce an infrareticulate pattern in *T. instructus*, but only a chagrinate pattern in *T. indubitabilis*." (from Jansonius and Hills, 1976, p.2903).

DISCUSSION: Potonie (1931a) proposed a new genus *Tiliaepollenites*. In 1953, Thomson and Pflug established a genus *Intratriporopollenites*, and instituted *Tiliaepollenites* as its junior synonym. Some authors (Krutzsch, 1961a and Mai, 1961) considered that the holotype of the type species is a contaminant of the extant *Tilia cordata*-type pollen. Mai noted only two species, among eight species assigned to the genus *Intratriporopollenites* by Thomson and Pflug, are tiliaceous, and others are not related to the Tiliaceae. Jansonius and Hills (1976) considered *Intratriporopollenites* as a junior synonym of *Tiliaepollenites*. The present author shares this opinion. Interestingly, *Intratriporopollenites* (Thomson and Pflug) Mai 1961 illustrated by Ashraf and Stinnesbeck (1988, pl.2, fig.10) from Brazil looks identical to the extant northwest European pollen *Tilia cordata*-type pollen described and illustrated by Christensen and Blackmore (1988, pls.1-3)

SUGGESTED AFFINITY: Bombacaceae-Sterculiaceae-Tiliaceae complex (Frederiksen, 1983).

Tiliaepollenites tetraforaminipites (Wodehouse) comb. nov.

[Plate 20, Figures 7,8]

Tilia tetraforaminipites Wodehouse 1933, p.516, fig.50.

Tilia tetraforaminipites Wodehouse; Pocknall 1987, pl.1, fig.6.

DESCRIPTION: Tetra- or penta-colporate pollen, outline rounded quadrangle or rounded pentagonal to nearly circular; apertures are equatorial, not located at the corners, but in the middle of the sides, sometimes protruded, vestibulum distinct, short colpi with distinct annuli; exine 1um thick, finely foveolate over entire surface, frequently shows folded polar region.

DISCUSSION: This species may be conspecific with *Tiliaepollenites vescipites* described in this study. The only difference is in the numbers of apertures. 25-37um in equatorial diameter (8 specimens measured).

OCCURRENCE: Middle Paleocene of Wind River Basin, Wyoming (Nichols and Ott, 1978); upper Paleocene of Powder River Basin, Wyoming and Montana (Pocknall, 1987); and Eocene of Colorado and Utah (Wodehouse, 1933). Upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study. Although there are only a limited number of reports of this species, the first appearance of this species generally coincides to that of *Tiliaepollenites vescipites*.

<u>Tiliaepollenites vescipites</u> (Wodehouse) comb. nov.

[Plate 20, Figure 9]

Tilia vescipites Wodehouse 1933, p.516, fig.49.

Tilia danei Anderson 1960, p.23, pl.7, figs.10,11.

Tiliaepollenites vescipites (Wodehouse) Robertson 1975, p.164, fig.64. (*nomen nudum*) (unpublished dissertation).

Tilia vescipites Wodehouse; Nichols and Ott 1978, pl.2, fig.17.

Intratriporopollenites sp.; Pocknall, 1987, pl.1, fig.20.

DESCRIPTION: Tricolporate pollen, outline circular-triangular to nearly circular; apertures equidistant at equator, sometimes protruded, vestibulum distinct, short colpi with distinct annuli; exine 1um thick and finely foveolate over entire surface.

DISCUSSION: Position of apertures, thick annuli, and exine structure distinguish this species from other similar forms. 25-35um in equatorial diameter (10 specimens measured). Illustrations by Nichols and Ott (1978) and Pocknall (1987) seem to have more distinct annuli than the Utah specimens possibly due to the differential interference contrast (Nomarski) illumination photography of those. *Tilia danei* originally described and illustrated by Anderson (1960) seems to be identical to this species except its smaller (18-23um) size. The North Dakota specimens (Robertson, 1975) is described as reticulate with 1um lumina.

OCCURRENCE: Lowermost Paleocene of New Mexico (*Tilia danei* Anderson 1960); middle Paleocene and younger strata of Wind River Basin, Wyoming (Nichols and Ott, 1978); and Eocene of Colorado and Utah (Wodehouse, 1933), Powder River Basin, Wyoming and Montana (Pocknall, 1987), and Williston Basin (Robertson, 1975). Upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study. Occurrence of this species shows an interesting but possibly fortuitous pattern, which is lowermost Paleocene (New Mexico) - middle to upper Paleocene (Utah and central Wyoming) - Eocene (northern Wyoming, Montana, and North Dakota, here this species is the Eocene index palynomorph!). This fact may reflect the warming trend during the Paleocene and Eocene time. This species possibly belonged to a mainly tropical family of plants (Christensen and Blackmore, 1988).

Genus Tricolpites Cookson 1947 ex Couper 1953 emend. Potonie 1960

TYPE SPECIES: *Tricolpites reticulatus* Cookson 1947 ex Couper 1953

DESCRIPTION: See Potonie (1960, p.95).

DISCUSSION: Potonie's emendation of this genus was accepted in this study. Thus, only finely reticulate (lumina less than 1um in diameter) tricolpate pollen are included in this genus.

Tricolpites hians Stanley 1965

[Plate 20, Figures 10,11]

Tricolpites hians Stanley 1965, p.321, pl.47, figs.24-27.

DESCRIPTION: See Stanley (1965, p.321).

DISCUSSION: This species includes the palynomorphs which have wider muri than their lumina, so they appear superficially to be foveolate.

OCCURRENCE: Campanian - Paleocene of the United States. Campanian of New Mexico (Jameossanaie, 1987), Maastrichtian of Wyoming (Farabee and Canright, 1986), Paleocene of South Dakota (Stanley, 1965) and Texas (Elsik, 1968b). Many samples throughout entire section. Few to abundant (up to 13.0%) in Castlegate Sandstone and Price River Formation, and very rare to few (up to 3.7%) in North Horn Formation.

<u>Tricolpites</u> cf. <u>T. parvistriatus</u> Norton 1967

[Plate 20, Figures 12,13]

Tricolpites parvistriatus Norton; Norton and Hall 1967, p.105, pl.1, fig.D.

Tricolpites parvistriatus Norton;; Norton and Hall 1969, p.45,pl.7,fig.2.

Tricolpites parvistriatus Norton; Leffingwell 1970, p.44, pl.8, figs.5a-b.

DESCRIPTION: See Norton and Hall (1967, p.105).

DISCUSSION: Utah specimens have longer colpi than the previously described species. 20-21um in equatorial diameter.

OCCURRENCE: Maastrichtian of Wyoming (Leffingwell, 1970) and Montana (Norton and Hall, 1969). Two specimens were recovered from the Castlegate Sandstone, and several specimens were seen outside the counted sums of Price River Formation, and Cretaceous interval of North Horn Formation. One specimen found in the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation is probably recycled.

<u>Tricolpites psilascabratus</u> Norton 1969

[Plate 20, Figures 14,15]

Tricolpites psilascabratus Norton; Norton and Hall 1969, p.45, pl.7, fig.3.

Tricolpites psilascabratus Norton; Stone 1973, p.86, pl.18, figs.109-110.

DESCRIPTION: See Norton and Hall (1969, p.45).

DISCUSSION: This species can be differentiated from similar forms by its long straight colpi which are rarely gaping. *Tricolpites erugatus* Hedlund (1966) described from Cenomanian of Oklahoma may be conspecific. The length ranges 20-25um (7 specimens measured).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973). Maastrichtian and Paleocene of Montana (Norton and Hall, 1969; Oltz, 1969). Mostly very rare to few throughout entire section. One sample (Pb14085, a coaly shale) in the upper interval of the Paleocene section (middle/late Paleocene age) yielded 7.0% in relative abundance.

Tricolpites reticulatus Cookson 1947

[Plate 20, Figures 16,17]

Tricolpites reticulata Cookson 1947, p.134, pl.15, fig.45.

Tricolpites microreticulata Belsky, Boltenhagen and Potonie 1965, p.75, pl.12, figs.8-9.

Tricolpites reticulatus Cookson; Norton and Hall 1969, pp.43-44, pl.7, fig.1.

Gunnera microreticulata (Belsky, Boltenhagen and Potonie) Leffingwell 1970, pp.37,40, pl.6, figs.7-8.

DESCRIPTION: See Norton and Hall (1969, p.44).

DISCUSSION: Utah specimens are identical to Wyoming species described by Leffingwell (1970) under the modern generic name *Gunnera*. In the present study, *Tricolpites*, form-genus name, was accepted for this species to distinguish it from modern genus. Size ranges 23-28um (5 specimens measured).

OCCURRENCE: Very rare to few in most samples of Cretaceous interval of the study section, two samples (Pb14550 and Pb14734) yielded 11.0% and 18.0% in relative abundances, respectively. One specimen was recovered from a sample of the lower interval of Paleocene section (middle Paleocene age), and nine specimens were found in two samples of the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation. R. Tschudy and B. Tschudy (1986) reported the extension of the range of this species to the Tertiary strata in southern Rocky Mountain Region. In the present study, it is not clear whether occurrences of this species in the Paleocene interval indicates recycling or not.

SUGGESTED AFFINITY: Probably Gunneraceae. Leffingwell (1970, p.37) noted that this species is morphologically similar to modern species *Gunnera petaloidea* Gaus.

Genus Tricolpopollenites Pflug and Thomson 1953

TYPE SPECIES: Tricolpopollenites parmularius (Potonie) Pflug and Thomson 1953

Tricolpopollenites cf. T. levitas B. Tschudy 1973

[Plate 20, Figure 18]

Tricolpopollenites levitas B. Tschudy 1973, p.25, pl.9, figs.1-6.

DESCRIPTION: See B. Tschudy (1973, p.25).

DISCUSSION: Thick psilate nature and thinning of exine towards the colpi margins are characteristic of this species. The Utah specimens (29-32um in equatorial diameter, 2 specimens measured) are approximately 25-40% larger than the Montana specimens (16-24um) originally described by B. Tschudy.

OCCURRENCE: Campanian of Montana (B. Tschudy, 1973). Two samples of the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation yielded three specimens, and several specimens were seen outside the counted sums from samples of lower interval of Paleocene strata (middle Paleocene age) of the North Horn Formation.

Tricolpopollenites lilliei (Couper) comb. nov.

[Plate 20, Figures 19,20]

Tricolpites lilliei Couper 1953, p.62, pl.8, figs.116-117.

Tubifloridites lilliei (*sic.*) (Couper) Farabee and Canright 1986, p.70, pl.24, fig.15 (should read Tubulifloridites lilliei).

DESCRIPTION: See Couper (1953, p.62).

DISCUSSION: Definition of the genus *Tricolpites* instituted in the present study excludes species which are not reticulate. Farabee and Canright (1986) combined this species with *Tubulifloridites* Potonie 1960. This was not the appropriate assignment, since *Tubulifloridites* includes pollen having exine covered with densely-spaced, strong spines. Couper's original description (1953) indicates the present species includes pollen having exine covered with sparsely-spaced, granular - papillae, which does not include echinate structural elements. The present author regards the forms found in this study as being assignable to the section (a) of the rather broad genus, *Tricolpopollenites*, explained by B. Tschudy (1973, p.24). Utah specimens range 21-24um in equatorial diameter (4 spceimens measured).

OCCURRENCE: Cretaceous of New Zealand (Couper, 1953). Campanian (Stone, 1973) and Maastrichtian (Farabee and Canright, 1986) of Wyoming. Paleocene of Montana (Norton and Hall, 1969). Price River Formation and upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation in this study. Very rare to rare.

Tricolpopollenites microreticulatus Norton 1969

[Plate 20, Figures 21,22]

Tricolpopollenites microreticulatus Norton 1969, p.47, pl.7, fig.7.

DESCRIPTION: See Norton and Hall (1969, p.47).

DISCUSSION: 11-12um X 11-12um (2 specimens measured). The Utah specimens are spherical, and smaller than Montana specimens (12-13um X 11-12um).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973). Maastrichtian (Norton and Hall, 1969) and Paleocene (Oltz, 1969) of Montana. Many samples throughout the section with up to 8.0% of counting sum in this study.

__*Tricolpopollenites variofoveatus*__ (McIntyre) Elsik 1968b

[Plate 21, Figures 1,2]

Tricolpites variofoveatus McIntyre 1965, p.210, figs.19-22.

Tricolpopollenites variofoveatus (McIntyre) Elsik 1968b, p.624, pl.31, figs.5-8,10.

Tricolpopollenites cf. *T. variofoveatus* (McIntyre) Elsik; Gies 1972, pp.148-151, pl.9, figs.1-3 (unpublished dissertation).

DESCRIPTION: See McIntyre (1965, p.210).

DISCUSSION: The generic diagnosis of *Rousea* includes "reticulation wider than 1u in mesocolpia but becoming finer at apocolpia and near margins of colpi" (from Jansonius and Hills, 1976). The size of lumina in mesocolpia of the present species are approximately 1um in diameter (all the previous records as well as the present study). Although the present species shares the characteristic feature, i.e. variable size of lumina, with *Rousea*, it is retained under *Tricolpopollenites* in this study because the species has many more features comparable to the type species of *Tricolpopollenites*, *T. parmularius*, such as prolate shape and smooth or faintly punctate exine. Gies (1972) discussed extensively the comparison among his specimens and other similar specimens. A summary of his discussion is follows: his specimens (*Tricolpopollenites* cf. *T. variofoveatus*; 16-25um in equatorial diameter) bridge the gap between Oltz's species (*Tricolpites apivariatus*; 23-28um in equatorial diameter) and McIntyre's species (*Tricolpites variofoveatus;* 10-21um in equatorial diameter); his specimens have two morphological variations although difference is gradational, *viz*. specimens with psilate polar area and specimens with finely reticulate polar area. Most Utah specimens show psilate polar areas.

OCCURRENCE: Upper Cretaceous of Colorado (Gies, 1972). Paleocene of Texas (Elsik, 1968b). Paleocene and lower Eocene of New Zealand (McIntyre, 1965). Many samples throughout the section in this study. Mostly 0.3 to 2.3% in relative abundance. One sample (Pb14077) in the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation yielded 30 specimens (10.0% of the counting sum).

Tricolpopollenites sp.1.

[Plate 21, Figures 3,4]

DESCRIPTION: Tricolpate pollen; prolate to subprolate, outline in equatorial view elliptical; colpi slit-like to slightly gaping, extending almost to margins of grain, usually obscured by structural elements; exine 0.5-1um thick, covered with moderately spaced clavae, tops of clavae are not in contact with each other; typical clavae are cylindrical in the lower half, bulging and forming the sphere in the upper half, 2-3um in length, 0.6-0.7um in width at base, sphere portion of clavae approximately 1um in diameter; 24-27um in polar axis, 18-21um in equatorial axis (3 specimens measured).

DISCUSSION: The long colpi and characteristically clavate exine distinguish this species from other species in this genus. This species is similar to *Ilex* spp. described by Frederiksen (1980a, 1983). The Utah species is, however, clearly tricolpate with slit-like colpi without any pore structure. *Ilexpollenites compactus* Stone (1973) has gemmate exine.

OCCURRENCE: Price River Formation and Cretaceous interval of North Horn Formation in this study.

Tricolpopollenites sp.2

[Plate 21, Figures 5,6]

DESCRIPTION: Tricolpate pollen; prolate to subprolate, amb circular in polar view, elliptical in equatorial view; colpi straight, slitlike, long, extending almost to the pole; exine 1.5-2um thick; densely spaced baculae are arranged in a reticulate pattern which gives the pseudoreticulate to foveolate appearance, lumina 0.2um in diameter; 14.5-16um in equatorial diameter (3 specimens measured), 18um in polar axis (1 specimen measured).

OCCURRENCE: Found only outside the counted sums of the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in this study.

Genus Triporopollenites (Pflug) Pflug and Thomson 1953

TYPE SPECIES: *Triporopollenites coryloides* Pflug 1953

Triporopollenites plektosus Anderson 1960

[Plate 21, Figure 7]

Triporopollenites plektosus Anderson 1960, p.27, pl.4, fig.14; pl.8, fig.16.

Triporopollenites plektosus Anderson; Leffingwell 1970, p.51, pl.10. figs.5a-b.

DESCRIPTION: See Anderson (1960, p.27).

SIZE RANGE: 20-22um in maximum diameter (2 specimens measured).

OCCURRENCE: Late Cretaceous and Paleocene of New Mexico (Anderson, 1960) and Wyoming (Leffingwell, 1970). One specimen from the Castlegate Sandstone and six samples from the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation with up to 1.7% relative abundance in this study.

Triporopollenites sp.1.

[Plate 21, Figures 8,9]

DESCRIPTION: 3-4 porate pollen, mostly tetraporate; irregular shape due to infolding of the walls; pores circular to elliptical, 2-3um in diameter, annulate, and variously protruded outwards; exine psilate, 1-1.5um thick; 27-31um in maximum diameter (6 specimens measured).

DISCUSSION: Folding in the wall obscures the true outline and shape of specimens seen. This species is similar to *Triporopollenites bituitus* (Potonie) Elsik which includes a wide variety of morphological forms.

OCCURRENCE: Two samples from upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation yielded 1 and 26 specimens, respectively.

Genus Ulmipollenites Wolff 1934 emend.

TYPE SPECIES: *Ulmipollenites undulosus* Wolff 1934

Ulmipollenites Wolff 1934, p.75.

Ulmuspollenites Raatz 1937, p.17 (*nomina nudum*).

Ulmoidites Potonie, Thomson, and Thiergart 1950, p.57 (*nomina nudum*).

Polyporopollenites Pflug; Thomson and Pflug 1953, p.90.

Ulmoideipites Anderson 1960, p.20.

Ulmoideipites Anderson; Norton and Hall 1969, p.41.

Ulmipollenites Wolff; Norton and Hall 1969, p.41.

Ulmipollenites (Wolff) Srivastava 1969a, pp.981-982.

Ulmoideipites Anderson; Sweet 1986, pp.1386-1387.

DESCRIPTION: See Anderson (1960, p.20).

EMENDED DESCRIPTION: Pores with slight, poorly to distinctly defined annuli, each pore is circular, or longitudinally or latitudinally elongate. Surface sculpture varies from verrucate to rugulate.

DISCUSSION: Debate about genus *Ulmipollenites* has been focused on its exine sculpture. Original descriptions and illustrations of Wolff (1934, p.75) and Potonie (1960, p.131) clearly show the rugulate nature of sculpture. Anderson (1960, p.20) described three species which have "ulmoid" sculpture under the genus *Ulmoideipites*. The ulmoid or irregularly verrucate sculpture on Anderson's specimens apparently included elongate verrucae (see Anderson 1960, pl.4, figs.9-12). Simpson (1961, p.447) described two species from Scotland under the extant genus *Planera*. In one of these, *P. hebridica*, the verrucate sculpture can be seen in the illustrations (Simpson, 1961, pl.14, figs.8-9); and the rugulate sculpture ("wavy surface") of the other, *P. mullensis*, can also be identified. Bratzeva's (1965) illustration shows faintly rugulate or, at least, elongate or connected verrucae in sculpture (pl.15, figs.2-3; pl.16, fig.3). Norton and Hall (1969, p.41) considered *Ulmipollenites* to include pollen with verrucate, and verrucate to rugulate sculpture of the exine. In 1969, Srivastava emended *Ulmipollenites* to include "slightly undulate to rugulate" sculpture of the exine, and considered this genus to be a senior synonym of *Ulmoideipites* designated by Anderson. Srivastava's illustrations (1969a, fig.30; 1972, pl.25, fig.19) show verrucate to faintly rugulate ornamentation of the exine. Frederiksen (1980a and 1983) included rugulate and verrucate forms in *Ulmipollenites* (Wolff) Srivastava. Sweet(1986) validated both genera *Ulmipollenites* and *Ulmoideipites* by noting the difference of sculptures by nuances of definition, i.e. slightly undulate to rugulate, and irregularly rugulate, respectively.

In this study, elongated or connected verrucae and brevirugulae are considered to be indistinguishable, and verrucate to rugulate sculptural characteristics are rather transitional. In descriptions of species, use of `ulmoid' or `undulated' was avoided. A key for six Paleocene species based on the Utah specimens is as follows:

1.a. Arci distinct -- go to 2

b. Arci lacking or indistinct ------------------------------------ go to 3

2.a. Amb triangular to subtriangular, triporate -------------- *U. tricostatus*

b. Amb quadratic to subquadratic, tetraporate ------------- *U. hebridicus*

3.a. Pores 3 in number -- go to 4

b. Pores 4 in number -- go to 5

c. Pores 5 in number -- go to 6

4.a. Exine distinctly rugulate, >29um ------------------------ *U.* sp. 1

b. Exine verrucate to rugulate, <28um ---------------------- *U. krempii*

5.a. Exine verrucate, <28um ------------------------------------ *U. krempii*

.b. Exine brevirugulate, >29um, pores elongate ------------ *U. undulosus*

6.a. Exine verrucate -- *U. planeraeformis*

b. Exine rugulate --- *U. undulosus*

SUGGESTED AFFINITY: See Anderson (1960, p.20).

Ulmipollenites hebridicus (Simpson) comb. nov.

[Plate 21, Figure 13]

Planera hebridica Simpson 1961, p.447, pl.14, figs.8-9.

Planera hebridica Simpson; Bratzeva 1965, pl.16, figs.5-6.

Ulmoideipites herbridicus (*sic.*) (Simpson) Sweet; Jerzykiewicz and Sweet 1986 pl.4, fig.28. (*Ulmoideipites herbridicus* should read *Ulmoideipites hebridicus*)

DESCRIPTION: For description see Simpson (1961, p.447). Supplementary descriptive notes based on the specimens studied here are as follows: Quadrate in polar view, pores are located at each of the four corners, interporia straight. Pores circular, about 2um in diameter, slightly off the equator, aspidate, surrounded by a marked thickening of the exine. Arci distinct. Exine verrucate. Size ranges 19-21um (2 specimens measured).

DISCUSSION: Simpson(1961) first reported this species in Scotland under the extant generic name *Planera*. It has been transferred to the genus *Ulmoideipites* by Elsik(1968b) and Sweet(1986). Due to the revised definition mentioned earlier, this species should be transferred to the genus *Ulmipollenites*. The number of pores (4), presence of arci, and verrucate exine sculpture distinguish *Ulmipollenites hebridicus* from other related species.

OCCURRENCE: Tertiary of Scotland (Simpson, 1961), Maastrichtian of Far East (Bratzeva, 1965), and Maastrichtian and Paleocene of Alberta (Jerzykiewicz and Sweet, 1986). Throughout the North Horn Formation. Very rare to rare except in a coaly shale sample Pb14091 (6.3%).

SUGGESTED AFFINITY: Ulmaceae. Simpson(1961) noted this species is morphologically similar to the extant monotypic species *Planera aquatica* (Ulmaceae), a small tree fringing water-courses in the southeastern United States.

Ulmipollenites krempii (Anderson) Frederiksen 1979

[Plate 21, Figures 10,11]

Ulmoideipites krempi Anderson 1960, pl.4, fig.12; pl.6, figs.2-3; pl.10, fig.8.

Ulmoideipites krempi Bratzeva 1965, pl.15, figs.7-8,10-12.

Ulmoideipites krempii Anderson; Elsik 1968b, p.608, pl.17, figs.4-5 only.

Ulmipollenites spp.; Leffingwell 1970, p.36, pl.7, figs.6,9.

Ulmoideipites krempii (Anderson) Srivastava 1972a, p.280, pl.25, fig.19. (*Ulmoideipites krempii* should read *Ulmipollenites krempii*)

Ulmus-type; Elsik and Dilcher 1974, pl.29, fig.94.

Ulmus spp; Elsik 1974, pl.2, figs.41 only.

Ulmipollenites krempii (Anderson) Frederiksen 1979, p.154, pl.3, figs.6-8.

Ulmipollenites krempii (Anderson) Frederiksen; Frederiksen 1980b, p.156, pl.1, figs.39-40.

Ulmipollenites krempii (Anderson) Frederiksen 1983, p.35, pl.9, figs.9-10.

Ulmoideipites krempii Anderson; Jerzykiewicz and Sweet, 1986, pl.4, fig.29.

DESCRIPTION: See Anderson (1960, p.20). Supplementary descriptive notes based on the specimens studied here are as follows: Exine sculpture is irregularly verrucate to faintly rugulate. Outline is subcircular to quadratic, especially most tetraporate members.

DISCUSSION: This species may be distinguished from *Ulmipollenites tricostatus* and *U. hebridicus* by its lack of or only faintly developed arci. Size ranges 20-27um (10 specimens measured).

OCCURRENCE: Uppermost Cretaceous and Tertiary in many parts of the world. Many samples throughout entire section with up to 9.7% in this study.

SUGGESTED AFFINITY: Ulmaceae.

Ulmipollenites planeraeformis (Anderson) Srivastava 1969b

[Plate 21, Figure 12]

Ulmoideipites planeraeformis Anderson 1960, p.20, pl.4, fig.13.

Ulmoideipites planeraeformis Anderson; Bratzeva 1965, pl.16, figs.1,2,7 only.

Ulmoideipites krempii (Anderson) Elsik 1968b, pl.17, fig.7 only.

Ulmipollenites planeraeformis (Anderson) Srivastava 1969a, p.982, fig.30.

DESCRIPTION: See Srivastava (1969b, p.982).

DISCUSSION: Anderson's (1960, p.20) and Srivastava's (1969b, p.982) descriptions and illustrations clearly define the species as pentaporate. *Ulmipollenites hebridicus* includes tetraporate ulmaceous forms. Thus, tetraporate *Ulmipollenites* pollen grains should be excluded from *Ulmipollenites planeraeformis*, and included in *U. hebridicus*. These include Bratzeva's specimens shown in her plate 16, figures 3 and 8. The number of pores and verrucate exine sculpture distinguish this species from other similar forms. The Utah specimens are smaller (about 24um, 2 specimens measured) than those reported previously for this species.

OCCURRENCE: Upper Cretaceous and lower Tertiary of various parts of the world. The lowermost sample from the upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation and lowermost Flagstaff sample yielded a single specimen each.

SUGGESTED AFFINITY: Ulmaceae. Morphologically similar to the pollen of extant species *Planera aquatica* (Simpson, 1961, p.447).

Ulmipollenites tricostatus (Anderson) Frederiksen 1980b

[Plate 21, Figure 16]

Ulmoideipites tricostatus Anderson 1960, p.20, pl.4, figs.9-11.; pl.6, figs.4-5; pl.7,fig.8; pl.8, figs.8-9.

Planera mullensis Simpson 1961, p.447, pl.14, figs.10,11.

Planera mullensis Anderson; Bratzeva 1965, pl.15, fig.3.

Ulmoideipites tricostatus Simpson; Bratzeva 1965, pl.15, figs.1,2,6.

Ulmipollenites tricostatus (Anderson) Frederiksen 1980b, pp.156-157, pl.1, fig.41.

Ulmipollenites tricostatus (Anderson) Frederiksen 1983, p.35, pl.9, figs.11-13.

Ulmoideipites tricostatus Anderson; Jerzykiewicz and Sweet 1986, pl.4, fig.22.

DESCRIPTION: See Anderson (1960, pp.20-21). A supplementary descriptive note based on the specimens studied here is that the exine sculpture is irregularly verrucate to faintly rugulate.

DISCUSSION: This species is distinguished from other similar forms by distinct arci and triangular outline. The size of the Utah specimens range 20-27um (6 specimens measured) in size.

OCCURRENCE: Uppermost Cretaceous and Tertiary of many parts of the world. Present in most samples throughout the section in this study with up to 7.0% in relative abundance.

SUGGESTED AFFINITY: Ulmaceae.

Ulmipollenites undulosus Wolff 1934

[Plate 21, Figures 14,15]

Ulmipollenites undulosus Wolff 1934, p.75, pl.5, fig.25.

Ulmipollenites undulosus Wolff; Potonie 1960, p.131, pl.8, fig.182.

Ulmipollenites undulosus Wolff; Norton and Hall 1969, p.41, pl.5, fig.23.

Ulmipollenites verrucatus Norton; Norton and Hall 1969, pp.41-42, pl.5, fig.24.

Ulmipollenites undulosus Wolff; Frederiksen 1980a, p.35, pl.9, figs.14-15.

Ulmipollenites undulosus Wolff; Frederiksen 1983, p.157, pl.2, figs.1-3.

ADDITIONAL SYNONYMY: See Frederiksen (1980b, p.157).

DESCRIPTION: See Jansonius and Hills (1976, p.3121) for English description directly translated from Potonie (1960, p.131). Supplementary descriptive notes based on the specimens studied here are as follows: Tetraporate or pentaporate pollen, oblate to slightly oblate, amb well-rounded quadratic to almost circular. Annulated pores are longitudinally elongate, pore dimension 2um X 5um. Arci faintly developed. Surface brevirugulate. Size ranges 29-33um (4 specimens measured).

DISCUSSION: Shape of pores, well-developed annuli, and brevirugulate sculpture distinguish this species from other similar forms. Piel's (1971) *Ulmus/Zelkova* sp.1 from Oligocene British Columbia is considered to be conspecific. His specimens have more distinct rugulate sculpture.

OCCURRENCE: Lower Tertiary of many parts of the world. Found in four samples from Paleocene interval of North Horn Formation in this study with up to 1.7% in relative abundance.

SUGGESTED AFFINITY: Ulmaceae.

Ulmipollenites sp.1

[Plate 21, Figures 17,18]

Ulmus spp. ; Elsik 1974, pl.2, fig.42 only.

