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**PALYNOLOGY AND ENVIRONMENTS OF DEPOSITION OF THE
LOWER MENEFEE FORMATION (LOWER CAMPANIAN), SOUTH
HOSPAH, MCKINLEY COUNTY, NEW MEXICO**

presented by

Abolfazl Jameossanaie

has been accepted towards fulfillment
of the requirements for

Ph. D. degree in Geology

Amel J. Cross

Major professor

Date *Aug 5, 1983*



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PALYNOLOGY AND ENVIRONMENTS OF DEPOSITION OF THE LOWER MENEFEE
FORMATION (LOWER CAMPANIAN), SOUTH HOSPAH AREA, MCKINLEY COUNTY,
NEW MEXICO

By
Abolfazl Jameossanaie

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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ABSTRACT

PALYNOLOGY AND ENVIRONMENTS OF DEPOSITIN OF THE LOWER
MENEFEE FORMATION (LOWER CAMPANIAN), SOUTH HOSPAH,
MCKINLEY COUNTY, NEW MEXICO

By

Abolfazl Jameossanaie

Coal-bearing deposits in the South Hospah area were sampled from four core sections for palynological analysis. Two-hundred sixty-three identified palynomorphs indicate a Late Cretaceous (early Campanian) age for these deposits. Four new genera, six new species, eight new combinations, one new rank, and one emended genus are designated.

Palynological, paleobotanical, and sedimentological evidence indicates that the sediments were deposited in lowland fresh-water environments under a maritime, warm-temperate climatic regime of high equability.

A new statistical approach was developed in this study in which Chi-square values calculated from two-by-two comparison of samples were standardized as Similarity Indices (S.I.). The S.I. values were then subjected to cluster analysis to establish the probable plant communities that contributed to the formation of the coal. Environmentally-controlled palynomorph assemblages were identified by examining the stratigraphic distribution and the sedimentological

characteristics of the members of each cluster unit in all four core sections. This criterion resulted in identification of four major palynofloras representing four distinct plant communities.

1 - Bottomland community characterized by a high relative frequency of tricolpate and gymnospermous (mainly Eucommiidites) pollen, restricted to clay- or silt-shales.

2 - Marsh community characterized by a high relative frequency of triporate pollen and gleicheniaceus spores, restricted to the clayey coal and black shale partings of the "Blue" seam.

3 - Taxodium-dominated swamp community characterized by exceptionally high relative frequency of taxodiaceous pollen, restricted to the clayey coal and black shale partings of the "Blue" seam.

4 - A swamp community characterized by exceptionally high relative frequency of Nyssa-type pollen, restricted to a thin coal zone ("Beige/Bronze") above the main ("Blue") seam.

Correlation of cluster analysis data with the sedimentological characteristics and stratigraphic position of the samples indicates that this new statistical approach may be quite useful in assessing community composition and variation in local depositional environments through relatively short stratigraphic intervals.

A major shift in the sedimentological and palynological composition of the samples above the "Blue" coal suggests an alluvial-dominated upper deltaic facies representing progradation of the Menefee delta into the area studied.

To my beloved brother, Manuchehr...

with my deep appreciation of his selfless sacrifices for the
family,

and...

To my dear friend, Jamshid...

a dedicated geologist,

a fine human being.

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Dr. Aureal T. Cross of the Department of Geological Sciences, and the Department of Botany and Plant Pathology, for directing my doctoral program and research, and for giving continuous moral support to me and to my family. Appreciation is also extended to my advisory committee, Dr. Robert L. Anstey and Dr. Chilton E. Prouty of the Department of Geological Sciences, and Dr. Ralph E. Taggart of the Department of Botany and Plant Pathology, for their encouragement and constructive suggestions and criticisms.

I would like to thank Professor Frank Kottlowski, Director, and Dr. Donald Wolbert, Vertebrate Paleontologist, of the New Mexico Bureau of Mines and Mineral Resources and Mr. John Taylor and Mr. John Tilton of the Chaco Energy Company, for providing core samples and facilities for field studies. Drs. Cross and Taggart kindly accompanied me in the field, for which I am very grateful.

Thanks are also due Mr. John Wright for his assistance in sampling cores, Mr. Kurt Kelley for drafting Figures 3 and 4, and Ms. Anne Tanner for typing the manuscript.

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ship and computer time. Generous awards from the Altrusa and Sage Foundations defrayed the cost of preparing this manuscript.

I owe, not only an unreserved appreciation, but a sincere apology to my wife, Fatemeh, and to my sons, Alireza and Javid, for selflessly sharing many hardships with me throughout this endeavor, for silently tolerating my long absences from home, and for devoting their love, care, and affection to me.

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I. INTRODUCTION

Objectives of This Study:

The principle goals of this investigation were to determine the paleoenvironments of coal swamp communities in the South Hospah, New Mexico Area, and to correlate the coal-bearing strata to the established regional stratigraphic sequences by means of palynological analysis.

Systematic descriptions and illustrations of the indigenous palynomorphs are required as the fundamental data base to be evaluated and interpreted to achieve the above goals and to document the geological and paleoecological interpretations. This systematic treatment is also the principal information base required to attain the following objectives:

- Determine the geologic age of this stratigraphic unit based on the palynoflora.
- Compare the palynology of the South Hospah section with other studied sections in the region, and in the western North America in general.
- Determine the nature and composition of the plant communities which contributed to the South Hospah Coal and associated strata, and interpret the paleoecology of these plant communities.

The results of this study should contribute to the knowledge of the Late Cretaceous pollen and spore floras, the source plants of these palynomorphs, and their paleogeographic and stratigraphic distribution.

Pertinent Palynological Studies:

Most of the palynological studies pertinent to the Upper Cretaceous strata of Western North America are summarized in Table 1. Emphasis has been given to biostratigraphic works. Abstracts have not been included. The list is not presumed to be complete. Particularly, many unpublished theses may have been overlooked. Except for general studies and reviews, the localities studied (state or province) have been plotted (Fig. 1). The distribution pattern shows the highest number of studies in Alberta, Montana, Colorado and Wyoming. Also, the age- distribution of the studied units indicates a large number of studies on Cenomanian, Campanian, and Maestrichtian rocks, with fewer for the Turonian, Coniacian and Santonian. This disproportionate distribution of studies geographically and stratigraphically reflects, to some extent, the geographic and stratigraphic distribution of fossil fuel deposits. This apparent unequal emphasis on palynology for different stratigraphic units and areas might be somewhat mitigated if the unpublished and proprietary studies by energy companies could be considered.

From a scientific standpoint, the consequence of this uneven emphasis on palynological studies, both in time and in space, is that precise stratigraphic and geographic ranges of the palynomorphs, particularly at the "local" levels, remains uncertain or unknown. On the other hand, there are always some limits (and hazards!) in extrapolating the time/space ranges of palynomorphs from distant sources. Comparative studies have shown that the stratigraphic range of many angiosperm pollen taxa from the eastern North America and the Rocky Mountain area do not necessarily coincide. Even within the

Rocky Mountain area, the ranges of palynomorphs may differ in different latitudes as a result of differences in environmental conditions, migration patterns, availability of comparable paleodepositional sites, etc.

Only a few palynological studies have been undertaken on the Cretaceous rocks of the State of New Mexico (Fig. 2). The earliest of such publications is the work of Anderson (1960). He studied outcrop samples from the Lewis Shale, and the Kirtland, Ojo Alamo, and Nacimiento Formations in the vicinity of Cuba, San Juan County, New Mexico. He described 88 palynomorphs, including 8 new genera (Bombacacipites, Brevicolporites, Confertisulcites, Intertriletes, Kurtzipites, Navisulcites, Rectosulcites, and Ulmoideipites) and 39 new species. The geologic age of Lewis Shale samples, according to R. Tschudy's interpretation (1980, fig. 2) of palynological data, is Upper Campanian; that of Kirtland Formation, is Maestrichtian; and the Ojo Alamo and Nacimiento Formations are Paleocene.

Sarjeant & Anderson (1969) re-studied some of the dinoflagellate cysts from the uppermost Lewis Shale (Campanian) of New Mexico. R. Tschudy (1973) made a palynological analysis of an 880 foot testhole (Gasbuggy core) from Rio Arriba County, New Mexico. The core was cut through the Nacimiento and Ojo Alamo Formations (Paleocene) which lie disconformably on the Fruitland Formation, the Pictured Cliffs Sandstone, and the Lewis Shale (Upper Campanian). The Kirtland Shale which lies between Fruitland and Ojo Alamo in other areas is missing in this core section, which indicates a local hiatus at the Upper Cretaceous - Paleocene boundary. The entire Maestrichtian and the uppermost part of Campanian (Baculites eliasi zone) are included in

this sedimentary gap, according to Tschudy (1973). He correlated this section with the composite section from the Raton Basin, Colorado, which includes Raton and Vermejo Formations and the upper part of the Trinidad Sandstone. He postulated that the top of Lewis Shale correlates with the Judith River - Bearpaw Shale boundary (Didymoceras stvensoni - Exiteloceras jenneyi boundary).

R. Tschudy (1976a) also studied 9 outcrop samples from the Dilco and Gibson Coal Members of the Crevasse Canyon Formation near Hosta Butte and Crownpoint, McKinley County (T.17 N., R.12 W., and T.16 N., R.12 W.), and one sample from the lowest coal in the Menefee Formation west of Farmington, San Juan County, New Mexico. Based on palynological information, he assigned a Coniacian - Santonian age (Scaphites corvensis through Clioscaphtes choteauensis zone) for these samples and considered the basal Menefee sample to be uppermost Santonian in age.

Zavada (1976) did his Master's thesis on the palynology of Fruitland Formation in New Mexico. This work was not available for examination at the time this study was being undertaken. Delfel (1979) studied the palynology of La Ventana Sandstone for her Master's research. This is a sedimentary "tongue" in the Cliff House Sandstone which was overlain by the Menefee Formation as the sea transgressed in the San Juan Basin in the vicinity of La Ventana, Sandoval County, New Mexico. She assigned a Maestrichtian age to this unit.

Table 1: Major Palynological Studies on the Upper Cretaceous Strata of Western North America.

C o d e	Author	Y	C	T	C	S	C	M	Location	Comments
		e	e	u	o	a	a	a		
		a	n	r	n	n	m	e		
		r	o	o	i	t	p	s		
		m	n	a	o	a	t			
		a		c	n	n	r			
		n								
1	Radforth & Rouse	54	-----						Brit.Colum.	
2	Rouse	56	-----						Brit.Colum.	thesis
3	Tschudy, R.	61	-----						Colo., Wyo.	
4	Newman	61	-----						Colorado	thesis
5	Newman	64	-----						Colorado	
6	Srivastava	67b	-----						general	review
7	Hall	69a	-----						general	Salviniaaceae, megasp. range
7a	Nichols & Jacobson	82	-----						Utah & Wyo.	
8	Penny	69	-----						general	
9	Ryder & Ames	70	-----						Ida., Mont.	
10	Bergad	72	-----						general	Salviniaaceae & Mar-
										sileaceae, megaspores
11	May	72a	-----						Utah	
12	Newman	72	-----						Montana	review, range chart
13	Rouse & Srivastava	72	-----						Canada	
14	Hall	74	-----						general	Salviniaaceae, megaspores
15	Norris et al.	75	-----?						W. Canada	
16	Singh	75	-----						W. Canada	review
17	Tschudy, R.	75	-----						Miss. Embay.	Normapolles
18	Tschudy, R.	76	-----						general	<u>Minerisporites</u>
19	Tschudy, R.	81							general	Normapolles, range chart
20	Melchior	65							Montana	thesis, Up. Cret., age?
21	Pierce	61	-						Minnesota	
22	Hall	63	-						Iowa	megaspores, microspores
23	Hedlund	63	-						Oklahoma	thesis
24	Ellis & Tschudy	64	-						Colorado	<u>Arcellites</u>
25	Hedlund	66	-						Oklahoma	
26	Panella	66	-						Colorado	thesis
27	Agasie & Kremp	67	-						Arizona	
28	Norris	67	-						Alberta	
29	Stanley	67	-						Alaska	
30	Hall & Peake	68	-						Minnesota	megaspores
31	Hedlund	68	-						Oklahoma	
32	Agasie	69	-						Arizona	
33	Hall	71	-						Minnesota	megaspores
34	Romans	72	-						Arizona	
35	May & Traverse	73	-						Utah	
36	Hall	75	-						general	megaspores
37	May	72b	-						Utah, Ariz.	

Continued on next page

Table 1: (continued)

C o d e	Author	Y e a r	C e n t r a l	T e r r i t o r y	C o n t i n u o u s	S t a t e	C o u n t y	M e t r o p o l i t a n	Location	Comments
38	Brown & Pierce	62	---						Texas	
39	Burgess	71	---						Wyoming	
40	Romans	75	---	?					Arizona	
41	Sarmiento	57	-----						Utah	range cf. Tschudy(81)
42	Upshaw	64	-----						Wyoming	zonation
43	Thompson	69	-----						Colorado	thesis
44	Sulkoske	75	-----						Wyoming	thesis
45	Bergad	73	-				----		W.N.Am.	megaspores
46	Griesbach	56	-						Wyoming	thesis
47	Upshaw	59	---						Wyoming	thesis
48	Upshaw	63	---						Wyoming	<u>Aequitriradites</u>
50	Stone	67	-						Texas	
51	Hall	67	-						Montana	megaspores
52	Griggs	70b	-----						Wyoming	thesis
53	Orlansky	71	?----	?					Utah	
54	Tschudy, R.	80	-----						Rockies	Normapolles
55	Tschudy, R.	76	---						N.Mex.	
56	Rouse, et al.	71	-----						Brit.Columb.	
57	McIntyre	74					- -		NW. Territ.	
58	Ames	51					---		Colorado	thesis
59	Hills & Jensen	66					---		Alberta	
60	Morgan	67					---		Oklahoma	thesis
61	Hall	69					---		Montana	megaspores
62	Sarjeant & Anderson	69				??-?			N.Mex.	dinoflagellates
63	Tschudy, B.	69				??-?			Alaska	<u>Aquilapollenites</u>
64	Gunther & Hills	72				---			Alberta	megaspores & seeds
65	Wall & Singh	75				---			Alberta	
66	Delfel	79				? -?			N.Mexico	thesis
67	Lohrengel	70				-			Utah	age after Tschudy, 1980
68	Tschudy, B.	71				-			Montana	
69	Tschudy, B.	73				-			Montana	
70	Zavada	76				-			N.Mexico	
71	Martinez	83?				-			Colorado	thesis
72	Anderson	60				---			N.Mexico	
73	Rouse	62				?---			Brit.Columb.	
74	Leopold & Tschudy, B.	65				---			Wyoming	
75	Newman	65				---			Colorado	thesis
76	Hall	68				---			Montana	megaspores
77	Lammons	69				---			Kansas	thesis

continued on next page

Table 1: (continued)

C o d e	Author	Y e a r	C e n t r a l	T e r m i n a l	C o n f i d e n t i f i c a t i o n	S t a t e	C o u n t y	M e m b e r s h i p	Location	Comments
78	Tschudy, B.	69						---	Alaska	<u>Aquilapollenites</u> & <u>Fibulapollis</u>
79	McLeroy	70						---	California	thesis
80	Tschudy, B. & Leopold	70						---	Rockies	<u>Aquilapollenites</u>
81	Tschudy, B.	70						---	Rockies	<u>Aquilapollenites</u>
82	Kidson	71						---	Colorado	thesis
83	Hall	74						---	general	Salviniaceae, mega- spores
84	Johnson, et al.	80						---	Colorado	
85	Gies	72						---	Colorado	thesis
86	Stone	71						-	Wyoming	thesis
87	Chmura	73						---	California	
88	Stone	73						-	Wyoming	
89	Tschudy, R.	73						---	N.Mexico	
90	Howell	54						-	Colorado	
91	Stanley	60						-	S.Dakota	thesis
92	Funkhouser	61						-	S.Dakota	<u>Aquilapollenites</u>
93	Stanley	61a						-	S.Dakota	
94	Stanley	61b						-	S.Dakota	
195	Tschudy, R.	61						-	Colo., Wyo.	
196	Rouse	62						-	Brit.Colum.	
197	Clarke	63						-	Colorado	thesis
198	Norton	63						-	Montana	thesis
199	Clarke	65						-	Colorado	fungal spores
100	Hills & Weiner	65						-	Brit.Colum.	<u>Azolla</u>
101	Norton	65						-	Montana	<u>Aquilapollenites</u>
102	Srivastava	65						-	Alberta	thesis
103	Stanley	65						-	S.Dakota	
104	Srivastava	66						-	Alberta	
105	Drugg	67						-	California	
106	Hall & Norton	67						-	Montana	
107	Norton & Hall	69						-	Montana	
108	Srivastava	67						-	Alberta	
109	Sriv. & Binda	69						-	Alberta	megaspore, <u>Balmei-</u> <u>sporites</u>
110	Zaitzeff	67						-	Texas	
111	Zaklinskaya	67						-	general	review
112	Binda & Sriv.	68						-	Alberta	megaspores, silici- fied
113	Hall & Swanson	68						-	Minnesota	megaspores
114	Srivastava	68a						-	Alberta	fungal spores
115	Srivastava	68b						-	Alberta	ephedralean pollen
116	Norton & Hall	69						-	Montana	

continued on next page

Table 1: (continued)

C o d e	Author	Y e a r	C e n t r a l	T e r m i n a l	C o o r d i n a t e	S e c o n d a r y	C o n f i d e n t i f i c a t i o n	M a j o r i t y	Location	Comments
117	Oltz	69						-	Montana	numerical analysis
118	Snead	69						-	Alberta	
119	Srivastava	69						-	Alberta	
120	Griggs	70a						-	Washington	
122	Srivastava	70						-	Alberta	
123	Zaitzeff & Cross	70						-	Texas	dinoflagellates
124	Bergad & Hall	71						-	N.Dakota	megaspores
125	Leffingwell	71						-	Wyoming	Cret.-Paleocene boundary
126	Oltz	71						-	Montana	cluster analysis
127	Srivastava	71a						-	Alberta	
128	Tschudy, R.	71						-	Rockies	Cret.-Tert. boundary
129	Rouse & Sriv.	72						-	NE.Yukon	
130	Srivastava	72						-	Alberta	
131	Artzner	74						-	N.Dakota	thesis
132	Robertson	73						-	Montana	<u>Marsypiletes</u>
133	Tschudy, R.	76c						-	Wyoming	Cret.-Tert. bound- ary
134	Lerbekomo et al.	79						-	Alberta	
135	Kumar	83?						-	Texas	thesis
136	Farabee	81						-	Wyoming	thesis



Figure 1 : Location Map of the Previous Palynological Studies on the Upper Cretaceous Strata of Western North America.

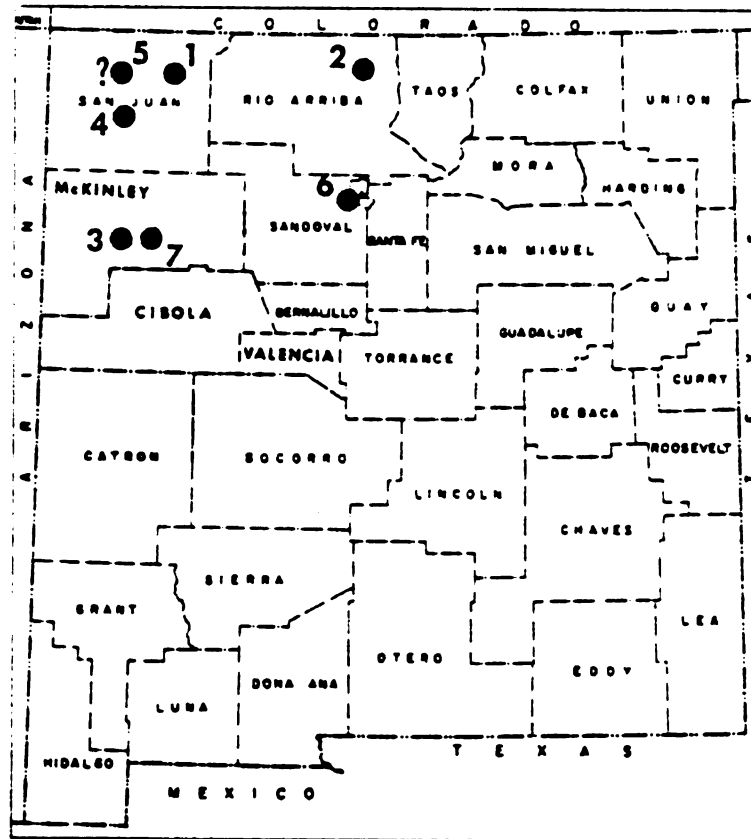


Figure 2: Location Map of the Previous Palynological Studies in New Mexico.

1. Anderson, 1960; Sarjeant & Anderson, 1969.
2. Tschudy, R.H., 1973a.
- 3,4. Tschudy, R.H., 1976a.
5. Zavada, 1976.
6. Delfel, 1979.
7. This study.

II. GEOLOGY

Geologic Setting:

The Rocky Mountain region was partially or completely inundated by the Western Interior Cretaceous seaway from the Middle Albian time through the Late Cretaceous until about mid-Maestrichtian. This epicontinental sea developed as an invasion in a northward direction from the Gulf of Mexico and southward from the Arctic Ocean. The western shoreline trended south-north from western New Mexico through central Utah and southwest Wyoming and western Montana. The broad east flank of the seaway extended to the area of the present Mississippi River (McGookey et al., 1972).

The land east of the seaway was topographically low. It contributed significant quantities of clastics only during Early Cretaceous and Early Cenomanian times (type-Dakota in eastern Nebraska).

The mesocordillera, extending along the west side of the seaway from Mexico through central Arizona, western Utah, and western Montana into Canada, contributed large quantities of sediments to this depositional basin. Because of the dominance of this western source of clastic sediments, rates of sedimentation were greater in the western part of the basin than to the east. Nevertheless, the Upper Cretaceous section on the west flank of the Western Interior Seaway is not complete because of variable rate of subsidence of the basin along this flank.

Deposition of sediments in this basin has been associated with periodic shifting of the sea level which has resulted in four major transgressive and regressive cycles during Late Cretaceous time (Fig. 3). Several explanations for the periodic shifting of the Cretaceous sea level have been proposed.

Contributing factors may be combinations of the following: the rates of epeirogenic subsidence; variations in the amount of orogenic activity and resulting amount of clastics transported to the basin; variation in eustatic sea level, possibly controlled by events outside the Rocky Mountain region; etc. (McGookey, et al., 1972).

The western shorelines were sandy and characterized by chains of barrier bars that separated extensive lagoons and estuaries from the open sea. Sea level and the position of shoreline at a particular geologic time can be interpreted by tracing the lateral extension of these transgressive and regressive coastal sand deposits.

Volcanic activity in the west throughout the Cretaceous Period produced some widespread ash falls which are generally identified as bentonite beds or tonsteins. These and thin carbonate beds deposited over the eastern half of the Cretaceous Seaway provide time markers for correlation. The marine fauna such as foraminifera, pelecypods, and particularly ammonites, found in limestones, shales and sandstones, have been the principal means of correlation in this region.

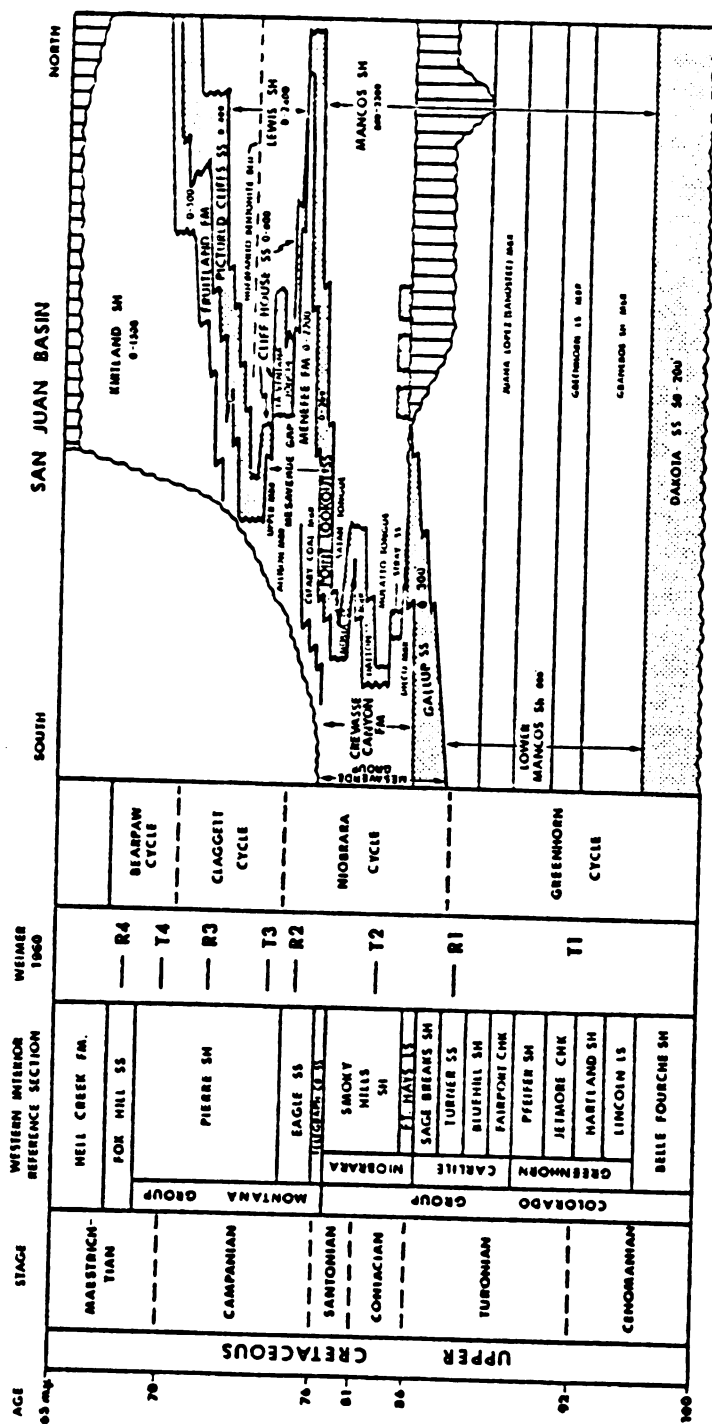
Four major transgressive regressive cycles have been determined in the Upper Cretaceous rocks. They are the Greenhorn, Niobrara, Claggett, and Bearpaw (Fig. 3).

Sedimentological History of the San Juan Basin:

The San Juan Basin is part of the large Western Interior geosyncline. Based on the lateral extent of the rock units, the basin is estimated to have been 100-150 miles (160-240 km) wide.

The entire area of the San Juan basin was subject to erosion

AGE	STAGE	WESTERN INTERIOR REFERENCE SECTION	WESTERN LAND	NUMBER	SAN JUAN BASIN	NUMBER
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during the Albian (Peterson and Kirk, in Fassett et al., 1977, p. 68, fig. 2). Most of the southwestern and southern parts of this basin were also exposed during the entire Early Cretaceous epoch. To the northwest, towards the sea, a regressive sandstone (Burro Canyon Formation) was deposited during the Early Cretaceous epoch (Peterson and Kirk, *ibid.*; Molenaar, in Fassett et al., 1977, p. XII).

Westward transgression of the Cretaceous seaway during the earliest Late Cretaceous time (Cenomanian) covered the entire basin under shallow water and a transgressive sand (the Dakota formation) was deposited disconformably upon the erosion surfaces of the Jurassic Morrison Formation to the southwest and the Lower Cretaceous Burro Canyon Formation to the northeast.

Small scale transgressions and regressions of the sea over the basin during the sedimentation of Dakota Sandstone resulted in the inter-fingering of the marine Mancos Shale with this sandstone which provides the basis for subdivisions of the Dakota into several lithological units locally. Abundant fossils of marine mollusks, mainly pelecypods and ammonites, in all of the units indicate that the entire formation is Cenomanian in age. The same age has been determined by a palynological study by R. Tschudy on the lowermost part of Dakota Formation in the basin (Cobban, in Fassett et al., 1977, p. 213). Further to the west and north in the San Juan basin, and in Arizona, terrestrial coal-bearing beds intertongue with the Dakota Formation. Palynological studies of the Dakota Sandstone outside the San Juan Basin in Arizona (Agasie and Kremp, 1967; Agasie, 1969; Romans, 1972), Utah (May, 1975), Iowa (Hall, 1963) and Minnesota (Pierce, 1961), indicate a similar time span and the wide geographic

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extent of this major transgression over the Rocky Mountain area. This makes up the Greenhorn Cycle, the first of the four major transgressive-regressive cycles in the Western Interior during the Late Cretaceous time (see McGookey et al., 1972, fig. 23).

More extensive transgression of the sea to the southwest resulted in deeper water further from shore in which the marine Lower Mancos Shale was deposited over the entire basin. The deepest marine facies during this invasion of the sea is marked by the Greenhorn Limestone Member in the middle of the lower Mancos Formation. The latest published study of the ammonites by Hook and Cobban (1979) reveals an Early to Late Turonian age for this portion of Mancos Formation in New Mexico. Thompson (1969) studied the palynomorphs of the Mancos Shale in southwest Colorado and suggested a Cenomanian-Turonian age for the lower Mancos Shale.

The regressive phase of the Greenhorn Cycle in San Juan Basin is marked by the deposition of the Gallup Sandstone which is a time-transgressive facies. Its geologic age varies from middle Turonian in the southwest part of the basin to latest Turonian as it migrates to the northwest along with the regressive fluctuations of the position of the shoreline. The Gallup Sandstone terminates in the middle of the basin where the maximum regression of the sea is marked by a general hiatus and an erosional surface as the Greenhorn Cycle was being completed (Fig. 3).

Another major transgression of the sea deposited the upper Mancos Shale on the erosional surface of the Turonian age. This invasion, which marks the second major sedimentary cycle in the Western Interior (Niobrara Cycle), was not as extensive as the first

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one, resulting in the accumulation of extensively terrestrial deposits over a vast area on the west and southwestern margins of the basin.

Considerable coal-bearing sediment (Crevasse Canyon Formation) accumulated in these terrestrial depositional environments. These deposits prograded seaward in concert with the withdrawal of the shoreline to the northeast as the regressive phase of Niobrara Cycle was being completed. The western and southwestern areas of coastal margin environments which were migrating to the northeast along with the retreating strandline were never again completely re-occupied by the sea. The general trend of regression was towards the east and northeast throughout the remainder of Cretaceous time. Although one other major transgressive-regressive pulse is recognized, each re-invasion was less extensive than the preceding transgression. The sea had retreated completely from the basin by Maestrichtian time. Because of this migration of the deltaic and extensive coastal deposits in which the coal-forming peats accumulated, there is a general shift of the principal coal sequences through time from the west (Arizona) towards the east into the San Juan Basin.

The regressive phase of the Niobrara Cycle can be traced by the Point Lookout Sandstone facies which is associated with the coal-bearing terrestrial deposits of Menefee Formation.

The third sedimentary cycle in the region (Claggett Cycle) is identified in the San Juan Basin by the transgressive marine Lewis Shale over part of the continental Menefee Formation. The advancing strandline of the Lewis Sea in the San Juan Basin is marked by the transgressive Cliff House Sandstone and the La Ventana Sandstone

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Tongue associated with it. The retreat of the Lewis Sea can be traced by the regressive Pictured Cliffs Sandstone and the overlying terrestrial deposits of the Fruitland and Kirtland Formations.

The last sedimentary cycle of the Upper Cretaceous in the region (Bearpaw) is not represented in the San Juan Basin because of the complete retreat of the mid-continent seaway from the area. The terrestrial Paleocene Ojo Alamo and Nacimiento Formations are deposited unconformably on an erosional surface of Upper Cretaceous rock units.

Upper Cretaceous Coal-Bearing Formations in the San Juan Basin:

Aside from minor and mostly non-commercial coal beds in the Dakota and Gallup Sandstones, the oldest coal-bearing terrestrial rock unit in the San Juan Basin is known as the Mesaverde Group. The lowest formation in this group is the Gallup Sandstone which is overlain by the coal-bearing Crevasse Canyon Formation. The latter has been differentiated into the lower Dilco Coal Member, the middle Bartlett Member, and the upper Gibson Coal Member.

To the north, the Crevasse Canyon Formation interfingers with the transgressive "Stray" Sandstone, regressive Dalton Sandstone, and Hosta Tongue of the Point Lookout Sandstone. The "Stray" Sandstone was deposited during the transgressive phase of Niobrara Cycle, but the Dalton and Hosta Sandstones are local pulses of the major regressive Point Lookout Sandstone (Fig. 3).

The second major coal-bearing formation of the Mesaverde Group is the Menefee Formation which lies partially on the Crevasse Canyon Formation, but mainly on the regressive Point Lookout Sandstone.

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The Menefee Formation has been divided into a lower Cleary Coal Member, a middle barren Allison Member, and an upper unnamed coal-bearing member.

The Mesaverde Group is capped by the regressive Cliff House Sandstone and the associated La Ventana Tongue, which together partially cover the Menefee Formation.

The most economically significant coal in the region is found in Fruitland Formation (Beaumont, 1968). It is relatively low in BTU content (9000 BTU), but is readily recovered by surface mining.

It should be mentioned that considerable oil has also accumulated in the Upper Cretaceous rocks of San Juan Basin. Lenticular sandstones within the Dakota Formation form large reservoirs for both gas and oil in San Juan and Rio Arriba Counties, New Mexico, and in Montezuma County, Colorado. The Gallup Sandstone, as well as sandstone bodies in Mancos Shale, produce oil in San Juan County and Rio Arriba County. The Point Lookout Sandstone, Cliff House Sandstone, sand bodies in the Menefee Formation, and the Pictured Cliffs Sandstone are gas productive (Reese, 1957).

Geographic and Stratigraphic Position of the Study Area:

The study area is located in the South Hospah Lease, adjacent to and on the western side of the Continental Divide, in the east-central part of McKinley County, New Mexico. It includes Sec. 1 , T.16 N., R.10 W. and Sec. 25-27 and 34-36 of T.17 N., R. 10 W., in Orphan Annie Rock Quadrangle and Laguna Castilla Quadrangle. The area is framed between 107°50' to 107°54' West longitude and 35°52' to 35°40' North Latitude (Fig. 4).

The coal-bearing rocks in the South Hospah Lease area are referred to as "Menefee Coal" by the geologists of the Chaco Energy Company. They claim to have reached the top of the Point Lookout Sandstone in their drillings (oral communication, John Taylor, summer, 1979). One of the published subsurface control points in the neighboring area is the drilling report on Hospah Oil Field, about 12 airline miles NE of the South Hospah area, on the NE cor., Sec. R. 9 W., T. 17 N., McKinley County, New Mexico (King & Wengerd, 1957). This report refers to the exposed beds on the surface as "the Cleary Coal" Member of Menefee Formation.

A well drilled in 1955 penetrated 7,830 feet (2400 m) of Upper Cretaceous, Jurassic, Triassic, Permian and the Pre-Cambrian rocks in this locality. The Upper Cretaceous strata include 2,478 feet (770 m) of Dakota Sandstone, the Greenhorn Limestone and Sanostee Sandstone Member of Mancos Shale, the Mancos Shale, the Hospah Tongue of the Gallup Sandstone, the Crevasse Canyon Formation, the Hosta Tongue of Point Lookout Sandstone, and the Cleary Coal Member of Menefee Formation (Upper Gibson of older nomenclature). The Cleary Coal Member forms the surface outcrop and has a thickness of 200 feet (61 m) in this subsurface section, according to this report. The following table has been taken from King & Wengerd (1957):

<u>Formation</u>	<u>Depth</u>	<u>+Elevation</u>	<u>Thickness</u>
Cleary Member of Menefee Fm.	0	6951'	200'
Hosta Tongue of Point Lookout SS.	200'	6751'	225'
Crevasse Canyon Fm.	425'	6526'	1115'
Hospah Tongue of Gallup SS.	1540'	5411'	360'
Mancos Sh.	1900'	5051'	120'
Sanostee SS. Mem. of Mancos	2020'	4931'	352'
Greenhorn Im.	2372'?	4579'	106'
Dakota SS.	2478'	4473'	266'
Jurassic (Morrison Fm.)	2744'	4207'	

The exposed rocks in the area consist mainly of shale beds and cross-bedded sandstones. The strata dip about 2-3 degrees to the NNE towards the center of the San Juan Basin. Coal seams are exposed locally at the surface.

A layer of shale above the main coal seam ("Blue Coal") contains fossil gymnosperm leaves and stems, including Araucaria and Sequoia, some monocot leaves including palms, and a variety of dicotyledonous leaves. This shale layer has been baked or fired in some spots, apparently prehistoric fires.

A sandstone bed above this shale contains many sandstone concretions associated with vertical tree stumps, abundant araucarian shoots, some palm leaves and roots, and some dicot leaves. Three sites were located where clusters of these concretions are exposed at the surface (Fig. 4).

Two silicified gymnospermous logs were also found at the sandstone level. Their positions have been marked on Figure 4 with asterisks. The leaf collection sites are indicated by arrows.

The paleobotanical aspect of the South Hospah area and the nature of the sandstone concretions with the associated wood and leaves is the subject of a separate study now in progress.

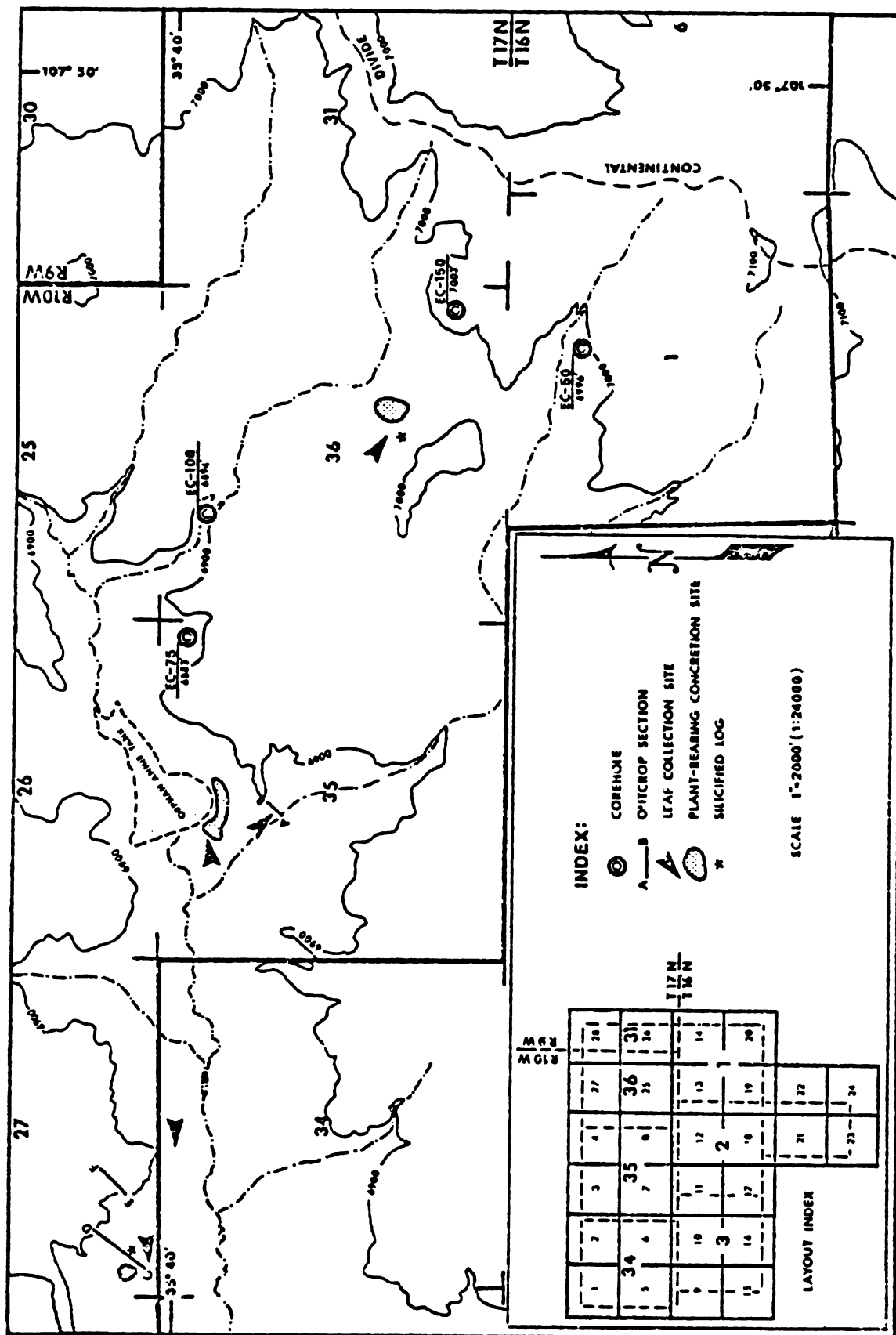


Figure 4: Location Map of the Study Area near South Hospah, McKinley, New Mexico.

III. FIELD AND LABORATORY PROCEDURES

Field Studies:

Two outcrop sections were measured and sampled in the study area. The first section is located in SW 1/4, SW 1/4 Sec. 27, T.17 N. , R.10 W., about 500 ' (150 m) west of 6972' sandstone promontory on the southern slope of a valley where a two-foot (61 cm) coal is exposed, and continued on up to the base of the promontory sandstone with an offset of about 500 ' (150 m) to the east at 6900' (2100 m) level. This section includes 96'7" (30 m) of sediments.

The second section was measured and sampled about 500 ' (150 m) south of Orphan Annie Tank, NE cor., SE 1/4, NW 1/4, Sec. 35, T.17 N., R.10 W., and includes nearly 30' (9 m) of sedimentary rock.

Four core sections with the following positions were also sampled:

EC-75: central point, SE 1/4, NE 1/4, Sec. 35, T.17 N., R.10 W., E 492,000', N 1,697,737'; el. 6884.0' (2095 m).
Total cored section 107'4" (32 m).