DESCRIPTION: Triporate pollen, oblate to slightly oblate, amb well-rounded, triangular to circular. Pores equatorial to subequatorial. Pores circular to longitudinally or latitudinally elongate, 3-4um in diameter. Arci faintly developed, not always present. Surface distinctly rugulate. Size ranges 30-34um (8 specimens measured).

DIFFERENTIAL DIAGNOSIS: Strongly convoluted triporate form is distinctive. Large size in addition to the convoluted, brain-like surface sculpture distinguish this species from *Ulmipollenites krempii.*

DISCUSSION: This species is similar to the faintly rugulate triporate members of *Ulmipollenites krempii.*

OCCURRENCE: Found in four samples of upper interval of Paleocene strata (middle/late Paleocene age) of North Horn Formation. Very rare to rare (up to 1.7%).

SUGGESTED AFFINITY: Ulmaceae.

Ulmipollenites sp.2

[Plate 21, Figures 19-21]

DESCRIPTION: 3 to 5 porate pollen; amb circular or rounded-quadranglular; pores equatorial to subequatorial, on the equatorial margin; pore round, 2um in diameter; arci present in some specimens, especially tetraporate members, 2-3um in width; surface distinctly rugulate; 14-23um in equatorial diameter (14 specimens measured).

DISCUSSION: The species described here includes specimens of wide morphological variation compared to other species recorded under the genus in the present study. Two common features among specimens of this species are the verrucate surface and small size. Stratigraphically the occurrences of this species is restricted to Cretaceous strata. This fact agrees well with Leffingwell's note on the Wyoming taxa. In his study, Maastrichtian members of *Ulmipollenites* are less than 25um in equatorial diameter, while Paleocene members are greater than 25um in equatorial diameter.

OCCURRENCE: Maastrichtian of Wyoming (Leffingwell, 1970). Restricted to the Cretaceous interval of North Horn Formation with high frequencies (up to 48.0%) in this study.

Genus Utriculites Chlonova 1969

TYPE SPECIES: *Utriculites visus* Chlonova 1969

DESCRIPTION: See Jansonius and Hills (1976, p.3144).

Utriculites cf. U. visus Chlonova 1969

[Plate 21, Figure 22]

DESCRIPTION: Same as the genus.

DISCUSSION: 24um in equatorial diameter (1 specimen measured). The wall structure of this species is distinct. The Utah spceimens show long and stout baculae in the exine. Although it does not show the foveolate - microreticulate nature of the surface, the single specimen found is very similar to *Utriculites visus*.

OCCURRENCE: Aptian - Cenomanian of Siberia (Chlonova, 1969). Early Campanian of New Mexico (Jameossanaie, 1987). Uppermost Price River Formation (Pb14733) in this study.

Genus Vitipites (Wodehouse) Potonie 1960

TYPE SPECIES: *Vitipites dubius* Wodehouse 1933

Vitis (Tourin.) L.; Stanley 1965, p.310.

DESCRIPTION: See Stanley (1965, p.310).

DISCUSSION: Potonie (1960) emended the description of this genus from tricolpate as described by Wodehouse (1933) to tricolporate.

SUGGESTED AFFINITY: Uncertain. Wodehouse (1933) recognized the morphological similarity of the type species with extant *Vitis vinifera*.

Vitipites affluens (Stanley) Farabee and Canright 1986

[Plate 21, Figure 23]

Vitis? *affluens* Stanley 1965, p.311, pl.46, figs.18-21.

DESCRIPTION: See Stanley (1965, p.311).

DISCUSSION: The Utah specimen is 18um in equatorial diameter (1 specimen measured). A margo is distinctly developed along the colpi in the Utah specimens as in those from South Dakota. Assignment of this species to the form genus *Vitipites* by Farabee and Canright seems to be appropriate, although illustrations of their specimens (pl.25, figs.12-13) show neither the presence of a margo or hexagonal outline.

OCCURRENCE: Paleocene of South Dakota (Stanley, 1965). One specimen was recovered from the Castlegate Sandstone sample (Pb14550) in this study.

Genus Wilsonipites Srivastava 1969

TYPE SPECIES: *Wilsonipites nevisensis* Srivastava 1969

DESCRIPTION: See Jansonius and Hills (1976, p.3247).

Wilsonipites cf. W. margocolpatus Muller *et al.* 1987

[Plate 21, Figure 24]

Wilsonipites margocolpatus Muller *et al.* 1987, p.49, pl.1, fig.1.

DESCRIPTION: See Muller *et al.* (1987, p.49).

DISCUSSION: The single specimen (22um in equatorial diameter) is smaller than the species described from Eocene strata of Venezuela (33um). *Tricolporopollenites* sp. E described by Jarzen (1982, pp.141-142, pl.1, figs.11-12) is very similar to this species, but different in being distinctly reticulate and with less rounded mesocolpia.

OCCURRENCE: One specimen was found outside the counted sum from the lower interval of Paleocene section (middle Paleocene age) of North Horn Formation.

Unknown pollen 1.

[Plate 21, Figure 25]

DESCRIPTION: Probably tricolpate pollen; amb rounded triangular with straight sides and truncated corners; shape of central body is obscured by densely spaced baculae; baculae very long (5um long and 1 um wide), diameter at proximal and distal ends approximately equal, tend to be less dense at polar regions; overall size 21um.

OCCURRENCE: One specimen was recovered from a sample (Pb14547) of the Price River Formation.

5. FUNGAL SPORES

Monocellate fungal spore 1.

[Plate 22, Figure 1]

DESCRIPTION: Monocellate, elongate-oval outline, aporate, psilate; size 21um X 11um.

Monocellate fungal spore 2.

[Plate 22, Figure 2]

DESCRIPTION: Monocellate, ovoid, monoporate, pore simple to protruding or annulate, 1.5um in diameter, psilate; size 15um X 11um.

Monocellate fungal spore 3.

[Plate 22, Figure 3]

DESCRIPTION: Monocellate, elongate-oval outline, monoporate, pore simple, 1um in diameter, scabrate to baculate; size 15um X 6um.

Monocellate fungal spore 4.

[Plate 22, Figure 4]

DESCRIPTION: Monocellate, nearly circular in outline, monoporate, pore modified to compound pore chamber, 1.5um in diameter, psilate; size 23um X 19um.

Monocellate fungal spore 5.

[Plate 22, Figure 5]

DESCRIPTION: Monocellate, tapered oval outline, monoporate, pore modified to compound pore chamber, 1um in diameter, psilate; size 16um X 8um.

Monocellate fungal spore 6.

[Plate 22, Figure 7]

DESCRIPTION: Monocellate, bag-like or kidney-shape, monoporate, pore modified to compound pore chamber, 3um in diameter, psilate; 41um in size.

Monocellate fungal spore 7.

[Plate 22, Figure 8]

DESCRIPTION: Monocellate, round, monoporate, pore annulate, 2um in diameter, psilate; size 19um.

Dicellate fungal spore 1.

[Plate 22, Figure 9]

DESCRIPTION: Dicellate, aporate, pointed extremities, psilate; size 31um X 13um.

Dicellate fungal spore 2.

[Plate 22, Figure 10]

DESCRIPTION: Dicellate, aporate, rounded extremities; size 25um X 15um.

Dicellate fungal spore 3.

[Plate 22, Figure 6]

DESCRIPTION: Dicellate, elongate-oval in outline, diporate, pores modified to pore chamber, 2um in diameter; size 23um X 11um.

Dicellate fungal spore 4.

[Plate 22, Figure 11]

DESCRIPTION: Dicellate, elongate-oval with pore end rounded, opposite and narrowly rounded, monoporate, pore modified to complex pore chamber, 5um in diameter; size 28um X 15um.

Multicellate fungal spore 1.

[Plate 22, Figure 12]

DESCRIPTION: Tricellate, diporate, pore simple, 0.5um in diameter, psilate; size 19um X 8um.

Multicellate fungal spore 2.

[Plate 22, Figure 13]

DESCRIPTION: Tricellate, cells nearly circular in single file, diporate, pores small annulate, pores are located in the first cell, one proximally, the other laterally, septa open in the opposite directions; 40um in overall size.

Multicellate fungal spore 3.

[Plate 22, Figure 14]

DESCRIPTION: Tricellate, cells cuneate, monoporate, pore modified to compound chamber, 5um in diameter, psilate; size 35um X 20um.

Multicellate fungal spore 4.

[Plate 22, Figures 15,19]

DESCRIPTION: Composed of three or more cells, monoporate, psilate. In some specimens, pore is extended and chambered as shown in pl.27, fig.16.

Multicellate fungal spore 5.

[Plate 22, Figure 16]

DESCRIPTION: Seven cells with six septa, monoporate, pore annulate, distal end is sharply pointed; 45um in overall length.

Multicellate fungal spore 6.

[Plate 22, Figure 20]

DESCRIPTION: Fragment of psilate multicellate fungal spore.

Multicellate fungal spore 7.

[Plate 22, Figure 21]

DESCRIPTION: Fragment of branching psilate multicellate fungal spore.

Muriform fungal spore 1.

[Plate 22, Figures 17,18]

DESCRIPTION: Both longitudinal and transverse septa are dividing nine cells, monoporate, pore annulate, 6um in diameter; size 28um X 13um.

Spirally coiled fungal spore 1.

[Plate 22, Figure 22]

Spirally coiled fungal spore 2.

[Plate 22, Figure 23]

Unknown fungal spore 1.

[Plate 22, Figure 24]

DESCRIPTION: Bottle-shape with ovoid pore, probably monocellate, monoporate.

Fungal scar.

[Plate 23, Figure 1]

Hyphae.

[Plate 23, Figure 2,3]

Genus Peronosporites Smith 1877

TYPE SPECIES: *Peronosporites antiquarius* Smith 1877

DESCRIPTION: Combined description by Jansonius and Hills (1978, p.3494) is as follow: "Mycelia and zoosporangia (or oogonia) found within the vascular axis of

Lepidodendron; mycelium septate (thereby corresponding to the extant *Peronospora*, and differing from *Pythium*); oogonia contain 7 or 8 zoospores, similar in size and appearance to those of *Peronospora infestans* (extant potato fungus) (i.e. about 35u diameter, the zoospores contained in them about 16 X 12u, as measured from the illustration)."

Peronosporites sp.

[Plate 23, Figures 4,5]

Peronosporites sp.; Singh 1983, pp.52-53, pl.9, figs.7-8.

DESCRIPTION: See Singh (1983, pp.52-53).

OCCURRENCE: Most specimens were recovered from a non-palyniferous sample (Pb14748) within the lower Paleocene interval (middle Paleocene in age) of North Horn Formation. Other samples yielded this species include Pb14742 (Cretaceous interval of North Horn Formation) and Pb14172 (non-palyniferous sample within the sample interval as Pb14748).

6. ALGAE

DIVISION CHLOROPHYTA

Genus Botryococcus Kutzing 1849

TYPE SPECIES: *Botryococcus braunii* Kutzing 1849

DISCUSSION: Traverse (1988, p.6) notes that all *Botryococcus* colonies belong to *B. braunii* Kutzing.

SUGGESTED AFFINITY: This natural taxon belongs to the family Botryococcaceae.

Botryococcus sp.

[Plate 23, Figure 6]

DESCRIPTION: See Norton and Hall (1969, p.11).

DISCUSSION: Most specimens from the Price Canyon samples are of small size (colony 50-60um)

OCCURRENCE: This extant taxon has an ancestry back to Ordovician if Traverse's concept is accepted. Forms similar to the present species have been widely reported in Upper Cretaceous to lower Tertiary strata of western North America. The occurrence is sporadic throughout the section in this study.

Genus Ovoidites Potonie 1951 ex Krutzsch 1959 emend. Potonie 1966

TYPE SPECIES: *Ovoidites ligneolus* Potonie 1951 ex Krutzsch 1959

Ovoidites (Potonie) emend Potonie 1966, pp.201-202, pl.15, fig.219.

ADDITIONAL SYNONYMY: See Stanley (1965, p.315).

DISCUSSION: There is no clear distinction and there is actually some overlap between this genus and *Schizosporis* Cookson and Dettmann. In the present study, however, these two are treated as separate genera.

SUGGESTED AFFINITY: Spores of the freshwater alga *Spirogyra* (Zygnemataceae). See Van Geel (1979) and Van Geel and Van der Hammen (1978) for details.

Ovoidites ligneolus (Potonie) Thomson and Pflug 1953

[Plate 23, Figure 7]

SYNONYMY AND DESCRIPTION: See Stanley (1965, p.316).

DISCUSSION: Overall length ranges 57-82um (5 specimens measured).

OCCURRENCE: Throughout the North Horn Formation in this study with up to 11.0% (Pb14738) in relative abundance.

Genus Pediastrum Meyer 1829

TYPE SPECIES: *Pediastrum simplex* Meyer 1829

SYNONYMY AND DESCRIPTION: See Stanley (1965, pp.234-235).

SUGGESTED AFFINITY: This natural taxon belongs to the family Hydrodictyaceae in the green algae.

Pediastrum paleogeneites Wilson and Hoffmeister 1953

[Plate 23, Figure 9]

Pediastrum paleogeneites Wilson and Hoffmeister 1953, p.756, pl.1, figs.7-8.

DESCRIPTION: See Wilson and Hoffmeister (1953, p.756).

size range: 60-100um in diameter of coenobia (5 specimens measured).

OCCURRENCE: Upper Campanian of Wyoming (Stone, 1973). Maastrichtian - Danian of California (Drugg, 1967). This species occurs sporadically throughout the Late Cretaceous and Paleocene section in this study.

Genus Schizosporis Cookson and Dettmann 1959

TYPE SPECIES: *Schizosporis reticulatus* Cookson and Dettmann 1959

DESCRIPTION: See Cookson and Dettmann (1959, p.213).

SUGGESTED AFFINITY: Zygnemataceae. Possibly spores of the freshwater alga *Spirogyra*

Schizosporis parvus Cookson and Dettmann 1959

[Plate 23, Figure 8]

Schizosporis parvus Cookson and Dettmann, 1959, p.216, pl.1, figs.15-20.

ADDITIONAL SYNONYMY: See Frederiksen (1983, p.86).

DESCRIPTION: See Cookson and Dettmann (1959, p.216).

SIZE RANGE: 40-72um X 18-32um (12 specimens measured).

OCCURRENCE: One specimen was found in uppermost sample (Pb14738) of Upper Cretaceous section, and many samples of Paleocene section yielded this species with up to 28.7% of the counting sum in this study.

Unknown alga 1.

[Plate 24, Figure 1]

DESCRIPTION: Body pentagonal, sides straight and of different lengths; large circular opening present in one face, sometimes opening has an outwardly folded lip; body size 28-51um, circular opening 20-31um in maximum diameter (6 specimens measured).

DISCUSSION: This simple form looks like the theca shed from a dinoflagellate at time of exit of the cyst. Tentatively this form is described under the category, green alage, in the present study.

OCCURRENCE: Six specimens were included in the counted sum of the uppermost sample (Pb14738) from the Cretaceous interval of North Horn Formation. Several specimens were found outside the counted sums from the same interval (Pb14737) and two samples of lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Unknown alga 2.

[Plate 24, Figure 2]

DESCRIPTION: Central body circular, covered with membrane; membrane thin, rugulate-striate in sculpture; in some specimens membrane wedged, giving the appearance of antapical horns of a dinoflagellate cyst; central body 28-30um, total 34-36um in maximum diameter (2 specimens measured).

DISCUSSION: No real characteristic of dinoflagellate was observed. This form is considered to be a fresh-water alga in this study.

OCCURRENCE: Five specimens were recovered from one sample (Pb14086) of the upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation.

DIVISION CHRYSOPHYTA - DIATOMS

Genus Actinoptychus

Actinoptychus senarius (Ehrenberg) Ehrenberg 1843

[Plate 24, Figure 3]

Actinoptychus senarius (Ehrenberg) Ehrenberg; Whiting and Schrader 1985, p.251, pl.1, figs.15-16.

ADDITIONAL SYNONYMY AND DESCRIPTION: See Whiting and Schrader (1985, p.251).

SIZE: Single specimen found is 39um in diameter.

OCCURRENCE: Price River Formation in this study.

Genus Actinocyclus

cf. Actinocyclus sp.

[Plate 24, Figure 4]

SIZE: 22um in diameter.

OCCURRENCE: Lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation in this study.

Genus Coscinodiscus

cf. Coscinodiscus nodulifer Schmidt

[Plate 24, Figure 5]

SIZE: 34um in diameter.

OCCURRENCE: Cretaceous interval of North Horn Formation in this study.

Genus Thalassiosira

cf. Thalassiosira sp.

[Plate 24, Figure 6]

SIZE: 45um in diameter.

DISCUSSION: Habib (1969) encountered similar forms in his study of middle Cretaceous of a deep-sea core (Palynomorph type A, pl.4, figs.8a-b).

OCCURRENCE: Upper interval of Paleocene section (middle/late Paleocene age) of North Horn Formation in this study.

DIVISION CHRYSOPHYTA - SILICOFLAGELLATES

Genus Distephanus Stohr 1880

TYPE SPECIES: *Distephanus speculum* (Ehrenberg) Stohr

(BASYONYM: *Dictyocha speculum* Ehrenberg 1839)

DESCRIPTION: See Glezer (1970, p.278).

Distephanus crux (Ehrenberg) Hack

[Plate 24, Figures 7,8]

Distephanus crux (Ehrenberg) Hack; Glezer (1970, pp.279-281), pl.18, figs.1-11; pl.19, figs.1-6.

DESCRIPTION: See Glezer (1970, p.279).

SIZE RANGE: Basal ring 27um in diameter, 34um in length; shorter horns 6um long, longer horns 15um long; apical ring 11um in diameter. (based on 1 specimen found)

DISCUSSION: This species has been reported only from marine strata of Pacific and Atlantic Coasts. The present author is puzzled by the occurrence of the single specimen of exclusively marine species which has been reported only from the younger strata than the study section. Another mystery is how this specimen could go through the standard palynological sample process which includes 24 hours of hydrofloric acid treatment. Following are possible answers for the above questions. To survive through the chemical treatment:

(1a) This specimen was covered by organic material which is resistant to the acids, and freed from it during the other treatments.

(1b) It was contaminated between the HF process and slide preparation.

To be found in the present study:

(2a) This species was euryhaline so that some members of it could exist in the freshwater inland lake during the North Horn time. For this assumption to be possible, the stratigraphic range of this species should extend back to late Paleocene.

(2b) This species was precipitated in the bottom sediment of the Late Cretaceous epicontinental sea, and later recycled to the younger sediments.

(2c) This specimen might have been carried from the Pacific Coast strata by more than one medium (implying the food chain) through several steps. Media include fish, birds, and other animals.

Although the single specimen is statistically meaningless, the presence of it has caught the attention and curiosity of the author. The author favors possibilities (1a) and (2a) to explain this puzzling phenomenon.

OCCURRENCE: Late Eocene to present of various parts of the world (see Glezer 1970 for detail). Occurrences in the United States are follows: Miocene of California, middle Miocene of Maryland, Neogene of California. Holocene of Atlantic Ocean (tropical zone, coasts of South America, San Matias Gulf). (*fide* Glezer, 1970) Single specimen was found in the upper interval of Paleocene section (middle/late Paleocene age) interval of North Horn Formation in this study.

DIVISION PYRRHOPHYTA - DINOFLAGELLATES

cf. Deflandrea microgranulata Stanley 1965

[Plate 24, Figure 9]

OCCURRENCE: Two specimens were found outside the counted sums from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

cf. Deflandrea sp.

[Plate 24, Figure 10]

OCCURRENCE: One specimen was found outside the counted sum from the Castlegate Sandstone.

Dinogymnium sp.

[Plate 24, Figure 11]

OCCURRENCE: One specimen was found outside the counted sum from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Palaeohystrichophora infusoriodes Deflandre 1934

[Plate 24, Figure 12]

DISCUSSION: Several specimens possibly related to this species were poorly preserved and most of the hair-like processes appear to have been lost.

OCCURRENCE: One specimen found outside the counted sum from the sample Pb14213 of the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation is regarded as being recycled from the older strata.

Unidentified dinoflagellate 1.

[Plate 25, Figure 1]

OCCURRENCE: Two specimens were found outside the counted sums from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Unidentified dinoflagellate 2.

[Plate 25, Figure 2]

OCCURRENCE: One specimen was found on a slide outside the counted sum from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Unidentified dinoflagellate 3.

[Plate 25, Figure 3]

OCCURRENCE: One specimen was found on a slide outside the counted sum from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

Unidentified dinoflagellate 4.

[Plate 25, Figure 4]

OCCURRENCE: One specimen was found on a slide outside the counted sum from the lower interval of Paleocene strata (middle Paleocene age) of North Horn Formation.

7. GROUP ACRITARCHA

SUBGROUP ACANTHOMORPHITAE

Genus Baltisphaeridium Eisenack 1958 emend. Eisenack 1969

TYPE SPECIES: *Baltisphaeridium longispinosum* (Eisenack) Eisenack 1958

SYNONYMY AND DESCRIPTION: See Singh (1964, p.139).

Baltisphaeridium multispinosum Singh 1964

[Plate 25, Figure 5]

Baltisphaeridium multispinosum Singh 1964, pp.141-142, pl.20, figs.1-2.

DESCRIPTION: See Singh (1964, p.141).

SIZE RANGE: 44-46um in maximum diameter of the central body. Processes approximately 10um in length (3 specimens measured).

OCCURRENCE: Middle Albian of Alberta (Singh, 1964). Lowermost Price River Formation in this study.

Baltisphaeridium sp.

[Plate 25, Figure 6]

OCCURRENCE: Several specimens were found outside the counted sum of Price River Formation sample (Pb14545).

Genus Micrhystridium Deflandre emend. Downie and Sarjeant 1963

TYPE SPECIES: *Micrhystridium inconspicuum* (Deflandre) Deflandre 1937

DESCRIPTION: See Downie and Sarjeant (1963, p.92).

Micrhystridium fragile Deflandre 1947

[Plate 25, Figure 8]

Micrhystridium fragile Deflandre; Singh 1971, pp.398-399, pl.74, fig.1.

ADDITIONAL synonymy and description: See Singh (1971, pp.398-399).

SIZE RANGE: 16um in maximum diameter of central body (1 specimen measured).

OCCURRENCE: Jurassic - Oligocene from the various parts of the world. Price River Formation in this study.

Micrhystridium inconspicuum (Deflandre) Deflandre 1937

[Plate 25, Figure 9]

Micrhystridium inconspicuum (Deflandre) Deflandre; Stover 1973, pp.59-60, pl.9, fig.38.

ADDITIONAL SYNONYMY: See Stover (1973, p.59).

SIZE RANGE: 12um in maximum diameter of the central body (1 specimen measured).

OCCURRENCE: Middle Jurassic - Campanian (see Stover, 1973). Price River Formation in this study.

Micrhystridium piliferum Deflandre 1937

[Plate 25, Figure 10]

Micrhystridium piliferum Deflandre; Stover 1973, p.60, pl.9, fig.39.

ADDITIONAL SYNONYMY: See Stover (1973, p.60).

DESCRIPTION: See Stanley (1965, p.233).

SIZE RANGE: 24um in maximum diameter of the central body (1 specimen measured).

OCCURRENCE: Cretaceous - Paleocene. Campanian of Wyoming (Stover, 1973). Paleocene of South Dakota (Stanley, 1965). Middle Paleocene(?) interval of North Horn Formation in this study.

SUBGROUP NETROMORPHITAE

Genus Leiofusa Eisenack 1938

TYPE SPECIES: *Leiofusa fusiformis* (Eisenack) Eisenack 1938

DESCRIPTION: See Norris and Sarjeant (1965, p.35).

Leiofusa jurassica Cookson and Eisenack 1958

[Plate 25, Figure 7]

Leiofusa jurassica Cookson and Eisenack 1958, p.51, pl.10, figs.3-4.

Leiofusa jurassica Cookson and Eisenack; Singh 1971, p.414, pl.75, figs.17-18.

DESCRIPTION: See Singh (1971, p.414).

SIZE RANGE: 34-39um in total length, 21-22um in length of the body, 16-17um in breadth of the body, 1.3 in the ratio of body length to breadth, 5-10um in length of the spine (2 specimens measured).

OCCURRENCE: Permian - Oligocene of various parts of the world. Price River Formation in this study.

SUBGROUP PTEROMORPHITAE

Genus Pterospermopsis Wetzel 1952

TYPE SPECIES: *Pterospermopsis danica* Wetzel 1952

DESCRIPTION: See Norris and Sarjeant (1965, p.52).

Pterospermopsis cf. P. eurypteris Cookson and Eisenack 1958

[Plate 25, Figure 12]

Pterospermopsis eurypteris Cookson and Eisenack 1958, p.49, pl.9, figs.9,13.

Pterospermopsis eurypteris Cookson and Eisenack; Singh 1971, p.421, pl.78, figs.1-3.

DESCRIPTION: See Singh (1971, p.421).

DISCUSSION: Utah species is significantly smaller than the previously recorded ones. 32-37um in total diameter, 17-19um in diameter of the central body (3 specimens measured).

OCCURRENCE: Barremian - Albian in the previous records.

Pterospermopsis sp.1

[Plate 25, Figure 13]

DESCRIPTION: Central body circular, sparsely covered with processes distributed all over the surface; processes unbranched, 1um in diameter, hollow, mostly same diameter throughout the length; processes connected by thin membrane, and show the reticulate pattern; reticulum polygonal, 2-3um in diameter; size of the central body 18-22um, processes 4-5um long (4 specimens measured).

OCCURRENCE: Castlegate Sandstone, upper Price River Formation, and the Cretaceous interval of North Horn Formation. Very rare to few.

cf. Polysphaeridium sp.

[Plate 25, Figure 11]

OCCURRENCE: Several specimens were found on a slide outside the counted sum of Price River Formation sample (Pb14732).

V. DISCUSSION OF STRATIGRAPHIC SIGNIFICANCE OF PALYNOLOGICAL DATA

In the interval comprised of the Castlegate Sandstone, Price River Formation and North Horn Formation at Price Canyon, three important floristic changes occur on the basis of the pollen and spores. These make it possible to divide the interval into four informal palynomorph assemblage zones. The assemblages characteristic of each zone are designated K1, K2, T1, and T2, from oldest to youngest. Ranges of characteristic palynomorph taxa for each zone are illustrated in Figure 9.

1. ASSEMBLAGE K1

The K1 assemblage zone in this study represents Castlegate Sandstone and Price River Formation. Taxa restricted to this zone in the Price Canyon samples are *Subtriporopollenites alpinus*, *Myrtipites* spp., *Cupuliferoideapollenites* sp. 1, *Eucommiidites couperi*, and *Biretisporites* spp. *Subtriporopollenites alpinus* occurs in three samples with 0.3 to 2.3 percent of the counted sums. *Myrtipites* spp., dominated by *M. laqueaeformis*, occur rather consistently throughout the zone with 0.3 to 3.7 percent of the total count. *Cupuliferoideapollenites* sp. 1 is present in the lowermost sample of the Price River Formation and disappears in the upper part of this zone. Relative frequencies range 0.3 to 2.0 percent of the total counts. *Eucommiidites couperi* occurs consistently throughout the zone with low relative abundances. *Biretisporites* spp. are restricted to this zone also. However, *Biretisporites* spp. are long-ranging spores, and are not considered to be significant stratigraphically.

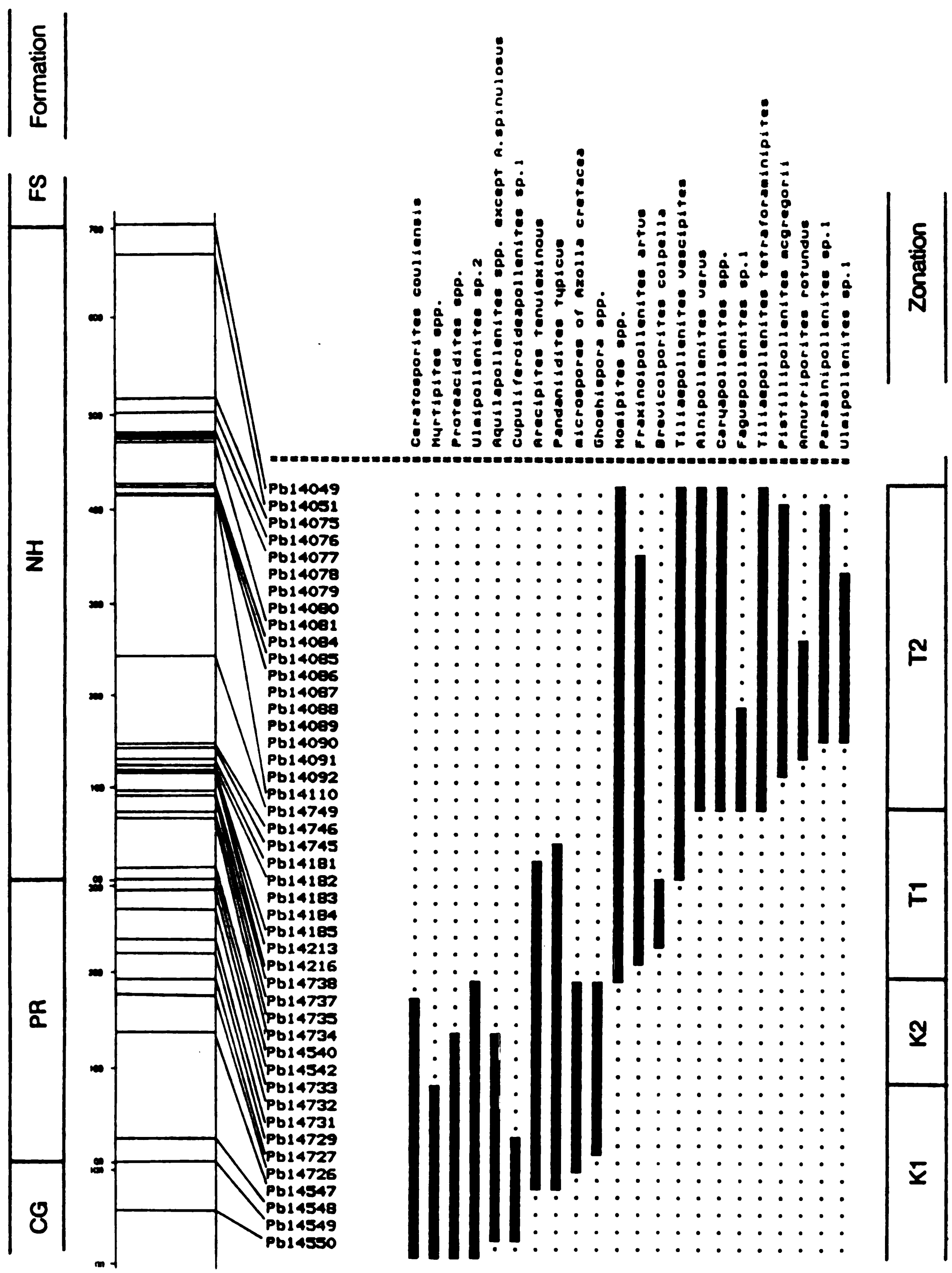

Figure 9. Ranges of characteristic palynomorph taxa for each zone. CG: Castlegate Sandstone, PR: Price River Formation, NH: North Horn Formation, and FS: lowermost stratum of Flagstaff Member of Green River Formation.

Proteacidites spp. are the most important elements of this assemblage. They occur in all samples in this zone with 1.7 to 11.7 percent of the counted sums. The only occurrence of these taxa above this zone is two specimens in one sample in the middle of the assemblage zone K2. *Cupuliferoideapollenites parvulus* has similar pattern of occurrences. It is present in most samples of this zone and constitutes 0.3 to 10.0 percent of the counted sums. The only occurrence above this zone is two specimens in one sample of the assemblage zone K2. *Ceratosporites couliensis* has a similar pattern of occurrence to that of *Cupuliferoideapollenites parvulus*. It occurs in most samples in this zone (0.3 to 2.3% of the total counts) and one sample (Pb14737; 1.0% relative frequency) from the zone K2. *Aquilapollenites* spp. except *A. spinulosus* are present in this zone with up to 1.7 percent relative frequency, and disappear in the middle of zone K2.

All samples of this assemblage zone yielded 5.0 to 35.0 percent of *Taxodiaceaepollenites hiatus* (average 13.8%), whereas samples of the assemblage zone K2 yielded low frequencies (0.7 to 1.7% of the total count) of this species. This fact indicates that the controlling factor was probably some type of environmental change, local or regional.

2. ASSEMBLAGE K2

This assemblage is characterized by the relatively high frequencies of *Ulmipollenites* and *Alnipollenites* spp. *Ulmipollenites* spp. occur in all samples. These taxa appear in the assemblage zone K1 and show scattered occurrences in that zone. In the assemblage zone K2, *Ulmipollenites* and *Alnipollenites* increase in abundance up to 48.7 percent and 8.3 percent of the counted sums, respectively. *Ulmipollenites* sp. 2 is an especially characteristic species of this zone. It is present in low frequencies in two samples of the Castlegate Sandstone and the Price River

Formation. In the assemblage zone K2, *Ulmipollenites* sp. 2 makes up as much as 48.0 percent of relative abundance (average 8.8%) of the counted sums. Microspores of *Azolla cretacea*, a floating water fern, appear in the middle of the assemblage zone K1 and become an important member of the assemblage K2 zone with increasing abundance until they disappear from recording levels at the top of the zone. Conversely, *Ghoshispora* spp., representing a fern of unidentified affinity, appear in the middle of the assemblage zone K1, and decrease in abundance through the assemblage zone K2 to the top of the zone. *Erdtmanipollis procumbentiformis* appears in this zone and is also present in the succeeding zone, although scattered and in low relative frequency, when present.

Presence or absence of these characteristic taxa, used to establish assemblage K2 may have been dependant on environmental or habitat changes that altered vegetation patterns. These may have been local (edaphic) or regional (climate, rainfall, etc.). Such factors could account for the floral changes indicated by the palynomorphs and, thus, this zonation may be useful only in the central Utah locale, and not applicable or directly correlative to the other basins. However, these taxa, along with palynomorphs characteristic of the assemblage zone K1, may be used to differentiate the Cretaceous strata into two zones for further discussion in age and environment which produced the flora.

3. ASSEMBLAGE T1

This assemblage is characterized by the appearances of *Momipites* spp. and *Fraxinoipollenites artus*, and the disappearances of *Pandaniidites typicus* and *Arecipites tenuiexinous* in the later part of this zone, and of *Confertisulcites gracilis*, and *Cyathidites* sp.1. The range of *Brevicolporites colpella* is confined to this Paleocene zone. *Momipites* spp., stratigraphically useful taxa in early Tertiary strata in western North America, are comprised of *M.actinus, M.anellus, M.inaequalis, M.leffingwellii, M.ventifluminis, M.waltmanensis*, and *M.wyomingensis* in this study. Some authors would assign to *Maceopolipollenites* the four species with sculptured polar region (*Momipites actinus, M.anellus, M.leffingwellii* and *M.ventifluminis*).

All *Momipites* species except *M.actinus* and *M.inaequalis*, which have very rare occurrences, are present from the lowermost sample of this zone. This fact prevents the present author from subdividing the zone on the basis of *Momipites* pollen zonation established in Wyoming (Nichols and Ott, 1978), and applied in Alberta (Demchuk, 1987). All samples in the zone yielded *Momipites* species with 1.0 to 13.0 percent of the counted sums except one sample (Pb14213), which shows 36.0 percent of the counted sum.

Another Paleocene pollen, *Fraxinoipollenites artus*, appears in this zone. Although this species was present in only two samples, with 0.3 and 2.3 percent of the counted sums, the occurrences are sporadic compared to the rather consistent occurrences in the later T2 zone.

The stratigraphic range of *Brevicolporites colpella* is restricted to three samples of the lower coal in this zone. In one sample (Pb14184), this species accounted for 31.0 percent of the counted sum. This is surely some relationship of this to the coal swamp.

Pandaniidites typicus that appeared in the Price River Formation interval of the K1 assemblage zone, disappears near the top of the T1 assemblage zone. Whereas specimens from samples of the K1 - K2 assemblage zone show folded and distorted conditions, specimens found in samples of T1 assemblage zone show excellent conditions of preservation. In assemblage zone T1, most samples contained 2.0 to 3.0 percent *Pandaniidites typicus* of the counted sums. This may indicate a specific difference in *Pandaniidites* of the K1 - K2 zone and of the T1 zone.

Several other species present in three or more samples (30.0% of the samples) disappeared in this zone. They include *Cyathidites* sp.1, *Confertisulcites gracilis*, and *Arecipites tenuiexinous*. These three palynomorphs show similar occurrences and abundances to those of *Pandaniidites typicus* as discussed above.

4. ASSEMBLAGE T2

This assemblage is characterized by the appearances and dominance of *Caryapollenites* spp. and *Pistillipollenites macgregorii*.

Caryapollenites spp., comprised of *C. imparalis, C. inelegans, C. veripites, C. wodehousei*, and *C.* sp. 1, are important elements in this zone. They appear at the lowermost stratigraphic level of the T2 assemblage zone and occur consistently in samples taken throughout the zone. Most samples show abundances of 2.0 to 4.0 percent of the total count. However, three samples show 18.0, 23.0, and 28.3 percentages of relative frequencies.

Pistillipollenites macgregorii appears near the base of this zone and occurs consistently throughout the zone with abundances of 5.0 to 16.0 percent. In two samples, this species contributes more than 30.0 percent of the relative frequencies of all palynomorphs.

Other important plants of the T2 zone include species of *Tiliaepollenites*. *Tiliaepollenites tetraforaminipites* appears at the base of this zone and occurs throughout the zone with 1.0 to 6.0 percent of the counted sums. In one sample (Pb14092), it attains 29.3 percent relative frequency. Another species of the genus, *Tiliaepollenites vescipites*, appears in the T1 assemblage zone, and is present consistently throughout the T2 assemblage zone with up to 19.0 percent of relative frequency.

The range of *Faguspollenites* sp.1 is restricted to the lower interval of this zone, and disappears at the Ford Creek Coal stratum (Pb14088).

Alnipollenites verus appears at the base of this zone and occurs consistently in the samples throughout the zone in low abundances (up to 1.0% of the counting sum).

5. QUANTITATIVE ANALYSIS OF ZONATION

The four assemblage zones established in the present study are easily recognizable in qualitative examinations. The palynological assemblages were also analyzed quantitatively to determine, more precisely, the magnitude of the floral changes.

The relations among samples can be evaluated statistically by cluster analysis, Q-mode factor analysis, and the principal component scores. For the purpose of clear and simple illustration, cluster analysis which produces a dendrogram was chosen in this study to interpret the relationship among samples as well as among different species. Unweighted pair-group method using arithmetic averages was applied for the clustering procedures. Distance coefficient matrix was calculated with the samples as the variables (see p.32 for more information).

For the palynological analysis, raw counting data were used and only species occurring in five and more samples were included. Figure 9 shows the result of this analysis.

At the 30.0 coefficient level (squared Euclidean distance), three clusters were differentiated. This grouping coincides with zonation established in a qualitative way except only one sample. Pb14084, being located in the middle of assemblage zone T2, was clustered with samples of assemblage zone T1. Absence of *Caryapollenites* spp., *Pistillipollenites macgregorii*, and *Tiliaepollenites*

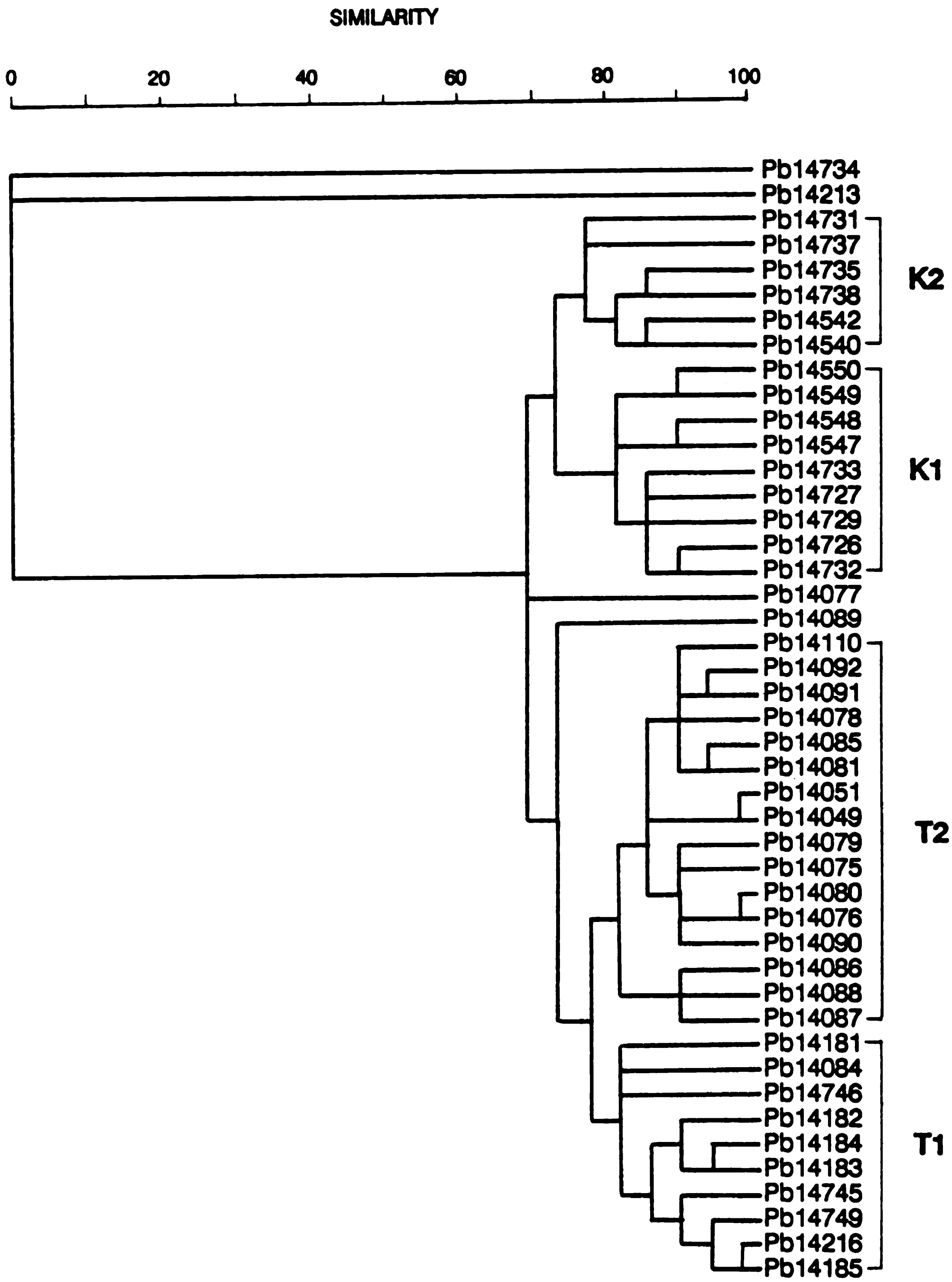

Figure 10. Dendrogram illustrating four clusters of samples.

tetraforaminipites caused by possible ecological contral is considered to account for this result.

VI. AGES OF THE PALYNOLOGICAL ASSEMBLAGES

1. CRETACEOUS

Myrtipites laqueaeformis (*al. Sporopollis laqueaeformis*), which is a characteristic element of the assemblage zone K1, has previous records only in Campanian strata in northwestern Colorado (Newman, 1965; *Sporopollis laqueaeformis*) and Wyoming (Stone, 1973; *Sporopollis* cf. *S. laqueaeformis*). The lowermost stratum of the Price River Formation in the present study (Pb14549) contained a single specimen of *Siberiapollis montanensis* which is stratigraphically restricted to the upper Campanian in the Rocky Mountain Region. *Subtriporopollenites alpinus*, a characteristic K1 assemblage taxon in this section, has been previously recorded only in Campanian strata of Montana (B. Tschudy, 1973). Although the quantitative comparison of the palynomorphs from the assemblage zone K1 and other palynological studies was not conducted, this assemblage shows very similar composition of palynomorphs to that of Stone's (Upper Campanian of Wyoming) and Lohrengel's (Upper Cretaceous of Utah). These results imply Campanian age for the assemblage K1 in the present study.

As discussed earlier briefly and will be discussed in the following chapter, the floral change between the assemblage K1 and K2 are considered to be the result of an ecological shift, probably from one habitat (or environment) to another on a coastal plain. High relative frequencies of *Ulmipollenites* sp. 2 identify the characteristic palynomorph in the K2 assemblage. This species is considered to represent an element plant of the Cretaceous assemblage in the type Lance area, Wyoming (Leffingwell, 1970; *Ulmipollenites* <25u). Collectively species of *Ulmipollenites* do not seem to have frequent occurrences in the strata younger than Maastrichtian. *Ulmipollenites* has not been recorded in palynological studies of the

Campanian or other Upper Cretaceous strata, *viz.* Lohrengel (1970, Utah), Jameossanniae (1987, New Mexico), Clarke (1963, New Mexico) and May (1972, Price River Formation, Utah). Upper Campanian strata in the vicinity of the northeast portion of the Rock Springs uplift of Wyoming (Stone, 1973) contained *Ulmipollenites* throughout the section with low relative frequencies (up to 4%), a condition similar to that found in the Price River Formation in the present study. Abundant occurrences of *Ulmipollenites* spp. and the presence of other palynomorphs characteristic of the latest Cretaceous strata indicate the assemblage K2 in the present study is probably Maastrichtian in age.

Figure 11 shows the four generalized patterns of extinction and survival of angiosperm pollen across the Cretaceous - Tertiary boundary in the Western Interior as interpreted by R. Tschudy and B. Tschudy (1986). Points that should be noted in this illustration include: taxa included in patterns B and C are not present or show very low abundances in the present study, implying late Maastrichtian and early Paleocene strata are not present. Taxa included in pattern D show an increase in numbers through the Campanian - Maastrichtian boundary. Two of the taxa included in this pattern, *viz. Ulmipollenites* spp. and *Alnipollenites* spp., are used to distinguish the assemblage zones K1 (upper Campanian) and K2 (lower Maastrichtian) in the present study along with other stratigraphically significant palynomorphs.

On the basis of these considerations, the assemblage zone K1, representing Castlegate Sandstone and Price River Formation in the Price Canyon Section, is considered to be Campanian in age. The Cretaceous interval of the North Horn Formation is considered to be early Maastrichtian in age. Upper Maastrichtian strata were apparently either never deposited or removed by erosion here as they are not present in the Price Canyon Section.

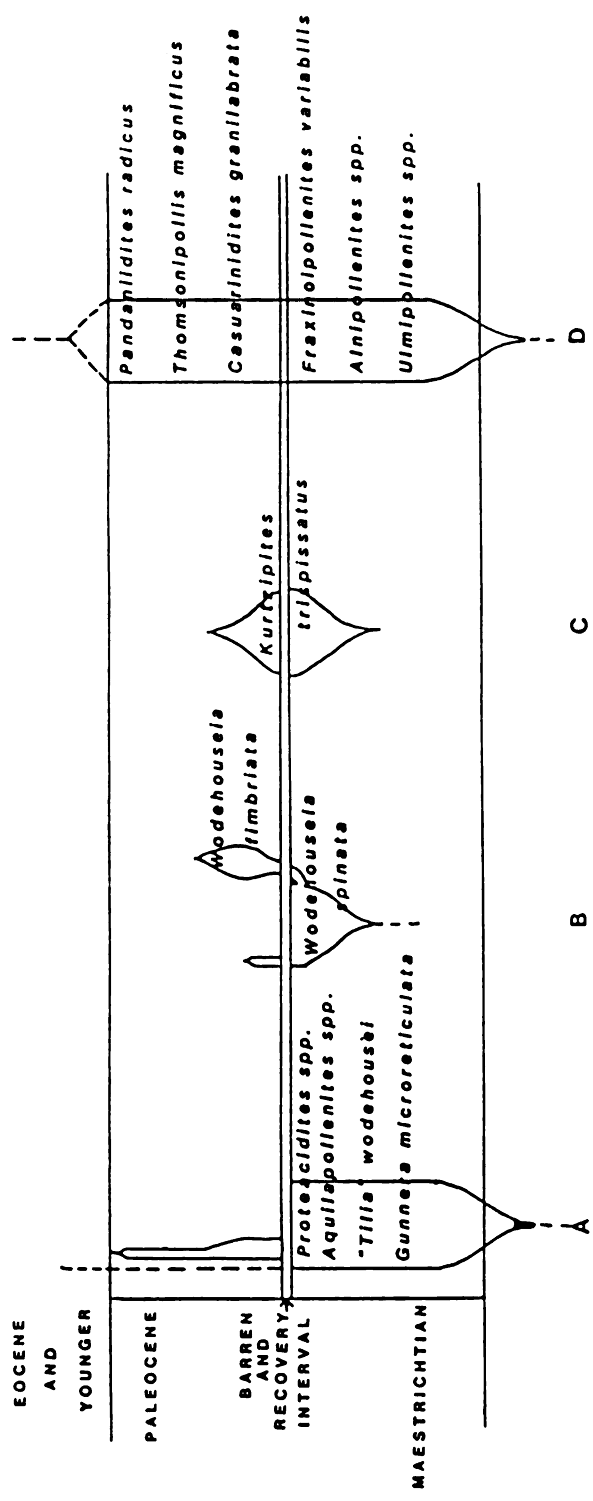

Figure 11. Patterns of extinction and survival across Cretaceous - Tertiary boundary, Western Interior (from R. Tschudy and B. Tschudy, 1986).

These results generally coincide with the data accumulated by Fouch *et al.* (1983) on the basis of marine molluscs and dinoflagellates, and nonmarine spores, pollen, molluscs, and calcareous microfossils (ostracodes and charophytes). In their study, Castlegate Sandstone and Price River Formation in Utah represent 79 to 74 Ma and 74 to 73 Ma, respectively, both of which comprise the upper Campanian age. Although the time span represented by the Castlegate Sandstone seems rather long (5 million years as compared to one million years for the Price River Formation), one sample (Pb14550) collected in the middle of the Castlegate Sandstone unit, does not show significant differences of the palynoflora from samples of the lower part of the Price River Formation.

2. PALEOCENE

The Paleocene interval of the North Horn Formation is characterized by the presence of diverse juglandaceous pollen, mostly *Momipites* and *Caryapollenites*. However, the paucity of productive samples and poor preservation of these pollen, except in coal samples make difficult the appropriate identification to species level. Therefore, effective application of the Paleocene zonation of Nichols and Ott (1978) on the basis of these taxa, which has proved to be highly useful elsewhere in basins of western North America was mitigated. In the present study, a significant number of specimens could be identified only to the generic level.

The pre-P1 zone represented by the absence of *Momipites* and the presence of other Tertiary taxa such as *Wodehouseia* (Jacobson and Nichols, 1982, p.736) and the lowermost zone (P1) of Nichols and Ott, which is characterized by the unique presence of *Momipites leffingwellii*, among the *Momipites* - *Caryapollenites* group, are not recognized in the present study. No *Wodehouseia* pollen were found in this study.

The P2 zone of Nichols and Ott was delineated by the occurrence of *Momipites waltmanensis* and *M. wyomingensis* along with *M. leffingwellii*, and absence of *Caryapollenites* or *Tilia* pollen. Their P3 zone is characterized by the initial appearances of *Momipites actinus* and *M. anellus*, and the presence of *Caryapollenites prodromus*, *Aquilapollenites spinulosus*, *Tilia vescipites*, and *T. tetraforaminipites*. The T1 assemblage zone of the present study is characterized by the appearances of *Momipites leffingwellii*, *M. waltmanensis*, *M. wyomingensis*, *M. anellus*, and *M. ventifluminis*. *Momipites ventifluminis* appears near the middle of Nichols and Ott's zone P3, as applied to the Utah-Wyoming thrust belt by Jacobson and Nichols (1982). The T1 assemblage zone of the present study does not show the presence of *Caryapollenites* and *Tiliaepollenites*. The presence of *Momipites anellus* and *M. ventifluminis*, in the lowermost sample of the T1 assemblage (Pb14216) of the present study may indicate that this assemblage zone does not include P2 zone of Nichols and Ott. However, the presence of *Momipites ventifluminis* and *M. anellus* may be less significant stratigraphically by their presence, than the absence of the very important and widespread *Caryapollenites* and *Tilia*-type pollen which are absent from the P2 zone of Nichols and Ott, but present and important in their P3 zone, and also absent in the T1 zone of this study. The P2 zone and possibly lower portion of P3 zone of the Nichols and Ott's zone may not be present in the North Horn Formation, as exposed in the Price Canyon Section, but the first appearance of *Momipites ventifluminis* and *M. anellus* may be earlier in the Price Canyon area of Utah, possibly because of warmer climate, and thus not as significant here in characterizing the P2 zone.

Aquilapollenites spinulosus, which is a characteristic palynomorph in zone P3 of Nichols and Ott and the *Aquilapollenites spinulosus* Zone of Pocknall (1987), are present in the lower part of the assemblage zone T2 with low abundance in the present study. Zone P4 of Nichols and Ott is characterized by the increased number of *Caryapollenites*, with new appearances of *C. wodehousei* and *C. imparalis* as illustrated by Jacobson and Nichols. *Pistillipollenites macgregorii* and *Insulapollenites rugulatus* appear in zone P5 of Nichols and Ott. In the present study, *Caryapollenites* spp., *Tiliaepollenites* spp., and *Pistillipollenites macgregorii* appear in the Ford Creek Coal samples, which are the lowermost strata of the assemblage zone T2 and overly thick intervening sandstone. The pattern of palynomorph ranges, along with the succession of lithologic units, implies probable existence of a hiatus between the assemblage zone T1 and T2. Ranges of *Momipites* spp. along with other taxa show the assemblage zone T1 in the present study is within the zone P3 of Nichols and Ott. A probable hiatus, if it is present here, is equivalent to the latest P3 zone and early part of the P4 of Nichols and Ott.

In the application of Nichols and Ott's Paleocene zonation in Utah and Wyoming, Jacobson and Nichols indicated the appearances of *Caryapollenites veripites* and *C. inelegans* to be at the base of zone P5. In the present study, these taxa occur in the upper five samples of the assemblage zone P2. In the study of Jacobson and Nichols, *Juglans-Pterocarya* type pollen characterizes zone P6 and *Platycarya platycaryoides* appears in zone E of Nichols and Ott. Those taxa were not found in the lowermost stratum of Flagstaff Member of the Green River Formation, the youngest sample analyzed here. Representation of the assemblage zones T1 and T2 and comparison with the zonation of Nichols and Ott (1978) is illustrated in Figure 12.

Pocknall's (1987) *Aquilapollenites spinulosus* zone may be equivalent to part of the time represented by the hiatus between the assemblage T1 and T2 in the present study. The only traces of this pollen were recovered from two samples of the Ford Creek Coal; this might be near the end of the range of this species. The *Pistillipollenites macgregorii* Subzone of *Caryapollenites* Assemblage Zone established by Pocknall, at least the lower part of it, may be equivalent to the

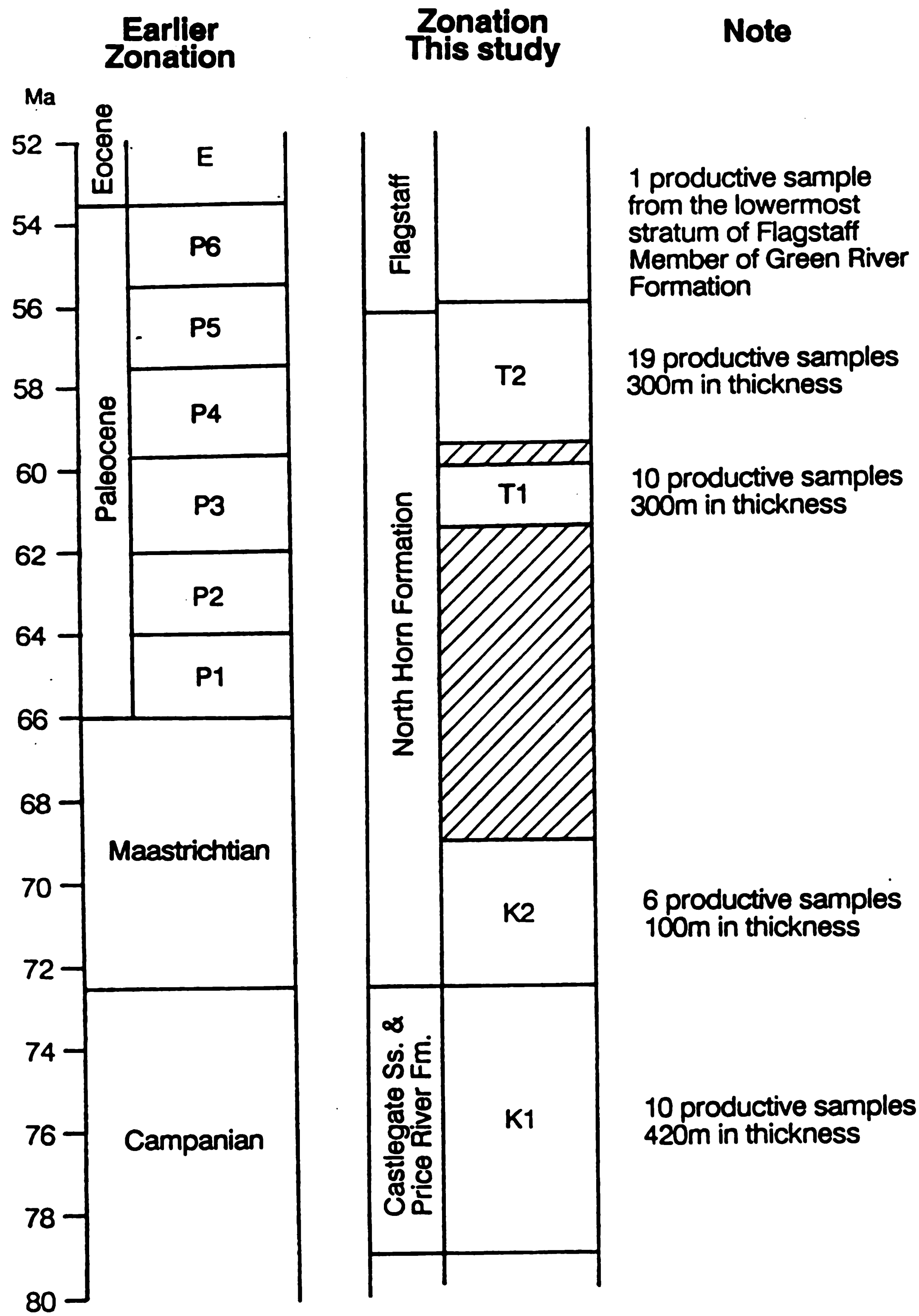

Figure 12. Age correlation of zonation established in this study to zonations of previous studies. Absolute ages of the first column are from Fouch *et al.* (1983) and Jacobson and Nichols (1982).

assemblage zone T2 of the present study. The pollen *Insulapollenites rugulatus*, reported in the basins of western North America, represents a stratigraphic range similar to that of *Pistillipollenites macgregorii* (Leffingwell, 1970; Nichols and Ott, 1978; Pocknall, 1987; and Demchuk, 1987). *Insulapollenites rugulatus* was not found in this study. This could be a control of paleoclimate during this time span, or difference in ecological niche utilized by each flora.