EC-100: West-central cor., NW 1/4, NE 1/4, Sec. 36, T.17 N., R.10 W., E 493,900'; N 1,697,612; el. 6892.9' (2098 m).
Total cored section 105' 0" (31 m).

EC-150: East-central point SE 1/4, SE 1/4, Sec. 36, T.17 N., R.10 W., E 497,000'; N 1,693,600'; el. 7008.0' (2103 m).
Total cored section 159' 9" (48 m).

EC-50: North-central cor., SW 1/4, NE 1/4, Sec. 1, T.16 N., R.10 W., E 495,613'; N 1,691,513'; el. 6996.2' (2099 m).
Total cored section 53' 11" (17 m).

The cored sections include a total of 233' (72 m) of subsurface rocks in

the South Hospah area. The location of outcrop sections and core-holes are shown on Fig. 4.

Sample Preparation Techniques:

It is desirable to apply a uniform technique of maceration for all samples treated in a single project in order to minimize the differential effects of chemical and physical processes on the heterogeneous assemblage of palynomorphs which may eventually result in statistical biases. However, the several lithologic types of rocks containing the palynomorphs exhibit quite different reactions to the chemical and physical treatments involved, and it is not possible to prepare all samples uniformly and extract all of the organic entities with equal quality or representation.

It is also preferable to expose the entrapped palynomorphs to the least chemical processing possible. The following simple technique proved to be fast, efficient, and appears to result in freeing most of the entrapped palynomorphs with a minimum of damage. It was relatively effective on almost all the South Hospah samples.

1- Place sample on waxed weighing paper spread upon a sheet of paper towel. Fold the waxed paper and the paper towel to cover the sample. Crush the sample by gentle pounding with a porcelain pestle; avoid powdering.

2- Mix the crushed sample by rolling the edges of the paper towel from all directions. Take a representative aliquot from the crushed pile, 2.5 g for coal and black shales, 5 to 10 g for dark-gray shale to light-gray shale and siltstone.

3- Transfer the sample to a labeled 100cc plastic centrifuge

tube and place the tube in crushed ice under a fume hood. Cover the sample with 50 cc of 49% cold HF. Stir frequently with a plastic stirring rod during the first hour. Stop any violent reaction by adding distilled water or 70% ethanol. Allow to stand for 12-24 hours.

4- Stir well, centrifuge, and decant the supernatant fraction. Wash once with 10% HCl and twice with distilled water.

5- Place the tube under the hood and gradually add 50 cc commercial strength (5.25%) cold sodium hypochlorite NaOCl (Trade name Clorox) with vigorous stirring. Stop any violent reaction by adding distilled water.

6- The sample should remain in the sodium hypochlorite solution just long enough for change of color (to a lighter shade) to appear which is the result of oxidation and bleaching of organic material. Fill the tube with distilled water and centrifuge immediately. Repeat washing with distilled water until the supernatant solution is clear. At this stage the palynomorphs are free and clean in most samples. Black shales and coal samples may need the following additional treatment:

Mix the residue in the tube with water and let stand for 30 seconds to allow the large pieces to settle out; collect the top portion in another labelled tube. Repeat the bleaching process on the large portion (steps 5 and 6) until a sufficient volume of residue is disaggregated and cleaned. Intermittent use of 5% KOH in the same manner accelerates the disaggregation process and dissolves a large portion of any vitrain present.

7- Add a few drops of 10% NH_4OH to each sample and stain the

palynomorphs with a few drops of 0.1% aqueous Safranin O.

Mix well and let stand for 2-3 minutes. Dilute with distilled water and wash until clear. (If red stain is too intense it may be partially cleared by washing in ethyl alcohol.)

8- Collect the residue in 6.75 cc screw-cap glass vials and cover with 1.5% HEC. (Hydroxyethyl Cellulose. Fisher Scientific Co., 34401 Industrial Road, Livonia, Michigan 48150).

Some of the more woody and/or highly vitrified coals did not respond to the above treatment. They were treated with a standard Schultz solution on a steam table for 15 minutes followed by a quick wash with 5% KOH.

Slide Preparation:

The presence of both very large and very small particles in the palynological residues is a nuisance in microscopic preparations. Very large particles are usually plant tissue fragments, cuticles, megaspores, seeds, and large dinoflagellates. They tend to cover the small and medium sized grains over a considerable portion of the coverglass area, and make the counting and identification difficult. Very fine particles include shredded organic structures and mineral matter (particularly silt-sized silica and clay minerals) which range in size from a fraction of a micrometer up to 5 μ m. They tend to "mask" the surface features by aggregation around or being deposited on the palynomorphs. The following technique proved successful for the preparation of slides from the South Hespah residues and resulted in considerable improvement in the quality of photographs:

1- Screen the residue thru a 177 μ m sieve to trap most of the

large material including large cuticles, megaspores and seeds.

Store the two fractions in separate labelled vials.

2- Allow the fine-fraction of the residue to settle in the vials on a surface free from vibration or disturbance for 24 hours. Uncap each vial gently, and carefully siphon off the supernatant fraction. This portion contains most of the unwanted, very fine particles. Repeated microscopic examination of these particles has indicated the absence of any small pollen grain or fungal spores. A considerable amount of the very fine-size particles can be normally removed by repeating this settling and decanting procedure (3 to 4 times).

3- Take up a few representative drops of the fine-fraction of the residue and dilute with distilled water in order to get the proper density or consistency for a properly dispersed preparation. The amount of distilled water varies for different residues and can be judged only by experience. The mounting procedure is as follows:

a. Take up a representative sample of the diluted residue with a pipette and put a few drops on each of the cover slips for the number of slides desired; place each on a slide warmer. Spread the residue over the entire surface of each coverslip with a toothpick or a thin glass rod made for this purpose. Allow the mounted residues to dry completely.

b. Pick up each cover slip and place it on a slightly raised stand (two sticks or toothpick mounted on a cardboard can be used for this purpose). Put 1-3 drops of mounting medium on the side of the cover glass with the adhering residue (both HSR and Clearmount have been used in this study). Hold a labelled microscope slide

upside down and lower it toward the cover slip in an oblique angle until it touches the mountant on the cover glass and picks up the glass. Center the cover slip on the slide and force out occasional air bubbles by gentle pressure on the cover slip.

c. Let the slide dry, right side up, for a few days at room temperature.

For making extra slides exclusively for photographic and identification purposes, the remaining diluted residues were screened thru a 44 μ m (325 Tyler mesh) sieve and slides made from both fractions, marking the sieve-size-ranges on the slides. Large microspores and pollen grains were isolated by this treatment and very good photographs were made possible.

Single mounts were made of the megaspores and seeds by hand-picking specimens from the coarse fraction of the residues (larger than 177 μ m), which was placed in a watch-glass, under a binocular dissecting microscope. Such palynomorphs were picked using a dissecting needle. They were then placed in a drop of HEC on a microscope slide and mounted after drying.

Procedures for Microscopic Study:

Prior to statistical evaluation of the assemblages, many microscopic slides were surveyed in a search of all the taxa making up the palynomorph assemblages in the South Hospah samples. This preliminary examination made possible the differentiation of most of the palynomorph taxa present in the samples. All examples of palynomorph taxa were photographed, using a Leitz Orthomat automatic

camera attached to a Leitz Ortholux microscope. Index cards were made for each of the 1600 photographs which were compiled for aiding in identification and literature search. Three prints were made from the negatives to be used on index cards and plates. The photographs were taken on Kodak Panatomic-X (ASA 32) film. The film was developed in Kodak Dektol developer, and fixed in Kodak Fixer. The prints were made on Kodabromide F-2, F-3, and F-4 paper and were developed in Kodak D-76 developer. The coordinates of the photographed specimens were recorded using the calibrations on the mechanical stage of the Leitz microscope number 591962, located in the Palynology Laboratory, Department of Geology, Michigan State University. The coordinates refer to the position of each grain in a slide mounted on the stage of microscope when the label is positioned to the left of the viewer. The coordinates of the upper left corner of the cover slip (as observed at the center of stage by the lowest magnification) were registered on each slide as a reference point to be used for relocation of the palynomorphs with other microscopes or in case the stage adjustment of the same microscope is changed by other users.

A sum of 300 identifiable palynomorphs was counted from each sample. This sum was predetermined by plotting the number of palynomorphs counted on the X axis against the number of new taxa encountered on the Y axis. A sample with a large number of taxa is usually selected for this purpose. A "best fitting" curve was then constructed through the resulting points. This curve usually has a sharp ascending component with a decrease in slope at a certain point. The sum (the value on the X axis) that lies to the right of

the sharp change in slope on the curve would normally include most of the taxa in the sample. This technique was first proposed by Wilson (1959), and has been explained frequently in the literature (Tschudy, 1969). It is not elaborated here. In order to follow a uniform pattern of observation and eliminate any bias, a set of random horizontal traverses were set up to be utilized for counting of palynomorphs on all microscope slides. A random number table was used for this purpose. In each traverse, no more than 100 grains were counted. Additional slides of the same sample were counted if the total of 300 was not reached by counting along 7 traverses in the first slide.

176 samples of coal and associated rocks from the South Hospah subsurface and outcrop sections were prepared for palynological analysis using the above-mentioned techniques. 94 samples contained sufficient spores and pollen for statistical study. A diverse assemblage of palynomorphs were differentiated, most of which were well-preserved. All of the black clay-shales and clayey coals and most of the dark gray clay-shales in these sections are highly productive. Light gray clay-shales are mostly barren or with very few palynomorphs. Very few palynomorphs were obtained from some of the pure coal layers. The absence or scarcity of palynomorphs in some of the coals is probably attributable to coal which contains a high percentage of wood as vitrain and/or fusain.

A total of 263 types of palynomorphs were differentiated from the South Hospah samples (Appendix A). The number of spores and pollen genera and species assigned to each major botanical group is summarized in Table 2:

Table 2: Number of Major Taxonomic Groups in South Hospah Assemblages.

<u>Botanical Group</u>	<u>Number of Genera</u>	<u>Number of Species</u>
angiosperms	31	75
gymnosperms	20	42
ferns	43	71
lycopods	10	12
bryophytes	7	18
algae	5	9
fungal spores	-	26 morphotypes
trichomes	-	10 morphotypes
Total		265

IV. SYSTEMATICS AND DESCRIPTION OF FOSSILS

Introduction: The palynomorphs recovered from the South Hospah samples have been described systematically according to their inferred affinity with the major taxonomic groups of plants. The systematic arrangement of the families, orders, classes and divisions in this treatment is according to their inferred evolutionary rank as arranged in botanical texts such as Scagel et al. (1965), Bierhorst (1971), and Taylor (1981). The genera and species described under each major taxonomic group have been arranged alphabetically. The forms with unnown affinity have been treated as incertae sedis. Where applicable, these types of palynormorphs have been arranged morphologically. For the dicot angiospermous pollen, morphological categories, i.e., tricolpate, tetracolpate, tricolporate, triporate, and polyad have been used. This partially taxonomic and partially morphologic approach in the systematic classification of dispersed fossil palynomorphs has been utilized in some publications such as Couper (1953, 1958), Singh (1964, 1971) and Pocock (1962, 1964).

DIVISION EUMYCOPHYTA (True Fungi)

Fungal Spore Type A

Plate 1, fig. 1

Description: Unicellate, aseptate, inaperturate, psilate fungal spores with circular outline and spherical shape. Wall single-layered, rigid, and usually without folding.

Occurrence: Late Mississippian to Recent (Elsik, unpublished). It is commonly found in Lower Campanian of New Mexico.

Measurements: 3-15 um.

Figured specimen: Pb12460-1 (119.0x37.9)

Fungal Spore Type B

Plate 1, figs. 2-4

Description: Unicellate, aseptate, psilate, monoporate fungal spores with spherical shape and circular amb. Pore simple, wall single-layered, about 1/2 um. Position of the pore is random because of random orientation of the grain in the process of compression.

Comments: Figure 4 shows a germinating spore, perhaps either an inaperturate (Type A) or a monoporate (Type B) fungal spore.

Occurrence: Early Carboniferous, Maestrichtian to Recent (Elsik, unpublished). This form occurs rarely in the Lower Campanian of New Mexico.

Measurements: 8-15 um.

Figured specimens: Pb12387-1 (124.4x33.9); Pb12394-1 (125.8x36.7); Pb12439-1 (110.2x36.9).

Fungal Spore Type C-1

Plate 1, fig. 5

Description: Unicellate, aseptate, psilate, monoporate fungal spores with a tear-drop shape, and annulate, apical pore. Wall single-layered, rigid, and about 1/2 μm thick; wall gradually thickens from the mid-cell towards the pore where it measures about 2/3 μm .

Comments: The position of the pore is always apical. No specimen with folding was found. Forms described by Clarke (1965) from the Upper Cretaceous Vermejo Formation of central Colorado as monoporate fungal spores (Lacrimasporonites levis) were found by Elsik (unpublished) to have a basal attachment scar and so they are not of the type described above.

Occurrence: Maestrichtian-Recent (Elsik, unpublished). A few grains of this type were found in the Lower Campanian of New Mexico.

Measurements: 11-14 x 8-9 μm ; 6-8 x 9-14 μm in Elsik (1968); 5-8 x 8-12 μm in Sheffy and Dilcher (1971).

Figured specimen: Pbl2342-8 (116.6 x 44.9)

Fungal Spore Type C-2

Plate 1, fig. 6

Description: Unicellate, aseptate, tear-drop shaped, apically monoporate fungal spores with psilate, single-layered wall of ca. 1 μm thickness. The apical pore positioned at the end of a short neck of ca. 1.5 μm length. Surface ornamented by fine scabrae.

Comments: The presence of a short neck and the finely-scabrate surface is characteristic of this type.

Occurrence: A single grain of this type was found in the Lower

Campanian of New Mexico.

Measurements: 20 x 11 μm .

Figured specimen: Pb12439-1 (123.6x40.2).

Fungal Spore Type D-1

Plate 1, fig. 7

Description: Unicellate, aseptate, sub-apically diporate fungal spores with elliptical outline. Wall smooth, $1/2 \mu\text{m}$ thick; pores apical, small, rounded, simple, non-protruding. One of the pores displaced slightly to the side of the long axis.

Comments: This form is distinguished by the sub-apical, small, non-protruding, simple pores and outline of the cell.

Occurrence: Only a few specimens of this type were encountered in the Lower Campanian of New Mexico. Diporate solitary fungal spores have been reported from Maestrichtian to Recent (Elsik, unpublished).

Measurements: 15 x 8 μm .

Figured specimen: Pb12387-2 (125.8x40.2)

Fungal Spore Type D-2

Plate 1, fig. 8

Description: Unicellate, aseptate, apically diporate, psilate fungal spores; pores polar, non-protruding, and simple; shape cylindrical with rounded ends which are truncated by the pores. Wall distinctly two-layered, each layer ca. $1/4 \mu\text{m}$ thick.

Comments: This form differs from the others by symmetrical shape around the long axis and apical, non-protruding pores.

Occurrence: Spores of this general morphology (Type D-1 to D-6) are

found from Maestrichtian to Recent (Elsik, unpublished). These are common forms among the fungal spores in the Lower Campanian of New Mexico.

Measurements: 7 x 14 um.

Figured specimen: Pb12387-1 (125.7x30.9).

Fungal Spore Type D-3

Plate 1, figs. 9,10

Description: Unicellate, aseptate, apically diporate, psilate fungal spores; both pores annulate, protruding, and polar in position. Wall single-layered, ca. 1 um thick. Shape fusiform, symmetrical around the long axis.

Comments: This form is distinct by symmetrical fusiform shape, and apical, annulate, protruding pores.

Occurrence: A commonly occurring form among the fungal spores in the Lower Campanian assemblage of New Mexico. Diporate forms of this general morphology (D-1 to D-6) have been reported from Maestrichtian to Recent (Elsik, unpublished).

Measurements: 14-17 um.

Figured specimens: Pb12516-1 (125.6x29.4); Pb12458-1 (119.0x38.7)

Fungal Spore Type D-4

Plate 1, figs. 11-14

Description: Unicellate, aseptate, psilate, diporate fungal spore with two apical, annulate pores. One of the pores slightly protruding. Shape ellipsoidal, irregular around the long axis, protruding more on one side and almost parallel to the axis on the

other side. Wall thickness variable, up to 1.5 μm , differentiated into two distinct layers.

Comments: This form is distinguished by two annulate apical pores (one of which is protruding), and its asymmetrical shape around the long axis. There is a wide range of morphological variation among the individuals of this group in terms of the degree of protrusion of the pores and their deviation from the polar position.

Occurrence: A common form among the fungal spores in the Lower Campanian assemblage of New Mexico. Spores of this general morphology (D-1 to D-6) have been reported from Maestrichtian to Recent (Elsik, unpublished).

Measurements: 12-17 x 8-9 μm .

Figured specimens: Pb 12516-1 (125.6 x 28.9), Pb12387-1 (129.2x38.1), Pb12516-1 (115.9x35.3 & 112.6x28.5).

Fungal Spore Type D-5

Plate 1, fig. 15

Description: Unicellate, aseptate, diporate, psilate fungal spores with a pear-shaped outline. Wall ca. $1/3 \mu\text{m}$ thick; pore very small, inconspicuous.

Comment: The pear-shaped outline is distinctive in this type.

Occurrence: Only a few grains were encountered in the Lower Campanian of New Mexico.

Measurements: 15 x 11 μm .

Figured specimen: Pb12518-1 (125.5 x 27.8).

Fungal Spore Type D-6

Plate 1, fig. 16

Description: Unicellate, aseptate, apically diporate fungal spores with irregularly granulate surface and polar, simple pores that cut a low depression on the outline of the cell. Shape ellipsoidal and symmetrical around the long axis.

Comments: This form is characterized by having a granulate surface.

Occurrence: Only one grain was encountered in the Lower Campanian of New Mexico.

Measurements: 20 x 15 um.

Figured specimen: Pb12387-1 (125.7x30.9).

Fungal Spore Type E-1

Plate 1, fig. 17

Description: Cylindrical, unicellate, aseptate, diporate fungal spore; one pore located on the flat end of the cell and the other on the opposite side along the long axis of the cell on the convex end. Pores small and simple. The pore on the flat side seems to be a septal pore or an attachment scar. Wall less than 1/2 um thick, ornamented by irregular, low verrucae.

Occurrence: This grain was found only occasionally in the Lower Campanian of New Mexico.

Measurements: 13 x 7 um.

Figured specimen: Pb12516-1 (117.9x27.2).

Fungal Spore Type E-2

Plate 1, figs. 18,19

Description: Unicellate, aseptate, apically diporate, elongated

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cylindrical (tube-shaped) fungal spores. Pores polar and simple, located at the center of the truncated polar areas. Wall single-layered and psilate.

Comments: These forms are unique in their morphology. The nature of pores in Figure 18 suggests that this cell may have detached from a chain of similar cells connected to it from both ends. An internal outline in the same specimen suggests the cytoplasmic contents in the cell. Figure 19 shows an irregularity in the width of the grain.

Occurrence: Four specimens of this type were found in the Lower Campanian assemblage of New Mexico. This form has not been reported elsewhere, and may be new.

Measurements: 5-7 x 25-33 μm (4 specimens).

Figured specimens: Pb12458-1 (125.5x45.9); Pb12387-2 (126.3x40.8).

Fungal Spore Type F

Plate 1, fig. 20

Description: Dicellate, monoseptate, di-aperturate fungal spores. Apertures in the form of longitudinal furrows along the axis of the grain, non-apical on individual cells. Septum very thick (3 μm), grain slightly constricted at the septal area. Shape fusiform; individual cells ellipsoidal.

Comments: This form is distinguished by its furrow-type aperture as opposed to pores in other aperturate forms.

Occurrence: Only a single grain was encountered in the Lower Campanian samples studied from New Mexico. Fungal spores with two or more cells and non-apical furrows have been previously reported from Late Paleocene to Recent (Elsik, unpublished).

Measurements: 17 x 7 μm .

Figured specimen: Pb12520-1 (112.6x38.9).

Fungal Spore Type G

Plate 1, fig. 21

Description: Dicellate, monoseptate, diporate, psilate fungal spore with a 2- or probably 3-layered wall. Pores small, annulate, and located towards the center of each cell. One cell slightly larger than the other. Individual cells circular in outline.

Comments: This form is distinguished by non-apical pores and relatively very thick wall.

Occurrence: Only one grain of this type was encountered in the Lower Campanian of New Mexico.

Measurements: 16 x 10 um.

Figured specimen: Pb12516-1 (125.5x25.6).

Fungal Spore Type H-1

Plate 1, figs. 22-23

Description: Dicellate, monoseptate, diporate fungal spores. Pores apical, annulate, non-protruding. Outline elongated, elliptical, slightly indented at septum. Wall 1.2 um thick, surface psilate.

Occurrence: This spore type was found in only one sample from the Lower Campanian of New Mexico. Spores of this morphology have been reported from Albian to Recent (Elsik, unpublished).

Measurements: 30-37 x 11-12 um (5 specimens).

Figured specimens: Pb12520-1 (112.6x24.0, 119.0x26.8)

Fungal Spore Type H-2

Plate 1, figs. 24-25

Description: Dicellate, monoseptate, apically diporate fungal spores. Pores annulate, non-protruding. Outline of the spore barrel-shaped with no indentation at septum. Wall single-layered, ca. 1/3-1/2 um thick, and psilate.

Comments: This form is shorter but wider than the spore type H-1. Also, it is not constricted at the septal area.

Occurrence: Rarely found in the Lower Campanian of New Mexico. This spore type has been previously reported from the Upper Cretaceous Vermejo Formation by Clarke (1965). Elsik (unpublished) determined a Paleocene?-Eocene to Recent range for this spore type.

Measurements: 19-24 x 10-15 um.

Figured specimens: Pb12439-1 (115.9x32.5), Pb12449-1 (122.9x39.7).

Fungal Spore Type H-3

Plate 1, fig. 26

Description: Similar to type H-2, except for larger size and thicker, multiple-layered wall (1.5 um).

Occurrence: A single grain was encountered in the Lower Campanian of New Mexico. The stratigraphic range has been given from Albian to Recent by Elsik (unpublished).

Measurements: 46 x 30 um.

Figured specimen: Pb12513-1 (124.6x29.0).

Fungal Spore H-4

Plate 1, fig. 27

Description: Dicellate, monoseptate, diporate, psilate fungal spores. Pores apical, rounded, annulate, protruding. Outline fusiform.

Comments: This spore type is different from other type H spores by having fusiform outline and protruding pores.

Occurrence: Found rarely in the Lower Campanian of New Mexico. This form is considered to range from Albian to Recent (Elsik, unpublished).

Measurements: 39 x 16 μm .

Figured specimen: Pb12487-1 (119.0x32.0).

Fungal Spore Type I

Plate 1, figs. 28-31

Description: Tetracellate (tetrad?), inaperturate fungal spores.

Individual cells rounded, of unequal size (generally two cells larger than the other two), arranged in a tetragonal tetrad form. Wall relatively very thick (1-1.5 μm), double- or multiple-layered, scabrate to granulate.

Occurrence: Found in one sample from the Lower Campanian of New Mexico. It seems that similar forms have not been reported previously. Involutisporonites (?) sp. in Elsik (1968a) may be similar to this form.

Measurements: 21-25 μm . Individual grains 7-15 μm .

Figured specimens: Pb12516-1 (113.1x34.0; 115.2x39.0; 112.5x35.7).

Fungal Spore Type J

Plate 2, figs. 1-13

Description: Multicellate, multiseptate, inaperturate, uniserial fungal spores. Amb clearly indented at septal areas. Adjacent cells connected by a small septal pore at the center of each septum.

Septal pore may or may not be detectable. The septa may be seen as unbroken, thick partitions between the cells, depending on the degree of compression, thickness of septa, and rigidity of cell walls (Plate 2, figs. 4-6, 9), or they may have a v-shaped rupture at the center with the septal pore located at the tip of the "V" (Plate 2, figs. 1-3, 7, 8, 10-13). Individual cells normally globular, but may be compressed (probably due to differential developmental conditions), and different in thickness. The terminal cells usually much thinner than other cells. These cells are usually broken (Plate 2, fig. 5) or completely detached and removed from the chain. In this case, the spore may look like a monoporate or diporate type with one or two terminal pores (Plate 2, figs 1, 2, 4, 6, 7, 9), but a septal trace or scar may be detected on the terminal cell that indicates detached and missing cell or cells.

The thin, terminal cells may occasionally have been preserved (Plate 2, figs. 8, 12, 13). The chain of cells may be straight (e.g., Plate 2, fig. 12), crooked (e.g., Plate 2, figs. 4, 7, 13), or coiled (Plate 2, figs. 10,11). Figures 1 and 2 on Plate 2 show chains of cells with end cells of the chain missing from both ends. The V-shaped rupture remains on the terminal cells. The original chain in Fig. 2 must have been crooked because the detachment scar on the upper cell is not aligned with the long axis of the spore. Figure 12 illustrates a gradual thinning of the cell wall towards the distal (?) end of the chain.

Comments: There are some variations in the wall thickness and general morphology of the specimens grouped into this type and they may belong to more than one spore type.

Occurrence: This spore type is occasionally found in samples from the Lower Campanian of New Mexico, but it is abundant in samples Pb12513 and Pb12518 (both samples are coaly shales from corehole # EC-100). This general spore group has been reported from Campanian to Recent (Elsik, unpublished).

Measurements: 20-65 x 13-16 μ m.

Figured specimens: Pb12476-1 (125.5x23.4), Pb12518-1 (111.4x30.6), Pb12518-1 (125.8x33.9), Pb12518-1 (121.4 x 42.1), Pb12513-1 (117.3x34.0; 109.2x29.9; 112.5x28.6), Pb12518-1 (117.3x28.1; 121.2x39.0; 119.0x27.5; 110.0x37.9), Pb12513-1(111.3x28.8), Pb12518-1 (125.4x40.8).

Fungal Spore Type K

Plate 2, fig. 14

Description: Multicellate, uniserial, multiseptate fungal spores. Septal pores very small. Individual cells different in outline; the proximal (?) cell larger, others decrease in size sequentially distally. Spore outline slightly indented at the septal areas.

Comments: Terminal pore or pores are not detectable in this form. The distal (?) cell shows a septal pore and thus indicates missing cell or cells.

Occurrence: Found very rarely in the Lower Campanian of New Mexico.

Measurements: 30 x 13 μ m.

Figured specimen: Pb12382-9 (117.4x35.0)

Fungal Spore Type L

Plate 2, fig. 15

Description: Multicellate, multiseptate, uniserial, inaperturate fungal spore; amb tube-shaped, straight with only occasional slight indentation at the septal points. Wall ca. 0.5 μ m thick, scabrate.

Occurrence: Occurs rarely in the Lower Campanian of New Mexico.

Measurements: 27 x 8 μ m.

Figured specimen: Pb12439-1 (112.8x31.6).

Fungal Spore Type M

Plate 2, fig. 16

Description: Multicellate, multiseptate, uniserial, fungal spores. Individual cells tetragonal; amb with no indentation at the septal area. Central cells large, decreasing in size towards the ends. Terminal pores undetectable.

Comments: The inconspicuous pore at the upper end of figure 16 is a septal pore and indicates a missing cell.

Occurrence: Occurs rarely in the Lower Campanian samples of New Mexico.

Measurements: 42 x 8 μ m.

Figured specimen: Pb12449-1 (119.0x35.1).

Fungal Spore Type N

Plate 2, fig. 17

Plate 3, figs. 1, 2

Description: Monoporate, multicellate, multiseptate, uniserial fungal spores arranged in a straight chain. Pore subapical, small, simple, and located on the terminal distal end. The proximal end is characterized by an attachment scar. Wall ca. 0.5 μ m thick, scabrate. Individual cells barrel-shaped, slightly indented at the

septal areas.

Comments: It is impossible to decide on the presence and the position of the terminal pores when dealing with broken specimens of this type, except by comparison with complete specimens. Figure 17 in Plate 2 illustrates a uniquely complete specimen of this type with a terminal pore. Figures 1 and 2 in Plate 3 are broken and so the nature of pores is uncertain.

Occurrence: Forms occurring commonly in the Lower Campanian of New Mexico. This form ranges from Campanian to Recent (Elsik, unpublished).

Measurements: 54-62 x 8-9 um.

Figured specimens: Pb12402-4 (113.9x43.5), Pb12520-1 (112.5x26.6).

Fungal Spore Type 0

Plate 3, fig. 3

Description: Inaperturate, multicellate, multiseptate, biserial fungal spores. The proximal side is divided into two branches of uniseriably arranged cells. Arrangement of the cells in the main body of spore is alternate. Wall 0.5-1 um thick, psilate, slightly indented at the septal areas.

Comments: This form is unique among the chain-like spores in being biserial and by forking of the cells at the proximal end.

Occurrence: Only a single grain was found in the Lower Campanian of New Mexico.

Measurements: 71 x 16 um; branched base 42 um wide.

Figured specimen: Pb12485-3 (113.8x40.1)

Fungal Spore? Type P

Plate 3, fig. 4

Description: An ellipsoidal body of irregularly-arranged cells with granulate outer wall.

Occurrence: A single specimen of this type was found in the Lower Campanian of New Mexico.

Measurements: 47 x 35 um.

Figured specimen: Pb12513-1 (120.8x28.8).

DIVISION CHLOROPHYTA (Green Algae)

Genus Ovoidites Potonie 1951 ex Krutzsch 1959

1959 Ovoidites Krutzsch, p. 249 (cf. Jansonius and Hills, 1976, p. 1841)

Type Species: Ovoidites ligneolus Pot. ex Krutzsch., *ibid.*

(designated by Krutzsch, *ibid.*).

Comments: There is no clear distinction between the genus Ovoidites, as described by Krutzsch (1959), and the genus Schizosporis Cookson and Dettman, 1959. These two forms are probably congeneric.

Ovoidites ligneolus (Pot., 1931) Th. & Pf., 1953

Plate 3, figs. 5, 6

- 1931 Pollenites ? ligneolus Pot., pl. 2, fig. V25a.
- 1953 Ovoidites ligneolus (Pot.) Thomson & Pflug, p.
- 1965 Ovoidites ligneolus (Pot.) Th. & Pf. in Stanley, p. 316,
pl. 32, figs. 12,13.

Description: See Stanley (1965).

Comments: B. Van Geel and Van der Hammen (1978, p. 387, pl. 4, fig. 46) discussed the affinity of Ovoidites with some species of Spirogyra of Zygnemataceae of the chlorophyta (green algae).

Occurrence: A few grains of this form were found in the Lower Campanian of New Mexico. It has been reported from Maestrichtian of NW South Dakota by Stanley (1965). Van Geel & Van der Hammen (1978, p. 377) gave a range of Carboniferous to Recent for the species of the genus Ovoidites (Spirogyra).

Measurements: 43 x 27 um. B. Van Geel and Van der Hammen, (1978, p. 387) gave a size range of 72-133 x 40-75 um for the Quaternary equivalent of this form.

Figured specimen: Pb12387-2 (127.7x34.6).

Genus Palambages O. Wetzel 1961

Type Species: Palambages morulosa O. Wetzel, 1961

Comments: Spherical colonies of spheroidal, membranous, thin-walled cells have been assigned to this genus. They resemble colonial green algae and have been affiliated with them by some authors.

Palambages sp. 1

Plate 3, fig. 7

Description: A spherical colony of uniform globular cells. Cell

walls ca 1 μ m thick. Surface scabrate. The number of cells in the colony exceeds 80.

Comments: The specimen illustrated here closely resembles the ones described by Singh (1971, p. 429, pl. 80, figs. 5-6) as Palambages Form A Manum and Cookson, except for the size. Singh noted in that report, however, that the size of the colony of Palambages and the number and size of the cells in it are extremely variable within the same species.

Occurrence: Albian and Upper Cretaceous of Australia and Canada (Singh, 1971). It also occurs in Campanian to Maestrichtian of NW Colorado (Gies, 1972), Maestrichtian of SW Texas (Zaitzeff, 1967), and Lower Campanian of New Mexico.

Measurements: 67 μ m (individual cells ca. 10-12 μ m). 118 (124) 130 μ m in Singh (1971).

Figured specimen: Pb12401-9 (114.4x37.2).

Palambages Sp. 2

Plate 3, fig. 8

Description: An irregular colony of spheroidal, inaperturate, very thin-walled, psilate, folded cells.

Comments: P. cf P. deflandrei in Thompson (1969, p. 46, pl. 12, fig. 3), P. Forma A in Stone (1973, p. 49, pl. 1, fig. 3), and P. sp. 1 (Gies, 1972, p. 231, pl. 16, figs. 12, 13) seem to be comparable to this form.

Occurrences: Turonian-Maestrichtian. Turonian to Santonian of SW Colorado (Thompson, 1969), Upper Campanian-Maestrichtian of NW Colorado (Gies, 1972), Lower Campanian of New Mexico.

Measurements: 40 x 55 um; individual cells 15-18 um.

Figured specimen: Pb12404-1 (121.0x41.0).

Genus Schizosporis Cookson & Dettman 1959a

1959a Schizosporis Cookson and Dettman, p. 213.

Type Species: Schizosporis reticulatus Cookson & Dettman, *ibid.*,
pl. 1, fig. 1

Comments: Non-aperturate forms with irregular equatorial line of separation are assigned to this genus.

Schizosporis cooksoni Pocock 1962

Plate 3, figs. 9, 10

1962 Schizosporis cooksoni Pocock, p. 76, pl. 13, figs. 197-198.

Comments: This form is similar to P. parvus, but has a thinner wall and smooth surface.

Occurrence Rare. The known range of this form is Upper Jurassic to Campanian (see Stone, 1971, p. 75).

Measurements: 30-40 um.

Figured specimens: Pb12379-2 (124.8x42.3); Pb12460-1 (115.8x25.3).

Schizosporis parvus Cookson & Dettman 1959a

Plate 4, figs. 3, 4

1959a Schizosporis parvus Cookson & Dettmann, p. 216, pl. 1, figs.
15-20.

1963 Schizosporis parvus Dettmann, p. 108, pl. 26, figs. 18-19.

Description: See Dettmann (l.c.).

Comments: B. Van Geel & Van der Hammen (1978, p. 385, pl. 3, figs.

34-41) discussed the affinity of S. parvus with the zygo-spores (spores formed sexually by conjugation between adjacent cells of the same filament or between different filaments) and aplanospores (spores produced asexually by division of vegetative cells) of some of the species of the genus Spirogyra (a green alga of the family Zygnemataceae). They also showed a relatively wide size range in the members of these species (40-97 x 18-38 um).

Although the specimen illustrated in Plate 4, fig. 4 is larger, it fits the circumscription of S. parvus in having thin wall, microgranulate surface and elliptical outline. S. cooksoni Pocock, 1962 has a thinner wall and a smooth surface.

Occurrence: Found rarely in the Lower Campanian of New Mexico. It has been recorded from Barremian to Paleocene (Stone, 1973, p. 62).

Measurements: 30-62 x 19-27 um. 90 x 60 um (Singh, 1964), 65-90x 35-50 um (Cookson & Dettmann, 1959). 40-97 x 18-38 um (Van Geel & Van der Hammen, 1978), 83 (90) 98 um (Stone, 1973), 31 x 66 um (Hedlund, 1966), 31-37 um (Agasie, 1969).

Figured specimens: Pb12533-3 (118.3x33.0; 121.1x36.9).

Schizosporis scabratus Stanley 1965

Plate 4, figs. 5-8

1965 Schizosporis scabratus Stanley, p. 269, pl. 35, figs. 10-17.

Description: See Stanley (l.c.)

Comments: This species is characterized by its spherical shape, thick wall, small size, and scabrate surface. It may split open along an incipient suture line. Its affinity is probably with green algae.

Occurrence: Maestrichtian Hell Creek Formation of NW South Dakota (Stanley, 1965), Upper Campanian - Maestrichtian of SW Colorado (Gies, 1973). It was found in relatively abundant number in sample Pb12387-2 (in a black shale on top of "Beige Coal" Well EC-150, Fig. 7) and occasionally in other samples from the Lower Campanian of New Mexico.

Measurements: 15-25 um. 15-40 um in Stanley (1965).

Figured specimens: Pb12387-2 (116.4x31.4; 121.5x29.9; 114.6x43.1), Pb12529-1 (119.0x28.7).

Schizosporis sp.

Plate 4, figs. 1, 2

Description: Spores ellipsoidal with rounded ends, wall 1.5 um thick, smooth with scattered blisters or pustules, usually split open along an irregular suture.

Comments: Schizosporis majusculus (Hedlund, 1966, p. 32, pl. 10, fig. 1) is much larger (47.5-130.0 x 142.5-207.5 um), has a thicker wall (3-4 um), and lacks blisters.

This form is probably assignable to the zygnemataceous green alga Spirogyra.

Occurrence: Occurs rarely in samples from the Lower Campanian of New Mexico.

Measurements: 62 x 41 um.

Figured specimens: Pb12379-2 (124.9x38.9), Pb12378-6 (118.6x39.7).

Algal Spore? Type A

Plate 4, figs. 9-11

Description: Small, hexagonal structures flattened into squares or

diamonds, with a triangular fold diagonally covering one-half the surface and dividing it into two equal triangles. There are two small, shallow notches at each side of two of the facing corners of the grain, where a slight thickening can be observed. Surface scabrate, wall very thin.

Comments: This palynomorph was reported by Leopold & Pakiser (1964, pl. 9, figs. 2-3) as cf. Tetraporina Naumova. The genus Tetraporina and its modern counterpart Mougeotia are characterized by four depressions or notches at the four corners of their tetragonal bodies. These modifications are observable only at two facing corners in the New Mexico forms. Nevertheless, this form may be affiliated with the spores of green algae.

Occurrence: Cenomanian-Turonian of western Alabama (Leopold & Pakiser, 1964), Occur commonly in the Lower Campanian of New Mexico.

Measurements: 17-20 μ m. 18-20 μ m in Leopold & Pakiser (1964).

Figured specimens: Pb12378-8 (115.9x39.1), Pb12457-2 (122.9x36.1), Pb12462-1 (115.8x39.5).

Algal Spore? Type B

Plate 4, fig. 12

Description: Spherical bodies with large semispherical bulges scattered on the surface which give an undulatory outline to the grain. Wall very thin, minutely granulate and wrinkled. The grain splits open along an irregular suture in a manner comparable to Schizosporis.

Comments: This form is probably a spore of a green alga.

Occurrence: A single grain of this type was found in the samples from the Lower Campanian of New Mexico.

Measurements: 53 um.

Figured specimen: Pb12413-1 (122.2x37.0).

DIVISION BRYOPHYTA

CLASS MUSCI (Mosses)

FAMILY SPHAGNACEAE

The Lower Campanian sphagnoid spores recovered from the South Hospah area are morphologically grouped into the following form genera:

- 1- Genus Stereisporites: spores with no apparent cingulum, with slight thickening of the exine at the corners, and with no distal polar modifications.
- 2- Genus Cingutritetes: spores with a thick cingulum, but with no distal polar modifications.
- 3- Genus Distverrusporis: spores with a distal polar, circular or irregularly circular, thickening (boss).
- 4- Genus Tripunctisporis: spores with three depressions around the polar area which have developed on a circular or irregular polar thickening.
- 5- Genus Distancorisporis: spores with a distal anchor-shaped thickening.

Genus Stereisporites Pflug in Thomson & Pflug 1953

SELECTED SYNONYMY:

1953(March) Stereisporites Pflug in Th. & Pf., p. 53

1953(March) Cingulatisporites Thomson in Th. & Pf., p. 58

1953(Nov.) Sphagnites Cookson, p. 463.

1956 Sphagnumsporites Raatz(1937)1938 ex Potonie, p. 17.

1961 Cingulatisporites Thomson emend. Pocock, p. 1235.

1966 Sphagnumisporites Levet-Carette, p. 154.

1967 Cingulatisporites Thomson emend. Hiltman. p. 172.

Type Species: Stereisporites stereoides (Pot. & Ven.)Pflug 1953,
p. 53.

Sporites stereoides Potonie & Venitz, 1934, p. 11, pl.
1, fig. 4.

Comments: This genus was proposed for sphagnoid trilete spores with no sculpture or structure, but not smoothly hyaline. Forms with cingulum and exinal modifications should be removed from this taxon.

Stereisporites sp. 1

Plate 5, fig. 1

Description: Very small, trilete spore. Amb strongly rounded triangular to semicircular. Trilete mark inconspicuous; differentiated by a slight thinning of the exine. Exine less than 0.5 μ m, slightly thickened at the corners; surface scabrate.

Comments: This form is distinguished by its very small size and the presence of a faint trilete mark.

Occurrence: Found rarely in the Lower Campanian of New Mexico.

Measurements: 12-13 μ m.

Figured specimens: Pb 12385-1 (129.2x38.4).

Stereisporites sp. 2

Plate 5, figs. 2-7

Description: Small azonotrilete spores; amb triangular, sides convex, corners rounded; rays of the trilete mark short, simple with no lips, less than 1/2 of the radius, usually ripped along one of the trilete angles and folded back; exine up to 8.5 μ m; ornamented with scattered granules of very low verrucae which leave an irregular negative reticulation pattern on the surface of the grain.

Comments: This form is distinguished by its small size, the nature of its trilete mark, and by the pattern of its ornamentation. It is relatively larger than S. sp. 1. Waanders (1974, pl. 1, fig. 14) illustrated a similar form.

Occurrence: This form is common among the sphagnoid spores in some of the samples from the lower Campanian of New Mexico. It was also reported from the Maestrichtian of New Jersey (Waanders, 1974).

Measurements: 20-23 μ m (4 specimens).

Figured specimens: Pb12385-1 (128.1x39.7), Pb12387-2 (117.9x41.5; 123.8x44.1; 126.1x29.4; 126.5x31.9).

Stereisporites sp. 3

Plate 5, fig. 8

Description: Trilete spores, amb rounded triangular, corners rounded; exine ca. 1/2 μ m, slightly thickened at the radial corners; surface covered with very low and faint verrucae, trilete mark short, ca. 1/2 the radius, slightly gaping, with no lip.