In the type Lance area, Lance Creek, Wyoming (Leffingwell, 1970), one Cretaceous zone (Assemblage A) and two Paleocene zones (Assemblage B and Assemblage C) were proposed. Assemblage A is approximately equivalent to the assemblage T2 in the present study, although Leffingwell's zone includes younger strata (upper Maastrichtian) which are not present in Price Canyon Section. Assemblage B of Leffingwell's is considered not to be present in the present study. Assemblage zone T1 and T2 in the Price Canyon Section are generally correlative with Assemblage C, on the basis of juglandaceous pollen biostratigraphy.

Zones established in this study can be almost directly compared with Newman's palynomorph zonation (1974). Assemblage zone K1 and K2 in the present study belong to his zone K. Assemblage zone T1 in this study is equivalent to Newman's zone P-2 which represents strata above the missing zone P-1. Assemblage zone T2 in the present study comprise the lower portion of his zone P-3 which is the latest zone in Paleocene.

In conclusion, assemblage zone T1 represents the P3 zone of Nichols and Ott excluding either lowermost or uppermost part of this (61.5 to 60 Ma). Following a hiatus probably representing the uppermost part of P3 zone and lowermost P4 zone of Nichols and Ott, the T2 assemblage zone starts at the lower P4 zone of Nichols and Ott. The upper limit of this zone does not extend to the base of the P6 zone, but includes some part of P5 zone of Nichols and Ott (59.5 to 56 Ma). Figure 12 summarizes the ages of four zones established here.

VII. CONSIDERATION OF RECYCLED PALYNOMORPHS AND THEIR POSSIBLE SIGNIFICANCE IN INTERPRETING TECTONIC EVENTS

The reworking of the sediment particles ia a major mechanism of the sedimentary processes. Fossils can be recycled and redeposited with remains of indigenous plants and animals. Pollen and spores, which have similar size range to that of silt, have a resistant organic wall that can be recycled and found well-preserved in younger strata. Recycled palynomorphs may be easily confused with those produced by plants contemporary to the time of deposition and interpreted as members of the indigenous assemblage, especially where they were derived from plants of only slightly older age.

Stratigraphically reworked palynomorphs have been reported from many lithologic units. Cross (1988) reported that up to 17 percent of the total palynomorphs present in some samples of the bottom sediments, 50km south of the north end of Gulf of California, were recycled from Cretaceous strata exposed on the Colorado Plateau, some 700km distance from the depositional site. At 350km south of the north end of the Gulf, this diminished to 5 percent. One can expect high percentages of recycled palynomorphs in a depositional basin which has an active inlet, such as a large river with high kinetic energy, able to carry large amounts of sediment containing palynomorphs, often for great distances, from their source rock units.

As mentioned earlier, recycled palynomorphs can easily be mistaken for elements of the indigenous assemblage in a rock stratum, and when distinction between an indigenous and an exotic (recycled) palynomorphs fails, this often results in extending the range of the earlier fossil taxon to the time of the indigenous components of the flora. Such errors have often been made in palynology and other branches of micropaleontology.

Some probable recycled palynomorphs are present in the strata of the Price Canyon Section. These do not show any significant differences in preservational condition from indigenous taxa. Criteria used here to distinguish recycled fossils from indigenous fossils are: fossils recovered are known to have only an older stratigraphic range or generally occur in older strata with very few exceptions; taxa known to have earlier ranges occur randomly, generally in very low abundance. Palynomorphs which satisfied both of above criteria were cautiously considered as possible recycled pollen. Gymnospermous pollen, many being long-ranging, were excluded from the list of possible recycled palynomorphs. Two gymnosperm pollen, *Eucommiidites couperi* and *Corollina*, have been considered to be easily recycled, but in this study, patterns of occurrences of these two taxa do not show adequate evidence of being reworked, and similar age strata in adjacent basins have yielded these pollen. It is difficult, if not impossible, to detect these types of recycled fossils. Palynomorphs considered to be recycled in this study are illustrated in Figure 13 with their generally accepted stratigraphic ranges. Among these, "unknown spore 1" has similar, if not the same, morphology as the central body of *Callialasporites trilobatus* which occurs in Jurassic and Lower Cretaceous strata. The pattern of distribution and abundance of this pollen, however, precludes the possibility of it being attributed to *Callialasporites trilobatus*, and it is excluded from the consideration of recycled palynomorphs.

The author hesitates to differentiate these probably recycled palynomorphs from the assemblage since there is no, and possibly there will never be, confident evidence of recycling for the taxa encountered here. In the present study, such probable recycled taxa with low abundance were treated as a differently from the indigenous flora and excluded from quantitative analyses.

Among the angiosperm records, *Clavatipollenites hughesii* and *Stellatopollis barghoornii* are considered to have been reworked from older strata. No other angiospermous pollen were recognized as probably recycled. It is possible that some recycled pollen from the earlier part of the Upper Cretaceous strata, mostly tricolpate, were not differentiated but included in indigenous taxa.

Patterns and timing of synorogenic sedimentation in Upper Cretaceous rocks of central and northeast Utah are discussed extensively in Fouch *et al.*(1983).

> "This period of tectonism was called the early Laramide orogeny by Spieker (1949). The thrust faulting(?) and folding coincides with thrusting along the Meade-Crawford thrust sheets in western Wyoming and north-central Utah (Royse and others, 1975) and its tectonic extensions in central Utah. The thrust-fold episode resulted in the cannibalistic erosion of previously formed Cretaceous and other Mesozoic and Paleozoic rocks whose detritus was spread in a sheetlike depositional complex extending from the west side of the plateau to western Colorado.... This sheetlike complex of quartzose sandstones makes up the Castlegate Sandstone and coeval stratigraphic units exposed in the Book Cliffs and in the subsurface of the eastern part of the Uinta Basin.... At its type exposures in Price Canyon, the Castlegate Sandstone is composed of fluvial braided-channel deposits....... In late Campanian time (approximately 73-74 Ma in this interpretation), renewed orogenic activity in the western part of the report area resulted in a new period of cannibalistic erosion of folded and faulted rocks and contemporaneous sedimentation.... Conglomerate and pebbly fluvial lithic sandstones of the Price River Formation in and west of the Wasatch Plateau grade eastward to lithic pebbly, fluvial units of the Price River Formation at its type area in Price Canyon....... Initiation of lacustrine deposition in Maestrichtian time began a period of similar styles of nonmarine sedimentation that continued into late Eocene or later time.... Nonmarine rocks formed through this period of time in Utah eventually onlapped the uplifted and eroded Campanian units of the Mesaverde Group primarily by late Paleocene and/or early Eocene time...."
> (From Fouch *et al.*, 1983).

Figure 13 indicates more occurrences of probable recycled palynomorphs in the Castlegate Sandstone and Price River Formation compared to all of the North Horn Formation. The different environments that produced these two sequences, fluvial and lacustrine, respectively, may explain the cause of this condition. As mentioned earlier, the more active headland erosion and seaward transport in a

Figure 13. Previously known ranges and occurrences in the Price Canyon Section of probably recycled palynomorphs. The lower box represents the previous records, and the upper box represents the stratigraphic distributions in the study section. Explanations of numbers are as follows.

1. *Undulatisporites pflugii*
2. *Cibotiumspora jurienensis*
3. *Todisporites minor*
4. Unknown spore 1
5. *Concavisporites parkinii*
6. *Dictyosporites speciosus*
7. *Undulatisporites undulapolus*
8. *Concavissimisporites michinus*
9. *Cirratriradites teter*
10. *Cibotiumspora juncta* (record in North America)
    10a. (record in Scotland)
11. *Polycingulatisporites reduncus* (record in North America)
    11a. (record in Pakistan and Denmark)
    11b. (record in California)
    11c. (record in U.S.S.R.)
12. *Densoisporites velatus* (record in North America)
    12a. (record in England)
    12b. (record in Germany)
    12c. (record in Australia)
    12d. (record in U.S.S.R.)

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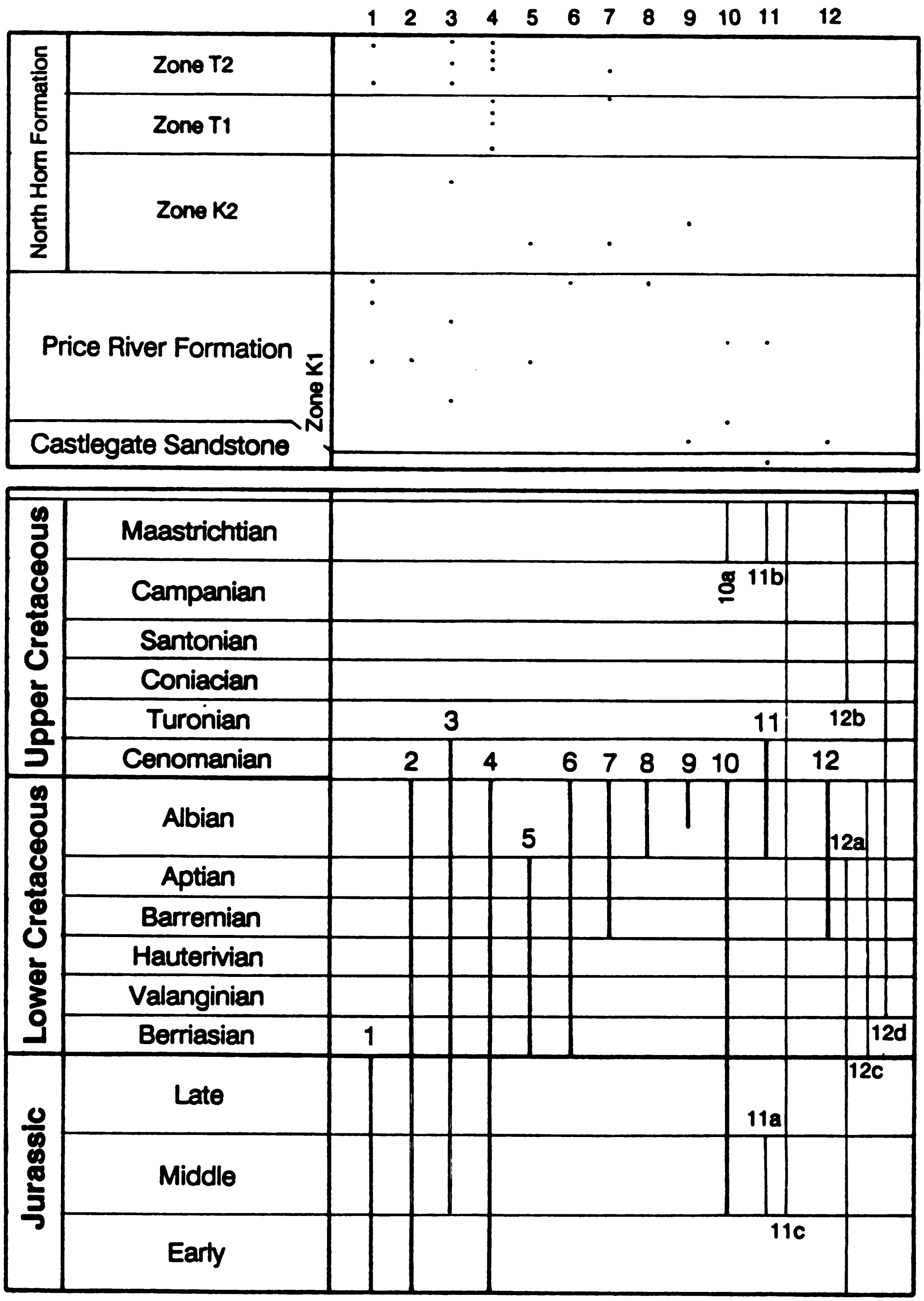

fluvial environment is likely to result in great sediment accumulation and with it, large amounts of recycled material may be redeposited along with the indigenous sediments.

The author mentioned the following in the first chapter of this study:

> "The identifiable spatial and temporal relationships in the distribution of the reworked palynomorphs indicate episodic rise and continuous denudation of the mesocordilleran highlands to the west. The concomitant deposition of reworked palynomorphs with indigenous floras provides evidence for the rate and time of erosion of the headlands which were the source of the sediments. As the headward-cutting streams dissected older and older rocks, the successively older palynomorphs freed from those rocks were transported and re-deposited with successively younger indigenous pollen and spores."

In this study, the presence of successively older reworked palynomorphs upward through the section were not noted. In fact, the upper interval of the study section yielded very few palynomorphs for which there was sufficient evidence available to consider them to be recycled. The majority of probably recycled palynomorphs in strata of the Price Canyon Section were found in the earlier fluvial members of the section. The recycled palynomorph assemblage may contain palynomorphs that were recycled more than once.

VIII. PALEOECOLOGY

1. INTRODUCTION

In the study of paleoecology of early Tertiary or older palynomorph assemblages, there are several obstacles to be considered as noted in Frederiksen (1985, p.5). First, many of Late Cretaceous and early Tertiary palynomorphs encountered in the present study have unknown or uncertain, sometimes debatable, botanical affinities with modern taxa. Second, even direct ancesters of modern plants may have occupied different ecological niches or may have had different ranges of ecological tolerance. Another aspect to be considered is allochthonous palynomorphs. This problem is more evident in non-coal samples. Palynoflora derived from non-coal swamp communities, such as on flood plains or deltas (lake margins and seas), may contain significant representation by taxa from floras outside the depositional site. Such exotic taxa are transported by wind and/or water (mostly rivers) for short distances or even up to several hundred miles.

With this perspective in mind, the possible depositional environments of the parent plants that produced the spores and pollen found in this study will be discussed quantitatively as well as qualitatively. The result of cluster analysis based on the presence/absence of palynomorphs that occur in five or more samples in this study is illustrated in Figure 14 (see p.31 for the statistical procedure).

2. STATISTICAL GROUPING

GROUP I

Group I includes a relatively large number of taxa.

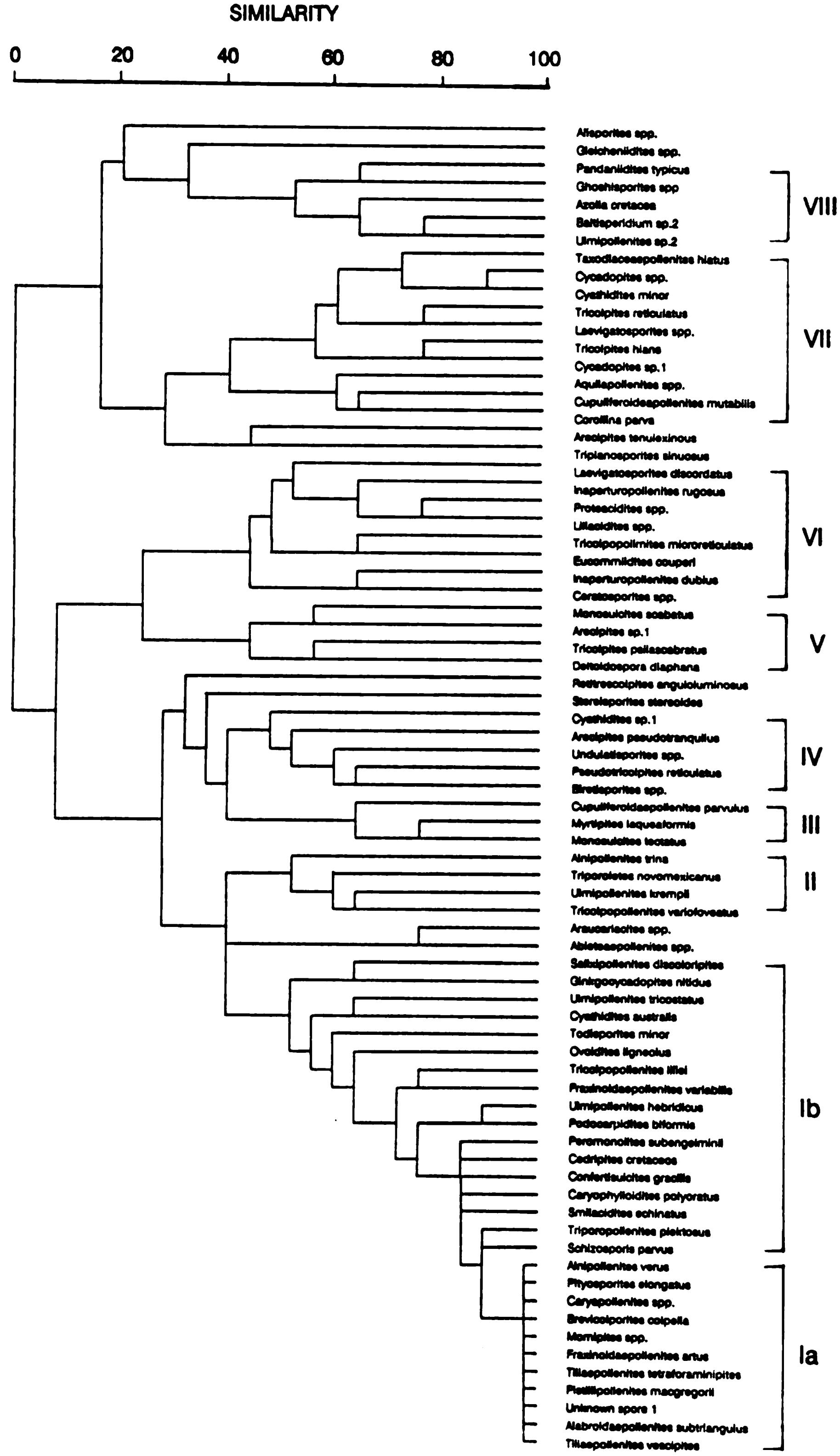

Figure 14. Dendrogram showing the result of cluster analysis of species presence/absence data.

Subgroup Ia

This subgroup contains mostly angiosperm pollen showing the highest degrees of similarity in occurrence. Among these, are *Tiliaepollenites* spp., *Momipites* spp., *Caryapollenites* spp. and *Pistillipollenites macgregorii* which are present throughout the upper part of the Price Canyon Section (Figure 15). *Momipites* and *Caryapollenites* have botanical affinities with modern genera *Engelhardia* and *Carya*, respectively. *Tiliaepollenites*, the form genus that includes *T. vescipites* and *T. tetraforaminipites*, is probably not related to extant genus *Tilia*. *Alnipollenites verus* is probably related to *Alnus*, a modern genus. *Pistillipollenites macgregorii* probably belongs to the Gentianaceae (Rouse, 1962; Rouse and Srivastava, 1970; and Crepet and Daghlian, 1981). *Engelhardia*, probably related to an extant subtropical-tropical montane plant, is considered by Frederiksen (1985) to have lived in lowland peat swamps during the early Tertiary. He also noted that some arboreal genera such as *Acer, Carya*, and *Engelhardia*, occasionally attributed by some to moist lowland environments, are as likely also to have lived in the uplands, especially along streams and lakes. Traverse (1955), in his study of Brandon lignite (Oligocene) of Vermont, noted the dominance of *Engelhardia*, *Carya*, and Ulmaceae pollen types in the lignitic sand. He interpreted these palynomorphs as having been derived from outside the peat swamp. Pflug (1957) considered *Momipites*, a major component of claystones associated with some brown coals of Germany (upper Eocene and upper Oligocene), to have come from the lake bank vegetation. He interpreted that the clay accumulated at least partly on the lake bottoms (*fide*. Frederiksen, 1985). *Alnus* is also thought to have had a lake and river margin habitat.

In the study of Eocene Green River Formation of Colorado and Utah, MacGinitie (1969), interpreted the presence of pollen taxa that had no record of their parent plants amongst the associated macrofossils, as being transported from

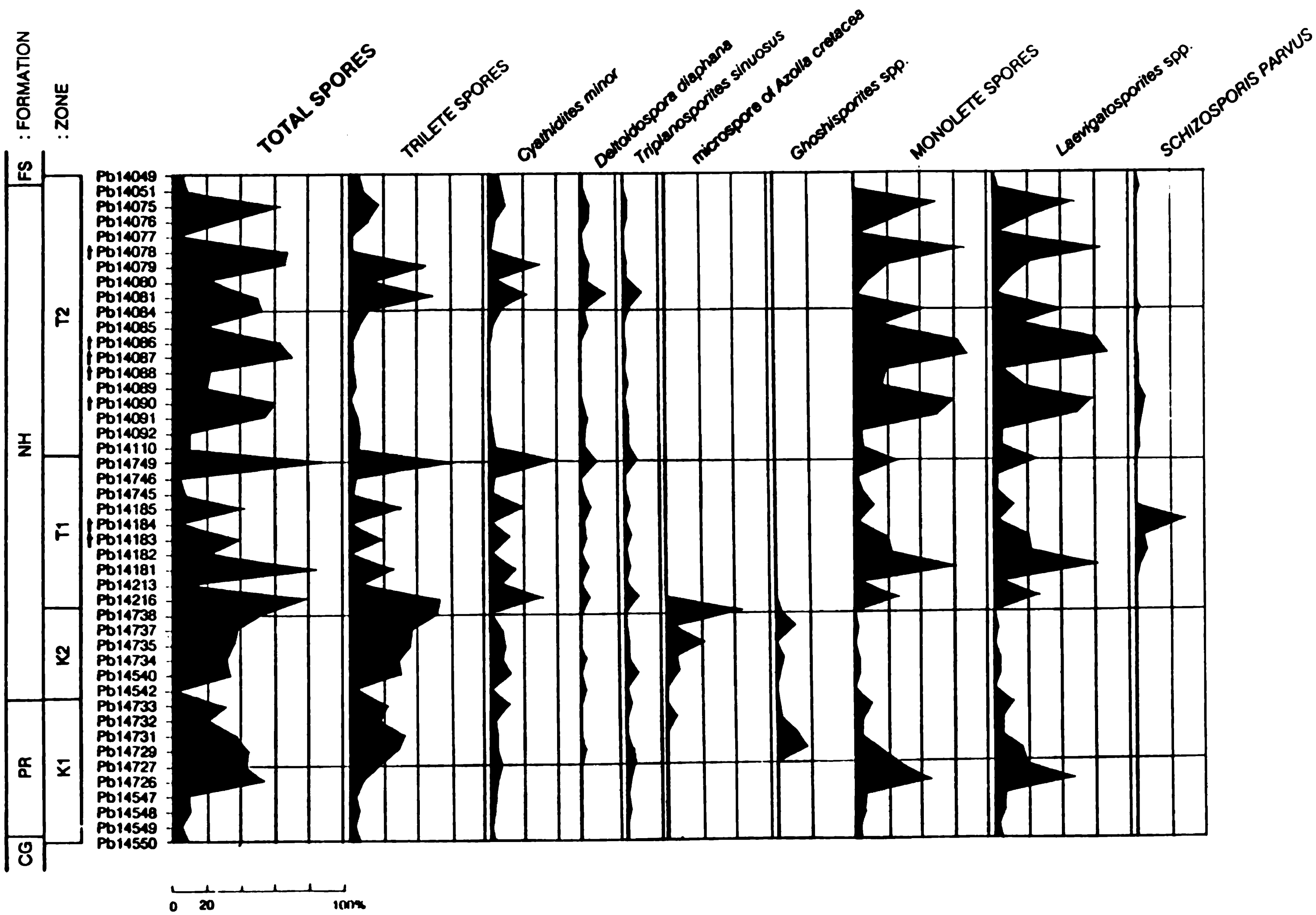

Figure 15. Pollen diagram of selected taxa. CG: Castlegate Sandstone, PR: Price River Formation, NH: North Horn Formation, and FS: Flagstaff Member of Green River Formation. † designates the coal sample.

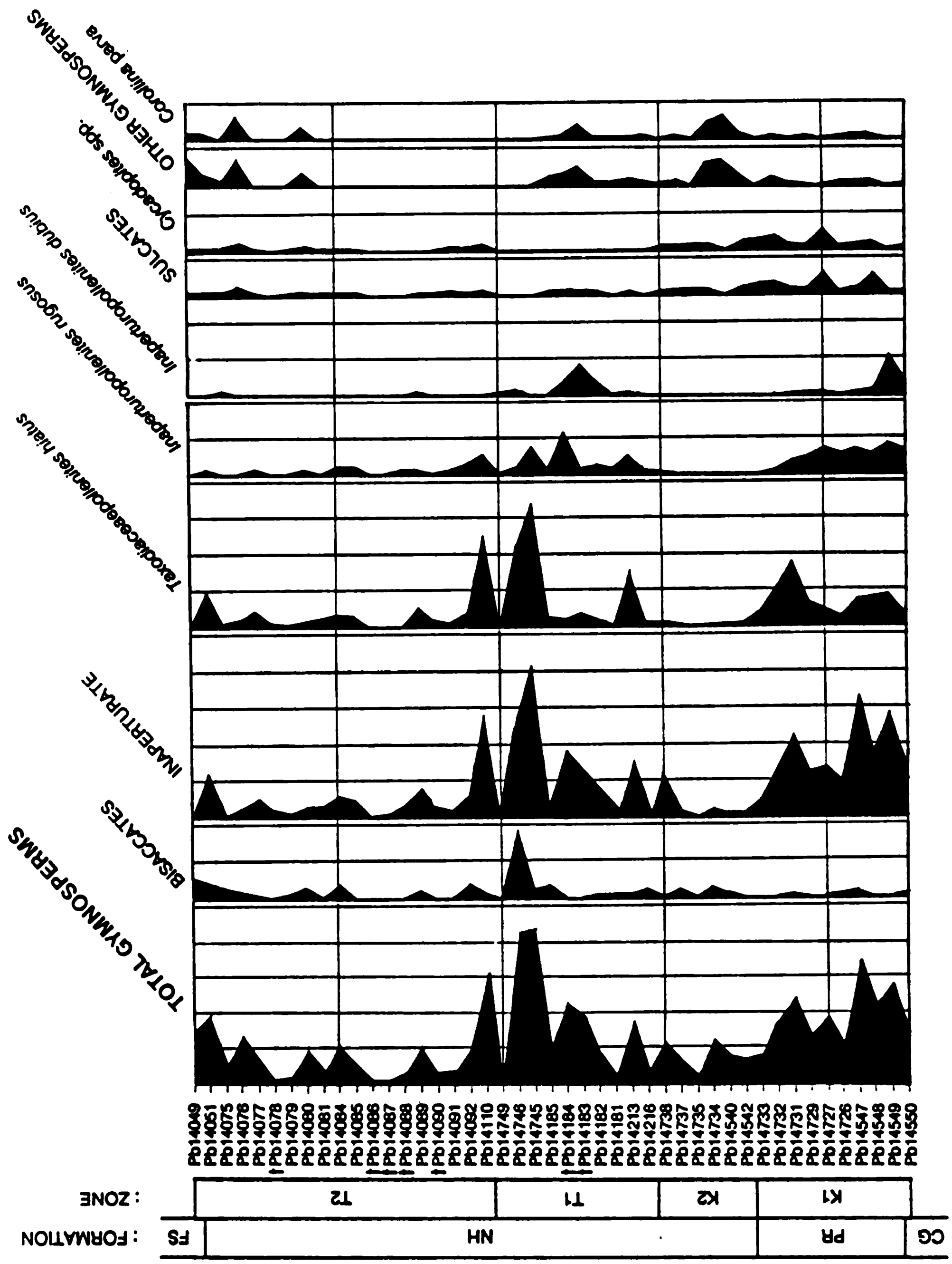

Figure 15. (cont'd).

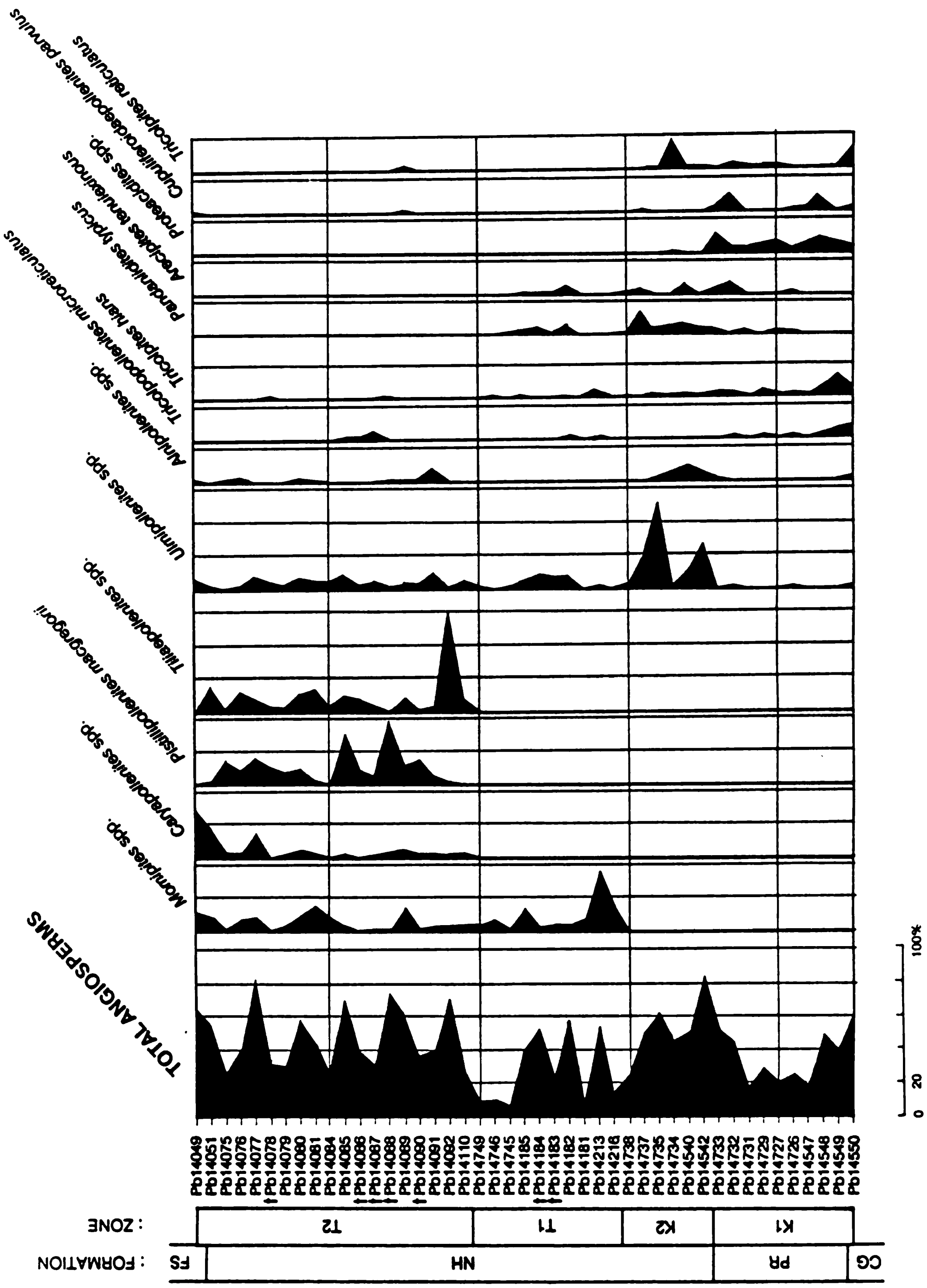

Figure 15. (cont'd).

vegetation of elevations above 3000ft (900m), or at least above the lake level. Those taxa include *Alnus, Cedrus, Carya*, and *Tilia*, as well as the coniferalean plants that produced bisaccate pollen. Low relative frequencies of palynomorphs, known to be produced by their parent plants in prolific amounts, may indicate that these taxa, *viz. Pinus, Podocarpus, Alnus*, and *Betula*, may have lived at some distance away, possibly in the upland (Frederiksen, 1985) or in extensive stands on surrounding coastal plains.

Pistillipollenites macgregorii is considered to be pollen of a plant belonging to a genus related to the Gentianaceae, a very large family widely distributed over the world, mainly in temperate to tropical regimes of the northern hemisphere. The extant family is mainly herbaceous but includes a few shrubs (Willis, 1973). Fossil flowers producing this pollen type indicate an entomophilous nature (bee pollination; Crepet and Daghlian, 1981). Rouse and Srivastava (1970) noticed this nature and frequent clumping of pollen, and suggested the deposition of *Pistillipollenites* close to the source. *Pistillipollenites* can be abundant in coal as well as in shale (Krutzsch and Vanhoorne, 1977; *fide*. Frederiksen, 1985). Some members of the family Gentianaceae (subfamily Menyanthoides), such as *Nymphoides* spp., are rooted aquatics with floating leaves, widely distributed in marshes, ponds and quiet waters of temperate regions of both hemispheres.

Figure 15 shows relatively low frequencies of *Momipites, Caryapollenites*, and *Tiliaepollenites* in coal samples, but high peaks of their frequencies in coaly shales or other dark gray shales. On the other hand *Pistillipollenites* has high frequencies in the coal beds.

Other elements clustered in Group Ia include *Brevicolporites colpella*, of unknown affinity which occurs in three samples of the lower coal, of the North Horn Formation in this study; "unknown spore" 1; *Pityosporites elongatus*, a bisaccate coniferalean pollen or prepollen with affinity to the pines or podocarps;

Alabroidaepollenites subtriangulus; and *Fraxinoipollenites artus* (probably of the Oleaceae, a large family widely distributed in tropical, subtropical and temperate regions, which includes ash, olive, lilac).

In summary, subgroup Ia represents the flora of lake-side peat-forming swamp or marsh and the surrounding area, probably a broad relatively low coastal plain. This interpretation is supported by the presence of a fresh-water alga, *Schizosporis parvus*, clustering closest to this subgroup. Whether the peat-forming environment was swamp or marsh is not known. In either case, however, the plant producing *Pistillipollenites* was a dominant rooted aquatic or understory herb or shrub of swamp or marsh habitat.

Subgroup Ib

Subgroup Ib is differentiated from the subgroup Ia, on the basis that the elements of Ib cluster to Ia later with a lower degree of similarity. Among the elements which constitutes the subgroup Ib are fresh water algae (*Schizosporis parvus* and *Ovoidites ligneolus*), trilete fern spore (*Cyathidites australis*), bisaccate gymnospermous pollen (*Cedripites cretaceous* and *Podocarpidites biformis*), and an angiosperm liana *Smilacipites echinatus*. Other important taxa included are *Ulmipollenites tricostatus* and *U. hebridicus*, which are believed to be ancestral species of the Ulmaceae, whose modern niche is lakeside or streamside, and *Peromonoletes subengelmanni* which Elsik (1968a) considered to be comparable to modern *Isoetes*, which is found in wet habitats. Its spores are dispersed by water (Frederiksen, 1985). Subgroup Ia, represents a group of plants of similar environment to that of subgroup Ia, probably occurring in somewhat wetter site.

GROUP II

Group II consists of *Ulmipollenites krempii*, *Alnipollenites trina*, *Rousea variofoveatus*, and *Triporoletes novomexicanus*. Most of modern *Alnus* and some *Ulmus/Zelkova* species indicate streamside or lakeside habitats. This group probably represents an environment similar to that occupied by subgroup Ia plants.

GROUP III

Group III is a rather small cluster consisting of *Myrtipites laqueaeformis, M. tectatus*, and *Cupuliferoideapollenites parvulus*. Affinities of these form species are not known. Small, psilate pollen species, such as *Cupuliferoideapollenites parvulus*, are probably produced by more than one type of parent plant.

GROUP IV

Group IV contains one fern spore (*Cyathidites* sp. 1) and two angiospermous pollen (*Pseudotricolpites reticulatus* and *Arecipites* cf. *A.pseudotranquillus*). The parent plants of these two angiosperms or their habitats are unknown.

GROUP V

Group V is represented by *Deltoidospora diaphana*, *Arecipites* sp. 1, *Monosulcites scabratus*, and *Tricolpites psilascabratus*. An interesting point here is that the three spore species, *viz. Cyathidites minor, Deltoidospora diaphana*, and *Triplanosporites sinuosus*, which, because of their similar morphologic features, are normally assigned to a single form-genus or at least to closely related taxa, belong to different groups in the cluster analysis. This seems to be evidence of either dissimilarity in habitats, and therefore they probably are from separate parent species of a natural genus, or they are unrelated plants that are convergent in the term of pollen/spore morphology.

GROUP VI

Major taxa included in group VI include *Laevigatosporites* spp., *Inaperturopollenites* spp. and *Proteacidites* spp. The first genus is considered to represent several fern spore taxa; the *Inaperturopollenites* may represent several taxa. However, it is worth noting that Nichols and Ting (1975), in their study of the plant macro- and micro-fossils of a Paleocene permineralized peat of North Dakota, interpreted the environment as a forested flood-plain swamp, developed in a warm temperate climate. This was based on the presence of a palynoflorule dominated by *Taxodiaceaepollenites* and *Laevigatosporites* with low species diversity, and along with the occurrences of megafossils of ferns and *Sequoia*. Other elements included in Group VI are *Ceratosporites, Eucommiidites couperi, Proteacidites* spp., and *Tricolpopollenites microreticulatus*. Srivastava (1969b) interpreted the environment producing proteaceous pollen as a subtropical climate supporting a rain-forest type of vegetation. Extant Proteaceae include species having entomophilous pollination. Most authors think most of Cretaceous *Proteacidites* are not related to Proteaceae.

GROUP VII

Group VII contains predominant pollen and spore taxa in this study such as the fern spore, *Cyathidites minor*, three gymnospermous pollen (*Taxodiaceaepollenites hiatus, Cycadopites* spp., and *Corollina parva*) and several angiospermous pollen (*Tricolpites reticulatus, T. hians, Cupuliferoideapollenites mutabilis, Aquilapollenites* spp., and *Liliacidites* spp). The gymnospermous plants represent *Sequoia*, *Metasequoia*, or *Cupressus*, or they may represent swamp plants such as *Taxodium* or *Glyptostrobus*. This group of plants is interpreted as representing a floodplain swamp.

GROUP VIII

Group VIII includes *Azolla cretacea*. This taxon is related to modern water fern, which indicates a fresh-water tropical to warm temperate in distribution. *Ghoshispora* spp. is probably another aquatic fern. *Baltisphaeridium* sp. 1. is considered to be a recycled taxon in this study. Other taxa included are *Gleicheniidites* spp., *Alisporites* spp., *Ulmipollenites* sp. 2, and *Pandaniidites typicus*. Some *Gleicheniidites* species were probably produced by climbing ferns (Machin, 1979 and Gruas-Cavagnetto, 1978; *fide*. Frederiksen, 1985). These were probably associated with trees of the forests or woodlands surrounding the lake. The environment of the water plants producing these palynomorphs in Group VIII is interpreted as a lake deposit. These water fern spores are admixed with spores and pollen from plants of surrounding communities. It is not clear why this apparent lake deposit (Group VIII) did not cluster with Group Ib, but there is some reason to believe that the stratigraphic distributions in the study section has influenced the separate clustering. This Group VIII represents taxa occurring mostly in the Cretaceous interval of the Price Canyon Section.

IX. RESULTS AND CONCLUSIONS

Forty-five samples, out of one-hundred-thirty samples collected from a 1100m section of Upper Cretaceous and Paleocene strata in the Price Canyon, Utah, were adequate for palynologic study. Two hundred forty six types of microfossils were differentiated and were assigned to fossil species or to some category of approximately equivalent rank. This suite of palynomorphs includes 65 spores of bryophytes and pteridophytes, 42 gymnospermous pollen, 114 angiospermous pollen, 25 fungal spores, 6 green algae, 4 diatoms, 1 silicoflagellate, 8 dinoflagellates, and 9 acritarchs. The marine microplankton found in these strata are considered to be recycled from earlier rocks. Many of the spores and pollen were also identified as having been recycled from earlier rocks.

One new genus, 36 new species, 13 new combinations, and 1 emended genus are tentatively designated. No new names are applied, because many of the new forms found occur in relatively low abundance and are insufficient in number to describe effectively. New names designated in unpublished dissertations, are considered not to be validly published.

Four informal biostratigraphic zones are established on the basis of stratigraphic ranges of selected pollen and spores, as well as on cluster analysis conducted for grouping the similar samples by their compositions and relative frequencies of palynomorph taxa. These are assemblage zones K1, K2, T1, and T2, in ascending order.

Ranges of *Subtriporopollenites alpinus*, *Myrtipites* spp., and *Cupuliferoideapollenites* sp.1 are restricted to the assemblage zone K1. *Proteacidites* spp. and *Cupuliferoideapollenites parvulus* are characteristic, and have consistent occurrences in this zone, although they have scattered records with low abundances in the next younger zone, K2. *Taxodiaceaepollenites hiatus* in zone K1 has high relative frequency (5-35%) compared to that of zone K2 (0.7-1.7%).

Assemblage zone K2 is characterized by abrupt increases in relative frequencies of *Ulmipollenites* and *Alnipollenites* spp., both of which were present in zone K1. Other characteristic taxa are *Ghoshispora* spp., which occurs only in the upper part of this zone with relatively high abundance, and the microspores of *Azolla cretacea*, which also appeared in zone K1. *Aquilapollenites* spp., which were widely distributed in the *Aquilapollenites* phytoprovince, including western North America, were found occasionally in zones K1 and K2. The occurrence of *Aquilapollenites* spp. is very low compared to their abundance in the Upper Cretaceous strata in northwestern Colorado recored by Gies (1972). Contrarily the abundance of *Proteacidites* spp. in his study (up to 2.2%) in samples, mainly from western Colorado, is relatively lower than that recorded in this study (1.3-8%). Another distinctive and characteristic taxon of the uppermost Cretaceous and lowermost Tertiary strata of western North America, *Wodehouseia* spp., was not seen in the present study, which strongly indicates the absence of strata representing that time span in the Price Canyon Section.

Momipites spp., such as *M. waltmanensis*, *M. wyomingensis*, *M. anellus*, and *M. ventifluminis*, are present from the lowermost sample of Tertiary zones (T1 and T2). *Fraxinoipollenites artus* appears in zone T1, whereas *Pandaniidites typicus* and *Arecipites tenuiexinous* disappear in the later part of the T1 zone. Occurrence of *Brevicolporites colpella* is restricted to the lower coal and associated dark gray shale in this zone.

At the base of the assemblage zone T2, *Caryapollenites* spp. and *Pistillipollenites macgregorii* appear and become major elements of this zone. *Tiliaepollenites* spp. are other important and abundant taxa in this zone.

Another major contribution of this study is that the strata exposed in the Price Canyon Section are correlated with the zones established in the adjacent basins of western North America. This makes it possible to extrapolate assignments from those basins to the four established biozones, *viz* 79-73Ma (assemblage zone K1, late Campanian), 73-69Ma (assemblage zone K2, early Maastrichtian), 61.5-60Ma (assemblage zone T1, middle Paleocene), and 59.5-56Ma (assemblage zone T2, late middle to early late Paleocene). To aid in establishing the absolute and relative ages, the following studies were invaluable: Fouch *et al.* (1983), for the Cretaceous interval; Nichols and Ott (1978) and Jacobson and Nichols (1982), for the Paleocene interval.

Recycled palynomorphs were distinguished, where possible, and separated from the indigenous palynomorph assemblage in order to study the patterns of their distribution in the Price River Section. These recycled spores and pollen principally represent Early Cretaceous and, Late and Middle Jurassic age and, less certainly, earlier age.

Species occurring in five or more samples were grouped for the paleoecological study on the basis of cluster analysis by utilizing the presence/absence data. Eight groups and two subgroups were formed. These may indicate environments of taphonomic assemblages, i.e. depositional sites, where the palynomorphs were preserved. The environments controlling the floras that produced the palynofloras studied here are interpreted as being a large river flood plain for the Castlegate and Price River Formations in the lower part of the section, and a suite of lacustrine, adjacent swamp or marsh, and lake bank deposits for the North Horn Formation.

A useful extension of the present study would involve further analysis of recycled palynomorphs. This might demonstrate the redeposition of palynomorphs derived from successively older rock sequences in the successively younger strata in this stratigraphic section.

Another desirable study would be to define the ranges of palynomorphs below in the Blackhawk Formation and older strata and above in the Flagstaff Member of Green River Formation and younger strata of late Paleocene and early Eocene, and to establish the more complete palynostratigraphic zones in the Price Canyon Section and its extensions.

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PALYNOLOGY AND PALEOECOLOGY OF UPPER CRETACEOUS - LOWER TERTIARY STRATA, PRICE CANYON, UTAH

Volume II

By

Myung S. Yi

A DISSERTATION

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APPENDICES

APPENDIX A. STRATIGRAPHIC POSITION OF PALYNOLOGIC SAMPLES IN MEASURED SECTION

APPENDIX A. STRATIGRAPHIC POSITION OF PALYNOLOGIC SAMPLES IN MEASURED SECTION.

Price Canyon Section, Carbon County, Utah. From SW1/4 Sec.26 T12S,R9E (20km north of Price, Utah), following the U.S.highway 6 and 50, to NW1/4 Sec.5 T12S,R9E (30km north of Price), Kyune 7.5 min. Quadrangle.

Maceration number	Sample number	Lithology	Sample thickness	Meters above base of fms
(*: productive samples)				
Flagstaff Member of Green River Formation				
Pb14047	9/3/84 I-109	reddish weathered shale more calcareous downwards	3.4m	16.0m
Pb14048	9/2/84 I-106	dark gray shale	1.8m	4.3m
*Pb14049	9/2/84 I-105	calcareous shale	1.6m	2.0m
North Horn Formation				
Pb14050	9/2/84 I-103	gray silty shale	2.2m	683.2m
*Pb14051	9/2/84 I-102	dark gray limestone interbedded with calcareous shale	4.5m	670.3m
Pb14052	9/2/84 I-101	highly weathered gray shale altered to reddish or greenish	0.7m	656.6m
Pb14053	9/2/84 I-100	gray shale interbedded with several thin layers of fine grained sandstone	4.0m	640.2m
Pb14054	9/2/84 I-99	dark gray shale interbedded with 10cm thick dark gray limestone bearing fresh-water molluscs and gastropods	2.7m	632.0m

Pb14055	9/2/84 I-98	light gray shale showing conchoidal fracture	4.0m	627.9m
Pb14056	8/31/84 I-97	greenish gray calcareous fine grained sandstone	5.0m	621.2m
Pb14057	8/31/84 I-96	greenish gray silty shale altered to reddish or greenish gray	2.2m	619.0m
Pb14058	8/31/84 I-95	dark gray shale inter-bedded with 1m thick greenish gray calcareous fine grained sandstone	5.0m	607.6m
Pb14059	8/29/84 I-94	gray shale	1.6m	603.9m
Pb14060	8/29/84 I-93	medium to finely bedded gray calcareous fine grained sandstone	5.0m	598.4m
Pb14061	8/29/84 I-92	massive gray calcareous fine grained sandstone	6.0m	582.7m
Pb14062	8/29/84 I-91	gray calcareous fine grained sandstone inter-bedded with siltstone forming slope	4.0m	573.1m
Pb14063	8/25/84 I-90	gray limestone	3.5m	569.2m
Pb14064	8/25/84 I-89	dark gray shale	0.5m	557.9m
Pb14065	8/25/84 I-88	dark gray calcareous shale bearing fresh water gastropods	4.0m	545.3m
Pb14066	8/25/84 I-87	dark gray shale bounded by lenticular sandstones	0.2m	541.6m
Pb14067	8/25/84 I-86	dark gray shale	0.2m	524.4m
Pb14068	8/25/84 I-85	dark gray shale	0.1m	520.9m
*Pb14075	8/25/84 I-84	dark gray shale	0.1m	520.3m
*Pb14076	8/25/84 I-83	dark gray calcareous shale bearing fresh water gastropods	1.0m	503.2m
*Pb14077	8/25/84 I-80	dark gray shale	2.0m	486.9m
*Pb14078	8/25/84 I-79	coal	0.1m	486.8m

*Pb14079	8/24/84 I-78	dark gray shale inter-bedded with several massive dark gray limestone beds	2.0m	477.6m
*Pb14080	8/24/84 I-77	dark gray shale inter-bedded with massive limestone layers	1.0m	474.8m
*Pb14081	8/24/84 I-76	dark gray shale	2.0m	472.4m
Pb14082	8/24/84 I-74	dark gray shale inter-bedded with several 10cm thick layers of fine grained sandstone	3.0m	446.8m
Pb14083	8/24/84 I-73	gray siltstone bearing fresh-water gastropods	1.0m	442.0m
*Pb14084	8/23/84 I-71	dark gray shale	0.3m	433.6m
*Pb14085	8/23/84 I-70	coaly shale	0.1m	426.3m
*Pb14086	8/23/84 I-69	coal	0.05m	422.45m
*Pb14087	8/23/84 I-68	coal	0.05m	422.4m
*Pb14088	8/23/84 I-67	coal	0.1m	422.3m
*Pb14089	8/23/84 I-66	coaly shale	0.2m	422.0m
*Pb14090	8/23/84 I-65	coal	0.1m	421.8m
*Pb14091	8/23/84 I-64	coaly shale	0.05m	421.65m
*Pb14092	8/23/84 I-63	coaly shale	0.1m	421.5m
*Pb14110	8/23/84 I-62	gray shale	0.4m	421.1m
Pb14111	8/23/84 I-60	dark gray shale	0.5m	414.2m
Pb14112	8/23/84 I-59	dark gray shale bearing fresh-water gastropods	0.8m	409.2m
Pb14113	8/23/84 I-57	black coaly shale	0.8m	405.2m
Pb14114	8/23/84 I-56	gray siltstone - very fine grained sandstone	0.2m	400.0m
Pb14115	8/23/84 I-55	dark gray siltstone	1.5m	376.8m
Pb14116	8/23/84 I-54	gray siltstone	3.0m	372.6m

Pb14117	8/23/84	I-53	dark gray siltstone	1.5m	370.0m
Pb14118	8/23/84	I-52	gray siltstone	1.0m	360.0m
Pb14119	8/22/84	I-51	dark gray siltstone	1.5m	356.2m
Pb14120	8/22/84	I-50	gray siltstone	1.0m	345.2m
Pb14130	8/22/84	I-49	gray resistant siltstone underlying massive sand-stone with sharp boundary	1.5m	335.9m
Pb14131	8/22/84	I-48	reddish gray weathered siltstone	1.0m	331.3m
Pb14159	8/22/84	I-47	gray lenticular siltstone	1.0m	328.7m
Pb14160	8/22/84	I-46	gray lenticular siltstone	1.5m	325.0m
Pb14161	8/22/84	I-45	gray siltstone weathered to bluish gray	2.0m	321.5m
Pb14162	8/22/84	I-44	gray siltstone	2.0m	318.4m
Pb14163	8/22/84	I-43	dark gray siltstone	1.0m	296.6m
Pb14164	8/22/84	I-42	irregularly bedded gray siltstone	0.5m	267.3m
Pb14750	8/24/86	I-15	dark gray shale	1.0m	261.8m
*Pb14749	8/24/86	I-14	dark gray shale	0.5m	247.0m
Pb14748	8/24/86	I-13	dark gray shale	0.5m	235.0m
Pb14165	8/21/84	I-41	gray shale	1.5m	233.3m
Pb14166	8/21/84	I-40	irregularly bedded dark gray siltstone	7.0m	224.1m
Pb14167	8/21/84	I-39	dark gray shale	5.0m	218.5m
Pb14168	8/21/84	I-38	dark gray shale	3.4m	210.8m
Pb14169	8/21/84	I-37	highly weathered gray shale	1.1m	206.3m
Pb14170	8/21/84	I-36	gray shale	2.2m	201.6m
Pb14171	8/21/84	I-35	greenish gray shale	3.1m	197.7m
Pb14172	8/21/84	I-34	greenish gray shale	1.0m	193.1m

Pb14173	8/20/84 I-33	dark gray shale	0.1m	180.2m
Pb14174	8/20/84 I-32	greenish gray shale	0.5m	177.6m
Pb14178	8/20/84 I-28	weathered gray shale	0.7m	174.8m
Pb14179	8/20/84 I-27	gray shale	1.6m	171.6m
Pb14175	8/20/84 I-31	fine-grained sandstone bearing fresh-water molluscs and gastropods	2.0m	168.0m
Pb14176	8/20/84 I-30	greenish gray shale coarsening upward	2.1m	165.9m
Pb14747	8/24/86 I-12	lenticular shale	0.2m	158.6m
*Pb14746	8/24/86 I-11	dark gray shale	1.0m	155.8m
Pb14177	8/20/84 I-29	greenish gray shale	1.5m	150.0m
*Pb14745	8/24/86 I-10	dark gray shale	1.4m	148.6m
Pb14180	8/20/84 I-26	gray shale	1.0m	145.2m
Pb14744	8/24/86 I-9	dark gray shale	1.0m	141.1m
*Pb14181	8/19/84 I-25	greenish gray shale interbedded with fine grained sandstone	4.8m	133.5m
*Pb14182	8/19/84 I-24	weathered coal	0.05m	132.2m
*Pb14183	8/19/84 I-23	coal	0.05m	132.15m
*Pb14184	8/19/84 I-22	coal	0.05m	132.1m
*Pb14185	8/19/84 I-21	dark coaly shale bearing some plant remains	1.8m	130.3m
*Pb14213	8/19/84 I-20	gray coaly shale bearing plant debris interbedded with lenticular sandstone in the middle	1.2m	128.9m
Pb14214	8/19/84 I-19	gray shale	0.3m	126.4m
Pb14743	8/24/86 I-8	dark gray shale	1.0m	124.8m
Pb14215	8/19/84 I-18	dark gray shale	0.5m	122.6m
Pb14742	8/24/86 I-7	dark gray shale	0.7m	121.9m

*Pb14216	8/19/84 I-17	gray shale	1.0m	120.5m
Pb14741	8/24/86 I-6	dark gray shale	1.3m	119.2m
Pb14217	8/19/84 I-16	gray shale bearing fresh-water gastropods	1.7m	115.7m
Pb14740	8/24/86 I-5	dark gray shale	1.0m	110.4m
Pb14218	8/17/84 I-15	greenish gray sandy shale-bearing fresh-water gastropods	0.4m	98.3m
Pb14739	8/24/86 I-4	dark gray shale	1.0m	97.1m
Pb14219	8/17/84 I-14	dark gray sandy shale	1.4m	95.7m
*Pb14738	18/24/86 I-3	dark gray shale	1.0m	93.3m
Pb14220	8/17/84 I-13	light gray medium-grained sandstone bearing fresh-water molluscs and gastropods	1.0m	92.0m
*Pb14737	8/24/86 I-2	dark gray shale	1.0m	91.0m
Pb14221	8/17/84 I-12	gray shale weathered to purple	0.5m	90.5m
Pb14736	8/24/86 I-1	dark gray shale	0.5m	86.4m
*Pb14735	8/24/86 II-2	dark gray shale	2.0m	71.7m
*Pb14734	8/24/86 II-1	dark gray shale	1.5m	67.4m
Pb14535	8/17/84 I-11	highly weathered shale intercalated with lenticular pebbly sandstone	0.2m	62.3m
Pb14536	8/17/84 I-10	highly weathered gray shale	0.1m	43.6m
Pb14537	8/17/84 I-9	highly weathered gray shale	1.5m	40.1m
Pb14538	8/17/84 I-8	dark gray shale bearing fresh-water gastropods	1.5m	25.6m
Pb14539	8/17/84 I-7	dark gray calcareous shale overlying lenticular conglomerate with 2-3cm pebbles	0.2m	24.9m

*Pb14540	8/17/84 I-6	dark gray calcareous	4.0m	13.3m
Pb14541	8/17/84 I-5	calcareous shale inter-calated by lenticular calcareous siltstone	4.4m	7.5m
*Pb14542	8/16/84 I-4	calcareous shale	3.0m	2.3m
Pb14544	8/16/84 I-2	gray shale bearing fresh-water gastropods	0.7m	1.6m
Pb14543	8/16/84 I-3	calcareous shale conta-ining 5-10cm diameter concretions	1.6m	0.0m

Price River Formation

*Pb14733	8/23/86 I-1	purple silty shale, soft. thinly bedded	0.8m	294.0m
Pb14545	8/16/84 I-1	lenticular coaly shale	0.1m	283.5m
*Pb14732	8/23/86 I-2	gray siltstone	0.5m	270.0m
*Pb14731	8/23/86 I-3	dark gray shale	0.5m	234.5m
Pb14730	8/23/86 I-4	dark gray shale	1.3m	217.5m
*Pb14729	8/23/86 I-5	dark gray shale	0.3m	214.2m
Pb14728	8/23/86 I-6	dark gray shale	1.7m	197.8m
*Pb14727	8/23/86 I-7	dark gray shale	1.8m	192.0m
*Pb14726	8/23/86 I-8	dark gray shale	1.0m	177.0m
Pb14546	8/27/84 II-1	highly weathered shale	2.0m	168.0m
*Pb14547	8/27/84 II-2	highly weathered gray	3.0m	140.0m
*Pb14548	8/28/84 II-3	highly weathered gray shale	1.0m	21.0m
*Pb14549	8/28/84 II-4	dark gray shale	0.5m	0.0m

Castlegate Sandstone

*Pb14550	8/28/84 II-5	irregularly spaced lenticular coaly shale embedded in the white fine grained 3.5m thick quartz sandstone	0.05m	65.0m

APPENDIX B. ABSOLUTE NUMBERS OF PALYNOMORPHS COUNTED IN PRODUCTIVE SAMPLES

SPORE SPECIES 1-57

	1 Appendicisporites cristatus	2 Azolla cretacea	3 Biretisporites sp.	4 Biretisporites sp.1	5 Biretisporites sp.2	6 Ceratosporites couliensis	7 Ceratosporites sp.	8 Chomotriletes minor	9 Cibotiumspora cf. C. jurienensis	10 Cibotiumspora juncta	11 Cicatricosisporites dorogensis	12 Cicatricosisporites ornatus	13 Cicatricosisporites sp.	14 Cicatricososporites norrisii	15 Cingutriletes congruens	16 Cirratriradites teter
Pb14049	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14051	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14075	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...
Pb14077	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14079	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14080	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14081	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14084	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14085	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14086	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14087	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14088	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14089	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14090	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14091	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14092	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14110	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14746	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14182	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14183	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14184	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14185	...	...	3	2	...	...	...	...	...	...	...	...	...	...	...	...
Pb14213	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
Pb14216	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...
Pb14738	...	131	...	...	3	...	...	...	...	...	...	...	...	...	1	...
Pb14737	...	10	...	...	...	3	...	1	...	...	...	...	...	...	...	...
Pb14735	...	66	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	...	15	...	...	...	...	...	5	...	...	...	...	...	2	...	10
Pb14540	...	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14542	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...
Pb14733	...	...	6	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14732	1	16	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14731	1	...	5	2	...	1	3	...	...	3	...	1	...	...	...	...
Pb14729	...	...	...	...	...	3	...	...	...	...	...	3	...	...	...	...
Pb14727	...	1	...	...	1	1	...	...	1	...	...	...	...	...	...	...
Pb14726	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...
Pb14547	...	...	...	...	...	1	...	...	...	...	...	...	1	...	...	...
Pb14548	...	...	...	...	...	4	...	...	...	1	...	...	1	...	...	...
Pb14549	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14550	...	...	...	...	...	7	...	...	...	...	...	...	...	...	...	...