Comments: The morphological characteristics of this form approximates that of the type species of the genus (S. stereoides). Hedlund (1968, p. 11, pl. 1., fig. 5) reported a similar form as

Sphagnumsporites psilatus (Ross) Couper from the Cenomanian of Oklahoma. Couper (1958, p. 131, pl. 15, figs. 1-2) described this species as grains with 2.5 to 3 μ m-thick wall. His illustration shows a probable distal thickening. The specimen illustrated by Groot et al. (1961, pl. 24, fig. 1) as Sphagnumsporites psilatus has a thin wall like the one illustrated here, but the poor illustration does not permit further comparison. Stereisporite stereoides (Pot. & Ven.) Pflug in Waanders (1974, p. 34, pl. 1, fig. 13, non fig. 14) is very close to the form illustrated here and probably conspecific with it.

Occurrence: This form occurs only occasionally in some samples from the Lower Campanian of New Mexico.

Measurements: 23 μ m.

Figured specimens: Pbl2408-1 (127.4x39.0).

Genus Cingutriletes Pierce 1961, emend. Dettmann, 1963

1961 Cingutriletes Pierce, p. 20

1963 Cingutriletes Pierce, emend. Dettmann, p. 69

Type Species: Cingutriletes congruens Pierce 1961, p. 25.

Plate 1, fig. 1

Comments: Pierce (1961) proposed this genus to incorporate cingulate or zonate with equatorial flange rather than cingulum. He included interradially crassate forms in this genus. Dettmann (1963) emended this genus to include only cingulate forms and redefined it with the circumscription of trilete, cingulate spores with subcircular to circular amb and smooth or almost smooth exine. However, she described a species under this generic concept, with a distinct

distal polar, circular thickening (i.e., C. clavus). Other authors (e.g., Singh, 1971) followed this approach, as well. This generic concept is here utilized in a restricted sense as outlined by Dettman (1963) and thus does not include forms with exinal modifications other than a distinct cingulum.

Cingutritetes congruens Pierce 1961

Plate 5, fig. 9

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

1963b Stereisporites congruens (Pierce) Krutzsch, p. 17.

Description: Cingulate trilete spores; amb rounded triangular, cingulum 4-5 μ m, trilete mark very small, ca. 1/3 the radius, with no lips, surface scabrate.

Comments: Cingulatisporites cf. C. levispeciosus Pflug in Hedlund (1966, pl. 1, fig. 6) and in Clarke (1963, pl. 4, fig. 6) and

Triletes sp. 7 in Martinez (doctoral dissertation, Michigan State University, 1983(?), pl. 16, fig. 18).

Occurrence: This form is common among the sphagnoid spores from the Lower Campanian of New Mexico. It was also reported from the Cenomanian of Oklahoma (Hedlund, 1966), Upper Cretaceous Vermejo Formation of Colorado (Clarke, 1963), and Campanian of NW Colorado (Martinez, 1983?).

Measurements: 43 μ m.

Figured specimens: Pb12500-1 (127.2x28.8)

Cingutritetes sp.

Plate 5, figs. 10-11

Description: Cingulate trilete spore; laesurae short, one-half the radius, subtended by a margo (not a distal thickening); margo ca. 1 um wide, tapering towards the tip of each laesura. Cingulum thick, up to 12 um; exine irregularly granulate.

Measurements: 35 um.

Occurrence: Occurs rarely in some samples from the Lower Campanian of New Mexico.

Figured specimen: Pb12387-1 (119.4x31.0).

Genus Distverrusporis n. gen.

Basionym:

1963b Stereisporites (Distverrusporis) Krutzsch, Atlas, pt. III, p. 14.

Type Species: Sphagnum antiquasporites Wilson & Webster, 1946, p. 273, fig. 2.

Description: Sphagnoid trilete spores with a distinct, cingulate or acingulate, circular or irregularly circular, distal polar thickening. Surface smooth or scabrate, irregularly granulate or spotted with weak, low verrucae.

Comments: The subgenus Stereisporites(Distverrusporis) Krutzsch (1963) is here raised to generic rank. This new genus is distinguished from Stereisporites Pflug and Cingutriletes (Pierce) Dettmann in having a circular or irregularly circular, distal, polar thickening.

Distverrusporis antiquasporites (Wilson & Webster) n. comb.

Plate 5, figs.12,13

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

1963 Sphagnumsporites antiquasporites (Wil. & Web.) Dettmann, p. 25.

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

Comments: See Dettmann (ibid.) for additional synonymy and remarks on this species. This form is very distinct by its distal boss, small size, and relatively thin exine with no conspicuous cingulum. The distal boss may appear as a linear thickening around the laesurae in some samples (Plate 5, fig. 12,).

Occurrence: Occurs rarely in the samples from Lower Campanian of New Mexico. It is widely distributed in various parts of the world from Jurassic to Tertiary (Singh, 1971, p. 33).

Measurements: 20-23 um. 20(27)36 um in Dettmann (1963).

Figured specimens: Pb12387-2 (123.8x40.2), Pb12374-3 (114.0x31.6).

Distverrusporis clavus (Balme) n. comb.

Plate 5, figs. 14,15

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

1959 Sphagnumsporites clavus (Balme) de Jersey, p. 348, pl. 1, fig. 2.

1963 Cingutritetes clavus (Balme) Dettmann, p. 69, pl. 14, figs.

5-8. Description: Rounded triangular, cingulate trilete spores with a distinct, rounded distal polar disc. Trilete mark small, not extending beyond the diameter of the distal disk when observed in polar view. Cingulum 2.5-3.5 um wide at the interradian centers, increasing to 3 to 4.5 um at the corners. Distal disk 4.5 to 10 um. Exine ornamented with very low verrucae.

Comments: See Dettmann (1963, p. 69) for further synonymy. She places Stereisporitescrassus (Cookson) Krutzsch 1959 in synonymy with Cingutriletesclavus which has been transferred to this new genus.

Occurrence: Occurs rarely in the Lower Campanian of New Mexico. It is widely distributed in various parts of the world from Jurassic to Tertiary (Singh, 1971, p. 33).

Measurements: 26-32 um. 25(34)45 um in Dettmann (1963).

Figured specimen: Pb12387-1 (125.1x47.7), Pb12387-2 (113.8x30.0).

Distverrusporis sp.

Plate 5, fig. 16

Description: Cingulate trilete spore with a distal polar, circular thickening. Trilete mark faint but long, reaching the inner margin of the cingulum. Distal disc ca. 5 um; cingulum 2 um at the corners, decreasing in size to 1.5 um towards the interradian areas.

Comments: This form is distinguished by its arcuate thickenings at the radial corners, its long trilete marks, and deltoid outline.

Occurrence: Occurs rarely in some of the samples from the Lower Campanian of New Mexico.

Measurements: 31 um.

Figured specimen: Pb12387-2 (117.5 x 43.0).

Genus Tripunctisporis n. gen.

Basionym:

1966 Stereisporites (Tripunctisporis) Krutzsch in Doring, et al.,
p. 73.

Type Species: Tripunctisporis maastrichtensis Krutzsch (new rank)

ibid. pl. 1, figs 3-5.

Description: See Jansonius & Hills (1976, p. 2722).

Comments: The subgenus Stereisporites (Tripunctisporis) Krutzsch (1966) is here elevated to generic rank. This new genus is easily distinguishable by a distinct circular or irregular distal polar thickening on which three thin spots have developed. The three thin spots underlie, or approximately underlie, the rays of trilete mark. One of the depressions may be obscure in some specimens. The distal thickening may be irregular but they are distinct from the triradiate thickening in the genus Distancorisporis.

Tripunctisporis sp. 1

Plate 5, figs. 17-18

Description: Spore outline irregularly rounded or subtriangular, exine 2 to 2.5 um thick, distal disc up to 12 um, thinning at its boundary, trilete mark obscure, subtended by three distal thin spots, one of which may be obscure. Exine covered with low verrucae.

Comments: This form is distinguished from T. sp. 2 by its irregular outline and smaller size. Forms illustrated by Waanders (1974, pl. 1, figs. 7-9) as Stereisporites cristalloides from Maestrichtian of New Jersey have long laesurae that extend almost to the periphery and triangular outline.

Occurrence: A rare sphagnoid spore in the samples from the lower Campanian of New Mexico.

Measurements: 25-27 um.

Figured Specimens: Pb12385-1 (128.0x32.9 & 124.6x32.9).

Tripunctisporis sp. 2

Plate 5, fig. 19

Description: Outline triangular, sides convex, radial corners rounded or pointed; wall surrounded by a thick, distinct cingulum (3.5-4 μ m thick), laesurae small, ca. 1/3 the radius, subtended by three distal depressions; distal thickening ca. 10 μ m wide, thinning at its boundary; surface covered with low verrucae.

Comments: This form is different from T. sp. 1 by its triangular outline and larger size. It is similar to Stereisporites cristalloides Krutzsch (1966) in Kumar (1983?)

Occurrence: Rare in the samples from the Lower Campanian of New Mexico. Also reported from the Maestrichtian of Texas (Kumar, *ibid.*).

Measurements: 32 μ m.

Figured specimen: Pb12430-1 (110.4x40.9).

Genus Distancorisporis Srivastava 1972a

1963b Stereisporites (Distancoraesporis) Krutzsch, p. 62.

1972c Distancorisporis Srivastava, p. 228.

Type Species: Distancorisporis germanicus (Krutzsch) Jansonius & Hills, 1976, p. 826.

Stereisporites (Distancoraesporis) germanicus

Krutzsch 1936b, p. 62, pl. 13, figs. 14-17.

Comments: Srivastava (1972a) elevated the subgenus Stereisporites (Distancorisporis) to generic rank to incorporate cingulate trilete spores having a distal triradiate boss. He corrected the subgeneric epithet Distancoraesporis to Distancorisporis. The type for the

subgenus was designated as type species by Jansonius & Hills (1976, p. 826) since Srivastava did not specify a type species.

Distancorisporis dakotaensis (Stanley) n. comb.

Plate 5, fig. 20, 21

- 1965 Cingulatisporites dakotaensis Stanley, p. 243, pl. 30, figs. 1-8.
- 1969 cf. Cingulatisporites dakotaensis Stanley in Snead, p. 26, pl. 5, figs. 1-2.
- 1972 Cingulatisporites dakotaensis Stanley in Gies, p. 37, pl. 1, fig. 8.
- 1972 Cingutriletes clavus (Balme) Dettmann 1963 in Srivastava, p. 10, pl. 6, figs. 8, 9, non fig. 7.
- 1974 Stereisporites dakotaensis (Stanley) Waanders, p. 32, pl. 1, figs. 10-12.

Description: See Stanley (1966, p. 244).

Comments: The characteristics of this species are subtriangular to subcircular outline, prominent Y-shaped distal thickening and thick cingulum. This Y-shaped structure gradually thins and flares out towards the periphery in D. sp. 1, but it has a sharp boundary in D. dakotaensis. Cingutriletes clavus in Srivastava (1972a, pl. 6, figs. 8,9) is conspecific with D. dakotaensis.

Occurrence: Occurs rarely in the samples from the Lower Campanian of New Mexico. It has been reported from the Maestrichtian and Paleocene of South Dakota (Stanley, 1965), Maestrichtian of Central Alberta (Snead, 1969), Campanian-Maestrichtian of NW Colorado (Gies, 1972), Maestrichtian of New Jersey (Waanders, 1974), Maestrichtian of

Texas (Kumar, 1983?), Campanian of NW Colorado (Martinez, 1983?).

Measurements: 25-30 μm .

Figured specimens: Pb12533-3 (122.4x39.5), Pb12460-1 (118.7x41.6).

Distancorisporis sp. 1

Plate 6, figs. 1, 2

Description: Amb rounded triangular, exine psilate, clearly differentiated into two layers, outer layer (cingulum) 4 μm wide, inner layer 1 μm . Trilete mark faint, extending ca one-half the radius. The arms of the distal thickening large, thinning and flaring out towards the periphery.

Measurements 27-31 μm .

Figured specimens: Pb12387-1 (120.0x30.8 & 128.3x33.7).

Distancorisporis sp. 2

Plate 6, fig. 3

Description: Amb irregularly circular, exine psilate, cingulum 2 μm wide; trilete mark short, faint, rays of trilete appear to be alternate with the arms of the distal boss; surface covered with dense or scattered low verrucae. The arms of the distal boss appear somewhat expanded distally (peripherally on the sphere) and are very thick.

Comments: The irregularly circular amb and the shape of distal boss is distinctive in this form.

Occurrence: Rare in the samples from the Lower Campanian of New Mexico.

Measurements: 20-22 μm .

Figured specimens: Pb12385-1 (124.1x35.5)

Distancorisporis sp. 3

Plate 6, fig. 4

Description: Amb rounded triangular with undulatory periphery; distal triradiate boss 11 um with relatively short and triangular arms; exine irregularly ornamented with low verrucae; cingulum 2-3 um at the interradiial area, 4 um at the corners.

Comments: This form is distinguished by its thick cingulum with undulating margin and arcuate radial thickenings, and by a short cingulum with triangular arms.

Occurrence: Rare in the samples from the Lower Campanian of New Mexico.

Measurements: 31 um.

Figured specimen: Pb12387-1 (127.8x31.0).

Distancorisporis sp. 4

Plate 6, fig. 5

Description: Amb rounded triangular; trilete mark long, reaching the periphery; exine ca. 0.5 to 1 um at interradiial areas, 2 um at the corners; distal triradiate boss not very thick, differentiated into a central circular area with three triangular arms attached; surface covered with sparse, low verrucae.

Comments: This form is distinguished by its thin wall with arcuate radial thickening and the shape of the distal boss.

Occurrence: Only a few grains were encountered in the samples from the Lower Campanian of New Mexico.

Measurements: 23 um.

Figured specimen: Pb12385-1 (123.4x40.3).

CLASS HEPATICAEE (Liverworts)

Genus Aequitriradites Delcourt & Sprumont 1955 emend.

Cookson & Dettmann 1961

1955 Aequitriradites Delcourt & Sprumont, p. 44.

1961 Aequitriradites Del. & Spr. emend. Cook. & Dett., p. 426.

1966 Aequitriradisporites Nakoman, p. 80.

Comments: A tetrahedral spore with a membranous zona.

Cirratriradites is foveolate; Styxisporites lacks sculptures on proximal face and the trilete mark does not extend onto the zona; Hymenozonotriletes has spinules on the zona and exine. Aequitriradisporites is an obligate junior synonym of Aequitriradites, having the same type species (cf. Jansonius & Hills 1975, p. 110).

Aequitriradites ornatus Upshaw 1963

Plate 6, fig. 6

1963 Aequitriradites ornatus Upshaw, p. 428, pl. 1, figs. 1-6, 9-14.

Occurrence: Upper Cretaceous Frontier Formation of Wyoming & Montana (Upshaw, 1963); Maestrichtian Edmonton Formation of Alberta, Canada (Srivastava, 1972a); Lower Cretaceous (Albian) Bockchito Formation of southern Oklahoma, U.S.A. (Wingate, 1980); Maestrichtian of Texas (Kumar, 1983?); Campanian of NW Colorado (Martinez, 1983?); Rarely occurs in the lower Campanian of New Mexico.

Measurements: 52 um (body). 47-72 um (body, in Upshaw, 1963).

Figured specimen: Pb12411-1 (112.6x29.8).

Aequitriradites spinulosus (Cookson & Dettmann, 1958b)

Cookson & Dettmann 1961

Plate 6, fig. 7

Comments: See Dettmann (1963, p. 93) for synonymy and description.Occurrence: Cretaceous, widespread (see Srivastava, 1972a, p. 4).

Very rare in the South Hospah assemblages.

Measurements: 55 um., 45-86 um in Dettmann (1963).Figured specimen: Pb12411-1 (116.5x41.6).Genus Triporoletes Mtchedlishvili 1960 emend. Playford 1971Synonymy: See Srivastava (1975b, p. 67).Type Species: Triporoletes cingularis Mtchedlishvili in Mtch. & Samoilovich, 1960, p. 128, figs. 13,14.Diagnosis: See Playford (1971, p. 551).Comments: Seductisporites Chlonova, 1961, Rouseisporites Pocock, 1963, and Ricciaesporites Nagy, 1968 are junior synonyms of Triporoletes (see Srivastava 1975b, p. 67. See also Srivastava 1972a, p. 34 and B. Tschudy 1973, p. 11 for further accounts on this form).Triporoletes novomexicanus (Anderson) Srivastava 1975

Plate 6, figs. 8-10

1960 Lycopodium novomexicanum Anderson, p. 14, pl. 1, fig. 2, pl. 8, fig. 1.1975 Triporoletes novomexicanus (Anderson) S. K. Srivastava, p. 69.Comments: See Anderson (1960, p. 14,15) for description, and Srivastava (1975b, p. 69) for additional synonymy. Gies (1972, p. 52-53) and Martinez (1983?) reported a similar form as Retitriteles cenomanicus Agasie. Gies (1972) mentioned the similarity of his form

with Anderson's species. The thin, peripheral zona may readily detached from the grain.

Occurrence: Maestrichtian-Paleocene of San Juan Basin, New Mexico (Anderson, 1960) and Wyoming (Leffingwell, 1971); Campanian-Maestrichtian of NW Colorado (Gies, 1972), Campanian of NW Colorado (Martinez, 1983?); rarely occurs in the Lower Campanian of New Mexico.

Measurements: 46-52 um (body). 42-60 um in Anderson (1960).

Figured specimens: Pb12379-2 (114.7x41.8); Pb12387-2 (113.8x38.7); Pb12401-12 (125.3x33.7).

DIVISION LYCOPHYTA (Club Mosses)

Genus Camarozonosporites Pant 1954 ex Potonie 1956, emend. Klaus 1960

1956 Camarozonosporites Potonie, Synopsis I, p. 65.

1960 Camarozonosporites Pot. emend. Klaus, p. 135.

Type Species: Camarozonosporites cretaceus (Weyl. & Kr.) Pot., *ibid.*

Rotaspora cretacea Weyland & Krieger 1953, p. 12, pl. 3, fig. 12.

Comments: Trilete microspores with prominent interr radial equatorial crassitudes and a distal rugulate sculpture are assignable to this genus, as emended by Klaus (1960). Rotaspora Schemel, 1950, has a wider cingulum which is thickened around the periphery and forms a narrow rim. Lycopodiacidites and Hamulatisporites both lack interr radial equatorial crassitudes. Coronatispora has a distal circular thickening.

Camarozonosporites hammenii Van Amerom 1965

1965 Camarozonosporites hammenii Van Amerom, p. 116, pl. 4, fig. 2,
pl. 8, figs. 1-2.

Description: (see Catalog of Fossil Spores & Pollen, 33-1).

Comments: C. rudis (Leschik) Klaus has prominent lipped laesurae that reach the equator. C. insignis Norris is larger (30-55 um) than C. hammenii. It also has the proximal face sculptured and relatively coarser distal rugulae. C. imberbis has much finer rugulae.

Occurrence: Van Amerom (1965) reported this species from the Upper Cretaceous of N. Spain. It occurs in low frequency in the samples from the Lower Campanian of New Mexico.

Measurements: 27-29 um. 31-37 um in Van Amerom (1965).

Affinity: Lycopodiaceae.

Figured specimens: Pb12394-1 (117.0x40.5); Pb12387-1 (114.1x45.7).

Camarozonosporites imberbis Van Amerom 1965

Plate 6, figs. 15-17

1965 Camarozonosporites imberbis Van Amerom, p. 118, pl. 6, figs. 2-3.

Description: (see Catalog of Fossil Spores and Pollen, 33-3).

Comments: See the discussion under C. hammenii.

Occurrence: Upper Cretaceous of N. Spain (Van Amerom, 1965). Lower Campanian of New Mexico.

Affinity: Lycopodiaceae

Measurements: 27-28 um. 25-37 um in Van Amerom (1965).

Figured specimens: Pb12387-2 (126.3x39.4).

Genus Ceratosporites Cookson & Dettmann 1958b

1958b Ceratosporites Cookson & Dettmann, p. 101.

Type Species: Ceratosporites equalis Cook. & Dett., ibid.

plate 14, fig. 17

Comments: Trilete microspores with blunt or sharp distal ornaments and smooth proximal surface. This genus can be distinguished from Neoraistrickia and Echinatisporites by having a smooth proximal surface.

Affinity: Selaginellaceae

Ceratosporites sp. Drugg 1967

Plate 7, fig. 1

1967 Ceratosporites sp. Drugg, p. 37, pl. 6, fig. 21.

Occurrence: Maestrichtian-Paleocene of California (Drugg, 1967).

Occurs rarely in the South Hospah assemblages.

Measurements: 30 um. 22-31 um in Drugg (1967).

Figured specimen: Pb12401-8 (113.8x33.9)

Genus Echinatisporis Krutzsch 1959

1959 Echinatisporis Krutzsch, p. 132.

Type Species: Echinatisporis longechinus Krutzsch, p. 133,

plate 20, figs. 217-219.

Comments: Azonate trilete spores with echinate exine on distal and proximal surfaces. The genus Acanthotriletes Naumova ex Potonie & Kremp, 1954 has dubious validity (See Srivastava, 1975b, p. 38).

Affinity: Selaginellaceae

Echinatisporis varispinosus (Pocock 1962) Srivastava 1975b

Plate 7, figs. 2,3

1962 Acanthotriletes varispinosus Pocock, p. 36, pl. 1, figs. 8-20.

1972a Ceratosporites pocockii Srivastava, p. 8. pl. 4, fig. 7.

1975b Echinatisporis varispinosus (Pocock) Sriv., p. 39, pl. 17,
figs. 8-14; pl. 18, figs. 1-4.

Comments: The spines in this species are not morphologically uniform. They usually have bulbous bases, but the apices may be sharp, bifurcated, blunt, and/or truncated.

Occurrence: Aptian-Maestrichtian of Western Canada, Upper Albian of Texas (cf. Srivastava, 1975b). Occurs occasionally in the South Hospah assemblages.

Measurements: 18-38 um (8 specimens). 20-38 um in Srivastava (1972).

Figured specimen: Pbl2466-1 (115.8x34.0).

Genus Hamulatisporis Krutzsch 1959 emend. Srivastava 1972a

1959 Hamulatisporis Krutzsch, p. 157.

1963a Camazonosporites subg. Hamulatisporis Krutzsch, p. 23.

1966 Hamulatisporites Nakoman, p. 77.

1972a Hamulatisporis Krutzsch emend. Srivastava, p. 15.

Type Species: Hamulatisporis hamulatus Krutzsch 1959, p. 157, pl. 29, fig. 326.

Comments: This genus, as emended by Srivastava (1972a), is restricted to rugulate azonotrilete spores without interradsial crassitudes. Hamulatisporites Nakoman 1966 is an obligate junior synonym of Hamulatisporis (cf. Jansonius & Hills, 1976, p. 1215).

Hamulatisporis rugulatus (Couper, 1958) Srivastava 1972a

Plate 7, fig. 4

1958 Perotrilites rugulatus Couper, p. 147, pl. 25, figs. 7-8.

1965 Hamulatisporis amplus Stanley, p. 242, pl. 29, figs. 1-6.

1972a Hamulatisporis rugulatus (Couper) Srivastava, p. 17,

plate 11, fig. 5; plate 12, figs. 1-3.

Comments: Srivastava (1972a, p. 17) transferred Couper's species Perotrilites rugulatus to Hamulatisporis rugulatus based on the valid argument that Couper's form does not have a perine but a zona(or, better to say, a cingulum), and its sculpture is rugulate, just as is the case in the genus Hamulatisporis. He further argued that P. rugulatus is similar to H. amplus Stanley, 1965, and that these two forms cannot be distinguished meaningfully. So he assigned H. amplus to the status of junior synonym of H. rugulatus. Inasmuch as Stanley did not compare his form with P. rugulatus and created a new species without reference to the previous available concepts, Srivastava's new combination seems to be valid and his synonymy is accepted here.

Occurrence: Srivastava (1972a) listed the occurrences of this species from Upper Triassic to Jurassic of Europe, Lower Senonian of Far East, Senonian to Paleocene of U.S.A., and Middle Paleocene of Australia. It is very rare in the Lower Campanian of New Mexico.

Affinity: Lycopodiaceae.

Measurements: 49-66 um., 50-70 um. in Stanley (1965); 63-77 um in Couper (1958); 45-66 um in Srivastava (1972a).

Figured specimen: Pb12387-2 (122.6x42.4).

Genus Minerisporites Potonie 1956

1956 Minerisporites Potonie, p. 67.

Type Species: Minerisporites mirabilis (Miner, 1935) Potonie, *ibid.*,

p. 618, pl. 23, fig. 1 (lectotype, designated by Potonie).

Comments: Subtriangular zonotrilete megaspore with prominent tectate laesurae which extend to the zona.

Affinity: Selaginellaceae? (Agasie, 1969).

Minerisporites mirabilis (Miner, 1935), Potonie 1956

Plate 7, fig. 5

1935 Selaginellites mirabilis Miner, p. 618, pl. 23, fig. 1.

1956 Minerisporites mirabilis (Miner 1935) Potonie, p. 67.

Occurrence: Fort Union Formation (Paleocene) of Montana, U.S.A.

(Miner, 1935), Dakota Sandstone (Cenomanian) of Iowa (Hall, 1963) and Arizona (Agasie, 1969). Occurs in several samples from the South Hospah.

Measurements: 426-720 um.

Figured specimen: Pb12535-1 (118.0x32.0)

Genus Neoraistrickia Potonie 1956

1956 Neoraistrickia Potonie p. 34.

Type Species: Neoraistrickia truncatus (Cookson) Potonie 1956, p. 36.

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

Comments: This genus was introduced by Potonie (1956) to accommodate Mesozoic azonotrilete, baculate microspores with subtriangular amb.

The Paleozoic genus Raistrickia includes forms with additional spinulae and conl. Baculatisporites is circular in outline.

Ceratosporites has smooth proximal face (see Dettmann, 1963, p. 35).

Affinity: Lycopodiaceae or Selaginellaceae (cf. Dettmann, 1963).

Neoraistrickia cf. N. speciosa Srivastava 1972

Plate 7, figs. 6,7

1972a Neoraistrickia speciosa Sriv., p. 25, pl. 22, figs. 2-4.Comments: This form is similar to N. speciosa Srivastava (1972a), but is smaller in size.Occurrence: Maestrichtian of Alberta, Canada in Srivastava (1972a), Occurs rarely in the Lower Campanian of New Mexico.Measurements: 23-27 um. 33-38 um (Srivastava, 1972a).Figured specimens: Pb12385-1 (126.3x43.5 & 127.8x33.7).Genus Peromonolites Couper 1953b1953b Peromonolites Couper, p. 32.Type Species: Peromonolites bowenii Couper, *ibid*, pl. 3, figs. 31-32.Comments: The concept of this genus was proposed by Couper (1953b) to include dispersed monolete spores surrounded by a perispore.Peromonolites sp.

Plate 7, figs. 8,9

Description: Spores monolete; elliptical in outline; monolete mark usually obscure; exine very thin, covered with granules, surrounded by a thin, delicate, granulate perine; perine usually folded, may readily detach from the body.Comments: These forms very closely resemble the specimens illustrated by Elsik (1968a, p. 288, pl. 5, figs. 5-7) as Isoetes subengelmanni from the Paleocene of Texas. I prefer to avoid assigning the dispersed fossil palynomorphs to biological taxa.

Therefore, I place these forms in the form genus Peromonolites, but acknowledge their affinity to the genus Isoetes. The modern species Isoetes savatieri, illustrated by Heusser (1971, pl. 2, fig. 12) from Chile, is also similar to the Campanian forms from New Mexico but its sculpture is finer.

Occurrence: Paleocene of Texas (Elsik, 1968a); to Santonian of Wyoming (Griggs, 1970, p. 42, pl. 1, figs. 5-6); Lower Campanian of New Mexico. It is a common component in samples Pb12455, Pb12457, Pb12458 and Pb12533.

Affinity: The modern genus Isoetes (cf. Elsik, 1969a).

Measurements: (based on 6 specimens): body: 19-25 x 12-18 um, body and perine: 32-41 x 20-27 um. Measurements in Elsik (1968a) are: body: 20-24 x 11-15 um, body and perine: 26-33 x 18-23 um.

Figured specimens: Pb12455-1 (115.9x31.9), Pb12533-3 (121.9x39.7).

Genus Perotrilites Couper 1953b

1953b Perotrilites Couper, p. 31.

Type Species: Perotrilites granulatus Couper, *ibid.*, pl. 3, fig. 28.

Comments: Couper (1953b) proposed this form as a triangular to spherical microspore enclosed by a distinct psilate or scabrate perispore.

Perotrilites sp. 1

Plate 7, figs. 10,11

Description: Zonotrilete spores with trilete amb, convex sides and pointed corners, surrounded by a thin, hyaline, psilate perispore; exine psilate or covered with scattered granules; laesurae short, ca. one third to one half the radius, simple with no lips, may be folded

and appear to extend to the periphery; the zona may be folded around the exine and so the wall may appear to be thicker than it normally is.

Comments: This form is distinct from P. granulatus Couper 1953 in having psilate endexine and ectexine. Rouse (1957, pl. 1, figs. 51-54) reported similar forms from the Campanian of western Canada as P. granulatus.

Occurrence: Campanian of W. Canada (Rouse, 1957). Occurs rarely in the South Hospah assemblages.

Affinity: Selaginellaceae?. These forms are comparable to Selaginellawallacei in Knox (1950) and in Krutzsch (1963b, p. 26).

Measurements: 38-50 um, wall thickness up to 3.5 um, perine 4-10 um.

Figured specimens: Pb12513-1 (112.5x28.8); Pb12387-2 (121.7x27.7).

Perotrilites sp. 2

Plate 7, figs. 12,13

Description: Rounded triangular trilete microspores with a reticulate perine which may be easily stripped off the grain, separated from the spore body by a 4 um cava.

Comments: Gies (1972, pl. 2, figs. 5-6) illustrated similar forms from the Upper Cretaceous of Colorado. Only two grains of this form were encountered in the counts of the South Hospah samples.

Affinity: Lycopodiaceae? Selaginellaceae?

Measurements: 28-30 um; lumina of reticulum ca. 1 um.

Figured specimens: Pb12344-1 (113.9x32.3 & 116.0x44.7)

Genus Sestrosporites Dettmann 1963

1963 Sestrosporites Dettmann, p. 66.

Type Species: Sestrosporites irregulatus (Couper) Dettmann *ibid.*,
pl. 27, figs. 1-3.
Foveotriletes irregulatus Couper 1958, p. 143, pl. 22,
fig. 9.

Comments: This genus is a foveolate, zonate or azonate trilete microspore characterized by development of an interradian crassitude. This character is absent in Foveotriletes Potonie, Foveosporites Balme, and Microreticulatisporites Knox. Vallizonosporites Doring 1965 from the Wealden of Germany was described as having distinct additional apiculate sculptural elements such as spinae, conl, bacula, etc. It is similar to Sestrosporites in other respects.

Sestrosporites pseudoalveolatus (Couper 1958) Dettmann 1963

Plate 7, fig. 14

Synonymy:

- 1958 Cingulatisporites pseudoalveolatus Couper, p. 147, pl. 25,
figs. 5-6.
- 1963 Cingulatisporites cf. C. pseudoalveolatus Couper: In Clarke,
p. 49, pl. 5, fig. 1.
- 1963 Sestrosporites pseudoalveolatus (Couper) Dettmann, p. 66,
pl. 13, figs. 11-16.
- 1964 Hymenzonotriletes pseudoalveolatus (Couper) Singh, p. 83,
pl. 10, figs. 1-3.
- 1965 Foveosporites cyclicus Stanley, p. 241, pl. 28, figs. 6-10.
- 1965 Vallizonosporites pseudoalveolatus (Couper) Doring, p. 60 .
- 1966 Foveotriletes subtriangularis auct. non Brenner; In Burger,

- p. 246, pl. 14, fig. 1.
- 1967 S. pseudoalveolatus: In Norris, p. 96, pl. 13, figs. 8-10.
- 1968 Foveosporites multifoveolatus auct. non Doring: In McLean, p. 1480, pl. 188, fig. 17.
- 1970 Aequitriradites ornatus auct. non Upshaw: In Griggs, p. 45, pl. 2, fig. 5.
- 1971 S. pseudoalveolatus: In Singh, p. 44, pl. 3, figs. 3-7.
- 1971 Cingulatisporites cf. C. pseudoalveolatus Couper: In Kidson, p. 61, pl. 2, fig. 1.
- 1972 S. pseudoalveolatus: In Geis, p. 53, pl. 2, fig. 8.
- 1974 S. pseudoalveolatus: In Waanders, p. 44, pl. 3, figs. 3-4.
- 1975 S. pseudoalveolatus: In Brideaux & McIntyre, p. 15, pl. 2, fig. 24.
- 1976 Vallizonosporites sp. Norvick & Burger, p. 135, pl. 25, fig. 4.

Comments The presence of the thin, membraneous zona in this species does not seem to develop secondarily as has been argued by Dettmann (1963, p. 66). The zona can be very easily detached in the process of maceration.

Occurrence: This form has been reported from the Middle Jurassic and Lower Cretaceous of Europe (Couper, 1958, Burger, 1966; Baltes, 1967), and Canada (Brideaux & McIntyre, 1975; Singh, 1964 & 1971; Norris, 1967), Lower Cretaceous of Australia (Dettmann, 1963; Norvick & Burger, 1976), and Albian - Maestrichtian of the United States (Stanley, 1965; Panella, 1966; Davis, 1963; Kidson, 1971; Gies, 1972; Waanders; 1974, Kumar, 1983? Martinez, 1983?). It is very rare in the Lower Campanian of New Mexico.

Affinity: Lycopodiaceae.

Measurements: 45-46 um. The size range reported in the literature is 37-68 um.

Figured specimen: Pbl2387-6 (114.8x39.8).

Genus Velosporites Hughes & Playford 1961

1961 Velosporites Hughes & Playford, p. 42.

Type Species: Velosporites echinatus Hughes & Playford, *ibid.*

plate 4, fig. 9.

Comments: This zonotrilete spore is distinct from Densoisporites Weyland & Kreiger emend Dettmann in lacking an equatorial cingulum and interr radial papillae. Crybelosporites Dettmann has proximally cavate sculptine. The name has been used for Paleozoic forms, but there is no morphological ground for erecting a new genus for similar Mesozoic forms (see Dettmann, 1963, p. 83).

Velosporites triquetrus (Lantz 1958) Dettmann 1963

Plate 7, fig. 15

1958 Laricoidites triquetrus Lantz, p. 926, pl. 5, figs. 51-54.

1963 Velosporites triquetrus (Lantz) Dettmann, p. 82, pl. 19, figs. 1-3.

Occurrence: Bathonian to Kimmeridgian of England (Lantz 1958); Cretaceous of SE Australia (Dettmann, 1963). Occurs occasionally in the Lower Campanian of New Mexico.

Measurements: 40-52 um. 48(60)70 um in Dettmann (1963).

Figured specimen: Pbl2379-6 (125.3x41.9).

DIVISION PTEROPHYTA (Ferns)

ORDER FILICALES

FAMILY OSMUNDACEAE

Genus Baculatisporites Thomsom & Pflug 1953

1953 Baculatisporites Thomson & Pflug, p. 56.

Type Species: Baculatisporites primarius (Wolff) Thom. & Pfl.,

ibid.

Sporites primarius Wolff 1934, p. 66, pl. 5, fig. 8.

Comments: Azonotrilete, baculate microspores with circular amb and simple, long laesurae. Osmundacidites Couper is granulate.

Conbaculatisporites Klaus is triangular in outline. Baculatitriletes

Von der Brelie has a prominent tectate laesurae.

Baculatisporites sp.

Plate 8, fig. 1

Description: Azonotrilete, baculate microspore with circular amb and long, simple, closed laesurae that reach proximal periphery. Baculae not densely spaced. Exine ca. 1 μ m thick.

Comments A single grain was identified in the South Hospah samples.

Measurements: 55 μ m; baculae up to 2 μ m.

Figured specimen: Pb12387-2 (116.7x45.0).

Genus Osmundacidites Couper 1953b

1953b Osmundacidites Couper, p. 20.

Synonymy: See Dettmann, 1963, p. 31.

Type Species: Osmundacidites wellmanii *ibid.*, pl. 1, fig. 5.

Comments: This genus includes granular to papillate (papilla = nipple) trilete spores with circular to subcircular amb. In Baculatisporites Thomson & Pflug the sculpture is distinctly baculate.

Osmundacidites sp.

Plate 8, fig. 2

Comments: This form is similar to O. wellmanii except for very sparse sculpture and thicker exine. Baculatisporites comaumensis (Cookson) Potonie, as illustrated in Dettmann (1963) is morphologically similar to this form, but the sculpture is distinctly baculate in Dettmann's forms. Only one grain of this type was encountered in the South Hospah samples.

Measurements: 39 μ m.

Figured specimen: Pb12362-1 (119.5x38.4).

Genus Todisporites Couper 1958

1958 Todisporites Couper, p. 134.

Type Species: Todisporites major Couper, *ibid.*, pl. 16, figs. 6-8.

Comments: This genus was erected by Couper (1958) to accommodate psilate, trilete spores with circular amb and simple, long laesurae similar to the spores of Todites williamsonii and T. princeps from

the Middle Jurassic of Yorkshire, England.

Todisporites major Couper 1958

Plate 8, fig. 3

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

Comments: Only a single grain of this type was found in the samples studied. This may be a recycled specimen from the older strata.

Affinity: Couper (1958) compared it with the spores of Todites williamsonii from the Lower to Middle Jurassic of Yorkshire, England.

Measurements: 54 um. Size range in Couper (1958) is 52(60)78 um.

Figured specimen: Pb12400-1 (115.4x35.7).

Todisporites minor Couper 1958

Plate 8, figs. 4,5

1958 Todisporites minor Couper, p. 134, pl. 16, figs. 9-10.

Comments: T. minor differs from T. major only in size range. Couper (1958) assigned grains smaller than 52 um. to this species. Only a single grain of this type was encountered in this study. It may be a recycled specimen from older strata.

Occurrence: Bajocian (Middle Jurassic) to Cenomanian (cf. Singh, 1971, p. 50).

Measurements: 32 um. Size range in Couper (1958) is 32(45)50 um.

Figured specimen: Pb12387-2 (125.8x36.0).

FAMILY SCHIZAEACEAE

Genus Appendicisporites Weyland & Krieger 1953

1953 Appendicisporites Wey. & Kr., p. 12.

Type Species: A. tricuspidatus Weyland & Greifeld in Wey. & Kr.,
ibid., p. 42, pl. 11, fig. 54.

Comments: Triangular to subtriangular trilete microspores with three radial appendices and an ectexine ornamented with ridges which are more or less parallel to the equatorial sides.

Appendicisporites cristatus (Markova 1961) Pocock 1965

Plate 8, figs. 6-10

1961 Anemia cristata Markova, p. 78, pl. 20, figs. 1a-b.

1964 Appendicisporites cristatus (Mark.) Pocock, p. 164, pl. 3,
figs. 9-10.

Description See Pocock (1965, p. 164).

Comments: The diagnostic character in this species is the fusing of adjacent ribs at the apices to form bulbous or attenuated appendices.

Occurrence: Middle Albian of Saskatchewan, Canada (Pocock, 1965), Late Cretaceous-Early Tertiary of NE Yukon, Canada (Rouse and Srivastava, 1972), Cenomanian of Bathurst Island, Australia (Norvick & Burger, 1976), Lower Campanian of New Mexico.

Measurements: 50-65 μ m (3 specimens). 45.5-50 μ m in Pocock (1964).

Figured specimens: Pb12378-2 (118.4x37.1); Pb12382-9 (122.1x29.7); Pb12458-2 (111.6x35.5).

Appendicisporites cf. A. pschekhaensis (Bolkhovitina 1961)

Pocock, 1965

Plate 9, fig.1

1965 Appendicisporites cf. A. pschekhaensis (Bolkh.) Pocock,

p. 165, pl. 3, fig. 11.

Description: See Pocock (1964, p. 165). See also Singh (1964, p. 50).

Comments: This form is characterized by relatively long appendices and few ribs which are parallel to the sides.

Occurrence: Neocomian to middle Albian of east-central Canada (Pocock, 1965; Singh, 1964); Neocomian of U.S.S.R. (Bolkhovitina, 1961). A single grain was found in the Lower Campanian of New Mexico. It may be a recycled specimen from the older strata.

Measurements: 66 um (1 specimen). 58 um in Singh (1964; 56 um in Pocock, 1965); 70-80 um (Russian forms, cf. Singh, 1964).

Figured specimen: Pb12401-12 (117.7x41.5).

Appendicisporites stellantis Wingate 1980

Plate 9, fig. 3

1980 Appendicisporites stellantis Wingate, p. 16, pl. 5, fig. 3-7.

Comments: This form is characterized by 10-20 stout columnar projections of about 7-12 um long on distal and equatorial zone.

Occurrence: It was first reported from the Albian of Southern Oklahoma. One grain of this type was found in the Lower Campanian of New Mexico. Although the size of this grain is larger than the range given by Wingate (1980), it is morphologically similar to the specimens he illustrated. The occurrence of this species in the South Hospah sediments may be the result of recycling of older sediments.

Measurements: 83 um.

Figured specimen: Pb12428-1 (117.5x39.9).

Appendicisporites tricornitatus Weyland & Greifeld 1953

Plate 9, fig. 2

Description: See Weyland & Greifeld in Weyland & Krieger (1953).

Comments: The plication in this species is canaliculate (ridges wider than grooves) as opposed to cicatricose plication in A. potomacensis Brenner in which ridges are narrower than grooves (see Brenner, 1963, p. 46 and Singh, 1971, p. 62). Forms called A. tricornitatus by Couper (1958), and by Groot & Penny (1960), were transferred to A. potomacensis by Brenner based on this characteristic.

Occurrence: Barremian to Lower Campanian. Lower Senonian of Germany (Weyland and Greifeld, 1953), Cenomanian Dakota Sandstone of Arizona, U.S.A. (Agasie, 1969), Lower Cretaceous Potomac Group of Maryland, U.S.A. (Brenner, 1963), Albian of Oklahoma, U.S.A. (Hedlund & Norris, 1968). It occurs rarely in the Lower Campanian of New Mexico.