	Concavisporites parkinii	Concavisporites sp.1	Concavisporites sp.2	Concavissimisporites cf. C.michinus	Cyathidites australis	Cyathidites minor	Cyathidites sp.1	Deltoidospora diaphana	Deltoidospora sp.	Densoisporites sp.	Densoisporites velatus	Dictyophyllidites harrisii	Dictyosporites cf. D.speciosus	Gabonisporis bacaricumulus	Genus et sp. nov. 1	Ghoshispora bella
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Pb14049	...	...	...	...	...	15	...	2	...	...	...	...	...	...	...	...
Pb14051	...	...	...	...	...	20	...	2	...	...	...	...	...	...	...	...
Pb14075	...	...	...	...	...	28	...	15	...	...	...	...	...	...	...	...
Pb14076	...	...	...	...	6	8	...	12	...	...	...	...	...	...	...	...
Pb14077	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	...	...	...	1	...	2	...	...	...	...	...	...	...	...
Pb14079	...	...	...	...	...	94	...	12	...	...	...	...	...	...	...	...
Pb14080	...	...	...	...	1	11	...	9	...	...	...	...	...	...	...	...
Pb14081	...	...	...	...	1	67	...	43	...	...	...	...	...	...	...	...
Pb14084	...	...	...	...	...	19	...	3	...	...	...	...	...	...	...	...
Pb14085	...	...	...	...	...	5	...	9	...	...	...	...	...	...	...	...
Pb14086	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...
Pb14087	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14088	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...
Pb14089	...	...	...	...	2	...	...	1	...	...	...	...	...	...	...	...
Pb14090	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14091	...	...	...	...	...	1	...	7	...	...	...	...	...	...	...	...
Pb14092	...	...	...	...	...	6	...	5	...	...	...	...	...	...	...	...
Pb14110	...	...	...	...	...	7	...	5	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	120	5	28	...	...	...	...	...	...	...	...
Pb14746	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...
Pb14745	...	...	...	...	...	3	...	2	...	...	...	...	...	...	...	...
Pb14181	...	...	...	...	1	60	...	15	...	...	...	...	...	...	...	...
Pb14182	...	...	...	...	...	3	...	3	...	...	...	...	...	...	...	...
Pb14183	...	...	...	...	...	34	...	4	7	...	...	...	...	...	...	...
Pb14184	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...
Pb14185	...	...	...	...	...	46	7	11	...	...	...	2	...	...	...	...
Pb14213	...	...	...	...	...	19	...	1	...	...	...	...	...	...	...	...
Pb14216	...	...	...	...	...	38	7	5	...	...	...	...	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Pb14737	...	...	...	...	...	19	14	1	...	...	...	...	...	...	...	8
Pb14735	...	...	...	...	3	24	...	...	...	...	...	10	...	...	...	...
Pb14734	...	...	...	...	...	21	6	7	...	...	...	...	...	...	...	9
Pb14540	2	...	...	...	...	35	...	...	...	...	...	...	...	...	...	6
Pb14542	...	...	...	...	1	1	...	4	...	...	...	...	...	...	...	1
Pb14733	...	...	...	1	...	34	5	...	...	...	...	...	1	...	...	3
Pb14732	...	...	...	...	...	7	2	...	...	...	...	1	...	...	...	6
Pb14731	...	...	...	...	5	11	...	...	...	...	...	6	...	1	...	35
Pb14729	...	...	1	...	...	9	1	2	...	...	...	...	...	...	...	46
Pb14727	1	...	...	...	...	21	2	1	...	...	...	...	...	...	...	...
Pb14726	...	...	...	...	...	11	...	1	...	...	...	...	...	1	3	...
Pb14547	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...
Pb14548	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...
Pb14549	...	1	...	...	...	...	...	1	...	...	1	...	...	...	...	...
Pb14550	...	...	...	...	...	6	...	1	...	...	...	...	...	...	...	...

	Ghoshispora major	Ghoshispora sp.	Gleicheniidites senonicus	Gleicheniidites simplex	Hamulatisporis cf. H.hamulatis	Hazaria cf. H.sheopiarii	Heliosporites altmarkensis	Laevigatosporites discordatus	Laevigatosporites haardtii	Laevigatosporites ovatus	Laevigatosporites sp.	Osmundacidites wellmanii	Peromonoletes subengelmanni	Polycingulatisporites reduncus	Polypodiites inangahuensis	Retitriletes nidus
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Pb14049	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...
Pb14051	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...
Pb14075	...	...	...	...	...	...	...	...	40	46	58	...	...	...	...	...
Pb14076	...	...	1	...	...	...	...	5	17	21	25	...	...	...	...	...
Pb14077	...	...	...	...	...	...	...	...	1	5	2	...	...	...	...	...
Pb14078	...	...	...	...	...	...	...	...	35	157	4	...	1	...	...	...
Pb14079	...	...	20	...	...	...	...	20	30	5	13	...	...	...	...	...
Pb14080	...	...	6	4	...	...	...	9	4	14	4	...	...	...	...	...
Pb14081	...	...	3	...	...	...	...	...	...	3	1	...	...	...	...	...
Pb14084	...	...	3	...	...	...	...	2	40	67	15	...	2	...	...	...
Pb14085	...	...	...	...	...	...	...	12	7	28	...	...	...	...	...	...
Pb14086	...	...	...	...	...	...	...	...	53	131	...	...	1	...	...	...
Pb14087	...	...	...	...	...	...	...	9	25	143	25	...	2	...	...	...
Pb14088	...	...	...	...	...	...	...	...	...	13	1	...	45	...	...	...
Pb14089	...	...	...	2	...	...	...	2	...	49	...	...	...	...	...	...
Pb14090	...	...	...	...	...	...	...	...	30	146	...	...	1	...	...	...
Pb14091	...	...	...	...	...	...	...	...	52	93	1	...	...	...	...	...
Pb14092	...	...	...	...	...	...	...	...	3	10	...	...	...	...	...	...
Pb14110	...	...	...	...	...	...	...	1	6	7	...	...	...	...	...	...
Pb14749	...	...	7	...	...	...	...	4	20	38	16	...	...	...	...	...
Pb14746	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...
Pb14745	...	...	...	...	...	...	...	...	...	...	4	...	12	...	...	...
Pb14181	...	...	5	...	...	...	...	3	6	22	4	...	...	...	...	...
Pb14182	...	...	...	...	...	...	...	4	4	...	...	...	...	...	...	...
Pb14183	...	...	4	...	...	...	1	...	10	40	10	...	...	...	...	...
Pb14184	...	...	...	...	...	...	...	1	1	48	15	...	...	...	...	...
Pb14185	...	...	2	...	...	...	...	...	57	103	23	...	1	...	...	...
Pb14213	...	...	...	...	...	...	...	...	4	8	...	...	...	...	...	...
Pb14216	...	...	4	...	...	...	...	...	14	12	6	...	...	...	...	...
Pb14738	...	7	...	1	...	...	...	...	...	...	...	...	...	...	...	...
Pb14737	11	14	...	...	...	...	...	...	...	4	...	...	...	...	...	...
Pb14735	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	...	3	3	...	...	...	...	...	...	7	...	1	...	...	...	...
Pb14540	...	...	1	7	...	...	...	2	...	4	2	...	...	...	...	...
Pb14542	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14733	...	1	...	6	...	...	...	...	...	27	4	1	...	...	...	...
Pb14732	...	1	2	...	...	...	1	1	...	1	10	...	...	...	...	...
Pb14731	1	...	...	...	...	...	12	2	...	10	...	...	...	...	...	...
Pb14729	9	...	1	...	...	...	...	10	...	37	...	...	...	1	...	...
Pb14727	...	...	2	1	...	19	...	3	3	50	3	...	1	...	...	...
Pb14726	...	...	...	...	...	...	...	47	25	65	1	...	...	...	...	1
Pb14547	...	...	...	...	...	...	...	3	...	5	...	...	...	...	...	...
Pb14548	...	...	...	...	...	...	...	...	...	13	2	...	...	...	1	...
Pb14549	...	...	1	1	1	...	...	1	...	2	4	...	...	...	...	...
Pb14550	...	...	...	2	...	...	...	1	...	5	4	...	...	1	...	...

	Stereisporites antiquasporites	Stereisporites stereoides	Todisporites minor	Todisporites sp.	Triplanosporites sinuosus	Triporoletes novomexicanus	Undulatisporites pflugii	Undulatisporites undulapolus	Unknown spore 1	
	49	50	51	52	53	54	55	56	57	
Pb14049	...	...	...	...	...	...	...	...	...	Pb14049
Pb14051	...	...	...	...	...	...	...	...	...	Pb14051
Pb14075	...	...	1	...	4	...	2	...	...	Pb14075
Pb14076	...	...	...	...	4	...	...	...	...	Pb14076
Pb14077	...	...	...	...	...	...	...	...	...	Pb14077
Pb14078	...	...	...	...	...	...	...	...	...	Pb14078
Pb14079	...	...	...	...	5	...	...	...	1	Pb14079
Pb14080	...	...	...	...	6	...	...	...	3	Pb14080
Pb14081	2	2	...	...	29	...	...	...	...	Pb14081
Pb14084	1	...	...	...	6	...	...	...	1	Pb14084
Pb14085	...	...	1	...	...	...	...	...	...	Pb14085
Pb14086	...	...	...	...	...	...	...	...	1	Pb14086
Pb14087	...	1	...	...	3	...	...	...	...	Pb14087
Pb14088	...	...	...	...	1	...	...	...	...	Pb14088
Pb14089	...	...	...	...	5	...	...	1	...	Pb14089
Pb14090	...	...	...	...	...	...	...	...	...	Pb14090
Pb14091	...	...	...	...	4	...	1	...	...	Pb14091
Pb14092	...	...	2	...	4	...	...	...	...	Pb14092
Pb14110	...	...	...	...	4	...	...	...	...	Pb14110
Pb14749	4	...	...	...	20	...	...	4	12	Pb14749
Pb14746	...	...	...	...	...	...	...	...	...	Pb14746
Pb14745	...	1	...	...	...	...	...	...	...	Pb14745
Pb14181	...	...	...	...	4	5	...	...	23	Pb14181
Pb14182	...	...	...	...	...	...	...	...	1	Pb14182
Pb14183	...	...	...	...	7	...	...	...	...	Pb14183
Pb14184	...	...	...	...	...	...	...	...	...	Pb14184
Pb14185	...	...	...	...	5	...	...	...	...	Pb14185
Pb14213	...	1	...	...	...	...	...	...	2	Pb14213
Pb14216	...	...	...	...	8	...	...	...	...	Pb14216
Pb14738	...	10	...	...	...	...	...	...	...	Pb14738
Pb14737	...	2	3	11	...	12	...	...	...	Pb14737
Pb14735	...	...	...	...	2	...	...	...	...	Pb14735
Pb14734	...	...	...	...	2	2	...	...	...	Pb14734
Pb14540	...	...	...	...	18	...	...	2	...	Pb14540
Pb14542	...	...	...	...	...	1	...	...	...	Pb14542
Pb14733	...	1	...	...	6	1	1	...	...	Pb14733
Pb14732	...	...	...	...	1	...	11	...	...	Pb14732
Pb14731	...	9	1	...	...	...	...	...	...	Pb14731
Pb14729	...	1	...	...	8	...	...	...	...	Pb14729
Pb14727	1	4	...	...	11	...	2	...	...	Pb14727
Pb14726	...	...	...	...	3	...	...	...	...	Pb14726
Pb14547	...	...	1	...	...	...	...	...	...	Pb14547
Pb14548	...	3	...	...	3	...	...	...	...	Pb14548
Pb14549	...	...	...	...	...	...	...	...	...	Pb14549
Pb14550	...	...	...	...	...	1	...	...	...	Pb14550

GYMNOSPERM POLLEN 1-46

	1 Abietineaepollenites microalatus	2 Abietineaepollenites sp.	3 Alisporites aff. A. rotundus	4 Alisporites grandis	5 Alisporites sp.	6 Alisporites thomasii	7 Araucariacites australis	8 Araucariacites sp.	9 Cedripites cretaceous	10 Cedripites parvus	11 Cerebropollenites sp.1	12 Confertisulcites gracilis	13 Confertisulcites sp.	14 Corollina parva	15 Corollina sp.	16 Cycadopites formosus
Pb14049	10	...	...	1	9	12	...	...	4	...	...	...	...	12	33	...
Pb14051	3	...	...	...	3	2	...	...	1	...	...	...	...	9	7	...
Pb14075	2	...	3	...	5	3	...	...	...	...	3	...	...	...	2	...
Pb14076	1	...	3	1	2	3	...	8	...	...	3	...	...	38	...	...
Pb14077	1	...	...	1	...	3	...	...	...	...	...	...	...	...	1	...
Pb14078	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
Pb14079	...	...	...	...	...	4	...	...	1	...	...	...	...	...	...	...
Pb14080	2	...	4	3	...	4	...	...	...	...	...	...	...	21	...	...
Pb14081	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14084	2	...	...	...	4	9	...	...	2	...	...	...	...	1	...	...
Pb14085	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14086	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
Pb14087	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14088	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14089	1	1	2	...	2	2	...	...	...	...	...	...	...	...	...	...
Pb14090	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14091	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14092	4	...	1	...	5	8	...	...	...	2	...	...	...	1	...	...
Pb14110	1	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
Pb14746	10	...	...	...	...	33	...	...	...	...	...	...	...	...	...	...
Pb14745	3	...	...	...	...	7	...	...	...	...	...	...	...	...	...	...
Pb14181	3	...	...	1	4	3	...	...	...	...	...	6	...	3	1	...
Pb14182	...	...	...	...	...	...	3	4	...	...	...	3	...	4	...	...
Pb14183	...	...	...	...	...	1	...	...	...	...	...	4	...	23	...	...
Pb14184	1	...	...	...	...	2	...	...	...	...	...	2	...	2	...	...
Pb14185	...	...	...	...	...	1	...	...	...	...	...	...	...	2	...	...
Pb14213	1	...	...	...	...	2	1	...	...	...	2	3	...	2	...	...
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14738	...	...	...	...	...	...	...	4	...	...	...	...	...	...	...	4
Pb14737	3	...	...	...	...	6	...	11	...	...	...	1	1	6	...	4
Pb14735	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	3	...	...	...	...	7	4	6	...	...	...	...	...	27	...	...
Pb14540	1	...	...	...	...	1	1	...	...	...	...	...	...	40	...	1
Pb14542	...	...	...	...	...	...	...	...	1	...	...	...	...	10	...	3
Pb14733	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	5
Pb14732	...	...	...	...	...	1	...	...	...	...	...	...	...	2	...	...
Pb14731	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14729	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	1
Pb14727	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14726	...	...	...	...	...	1	...	...	...	...	...	...	...	3	...	...
Pb14547	1	...	...	...	...	...	...	48	...	...	...	...	...	2	...	...
Pb14548	...	...	...	...	...	...	1	6	...	...	...	...	2	8	...	1
Pb14549	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14550	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

	17 Cycadopites giganteus	18 Cycadopites scabratus	19 Cycadopites sp.	20 Cycadopites sp.1	21 Equisetosporites cf. E.concinnus	22 Equisetosporites cf. E.ovatus	23 Equisetosporites eocenipites	24 Equisetosporites sp.	25 Eucommiidites couperi	26 Ginkgocycadophytus nitidus	27 Inaperturopollenites dubius	28 Inaperturopollenites rugosus	29 Inaperturopollenites rugulatus	30 Inaperturopollenites sp.	31 Inaperturopollenites sp.1	32 Monocolpopollenites sp.1
Pb14049	...	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14051	...	4	...	...	...	...	...	...	...	...	1	6	...	...	...	...
Pb14075	...	5	...	...	...	...	...	...	...	...	2	...	...	...	...	...
Pb14076	...	10	...	...	...	...	...	...	...	...	1	...	...	...	...	...
Pb14077	...	2	...	...	...	...	...	...	...	...	...	7	...	...	...	...
Pb14078	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14079	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14080	...	5	...	...	...	...	...	...	...	...	...	5	...	2	...	...
Pb14081	...	2	...	...	...	...	...	...	...	...	...	...	...	4	...	...
Pb14084	...	2	...	...	...	...	...	...	...	...	...	9	...	10	...	...
Pb14085	...	2	...	...	...	...	...	...	...	...	...	9	...	...	...	...
Pb14086	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14087	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
Pb14088	...	...	...	...	...	...	...	...	...	...	...	6	...	11	...	...
Pb14089	1	...	...	...	...	...	...	...	...	2	3	4	...	9	...	...
Pb14090	...	1	...	...	...	...	...	...	...	1	...	3	...	5	...	...
Pb14091	...	5	...	...	...	...	...	...	...	...	...	5	...	3	...	...
Pb14092	...	2	...	...	...	...	...	...	...	...	...	14	...	...	...	...
Pb14110	...	7	...	...	...	...	...	...	...	...	...	31	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...
Pb14746	...	...	...	...	...	...	...	...	...	...	2	6	...	...	...	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	46	...	...	...	...
Pb14181	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...
Pb14182	...	2	...	...	...	...	...	...	...	...	23	68	...	...	...	...
Pb14183	...	...	2	...	...	...	...	...	...	...	51	7	...	...	...	...
Pb14184	...	...	...	...	...	...	...	...	...	...	20	13	...	...	...	...
Pb14185	...	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...
Pb14213	...	...	...	...	...	...	...	...	...	3	2	27	...	...	...	...
Pb14216	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	3	...	...	52	...
Pb14737	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...
Pb14735	...	2	...	6	1	...	...	...	...	...	...	...	...	...	...	...
Pb14734	1	4	...	3	2	...	9	...	...	...	1	...	...	...	...	...
Pb14540	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14542	2	...	...	7	...	...	9	1	...	...	...	...	...	...	...	...
Pb14733	...	...	...	11	...	...	...	...	1	3	...	1	...	...	...	1
Pb14732	...	6	...	14	...	...	...	...	1	...	...	6	...	...	...	...
Pb14731	...	7	1	...	...	...	...	...	...	...	3	19	...	...	...	...
Pb14729	...	2	...	1	...	...	...	...	1	1	2	27	...	...	...	...
Pb14727	...	11	...	24	...	1	...	...	1	...	3	44	...	...	...	...
Pb14726	...	1	...	2	...	...	...	...	...	...	...	36	1	...	...	...
Pb14547	...	2	...	1	1	...	...	...	1	...	2	18	...	...	...	...
Pb14548	...	3	...	7	...	...	...	2	8	9	5	34	...	1	...	...
Pb14549	...	...	...	1	...	...	...	...	1	...	63	48	...	...	...	...
Pb14550	...	2	...	3	...	...	...	...	1	...	20	38	1	2	1	...

	Monocolpopollenites tranquilloides	Phyllocladidites cf. P.ruei	Pityosporites constrictus	Pityosporites elongatus	Pityosporites grandis	Podocarpidites biformis	Podocarpidites cf. P.decorus	Podocarpidites ornatus	Podocarpidites otagoensis	Podocarpidites sp.	Pristinuspollenites microsaccus	Pristinuspollenites sp.1	Taxodiaceaepollenites hiatus	Zonalapollenites sp.
	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Pb14049	...	...	...	5	...	1	...	...	...	1	...	...	2	...
Pb14051	...	...	...	8	...	5	...	2	1	...	...	...	61	...
Pb14075	...	...	...	...	...	1	...	...	...	...	...	...	4	...
Pb14076	...	...	...	...	...	...	...	...	...	...	...	...	10	...
Pb14077	...	...	...	...	...	...	...	...	...	...	...	...	25	...
Pb14078	...	...	...	...	...	...	...	...	...	...	...	...	4	...
Pb14079	...	...	...	...	...	...	...	...	...	...	...	...	3	...
Pb14080	...	...	...	3	...	...	...	...	...	...	...	...	8	...
Pb14081	...	...	...	...	...	...	...	...	...	...	...	...	14	...
Pb14084	...	...	...	...	...	5	...	...	...	...	...	...	20	...
Pb14085	...	...	...	...	...	...	...	...	...	...	...	...	18	...
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Pb14089	...	...	...	...	...	...	...	...	...	...	...	1	32	...
Pb14090	...	...	...	...	...	...	...	...	...	...	...	...	7	...
Pb14091	...	...	...	...	...	...	...	...	...	...	...	...	5	...
Pb14092	...	...	...	...	...	...	...	...	...	...	...	...	23	...
Pb14110	...	...	...	...	...	...	...	...	...	...	...	...	150	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	3	...
Pb14746	...	...	2	11	...	4	...	1	...	...	...	...	78	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	205	...
Pb14181	...	...	...	3	...	3	...	1	...	...	...	...	15	...
Pb14182	...	...	...	...	...	...	...	...	...	...	...	...	11	...
Pb14183	...	...	...	...	...	...	...	...	...	...	...	...	20	...
Pb14184	...	...	...	...	...	...	...	...	...	...	...	...	9	...
Pb14185	...	...	...	...	...	1	...	...	...	...	...	...	2	...
Pb14213	...	...	...	...	...	...	...	...	...	...	...	...	61	...
Pb14216	...	...	...	...	...	2	...	...	...	...	...	...	2	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	5	...
Pb14737	...	...	...	...	...	...	...	...	...	...	...	...	3	...
Pb14735	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	...	...	...	...	...	1	...	...	...	2	1	...	2	...
Pb14540	...	...	...	...	...	...	...	...	...	...	...	...	3	...
Pb14542	...	...	...	...	...	...	...	...	...	...	...	...	5	...
Pb14733	...	...	...	...	...	...	...	...	...	...	...	...	22	...
Pb14732	...	...	...	...	...	...	...	...	...	...	...	...	66	...
Pb14731	...	...	...	...	1	...	...	...	...	...	...	...	105	...
Pb14729	2	...	1	...	...	...	...	...	...	...	...	...	41	...
Pb14727	...	...	...	...	...	...	...	...	...	...	...	...	28	...
Pb14726	...	...	...	...	...	...	...	...	...	...	2	1	15	...
Pb14547	...	...	...	...	...	...	2	...	...	...	...	...	20	...
Pb14548	...	...	...	...	...	...	...	...	...	...	...	...	46	...
Pb14549	...	...	...	...	...	...	...	...	...	...	...	...	53	...
Pb14550	...	1	...	...	1	...	...	...	...	...	2	...	19	2

ANGIOSPERM POLLEN 1-114

	1 Aesulidites circumstriatus	2 Alabroidaepollenites subtriangulus	3 Alnipollenites quadrapollenites	4 Alnipollenites sp.	5 Alnipollenites trina	6 Alnipollenites verus	7 Annutriporites rotundus	8 Aquilapollenites amplus	9 Aquilapollenites argutus	10 Aquilapollenites augustus	11 Aquilapollenites sp.	12 Aquilapollenites spinulosus	13 Arecipites cf. A.pseudotranquillus	14 Arecipites columellus	15 Arecipites sp.	16 Arecipites sp.1
Pb14049	...	...	...	2	...	3	...	...	...	...	...	...	1	...	...	...
Pb14051	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14075	...	7	...	3	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	4	...	4	...	1	...	...	...	...	...	...	...	...	...	...
Pb14077	...	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...
Pb14079	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14080	...	22	...	6	...	...	...	...	...	...	...	...	...	...	...	...
Pb14081	...	...	...	3	...	...	...	...	...	...	...	...	8	...	...	1
Pb14084	...	...	...	...	...	...	6	...	...	...	...	...	...	...	...	...
Pb14085	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4
Pb14086	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	1
Pb14087	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14088	...	...	...	...	...	2	4	...	...	...	...	...	...	...	...	...
Pb14089	...	2	...	...	1	2	...	...	...	...	...	2	...	...	...	2
Pb14090	...	...	...	1	...	1	3	...	...	...	...	...	...	...	...	4
Pb14091	...	...	...	3	20	...	...	...	...	...	...	...	...	...	...	3
Pb14092	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14110	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14746	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Pb14182	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14183	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14184	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14185	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14213	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	8	...	3	1
Pb14737	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	3
Pb14735	3	...	...	...	6	...	...	...	...	...	...	...	...	...	1	...
Pb14734	...	...	3	...	14	...	...	3	...	...	5	...	...	...	...	...
Pb14540	...	...	...	...	25	...	...	...	...	...	1	...	...	...	5	...
Pb14542	...	...	...	...	15	...	...	...	...	...	1	...	...	...	...	...
Pb14733	...	...	...	...	3	...	...	...	...	...	1	...	1	...	9	...
Pb14732	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14731	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...
Pb14729	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16
Pb14727	...	...	...	1	...	...	...	...	...	...	...	...	3	...	2	...
Pb14726	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Pb14547	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...
Pb14548	...	...	...	...	...	...	...	...	4	...	...	...	...	...	...	...
Pb14549	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	2
Pb14550	...	...	...	2	...	...	...	...	...	...	...	...	3	...	1	10

	17 Arecipites tenuiexinous	18 Brevicolporites colpella	19 Caryapollenites imparalis	20 Caryapollenites inelegans	21 Caryapollenites sp.	22 Caryapollenites sp.1	23 Caryapollenites veripites	24 Caryapollenites wodehousei	25 Caryophyllidites polyoratus	26 Clavatipollenites hughesii	27 Cranwellia rumseyensis	28 Cranwellia sp.1	29 Cupuliferoideapollenites mutabilis	30 Cupuliferoideapollenites parvulus	31 Cupuliferoideapollenites sp.1	32 Dyadonapites reticulatus
Pb14049	...	...	...	3	58	2	16	1	19	...	...	...	...	4	...	...
Pb14051	...	...	2	25	22	...	5	...	3	...	...	...	...	...	...	...
Pb14075	...	...	...	1	6	...	...	...	9	...	...	...	...	...	...	...
Pb14076	...	...	...	1	6	...	...	...	15	...	...	...	...	...	...	...
Pb14077	...	...	23	6	35	5	...	...	2	...	...	...	...	...	...	...
Pb14078	...	...	...	...	...	...	...	...	5	...	...	...	1	...	...	...
Pb14079	...	...	...	...	4	1	...	...	2	...	...	...	...	...	...	...
Pb14080	...	...	...	...	10	3	...	...	14	...	...	...	...	...	...	...
Pb14081	...	...	...	...	4	...	...	...	3	...	...	...	...	...	...	...
Pb14084	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14085	...	...	...	...	1	3	...	...	3	...	...	...	...	...	...	...
Pb14086	...	...	7	...	...	...	...	...	6	...	...	...	...	...	...	...
Pb14087	...	...	1	...	4	2	...	...	2	...	...	...	...	...	...	...
Pb14088	...	...	...	...	5	4	...	...	5	...	...	...	...	1	...	...
Pb14089	...	...	1	...	9	1	2	...	2	...	...	...	2	2	...	...
Pb14090	...	...	1	...	4	...	...	...	4	...	...	...	1	...	...	...
Pb14091	...	...	1	...	3	...	...	1	1	...	...	...	1	...	...	...
Pb14092	...	...	1	...	2	1	...	...	4	...	...	...	...	...	...	...
Pb14110	...	...	...	...	4	...	...	...	2	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...
Pb14746	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14182	3	15	...	...	...	...	...	...	...	...	...	...	...	...	...	11
Pb14183	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14184	16	93	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14185	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14213	...	...	...	...	...	...	...	...	...	...	...	...	6	...	...	...
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14738	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14737	8	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14735	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...
Pb14540	14	...	...	...	...	...	...	...	2	...	...	...	2	...	...	...
Pb14542	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	...
Pb14733	10	...	...	...	...	...	...	...	...	...	1	6	12	11	...	...
Pb14732	21	...	...	...	...	...	...	...	...	...	...	...	4	30	...	10
Pb14731	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2
Pb14729	1	...	...	...	...	...	...	...	...	1	...	...	3	...	3	...
Pb14727	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...
Pb14726	4	...	...	...	...	...	...	...	...	1	...	...	1	3	5	5
Pb14547	...	...	...	...	...	...	...	...	...	...	...	...	4	2	...	...
Pb14548	...	...	...	...	...	...	...	...	...	...	...	...	2	24	6	...
Pb14549	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...
Pb14550	...	...	...	...	...	...	...	...	...	...	...	...	6	6	...	...

	Erdtmanipollis procumbentiformis	Faguspollenites sp.1	Fraxinoipollenites artus	Fraxinoipollenites variabilis	Inaperturotetradites scabratus	Kurtzipites annulatus	Kurtzipites trispissatus	Labraferoidaepollenites dilatus	Libopollis jarzenii	Liliacidites cf. L.complexus	Liliacidites leei	Liliacidites sp.	Liliacidites variegatus	Margocolporites puercoensis	Momipites actinus	Momipites anellus
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Pb14049	...	...	...	...	...	...	...	...	...	...	...	11	...	...	1	...
Pb14051	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14075	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14077	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14079	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14080	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14081	...	...	6	...	...	...	...	...	...	...	...	...	...	...	...	10
Pb14084	...	...	1	3	...	...	...	...	...	...	...	1	...	...	...	...
Pb14085	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14086	...	...	2	2	...	...	...	...	...	...	...	1	...	...	...	...
Pb14087	...	...	2	3	...	...	...	...	...	...	...	...	...	...	...	...
Pb14088	1	25	...	5	...	...	...	...	...	3	...	7	...	...	...	...
Pb14089	...	3	1	1	...	...	...	...	...	...	...	4	...	...	...	2
Pb14090	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...
Pb14091	...	1	...	...	...	...	...	...	...	...	...	2	...	...	...	1
Pb14092	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...
Pb14110	...	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Pb14746	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	...	...	...	2	...	12	...	...	...	...	...	4	...	...	...	5
Pb14182	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	2
Pb14183	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	2
Pb14184	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	2
Pb14185	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9
Pb14213	1	...	7	...	...	...	...	...	...	...	...	...	...	...	...	4
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14737	5	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...
Pb14735	...	...	...	...	...	...	...	...	...	...	...	5	...	...	...	...
Pb14734	...	...	...	...	...	...	3	...	...	...	...	4	...	...	...	...
Pb14540	...	...	...	...	...	...	...	...	...	5	...	...	...	...	...	...
Pb14542	1	...	...	...	...	...	...	...	...	7	...	4	...	...	...	...
Pb14733	...	...	...	...	...	...	...	1	1	7	...	...	...	...	...	...
Pb14732	...	...	...	...	...	...	...	...	...	5	...	1	...	...	...	...
Pb14731	...	...	...	3	4	...	...	...	...	...	...	...	...	...	...	...
Pb14729	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...
Pb14727	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14726	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...
Pb14547	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14548	...	...	...	1	...	...	1	...	...	2	...	...	...	...	...	...
Pb14549	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...
Pb14550	...	...	...	...	...	...	...	1	...	2	2	...	...	1	...	...

	Momipites inaequalis	Momipites leffingwellii	Momipites sp.	Momipites ventifluminis	Momipites waltmanensis	Momipites wyomingensis	Monosulcites scabratus	Monosulcites sp.1	Monosulcites sp.2	Monosulcites tectatus	Myrtaceidites solidus	Myrtipites laqueaeformis	Myrtipites tectus	Nyssapollenites minima	Nyssapollenites pseudocruciatus	Pandaniidites sp.
	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Pb14049	...	...	32	2	...	...	...	...	...	...	...	...	...	...	...	...
Pb14051	...	...	22	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14075	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	...	14	...	...	6	...	...	...	...	...	...	...	...	...	...
Pb14077	...	...	16	...	...	10	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14079	1	...	7	1	...	1	...	...	...	...	...	...	...	...	...	...
Pb14080	...	...	18	3	...	10	...	...	...	...	...	...	...	...	...	...
Pb14081	...	...	29	6	...	...	...	...	...	...	...	...	...	...	...	...
Pb14084	...	...	10	...	11	3	1	...	...	...	...	...	...	...	1	...
Pb14085	...	...	3	...	2	3	...	...	...	...	...	...	...	...	...	...
Pb14086	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...
Pb14087	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14088	...	...	...	1	...	1	...	...	...	...	...	...	...	...	7	...
Pb14089	...	...	28	...	...	14	...	...	...	...	...	...	...	...	...	...
Pb14090	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14091	...	...	7	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14092	...	...	2	...	2	3	...	...	...	...	...	...	...	...	...	...
Pb14110	...	...	8	...	3	...	...	...	1	...	...	...	...	...	...	...
Pb14749	...	...	4	...	2	4	...	...	...	...	...	...	...	...	...	...
Pb14746	...	...	2	...	7	1	...	...	...	...	...	...	...	...	...	...
Pb14745	...	...	1	...	2	...	...	...	...	...	...	...	...	...	...	...
Pb14181	...	8	11	1	9	6	...	...	...	...	1	...	...	2	...	...
Pb14182	...	...	1	...	...	3	...	...	...	...	...	...	...	...	...	...
Pb14183	...	1	6	...	2	...	27	...	...	...	...	...	...	...	...	...
Pb14184	...	2	3	...	...	...	6	...	...	...	...	...	...	...	...	...
Pb14185	...	1	6	...	...	4	...	...	...	...	...	...	...	...	...	...
Pb14213	...	2	23	...	29	49	...	...	...	2	...	...	...	...	...	...
Pb14216	...	2	7	1	1	3	...	...	...	...	...	...	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14737	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1
Pb14735	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14540	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14542	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...
Pb14733	...	...	...	...	...	...	1	...	...	7	...	3	4	...	...	...
Pb14732	...	...	...	...	...	...	...	...	...	...	2	1	3	...	...	...
Pb14731	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14729	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...
Pb14727	...	...	...	...	...	...	3	2	...	3	...	1	...	...	...	...
Pb14726	...	...	...	...	...	...	9	...	...	1	...	8	...	...	...	...
Pb14547	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14548	...	...	...	...	...	...	...	...	...	2	...	11	...	...	...	...
Pb14549	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...
Pb14550	...	...	...	...	...	...	11	...	...	3	...	1	...	1	...	...

	Pandaniidites typicus	Paraalnipollenites sp.1	Pistillipollenites macgregorii	Pistillipollenites sp.	Polotricolporites cf. P. rotundus	Proteacidites retusus	Proteacidites sp.	Proteacidites sp.1	Proteacidites sp.2	Proteacidites thalmanni	Pseudotricolpites reticulatus	Retitrescolpites anguloluminosus	Retitrescolpites sp.	Rousea sp.1	Rousea sp.2	Salixipollenites discoloripites
	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Pb14049	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14051	...	5	6	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14075	...	...	...	43	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	...	28	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14077	...	...	48	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14078	...	...	29	...	2	...	...	...	...	...	...	...	...	...	...	...
Pb14079	...	10	15	4	...	...	...	...	...	...	...	1	...	...	...	...
Pb14080	...	...	25	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14081	...	...	5	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14084	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14085	...	...	91	...	...	...	...	...	...	...	...	...	...	...	1	...
Pb14086	...	...	26	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14087	...	...	15	...	...	...	...	...	...	...	...	...	...	...	2	...
Pb14088	...	...	109	2	...	...	...	...	...	...	...	...	...	...	2	...
Pb14089	...	2	34	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14090	...	...	42	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14091	...	...	13	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14092	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...
Pb14110	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14746	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14745	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	6	...	...	...	...	...	...	...	...	...	...	1	...	...	...	4
Pb14182	9	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...
Pb14183	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14184	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14185	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...
Pb14213	...	...	...	...	...	...	...	...	...	...	1	2	...	...	...	8
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14738	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14737	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14735	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14734	18	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...
Pb14540	21	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14542	10	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...
Pb14733	9	...	...	...	...	24	3	8	...	...	4	2	...	...	...	4
Pb14732	1	...	...	...	...	4	7	...	...	2	3	5	...	...	...	...
Pb14731	11	...	...	...	...	4	2	...	...	4	...	1	...	...	...	...
Pb14729	...	...	...	...	...	4	...	...	1	9	1	1	2	...	...	...
Pb14727	4	...	...	...	...	12	...	...	...	10	1	...	...	...	...	...
Pb14726	2	...	...	...	...	4	...	...	...	4	2	1	...	...	...	...
Pb14547	...	...	...	...	...	5	1	...	...	3	...	...	...	...	...	...
Pb14548	...	...	...	...	...	20	2	...	1	4	...	...	...	2	...	3
Pb14549	...	...	...	...	...	11	...	...	1	8	...	...	...	...	...	11
Pb14550	...	...	...	...	...	8	...	...	1	3	...	11	...	...	...	7

	Siberiapollis montanensis	Simpsonipollis mullensis	Smilacipites echinatus	Smilacipites herbaceoides	Stellatopollis barghoornii	Stephanocolpites fredericksburgensis	Striatopollis tectatus	Striatopollis trochuensis	Subtriporopollenites alpinus	Tiliaepollenites sp.	Tiliaepollenites tetraforaminipites	Tiliaepollenites vescipites	Tricolpites cf. T.parvistriatus	Tricolpites hians	Tricolpites psilascabratus	Tricolpites reticulatus
	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Pb14049	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
Pb14051	...	...	...	...	...	...	...	...	...	...	18	28	...	...	2	...
Pb14075	...	...	2	...	...	...	...	...	...	...	...	2	1	...	...	...
Pb14076	...	...	...	...	...	...	...	...	...	...	6	30	...	...	2	...
Pb14077	...	1	1	...	...	...	...	...	...	...	19	1	...	...	...	...
Pb14078	...	3	...	...	...	...	...	...	...	...	7	1	...	4	5	...
Pb14079	...	...	1	...	...	...	...	...	...	...	...	4	...	...	...	...
Pb14080	...	5	2	...	...	...	...	...	...	...	3	30	...	...	2	...
Pb14081	...	...	...	...	...	...	...	...	...	5	22	12	...	...	...	...
Pb14084	...	...	...	...	...	...	...	1	...	...	...	8	...	1	1	1
Pb14085	...	...	...	...	...	...	...	...	...	...	26	2	...	...	21	...
Pb14086	...	...	...	...	...	...	...	1	...	...	9	10	...	...	4	...
Pb14087	...	...	1	...	...	...	...	...	...	...	10	...	...	...	3	...
Pb14088	...	2	3	...	...	...	...	...	...	...	...	...	...	2	1	...
Pb14089	...	...	2	...	...	...	...	...	...	...	19	5	...	1	...	8
Pb14090	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...
Pb14091	...	...	...	...	...	...	...	...	...	...	4	...	...	...	2	...
Pb14092	...	...	...	...	...	...	...	...	...	34	88	57	...	...	1	...
Pb14110	...	...	2	3	...	...	...	...	...	...	5	12	...	...	1	...
Pb14749	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14746	...	...	1	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14745	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14181	...	...	1	1	...	...	...	1	...	...	...	3	...	5	...	...
Pb14182	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
Pb14183	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14184	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
Pb14185	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14213	...	...	...	...	...	...	...	...	...	...	...	...	...	14	...	1
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
Pb14737	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Pb14735	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	2
Pb14734	...	...	...	...	9	...	...	...	...	...	...	...	...	2	1	54
Pb14540	...	...	...	...	...	...	2	...	...	...	...	...	...	4	...	4
Pb14542	...	...	6	...	...	10	13	...	...	...	...	...	...	2	7	4
Pb14733	...	...	...	...	...	...	...	...	3	...	...	...	...	13	...	3
Pb14732	...	...	...	...	...	...	...	...	7	...	...	...	...	10	...	11
Pb14731	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6
Pb14729	...	...	...	...	1	...	...	...	...	...	...	...	...	16	...	7
Pb14727	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	7
Pb14726	...	...	...	...	...	...	...	...	...	...	...	...	...	9	1	3
Pb14547	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...
Pb14548	...	...	...	...	...	...	...	...	...	...	...	...	...	26	6	2
Pb14549	1	...	...	...	...	...	...	...	...	...	...	...	...	39	4	2
Pb14550	...	...	...	...	1	...	...	...	1	...	...	...	2	21	6	33

	Tricolpopollenites cf. T. levitas	Tricolpopollenites lilliei	Tricolpopollenites microreticulatus	Tricolpopollenites sp.	Tricolpopollenites sp.1	Tricolpopollenites variofoveatus	Triporopollenites plektosus	Triporopollenites sp.1	Ulmipollenites hebridicus	Ulmipollenites krempii	Ulmipollenites planeraeformis	Ulmipollenites sp.	Ulmipollenites sp.1	Ulmipollenites sp.2	Ulmipollenites tricostatus	Ulmipollenites undulosus
	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
Pb14049	...	...	...	...	...	1	...	...	...	5	1	11	...	...	...	5
Pb14051	...	...	...	...	...	3	...	...	...	10	...	...	...	...	5	...
Pb14075	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14076	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...
Pb14077	...	...	...	...	...	30	...	...	5	8	...	8	...	...	11	...
Pb14078	...	...	...	...	...	...	...	...	2	20	...	...	5	...	4	...
Pb14079	...	...	...	...	...	1	3	26	2	...	...	1	...	...	4	1
Pb14080	...	...	...	...	...	2	...	...	...	...	...	2	...	...	15	...
Pb14081	...	...	...	...	...	...	...	...	1	1	...	...	...	...	13	...
Pb14084	...	...	...	...	...	1	1	...	2	...	...	5	1	...	6	...
Pb14085	...	...	6	...	...	1	...	...	1	7	...	10	...	...	15	...
Pb14086	1	...	4	...	...	1	...	...	...	26	...	4	...	...	2	...
Pb14087	2	1	16	...	...	...	1	...	...	6	...	4	3	...	6	...
Pb14088	...	...	1	7	...	4	1	...	...	16	...	...	...	...	1	...
Pb14089	...	...	1	...	...	1	3	...	...	2	...	5	2	...	1	...
Pb14090	...	...	2	...	...	...	...	...	...	14	...	8	...	...	...	...
Pb14091	...	4	...	...	...	1	...	...	19	...	...	15	...	...	9	...
Pb14092	...	...	...	...	...	3	...	...	2	1	...	...	...	...	1	...
Pb14110	...	1	...	...	...	1	5	1	...	6	1	1	...	...	11	...
Pb14749	...	...	...	...	...	1	...	...	...	...	...	3	...	...	...	...
Pb14746	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Pb14745	...	...	...	...	...	7	...	...	...	...	...	2	...	...	...	...
Pb14181	...	...	...	...	...	5	...	...	1	...	...	10	...	...	...	...
Pb14182	...	...	...	...	...	1	...	...	...	...	...	12	...	...	10	1
Pb14183	...	...	...	...	...	...	...	...	...	...	...	5	...	...	13	...
Pb14184	...	...	4	...	...	...	...	...	...	1	...	8	...	...	8	3
Pb14185	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14213	...	...	6	...	...	...	...	...	...	...	...	3	...	...	...	...
Pb14216	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14738	...	...	...	...	...	...	...	...	...	...	...	...	...	8	...	...
Pb14737	...	...	...	...	...	2	...	...	...	...	...	...	...	59	...	...
Pb14735	...	...	...	...	...	...	...	...	3	...	...	5	...	144	...	...
Pb14734	...	...	...	...	...	...	...	...	6	...	...	...	...	3	...	...
Pb14540	...	...	...	...	...	1	...	...	...	12	...	15	...	13	3	...
Pb14542	...	...	...	...	...	6	...	...	...	29	...	28	...	26	21	...
Pb14733	...	...	...	...	...	1	...	...	...	3	...	...	...	...	...	...
Pb14732	...	...	5	...	...	...	...	...	...	1	...	2	...	2	...	...
Pb14731	...	2	...	...	4	...	...	...	...	...	...	...	...	...	1	...
Pb14729	...	4	8	...	5	...	...	...	...	...	...	...	...	...	...	...
Pb14727	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14726	...	...	4	...	...	...	...	...	...	...	...	...	...	...	2	...
Pb14547	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pb14548	...	...	7	...	3	8	...	...	...	...	...	...	...	...	...	...
Pb14549	...	...	21	...	...	...	1	...	...	...	...	...	...	...	...	...
Pb14550	...	...	24	...	...	1	...	...	...	4	...	...	...	4	...	...

	Unknown pollen 1	Utriculites cf. U.visus	
	113	114	
Pb14049	...	...	Pb14049
Pb14051	...	...	Pb14051
Pb14075	...	...	Pb14075
Pb14076	...	...	Pb14076
Pb14077	...	...	Pb14077
Pb14078	...	...	Pb14078
Pb14079	...	...	Pb14079
Pb14080	...	...	Pb14080
Pb14081	...	...	Pb14081
Pb14084	...	...	Pb14084
Pb14085	...	...	Pb14085
Pb14086	...	...	Pb14086
Pb14087	...	...	Pb14087
Pb14088	...	...	Pb14088
Pb14089	...	...	Pb14089
Pb14090	...	...	Pb14090
Pb14091	...	...	Pb14091
Pb14092	...	...	Pb14092
Pb14110	...	...	Pb14110
Pb14749	...	...	Pb14749
Pb14746	...	...	Pb14746
Pb14745	...	...	Pb14745
Pb14181	...	...	Pb14181
Pb14182	...	...	Pb14182
Pb14183	...	...	Pb14183
Pb14184	...	...	Pb14184
Pb14185	...	...	Pb14185
Pb14213	...	...	Pb14213
Pb14216	...	...	Pb14216
Pb14738	...	...	Pb14738
Pb14737	...	...	Pb14737
Pb14735	...	...	Pb14735
Pb14734	...	...	Pb14734
Pb14540	...	...	Pb14540
Pb14542	...	...	Pb14542
Pb14733	...	1	Pb14733
Pb14732	...	...	Pb14732
Pb14731	...	...	Pb14731
Pb14729	...	...	Pb14729
Pb14727	...	...	Pb14727
Pb14726	...	...	Pb14726
Pb14547	1	...	Pb14547
Pb14548	...	...	Pb14548
Pb14549	...	...	Pb14549
Pb14550	...	...	Pb14550

ALGAE AND ACRITARCHS 1-10

	1 Baltisphaeridium multispinosum	2 Baltisphaeridium sp.	3 Diatoms	4 Leiofusa jurassica	5 Micrhystridium fragile	6 Ovoidites ligneolus	7 Pterospermopsis cf. P.eurypteris	8 Schizosporis parvus	9 Unknown alga 1	10 Unknown alga 2	
Pb14049	..	..	..	..	..	4	..	2	..	..	Pb14049
Pb14051	..	..	..	..	..	1	..	4	..	..	Pb14051
Pb14075	..	..	..	..	..	..	..	..	..	..	Pb14075
Pb14076	..	..	..	..	..	..	..	..	..	..	Pb14076
Pb14077	..	..	..	..	..	..	..	..	..	..	Pb14077
Pb14078	..	..	..	..	..	..	..	1	..	..	Pb14078
Pb14079	..	..	..	..	..	..	..	..	..	..	Pb14079
Pb14080	..	..	..	..	..	..	..	..	..	..	Pb14080
Pb14081	..	..	..	..	..	..	..	..	..	..	Pb14081
Pb14084	..	..	2	..	..	..	..	6	..	..	Pb14084
Pb14085	..	..	..	..	..	..	..	..	..	5	Pb14085
Pb14086	..	..	..	..	..	..	..	..	..	..	Pb14086
Pb14087	..	..	..	..	..	..	..	2	..	..	Pb14087
Pb14088	..	..	..	..	..	..	..	2	..	..	Pb14088
Pb14089	..	..	..	..	..	..	..	3	..	..	Pb14089
Pb14090	..	..	..	..	..	..	..	14	..	..	Pb14090
Pb14091	..	..	..	..	..	..	..	11	..	..	Pb14091
Pb14092	..	..	..	..	..	..	..	4	..	..	Pb14092
Pb14110	..	..	..	..	..	..	..	4	..	..	Pb14110
Pb14749	..	..	..	..	..	..	..	..	..	..	Pb14749
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Pb14745	..	..	..	..	..	..	..	..	..	..	Pb14745
Pb14181	..	..	..	..	..	..	..	..	..	..	Pb14181
Pb14182	..	..	..	..	..	..	..	86	..	..	Pb14182
Pb14183	..	..	..	..	..	..	..	13	..	..	Pb14183
Pb14184	..	..	..	..	..	1	..	17	..	..	Pb14184
Pb14185	..	..	..	..	..	..	..	4	..	..	Pb14185
Pb14213	..	..	..	..	..	..	..	1	..	..	Pb14213
Pb14216	..	..	..	..	..	..	..	..	..	..	Pb14216
Pb14738	..	9	..	..	..	33	..	1	6	..	Pb14738
Pb14737	..	..	..	..	..	..	..	..	..	..	Pb14737
Pb14735	..	5	..	..	..	..	..	..	..	..	Pb14735
Pb14734	..	3	..	..	..	1	..	..	..	..	Pb14734
Pb14540	..	10	..	..	..	..	..	..	..	..	Pb14540
Pb14542	..	7	..	..	..	1	..	..	..	..	Pb14542
Pb14733	..	..	..	..	..	..	..	..	..	..	Pb14733
Pb14732	..	3	..	..	..	..	..	..	..	..	Pb14732
Pb14731	..	5	..	..	..	..	..	..	..	..	Pb14731
Pb14729	..	..	..	..	..	..	..	..	..	..	Pb14729
Pb14727	..	..	..	..	..	..	..	..	..	..	Pb14727
Pb14726	..	..	..	..	..	..	..	..	..	..	Pb14726
Pb14547	..	..	1	2	1	..	2	..	..	..	Pb14547
Pb14548	..	..	..	..	..	..	..	..	..	..	Pb14548
Pb14549	10	..	..	..	..	..	..	..	..	..	Pb14549
Pb14550	..	2	..	..	..	..	..	..	..	..	Pb14550

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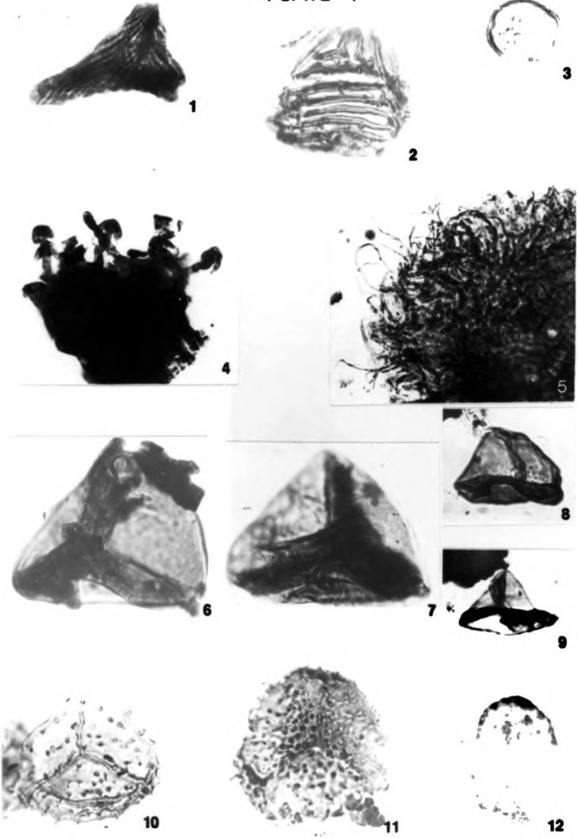

PLATE 2

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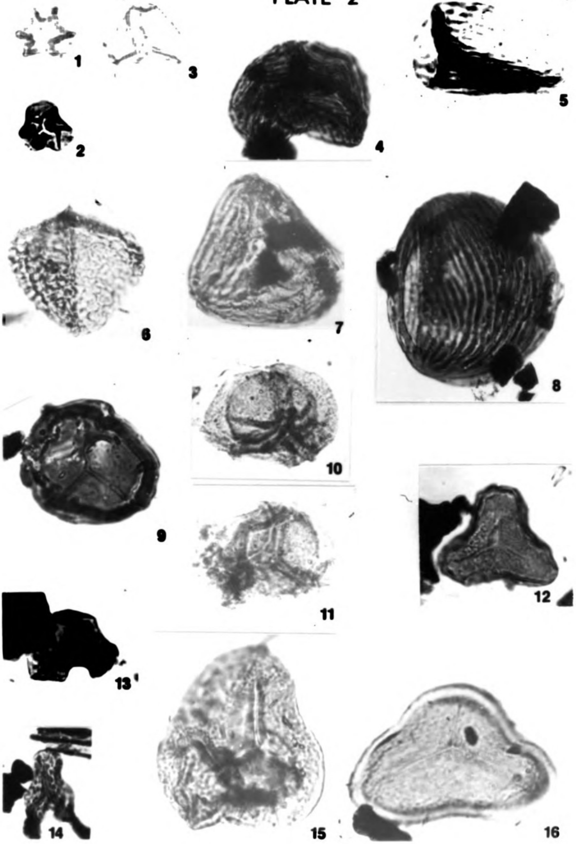
PLATE 2



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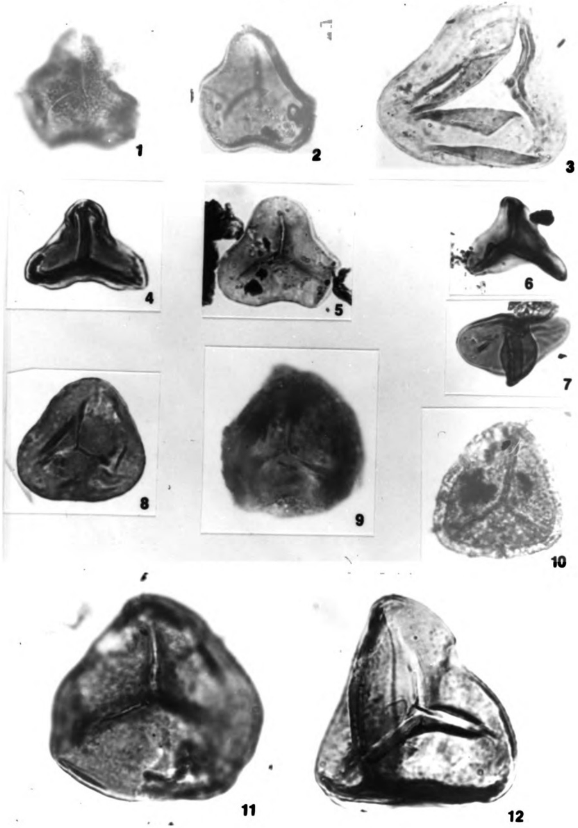

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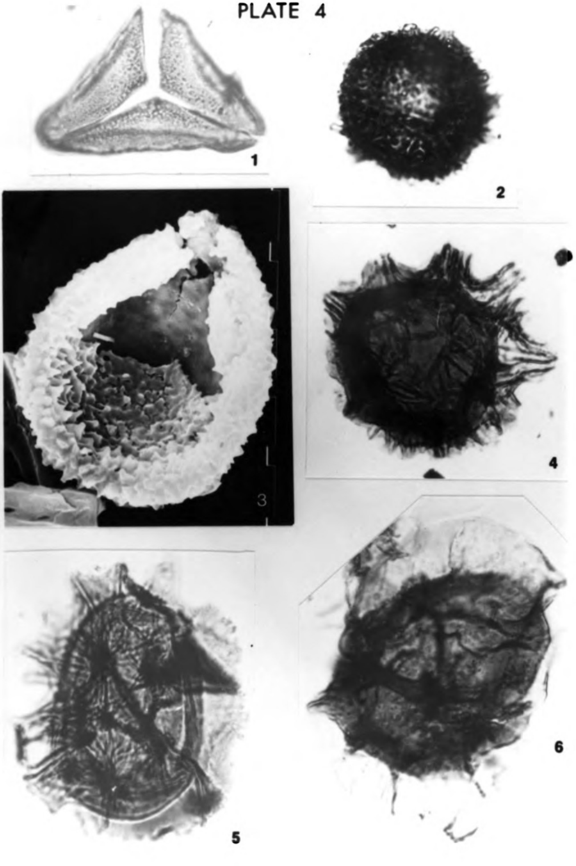

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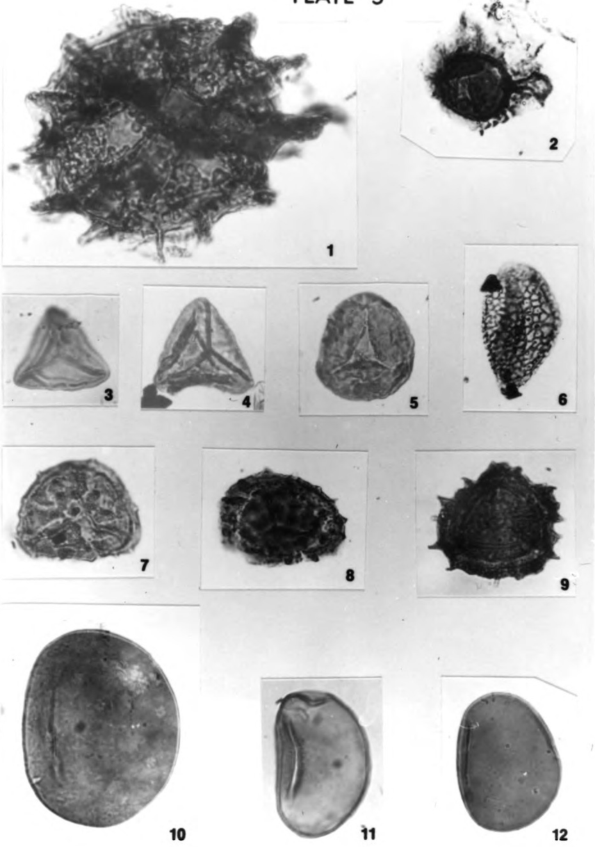

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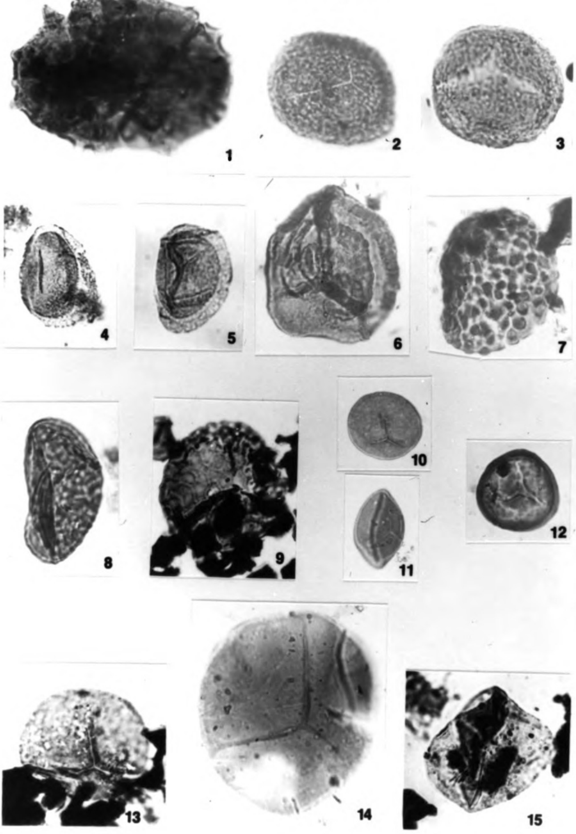