Measurements: 51,54 um (2 specimens). 40-65 um in Singh (1964).

Figured specimen: Pb12378-5 (119.0x34.2).

Genus Chomotriletes Naumova 1953

1953 Chomotriletes Naumova, p. 39.

Type Species: Chomotriletes vedugensis Naumova, *ibid.*, pl. 7, fig. 21.

Description: See Pocock, 1962, p. 38.

Comments: Circular or irregularly circular microspores with no trilete mark (or a faint one) and concentric ridges ("thumb prints") on at least one face.

Chomotriletes fragilis Pocock 1962

Plate 9, figs. 4,5

1962 Chomotriletes fragilis Pocock, p. 39, pl. 2, figs. 30-32.

Occurrence: Lower Cretaceous Mannville Formation of W. Canada (Pocock, 1962); Cenomanian Dakota Formation of Arizona (Agasie, 1969); Campanian-Maestrichtian of NW Colorado (Gies, 1972); rare in the Lower Campanian of New Mexico.

Measurements: 25-33 x 28-35 um (4 specimens). 23-25 um in Pocock (1962); 26.5(30)36 um in Agasie (1969).

Figured specimens: Pb12394-1 (124.0x32.4), Pb12378-8 (126.5x36.8).

Genus Cicatricosisporites Potonie & Gelletich 19331933 Cicatricosisporites Pot. & Gell., p. 522.

Type Species: C. dorogensis Pot. & Gell., ibid. pl. 1, fig. 1.

Comments: Azonotrilete microspores with cicatricose or canaliculate ridges on the exine and with no appendices. See Dettmann (1963, p. 52) for synonymy and discussion.

Cicatricosisporites australiensis (Cookson 1953) Potonie 1956

Plate 9, fig. 6

1953 Mohrioisporites australiensis Cookson, p. 470, pl. 2, figs. 29-34.

1956 Cicatricosisporites australiensis (Cookson) Pot., p. 48.

Comments: For synonymy and description see Dettmann, 1963, p. 53.

Occurrence: Widespread in the Lower and Upper Cretaceous (see Dettmann, 1963, p. 53 and Singh, 1972, p. 69). Occurs rarely in the Lower Campanian of New Mexico. Measurements: 34-40 um (3 specimens); 36(51)70 um in Dettmann (1963).

Figured specimen: Pbl2411-1 (125.4x38.1).

Cicatricosisporites cuneiformis Pocock 1964

Plate 9, fig. 7

1964 Cicatricosisporites cuneiformis Pocock, p. 158, pl. 2, fig. 17

Description: See Pocock (1964). See also Norvick & Burger (1976).

Comments: Clockwise spiralling of ribs on the proximal surface is characteristic of this species.

Occurrence: Middle Albian of Saskatchewan, Canada (Pocock, 1964), Late Albian & early Late Cretaceous of E. Australia (Playford & Dettmann, 1968), Cenomanian of Australia (Norvick & Burger, 1976). This form is rare in the South Hespah assemblages and probably recycled from the older strata.

Measurements: 36 um (1 specimen). 40-51 um in Norvick & Burger (1976). Size range not given in Pocock.

Figured specimen: Pbl2402-4 (108.8x41.3).

Cicatricosisporites hallei Delcourt & Sprumont 1955

Plate 9, figs. 8-11

1955 Cicatricosisporites hallei Del. & Spr., p. 17, pl. 1, fig. 1.

Description: see Delcourt, Dettmann & Hughes (1963). See also Singh, (1971, p. 72).

Comments: The distal rib pattern of this species consists of two sets of plicae. The ribs of each set are parallel to one another and oblique to the ribs of the other set (see Singh, 1971, p. 72 and fig. 7). The proximal pattern of ribs does not show the clockwise spiralling as it does in C. cuneiformis. Several corroded specimens were encountered in the samples. Figure 11 in plate 9 illustrates

this stage of preservation.

Occurrence: Singh (1971) gave a range of Lower Cretaceous and Cenomanian for this form. It occurs rarely in the Lower Campanian of New Mexico. It also occurs in the Maestrichtian of Texas (Kumar, 1982?). These occurrences probably represent recycled specimens from older strata.

Measurements: 46-50 μ m.

Figured specimen: Pb12402-5 (113.1x37.6); Pb12401-12 (117.5x28.5).

Genus Microfoveolatosporis Krutzsch 1959 emend. Potonie 1966

1957 Schizaea fromensis Cookson, p. 43.

1957 Schizaea albertonensis Cookson, p. 43.

1957 Schizaea punctata Cookson, p. 43.

1959 Microfoveolatosporis Krutzsch, p. 211.

1959 Reticulosporis Krutzsch, p. 228.

1961 Retimonoletes Pierce, p. 33.

1963 Cuddaloria Thiergart & Frantz, p. 43.

1966 Microfoveolatosporis Krutzsch, emend. Potonie, p. 103.

1966 Microfoveolatosporites Nakoman, p. 68.

1969 Schizaeoisporites sp. Penny, p. 343.

Type Species: Microfoveolatosporis pseudodentatus Krutzsch, 1959,
p. 212, pl. 41, fig. 463.

Comments: Azonomonolete microspore with foveo-reticulate sculpture and oval lateral outline; the thickness of muri is either more than, or at least half, the lumina diameter. Potonie emended the concept of this genus to encompass the characteristics of Reticulosporis Krutzsch. Srivastava (1971, p. 261) indicated that spores with very thin and/or crested muri should not be included in this concept. The

genus Retimonoletes Pierce (1961, p. 33) was described as a foveoid-reticulate monolete spore. This description and the morphological characteristics of the type species of this genus revealed from the illustration suggests that Retimonoletes is conspecific with, and a junior synonym of, Microfoveolatosporis. Reticulosporis, Retimonoletes, and Cuddaloria were considered as junior synonyms of Microfoveolatosporis by Srivastava (1971, p. 261) and Potonie (1966, p. 103). Neyvelisporites Ramanujam 1972 can be differentiated from this genus by having rounded pits which do not form reticulate patterns. Foveomonoletes Van der Hammen 1954 ex Mathur 1966 lacks sufficient diagnosis for comparison.

Microfoveolatosporites Nakoman is an obligate junior synonym of Microfoveolatosporis Krutzsch, because it has the same type species (see Jansonius & Hills, 1976, p. 1654). Schizaeoisporites sp. in Penny (1969, in Tschudy & Scott, p. 343, pl. 16-2, fig. 18) is a misnomer because the type species of this genus is cicatricose or canaliculate rather than reticulate. Forms described by Cookson (1957, p. 43) as Schizaea fromensis, S. albertonensis, and S. punctata match the circumscription of Microfoveolatosporis and should be transferred to it (see the introductory notes on taxonomic treatment). The forms comparable to the extant genus Schizaea and assignable to the form-genus Microfoveolatosporis have been reported from Albian to Miocene from different parts of the world. (Cookson, 1957; Krutzsch, 1959; Pierce, 1961; Thiergart and Frantz, 1963; Elsik, 1968a; Srivastava, 1971a; Felix and Burbridge, 1973; Harris, 1974; Romans, 1972 and 1975; Norvick & Burger, 1976, etc.)

Affinity: The form-species assignable to this genus have been compared to different extant species of Schizaea. (See Cookson, 1957

Pierce, 1961; Dettmann, 1963; Srivastava, 1971a).

Microfoveolatosporis foveolatus (Pierce 1961) n. comb.

Plate 10, figs. 1,2

1961 Retimonoletes foveolatus Pierce, p. 33, pl. 1, fig. 32.

1972 R. foveolatus Pierce, in Romans, p. 123.

1975 R. foveolatus Pierce in Romans, p. 300.

Description (here revised): Azonate, foveo-reticulate, monolete microspore; laesura about 2/3 the length of the grain; outline subcircular to elliptical, and minutely serrate or smooth; exine between 2-5 μ m thick, endexine with no structure, 0.3 μ m thick, ectexine made up of club-shaped projections (clavae); the heads of the clavae fuse to form a foveo-reticulate or pitted pattern. The muri wider than the lumina.

Occurrence: Cenomanian of Minnesota (Pierce, 1961), Turonian (Toreva Formation) of Arizona (Romans, 1972). It occurs occasionally in the Lower Campanian of New Mexico.

Affinity: Pierce (1961) compared this form with the spore of the extant species Schizaea pusilla Pursh and S. skottsbergii Selling.

Measurements: 60(70)75 x 86(97)116 μ m. 55(82)110 x 21(55)79 μ m in Romans (1972).

Figured specimens: Pb12387-5 (117.3x41.3); Pb12387-6 (114.2x31.6).

Genus Microreticulatisporites Knox 1950 emend. Bharadwaj 1956 •

1950 Microreticulatisporites Knox, p. 320.

1956 Microreticulatisporites Knox emend. Bharad., p. 127.

Type Species: Microreticulatisporites lacunosus (Ibr.) Knox, ibid.

Reticulatisporites lacunosus Ibr. 1933, p. 36, pl. 6,
fig. 50, designated by Potonie & Kremp 1954, p. 143.

Comments: According to Bharadwaj's emendation, this genus is restricted to triangular trilete spores with extrareticulate sculpture and lumina smaller than three μ m in diameter (see Jansonius & Hills, 1976, p. 1661).

Microreticulatisporites uniformis Singh 1964

Plate 10, fig. 3

- 1963 Lycopodiumsporites sp. A. Clarke, p. 42, pl. 3, fig. 7.
1964 Microreticulatisporites uniformis Singh, p. 97, pl. 13, figs. 5-7.
1967 Microreticulatisporites cf. M. uniformis: In Drugg, p. 40, pl. 6, fig. 28.
1968a Microreticulatisporites spp. Elsik, p. 306, pl. 12, figs. 1-8.
1971 Microreticulatisporites uniformis Singh: In Singh, p. 127, pl. 17, figs. 17-19.
1975 Microreticulatisporites uniformis Singh: In Brideaux & McIntyre, pl. 1, fig. 28.

Comments: A morphological gradation can be observed between this form and Cicatricosisporites ornatus Srivastava. Elsik (1968a, p. 306, pl. 13, fig. 6) illustrated a similar gradation.

Occurrence: Aptian to Paleocene. Aptian-Albian of District of Mackenzie, Canada (Brideaux & McIntyre, 1975); Aptian-Early Cenomanian of Alberta, Canada, and Colorado and Nebraska, U.S.A. (Singh, 1971); Maestrichtian of Central Colorado (Clarke, 1963); Maestrichtian-Danian of California, U.S.A. (Drugg, 1967); Paleocene

of Texas (Elsik, 1968). It occurs rarely in the South Hoshpan assemblages.

Measurements 44 um. 44-48 um in Singh (1964); 45-53 um in Drugg (1967).

Figured specimen: Pb12401-10 (121.9x28.6).

Genus Soccorosporites new genus

Basionym:

1957 Schizaea reticulata Cookson, p. 42

Type Species: Soccorosporites reticulatus (Cookson 1957) n. comb.

Description: Ellipsoidal, reticulate, monolete spore. Exine thick. Muri smooth, thick, rounded in cross section, and without any supratectal processes; lumina large, decreasing in size towards the laesura. Minimum diameter of lumina 2 um; lumina always larger than the muri so that the sculpture is never foveolate but always reticulate. Laesura ca. 1/2 the length of the grain.

Comments: This concept is hereby proposed to accommodate fossil dispersed reticulate monolete spores with large mesh size (more than two um) and no supratectal projections. This form has been frequently assigned to the extant genus Schizaea. Assigning the dispersed fossil palynomorphs to natural genera is not justifiable in my opinion.

Hazaria Srivastava 1971 has supratectal processes and thin muri.

Microfoveolatosporis Krutzsch 1959 has much smaller lumina (foveae).

Schweitzerisporites Kaiser 1976 has polygonal, irregular, and very large lumina (20-30 um in type species).

Name Derivation: After the city of Socorro, New Mexico.

Soccorosporites reticulatus (Cookson 1957) n. comb.

Plate 10, figs. 4,5

- 1957 Schizaea reticulata Cookson, p. 42, pl. 8, figs. 1-2.
 1973 Schizaea reticulata Cookson in Felix & Burbridge, p. 9,
 pl. 1, fig. 12.
 1974 Reticuloidosporites sp. McIntyre, pl. 14, fig. 32.

Description: Ellipsoidal, reticulate, monolete spore. Laesura closed, slightly lipped, 38 μ m long. Exine 3-4 μ m thick, two-layered, endexine very thin (ca. 0.3 μ m), ectexine with no internal structure, muri of reticulum 1.5-2.5 μ m thick, rounded in cross section; lumina 2-7 μ m, decreasing in size toward the laesura, hexagonal to pentagonal with unequal sides.

Occurrence: Paleocene of Australia (Cookson 1957), Maestrichtian of Arctic Canada (Felix & Burbridge 1973), Campanian-Maestrichtian of District of Mackenzie, Canada (McIntyre 1974); occurs rarely in the South Hespah samples.

Measurements: 45-53 x 68 μ m. 75 x 60 μ m in Cookson (1957), 54 x 72 μ m in Felix & Burbridge (1973).

Figured specimen: Pb12387-5 (117.0x38.3).

FAMILY GLEICHENIACEAE

Genus Deltoidospora Miner 1935

- 1935 Deltoidospora Miner, p. 618.

Type Species: Deltoidospora hallii Miner, *ibid.*, pl. 24, fig. 7.

Comments: Deltoid, azonotrilete microspores with a simple laesurae which extend more than 2/3 of spore radius.

Deltoidospora hallii Miner 1935

Plate 10, fig. 6

Occurrence: Jurassic and Cretaceous, widespread. It occurs rarely in the Lower Campanian of New Mexico.

Affinity: Miner (1935) related this spore to the Mesozoic forms Gleichenites and Gleichenopsis.

Measurements: 20-35 um.

Figured specimen: Pb12385-1 (129.0x38.9).

Genus Gleicheniidites Ross 1949

1949 Gleicheniidites Ross, p. 31.

Type Species: Gleicheniidites senonicus Ross, *ibid.*, pl. 1, fig. 3.

Comments: For synonymy and revised diagnosis see Skarby, 1964.

Skarby's comprehensive study (Skarby, 1964) showed that there is a wide range of variation in the morphology and size of both fossil and modern gleicheniaceous spores. She argued that the fossil dispersed spores cannot be assigned to either of the two modern gleicheniaceous genera with trilete spores. This genus, as revised by Skarby (1964), includes triangular trilete spores with equatorial interradianal crassitudes, discontinuous at the corners.

Gleicheniidites senonicus Ross 1949

Plate 10, figs. 7,8

Description: See Skarby, 1964.

Comments: This species differs from G. triplex (Bolkhovitina) Krutzsch 1959 in lacking radial thickenings. G. feronensis Delcourt & Sprumont 1957 and G. radiatus (Bolkovitina) Krutzsch 1959 are

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larger than G. senonicus (cf. Skarby, 1964, p. 66).

Occurrence: Jurassic to Recent; widespread. This form occurs abundantly in the Lower Campanian of New Mexico.

Measurements: 20(30.8)44 um (11 specimens). 24(ca. 30)41 um in Skarby (1964).

Figured specimens: Pb12428-1 (126.6x37.4 & 119.4 x 30.2).

Genus Ornamentifera Bolkhovitina 1966

1966 Ornamentifera Bolk., p. 69

Synonymy: See Dettmann & Playford, 1968, p. 77.

Type Species: Ornamentifera echinata (Bolk.) Bolk., ibid.

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

Comments: This genus was diagnosed as gleicheniaceous-type pollen with sculptural projections. It is easily distinguishable from the form-genus Gleicheniidites Ross by having surface ornamentations of different types.

Ornamentifera tuberculata (Grigoreva) Bolkhovitina 1966

Plate 10, fig. 9

1961 Gleicheniidites tuberculatus Grigoreva in Samoilovitch et al. p. 62, pl. 16. figs. 4a-c, 5a-c, pl. L, fig. 3 (See Catalog of Fossil Spores and Pollen, vol. 30, p. 31).

1966 Ornamentifera tuberculata (Grigoreva) Bolkhovitina, p. 70

Description: Tricrassate trilete microspore; amb triangular, sides convex, corners acutely rounded; laesurae long, reaching equator; exine thin, ornamented with tubercula.

Comments: Ornamentifera echinata is echinate.

Occurrence: Aptian-Albian of Siberia, U.S.S.R. (Grigoreva, 1961).

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Measurements:

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FAMILY MATON

Genus Bireti

1955 Bireti

1957 Hymen

1963 Bireti

P. 28

Type Species

It is abundant in some of the samples from the Lower Campanian of New Mexico.

Measurements: 40(47)52 um (15 specimens).

Figured specimen: Pb12430-1 (114.6x36.9).

Ornamentifera sp.

Plate 10, fig. 10.

Description: Trilete spore, laesurae long, reaching the equator; kyrtocone distinct, amb triangular, corners rounded, sides straight to concave, surface granulate.

Comments: Ornamentifera tuberculata has much larger ornamentation and larger size. Gleicheniidites confusus Hedlund 1966 superficially resembles this form, but it is pitted.

Occurrence: Occurs occasionally in the South Hospah samples.

Measurements: 26 um.

Figured specimen: Pb12387-1 (122.2x33.5).

FAMILY MATONIACEAE

Genus Biretisporites Delcourt & Sprumont 1955 emend.

Delcourt, Dettmann & Hughes 1963

1955 Biretisporites Delcourt & Sprumont, p. 40.

1957 Hymenophyllumsporites Rouse, p. 363.

1963 Biretisporites Delcourt & Sprumont emend. Delcourt et al.,
p. 284.

Type Species: Biretisporites potoniaei Delcourt and Sprumont, *ibid.*,
fig. 10; holotype re-illustrated (photograph) in

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Delcourt et al., *ibid.*, pl. 42, fig. 12-13.

Comments: This genus, as emended by Delcourt, et al. (1963), is characterized by a well-defined margo along the laesurae, a triangular to subtriangular amb, and smooth exine. It differs from Matonisporites by lacking apical thickening (radial crassitude or valvae). Hymenophyllumsporites is the junior synonym of Biretisporites.

Biretisporites sp 1

Plate 10, fig. 11

Comments: This form basically resembles B. pononiaei Delcourt & Sprumont 1955, but has thinner exine, much smaller size, and slightly undulated laesurae. Only a few grains of this type were found in the South Hospah samples.

Measurements: 28 μ m. The size range given in literature for B. pononiaei is 45-60 μ m.

Figured specimen: pb12384-7 (126.8x41.2).

Biretisporites sp. 2

Plate 10, figs. 12,13

Comments: This form is extremely small with rounded triangular amb, relatively thick margo and thin exine. Surface of the grain is covered with few scattered granula. One grain of this type was identified in the New Mexico samples.

Measurements: 12 μ m.

Figured specimen: Pb12385-1 (123.5x45.0).

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Measurements:

Occurrence:

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Biretisporites sp. 3

Plate 10, figs. 14,15

Description: Amb triangular with convex sides and rounded corners (expanded grains rounded triangular to semi-circular); exine psilate, uniform in thickness; trilete mark lipped by a thick margo, extending 1/2 to 3/4 of the radius.

Comments: Romans (1975, p. 308, pl. 4, figs. 9-11) reported larger, but otherwise closely similar forms under the name of Matonisporites sp. A from the Upper Cretaceous of Arizona. See also the comments under Matonisporites sp. 4. This form occurs commonly in the South Hospah assemblages.

Measurements: 73-79 um (4 specimens), exine up to 2 um; margo 1-3 um. 76(98)120 um in Romans (1975).

Figured specimens: Pb12387-5 (116.4x41.0); pb12404-1 (120.5x30.5).

Biretisporites sp. 4 cf. Matonisporites equiexinus Couper 1958

Plate 11, fig. 1

Comments: This form shows the undulation that is seen along the laesurae arms of the type species of Matonisporites equiexinus. It is also similar to that form in other morphological features. It is not assigned to that species, however, because it does not fit the circumscription of the genus Matonisporites as accepted in this treatment.

Measurements: 42 um. 40(52)68 um in Couper (1958).

Occurrence: Occasional in South Hospah samples.

Figured specimen: Pb12384-7 (126.2x38.2).

Genus

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Type Species:

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Genus Matonisorites Couper 1958 emend. Dettmann 1963

1958 Matonisorites Couper, p. 139

1963 Matonisorites Couper emend. Dettmann, p. 58.

Type Species: Matonisorites phlebopteroides Couper 1958, p. 140,
pl. 20, figs. 15-17.

Comments: According to Dettmann's emendation, and that of Hiltmann (1967, p. 151), Potonie (1970, Synopsis V., P. 46) and Bharadwaj & Kumar (1972, p. 215), the thickening of exine at the equatorial apices (radial crassitudes or valvae) which has been illustrated in the type species should be considered as a generic diagnostic feature (see Jansonius & Hills 1975). Therefore, M. equiexinus Couper, 1958 should be transferred to the genus Biretisporites on the grounds that it does not possess radial crassitudes.

Matonisorites sp. 1 cf. M. phlebopteroides Couper 1958

Plate 11, fig. 2

1958 Matonisorites phlebopteroides Couper, p. 140, pl. 20, figs.
15-17.

Comments: The type specimen of M. phlebopteroides has concave sides. The forms found in the Lower Menefee Formation have more or less straight sides and less differentiated apical crassitude.

Measurements: 78-90 μ m, exine 2-3 μ m between apices, 5-7 μ m at the apices (4 specimens).

Figured specimen: Pb12428-8 (125.8x33.6).

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Matonisorites sp. 2

Plate 11, fig. 3

Description: Amb triangular, sides straight or slightly convex, apices rounded, exine psilate, 2-4 um at the apices, 1-2 um elsewhere. Trilete mark lipped by a 2-3 um thick margo, margo slightly bifurcated at the tip of each laesurae arm.

Comments: M. equiexinus Couper (1958) has a uniform spore wall with no differentiation at the apices. A gradation can be observed between this form and Biretisorites sp. 1. The separation between these two forms may be arbitrary.

Measurements: 43-74 um (7 specimens).

Figured specimen: Pb12387-5 (116.5x40.4).

FAMILY CHEIROPLEURIACEAE

Genus Dictyophyllidites Couper 1958 emend Dettmann 1963

1958 Dictyophyllidites Couper, p. 140.

1963 Dictyophyllidites Couper emend. Dettmann, p. 27.

Type Species: Dictyophyllidites harrisii Couper, *ibid.*, pl. 21, figs. 5-6.

Comments: This genus, as emended by Dettmann (1963), comprises trilete microspores with triangular amb, unsculptured exine thickened around the laesurae margins, and lipped laesurae.

Affinity: Couper (1958) compared this form with the spores of the Jurassic fern Dictyophyllum. Singh (1971) commented on the similarity of this form with the spores of the Mesozoic fossil genera Dictyophyllum (Cheiroleuriaceae), Phlebopteris (Matoniaceae) and some modern matoniaceous ferns.

Occurrence

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Measurements

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1956 F

1959 F

1967 L

Type Specimens

Dictyophyllidites harrissii Couper 1958

Plate 11, fig. 4

Occurrence: Jurassic and Cretaceous. Only one specimen of this type was observed in the South Hospah samples.

Measurement: 35 um (one specimen). Size range in Couper (1958) is 36(45)56 um.

Figured specimen: Pb12374-3 (122.9x42.1).

FAMILY POLYPODIACEAE

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

- 1933 Laevigatosporites Ibrahim, p. 39.
- 1937 Polypodiumsporites Raatz, p. 10
- 1940 Phaseolites Wilson & Coe, p. 182.
- 1944 Laevigatosporites Ibrahim, 1933 emend. Schopf, Wilson &
Bentall, p. 36.
- 1954 Monoteles Van der Hammen, p. 83.
- 1956 Monolites Cookson ex Potonie, p. 77.
- 1956 Polypodiaceasporites Thiergart ex Potonie, p. 76.
- 1956 Psilamonoletes Van der Hammen, p. 116.
- 1959 Extrapunctatosporis Krutzsch, p. 199.
- 1967 Intrapunctosporis (Intrapunctatosporis) Krutzsch, p. 24.

Type Species: Laevigatosporites vulgaris (Ibrahim 1932)

Ibrahim, 1933, p. 39, pl. 2, fig. 16.

Sporonites vulgaris Ibrahim, 1932, p. 448, pl. 15,
fig. 16.

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Comments: According to Schopf et al. (1944), this genus encompasses bean-shaped, monolete spores having smooth exine or finely punctate, apiculate, or rugose sculpture.

Affinity: Srivastava (1971, p. 253) discussed the difficulty of assigning any definite botanical affinity to Laevigatosporites. He contended that many extant fern genera produce spores with a smooth monolete endospore and a sculptured perispore which is easily lost. This could result in similar appearance to unrelated forms if the endospore were lost. The forms described here are tentatively assigned to the fern family Polypodiaceae.

Laevigatosporites haardti (Potonie & Venitz) Thomson & Pflug, 1953

Plate 11, figs. 5,6

1934 Sporites haardti Pot. & Ven., p. 13, pl. 1, fig. 13.

1953 Laevigatosporites haardti (Pot. & Ven.) Thomson & Pflug,
p. 59, pl. 3, figs. 27-28.

Comments: This species is characteristically bean-shaped, whereas L. ovatus is oval.

Measurements: 32 um. 25-70 um in Thomson & Pflug (1953); 35-40 um in Srivastava (1972).

Figured specimens: Pb12378-2 (126.7x43.3).

Laevigatosporites ovatus Wilson & Webster 1946

Plate 11, fig. 7

1946 Laevigatosporites ovatus Wilson & Webster, p. 273, fig. 5.

Comments: L. gracilis Wilson & Webster (1946, p. 273, fig. 4) does not seem to be meaningfully different from L. ovatus.

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Occurrence: Upper Paleozoic to Cenozoic, worldwide.

Measurements: 32 x 22 um. Size range given for this species in the literature is 31-44 x 19-36 um (Wilson & Webster, 1946; Pocock, 1962; Srivastava, 1971).

Figured Specimen: Pb12402-4 (123.9x37.1).

Laevigatosporites pseudodiscordatus Krutzsch 1959

Plate 11, figs. 8,9

1959 Laevigatosporites pseudodiscordatus Krutzsch, p. 196,
pl. 39. fig. 432.

Comments: Ellipsoidal monolete spore, monolete mark closed, extending almost to the poles, slightly lipped, exine 2-2.5 um thick and vaguely apiculate.

Measurements: 42-64x38-51 um, P/E = 1.26. Size range in Krutzsch (1959) is 50-80 um.

Occurrence: Middle Eocene of Germany (Krutzsch 1959). Lower Campanian of New Mexico.

Figured specimen: Pb12401-10 (122.7x36.9), Pb12462-1 (112.6x43.9).

Laevigatosporites sp.

Plate 11, fig. 10

Description: Ellipsoidal, psilate, monolete spore; laesura lipped by a margo, extending the entire length of the grain, curving slightly at both ends, closed except ca. 1/3 the length near the center where it is gapped; exine very thin.

Measurements: 32 x 21 um.

Figured specimen: Pb12439-1 (110.5x46.0).

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Genus Polypodiidites Ross 1949

- 1949 Polypodiidites Ross, p. 33.
 1953 Verrucatosporites Pflug & Thomson, p. 59.
 1956 Verrumonoletes, Van der Hammen, pl 116.
 1959 Gemmatosporis Krutzsch, p. 203.
 1961 Gemmamonoletes Pierce, p. 21.

Type Species: Polypodiidites senonicus Ross, 1944, p. 33, pl. 1, fig. 9.

Comments: This genus can be differentiated from Polypodiisporonites Potonie 1931 and its junior synonym Reticuloidosporites Pflug 1953 by having widely-spaced gemmae or verrucae which do not form a negative reticulum, or if so, the negative reticulum is much less discernible than in the latter forms. Jansonius & Hills (1976, p. 2104) noted that Polypodiidites has markedly reduced proximal sculpture.

Polypodiidites prosecundus (Elsik 1968a) n. comb.

Plate 11, figs. 11-13

- 1968a Verrucatosporites prosecundus Elsik, p. 291, pl. 7, fig. 3.
 1974 Polypodiidites sp. Harris, p. 510, pl. 1, fig. 2.

Description: Spores oval to reniform; monolete; verrucate to botryoidal; sculptures heaviest away from the monolete mark; laesura 2/3 to 3/4 of the longest axis.

Occurrence: Paleocene of Texas (Elsik, 1968a), Paleocene of Australia (Harris, 1974).

Measurements: 30 x 40 um. (Elsik 1968a); 33 x 26 um. (Harris 1974); 29-31 x 37-40 um (this study).

Figured specimens: Pb12387-2 (122.6x36.7 & 126.3x36.7); Pb12466-1 (125.9x28.1).

Polypodioidites sp. 1

Plate 11, fig. 14,15

Description: Bean-shaped, verrucate or gemmate monolete spores. Sculpture 1-2 μ m in diameter, widely and randomly scattered on the grain. Exine 1.5 - 2 μ m thick.

Measurements: 28x18 μ m.

Figured specimen: Pb12378-2 (127.2x46.3).

Polypodioidites sp. 2

Plate 12, fig. 1

Description: Verrucate, monolete spore; verrucae widely scattered on the grain; equatorial amb plano-convex, distal surface convex, proximal surface flattened and somewhat constricted; monolete mark not conspicuous; exine ca. 2 μ m thick.

Measurements: 20 x 17 μ m.

Figured specimen: Pb12385-5 (111.3x32.7).

Genus Polypodiisporonites Potonie 1931

1931 Polypodiisporonites Potonie, p. 556.

1953 Reticuloidosporites Pflug, p. 60.

1956 Polypodiisporites Potonie, p. 78.

1961 Polypodiisporites Chlonova, p. 42.

Type Species: Polypodiisporonites favus Potonie, 1931, p. 556,

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Description: Verrucate monolete spores; verrucae densely-spaced and separated by grooves that form a conspicuous negative reticulum.

Comments: Polypodiisporites Potonie is an obligate junior synonym as it has the same type species. Polypodiisporites Chlonova is a junior homonym, and probably a junior synonym of Polypodiisporites Potonie. Reticuloidosporites Pflug has the same sculptural and morphological patterns as Polypodiisporonites. This genus is distinct from Polypodiidites Ross by having flat, densely-spaced verrucae whose spacing makes a negative reticulum.

Polypodiisporonites sp. 1.

Plate 12, figs. 2-4

Description: Shape oval; surface with negative reticulation; monolete scar short, ca. 1/2 the length of the body, simple with no lips.

Occurrence: Rare.

Measurements: 25(27)29 x 33(37)39 μ m.

Figured specimens: Pb12387-1 (111.3x40.6); Pb12342-7 (119.4x40.9); Pb12342-8 (123.2x40.5).

Polypodiisporonites sp. 2

Plate 12, fig. 5

Description: Bean-shaped, verrucate, monolete spore; verrucae low and polygonal in base, making a negative reticulum. Laesura ca. 1/2 the length of the grain.

Comments: P. sp. 1 is oval and slightly shorter.

Measurements: 44 x 27 μ m.

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Figured specimen: Pb12342-8 (119.8x34.4).

FAMILY CYATHEACEAE-DICKSONIACEAE

Genus Cyathidites Couper 1953b

1953b Cyathidites Couper, p. 27.

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

Cyathidites australis Couper 1953b

Plate 12, fig. 6

Comments: Couper (1953b) assigned grains larger than 52 um to this species, and the smaller ones to C. minor.

Occurrence: Jurassic and Cretaceous, worldwide.

Figured specimens: Pb12378-7 (119.4x36.4).

Cyathidites minor Couper 1953b

Plate 12, fig. 7

1953b Cyathidites minor Couper, p. 28, pl. 2, fig. 13.

Occurrence: Jurassic and Cretaceous, worldwide.

Figured specimen: Pb12385-1 (118.1x43.2)

Genus Kuylisporites Potonie 1956

1956 Kuylisporites Potonie, Synopsis I, p. 38.

Type Species: Kuylisporites waterbolki Pot., *ibid.*

Kuylisporites scutatus Newman 1965

Plate 12, figs. 8,9

1965 Kuylisporites scutatus Newman, p. 9, pl. 1, fig. 1.

Occurrence: Se

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Measurements:

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Occurrence: Senonian of Western U.S.A. Lower Campanian of NW Colorado (Newman, 1965); Middle Santonian to Middle Campanian of Montana (Newman, 1972); Campanian-Maestrichtian (undifferentiated) of NW Colorado (Kidson, 1971; Gies, 1972); Coniacian-Santonian of SW Colorado (Thompson, 1969).

Measurements: 27-30 μm (5 specimens). 23(27)29 μm in Newman (1965), 24-30 μm in Gies (1972), up to 30 μm in Kidson (1971).

Figured specimens: Pb12387-1 (126.5x36.9); Pb12402-4 (120.8x38.8)

Kuylisporites sp.

Plate 12, fig. 10

Description: Amb triangular, sides convex. Corners rounded, exine ca. 1 μm thick, psilate; laesurae simple, long, reach almost to the periphery.

Comments: This form is distinct from K. scutatus by having a long, simple laesurae and a psilate exine. It lacks scattered pits as in the type species of the genus.

Measurements: 34 μm .

Figured specimen: Pb12387-2 (120.1x29.0).

DIVISION PTEROPHYTA - Incertae Sedis (Microspores)

Genus Cardioangulina Maljavkina 1949, 1958 ex Potonie 1960

1949 Cardioangulina Malj., p. 30,36.

1958 Cardioangulina Malj., p. 73.

1960 Cardioangulina Malj. ex Pot., p. 28.

Type Species: Cardioangulina trichacantha Malj. 1949, l.c., p. 37,

Description

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pl. 2, fig. 8 (designated by Potonie 1960, l.c.)

Cardioangulina sp. 1

Plate 12, fig. 11

Description: trilete spores; amb trilobate, sides deeply concave, corners rounded; exine ca. 2 μ m thick, made up of two layers; surface smooth; trilete mark long, almost reaching the periphery, slightly thickened by a thin margo.

Occurrence: Occasional.

Measurements: 35 μ m.

Figured specimen: Pb12533.3 (115.7x31.8).

Cardioangulina sp. 2

Plate 12, fig. 12

Description: Trilete spores; amb trilobate, sides concave, corners broadly rounded; exine very thick, apparently made up of three layers, up to 5 μ m thick, surface scabrate; trilete mark long, simple.

Comments: This form is distinct from C. sp. 1 by having a much thicker exine and scabrate surface.

Occurrence: Occasional.

Measurements: 45 μ m.

Figured specimen: Pb12456-1 (113.7x29.4).

Genus Cirratriradites Wilson & Coe 1940

1940 Cirratriradites Wilson & Coe, p. 183.

Type Species: Cirratriradites maculatus Wilson & Coe, *ibid.*,

Occurrence:

1967).

Measurements

Figured species

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Occurrence:

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Figured species

Genus

1953 Con

1959 Con

Type Species

fig. 7 (reillustrated in Wilson 1966, p. 39).

Cirratriradites teter Norris 1967

Plate 12, fig. 13

Occurrence: Albian-Cenomanian of central Alberta, Canada (Norris, 1967).

Measurements: 37 um. 27-45 um in Norris (1967).

Figured specimen: Pb12378-1 (118.5x33.0).

Genus Concavissimisporites Delcourt & Sprumont 1955

1955 Concavissimisporites Del. & Spr., p. 25

Type Species: Concavissimisporites verrucosus Del. & Spr., *ibid.*,
pl. 2, fig. 1.

Concavissimisporites sp.

Plate 12, fig. 14

Description: Trilete spore, amb trilobate, sides deeply concave, exine 1-2 um thick; surface granulate to verrucate.

Occurrence: Occasional.

Measurement: 48 um.

Figured specimen: Pb12470-1 (128.0x35.7).

Genus Concavisporites Pflug in Thomson & Pflug 1953 emend.

Krutzsch 1959

1953 Concavisporites Pflug in Th. & Pf., p. 49.

1959 Concavisporites Pflug emend. Krutzsch, p. 116.

Type Species: Concavisporites rugulatus Pflug, *ibid.*, pl. 1, fig. 19.

Description:

Comments: T

spores chara

reported fro

Description:

mark closed,

sides strong

Comments: C

a similar fo

Measurements

Figured spec

1959 Foran

Type Species

Description:

circular; ex

covered with

spacing; the

mark extends

Description: See Krutzsch (1959, p. 116).

Comments: The concept of toriate and concavely triangular trilete spores characterize this genus. The species of this genus have been reported from Rhaetian to Upper Tertiary (cf. Krutzsch, 1959).

Concavisporites sp.

Plate 12, fig. 15

Description: Concavely triangular, toriate trilete spore; trilete mark closed, extending $3/4$ of the radius; radial corners rounded; sides strongly convex; exine ca. 2.5 μm thick, smooth.

Comments: Groot et al. (1961, p. 129, pl. 24, fig. 11) illustrated a similar form from the Cenomanian-Turonian of the eastern U.S.A.

Measurements: 43 μm .

Figured specimen: Pb12401-12 (123.0x31.7).

Genus Foraminisporis Krutzsch 1959

1959 Foraminisporis Krutzsch, p. 130.

Type Species: Foraminisporis foraminis Krutzsch, *ibid.*, pl. 19, figs. 203-206.

Foraminisporis sp.

Plate 13, fig. 1

Description: Trilete spore; amb rounded triangular to irregularly circular; exine apparently two-layered, ca. 1.5 μm thick; surface covered with large granules up to $3/4$ μm wide and with 1-2 μm spacing; the ornamentation reduced towards the periphery; trilete mark extends to the margin.

Occurrence:

Measurements:

Figured specimen

1957 Foveos

Type Species:

Comments: F

irregular fo

and fine fov

Sestrosporit

Description

apices; lae

ornamented

Comments:

Foveosporit

Maestrichti

Measurement

Figured spe

Description

triangular

Occurrence: Only a few grains of this type were observed.

Measurements: 37 μ m.

Figured specimen: Pb12374-3 (121.6x31.2).

Genus Foveosporites Balme 1957

1957 Foveosporites Balme, p. 17

Type Species: Foveosporites canalis Balme, *ibid.*, pl. 1, fig. 15.

Comments: Foveosporites is rounded triangular or circular with irregular fovae, whereas Foveotrilletes has concave or straight sides and fine foveo-reticulate muri (punctate). Both genera differ from Sestrosporites by lacking the interrarial crassitudes.

Foveosporites sp. 1

Plate 13, figs. 2,3

Description: Azonotrillete microspore; amb deltoid with rounded apices; laesurae simple, extending ca. 2/3 of radius; exine thin, ornamented by irregular, small fovae.

Comments: Drugg (1967) reported a similar form designated as

Foveosporites sp. III (p. 39, pl. 6, fig. 32) from the

Maestrichtian-Danian of California, U.S.A.

Measurements: 35 μ m. 35-45 μ m in Drugg (1967).

Figured specimens: Pb12438-2 (119.6x33.1).

Foveosporites sp. 2

Plate 13, fig. 4

Description: Azonotrillete, foveolate microspore; amb rounded triangular; laesurae extending 2/3 of the radius with faint margo.

Exine ca. 0.5 μ m thick.

Measurements: 37 μ m.

Figured specimen: Pb12379-3 (123.6x45.0).

Genus Granulatisporites Ibrahim 1933 emend. Potonie & Kremp 1954

1933 Granulatisporites Ibrahim, p. 21.

1954 Granulatisporites Ibr. emend. Pot. & Kremp, p. 126.

Type Species: Granulatisporites granulatus Ibrahim, ibid., pl. 6,
fig. 51.

Comments: This concept applies to azonate, granulate trilete spores
with rounded triangular amb and simple laesurae.

Granulatisporites granulatus Ibrahim 1933

Plate 13, fig. 5

Occurrence: Occasional.

Measurements: 25 μ m. 25-35 μ m in Ibrahim (1933).

Figured specimen: Pb12387-1 (120.0x35.0).

Genus Quadripollis Drugg 1967

1967 Quadripollis Drugg, p. 62.

Type Species: Quadripollis krempfi Drugg, ibid., pl. 8, figs. 55-56.

Comments: Drugg (1967) erected this genus to accommodate
inaperturate palynomorphs united in permanent tetrahedral tetrads.

Quadripollis sp.

Plate 13, figs. 6-9

Description: Shape of the tetrad pyramidal; individual grains with

very thick wa

the form genu

Measurements:

Figured spec

1959 Toroi

1966 Toroi

Type Species:

Comments: Th

microspores v

1965 Toroi

(in C.

Occurrence:

1965). Only

Hospah sampl

Measurements:

Figured spec

1959 Toroi

very thick wall, densely granulate, closely resembling the grains of the form genus Densoisporites.

Measurements: 50x48 um. Wall thickness of the grains 12 um.

Figured specimen: Pb12401-12 (123.8x37.7).

Genus Toroisporis Krutzsch 1959

1959 Toroisporis Krutzsch, p. 90.

1966 Toroisporites Nakoman, p. 74.

Type Species: Toroisporis torus (Pflug) Krutz., ibid.,

Laevigatosporites neddeni Pot. subsp. torus Pflug

in Thomson & Pflug, 1953, p. 54, pl. 2, fig. 14.

Comments: This genus was erected for toriate azonotrilete microspores with no equatorial radial or interrational thickenings.

Toroisporis delicatus Doring 1965

Plate 13, fig. 10

1965 Toroisporis delicatus Doring, p. 26, pl. 2, figs. 8-9.

(in Catalog of Fossil Spores and Pollen, vol. 36, p. 86.)

Occurrence: Lower Cretaceous (Wealden F) of NW Germany (Doring, 1965). Only a few grains of this type were observed in the South Hespah samples.

Measurements: 35 um.

Figured specimen: Pb12470-1 (119.1x37.4).

Toroisporis longitorus Krutzsch 1959

Plate 13, figs. 11-13

1959 Toroisporis longitorus Krutzsch (in Catalog of Fossil Spores

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and Pollen, vol. 19, p. 122).

Occurrences: This form was reported by Thompson (1969, pl. 14, fig. 10) from the Coniacian-Santonian of SW Colorado and by Gies (1972, p. 59, pl. 2, fig. 14) from the Campanian-Maestrichtian of NW Colorado. A few grains of this type were found in the South Hospah samples.

Measurements: 50-53 μm .

Figured specimens: Pb12533-3 (112.9x39.1), Pb12432-1 (118.1x41.3).

Genus Undulatisporites Pflug in Thomson & Pflug 1953

1953 Undulatisporites Pflug in Thomson & Pflug, p. 52.

Type Species: Undulatisporites microcutis Pflug, *ibid.*, pl. 1, fig. 81.

Comments: This genus is characterized by having sinuous laesurae and rounded triangular amb with convex sides.

Undulatisporites sinuosis Groot & Groot 1962a

Plate 14, figs. 1,2

1962a Undulatisporites sinuosis Groot & Groot, p. 154, pl. 6, fig. 3.

Comments: This species is a rounded triangular trilete spore with a well-defined, lipped, undulating laesurae that reach to the proximal margin, and a scabrate exine. Groot & Groot (1962a) indicated that a somewhat similar form has been described by Couper (1958, pl. 16, fig. 13) as an immature spore of Anemia philliditis.

Measurements: 19 μm . 25-30 μm in Groot & Groot (1962a).

Figured specimen: Pb12374-3 (123.0x30.8).

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Undulatisporites sp. 1

Plate 14, fig. 3

Description: Azonotrilete spore with undulating trilete mark reaching the proximal margin, lipped by a thick margo; amb triangular, sides convex, corners more or less sharp; exine thin and densely granulate.

Comments: This species is distinct from the others described here by its amb outline and densely granulate exine.

Measurements: 27 x 25 μ m.

Figured specimen: Pb12378-5 (120.0x31.9)

Undulatisporites sp. 2

Plate 14, fig. 4

Description: Azonotrilete spore with undulating trilete mark; Laesurae reaching the periphery and supported by a thick margo; amb rounded triangular to oval. Exine thin and sculptured by granules, grading into nipple-like projections (papillae) towards the proximal pole.

Comments: This species can be readily distinguished from the other species described here by its almost oval amb and granular to papillate sculpture.

Measurements: 28 x 25 μ m.

Figured specimen: Pb12378-2 (128.9x44.7).

Genus Verrucatosporites Pflug 1953

1953 Verrucatosporites Pflug in Thomson & Pflug, p. 59.

Type Species: Verrucatosporites alienus (Pot.) Thomson & Pflug,

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ibid., pl. 3, fig. 47.

Sporonites alienus Potonie, 1931, p. 556, fig. 1.

Verrucatosporites pseudoreticulatus Hedlund, 1966.

Plate 14, fig. 5

1966 Verrucatosporites pseudoreticulatus Hedlund, p. 21. pl. 5,
figs. 7a,b.

Comments: See Hedlund (ibid.) for description of this species. The form illustrated here is longer than Hedlund's specimens. Hedlund assigned this species to the Mesozoic Tmesipteris and compared it to the modern species Tmesipteris tannensis which belongs to the monogeneric family Tmesipteridaceae, the epiphytic Psilophytes growing on trunks of tree ferns in Australia and New Zealand.

Occurrence: Cenomanian of Oklahoma (Hedlund, 1966). One specimen was found in the South Hospah sediments.

Measurements: 24 x 67 μm . the range given by Hedlund (1966) is 22.5-30 x 50-60 μm .

Figured specimen: Pb12496-1 (117.4x29.6).

Genus Verrucosisporites Ibrahim 1933 emend. Smith 1971

1933 Verrucosisporites Ibrahim, p. 24.

1971 Verrucosisporites Ibr. emend. Smith, p. 43.

Type Species: Verrucosisporites verrucosus, Ibrahim, ibid., p. 25,
pl. 2, fig. 17.

Verrucosisporites sp. 1

Plate 14, figs. 6-8

Description: Distally verrucate trilete spore with a circular amb;

trilete mark long, extending $3/4$ of the radius, distinctly marked by minute lips; proximal surface minutely granulate.

Comments: This form is larger than others described here, and has a longer laesurae.

Measurements: 40-42 μm .

Figured specimens: Pb12374-3 (119.7x42.2 & 115.2x35.5).

Verrucosisporites sp. 2

Plate 14, figs. 9-10

Description: Distally- verrucate trilete spore with rounded amb; trilete mark short, about $1/2$ the radius, slightly lipped; proximal surface psilate or minutely granular.

Measurements: 31 μm .

Figured specimens: Pb12382-10 (125.6x31.4); Pb12411-1 (122.4x40.6).

Verrucosisporites sp. 3

Plate 14, fig. 11

Description: Distally verrucate trilete spore with rounded amb; laesurae short, extending ca. $1/2$ the radius, markedly lipped by a thick margo. Sculptures greatly reduced on the proximal surface.

Comments: This form is smaller than the other forms described here. It is distinguished by a thick margo along the laesurae.

Measurements: 27 μm .

Figured specimens: Pb12401-12 (114.4x32.8).

Unidentified Spore A

Plate 14, figs. 12-15

Description: Azonotrilete spores; laesurae long, reaching almost to the proximal contour, may be masked by the verrucae; amb rounded triangular to circular or oval; exine 1-2 μm thick, both proximal and distal surfaces sculptured by verrucae or rugulae that are more or less oriented radially from the pole to the periphery in equatorial view. The spaces between the projections make an anastomosing groove pattern. The grooves are observable on the contour and indicate the continuation of the pattern on the other side.

Comments: Emphanisporites McGregor 1961 from the Devonian of Canada and Emphanizonosporites Schultz 1968 have distinct, unbroken radial plicae only on proximal side (distal side laevigate) and, in some species, an annulate concentric thickening. Virgatasporites Combaz 1968 from Tremadocian of Sahara has poorly-developed, anastomosing, radial ribs on proximal side. Radorugoisporites Zhang 1978 from the Lower Cretaceous of China has been described as having a psilate proximal surface, a rugulate distal surface (Zhang must have meant "rugulae" when he used the term "rugae", which means infolds or furrows rather than ribs or striae), and a smooth contour. The ribs in Zhang's genus are extended almost to the periphery of the proximal side; some that do not reach the periphery, change into dotted lines (cf. Jansonius & Hills, 1979, p. 3600). I did not have access to Zhang's material for comparison with forms from New Mexico.

Measurements: 45-52 μm .

Figured specimens: Pb12379-3 (117.7x30.8); Pb12411-1 (110.8x37.5).

Unidentified Spore B

Plate 14, figs. 16,17

Figure

Figure

Figure

Figure

DIVISION

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Type Sp

Comment

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1958a

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Figured specimen: Pb12401-12 (112.8x37.4).

Unidentified Spore C

Plate 14, fig. 18

Figured specimen: Pb12442-1 (127.4x40.6).

Unidentified Spore D, type 1

Plate 15, figs. 1-4

Figured specimens: Pb12387-5 (117.0x39.7; 125.8x31.8; 117.7x29.4)

Unidentified Spore D, type 2

Plate 15, fig. 5

Figured specimen: Pb12411-1 (111.6x36.4).

DIVISION PTEROPHYTA - Incertae Sedis (Megaspores)

Genus Balmeisporites Cookson & Dettmann 1958a

1958a Balmeisporites Cookson & Dettman, p. 42.

Type Species: Balmeisporites holodictyus Cookson & Dettman, *ibid.*,
pl. 2, fig. 1.

Comments: For the latest interpretation on the status and synonymy
of the genus Balmeisporites see Srivastava 1978a.

Balmeisporites glenelgensis Cookson & Dettmann 1958a

Plate 15, figs. 6,7

1958a Balmeisporites glenelgensis Cookson & Dettman, p. 43, pl. 2,
fig. 1.

Occurrence

Cenomanian

Mexico.

Measurement

(Hedlund, 1

Figured spe

1973 Balm

pl.

Comments:

of the genus

Occurrence:

(Bergad, 197

Measurements

acrolamella

Figured spe

1954 Dicty

Type Species

1964 Dicty

Comments:

Occurrence: Upper cretaceous of Victoria (Cookson & Dettman, 1958a), Cenomanian of Oklahoma (Hedlund, 1966). Lower Campanian of New Mexico.

Measurements: 107-135 um (Cookson & Dettman, 1958a), 187.5 um (Hedlund, 1966), 195-200 um (this study).

Figured specimens: Pb12441-8 (123.3x38.4).

Balmeisporites rigidus Bergad 1973

Plate 15, figs. 8-11

1973 Balmeisporites rigidus Bergad, p. 59, pl. 3, fig. 12-14, pl. 4, figs. 1-2.

Comments: This species is distinct from the other reticulate members of the genus by the lack of equatorial wings and double-walled muri.

Occurrence: Hell Creek Formation (Maestrichtian) of Montana (Bergad, 1973), Lower Campanian of New Mexico.

Measurements: 200 um. body size (exclusive of the perine and acrolamella) 80(119)145 um in Bergad (1973).

Figured specimens: Pb12456-1 (119.0x30.7); Pb12441-4 (112.0x36.3).

Genus Dictyothylakos Horst 1954

1954 Dictyothylakos Horst, p. 610.

Type Species: D. pesslerae Horst, p. 610-613.

Dictyothylakos sp. Singh 1964

Plate 15, figs. 12-14

1964 Dictyothylakos sp. Singh, p. 169, pl. 29, figs. 1-3.

Comments: Singh (1964) illustrated reticulate tissues with thick

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rounded strands ranging between 15 to 35 micrometers and with mesh sizes of more than 200 micrometers from Mannville Group of East-Central Alberta, Canada. He described them as perispore covering of the megaspore Thylakosporites retarius (Hughes, 1955) Potonie 1956. Gunther & Hills (1972) reported these forms from Campanian-Maestrichtian of Alberta, Canada and designated them as Dictyothylakos sp. A. I found similar entities in the coarse fraction (larger than 177 μ m) of the maceration residues from the Menefee Formation. These hollow "perispores" are relatively strong. They tolerate moderate pressure from dissecting needle and bounce back when pressure is released. I found no megaspore with this type of "perispore" attached to it.

Occurrence: Barremian? to Middle Albian of north-central Canada (Singh, 1964); Campanian-Maestrichtian of Alberta, Canada (Gunther & Hills, 1972), Lower Campanian of New Mexico.

Figured specimens: Pb12535-1 (116.0x35.5); Pb12387-6 (109.6x35.0); Pb12441-6 (115.3x44.1).

Genus Echitriletes Potonie 1956

1956 Echitriletes Potonie, Synopsis I, p. 36.

Type Species: Echitriletes lanatus (Dijkstra) Pot., *ibid.*

Triletes lanatus Dijkstra 1951, p. 11, pl. 2, fig. 22.

Comments: Trilete megaspores with capillate to spinate ornamentation are assigned to this genus.

Echitriletes sp.

Plate 16, fig. 1

Description: Azonotrilete, spinate megaspore; trilete mark ca. 15 μ m wide, extending almost to the periphery; spines short and

widely-spa

differenti

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Figured sp

1973 Pax

Type Specif

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Comments:

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(1973) pro

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Measureme

widely-spaced on both distal and proximal surfaces. Contact area not differentiated.

Measurements: Ca. 430 um.

Figured specimen: Pb12441-7 (123.7x40.2).

Genus Paxillitriletes Hall & Nicolson 1973

1973 Paxillitriletes Hall and Nicolson, p. 319.

Type Species: P. reticulatus (Madler, 1954) Hall & Nicolson, 1973.

Thomsonia reticulatus Madler, p. 150, pl. 5, fig. 15,

Wealden (Lower Cretaceous), Germany.

Description: Megaspores having protuberances along the laesurae or their vicinity, a narrow equatorial zona, and labra that reach the margin of the spore or even extending beyond it.

Comments: Thomsonia Madler is a homonym of Thomsonia Wallich (1830), an extant member of the angiosperm family Araceae. Hall & Nicolson (1973) proposed the new name Paxillitriletes.

Paxillitriletes fairlightensis (Batten, 1969) Hall & Nicolson 1973

Plate 16, fig. 2

1969 Thomsonia fairlightensis Batten, p. 340, pl. 64, fig. 10.

1973 Paxillitriletes fairlightensis (Batten) Hall & Nicolson,
p. 319.

Description: See Hall & Nicolson, 1973.

Occurrence: Wealden (Lower Cretaceous) of England (Batten, 1969), Hauterivian of Canada (Sweet, 1979). One specimen of this form was found in the South Hospah samples.

Measurements: 470 um.

Figured specimen
preparation).

Figured specimen

Figured specimen
(111.3x28.8).

DIVISION CYCAD
ORDER CYCAD

Genus Cy

1933 Cycad

1946 Cycad

Type Species:

Comments: This

grains similar

furrow that ex

at the ends.

in this genus

Figured specimen: Pb12519 (specimen was destroyed in SEM preparation).

Unidentified Megaspore A

Plate 16, figs. 3,4

Figured specimen: Pb12455-4 (125.3x39.1).

Unidentified Megaspore B

Plate 16, figs. 5-7

Figured specimens: Pb12454-1 (126.9x32.3, 118.8x32.2); Pb12454-4 (111.3x28.8).

DIVISION CYCADOPHYTA-GINKGOPHYTA

ORDER CYCADALES-GINKGOALES

Genus Cycadopites Wodehouse 1933 ex Wilson & Webster 1946

1933 Cycadopites Wodehouse, p. 483.

1946 Cycadopites Wilson & Webster, p. 274.

Type Species: Cycadopites follicularis Wilson & Webster, *ibid.*, pl. 1, fig. 7.

Comments: This genus was proposed for prolate monosulcate pollen grains similar to those of the gymnospermous genus Cycas, with a furrow that extends the entire length of the grain and is always open at the ends. Nichols et al. (1973) compared the structure of sulcus in this genus with other monosulcate grains produced by angiosperms.

Cycadopites sp. 1

Description:

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Comments: T

assemblage.

Measurements

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Description:

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Measurements

Figured spec

Description:

rounded; sul

gaping at bo

less than 1

Plate 17, fig. 1

Description: Fusiform, monosulcate pollen grains; length nearly twice the width. Sulcus extending the entire length of the grain, sulcus sides parallel or touching, but not overlapping. Exine thin (less than 1 μ m thick) and psilate.

Comments: This form is the smallest monosulcate pollen found in this assemblage.

Measurements: 13-18 x 6-10 μ m (5 specimens).

Figured specimen: Pb12385-1 (127.9x38.7).

Cycadopites sp. 2

Plate 17, fig. 2

Description: Fusiform monosulcate pollen; ends truncated; sulcus extending the entire length of the grain, gaping at both ends and slightly overlapping towards the center. Exine ca. 1 μ m thick, psilate.

Comments: This form is larger and wider than C. sp. 1, and has a thicker exine.

Measurements: 13 x 20 μ m.

Figured specimen: Pb12387-2 (126.8x34.6).

Cycadopites sp. 3

Plate 17, fig. 3

Description: Elliptical, monosulcate pollen grains; ends acutely rounded; sulcus running the entire length of the grain, slightly gaping at both ends, sides parallel at the rest of the grain. Exine less than 1 μ m thick, psilate.

Comments: Th

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Measurements:

Figured speci

Description:

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Comments: T

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Measurements:

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ORDER BENNE

1957 Exe

Type Speci

Comments:

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Comments: This form is distinct from other forms described here by having elliptical outline with acutely rounded ends, and a sulcus with parallel sides.

Measurements: 30 x 16 um.

Figured specimen: Pb12511-1 (112.5x37.7).

Cycadopites sp. 4

Plate 17, fig. 4

Description: Large monosulcate pollen; outline fusiform; sulcus running the entire length of the grain, largely gaping at one end and completely overlapping at the rest of the grain; exine up to 2 um thick, minutely granulate.

Comments: This form can be differentiated from others described here by having larger size, thicker exine, and different sulcus form.

Measurements: 45x21 um.

Figured specimen: Pb12430-1 (125.5x36.9).

ORDER BENNETTITALES

Genus Exesipollenites Balme 1957

1957 Exesipollenites Balme, p. 39

Type Species: Exesipollenites tumulus Balme, *ibid.*, pl. 11, figs. 123-125.

Exesipollenite tumulus Balme 1957

Plate 17, fig. 5

Comments: Rouse (1959, pl. 1, fig. 24) reported a similar form, but he did not assign it to this species. Harris (1974) found similar

pollen grains

Williamsoniella

Occurrence: Ju

some samples fr

Measurements:

Figured specimen

1958 Spherip

Type Species:

Comments: Th

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Exesipollenit

pollen sac on

Williamsonie

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1958 Cras

1965 Sphe

pl.

Occurrence

Australia

Hospah sam

pollen grains in an intact pollen sac on the Bennett-Italian species Williamsoniella lignieri from the Bajocian of Yorkshire.

Occurrence: Jurassic-Cretaceous, widespread. Occurs commonly in some samples from the South Hospah.

Measurements: 27(33)45 um (8 specimens). 25(30)33 um in Balme (1957).

Figured specimen: Pb12374-3 (123.0x30.8).

Genus Spheripollenites Couper 1958

1958 Spheripollenites Couper, p. 158.

Type Species: Spheripollenites scabratus Couper, *ibid.*, pl. 31, figs. 12-14.

Comments: This genus differs from Exesipollenites Balme in having a poorly-developed pore. Couper (1958) assigned grains smaller than 45 um to this genus. Harris (1974) found pollen grains similar to Exesipollenites scabratus and Spheripollenites sp. in an intact pollen sac on the type specimen of the bennettitalian species Williamsoniella lignieri from Bajocian of Yorkshire.

Spheripollenites classopolloides (Nilsson 1958)

Playford & Dettmann 1965

Plate 17, fig. 6

1958 Crassipollenites classopolloides Nilsson, p. 74, pl. 7, figs. 3-5.

1965 Spheripollenites classopolloides (Nil.) Play. & Dett., p. 160, pl. 17, figs. 62-64.

Occurrence: Rhaetic-Liassic of Sweden (Nilsson 1958) and S.

Australia (Playford & Dettmann 1965). Occurs rarely in the South Hospah samples. It may be a recycled grain.

Measurement:

Figured species:

1958 Species

Occurrence:

1958) and C

of New Mexi

Measurement:

(1958); 22(1

Figured species:

DIVISION CON

FAMILY CHE

1953 Class

Type Species

20-25, 29-37

Synonymy: S

Comments: S

1977) for a

also Srivast

and scanning

Measurements: 27 um. 24(30)40 um in Playford & Dettmann (1965).

Figured specimen: Pb12394-1 (123.8x42.4).

Spheripollenites scabratus Couper 1958

Plate 17, fig. 7

1958 Spheripollenites scabratus Couper, p. 158, pl. 31, figs. 12-14.

Occurrence: Middle Jurassic to Lower Cretaceous of England (Couper 1958) and Canada (Pocock 1962); Rarely occurs in the Lower Campanian of New Mexico.

Measurements: 21(38)47 um (16 specimens). 25(30)42 um in Couper (1958); 22(33)48 um in Pocock (1967).

Figured specimen: Pb12414-7 (123.3x41.1).

DIVISION CONIFEROPHYTA

FAMILY CHEIROLEPIDIACEAE (extinct)

Genus Classopollis Pflug 1953

1953 Classopollis Pflug, p. 91

Type Species Classopollisclassoides Pflug, ibid., pl. 16, figs. 20-25, 29-37.

Synonymy: See Srivastava (1976).

Comments: See Jansonius & Hills (1976, p. 504, 505 and 1977, p. 1977) for a review of taxonomic treatment by different authors. See also Srivastava (1976) for the most recent review of the literature and scanning electron microscopic study of this genus.

Classopollis classoides Pflug 1953

Plate 17, figs. 8,9

Occurrence

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Pb12384-1

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Comments:

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Occurrence

of Oklahom

Campanian

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Figured s

1963 Ci

Comments:

genus Cla

Occurrence

Measureme

Figured s

Occurrence: Triassic-Cretaceous, widespread.

Measurements: 20(24)31 μm (16 specimens).

Figured specimens: Pb12513-1 (112.5x41.5); Pb12387-2 (126.3x35.4);
Pb12384-1 (125.6x33.8); Pb12442-1 (122.3x43.3).

cf. Classopollis martinottii Reyre 1970

Plate 17, figs. 10-12

1970 Classopollis martinottii Reyre 1970

Comments: See Srivastava (1975b, p. 77, pls. 34-36) for SEM illustrations and detail morphological study of this species. The forms found in the South Hospah samples are smaller in size.

Occurrence: Berriasian-Valanginian of Israel (Reyre, 1970), Albian of Oklahoma (Srivastava, 1975b). Occurs occasionally in the Lower Campanian of New Mexico.

Measurements: 21,25 μm (2 specimens); 28-33 μm in Reyre, (1970);
26-34 μm in Srivastava (1975).

Figured specimens: Pb12385-1 (119.0x31.7); Pb12378-5 (118.6x30.7).

Classopollis cf. Circulina parva Brenner 1963

Plate 17, fig. 13

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

Comments: Circulina parva corresponds to the circumscription of the genus Classopollis as accepted here.

Occurrence: Rare.

Measurements: 16-21 μm (9 specimens).

Figured specimen: Pb12385-1 (126.8x32.6).

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FAMILY TAXODIACEAE - CUPRESSACEAE

Genus Inaperturopollenites Pflug & Thomson in Thomson & Pflug 1953

emend. Potonie 1958

1953 Inaperturopollenites Pf. & Thom., p. 64.

1958 Inaperturopollenites Pfl. & Th. emend. Pot., p. 17.

Type Species: Inaperturopollenites dubius (Pot. & Ven.) ex. Th. & Pfl. Ibid.

Pollenites magnus f. dubius (Potonie & Venitz 1934, p. 17, pl. 2, fig. 21. (holotype indicated in Potonie 1958, Synopsis II, p. 77)).

Comments: This concept, as emended by Potonie (1958), is applied for inaperturate pollen grains with circular amb, and thin infrapunctate exine with many secondary folds. Laricoidites is larger and has thicker wall and psilate surface.

Inaperturopollenites dubius (Potonie & Venitz) Thomson & Pflug 1953

Plate 17, fig. 14

1934 Pollenites magnus dubius Pot. & Ven., p. 17, pl. 2, fig. 21.

1953 Inaperturopollenites dubius (Pot. & Ven.) Thom. & Pfl., p. 65, figs. 1-13.

Occurrence: Lower Cretaceous Potomac Group of Maryland, U.S.A.

(Brenner 1963), Albion of Maryland and Delaware, U.S.A. (Groot & Penny, 1960), Cenomanian-Turonian of eastern U.S.A. (Groot et al., 1961), Campanian-Maestrichtian of NW Colorado (Gies, 1972). This form occurs commonly in the South Hosphah samples.

Measurements: 31-35 um (3 specimens). Ca. 35 um in Groot & Penny

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Pb12400-1

(1960) and Groot, et al (1961).

Figured specimen: Pb12439-1 (127.3x27.0).

Inaperturopollenites minor Kedves 1961

Plate 17, figs. 15-17

1961 Inaperturopollenites minor Kedves, p. 143, pl. 19, fig. 6.

Comments: This species is distinct from others by its small size, thin wall, and fine sculpture.

Occurrence: Campanian-Maestrichtian of Utah, U.S.A. (Lohrengel, 1970); occurs rarely in the Lower Campanian samples from New Mexico.

Measurements: 14-20 um (3 specimens). 10-20 um in Lohrengel (1970).

Figured specimens: Pb12385-1 (128.0x35.3 & 129.3x31.8); Pb12533-1 (112.6x30.9).

Inaperturopollentites cf. I. tenuis Kimyai 1966

Plate 17, figs. 18-20

1966 Inaperturopollenites tenuis Kimyai, p. 470, pl. 2, fig. 10.

Comments: The grains encountered in this study are smaller than the ones reported by Kimyai (1966).

Occurrence: Cenomanian of New Jersey (Kimai, 1966). It is rare in the South Hespah samples.

Measurements: 23-25 um (3 specimens). 30-35 um in Kimyai (1966).

Figured specimens: Pb12385-1 (124.0x30.8); Pb12387-2 (126.4x38.9); Pb12400-1 (127.0x36.4).

Inaperturopollenites sp.

Plate 17, fig. 21

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Comments: This form resembles I. dubius, but it does not fit the reported size range for this species.

Measurements: 21-25 um (2 specimens).

Figured specimen: Pb12385-1 (119.2x31.7).

Genus Sequoiapollenites Thiergart 1938

1938 Sequoiapollenites Thiergart, p. 301.

Type Species: Sequoiapollenites polyformosus Thiergart, *ibid.*,
pl. 23, fig. 6.

Comments: The form genus Sequoiapollenites is readily distinguished by possessing a ligula. However, this structure may be obscured by different preservation factors and by the orientation of grain in the process of compaction. These factors may account for the scarcity of these grains in the South Hospah assemblages despite the common occurrence of the Sequoia-type fossil leaves in the outcrop samples. The genus has been reported from the Upper Cretaceous and younger strata (see Thiergart, 1938; Manum, 1962; Leopold & Pakeiser, 1964; Stanley, 1965; Snead, 1969).

Affinity: The taxodiaceous genus Cryptomaria, Glyptostrobus, Metasequoia, Sequoia, and Taxodium produce more or less similar pollen grains (Stanley, 1965, p. 282). However, the form genus Sequoia-pollenites is most likely to have been produced by the genus Sequoia.

Sequoiapollenites spp.

Plate 17, figs. 22-24

Comments: Only a few grains of this type were found in the South Hospah samples. Sequoiapollenites paleocenicus has a scabrate exine.

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Measurements: 16-31 μ m.

Figured specimens: Pb12432-1 (120.8x38.7); Pb12430-1 (120.6x42.8);
Pb12507-1 (114.0x33.5).

Genus Taxodiaceapollenites Kremp. 1949 ex Potonie 1958

1949 Taxodiaceapollenites Kremp, p. 59.

1958 Taxodiaceapollenites Kremp ex Potonie, p. 78.

Type Species: Taxodiaceapollenites hiatus Pot. ex. Pot. 1958, *ibid.*

Taxodiaceae-Pollenites hiatus Pot. in Kremp, *ibid.*

Pollenites hiatus Pot., 1932, p. 5, fig. 27.

Comments: This form is characterized by its tendency to split open along a more or less straight, radial line. The edges of the wall around the break are usually folded back.

Taxodiaceapollenites hiatus Potonie 1958

Plate 17, fig. 25

Occurrence: Middle Albian to Miocene (Singh, 1971). This form is common to abundant in the South Hospah samples.

Measurements: 25-35 μ m (3 specimens).

Figured specimen: Pb12385-1 (124.9x39.8).

FAMILY ARAUCARIACEAE

Genus Araucariacites Cookson 1947 ex Couper 1953

1947 Araucariacites Cookson, p. 130.

1953 Araucariacites Couper, p. 39.

Type Species: Araucariacites australis Cookson, *ibid.*, p. 130,
pl. 13, fig. 3 (lectotype designated by Potonie 1958).

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Synopsis II, p. 81.).

Araucariacites atlanticus (Groot, Penny & Groot 1961) n. comb.

Plate 17, fig. 26

1961 Inaperturopollenites atlanticus Groot et al., p. 130.

pl. 24, fig. 18.

1963 Araucariacites australis Cookson: In Dettmann, p. 105, pl.

26, fig. 15.

1969 Araucariacites sp. Penny, pl. 16-2, fig. 16.

1975 Araucariacitesaustralis Cookson: In Bredfeaux & McIntyre,

pl. 4, fig. 15.

Description: Large inaperturate pollen, exine relatively thin, ca.

1 um thick, uniformly granulate, folded.

Comments: This form was compared with some modern araucarian pollen

by Groot et al. (1961). It should not be retained in the genus

Inaperturopollenites on this ground. A. australis has coarser and

less uniform sculpture and thicker exine.

Occurrence: Cenomanian-Turonian of eastern U.S.A. (Groot et al.,

1961), Cretaceous of SE Australia (Dettmann 1963), Aptian-Albian of

District of Mackenzie, Canada (Brideaux & McIntyre 1975). Occurs

rarely in the Lower Campanian of New Mexico.

Measurements: 50-79 um (3 specimens). 60-70 um in Groot et al.

(1961); 50(68)91 um in Dettmann (1963).

Figured specimen: Pb12387-2 (116.8x32.3).

Araucariacites australis Cookson 1947 ex Couper 1953b

Plate 17, fig. 27

1947 Araucariacites australis Cookson, p. 130, pl. 13, fig. 3.

1953b Araucariacites australis Couper, p. 39.

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Measurements: 58-83 μ m (8 specimens).

Figured specimen: Pb12385-1 (125.2x40.5).

Araucariacites limbatus (Balme 1957) Habib 1969

Plate 18, figs. 1-3

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

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

Comments: A. limbatus differs from A. australis in having thicker exine, finer sculpture, and in thinning of the exine at the polar region of the grain.

Occurrence: Rare to common.

Measurements: 37(53)70 x 49(63)81 μ m (19 specimens).

Figured specimens: Pb12382-10 (109.5x31.5); Pb12378-6 (126.7x33.0); Pb12387-5 (117.7x33.3).

Araucariacites sp.

Plate 18, fig. 4

Comments: This form exhibits all of the characteristics of the other form species assigned to the genus Araucariacites, but it is much smaller.

Measurements: 25 x 28 μ m.

Figured specimen: Pb12400-1 (126.2x32.0).

Genus Inaperturotetradites Van Hoeken-Klinkenberg 1964

1964 Inaperturotetradites van Hoeken-Klinkenberg, p. 226.

Type Species: Inaperturotetradites lacunosus van Hoeken-Klinkenberg, *ibid.*, pl. 6, figs. 17a-b.

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Inaperturotetradites sp.

Plate 18, figs. 5-7

Comments: Inaperturotetradites scabratus B. Tschudy (1973, p. 32, pl. 11, figs. 18,19) was described as tetrahedral tetrads with inaperturate, thin-walled, scabrate individual grains. the form encountered in this study superficially resembles I. scabratus except for its larger size range and thicker wall.

Occurrence: Occasional in the South Hospah samples.

Affinity: The individual grains of this type of tetrads are close - in morphology and size - to the grains assignable to Araucariacites australis (Araucariaceae) found in the studied material.

Measurements: 49, 64 um (2 specimens).

Figured specimens: Pb12378-5 (119.8x33.0); Pb12378-8 (122.1x38.7).

FAMILY PINACEAE

Genus Alisporites Daugherty 1941

1941 Alisporites Daugherty, p. 98.

Type Species: Alisporites opii Daugherty, ibid., pl. 34, fig. 2.

Alisporites sp.

Plate 18, fig. 8

Measurements: Length of the grain 94 um; length of the body 28 um; length of the wings 24 and 21 um; breadth of wings 31 um.

Figured specimen: Pb12387-7 (124.3x32.8).

Genus Zonalapollenites Pflug 1953

1953 Zonalapollenites Pflug in Thomson & Pflug, p. 66.

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FAMILY PODOC.

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1958 Tsugaepollenites Potonie & Venitz ex Potonie 1958.

Type Species: Zonalapollenites igniculus (Pot.) Pocock 1968, p. 640
(designated by Pocock, *ibid.*).

Sporonites igniculus Potonie 1931, p. 556, fig. 2.

Comments: This genus is characterized by having an equatorial velum with radial plication. Callialasporites has a saccus rather than a velum. Tsugaepollenites was validated in 1958. It is an obligate junior synonym, having the same type species as Zonalapollenites (see Jansonius & Hills, 1976, p. 3265).

Zonalapollenites sp.

Plate 18, figs. 9,10

Description: Pollen grain spherical, outline circular, exine made up of two distinct layers: inner layer 0.5 μ m thick, uniform in thickness except at the polar areas of the grain where it is discontinued and an ora of ca. 6 μ m is formed; the outer layer irregular, up to 5 μ m thick, modified into thick and broad rugulate ornamentation that covers the grain as a velum up to ca. 45 degree latitude at each hemisphere.

Occurrence: A few grains of this type were observed in the South Hospah samples.

Measurements: 40 μ m.

Figured specimen: Pb12454-1 (113.6x43.4);

FAMILY PODOCARPACEAE

Genus Parvisaccites Couper 1958

1958 Parvisaccites Couper, p. 154.

Type Species: Parvisaccites radiatus Couper, *ibid.*, pl. 29, figs.

5-8, pl. 30, figs. 1-2.

Affinity: Cacrydium (Podocarpaceae).

Parvisaccites radiatus Couper 1958

Plate 18, figs. 11,12

1958 Parvisaccites radiatus Couper, p. 154, pl. 29, figs. 5-8,
pl. 30, figs. 1-2.

1961 Retibivesiculites parvus Pierce, p. 38, pl. 2, figs. 51-52.

1964 Podocarpidites otagoensis Couper 1953 In: Cahoon, p. 66,
pl. 12, fig. 72.

Occurrence: Uppermost Jurassic to Albian of Europe, Barremian to Cenomanian of Canada, and U.S.A. (cf. Singh, 1971). Only a few gains of this kind were found in the South Hospah samples.

Affinity: With the modern podocarpaceous genus Dacrydium.

Measurements: 64-69 μ m. The size range given in the literature is between 38-75 μ m.

Figured specimen: Pb12384-7 (114.4x31.3); Pb12510-1 (117.6x30.0)

Genus Phyllocladidites Cookson ex Couper 1953b

1953b Phyllocladidites Couper, p. 38,

1966 Phyllocladipollenites Levet-Carette, p. 166.

1969 Dacrydiumites Cookson 1953 ex Nagy, p. 66.

non 1965 Dacrydiumites Cookson ex Harris, p.

Type Species: Phyllocladidites mawsonii Cookson ex Couper, *ibid.*

Disaccites (Phyllocladidites)mawsonii Cookson 1947,
p. 133, pl. 14, fig. 26, (lectotype designated by
Potonie, 1958, Synopsis II, p. 69).

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Comments: Phyllocladipollenites Leve-Carette 1966 and Dacrydiumites Nagy 1969 are obligate junior synonyms of Phyllocladidites, having the same type species (see Jansonius & Hills, 1976, p. 734 and 1990). Phyllocladipollenites Nagy 1969 is different in morphology, but it is an illegitimate name (junior homonym of Phyllocladipollenites Level-Carette). Dacrydiumites Cookson 1953 ex Harris 1965 is a valid name, but was proposed for a morphologically-different form. This practice is one of the sources of confusion in taxonomy (see Jansonius & Hills 1976, p. 735).

The genus Phyllocladidites differs from Parvisaccites in having a smooth to scabrate exine and very small, noninflated, incipient sacci that resemble folds in the exine.

Phyllocladidites inchoatus (Pierce 1961) Norris 1967

Plate 19, fig. 1

1961 Granabivesiculites inchoatus Pierce, p. 35, pl. 2, fig. 38.

1967 Phyllocladidites inchoatus (Pierce) Norris, p. 103, pl. 15, figs. 8-9, pl. 16, figs. 1-2.

1970 Monosulcate type 1 In: Griggs, p. 82, pl. 11, fig. 5.

1980 Phyllocladidites sp. cf. P. inchoatus (Pierce) Norris In: Wingate, p. 38, pl. 14, fig. 6.

Occurrence: Albian to Santonian. Cenomanian of Minnesota (Pierce, 1961), Albian-Cenomanian of central Alberta (Norris, 1967); Albian of Southern Oklahoma (Wingate, 1980), Turonian to Santonian of Wyoming (Griggs, 1970). Occurs occasionally in the South Hoshpah samples.

Affinity: Similar to the pollen of the modern podocarpaceous genus Dacrydium.

Measurements: 48x49 um. 37 x 46 um in Pierce (1961); 38-53 x 34-55 um in Norris (1967); 50-70 um in Griggs (1970); 40(49)52 x 27(38)45 & 33(49)60 x 45(61)73 um in Wingate (1980).

Figured specimen: Pb12404-1 (117.0x40.8).

Genus Rugubivesiculites Pierce 1961

1961 Rugubivesiculites Pierce, p. 39.

Type Species: Rugubivesiculites convolutus Pierce, *ibid.*,
pl. 2, fig. 57.

Comments: Bisaccate pollen grains having rugulate sculpture on the distal surface.

Rugubivesiculites rugosus Pierce 1961

Plate 19, fig. 2

1961 Rugubivesiculites rugosus Pierce, p. 40, pl. 2, figs. 59, 60.

Comments: The bladders are broadly attached to the central body and rugulae are dense and broad with sharp angular bends.

Occurrence: Late Albian-Maestrichtian of North America. Late Albian and Cenomanian of Canada and U.S.A. (Singh 1971, p. 167), Campanian-Maestrichtian of Colorado (Gies 1972), Maestrichtian of New Jersey (Waanders 1974). A few grains of this form were found in the South Hospah samples.

Measurements: 55 um. 76 um in Pierce (1961); 65 um in Waanders (1974).

Figured specimen: Pb12414-7 (115.2x40.7).

DIVISION GNETOPHYTA

ORDER EPHEDRALES

FAMILY EPHEDRACEAE

Genus Equisetosporites Daugherty 1941 emend. Singh 1964

Synonymy: See Singh (1964, p. 129).

Type Species: Equisetosporites chinleana Daugherty 1941, p. 63, pl. 24, fig. 4.

Comments: Acolpate, ellipsoid, polyplicate, dispersed fossil pollen grains with straight, unbranched plicae similar to ephedralean pollen.

Equisetosporites jansonii Pocock 1964

Plate 19, figs. 3,4

1964 Equisetosporites jansonii, Pocock, p. 149, pl. 1, figs. 26,27.

Description: See Pocock, ibid.

Comment: This form is a large, alete ephedralean pollen with 14-15 parallel, broad ribs that are longitudinally twisted around the grain. The specimen illustrated here is smaller but very closely similar to Pocock's illustration.

Occurrence: This form was reported by Pocock (1964) from the Albian (Upper Mannville Group) of Saskatoon area (Saskatchewan, Canada). A single grain was observed in the Lower Campanian of New Mexico.

Measurements: 67 x 34 μ m. The size range given by Pocock (1964) is 82-90 x 40.8-43 μ m.

Figured specimen: Pb12494-1 (120.3x31.1).

Equisetasporites menakae Srivastava 1968b

Plate 19, fig. 5

1968b Equisetosporites menakae Srivastava, p. 217, fig. 12.

Comments: This form is distinct by having a prolate spherical shape,

7-8 broad ridges, and a small size.

Occurrence: Maestrichtian of Alberta, Canada (Srivastava, 1968b).

Occurs occasionally in the Lower Campanian of New Mexico.

Measurements: 26 x 22 um. The size range in Srivastava (1968b) is 32.8 x 30.4 um.

Figured specimen: Pb12457-1 (119.0x44.6).

Equisetosporites rousei Pocock 1964

Plate 19, figs. 6,7

1964 Equisetosporites rousei Pocock, p. 148, pl. 1, figs. 6,7,17.

Comments: This form has about 14 longitudinal ridges on the exine.

E. multicostatus is close in morphology, but is characterized by numerous (18-24) narrow plicae which are closely spaced.

Occurrence: It was first reported from the Albion of Canada (Pocock, 1964). Like other Ephedralean pollen, it is very rare and occurs only occasionally in the Lower Campanian of New Mexico.

Measurements: 27-33 x 12-14 um. The size range given in Pocock (1964) is 31.5 x 14.4 um.

Figured specimens: Pb12439-1 (122.9x38.2); Pb12408-1 (127.7x43.0).

Equisetosporites sp.

Plate 19, fig. 8

Description: Elongated, slender, polyPLICATE pollen grain. The surface ornamented by 7 plicae, each ca. 1.5 um wide, separated by ca. 1/2 um-wide-furrows. Plicae fuse at both ends of the grain and do not cross over to the other side.

Measurements: 28 x 7 um (1 specimen).

Figured specimen: Pb12385-5 (118.8x30.3).

Genus Steevesipollenites Stover 1964b

1964b Steevesipollinites Stover, p. 151.

Type Species: Steevesipollenites multilineatus Stover, *ibid.*,
pl. 2, figs. 1-6.

Comments: This genus was erected for acolpate, elongated, polylicate pollen grains with conspicuously modified poles. It differs from Equisetosporites by having prominent and clearly differentiated structures at the poles. Vittatina cretacea Pocock (1962) has foveolate polar rudimentary sacchi and is only distally plicate. Ephedripites corrugarus Wilson (1962) from the Lower Permian Flowerpot Formation shows a slight differentiation at one end.

Steevesipollenites cf. S. binodosus Stover 1964b

Plate 19, fig. 9

1964b Steevesipollenites binodosus Stover, p. 151, pl. 2, figs. 7-9.

Comments: This species was originally reported from Albian-Turonian strata of senegal basin, West Africa. Its size range was given as 50-64 μ m. The present specimen is only 28 μ m long but has relatively larger polar knobs. The form illustrated by Romans (1975, p. 318, pl. 7, figs. 6-7) from Cenomanian Dakota Sandstone of Arizona as S. binodosus has elongated nodes as opposed to semicircular nodes in the original material. It also has more expanded equatorial region. My measurements on Stover's illustrations show a shape index of 0.38-0.40 whereas in Romans' form the index is 0.75. This form is

rare, both in my material and in that of Romans. More specimens are required for statistical analysis and morphological differentiation of American forms.

Occurrence: Albion-Turonian of W. Africa (Stover, 1964b).

Figured specimen: Pb12387-2 (115.1x43.0)

GYNMOSPERMAE - INCERTAE SEDIS

Genus Callialasporites Dev. 1961

1961 (1959) Callialasporites Dev, p. 48.

Synonymy: See Srivastava 1975b, p. 73.

Type Species: Callialasporites trilobatus (Balme) Dev 1961, p. 48.

Zonalapollenites trilobatus Balme 1957, p. 33, pl. 8,
fig. 91.

Comments: Monosaccate pollen grains with a radially folded bladder.

Zonalapollenites has a velum rather than a saccus.

Callialasporites dampieri (Balme 1957) Dev 1961

Plate 19, figs. 10-13

Synonymy: See Srivastava 1975b, p. 75.