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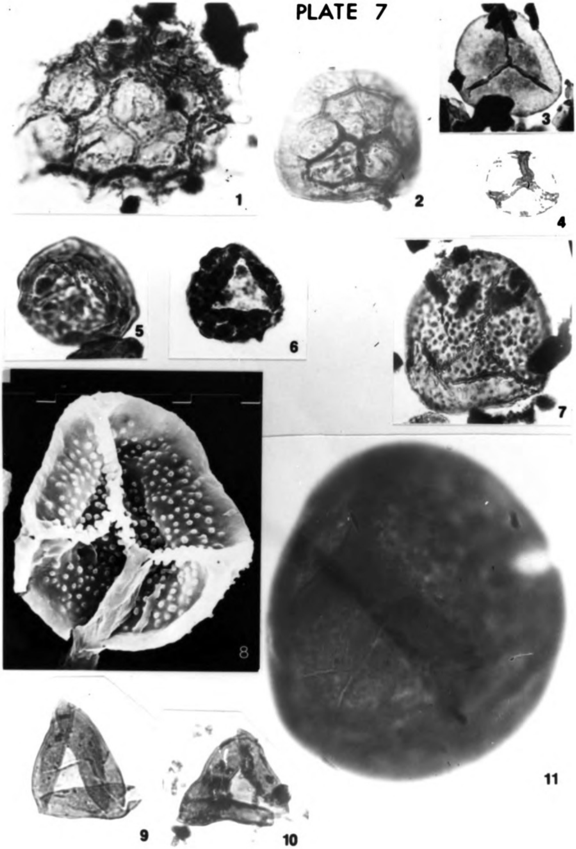

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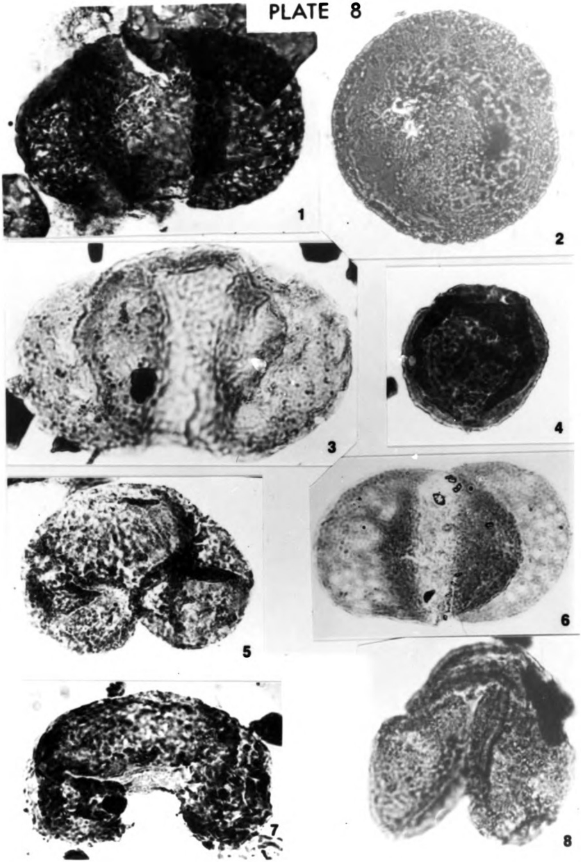

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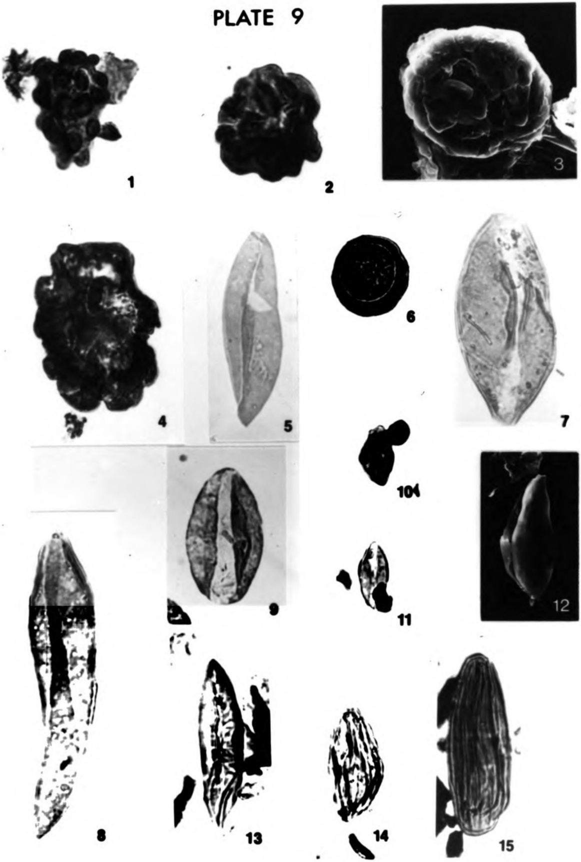

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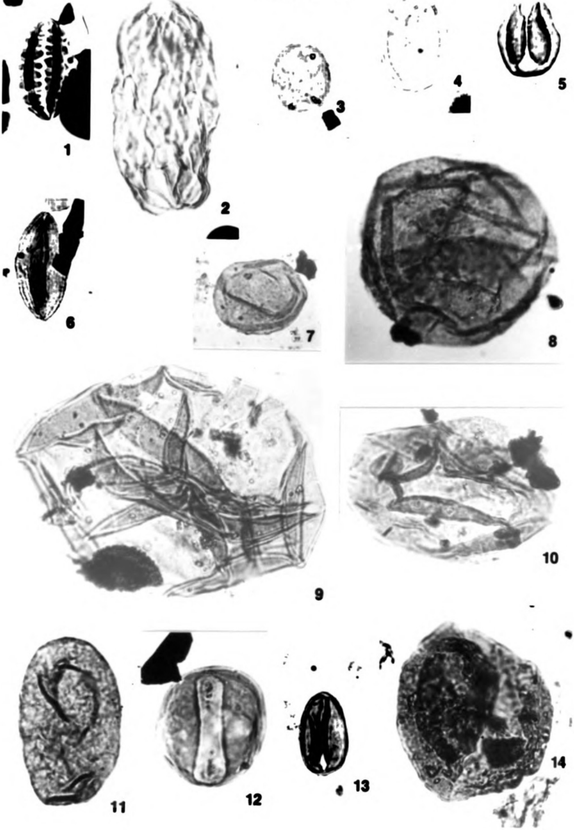

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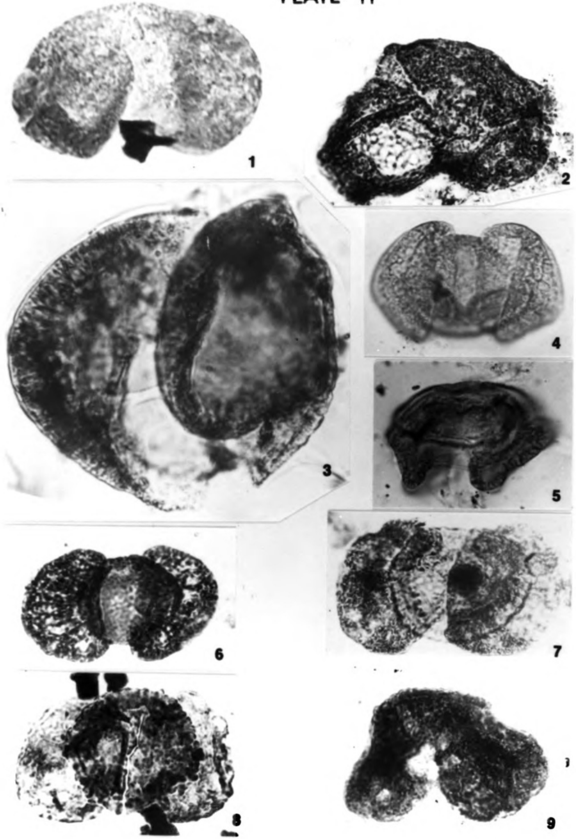

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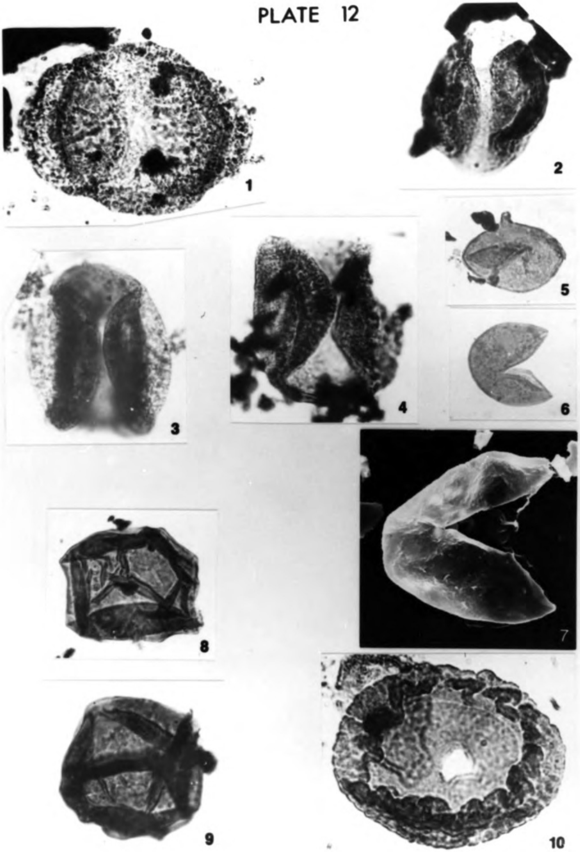

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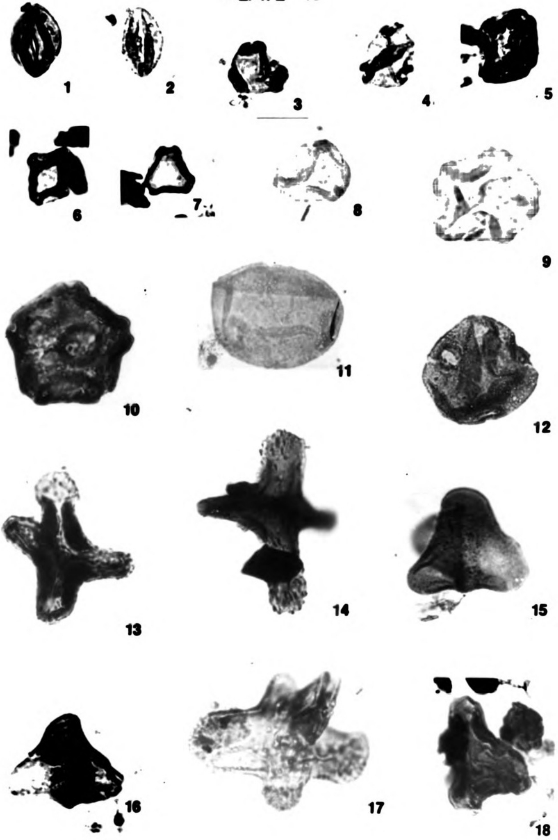

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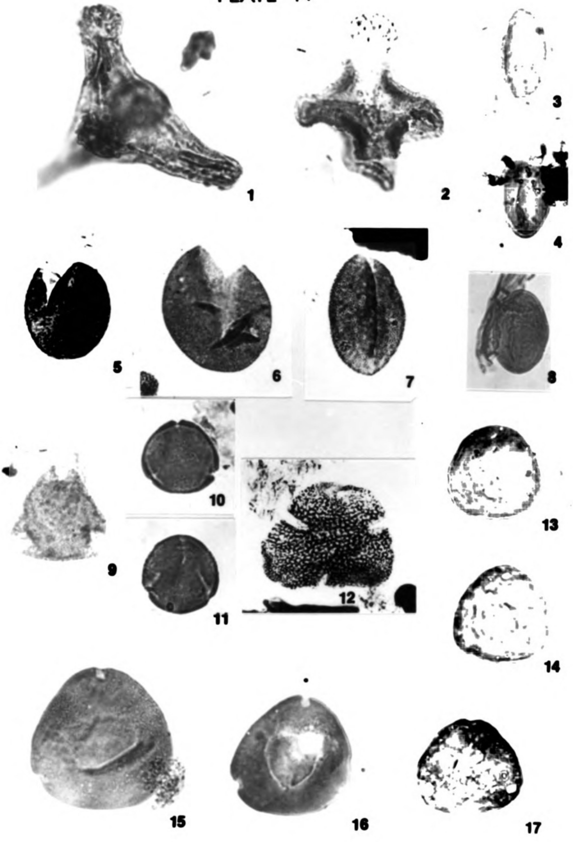

PLATE 15

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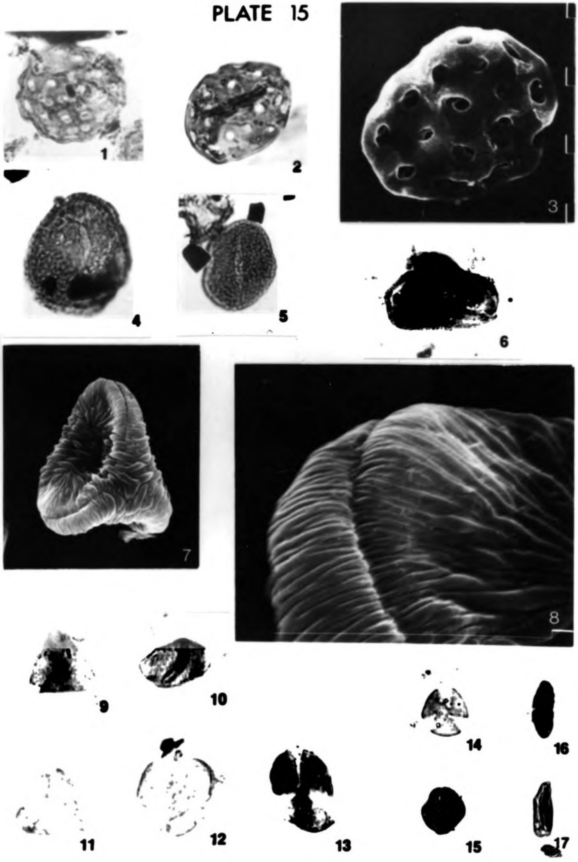

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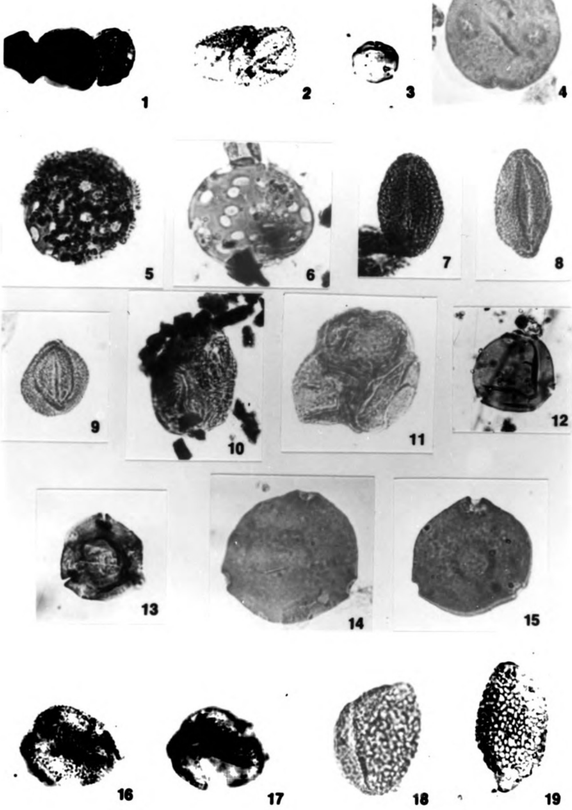

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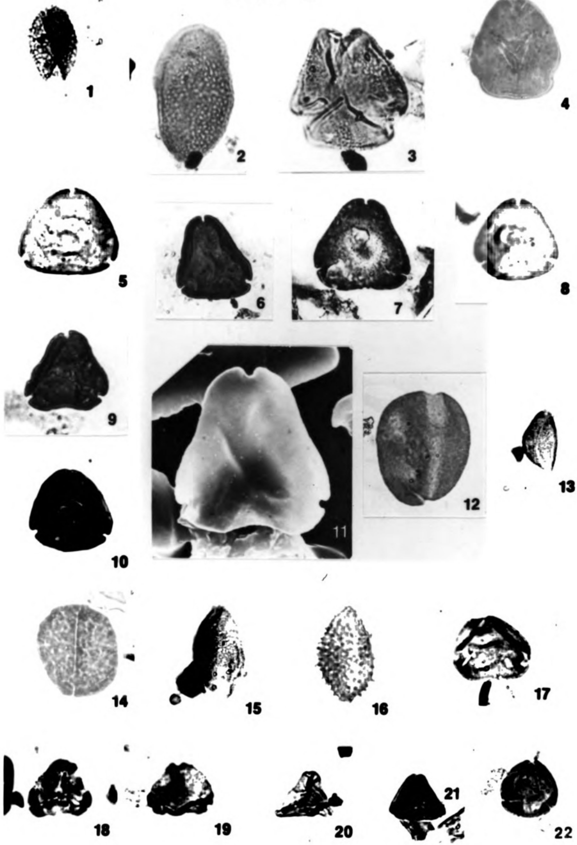
PLATE 17



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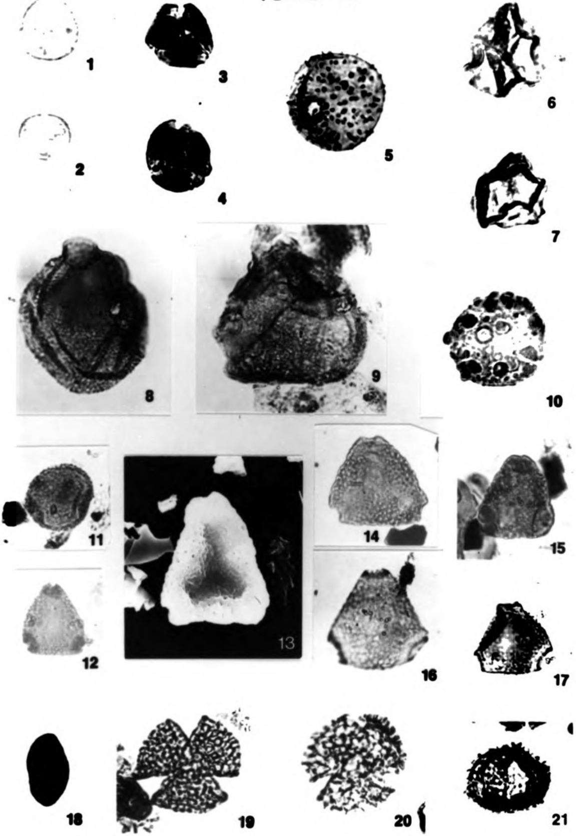

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PLATE 19

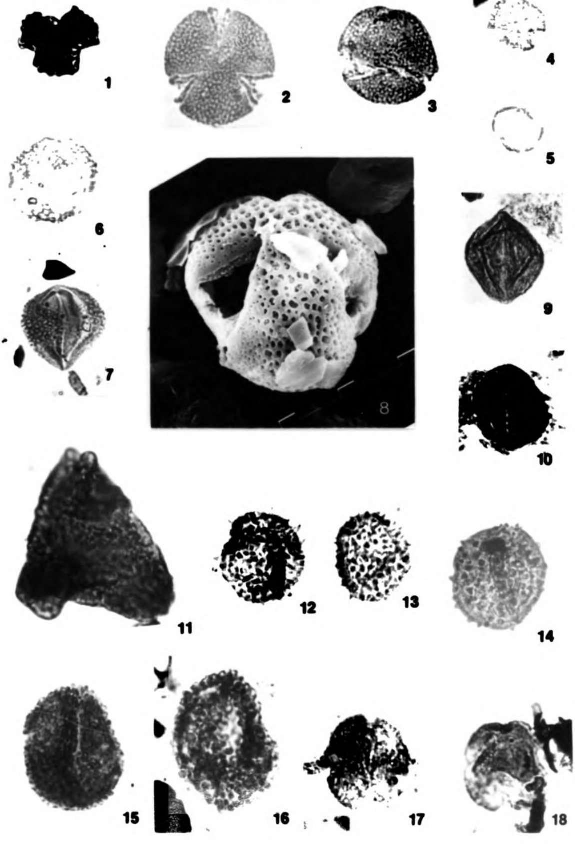

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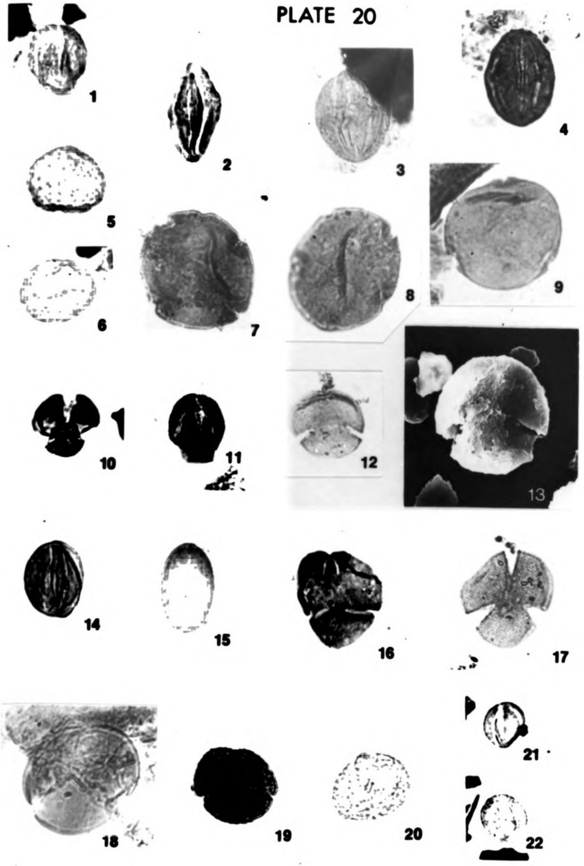
PLATE 20



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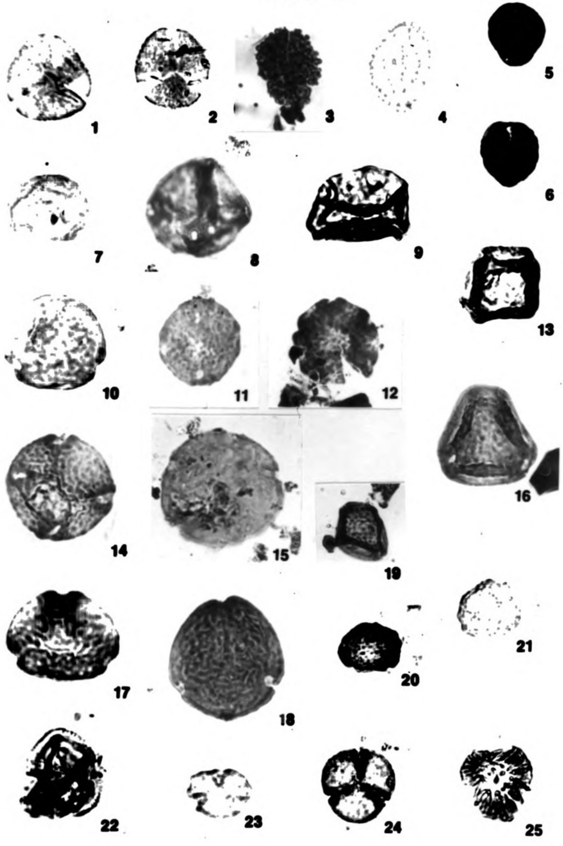

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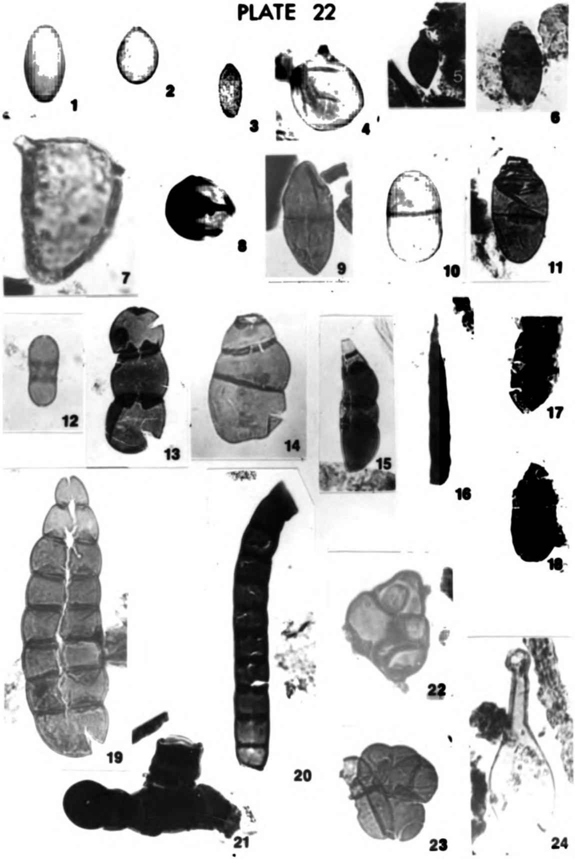

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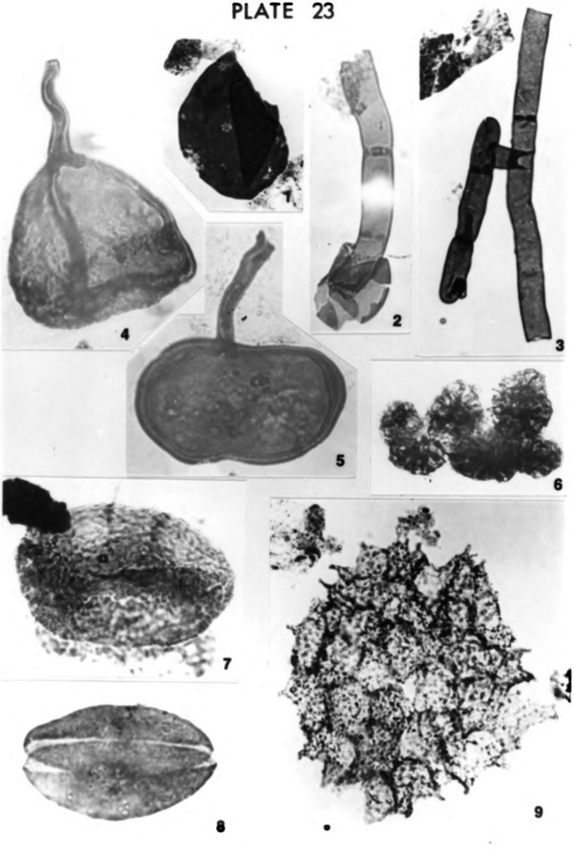

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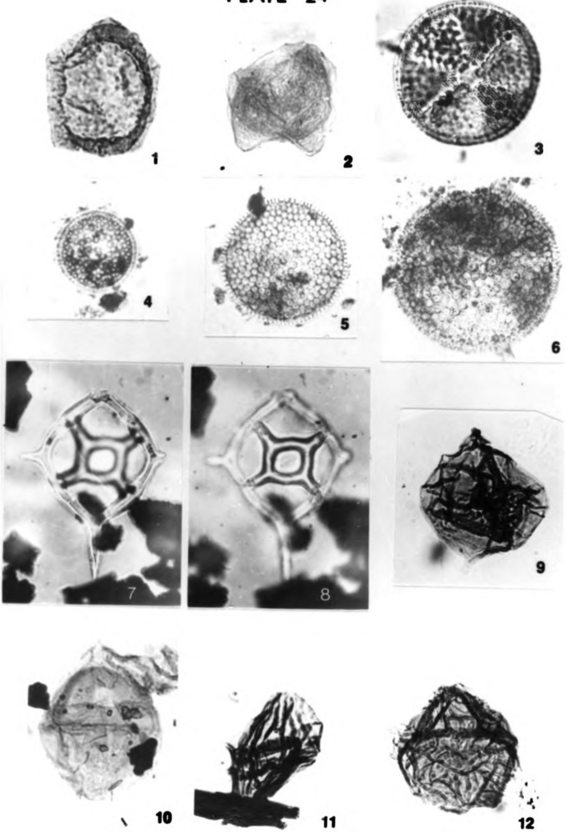

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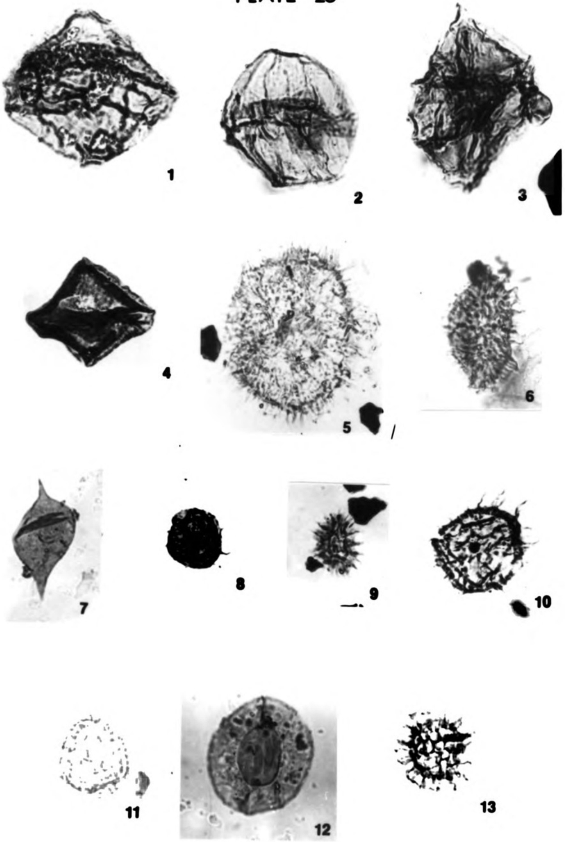

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