Comments: Zonalapollenites dampieri Balme, Applanopsis dampieri (Balme) Doring, Pflugipollenites dampieri Balme) Pocock, Tsugaepollenites dampieri (Balme) Dettmann, and Applanopispollenites dampieri (Balme) Levett-Carette are synonymous with Callialasporites dampieri.

Occurrence: Jurassic to Eocene, widespread (cf. Dettmann 1963; Singh 1971, p. 175). Occurs occasionally in the South Hospah samples.

Affinity: This pollen has been compared to the pollen of the

podocarpaceous male cone Apterocladus lanceolatus and the
auracariaceous Brachyphyllum mamillare (cf. Srivastava 1975b p. 75).
Measurements: 53-55 um (3 specimens). The size range given in
literature is 53-80 um.

Figured specimens: Pb12374-3 (125.5x34.8); Pb12458-1 (118.0x42.8);
Pb12513-1 (114.1x30.0); Pb12439-1 (116.2x37.0).

GYMNOSPERMAE - INCERTAE SEDIS

Genus Eucommiidites Erdtman 1948

- 1948 Eucommiidites Erdtman, p. 267.
- 1953 Protoquercus Bolkhovitina, p. 93.
- 1957 Trifossapollenites Rouse, p. 372.
- 1958 Eucommiidites (Erdtman) Potonie, p. 87.
- 1958 Eucommiidites Erdtman emend. Couper, p. 160.
- 1961 Psilatricolpites Pierce, p. 49.
- 1961 Eucommiidites Erdtman emend. Hughes, p. 292.
- 1963 Eucommiidipollenites Levet-Carett, p. 120.

Type Species: Eucommiidites troedssonii (Erdtman) Potonie 1958,
p. 87.

Tricolpites (Eucommiidites) Troedssonii Erdtman 1948,
p. 267, fig. 15 (lectotype designated by Potonie,
l. c.).

Description: See Hughes (1961). See also Couper (1958) for detail
comparison of this genus with angiospermous pollen, and Doyle et al.
(1975) for SEM and TEM examinations.

Comments: The validity of this genus as proposed by Erdtman (1948)
was discussed by Hughes (1961). This was also acknowledged by Couper
(1958) by citing Erdtman as the original author. This citation has

been vastly used by authors since then. The above synonymy is based on the acceptance of the validity of Erdtman's original proposal. Jansonius & Hills (1976) believe that Potonie (1958) validated this genus.

The type species (lectotype) of this genus was designated by Potonie (1958, January). Couper (1958, March), who was apparently unaware of Potonie's latest publication at the time, designated the type species separately. Based on Hughes' emendation, this genus is diagnosed as an oval pollen grain having a long furrow with rounded ends on one face and a ring-furrow on the opposite side near the margin (zonisulcate). The zonisulcus may be incomplete at the ends in the long axis.

Occurrence: Jurassic to Cretaceous, widespread. The abundance of this genus seems to decline after Albian. Srivastava (1978) contended that this genus, along with Classopollis, Cerebropollenites, and Callialasporites, disappeared by the end of Turonian, and that the records of these forms from the younger strata do not seem to be reliable and may represent reworked specimens. The abundance and morphological diversity of Eucommiidites and Classopollis in the present material does not confirm this idea. The presence of both palynomorphs in the allochthonous coal beds of South Hospah confirms their extension, at least to the Early Campanian time.

Affinity: Erdtman (1948) considered this pollen as a tricolpate angiospermous pollen and compared it with the pollen of Eucommia ulmoides Oliv. Couper (1958) suggested a gymnospermous affinity for this grain. Potonie (1958) grouped the genus with the gymnospermous

praecolpates rather than angiospermous grains. Couper (1958) restudied the original material of Erdtman and ruled out their affinity to angiospermous pollen grains. He emended the genus as having a broad distal sulcus of gymnospermous type and two minor proximal "colpi". Hughes (1961) found this pollen in the micropyle and pollen chamber of 4 Lower Cretaceous gymnospermous seeds (Spermatites). Brenner (1963) studied 20 seeds similar to those found by Hughes and observed Eucommiidites in the micropyle and pollen chamber of 12 of them. He postulated that this association is natural rather than coincidental. Cittert (1971) isolated this genus from gymnospermous cones, possibly of Cycadalian affinity.

Eucommiidites crossii n. sp.

Plate 22, figs. 1-10

Holotype: Pb12428-7 (124.4x38.8).

Description: Pollen grains ellipsoidal with elliptical equatorial outline and circular polar outline; exine relatively very thick (1.5-2 μ m), sharply decreasing in thickness towards the apertures. Apertures consist of a short sulcus and two longer sulci that almost join at the polar areas and tend to make a subequatorial zoni-sulcus. Surface scabrate or covered with scattered granules.

Comments: This form is morphologically close to E. delcourtii Hughes, 1961. Hughes' species, however, has scattered small shallow pits, thinner exine (1-1.5 μ m), and larger size (see measurements below). E. hughesii n. sp. is smaller and has thinner exine with psilate surface. E. minor Groot & Penny, 1960 is probably

conspecific with E. troedsonii (see discussion under the latter species). E. minor Groot & Penny sensu Hughes, 1961 is larger and has a psilate surface.

Occurrence: This form occurs abundantly in the South Hospah samples.

Measurements: 18(18)20 x 12(15.5)18 μ m (12 specimens measured). P/E = 1.18(1.27)1.39 (6 specimens). The size range of E. delcourtii Hughes is 16(19)23 μ m (polar diameter).

Derivation of specific epithet: For Professor Aureal T. Cross of Michigan State University.

Figured specimens: Pb12428-7 (124.4x38.8; 124.3x31.4; 118.6x29.2); Pb12428-1 (126.6x33.4 & 127.3x31.4; Pb12518-1 (122.2x44.2); Pb12529-1 (118.9x34.3 & 118.9x35.0); Pb12428-8 (113.3x33.2); Pb12432-1 (117.4x39.6).

Eucommiidites hughesii n. sp.

Plate 20, figs. 11-15

Holotype: Pb12387-2 (123.8x35.5), (equatorial view; "E1" sensu Couper, 1958).

Paratypes: Pb12387-2 (117.0x42.8), (oblique equatorial view); pb12387-2 (117.3x44.0), (oblique polar view); Pb12387-2 (116.9x35.5), (equatorial view; "E2" sensu Couper 1958).

Description: Pollen grains ellipsoidal with elliptical equatorial outline having an elongated sulcus with rounded and flared ends, surrounded by a narrower subequatorial zoni-sulcus. The zoni-sulcus may be disconnected at the polar ends. Exine psilate, about 0.5-1 μ m thick.

Comments: This species is readily distinguishable from E. minor (sensu Hughes, 1961) by having smaller size and thinner exine. The

exine thickness in E. minor is 1.5-2 μ m, and the size range is 18-25 μ m. Even the largest grains of E. hughesii, which overlap the lowest size range of E. minor, have markedly thinner wall. E. hughesii differs from E. crossii by having psilate exine which is markedly thinner.

Measurements: 14(16.6)20 x 9(12.6)15 μ m (18 specimens). P/E = 1.16(1.45)1.66 (14 specimens).

Derivation of specific epithet: For Dr. Norman F. Hughes, in recognition of his contribution to the study of Eucommiidites.

Figured specimens: Pb12387-2 (123.8x35.5, 117.0x42.8, 117.3x44.0, 116.9x35.5, 126.3x36.1).

Eucommiidites troedsonii Erdtman 1948 emend. Hughes 1961

Plate 20, figs. 16-20

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

1960 Eucommiidites minor Groot & Penny, p. 234, pl. 2, fig. 14.

non1961 Eucommiidites minor Groot & Penny in Hughes, p. ,pl. ,fig.

1961 Psilatricopites psilatus Pierce, p. 49, pl. 3, figs. 98-99.

Comments: The type species of E. minor Groot & Penny is not significantly different from E. troedsonii. Hughes (1961) reported a form under E. minor which does not resemble the holotype of that species. He commented on the superficial description of E. minor. Brenner (1963) suggested that this concept should be renamed. This should be done based on the material illustrated by Hughes (1961). E. troedsonii is larger than E. crossii n. sp. and E. hughesii.

Occurrence: Triassic to Cretaceous, widespread.

Measurements: 24 μ m.

Figured specimens: Pb12374-3 (111.3x43.3); Pb12460-1 (122.2x38.5);
149Pb12456-1 (117.1x40.1); Pb 12342-2 (123.6x33.7); Pb12342-1
(121.5x42.7).

Genus Perinopollenites Couper 1958

1958 Perinopollenites Couper, p. 152.

Type Species: Perinopollenites elatoides Couper, *ibid.*, pl. 27,
figs. 9-11.

Perinopollenites sp.

Plate 20, figs. 21,22

Description: Perinate pollen grains; amb circular; perine 4-5 um wide, psilate, distinctly separated from the central body by a wrinkled or thickened area of ca. 2 um wide. Central body psilate with a polar poroid thinning of ca. 4 um.

Comments: This form is morphologically similar to P. elatoides Couper (1958), but is much smaller than all the given size ranges for this species in the reviewed literature. The size range in Couper (1958) was given as 30(48)54 um. Similar forms were reported by Brenner (1963) with a size range of 35 & 45 um. The size range was not given in Brideaux & McIntyre (1975), but their illustrations measure 32 & 34 um. The size range in Burger (1966) is 38-60 um; in Hedlund 32.4x37.8 um, and in Pocock (1962) 38-50 um. Pocock (1962, p .60 mentioned that the poroid structure is not always clearly shown.

Affinity: Couper (1958) compared P. elatoides with the British Jurassic taxodiaceous megafossil Elatides williamsonii.

Measurements: 24 um.

Figured specimens: Pb12379-3 (127.6x30.2); Pb12457-1 (113.7x35.1).

Genus Spermatites Miner 1935

1935 Spermatites Miner, p. 597.

Type Species: Spermatites elongatus Miner, p. 597, pl. 19, fig. 33,
(lectotype, designated by Jansonius & Hills, 1976,
p. 2633).

Description: Subprolate to perprolate nucellar cuticles of
gymnospermous seeds with square, hexagonal or rectangular cell walls,
a protruding micropyle, and a sessile or short-stalked base made up
of a dense mass of compact cells.

Comments: The megasporangial structures are described here along
with Eucommiidites to express the association of these two
reproductive structures.

Miner (1935) described this form as having unknown affinity,
possibly primitive seeds; Hughes (1961) reported several
Eucommiidites delcourtii in micropyle and pollen chamber of four
specimens of Spermatites pettensis from the Lower Cretaceous of England
and suggested Chlamydospermales as the most likely group to assign
this type of seeds to. Brenner (1963, p. 86) found numerous seeds
similar to those described by Hughes in a clayball from the Patuxent
(Lower Cretaceous) of Virginia. He examined 20 specimens and
observed Eucommiidites troedssonii in the micropylar tube of 12
specimens. His discovery further weakens the possibility of
fortuitous entering of a foreign pollen in the micropylar tube of the
seeds as was demonstrated by Sahní (1915) in case of some recent
Ginkgo ovules.

Spermatites ellipticus Miner 1935

Plate 20, figs. 23,24

Plate 21, figs. 1,2

1935 Spermatites ellipticus Miner, p. 599, plate 19, fig. 41,
43-47.

Occurrence: Upper Cretaceous (?Cenomanian) of Greenland (Miner, 1935), base of Cenomanian of southwestern France (Colin, 1973), Cenomanian of Iowa, U.S.A. (Schemel, 1950), Maestrichtian of Canada (Binda, 1968).

Measurements: Length = 650-770 μ m, width 270-350 μ m, L/W = 2.1-2.4.
Dimensions in Colin (1973): Length = 810-1200 μ m, width = 300-550 μ m.
L/W = 2.17.

Figured specimens: Pb12462-1 (121.0x35.0 and 121.0x38.0).

Spermatites elongatus Miner 1935

Plate 21, fig. 3

1935 Spermatites elongatus Miner, p. 597, pl. 19, fig. 33.

Occurrence: Upper Cretaceous (?Cenomanian) of Greenland (Miner, 1935).

Measurements: Length = 730(955)1080 μ m, width = 298(354)448 μ m, L/W = 2.41-2.7 (Miner, 1935); length = 1360 μ m, width 480 μ m, L/W = 2.83 (this study).

Figured specimen: Pb12535-1 (127.3x32.2).

Spermatites sp. 1

Plate 21, fig. 4

Description: Subprolate nucellar tissue with a broad base and a protruding micropyle. About 35 um of the micropylar tube remained on the specimen. The nucellar cuticle surrounded by another layer of tissue with a 50 um gap between the two layers.

Comments: This form is close in dimensions and geometry to S. orbicularis Miner 1935. The latter is oblate spherical to prolate spherical.

Measurements: Length = 800 um, width = 610 um, L/W = 1.31.

Figured specimen: Pb12535-1 (127.0x36.5).

Spermatites sp. 2

Plate 21, fig. 5

Description: Prolate nucellar tissue with well-defined, elongated cells which give the striated appearance to the palynomorph.

Examination under high magnification shows that the sides of the elongated cells are not smooth, but indented with protrusions.

Measurements: Length = 660 um, width = 410 um, L/w = 1.61 um.

Figured specimen: Pb12535-1 (121.5x32.7).

DIVISION MAGNOLIOPHYTA (Flowering Plants)

MONOCOLPATE POLLEN GRAINS

Genus Clavatipollenites Couper 1958

1958 Clavatipollenites Couper, p. 159.

Type Species: Clavatipollenites hughesii Couper, *ibid.*, pl. 31, figs. 19-22.

Comments: Doyle, *et al.* (1975, p. 450-454) discussed the morphology

and the angiospermous affinity of this genus, accompanied by light microscopic, TEM and SEM illustrations. This form was first reported by Couper (1958) from Barremian of England. It is supposedly the oldest well-documented angiospermous pollen known so far. Its classification with monocot pollen in this treatment is only tentative.

Clavatipollenites minutus Brenner 1963

Plate 22, figs. 1,2

1963 Clavatipollenites minutus Brenner, p. 95, pl. 41, figs. 8-9.

Comments: Brenner (1963) separated this species from C. hughesii Couper only based on its smaller size.

Measurements: 19x18 μ m.

Figured specimen: Pb12456-1 (122.2x33.6).

Genus Liliacidites Couper 1953b

1953b Liliacidites Couper, p. 56.

Type Species: Liliacidites kaitangataensis Couper, *ibid.*, pl. 7, fig. 97.

Comments: Couper (1953b) erected this genus for liliaceous monosulcate (and occasionally tricotomosulcate) dispersed fossil pollen grains with reticulate exine. Krutzsch (1970) restricted the diagnosis to tectate reticulate grains and propose Liliapollis Krutzsch 1970 for those lacking a tectum to connect the collumellate sculpture (see Jansonius & Hills, 1975, p. 1489-1490). Singh (1971) pointed out the larger lumina in the middle region of the grain which gradually decrease in size towards the polar ends.

Liliacidites intermedius Couper 1953b

Plate 22, figs. 3-5

1953b Liliacidites intermedius Couper, p. 56, l. 7, fig. 100.Comments: See Couper (1953b) for description.Occurrence: Upper Cretaceous to Miocene (cf. Couper, 1953b, p. 57).

It occurs rarely in the South Hospah samples.

Measurements: 28-33 x 38-47 um (one specimen). Size range in Couper (1953b) is 44(44)53 um (Longitudinal dimension).Figured Specimens: Pb12387-2 (123.1x32.6); Pb12379-3 (122.3x44.1).Liliacidites sp. 1

Plate 22, fig. 6

Description: Monocolpate reticulate pollen; equatorial outline prolate; lumina up to 2 um wide at the central part of the grain, decreasing in size towards the poles, meshes of reticulation polygonal, muri ca. 0.25-0.5 um thick; exine ca. 0.5 um thick.Comments: This form is distinct by having a small size and relatively large, polygonal reticulation.Occurrence: Rare.Measurement: 17 x 12 um.Figured specimen: Pb12484-1 (119.0x38.7).Liliacidites sp. 2

Plate 22, figs. 7,8

Description: Reticulate monocolpate pollen; equatorial outline prolate; muri ca. 0.5 um, irregular in shape, making a vermiculate pattern on the grain; lumina also varying in shape and size.

Comments: The vermiculate pattern of the muri is characteristic of this form.

Occurrence: Rare.

Measurements: 14-18 x 20-23 μm .

Figured specimens: Pb12519-1 (112.5x33.9); Pb12462-1 (122.2x30.1).

Liliacidites sp. 3

Plate 22, fig. 9

Description: Reticulate monocolpate pollen, equatorial outline prolate; exine ca. 1.3 μm thick, baculate, baculae fuse to form a fine reticulation with lumina up to $3/4$ μm wide at the center and decreasing in size towards the longitudinal ends, muri ca. $1/3$ μm thick and make a polygonal pattern.

Comments: The reticulation is relatively very small in this form.

Occurrence: Rare.

Measurements: 26 x 16 μm .

Figured specimen: Pb12387-2 (121.2x39.7).

Liliacidites sp. 4

Plate 22, fig. 10

Description: Pollen grain prolate; reticulate; monocolpate; reticulation relatively large at the center (up to 2 μm), decreasing in size towards the longitudinal ends; muri ca. $1/3$ μm thick, forming an irregular polygonal pattern; exine ca. 1 μm thick.

Comments: This form is close to L. sp. 3 in outline, but differs in having much larger reticulation.

Occurrence: Rare.

Measurements: 29 x 17 μm .

Figured specimen: Pb12466-1 (125.6x30.7).

Liliacidites sp. 5

Plate 22, fig. 11

Description: Pollen grain prolate; reticulate; monocolpate; reticulation up to 3 μm at the center of the proximal side, sharply decreasing in size at the longitudinal polar areas and the distal area where the colpus is located; colpus extending the entire length of the grain.

Comments: The differential reticulation of the proximal and distal side of the grain is characteristic of this form.

Occurrence: Rare.

Measurement: 34x24 μm .

Figured specimen: Pb12454-1 (116.1x45.0).

Liliacidites sp. 6

Plate 22, figs. 12-15

Description: Pollen grain subprolate, reticulate, monocolpate; reticulation up to 3 μm at the central part of the grain, slightly decreasing towards the longitudinal poles but sharply dropping in size only at a small area of each pole; muri up to 1 μm thick, forming a more or less regular polygonal pattern.

Comments: This form is subprolate (slightly less elongated than the previously-described forms) and has a relatively large, regular reticulation pattern that only slightly decreases in size towards the longitudinal ends.

Occurrence: Rare, but the most frequently occurring species among the Liliacidites forms found in the South Hospah assemblages.

Measurements: 25-27 x 20-22 μ m.

Figured specimens: Pb12382-2 (124.1x37.1); Pb12387-2 (121.0x44.0); Pb12404-6 (121.4x37.9).

Genus Monocolpopollenites Pflug & Thomson in Thomson & Pflug 1953

emend. Nichols, Ames, & Traverse 1973

Type Species: Monocolpopollenites tranquilus (Potonie 1934)

Thomson & Pflug 1953, p.

Pollenites tranquillus Potonie 1934, p., pl. , fig.

Comments: This genus, as emended by Nichols et al. (1973) is restricted to monocolpate pollen grains having a colpus with flared or rounded ends, with or without margo, and a psilate, scabrate, or reticulate exine.

Monocolpopollenites reticulatus Nichols et al., 1973

Plate 22, figs. 16-23

1973 Monocolpopollenites reticulatus Nichols, Ames & Traverse, p. 254, pl. 2, figs. 10-13.

Comments: Nichols et al. (1973) assigned this form to some family of the Liliophyta.

Occurrence: Late Paleocene of Texas (Nichols et al., 1973).

It occurs commonly in some of the South Hospah samples.

Measurements: 24(27)30 x 15(21)23 μ m (7 specimens).

Figured specimens: Pb12466-1 (111.4x37.9, 119.1x26.6); Pb12486-1 (125.5x34.8); Pb12533-3 (118.1x40.7, 116.8x30.7); Pb12486-1 (120.0x29.9, 112.6x39.3, 121.4x29.6).

Monocolpopollenites cf. M. texensis Nichols, Ames. & Traverse 1973

Plate 22, fig. 24

1973 Monocolpopollenites texensis Nichols et al., p. 254, pl. 2,
figs. 10-13.

Comments: This form is morphologically similar to, but smaller than,
M. texensis.

Measurements: 12 x 19 μ m.

Figured specimen: Pb12387-2 (120.6 x 37.9).

Monocolpopollenites sp.

Plate 22, figs. 25,26

Description: Pollen grain subprolate to prolate, monocolpate, colpus
extending the entire length of the grain, flaring at both ends, both
sides of the colpus folded back and produce an open, parallel-sided
channel at the central part; exine ca. 1 μ m thick, uniformly pitted.

Occurrence: Rare.

Measurements: 22-34 x 20-25 μ m.

Figured specimens: Pb12467-1 (112.5x44.9); Pb12494-1 (123.0x27.0).

Genus Retimonocolpites Pierce 1961 emend.

1961 Retimonocolpites Pierce, p. 47.

Type Species: Retimonocolpites dividiuus Pierce, ibid., pl. 3, fig.
87.

Emended Diagnosis: Monocolpate, reticulate pollen grains; sculptures
more or less uniform (not differentiated into coarse and fine
reticulum) and has a tendency to detach from the exine.

Comments: Pierce (1961) mentioned the occasional separation of the

reticulum from endexine in this genus. He did not make any comments on the size-variation of reticulum. His illustration does not suggest any differentiation of the sculpture into coarse and fine reticulation. Singh (1971, p. 188-189) transferred Pierce's species of Retimonocolpites into Liliacidites. Doyle et al., (1975) commented on their preference to separate these two genera on the basis of the differentiation of sculpture in Liliacidites and the presence of a uniform reticulum in Retimonocolpites. However, they did not formulate a formal emendation of Retimonocolpites. The above emendation is here given in order to clarify this distinction.

Retimonocolpites sp. 1

Plate 22, figs. 27-30

Description: Monocolpate, reticulate pollen; outline subprolate spheroidal in equatorial view; lumina of the reticulum 1-2.5 μm , muri very thin, ca. 0.2 μm thick, 0.5-1 μm high, made up of baculae which fuse and make a reticulation pattern at the surface. The fusion of the baculae masks the pattern and size of the reticulation produced by the bases of baculae. As a result, the surface in some specimens looks to be only granulate rather than reticulate. Colpus closed, lipped by a margo, curved or undulated in most of the specimens. Reticulation uniform and undifferentiated. The reticulum tends to detach from the endexine in some specimens.

Comments: This form is characterized by having spheroidal outline, curved, closed colpus, and finely reticulate to granulate appearance of sculpture at the surface view.

Measurements: 28(29)32 x 20(33)35 μm ; P/E = 1.07(1.14)1.18 (seven

specimens).

Figured specimens: Pb12342-1 (125.2x37.0, 117.8x41.3, 117.7x37.5, 117.5x32.9).

?Retimonocolpites sp. 2

Plate 23, fig. 1

Description: Pollen grains monocolpate, spherical; exine semitectate, reticulate, with extratectal spines; meshes of the reticulum up to 5 μ m with undulating vermiculate walls.

Comments: This form is distinct from R. sp. 1 by having much larger reticulation and by the vermiculate shape of muri.

Measurements: 32 μ m (one specimen).

Figured specimen: Pb12342-1 (123.5x37.6).

MONOPORATE POLLEN GRAINS:

Genus Sparganiaceapollenites Thiergart 1937

1937 Sparganiaceapollenites Thiergart, p. 307.

Type Species: Sparganiaceapollenites polygonalis Thierg., *ibid.*, pl. 24, fig. 11 (designated by Potonie, 1960, p. 112).

Description: See Jansonius & Hills (1976, p. 2627).

Comments: This concept was assigned by Thiergart (1937) to rounded, monoporate, reticulate pollen grains resembling the pollen of

Sparganium and Typha. The names Typhidites Chitaley 1951 [Proc. Nat. Inst. Sci. India, 17(5):376] and Sparganioidites Potonie, Thomson & Thiergart 1951 are "nomen nudum". The genus Graminidites Cookson *ex* Potonie 1960 has an annulate pore and finely granulate exine.

Sparganiaceapollenites hospahensis n. sp.

Plate 23, figs. 2-4

Holotype: Pb12454-4 (118.2x26.6).

Description: Pollen grains monoporate, pore (ora) simple, with no distinct margin, ca. 6 μ m wide, rounded; exine less than 1 μ m thick, finely reticulate, mesh of reticulum ca. 1/4 μ m up to ca. 1 μ m. outline of the pollen normally rounded.

Comments: S. polygonalis has a thicker exine, smaller pore, and smaller average size than S. hospahensis n. sp. S. hospahensis closely resembles the pollen of Typha.

Occurrence: The fossil leaf of Typha was reported by Dorf (1942, p. 45, pl. 1, fig. 12) from the Maestrichtian of Wyoming. The occurrence of the pollen in the Lower Campanian of New Mexico seems to be the first record from the rocks of this age.

Measurements: 25(27)28 μ m.

Figured specimens: Pb12454-4 (118.2x26.6), Pb12454-1 (116.2x31.4, 117.4x39.0).

TRICOLPATE POLLEN GRAINS

Genus Cupuliferoidapollenites Thomson 1950

ex Potonie 1960

1960 Cupuliferoidapollenites Pot., p. 92.

Type Species: Cupuliferoidapollenitesliblarensis (Thomson in Pot. Th. & Th.) Pot., ibid.

Pollenites liblarensis Thomson in Pot., Th. & Th., 1950, p. 55, 66, pl. 8, fig. 26.

Comments: This genus is distinct from Tricolpites by having hyaline, laevigate exine (see Dettmann, 1973, p. 12 for taxonomic discussion on psilate tricolpate pollen grains.).

Cupuliferoidaepollenites parvulus (Groot & Penny 1960) Dettmann 1973

Plate 23, fig. 5

1960 Tricolpopollenites parvulus Groot & Penny, p. 232, pl. 2, figs 8-9.

1967 Psilatricolpites parvulus (G. & P.) Norris, p. 107, pl. 27, fig. 5-7.

1973 Cupuliferoidaepollenites parvulus (G. & P.) Dettmann, p. 12.

Description: See Dettmann (1973, p. 12).

Occurrence: Late Albian to Turonian of North America; Turonian of northern Australia (Dettmann, 1973). Lower Campanian of New Mexico.

Measurements: Polar diameter 11-14 μm (3 specimens). Size range in Dettmann (1973) is 7(10)13 μm (equatorial diameter) and 10(12)14 μm (polar diameter).

Figured specimen: Pb12408-1 (128.5x29.7).

Cupuliferoidaepollenites sanjuanensis n. sp.

Plate 23, figs. 6-15

Holotype: Pb12462-1 (115.9x30.6).

Description: Pollen grains tricolpate, subprolate to prolate; colpi narrow, ca. half the radius or longer; polar outline circular; exine very thin, ca. 0.5 μm or less, with no apparent structure; surface smooth, hyaline.

Occurrence: Common to abundant.

Measurements: 16-20 x 18-24 μ m.

Figured specimens: Pb12462-1 (115.9x30.6); Pb12384-7 (115.8x39.6);
Pb12387-2 (113.4x34.7); Pb12342-7 (124.7x40.9, 127.1x39.1,
126.5x26.2); Pb12342-3 (125.5x41.3); Pb12342-8 (118.8x45.0,
116.8x44.5); Pb12342-2 (123.5x34.1).

Genus Fraxinoipollenites Potonie 1951 ex Potonie 1960

1951 Fraxinoipollenites Potonie, p. 277

1960 Fraxinoipollenites Potonie, p. 94

Type Species: Fraxinoipollenites pudicus (Pot.) Pot. 1951 ex Pot.
1960.

Pollenites confinis pudicus Pot., 1934, p. 90, pl. 5,
fig. 12.

Comments: For synonymy and generic diagnosis see Stanley (1965, p.
305). Tricolpate pollen grains with long, distinct colpi and
scabrate to reticulate sculpture are assigned to this concept.

Fraxinoipollenites variabilis Stanley 1965

Plate 23, figs. 16-18

1965 Fraxinoipollenites variabilis Stanley, p. 306, pl. 45, figs.
29-35.

Comments: This form was described by Stanley (1965) as a prolate
one. The shape class index given by him is 1.1-1.5. This index, as
well as the illustrations in his plate 45 indicate a range of
variation between prolate spherical to prolate.

F. venustus Singh (1971, p. 196, pl. 29, figs. 12-14) from the
Albian of Alberta, Canada, is prolate and has larger lumina at the

polar regions.

Occurrence: Maestrichtian of NW South Dakota (Stanley, 1965); Lower Campanian of New Mexico (occasional).

Measurements: Polar axis 25 um, equatorial axis 19-22 um.

Figured specimens: Pb12387-2 (123x34.1); Pb12462-1 (112.6x28.8).

Genus Rousea Srivastava 1969a

1969a Rousea Srivastava, p. 52.

Type Species: Rousea subtilis Srivastava, *ibid.*, p. 53, pl. 1, fig. 7.

Comments: This genus is distinct from Tricolpites by differentiation of the mesh size. The reticulation in this form is largest at the mesocolpial areas, decreasing at the poles and along the colpal margins. Tricolpites has a uniform reticulation.

Rousea georgensis (Brenner) Dettmann 1973

Plate 23, figs. 19,20

1963 Retitricolpites georgensis Brenner, p. 91, pl. 38, figs. 6,7.

1971 Tricolpites georgensis (Brenner) Burger, p. 7, pl. 3, figs. 2-4.

1973 Rousea georgensis (Brenner) Dettmann, p. 14, pl. 2, figs. 16,17.

Comments: This name was assigned to the South Hospah specimens based on comparison with the original illustrations for the species in Brenner (1963). Srivastava (1981a, p. 15) gives the range of this species as Middle Albian to Cenomanian. The South Hospah specimens may be recycled fossils, probably from the Dakota Sandstone in San

Juan Basin. However, the more precise stratigraphic range of many Upper Cretaceous palynomorphs, including this taxon, is yet to be established.

Measurements: 30 x 24 μm .

Figured specimens: Pb12362-1 (116.0x34.2); Pb12457-1 (120.7x41.2).

Rousea sp.

Plate 23, figs. 21-23

1972 Tricolpites sp. A Miki, pl. 2, fig. 14.)

Description: Small, reticulate, tricolpate pollen grain; outline in polar view triangular; colpi half the radius, gaping; reticulation restricted to the apocolpial area, the rest of the exine psilate; meshes of the reticulum up to ca. $3/4 \mu\text{m}$; endexine ca. 0.1 μm , ectexine 0.5 μm thick.

Comments: Tricolpites varifoveatus McIntyre 1965 is distinct from this species by having larger size and different outline.

Retitricolpites fragosus Hedlund & Norris 1968 is characterized by a thick exine and a reticulation which is restricted to the polar areas. Miki (1972) reported similar forms from the Upper Cretaceous of Japan as Tricolpites sp. A.

Occurrence: Coniacian-Santonian Futaba Group, NE Japan (Miki, 1972); Lower Campanian of New Mexico.

Measurements: 14 μm .

Figured specimen: Pb12385-1 (124.0x39.6).

Genus Striatopollis Krutzsch 1959

1959 Striatopollis Krutzsch, p.

Type Species: Striatopollis sarstedtensis Krutzsch, *ibid.*,
pl. 14, fig. 1.

Striatopollis paraneus (Norris) Singh 1971

Plate 23, fig. 24

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

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

Comments: Only a single specimen of this type was found in the South
Hospah samples. It may be a reworked fossil from the older rocks in
the basin.

Occurrence: Middle and late Albian of Canada and U.S.A. (Norris,
1967; Hedlund & Norris, 1968; Singh, 1971; Wingate, 1980).

Cenomanian of Australia (Dettmann, 1973).

Measurements: 18 μ m (equatorial diameter).

Figured specimen: Pb12454-1 (112.5x33.1).

Genus Tricolpites Cookson 1947 ex Couper 1953b emend.

R. Potonie 1960

Type Species: Tricolpitesreticulatus Cookson ex Couper, 1953b, p.
134, pl. 15, fig. 45.

Comments: For synonymy and discussion see Srivastava (1975b, p. 98).
This genus, as emended by Potonie (1960), accommodates tricolpate,
isopolar, oblate to subprolate pollen grains having a uniform
reticulum with mesh size of 1-2 μ m or less. Gunnerites Cookson &
Pike 1954 is conspecific with Tricolpites, and thus a junior synonym
of the latter genus. Retitricolpites (van der Hammen) Pierce 1961,

and Retitricolpites van der Hammen ex van der Hammen & Wijmstra (1964) are illegitimate names (see Srivastava 1975b, p. 98).

Tricolpites aoristus Chmura 1973

Plate 23, figs. 25,26

1967 Tricolpites sp. B. Drugg, p. 49, pl. 7, fig. 41.

1973 Tricolpites aoristus Chmura, p. 109, pl. 22, fig. 19.

Occurrence: Maestrichtian-Danian (Upper Monero Formation) of Escarpado Canyon, California (Drugg, 1967); Campanian-Maestrichtian of Western San Joaquin Valley, California (Chmura, 1973). Lower Campanian of New Mexico (common).

Measurements: 13-20 μ m (3 specimens). Size range in Drugg (1967) is 13-17 μ m; in Chmura (1973) is 14-23 μ m.

Figured specimens: Pb12408-1 (124.0x34.3); Pb12385-1 (128.0x39.2).

Tricolpites confossipollis Srivastava 1975b

Plate 23, figs. 27,28

1975b Tricolpites confossipollis Srivastava, p. 98, pl. 45, fig. 6.

Comments: The occurrence of this species in the South Hospah samples may indicate recycling of the older deposits.

Occurrence: Middle Albian of Oklahoma (Srivastava, 1975b).

Measurements: 18 x 28 μ m.

Figured specimen: Pb12385-5 (112.6x34.0).

Tricolpites crassimurus (Groot & Penny 1960) Singh 1971

Plate 23, fig. 29-31

1960 Tricolpopollenites crassimurus Groot & Penny, p. 232, pl. 2,

1971 Tricolpites crassimurus (Groot & Penny) Singh, p. 207, pl. 32, figs. 4-6.

Comments: This form was proposed as a scabrate, fossaperturate, tricolpate pollen resembling the pollen grains of the modern genus Quercus. According to Singh (1971, p. 208), this species can be distinguished from Tricolpites sagax Norris 1967 by having a larger size, thinner endexine, and scabrate surface. Some of the specimens illustrated by Srivastava (1975b, pl. 46, figs. 13 & 14, pl. 47, figs. 1 & 2)) as T. sagax resemble T. crassimurus.

Occurrence: Late Albian to Coniacian (See Srivastava 1975b, p. 100); lower Campanian of New Mexico.

Measurements: 30 μ m (1 specimen).

Figured specimens: Pb12401-12 (113.7x28.9); Pb12466-1 (120.7x38.5).

Tricolpites hians Stanley 1965

Plate 23, figs. 32-36

1965 Tricolpites hians Stanley, p. 321, pl. 47, figs. 24-27.

1965 Tricolpites parvus Stanley, p. 322, pl. 47, figs. 28-31.

Comments: Stanley (1965) described this species as an oblate form. He did not illustrate any specimen in equatorial view to demonstrate this shape. My measurements on 14 equatorially-oriented grains from the South Hospah material show that the shape index has an average of 1.22, and no single grain has a P/E ratio of equal or less than 0.75 to be categorized as oblate. This form should be considered subprolate in general, and may vary between prolate spherical to prolate (see the measurements above). The description given by Stanley for T. hians and T. parvus are almost identical, except for

slightly thicker endexine in T. parvus. These two forms seem to be conspecific. Forms illustrated by Elsik (1968b) as

Tricolpopollenites hians (Stanley) Elsik have larger reticulation and do not seem to fit the range of variation of Stanley's concept.

Occurrence: Middle Albian of N. Alberta, Canada (Singh, 1971).

Early Paleocene of South Dakota (Stanley, 1965). Lower Campanian of New Mexico (common to abundant; very abundant in some samples).

Measurements: Equatorial diameter = 11(16)22 μ m; polar diameter = 15(18)19 μ m; P/E = 1.12(1.22)1.45) μ m (22 specimens).

Figured specimens: Pb12382-2 (124.2x33.4); Pb12486-1 (127.1x26.2); Pb12374-3 (124.5x38.0, 112.6x35.1, 115.5x31.7).

Tricolpites minutus (Pierce, 1961) n. comb.

Plate 24, figs. 1-5

1961 Retitricolpites minutus Pierce, p. 52, pl. 3, figs. 109-110.

non 1963 Tricolpopollenites minutus Brenner, p. 93, pl. 40, figs. 5-6.

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

1973 Tricolpites minutus (Brenner) Dettmann, p. 12, pl. 4, figs. 1-4.

1975 Tricolpites minutus (Brenner) Dettmann, in: Doyle, et al., p. 470, pl. 10, figs. 1-8.

Comments: The literature is somewhat confusing on the nomenclature of small reticulate tricolpate pollen grains. Brenner (1963) illustrated apparently psilate tricolpate pollen grains which he named Tricolpopollenites minutus and described as having

microreticulate exine. Singh (1971) rightfully transferred this form to the genus Cupuliferoideapollenites, but his interpretation of the wall structure is not detectable in Brenner's original illustrations. Also, his illustrations show the baculate ectexine which is not observable in Brenner's forms. Dettmann (1973) transferred Tricolpopollenites minutus Brenner into the genus Tricolpites and described it as semitectate, reticulate tricopate pollen. The semitectate feature has not been demonstrated in Brenner's illustrations. Figure (2) of Dettmann's four illustrations on her plate 4 seems to have baculate colpi, and thus may conform with the genus Phimopollenites Dettman *ibid.* Doyle, et al. (1975, p. 470) accepted Dettmann's combination, but illustrated light and scanning electron micrographs which very clearly show the semitectate reticulate nature of exine.

Tricolpites minutus (Pierce) n. comb. and Tricolpites micromunus (Groot & Penny 1960) Burger 1970 are morphologically very close, and it is practically very difficult to differentiate them under light microscope. SEM micrographs illustrated in the literature (Doyle et al., 1975, pl. 10; Srivastava, 1975b, pl. 46, figs. 8-19) show a wide range of morphological variations. As suggested by Brenner (1963), several biological species may well be included under this taxon.

Occurrence: Upper Albian (see Doyle et al., 1975) and Upper Cretaceous (see Gies, 1972; Srivastava, 1975b). It is abundant in the Lower Campanian of New Mexico.

Measurements: 5(9)15 x 7(10)17 um (15 specimens).

Figured specimens: Pb12387-2 (113.9x38.7); Pb12408-1 (129.1x32.2, 128.5x31.3); Pb12344-1 (113.8x30.1).

Tricolpites mutabilis Leffingwell 1971

Plate 24, figs. 6-10

1971 Tricolpites mutabilis Leffingwell, p. 44, pl. 8, figs. 1-3.

Comments: This species is characterized by abrupt thinning of the exine around the colpi. T. mutabilis in Gies (1972, p. 139, pl. 8, figs. 19,20) does not show this feature.

Occurrence: Maestrichtian Lance Formation of Wyoming (Leffingwell, 1971); Lower Campanian of New Mexico (common).

Measurements: 20, 26 um (2 specimens). Size range in Leffingwell (1971) is 17-21 um.

Figured specimens: Pb12463-1 (125.5x44.6); Pb12342-2 (122.1x36.7); Pb12465-1 (120.6x39.7); Pb12342-1 (125.6x43.1); Pb12463-1 (123.7x36.6).

Tricolpites reticulatus Cookson 1947 ex Couper 1953b

Plate 24, figs. 11,12

Comments: For synonymy see Jarzen (1980, p. 119-121). This species was designated by Cookson (1947) to receive oblate tricolpate pollen grains with circular to subtriangular polar outline, broadly rounded corners and very finely- and evenly- reticulated exine. The colpi are located between corners. Cookson & Pike's species Gunnerites reticulatus, Newman's species Tricolpites interangulus, and Leffingwell's species Gunnera microreticulata are all conspecific and junior synonyms of T. reticulatus.

Occurrence: Upper Cenomanian to Late Quaternary. Its earliest appearance in the western interior of North America is Campanian, and has been frequently reported from the Maestrichtian of this region. It appears in Middle Eocene of Wyoming and Late Quaternary of

Hawaiian Islands (see Jarzen, 1980 for detail).

Affinity: Gunneraceae, genus Gunnera.

Figured specimens: Pb12342-8 (118.3x40.6); Pb12382-10 (122.8x36.4).

Tricolpites vulgaris (Pierce 1961) Srivastava 1969a

Plate 24, figs. 13,14

1961 Retitricolpites vulgaris Pierce, p. 50, pl. 3, figs. 101-102.

1969a Tricolpites vulgaris (Pierce) Srivastava, p. 57, pl. 1,
figs. 20-22.

Description: See Srivastava (1975b, p. 102).

Occurrence: Middle Albian to Maestrichtian of Canada and U.S.A.

(see Srivastava, 1975b, p. 103). It occurs commonly in the Lower
Campanian of New Mexico.

Measurements: Polar diameter = 17-22 μ m (4 specimens). Size range
given in the literature is 15-31 μ m (see Pierce, 1961; Norris, 1967;
Singh, 1971; Srivastava, 1969a & 1975b).

Figured specimens: Pb12385-1 (123.4x40.1, 128.7x40.0).

Tricolpites sp. 1

Plate 24, fig. 15

Description: Amb triangular, sides straight, colpi long, gaping,
surface scabrate to granulate, exine very thin (ca. 0.2 μ m), endexine
and ectexine hard to differentiate.

Comments: Similar forms were reported as T. mutabilis Leffingwell
1971 by Gies (1972) from the Campanian-Maestrichtian of NW Colorado.
However, Gies' form and my specimens lack the abrupt thinning of the
exine around the colpi, characteristic of T. mutabilis.

Measurements: 14, 19 μm (2 specimens).

Figured specimen: Pbl2385-1 (128.0x44.3).

Tricolpites sp. 2

Plate 24, figs. 16-18

Description: Syn-tricolpate, fossaperturate, oblate spherical pollen grains; colpi narrow and closed; polar amb trilobate; exine reticulate, ca. 1 μm thick.

Measurements: 11-15 x 12-17 μm ; P/E = 1-1.3 (4 specimens).

Figured specimens: Pbl2387-2 (121.1x39.0; 122.7 x 40.1; 122.4x46.1).

Tricolpites sp. 3

Plate 24, fig. 19

Description: Tricolpate pollen; colpi short, open; exine uniformly reticulate, lumina ca. 1 μm wide.

Comments: A single specimen of this type was observed in the South Hospah samples.

Measurements: 17 μm .

Figured specimen: Pbl2476-1 (115.8x35.6).

Tricolpites sp. 4

Plate 24, figs. 20,21

Description: Tricolpate pollen, colpi open, very short (brevicolpate), ragged; polar outline triangular with convex sides; exine ca. 0.5 μm thick, surface scabrate.

Comments: The brevicolpate colpi, triangular polar outline, and scabrate surface are characteristics of this form. It is rare in the

South Hospah samples.

Measurements: 20-24 μm .

Figured specimens: Pb12387-2 (121.3x41.5); Pb12432-1 (112.6x33.9).

Tricolpites sp. 5

Plate 24, fig. 22

Description: Tricolpate pollen, colpi short, less than 1/2 the radius at polar view, ragged; polar outline perfectly circular; exine ca. 0.5 μm thick, minutely scabrate.

Comments: A single grain of this type was encountered. It can be distinguished from T. sp. 4 by having circular polar outline and smoother exine.

Measurements: 17 μm .

Figured specimen: Pb12454-1 (117.4x36.1).

Tricolpites sp. 6

Plate 24, figs. 23-25

Description: Tricolpate pollen subprolate; colpi almost reaching the poles, open; exine ca. 1 μm thick, two-layered, each layer ca. 0.5 μm thick; ectexine finely reticulae, lumina ca. 0.2 μm , slightly larger at the polar areas.

Measurements: 15 μm .

Figured specimens: Pb12456-1 (123.0x37.9, 122.2x37.4).

Tricolpate Genus A sp.

Plate 24, figs. 26,27

Description: Tricolpate (or tricolporoidate) foveo-reticulae pollen

grains. Outline in equatorial view prolate with rounded ends, circular in polar view. Colpi long, gaping. Meshes of reticulum 1 μm and larger at the apocolpial and the central part of the mesocolpial area, gradually decreasing in size towards the colpi. Muri 1-1.5 μm thick, 1 μm high; endexine very thin, ectexine ca. 1 μm thick.

Comments: The diagnostic feature of this genus is the conspicuous reticulation pattern at the apocolpial and the center of the mesocolpial area which fades away towards the colpi. The genus Rousea Srivastava 1975 can be distinguished from this form by having a large reticulum only at the mesocolpial area which gradually gets finer and disappears towards the apocolpia. Rousea is reticulate rather than foveo-reticulate. Tricolpites has a uniform reticulation all over the body.

Measurements: 23-34 x 29-48 μm ; P/E = 1.35-1.41 (5 specimens).

Figured specimens: Pb12404-1 (116.2x28.0); Pb12342-1 (118.5x40.0).

TETRACOLPATE POLLEN GRAINS:

Genus Utriculites Chlonova 1969

1969 Utriculites Chlonova, p. 58. (cf. Jansonius & Hills, 1976, p. 3144).

Type Species: Utriculites visus Chlonova, *ibid.*, pl. 13, figs. 3-5.

Comments: This form is a tetraperturate reticulate pollen with distinct, smooth endexine and a baculate ectexine.

Utriculites visus Chlonova 1969

Plate 24, figs. 28,29

Description: See Jansonius & Hills (1976, p. 3144) for English

translation of Russian description.

Comments: This assignment is based on description and drawing in Jansonius & Hills (l.c.).

Occurrence: Aptian-Albian-?Cenomanian of Siberia (Chlonoma, 1969).

Only a few specimens were encountered in the South Hospah samples.

Measurements: 20,23 um (2 specimens).

Figured specimens: Pb12413-7 (125.5x36.8); Pb12456-1 (112.5x32.8).

TRICOLPORATE POLLEN GRAINS:

Genus Holkopollenites Fairchild 1966

1966 Holkopollenites Fairchild, in Stover, Elsik, and Fairchild,
p. 6.

Type Sepcies: Holkopollenites chemardensis Fairchild, *ibid.*, pl. 2
fig. 8a-d.

Comments: See Fairchild (*ibid.*) for description. The characteristic features of this genus are tricolporate aperture with thickened colpi and irregular channeling pattern on the exine. The latter chracter differentiates this form from Nyssapollenites, Margocolporites, and Rhoipites.

Holkopollenites sp. 1

Plate 24, figs. 30,31

Description: Pollen grains tricolporate, colpi short, less than 1/2 the radius at polar view, thickened by a margo; polar outline deltoid; apertures at the corners; exine relatively very thick, 2.5 to 3 um, distinctly layered, incised by irregular channels more or less parallel to the sides of the grain in polar view.

Comments: This form is smaller than the holotype of the genus and has shorter colpi, but otherwise closely resembles it.

Occurrence: Only a few grains of this type were encountered in this study. The holotype of the genus was reported from the Paleocene of Louisiana.

Measurements: 20 um.

Figured specimen: Pb12513-1 (119.1x39.0).

Holkopollenites sp. 2

Plate 24, figs. 32,33

Description: Pollen grains tricolporate prolate spherical (P/E = 1.1) colpi reaching almost to the poles at the polar view, thickened by a prominent margo; polar outline triangular, sides convex, exine ca. 2-5 um thick, dense, differentiated into two layers of equal thickness, ectexine incised by shallow channels which made a network pattern on the surface.

Comments: This form differs from H. sp. 1 by convex sides at polar views longer colpi, and denser exine with shallower incisions.

Occurrence: Only a few grains of this type was encountered in this study.

Measurements: 27-30 um (equatorial diameter).

Figured specimens: Pb12402-5 (116.0x40.1; 116.5x32.6).

Holkopollenites sp. 3

Plate 24, figs. 34,35

Description: As for H. sp. 2 except for smaller size, shorter colpi, and even shallower incisions on the surface.

Occurrence: Only a few grains were encountered in this study.

Measurements: 22 um.

Figured specimen: Pb12382-10 (121.7x38.6).

Genus Margocolporites Ramanujam 1966 ex Srivastava 1969a

1966 Margocolporites Ramanujam, p. 173.

1969a Margocolporites Ram. ex Sriv., p. 984.

Type Species: Margocolporites tsukadai Ram., *ibid.*,

pl. 4, fig. 64, 65 (designated by Sriv., *l.c.*)

Comments: This genus was proposed as oblate to suboblate, reticulate or retipilate, tricolporate pollen with a distinct margo around the colpi. The type species was compared with the grain of Caesalpinia and Mezoneuron by Srivastava (*l.c.*), but he later used the generic concept in a broader sense (e.g., Srivastava, 1972b).

The genus Rhoipites Wodehouse 1933 is apparently not margocolporate. Srivastava (1969a, 1972b) did not compare Rhoipites with Margocolporites, but pointed out the presence of margo in Rhoipitescryptoporus Srivastava (1972b, p. 270). Also, it is not clear whether the exine in Rhoipites is truly reticulate or only pitted. Although this genus has been used by different authors for tricolporate pollen grains, but its circumscription seems to me to be ambiguous. The genus Rhoipited has been used in this study, only for small reticulate tricolporate pollen without a margo or with a faint one.

The genus Margocolporites has been used in this treatment for all tricolporate pollen grains with a distinct margo and a pitted or reticulate exine (see discussion under M. cribellatus).

Nyssapollenites differs from this genus by having suboblate equatorial outline, rhombic meridian, and infrapunctate exine.

Tricolporites Cookson 1947 is psilate and lacks thickenings around the germinals.

Margocolporites kruschii (Potonie, 1931) n. comb.

Plate 25, figs. 1-6

- 1931 Pollenites kruschii Potonie, p. 4, fig. 11.
- 1953 Pollenites kruschii subsp. pseudolaesus (Pot.) Thomson & Pflug (pars.), p. 104, pl. 13, figs. 50, 59, 60 (non figs. 47-49, 51-58, 61-63).
- 1967 Tricolporopollenites kruschii scutellatus (Pot.) Krutzsch, in: Drugg, p. 50, pl. 7, fig. 43.
- 1968b Tricolporopollenites kruschii (Pot.) Thomson & Pflug in: Elsik (Pars.), p. 628, pl. 31, figs. 11, 13-15, pl. 32, figs. 1-3, 7 (non pl. 31, figs. 1-4, 9, 12, 16; pl. 32, figs. 4-6; pl. 33, figs. 1-3, 8).
- 1972b Margocolporites cribellatus Srivastava, p. 260, pl. 19, figs. 1-8, pl. 20, figs. 1, 2.

Description (based on present specimens): Pollen grains tricolporate, prolate spherical, ranging from spheroidal to subprolate; polar outline triangular with convex sides and broadly rounded corners. Colpi long, extending almost to the poles, marked by a conspicuous marginal thickening (2-3 μ m); ora with no apparent thickening, 5-6 μ m wide. Exine 2-2.5 μ m thick, endexine as thick as ekexine or slightly thicker, ekexine made up of closely spaced and fused baculae which make a pitted pattern on the surface of the

grain. The exine looks acolumellate or intrapunctate in optical cross section, as a result of tightly-spaced, short baculae with fused heads.

Comments: The morphology of this species conforms with the circumscription of Pollenites kruschii Potonie 1931 (see catalog of Fossil Spores & Pollen, 1-102). Thomson & Pflug (1953) transferred P. kruschii to Tricolporopollenites and described several subspecies which broadened the original circumscription outlined by Potonie (1931). The same generalization was practiced by Elsik (1968b) by including largely-reticulate forms in T. kruschii. Srivastava (1972) proposed Margocolporites cribellatus and stated that his form is distinct from Pollenites kruschii in having a reticulate exine. However, his light and SEM illustrations do not clearly substantiate this type of structure. Rather, they illustrate a pitted structure characterized by pits that are much smaller in size than the width of the "spacing" exine between them (see Srivastava, *ibid.*, plate XIX, figs. 1, 2, 7, 8). Also, he described this form as being oblate, but did not document it either by measurements or by equatorially-oriented illustrations. Srivastava's forms fit the circumscription of Margocolporites kruschii in my opinion.

Occurrence: Meastrichtian-Danian of California (Drugg, 1967); Paleocene of Texas (Elsik, 1968b), Alabama (Srivastava, 1972), and Europe (Krutzsch et al., 1960; Thomson & Pflug, 1953). Lower Campanian of New Mexico.

Measurements: Polar diameter = 22(32)38 μ m; equatorial diameter = 24(35)41 μ m; P/E = 1.0(1.1)1.3) (20 specimens). Equatorial diameter in Srivastava (1972b) is 20-38 μ m (20 specimens measured).

Figured specimens: Pb12402-5 (116.1x33.1; 121.8x28.8; 123.3x32.5; 125.5x27.0; Pb12400-5 (119.4x26.1); pb12401-12 (114.8x33.0).

Margocolporites lihokus Srivastava 1972b

Plate 25, fig. 7

Description: See Srivastava, 1972b.

Comments: This form is morphologically similar to M. kruschii (Pot.) n. com., but differs from it in having a distinctly reticulate exine. Srivastava compared this form with some of the forms illustrated by Elsik, 1968b (namely, Elsik's pl. 32, figs. 4, 5; pl. 33, figs. 1-3, 8).

Occurrence: Paleocene of Texas (Elsik, 1968b); Paleocene of Alabama (Srivastava, 1972b). Lower Campanian of New Mexico.

Measurements: 42 μ m.

Figured specimen: Pb12467-1 (112.5x37.6).

Margocolporites sp. 1

Plate 25, figs. 8-11

Description: Pollen grains tricolporate; prolate; polar outline triangular, sides straight or slightly concave; colpi lipped by a 1.5 μ m-thick margo, extending 1/3 to 1/2 of the radius, ora conspicuous, 5 μ m wide. Exine ca. 1.5 μ m thick endexine and ectexine of the same thickness; ectexine baculate, baculae heads fusing to form a reticulate pattern; reticulation larger at the mesocolpial and apocolpial region, decreasing in size towards the colpi.

Comments: This form is partially similar to Tricolporopollenites kruschii in Elsik, 1968b (p. 628, pl. 30, figs. 7-10; pl. 31, figs.

1-4, 9.11-16; pl. 34, figs. 1-5).

Affinity: Nyssaceae. At least in part with Nyssa (cf. Elsik, 1968b).

Measurements: Polar diameter = 19-26 μm ; equatorial diameter = 31-40 μm (3 specimens).

Figured specimens: Pb12414-7 (123.0x39.7 & 123.9x39.6); Pb12404-6 (125.5x28.2).

Margocolporites sp. 2

Plate 25, figs. 12,13

Description: Pollen grains tricolporate; polar amb triangular, sides convex, corners rounded; exine 1 μm thick, reticulate, endexine very thin, ectexine baculate; colpi and pores thickened by a margo, the colpal thickening very distinct, ca. 2 μm thick.

Measurements: 24, 25 μm (2 specimens).

Figured specimens: Pb12387-2 (113.8x42.6); Pb12382-2 (124.2x35.3).

Genus Nyssapollenites Thiergart 1937,1938 ex Potonie 1960
1937(1938) Nyassapollenites Thiergart, p. 322.

1960 Nyssapollenites Thiergart ex Potonie, p. 103.

Type Species: Nyssapollenites pseudocruciatus (Pot.) Thiergart,
ibid.

Pollenites pseudocruciatus Potonie 1931, p. 328,
pl. 1, fig. 10.

Description: See Potonie (1960, p. 103). See also Jansonius & Hills (1976, p. 1794) for English translation of the German text.

Comments: Potonie (1960) validated this genus by giving a generic

diagnosis. This genus includes suboblate to spherical, angulaperturate, tricolporate pollen grains with triangular to rounded triangular amb. The margins of the colpi and the pores are distinctly thickened and the exine is infrapunctate.

Nyssapollenites albertensis Singh 1971

Plate 25, figs. 14-16

1971 Nyssapollenites albertensis Singh, p. , pl. , fig.

Comments: Tricolpites membranous Couper 1960 in Lohrengel 1970 is apparently a misidentified form. It resembles N. albertensis. Vitis ? affluens Stanley 1965 is similar to this form, as well. This species is distinct from N. sp. 1 by having a triangular amb with more straight sides. The equatorial outline of this form is prolate (see the measurements below).

Occurrence: Albian to Lower Cenomanian of Canada & U.S.A. (see Singh, 1971). Rare to common in the South Hospah samples.

Measurements: Polar diameter = 10(14.6)22 μ m; equatorial diameter = 14(21)31 μ m (21 specimens); P/E = 1.4 (an average of 9 measurements).

Figured specimens: Pb12385-1 (124.9x40.7, 120.0x41.1); Pb12439-1 (112.2x37.1).

Nyssapollenites sp. 1

Plate 25, figs. 17-19

Description: Amb subtriangular; colpi almost reaching the pole, pores (including the rim) 5-6 μ m, both the pores and the colpi distinctly thickened; exine up to 1.5 μ m thick, psilate or slightly

scabrate.

Comments: Tricolpopollenites planus Groot & Penny, 1960 does not have the thickening of the colpi and distinct pores.

Tricolporopollenites orbiculatus Groot, Penny & Groot, 1961 does not show the thickening of the colpi. Tricolporopollenites aliquantulus Hedlund 1966 is close in morphology, but smaller than my forms.

Hedlund's specimen is probably congeneric with Nyssapollenites.

Porocolpopollenites mikiensis Takahashi 1961 in Lohrengel 1970 has straight sides and shorter colpi. It may also be congeneric with Nyssapollenites.

Measurements: Polar diameter = 15-18 x 17-20 μ m.

Figured specimens: Pb12384-7 (112.2x34.7, 126.7x31.1, 123.5x42.0).

Nyssapollenites sp. 2

Plate 25, figs. 20,21

Description: Pollen grains tricolporate, prolate, polar amb triangular, sides convex, corners sharp; exine less than 0.5 μ m thick, psilate, germinals thickened by a margo.

Comments: This form is distinct by having a very small size.

Measurements: 14 x 10 μ m (2 specimens).

Figured specimens: Pb12385-1 (127.6x35.0 & 129.2x34.9).

Genus Perinotricolporites n. gen.

Type Species: Perinotricolporites delicatus n. sp.,

plate 25, figs. 22-27

Description: Tricolporate pollen grains surrounded by a delicate perine that can be easily detached from the body of the pollen.

Perinotricolporites delicatus n. sp.

Plate 25, figs. 22-27

Holotype: Pb12402-4 (123.8x37.2), Plate 25, fig. 22.Paratype: Pb12385-6 (119.1x43.5), Plate 25, fig. 23.

Description: Pollen grains tricolporate, polar amb triangular with convex sides and rounded corners; exine ca. 3/4 μ m thick, scabrate or psilate, surrounded by a delicate perine which can be easily detached from the grain, ca. 2-4 μ m wide; colpi ca. half the radius, thickened by a distinct margo.

Comments: This form is distinct by having a perine. Only two specimens with perine attached to the main body were recovered from the South Hospah samples. However, it is morphologically so unique and distinct that a new name, especially at the generic level, seems to be appropriate for it.

Measurements: Polar diameter 26 μ m; 17 μ m without the perine (2 specimens).

Figured specimens: Pb12402-4 (123.8x37.2); Pb12385-6 (119.1x43.5); Pb12385-1 (127.2x32.6, 127.2x43.2, 127.5x30.1); Pb12387-2 (125.9x35).

Genus Rhoipites Wodehouse 19331933 Rhoipites Wodehouse, p. 513.Type Species: Rhoipites bradleyi Wodehouse, ibid.Rhoipites globosus Stanley 1965

Plate 25, figs. 28-30

1965 Rhoipites globosus Stanley, p. 286, pl. 42, figs. 1-13.

Occurrence: Maestrichtian of NW South Dakota (Stanley, 1965); Lower Campanian of New Mexico.

Measurements: Polar diameter = 16 μ m; equatorial diameter = 13 μ m (1 specimen). Size range in Stanley is 17-20 μ m (polar diameter) and 14-18 μ m (equatorial diameter).

Figured specimens: Pb12387-2 (121.6 x 28.8); Pb12404-6 (123.3x28.7); Pb12408-1 (128.5x40.3).

Rhoipites sp.

Plate 25, figs. 31-36

Description: Pollen grains tricolporate, prolate; polar amb rounded triangular, exine very thin, finely reticulate; colpi bordered by a margo, size very small.

Comments: This form is distinct by having a very small size. It may easily be mistaken for Tricolpites micromunus.

Measurements: Polar diameter 6-8 μ m; equatorial diameter 9-12 μ m (2 specimens).

Figured specimens: Pb12386-6 (112.1x37.7); Pb12387-2 (126.4x30.0, 128.9x33.9); Pb12408-1 (113.7x38.2); Pb12402-5 (112.5x30.6).

Genus Ranunculacidites Sah, 1967

1967 Ranunculacidites Sah, p. 53.

Type Species: Ranunculacidites communis Sah, ibid., pl. 5, fig. 11.

Comments: This form is a tricolp(or)ate grain with colpi covered by a plug (periculum, sensu Erdtman, 1952, p. 466).

Ranunculacidites sp.

Plate 26, figs. 1,2

Comments: The type species has irregular and fine reticulation.

It has been reported from the Neogene of Africa. The South Hospah specimens are microgranular.

Measurements: 18-21 μm .

Figured specimens: Pb12387-2 (127.2x41.0, 120.6x38.0).

Tricolporate Forma A

Plate 26, figs. 3-6

Description: Pollen grains tricolporate; polar amb rounded triangular; colpi very short (brevicolporate) less than $1/2$ the radius, thickened by a margo; ora indistinct; exine 1 μm thick, finely granulate.

Measurements: 24 μm (4 specimens).

Figured specimens: Pb12382-10 (127.9x31.7, 118.1x38.1, 125.3x33.9); Pb12400-5 (119.1x38.1).

Tricolporate Forma B

Plate 26, figs. 7-11

Description: Pollen grains tricolporate; polar amb triangular, sides straight to convex, corners rounded; colpi gaped, long, extending almost to the poles, with no thickening; pores indistinct; exine ca. 0.5 μm thick, psilate to scabrate.

Comments: This form is different from Nyssapollenites by lacking the margo around the colpi.

Measurements: Polar diameter = 13-19 μm (5 specimens).

Figured specimens: Pb12342-7 (124.0x45.3, 119.3x29.6, 123.9x39.5, 126.4x39.0); Pb12342-8 (110.5x42.9).

Tricolporate Forama C

Plate 26, figs. 12,13

Description: Pollen grain tricolporate, colpi ca. 0.5 the radius at polar view; subtended by a distinct margo; polar outline triangular, sides straight or slightly convex, corners truncated; exine markedly reticulate but the reticulation restricted to the mesocolpial areas, the exine around the colpi is psilate and structureless.

Comments: This form is distinct by having reticulation at the mesocolpial region only. It probably belongs to a new genus, but it is not here treated as so because of scarcity of the specimens needed to warrant the detailed morphological features.

Measurements: 16 μ m (equatorial diameter).

Figured specimens: Pb12387-2 (123.8x38.2); Pb12404-6 (112.7x38.1).

TRIPORATE POLLEN GRAINS:

Genus Casuarinidites Cookson & Pike 1954

1954 Casuarinidites Cookson & Pike 1954, p. 200

Type Species: Casuarinidites cainozoicus Cookson & Pike, *ibid.*,
pl. 1, fig. 1. (holotype designated by Potonie, 1960,
Synopsis III, p. 114).

Comments: This genus, as revised by Srivastava (1972, p. 242) is characterized by having triangular to subcircular amb with convex sides and 2-5 circular to slightly elliptical pores at the angles which are usually aspidate. Ektexine is thicker than endexine and no atrium is present. This concept was proposed by Cookson & Pike (1954) to accommodate the palynomorphs similar to those in the family Casuarinaceae. However, pollen grains more or less similar to those

in Casuarinaceae are also produced by Betulaceae, Myricaceae, and Juglandaceae (See Erdtman, 1952, pp. 73, 104, 216, 278).

Casuarinidites granilabratus (Stanley 1965) Srivastava 1972b

Plate 26, figs. 14-20

1965 Corylus granilabratus Stanley, p. 293, pl. IXIII, figs. 17-28.

1972b Casuarinidites granilabratus (Stanley) Sriv., p. 243, pl. 9, figs. 1-12, pl. 10, figs. 1-4.

Comments: For synonymy and description see Srivastava (1972b, p. 243). Wolfe (1976) has also reported tetraporate forms of this genus (C. sp. B Wolfe) from the Coniacian of East Coast (see Bebout, 1981, pl. 12, fig. 8).

Occurrence: Paleocene of Alabama (Srivastava, 1972b), Texas (Ellsik, 1968), Germany (Krutzsch, 1970), Scotland (Simpson, 1961).

Measurements: 21(25)30 μ m (6 specimens). Size range in Srivastava (1972b) is 19-38 μ m (25 specimens measured).

Figured specimens: Pb12523-1 (111.1x31.2; 114.9x36.1; 116.3x30.4); Pb12458-1 (112.3x31.8; 119.9x28.5); Pb12387-2 (126.3x33.2).

Casuarinidites microgranulatus n. sp.

Plate 26, figs. 21-27

Holotype: Pb12462-1 (125.0x29.2), Plate 26, fig. 22.

Description: Pollen grains normally triporate, occasionally diporate or tetraporate; equatorial outline usually triangular with slightly convex sides; pores always equatorial and angular, simple, slightly aspidate, with weak annulus; exine ca. 1 μ m thick, endexine ca. 1/4 μ m, ectexine ca. 3/4 μ m, made up of minute pila that are closely

packed; the interspaces of the pila produce minute punctae; the pilate structure of the wall is observable in the optical section of the exine around the edges of the grain. It is one of the characteristics of this species. The surface of the grain appears to be microgranulate.

Comments: Wolfe (1976) has also reported tetraporate forms of this genus (C. sp. B Wolfe) from the Coniacian of East Coast (see Bebout, 1981, pl. 12, fig. 8).

Occurrence: Common to abundant in some of the South Hospah samples.

Measurements: 21(25)32 um (7 specimens).

Figured specimens: Pb12518-1 (126.4x29.9); Pb12462-1 (125.0x29.2); Pb12460-1 (122.3x41.1, 122.2x40.9); Pb12529-1 (125.5x35.7); Pb12470-1 (119.0x32.3); Pb12460-1 (125.3x35.2).

Casuarinidites sp.

Plate 26, figs. 28, 29

Description: Pollen grains triporate, pores equatorial, up to 3 um large, surrounded by strong and very conspicuous annuli, located at the angles of the grain; equatorial outline slightly elongated triangular, sides convex; exine relatively very thick, made up of two distinct layers, endexine ca. half the ectexine; surface psilate.

Occurrence: Occasionally occurs in some of the South Hospah samples.

Measurements: 17-21 um.

Figured specimens: Pb12382-10 (115.4x30.2); Pb12385-5 (112.6x34.0).

1968 Labrapollis Krutzsch, p. 62

Type Species: Labrapollis labraferus (Pot.) Krutzsch, *ibid.*, p. 63,
pl. 1, fig. 2-5.

Pollenites labraferus Potonie, 1931, p. 2, fig. 7.

Triporopollenites labraferus (Pot.) Thomson & Pflug,
1953, p. 84.

Description: See Jansonius & Hills (1976, p. 1423).

Comments: This genus is characterized by having a small size,
rounded to over-rounded amb (with the germinals at the center of the
sides) and three plicae subtending the pores.

Labrapollis sp. 1

Plate 26, figs. 30-32

Description: Amb triangular, pores simple, located at the center of
the sides, exine psilate, plicae distinct.

Occurrence: Rare.

Measurements: 13-15 um (2 specimens).

Figured specimens: Pb12385-1 (124.7x34.0 & 124.6x28.4).

Labrapollis sp. 2

Plate 26, fig. 33

Description: Amb over-rounded, pores slightly annulate, positioned
at the center of the sides; exine scabrate, plicae straight, parallel
to the sides.

Comments: This form is distinct from L. sp. 1 by having scabrate
exine, slightly annulate pores, and less distinct plicae.

Occurrence: Only occasionally occurs in a few of the South Hospah
samples.

Measurements: 16 um (1 specimens).

Figured specimen: Pb12385-1 (116.5x39.3).

Genus Momipites Wodehouse 1933 emend. Frederiksen & Christopher 1978

1933 Momipites Wodehouse, p. 511.

1978 Momipites Wodehouse emend, Frederikson & Christopher, p. 128.

Type Species: Momipites coryloides Wodehouse, *ibid.*, fig. 43.

Comments: For description, synonymy and discussion see Frederikson & Christopher 1978, p. 128. See also Nichols (1973) and Nichols & Ott (1978) for further accounts on this genus and related genera.

This genus, as emended by Frederikson & Christopher (1978), includes triatrate, triangular to circular triporate pollen grains with equatorial pores, distinct atria, granulate exine, and possibly a large thinned polar area. Forms with multiple thin spots, pseudocolpi, and triradiate folds do not belong to this genus.

Affinity: Juglandaceae.

Momipites wyomingensis Nichols & Ott 1978

Plate 26, figs. 34,35

1973 Momipites sp. Nichols, pl. 1, fig. 5.

1978 Momipites wyomingensis Nichols & Ott, p. 100, pl. 1, figs. 1-4.

Comments: This species is characterized by the absence of special structures of the exine at the poles. Nichols & Ott (1978) compared this form with M. Coryloides Wodehouse, the type species of the genus, and with the extant genera Engelhardia and Alfaroa. They stated, however, that it is smaller than the type species and larger

than the modern species. Momipites sp. Nichols (1973) is conspecific with this species.

Occurrence: Paleocene of Texas (Nichols, 1973, reported it as Momipites sp.) and the Paleocene of Wyoming (Nichols & Ott, 1978).

Affinity: Juglandaceae. Nichols & Ott (1978) commented on the resemblance of this form with the pollen of the modern genera Engelhardia and Alfaroa. It is rare in the South Hoshpah samples.

Measurements: 20, 26 μ m (2 specimens). Size range given in Nichols & Ott (1978) is 19-27 μ m (57 specimens measured).

Figured specimens: Pbl2385-1 (115.0x45.0 & 117.9x35.2).

Genus Plicapollis Pflug 1953 emend. R. Tschudy 1975

1953 Plicapollis Pflug, p. 97.

1975 Plicapollis Pflug emend. R. Tschudy, p. 17.

Type Species: Plicapollis sarta Pflug, *ibid.*, pl. 19, figs. 7-9.

Description: See Tschudy (1975, p. 17).

Comments: This genus was inadequately described by Pflug (1953) and referred to as a tricolporate pollen grain. As emended by Tschudy (1975), it includes triporate normapollis-type pollen with prominent plicae, strongly annulate exogerminals and thickened endogerminals, and vestibulum. Species of Plicapollis have been reported from the Middle Turonian to the Upper Campanian of western North America. (cf. R. Tschudy, 1980, p. 10).

?Plicapollis rusticus R. H. Tschudy 1975

Plate 26, figs. 36-38

1975 Plicapollis rusticus R. H. Tschudy, p. 18, pl. 10, figs. 10-21.

Comments: These forms resemble P. rusticus, but their preservation and their scarcity in the samples does not allow further reconciliation.

Measurements: 19,23 um (2 specimens).

Figured specimens: Pb12378-8 (119.1x43.7); Pb12379-3 (121.5x44.3).

Plicapollis sarta Pflug 1953

Plate 26, figs. 39-41

1953 Plicapollis sarta Pflug in Thomson & Pflug, p. 97, pl. 19, figs. 7-9.

Comments: See Pflug (l.c.) for description.

Occurrence: Only occasionally occurs in some of the South Hospah samples.

Measurements: 19-20 um.

Figured specimens: Pb12432-1 (117.4x30.0); Pb12470-1 (116.8x37.7); Pb12505-1 (117.6x32.7).

Plicapollis spp.

Plate 27, figs. 1-6

Comments: A number of small, plicate triporate pollen grains occur in the South Hospah sample which illustrate different stages of development of the "typical" plicae as found in Plicapollis.

Similar, but larger, forms were illustrated by Pacltova (1981, pl. 9, figs. 2, 2b,2c) from the Santonian of Bohemia as transitional forms between Plicapollis and Complexiopollis.

Figured specimens: Pb12428-8 (118.4x41.6); Pb12408-1 (121.7x40.4); Pb12486-1 (117.4x33.4); Pb12496-1 (120.0x38.9).

Genus Proteacidites Cookson ex Couper 1953b

1953b Proteacidites Cookson ex Potonie, p. 42.

Type Species: Proteacidites adenanthoides Cookson, 1950, p. 172,
pl. 2, fig. 21.

Comments: Martin & Harris (1975) contended that P. thalmanii and P. retusus Anderson (1960) both have short colpi and must be excluded from Proteacidites. Apparently, this is not based on the re-study of the type material. Anderson's illustrations are poor and one should re-examine his original preparations and possibly study new samples from his sampling localities before one can make any judgement.

Srivastava (1969a) emended the genus Beaupreadites Cookson to accommodate colpoid proteaceous pollen grains, and illustrated the construction of the aperture as a colporate one. However, he illustrated a triporate pollen as P. thalmanii. Martin (1973) interpreted the aperture as colpoid with post-atrium. The proteaceous forms studies here are all triporate, but some of them may, at least superficially resemble Anderson's species. Their assignment to Proteacidites is tentative because of the current discrepancy of the circumscription of the genus and arguments raised on the legitimacy of the previously-assigned names in the literature.

The youngest report of this genus in the Rocky Mountain area is Coniacian (see Thompson, 1969).

Proteacidites retusus Anderson 1960

Plate 27, figs. 7-9

1960 Proteacidites retusus Anderson, p. 21, pl. 2, figs. 5-7.

Description: Polar amb triangular, sides slightly convex, corners

acutely rounded, pores distinctly annulate, meshes larger around the equatorial area, decreasing towards the poles.

Comments: Small size, fine reticulation and wide annulus is distinct in this form.

Measurements: Equatorial diameter = 14-22 μm (4 specimens).

Figured specimens: Pb12385-1 (115.8x32.1 & 117.1x30.0); Pb12349-1 (118.0x40.3).

Proteacidites thalmanni Anderson 1960

Plate 27, fig. 10

1960 Proteacidites thalmanni Anderson, p. 21, pl. 2, figs. 1-4.

Description: Polar amb triangular, sides slightly convex, corners sharp, notched by the pores, pores annulate, exine ca. 0.5 μm thick, coarsely reticulate around the equatorial area, decreasing in size towards the poles.

Comments: Large size and large reticulation is characteristic of this form.

Measurements: 24 μm (2 specimens).

Figured specimen: Pb12385-1 (119.3x39.0).

Proteacidites sp. 1

Plate 27, fig. 11

Description: Polar outline triangular, sides straight, corners sharp, exine more or less uniformly-reticulate, ca. 1 μm thick; pores equatorial, angulaperturate, with a weak annulus.

Comments: The outline and the uniform pattern of reticulation are the characteristics of this form.

Measurements: Equatorial diameter = 20 μ m (1 specimen).

Figured specimen: Pb12428-1 (124.9x31.4).

Proteacidites sp. 2

Plate 27, fig. 12

Description: Polar amb rounded triangular to circular, grain angulaperturate, pores circular, annulate, exine thin, reticulate (less than 0.5 μ m). Reticulation coarser at the equatorial area, decreasing in size towards the poles.

Comments: This form is morphologically close to, but smaller than, P. sp. in Anderson (1960, p. 21, pl. 2, fig. 8).

Measurements: Equatorial diameter = 17 μ m (1 specimen).

Figured specimen: Pb 12387-2 (127.3x37.0).

Genus Pseudoplicapollis Krutzsch in Goczan, et al 1967

emend. Christopher 1979

1969 Pseudoplicapollis Krutzsch in Goczan, Groot, Krutzsch & Pechtova, p. 496.

1979 Pseudoplicapollis Krutzsch emend. Christopher, p. 113.

Type Species: Pseudoplicapollis palaeocaenicus Krutzsch, *ibid.*, pl. 14, figs. 26-31.

Emended description: See Christopher (1979, p. 113).

Comments: The species of Pseudoplicapollis have been reported from the Middle Turonian to the Upper Campanian of the western North America (cf. R. Tschudy, 1980, p. 10).

Pseudoplicapollis cuneata Christopher 1979

Plate 27, figs. 13-20

1979 Pseudoplicapollis cuneata Christopher, p. 113, pl. 7,
figs. 6-7, pl. 8, figs. 17-21.

Comments: See Christopher (ibid.) for description.

Occurrence: Rare. It has been reported from the Santonian of New Jersey by Christopher (1979).

Measurements: Equatorial diameter = 17(20)25 μ m (9 specimens). Size range in Christopher (1979) is 17(20)24 μ m.

Figured specimens: Pb12387-2 (127.2x27.5, 126.4x38.9); Pb12511-1 (122.3x35.3); Pb12518-1 (111.1x37.8); Pb12385-6 (119.0x47.6); Pb12457-1 (119.0x44.6); Pb12342-3 (119.2x40.8).

cf. Pseudoplicapollis newmanii Nichols & Jacobson 1982

Plate 27, figs. 21-23

1982 Pseudoplicapollis newmanii Nichols & Jacobson, p. 140, pl. 4,
figs. 5-6.

Comments: This form is characterized by having prominent plicae which often appear as double folds, and triangular endoporal structures that extend into the vestibula (Nichols & Jacobson, 1982).

Occurrence: This form has been reported from the Campanian strata of Colorado, Wyoming, and New Mexico (see Nichols & Jacobson, 1982).

Its occurrence in the South Hesperian samples is rare to common.

Measurements: 20-23 μ m.

Figured specimens: Pb12387-2 (123.8x34.0; 125.8x43.5; 123.2x32.5).

Genus Pseudovacuopollis Krutzsch 1967

1967 Pseudovacuopollis Krutzsch in Goczan et al., p. 499.

Type Species: Pseudovacuopollis intraconcaus Krutzsch, *ibid.*,
pl. 15, figs. 1-5.

Comments: This genus was differentiated by Krutzsch (1967) from the genus Vacuopollis by tendency toward development of a constriction in the interapertural area and more strongly differentiated endexinal lamellae. The range of this genus was given by Goczan et al. (1967) as Coniacian to Maestrichtian.

Pseudovacuopollis involutus R. Tschudy 1975

Pl. 27, figs. 24,25

1975 Pseudovacuopollis involutus R. Tschudy, p. 23, pl. 4, figs.
1-12.

Comments: see R. Tschudy (1975) for description and comparison with other species.

Occurrence: R. Tschudy (1975) reported this species from the Upper Campanian and Maestrichtian of Mississippi Embayment area.

Measurements: 22-23. The type species ranges 22-28 μ m.

Figured specimens: Pb12387-2 (115.8x31.0), Pb12456-1 (112.5x34.4)

Genus Triatriopollenites Pflug 1953

1953 Triatriopollenites Pflug in Thomson & Pflug, p. 76

Type Species: Triatriopollenites rurensis Pflug & Thomson,
in Thomson & Pflug, *ibid.* p. 79, pl. 7, fig. 94.

Comments: This genus is characterized by three annulate, simple pores subtended by atria.

Triatriopollenites globosus Pflug 1953

Plate 27, figs. 26-32

1953 Triatriopollenite globosus Pflug in Thomson & Pflug, p. 81,
pl. 8, figs. 76-77.

Comments: This form is distinct by having small size, circular to over-rounded triangular equatorial outline, and three atria at the base of each pore. The secondary folding may occur in some specimens which gives the false impression of plicae and may consequently be mistaken for the genus Labrapollis. Similar forms have been illustrated from Turonian-Santonian of New Jersey as Labrapollis sp. D by Christopher (1978, pl. 2, figs. 12-13).

Occurrence: Rare to common.

Measurements: 11(15)17) um (6 specimens).

Figured specimens: Pb12385-1 (124.6x35.4); Pb12456-1 (115.8x35.6, 112.5x45.1, 119.,0x36.9); Pb12449-1 (117.4x29.3, 123.0x38.8).

Genus Tripoporopollenites Pflug & Thomson in Th. & Pf. 1953

1953 Tripoporopollenites Pflug & Thomson in Th. & Pf., p. 82.

Type Species: Tripoporopollenites coryloides Pflug in Th. & Pf.,
ibid., pl. 9, fig. 20.

Comments: This genus was raised for triporate pollen grains with triangular to rounded triangular amb and occasional annulus or labrum. The pore structure has been compared by the authors to the ones in Corylus and Ostrya.

Tripoporopollenite sp. 1

Plate 27, figs.33,34

Description: Pollen grains triporate, pores equatorial, round,

simple, non-atriate, slightly protruding; polar outline deltoid;
exine very thin, scabrate.

Measurements: 29, 35 μm (2 specimens).

Figured specimens: Pb12114-5 (118.0x43.0, 125.0x44.7).

Triporopollenites Sp. 2

Plate 27, figs. 35-36

Description: Pollen grains triporate, pores equatorial, one of the pores may be subequatorial, pores simple, non-protruding, non-atriate, circular; polar outline triangular with convex sides, surface scabrate.

Comments: This form is different from T. sp. 1 by having non-protruding pore areas.

Measurements: 27-28 μm .

Figured specimens: Pb12463-1 (124.3x35.7); Pb12342-7 (120.7x25.8).

Triporopollenites sp. 3

Plate 28, figs. 1,2

Description: Small di- or tri- porate pollen grain; equatorial outline circular; pores small, annulate; exine very thin, layers undetectable; surface psilate; no atria, endannuli, or plicae.

Measurements: 14-15 μm (2 specimens).

Figured specimens: Pb12411-1 (125.4x37.0); Pb12400-5 (119.1x30.9).

Genus Vacuopollis Pflug 1953

1953 Vacuopollis Pflug, p. 103.

1953 Conclavipollis Pflug, p. 105.

Type Species: Vacuopollis percentus Pflug, *ibid.*, pl. 20, figs.

24-26.

Description: See Goczan *et al* (1967). This genus has been defined as slightly convex to slightly concave triangular, triporate, normapollens pollen with annulate exogerminal and distinctly baculate annuli, broad atriate vestibulum, and with no endogerminal thickening, oculi, plicae or arcus. Pseudovacupollis is constricted at the sides of the amb. Goczan *et al.* (1967) and Skarby (1968) did not find any distinction between this genus and Conclavipollis Pflug. Skarby (1968) placed these two genera, along with many others, in Extratriporopollenites Pflug *emend.* Skarby. This broad generalization is not justifiable in my opinion. This genus ranges from Turonian to Campanian in the western North America (Tschudy, 1980).

Vacuopollis orthopyramis Pflug in Thomson & Pflug 1953

Plate 28, fig. 3

1953 Vacuopollis orthopyramis Pflug in Th. & Pf., p. 104, pl. 20, figs. 17-20.

Occurrence: Middle Senonian of Germany (Pflug, 1953). It is common in the South Hospah samples.

Measurements: 25 μ m.

Figured specimen: Pb12387-2 (121.5x45.2).

Vacuopollis semiconcavus Pflug in Thomson & Pflug 1953

Plate 28, figs. 4-7

1953 Vacuopollis semiconcavus Pflug in Th. & Pfl., p. 104, pl. 20,

figs. 1-9.

Occurrence: Middle Senonian of Germany (Pflug, 1953). It is common in the Lower Campanian of New Mexico.

Measurements: 18-23 μ m (6 specimens).

Figured specimens: Pb12385-1 (129.4x35.8, 124.6x38.8); Pb12387-1 (127.9x32.6, 128.5x36.3).

POLYADS:

Polyadopollenites Pflug & Thomson 1953

1953 Polyadopollenites Pflug & Thomson in Th. & Pf., p. 112.

Type Species: Polyadopollenites multipartitus Pflug, *ibid.*, pl. 15, fig. 65.

Comments: This form genus was proposed by Pflug and Thomson to accommodate the fossil dispersed polyads resembling the pollen massulae of the modern genus Acacia (Mimosaceae). Herengreen has described eight-celled polyads from the Cenomanian of Brazil (cf. Muller, 1981). Mimosaceous-type polyads have also been described by Kedves from the Coniacian-Santonian and the Lower Paleocene of Egypt (Muller, 1981, p. 56).

Polyadopollenites Sp. 1

Plate 28, fig. 8

Description: A massula of pollen grains made up of ca. 12 grains; outline circular; individual grains very much like P. sp. 2 in size and shape.

Comments: A single grain of this type was found in the South Hospah samples. P. sp. 1 and P. sp. 2 may be members of the same species.

Measurements: 11 μ m.

Figured specimen: Pb12387-2 (114.8x30.0).

Polyadopollenites sp. 2

Plate 28, fig. 9

Description: A massula of about 25 pollen grains; outline circular; individual grains with tetragonal to pentagonal outline, without any apparent aperture.

Comments: The forms reported by Cookson (1954) from the Tertiary of Australia are much larger than this form.

Occurrence: A single grain of this type was found in the South Hospah samples. The apparently entemophyllous nature of pollination in the plant producing these pollen may explain their scarcity.

Measurements: 18 μ m.

Figured specimen: Pb12387-2 (114.4x31.7).

MISCELLANEOUS PLANT ORGANS:

Trichome Type 1

Plate 28, fig. 10

Description: Small, slender lanceolate, arrow-head-shaped plant hair; constricted at the base. A slit-like furrow is located about one μ m above the base and tapers out towards the tip. The surface is not ornamented.

Measurements: ca. 13 μ m long and 3 μ m wide.

Figured specimen: Pb12401-9 (125.5x34.7).

Trichome Type 2

Plate 28, figs. 11,12

Description: Thorn-shape slender conical trichome with a sharp tip and a broadened or bulbous base at the point of detachment. The wall smooth and very conspicuous, one μm thick.

Comments: Fig. 3 has irregular margin; fig. 2 is bulbous.

Measurements: 29-39 μm long; 4-5 μm wide at the base (2 specimens).

Figured specimens: Pb12520-1 (122.2x41.3, 125.5x31.4).

Trichome Type 3

Plate 28, fig. 13

Description: Sickle-like trichome with pointed tip and broad base. This form is bent more than 90 degrees toward the tip at about two-thirds of the length from the base. The wall is one μm thick and conspicuous. The base is irregular, possibly broken off.

Measurements: Longest dimension 30 μm , base 9 μm .

Figured specimen: Pb12465-1 (122.3x36.2).

Trichome Type 4

Plate 28, figs. 14,15

Description: Sickle-shaped plant hair with pointed tip, unconstricted base, and roughened surface. The base is broken.

Comments: Elsik (1968b) reported the same hair type from the Paleocene of Texas.

Measurements: 18-20 μm long, up to 2-3 μm wide.

Figured specimens: Pb12379-3 (126.6x46.6), Pb12462-1 (112.5x37.9).

Trichome Type 5

Plate 28, fig. 16

Description: Sickle-shaped plant hair with pointed tip, slightly constricted, broken base, smooth surface, and two spine-like projections emerging obliquely from the concave side. Wall slightly thicker at the base.

Comments: This may be an appendage detached from a zooplanktonic entity.

Measurement: 21 x 5 um; width decreases to 3 um at the constricted base.

Figured specimen: Pb12378-8 (125.5x43.3).

Trichome Type 6

Plate 28, figs. 17,18

Description: Slender, attenuated, sword-shaped plant hair. Slightly curved at the middle; tip pointed; surface smooth; contour slightly uneven; base constricted.

Measurements: Length 31-45 um; maximum thickness 3 um reducing to 1.5-2 um at the base .

Figured specimens: Pb12385-5 (112.5x45.5), Pb12470-1 (125.5x38.5).

Trichome Type 7

Plate 28, figs. 19,20

Description: Long, attenuated, slender plant hair with pointed tip, slightly swollen base, and rough surface. The body is curved 90-110 at about one tenths of the length from the base, slightly uneven; base constricted.

Measurements: 57-72 μm long and 3 μm thick. The supposedly horizontal part at the base is 9 to 10 μm long (2 specimens measured).

Figured specimens: Pb12378-8 (119.0x34.8); Pb12484-1 (117.4x33.7).

Trichome Type 8

Plate 28, fig. 21

Description: Long, slender (twig-like) trichome; bristle-tipped with minute, short, spine-like projections arranged spirally on the surface emerging at 45° angle. Base is constricted, tip is blunt.

Measurements: 62 μm long, up to 4 μm wide.

Figured specimen: Pb12460-1 (110.9x33.1).

Trichome Type 9

Plate 28, figs. 22,23

Description: Spike-shaped or cone-shaped plant hair with elongate triangular outline, and thin, tufted "spines". The base constricted and free of spines, may be detached from the tufted main body.

Measurements: 20 x 12-13 μm .

Figured specimens: Pb12385-5 (112.5x42.8); Pb12513-1 (120.6x31.7).

Trichome Type 10

Plate 28, fig. 24

Description: Shepherd's purse-like trichome. The body is covered with minute, thick, short spine-like projections.

Measurements: 34 μm long; up to 10 μm wide at the base (1 specimen measured).

Figured specimen: Pb12460-1 (115.8x32.1).

Vascular Tissues

Plate 28, figs. 25-28

Comments: The illustrated vascular tissues show the xylem cells with bordered pits typical of the gymnosperms.

Figured specimens: Pb12442-1 (111.7x41.8); Pb12382-9 (124.5x44.8);
Pb12382-10 (124.0x38.6); Pb12484-1 (123.9x30.0).

V. Statistical Analysis of the Data and Reconstruction of Plant Communities

Mosimann (1965) suggested a Chi-square test for correlation of palynological samples from different levels in peat deposits. In such a test, the assumption is that the pollen count for "n" samples is in hand. In each sample, "k" taxa have been counted. The null hypothesis that these "n" samples are from the same level of peat is tested by the following multinomial homogeneity (chi-square) test.

<u>SAMPLE No.</u>	<u>TAXON(a)</u>	<u>TAXON(b)</u>	- - -	<u>TAXON (k)</u>	<u>TOTAL</u>
1	X_{a_1}	X_{b_1}	- - -	X_{k_1}	N_1
2	X_{a_2}	X_{b_2}	- - -	X_{k_2}	N_2
-	-	-	- - -	-	-
-	-	-	- - -	-	-
-	-	-	- - -	-	-
n	X_{an}	X_{bn}	- - -	X_{kn}	N_n
<u>COLUMN TOTAL</u>	X'_a	X'_b	- - -	X'_k	N'

$$\chi^2 = \left(\frac{\sum X_a^2 / N}{\hat{p}_a} + \frac{\sum X_b^2 / N}{\hat{p}_b} + \dots + \frac{\sum X_k^2 / N}{\hat{p}_k} \right) - N'$$

WHERE

$$\sum X_a^2 / N = (X_{a_1}^2 / N_1) + (X_{a_2}^2 / N_2) + \dots + (X_{an}^2 / N_n)$$

AND

$$\hat{p}_a = X'_a / N'$$

similarly:

SIMILARLY

$$\Sigma x_b^2 / N = (x_{b_1}^2 / N_1) + (x_{b_2}^2 / N_2) + \dots + (x_{b_n}^2 / N_n)$$

AND

$$\hat{p}_b = x'_b / N'$$

In a special case in which all "n"'s are equal ($N_1 = N_2 = \dots N_n = n$), the individual divisions are not necessary.

$$\text{IF } N_1 = N_2 = N_3 = \dots = N_n = N$$

THEN

$$\Sigma x_a^2 / N = \frac{1}{N} (x_{a_1}^2 + x_{a_2}^2 + \dots + x_{a_n}^2)$$

The degree of freedom is:

$$D = (n-1)(k-1)$$

where, n = number of column, and k = number of rows.

The calculated Chi-square value obtained through the above procedure is then compared with the expected value of Chi-square at the same degree of freedom, using standard Chi-square tables. If the calculated value is smaller than the expected one, then the null hypothesis (H_0) that the compared samples are of the same level is validated.

I adapted this test to compare the South Hospah samples two-by-two with the assumption that pair samples from similar environments of the coal-producing marsh/swamp complex would show no significant difference.

The number of elements in each sample (k) is determined by the number of palynomorph taxa or groups of taxa counted. This number can be reduced by subsequent lumping of the counted taxa into larger

groups after counting. Other specifications in this special case are:

TWO-BY-TWO COMPARISON OF SAMPLES

$$n=2$$

$$N_1=N_2=N=300$$

$$N'=N_1+N_2=600$$

$$\hat{P} = \frac{x_{a1}+x_{a2}}{600} ; \hat{P} = \frac{x_{b1}+x_{b2}}{600} ; \text{etc.}$$

$$\sum x_a^2/N = \frac{x_{a1}^2+x_{a2}^2}{300} ; \sum x_b^2 = \frac{x_{b1}^2+x_{b2}^2}{300} ; \text{etc.}$$

THUS

$$\chi^2 = \left[\frac{(x_{a1}^2 + x_{a2}^2)/300}{(x_{a1} + x_{a2})/600} + \dots + \frac{(x_{k1}^2 + x_{k2}^2)/300}{(x_{k1} + x_{k2})/600} \right] - 600$$

OR

$$\chi^2 = 2 \left(\frac{x_{a1}^2 + x_{a2}^2}{x_{a1} + x_{a2}} + \dots + \frac{x_{k1}^2 + x_{k2}^2}{x_{k1} + x_{k2}} \right) - 600$$

I performed this test for 68 samples. 51 potential elements were considered in each sample. The results of the computations revealed that there were only five pairs of comparisons with no significant difference at 0.05 level. Four of the five pairs were samples taken from the same core section with an interval of a few inches.

In order to examine the effect of lumping of palynomorphs, I performed a similar test at 12 degrees of freedom by lumping the 51 elements in each sample into 13 larger groups. This modification

resulted in the number of similar pairs to increase from 5 to 8, but with the same pattern as in the previous test.

After observing the results, I decided that the theoretical level of significance may not be meaningful in the population under study. My logic was that all Chi-square values calculated in this procedure should indicate some degree of similarity and association between two samples being compared. However, the majority of these values are practically rejected and ignored as being "insignificant" when an arbitrary level of significance is established in conventional statistical analyses. Thus, I decided to seek a criterion through which I could visualize the pattern of all the calculated Chi-square values. The most useful method of such observation is cluster analysis. In this analysis, the Chi-square values can be considered as coefficients of similarity regardless of their level of significance, and the hierarchic level of coefficients can be illustrated by plotting a dendrogram. The remotely associated samples would automatically be fused at the lower levels. Selection of the levels of clustering is quite subjective and can be shifted to lower or higher levels, but the entire pattern of all possible clusterings is drawn as a permanent diagram for any desired manipulation.

In order to investigate the above-mentioned potential, the CLUSTAN subroutine available in the Michigan State University computer system was used.

In preparation of data for this statistical package, I found it desirable to convert the calculated Chi-square values into

"standardized" values with predictable range of variation. This was done by adopting the following conversion equation:

$$\text{SIMILARITY INDEX(S.I.)} = 1 - \frac{\chi^2}{\chi_{\max}^2}$$

where, χ^2 is a calculated Chi-square value, and $\chi_{\max}^2$ is the highest Chi-square value among all the possible pair comparisons. The above index has a predictable range of variation between zero and unity and is comparable to "Phi" statistic in two by two contingency tables. Only the most remotely comparable pair having the maximum Chi-square value in a given test would have a "S. I." equal to zero. As the degree of association between two samples increases, the "S. I." value approaches unity.

In order to prepare suitable similarity index matrix for the CLUSTAN package, a BASIC computer program was prepared to read the relative percentage of 51 elements in all samples, compare each pair of samples in a combinatorial fashion (1), calculate the similarity index value (S. I.) for each pair comparison, and store the results in a triangular matrix. This matrix can then be read by the CLUSTAN subroutine to perform a hierarchial fusion and plot results as a cluster diagram (dendrogram).

(1) when samples "a" and "b" are compared, then the redundant comparison of "b" and "a" is omitted.

Figure (5) shows the dendrogram plotted by CLUSTAN for 94 samples from four core sections in South Hospah using the similarity index matrix calculated in this study. The 51 elements in each sample were combined into 13 larger groups, and the relative frequencies of these groups were utilized for calculation of similarity indices.

As seen in Figure (5), four major subclusters can be identified. They have been designated by letters "A", "B", "C" and "D". The average relative frequencies of 13 major elements in the four major pollen floras have been illustrated in Figure (6). These four units may be considered as representative pollen floras of four local plant communities with significantly different vegetational composition. This, in turn, may reflect four different local habitats or environments which controlled the composition of the plant communities and partially determined the composition of the pollen flora.

This assumption is strengthened by examining the pattern of distribution of samples from each unit along the lithological section. This has been illustrated in Figure (7) by designating appropriate letters ("A", "B", "C" and "D") to each sample. As revealed in Figure (7), all samples taken from clay and mud shales belong to pollen flora type "A". On the other hand, all type "B" pollen floras are restricted to the "Blue" and "Green" coal seams. With one exception (Pb12532), the type "A" pollen flora in coal seams is restricted to clayey coal zones and to isolated, thin coal beds (≤ 1 ft). Type "C" pollen flora is confined to the clay shale and clayey coal zones of the "Blue" coal or the clay shale parting between the "Blue" and the underlying "Green" coal. With a few

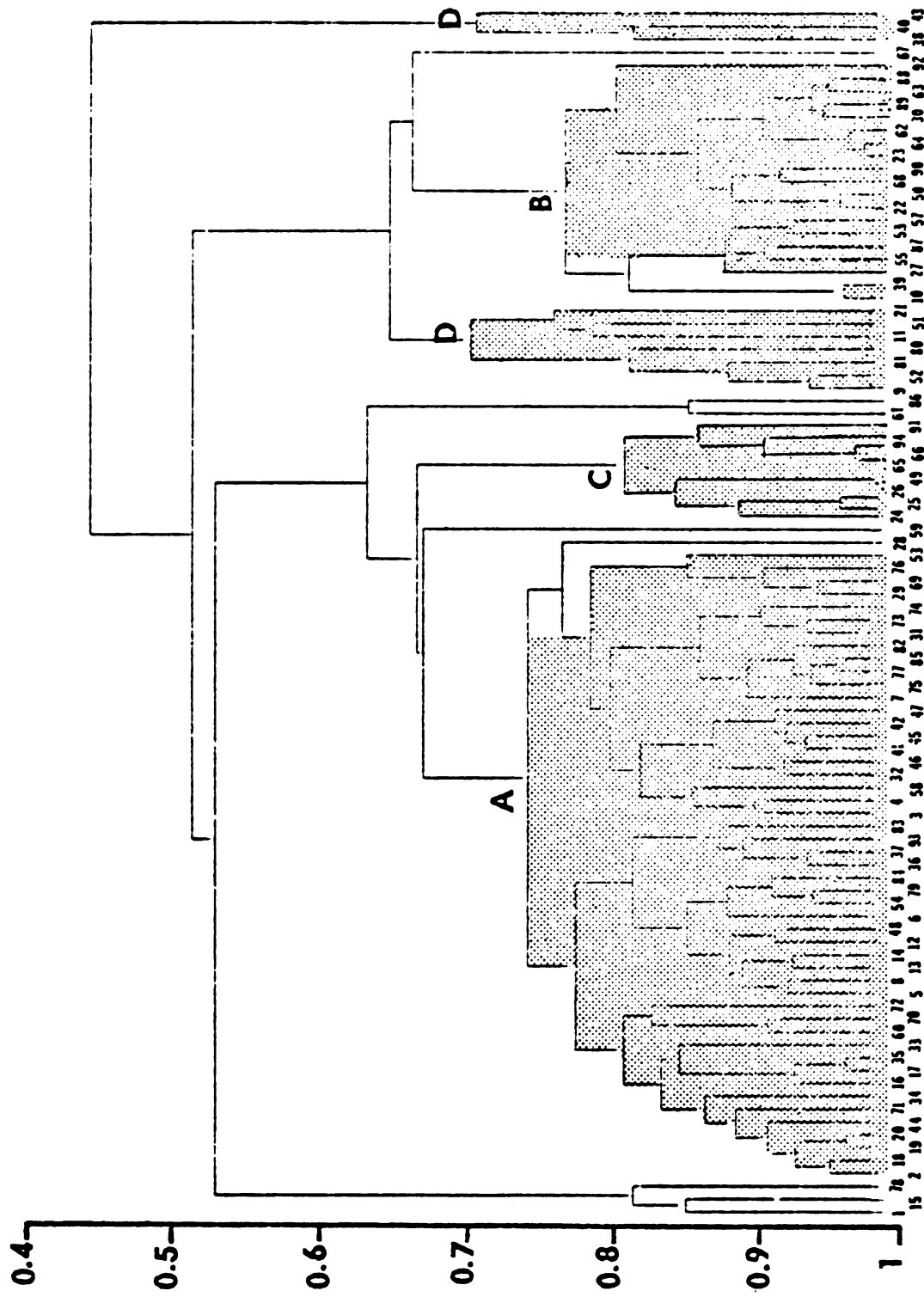


Figure 5: Cluster Analysis of the South Hospah Samples.

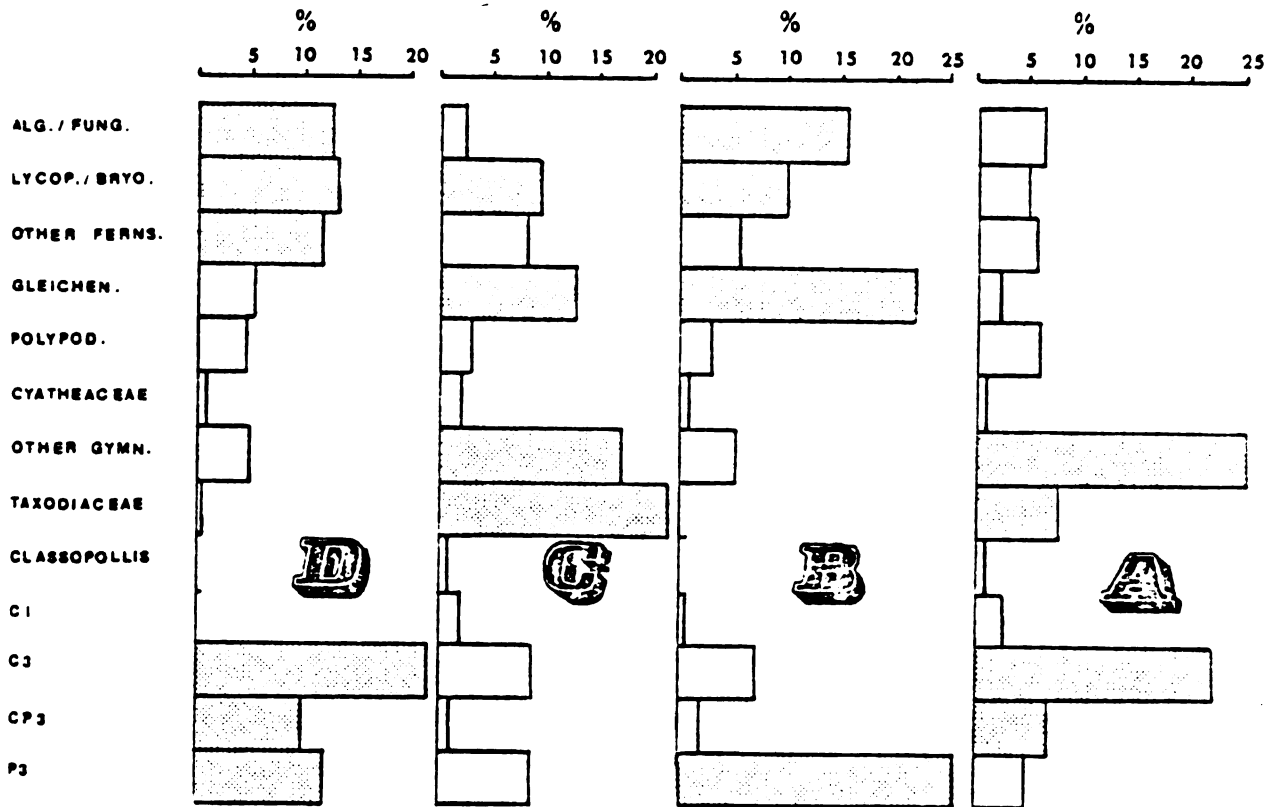


Figure 6: Average Relative Frequencies of Pollen Taxa in the Four Cluster Units of the South Hospah Samples.

Figure 7: Stratigraphic Profile of the Four South Hospah Core Sections. Sampling points have been shown by tick marks on the left side of each section. The sequential numbers correspond to the following sample codes used in this study.

EC-150:

1=Pb12374	11=Pb12394	21=Pb12415
2=Pb12375	12=Pb12400	22=Pb12416
3=Pb12378	13=Pb12401	23=Pb12417
4=Pb12379	14=Pb12402	24=Pb12428
5=Pb12382	15=Pb12403	25=Pb12430
6=Pb12384	16=Pb12404	26=Pb12432
7=Pb12385	17=Pb12408	27=Pb12435
8=Pb12386	18=Pb12411	28=Pb12439
9=Pb13241	19=Pb12413	29=Pb12442
10=Pb12387	20=Pb12414	30=Pb12445
		31=Pb12449

EC-75:

32=Pb12453	41=Pb12462	50=Pb12473
33=Pb12454	42=Pb12463	51=Pb12474
34=Pb12455	43=Pb1246	52=Pb13238
35=Pb12456	44=Pb12465	53=Pb12476
36=Pb12457	45=Pb12466	54=Pb12478
37=Pb12458	46=Pb12467	55=Pb12483
38=Pb12459	47=Pb12470	56=Pb12484
39=Pb12460	48=Pb12471	57=Pb12485
40=Pb12461	49=Pb12472	58=Pb12486
		59=Pb12487

EC-50:

60=Pb12492	64=Pb13212	68=Pb13216
61=Pb12494	65=Pb12496	69=Pb12500
62=Pb13210	66=Pb12498	70=Pb12501
63=Pb13211	67=Pb13215	

EC-100:

71=Pb12504	79=Pb12515	87=Pb12523
72=Pb12505	80=Pb12516	88=Pb12524
73=Pb12506	81=Pb12517	89=Pb12525
74=Pb12508	82=Pb12518	90=Pb12527
75=Pb12511	83=Pb12519	91=Pb12529
76=Pb12512	84=Pb12520	92=Pb12530
77=Pb12513	85=Pb12521	93=Pb12533
78=Pb12514	86=Pb12522	94=Pb12534

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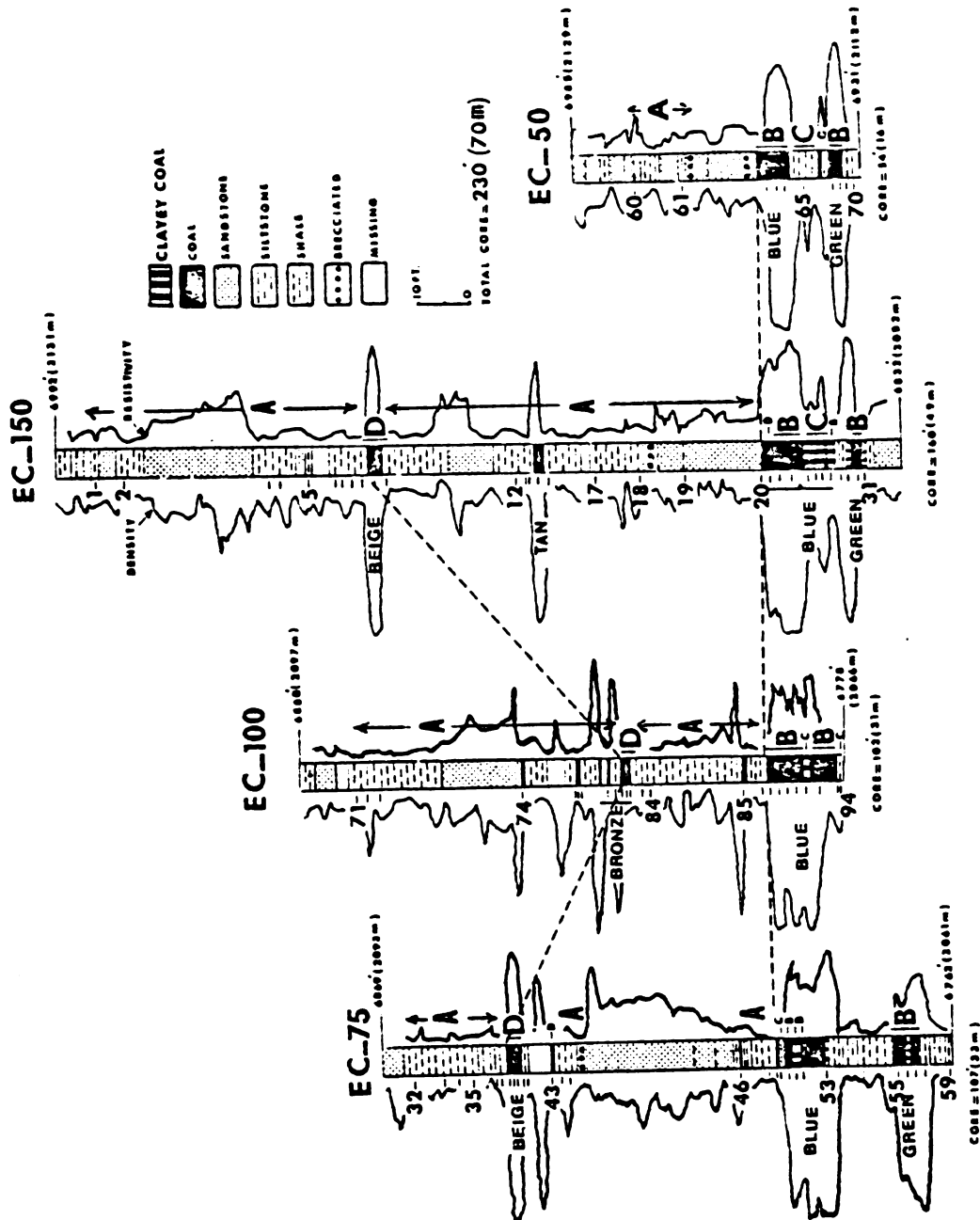


Figure 7: Stratigraphic Profile of the Four South Illoshah Core Sections.

ROCK TYPE POLLEN ASSEMBLAGE	C OAL	CLAYEY COAL	SHALE	ROW TOTAL
A	6 (Y ₁₁) 9.4**	*19.6 3 5.4 1	47 31 8.2	56 (R ₁)
B	17 15.8	6 7 2 1.8 .02	0 10.5 10.5	19
C	0 3	3 4 0.9 10.7	5 5 0	9
D	10 12.07	3 5 0 .9	0 5.5 5.5	10
COLUMN TOTAL	33 (C ₁)	9	52	94 (n = Σ R _i = Σ C _i)

$$* E_{ij} = \frac{R_i C_j}{n}$$

$$** T_{ij} = \frac{(Y_{ij} - E_{ij})^2}{E_{ij}}$$

$$\chi^2 = \sum T_{ij} = 77.09$$

$$\chi^2 = 12.59$$

$$.05(6)$$

Table 3: Contingency Table for the South Hospah Pollen Assemblages and the Lithologic Units.

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exceptions, type "D" samples are restricted to the "Beige/Bronze" coal zone.

It may be argued that the correlation between the pollen flora and the rock units is fortuitous. One of the statistical criteria for examining this possibility is to set up a contingency table for the two variables and calculate the multinomial Chi-square value. If the calculated Chi-square value is smaller than the tabulated value at the same degree of freedom, then the hypothesis that the two variables are independent is accepted. To perform this test, the frequency of occurrence of each palynoflora type in the coal layers, in the clayey coals, and in the shale layers was tabulated in a contingency table (Table 3). The calculated Chi-square value for this table is larger than the tabulated value at .05 level of significance and 6 degrees of freedom. Therefore, the hypothesis that the pollen assemblages and the lithological units are independent, and that their association is a mere consequence of chance does not appear to be supported.

Pollen flora type "A" can be contrasted with the other types by having a high average relative frequency of gymnospermous pollen (mostly Eucommiidites) and tricolporate angiospermous pollen. The restriction of this pollen type in shales and some thin, isolated coal beds and clayey coal zones suggests that it was mainly contributed by bottomland vegetation surrounding the marsh/swamp environment of coal deposition.

The occurrence of this pollen flora in the clayey coal zones may indicate "contamination" of the peat by overbank or crevasse play deposits of deltaic distributaries containing transported

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palynomorphs from the bottomland flora. However, it is less probable that isolated, thin, "pure" coal beds containing type "A" pollen flora have been "contaminated" by water-transported palynomorphs. Rather, it is more plausible that these thin coals have formed in relatively restricted environments of deposition and their pollen flora have been influenced by wind-blown palynomorphs from the surrounding bottomland vegetation.

Exceptionally high relative frequency of Eucommiidites in the pollen flora type "A" and its rare occurrence in coal beds strongly suggests that the extinct gynospermous plants producing this pollen were the members of bottomland plant community and probably did not contribute to the accumulation of peat in the South Hoshpah Cretaceous Swamp.

Pollen flora type "B" is exclusively restricted to the "Blue" and "Green" coal seams (Fig. 7). It is dominated, in average, by triporate pollen (mainly those assignable to some members of the modern families Myricaceae, Juglandaceae, and Casuarinaceae), gleicheniaceus, lycopodiaceous, and bryophytic spores, and algal/fungal elements. The frequency of gymnospermous pollen is insignificant in this type.

The type of vegetation represented by this pollen flora may be characterized by shrubby and arborescent angiosperms (hardwood trees) and gleicheniaceus ferns. The modern analogs of this peat-forming vegetation can be found in grass-marsh environments which have patches of trees ("tree houses") in the Okefenokee Swamp. The "tree houses" in this modern peat swamp are surrounded by dense fringes of herbaceous vegetation dominated by Woodwardia virginica (Virginia

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chainfern) in the family Blechnaceae (Spackman, et al., 1974, p. 82). The pollen signature of these modern marshes are comparable with the type "B" pollen flora of the South Hospah section in having a high content of triporate pollen and herbaceous palynomorphs (Spackman, et al., 1964, fig. 16). The herbaceous palynomorphs in the type "B" pollen flora are dominantly *Gleichenia*-type spores. The high percentage of pine pollen in these modern environments can be ignored because pine does not grow in the immediate vicinity of the marsh. The over-representation of the pine pollen is due to prolific production and aerodynamic character of this pollen which is being transported into the marsh environment from the surrounding habitats where pine trees grow. Moreover, the absence of pine pollen in the pollen flora type "B" reflects the general absence of this pollen from the entire South Hospah section.

It should be emphasized that close comparison of the South Hospah pollen flora with pollen signature of any modern peat flora is impossible due to the fact that some of the major components of the modern marsh environments such as grasses (Poaceae) and sedges (Cyperaceae) had not yet evolved by Campanian time.

From 27 "pure" coal samples in the "Blue" and "Green" coal seams, only 3 have a different palynological composition from type "B". The uniform palynological composition and the considerable thickness of these two coal beds is suggestive of a relatively widespread swamp community that was stable for an extended period. The pollen spectra of such environments are comprised primarily of locally-derived palynomorphs although wind-blown palynomorphs contributed by surrounding bottomland vegetation do influence the

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Comparative examination of the major palynological components of the coal beds also reveals the basic palynological contrast between the "Blue/Green" coal and other overlying coals. Frequencies of 8 major palynological components of the coal beds in the core sections have been shown in Figures (8 to 11) for the purpose of this comparison⁽¹⁾. The first component presented in these figures (P3) indicates only the triporate pollen resembling those produced by some members of the modern families Juglandaceae, Myricaceae, and Casuarinaceae. The second component (CP3) represents the tricolporate pollen grains that have probably been produced mainly by some members of the family Nyssaceae. The third component includes all other triporate, tricolpate, monocolpate, and monoporate angiospermous pollen grains. Other components are self explanatory.

The pollen spectra in both "Blue and "Green" coals are dominated by gleicheniaceous spores and triporate pollen grains. This composition corresponds to the type "B" pollen flora revealed by dendrogram (Figures 5 and 6).

(1) The number of fungal/algal elements were subtracted from the total count in calculating the relative frequencies. The relative percentages equal to or less than 12% have been omitted. This arbitrary lower limit was arrived at by plotting the frequency distribution of all relative percentages in the samples involved.

The resulting scatter diagram showed that the low percentages tend to cluster around 7% and drop in frequency at 12%. The frequency then increases towards the higher percentages.

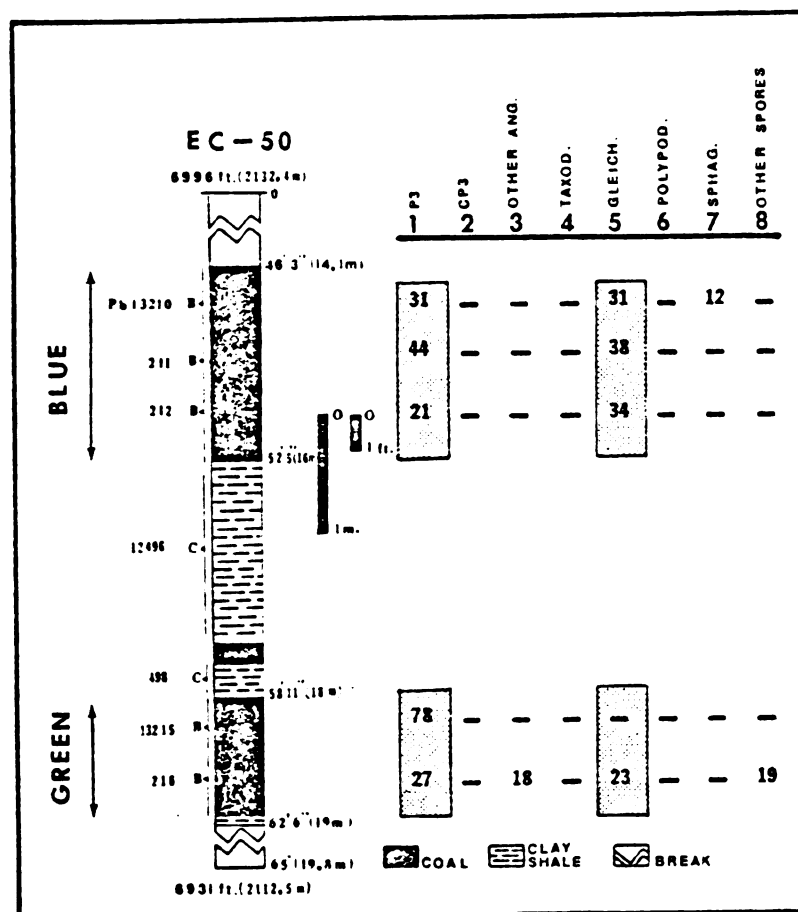


Figure 3: Relative Frequencies of Eight Major Palynomorph Groups in Core Section EC-50.

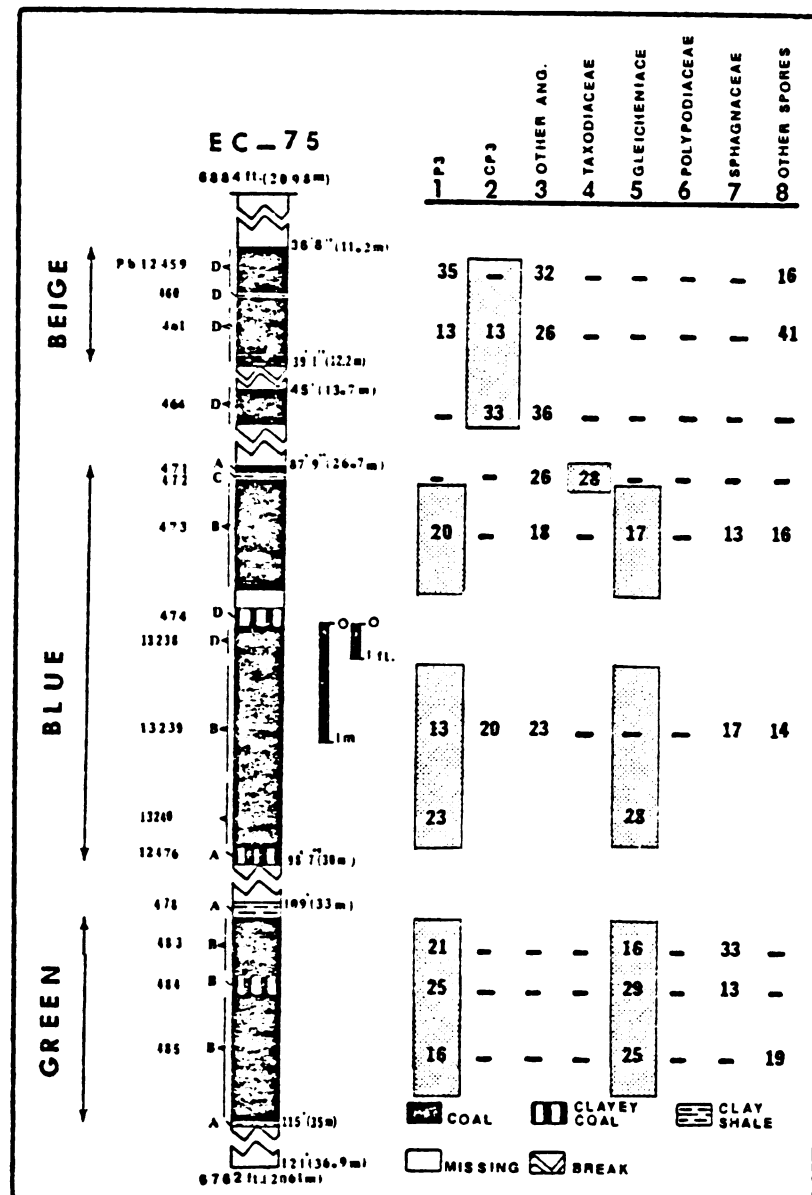


Figure 9: Relative Frequencies of Eight Major Palynomorph Groups in Core Section EC-75.

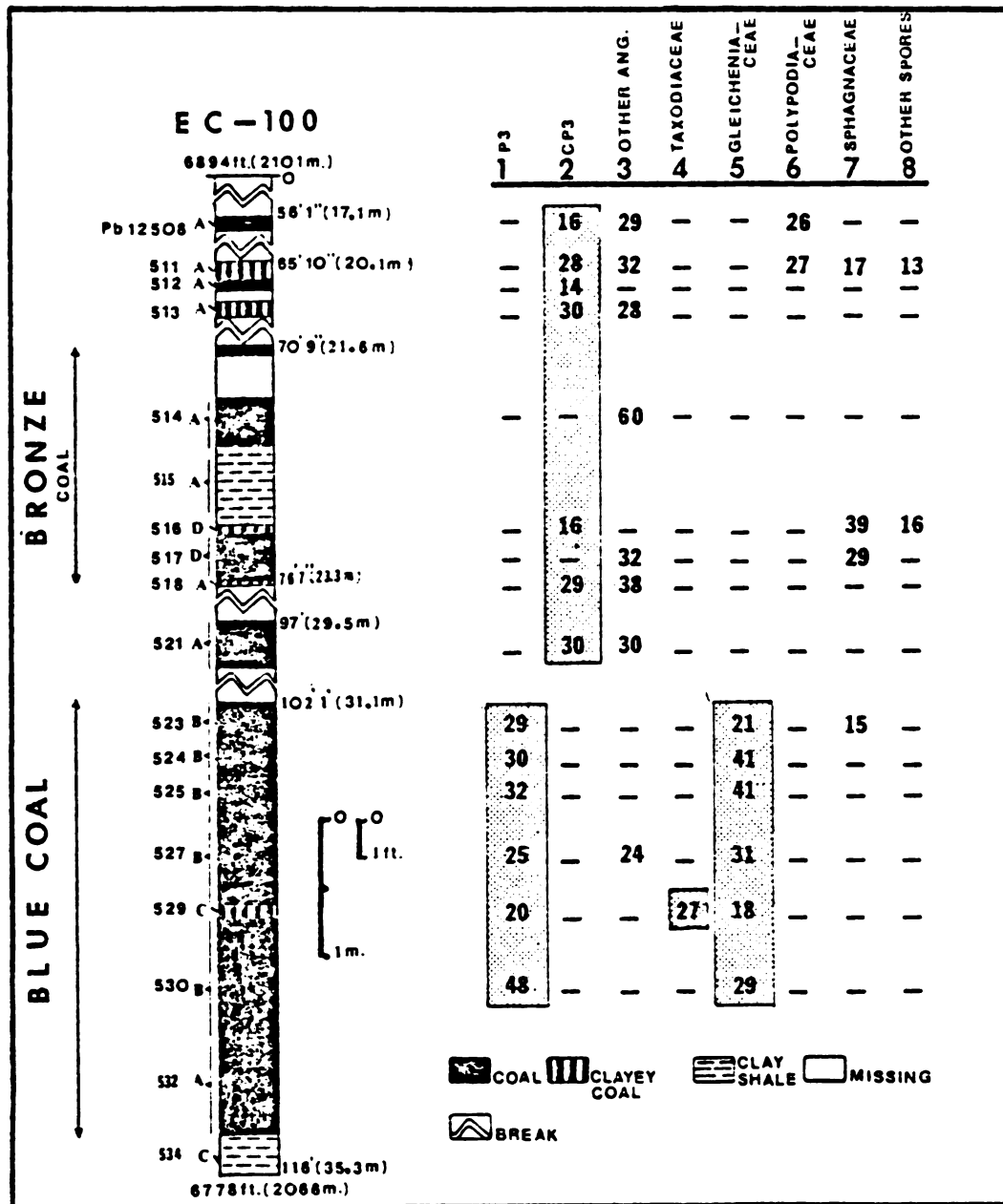


Figure 10: Relative Frequencies of Eight Major Palynomorph Groups in Core Section EC-100.

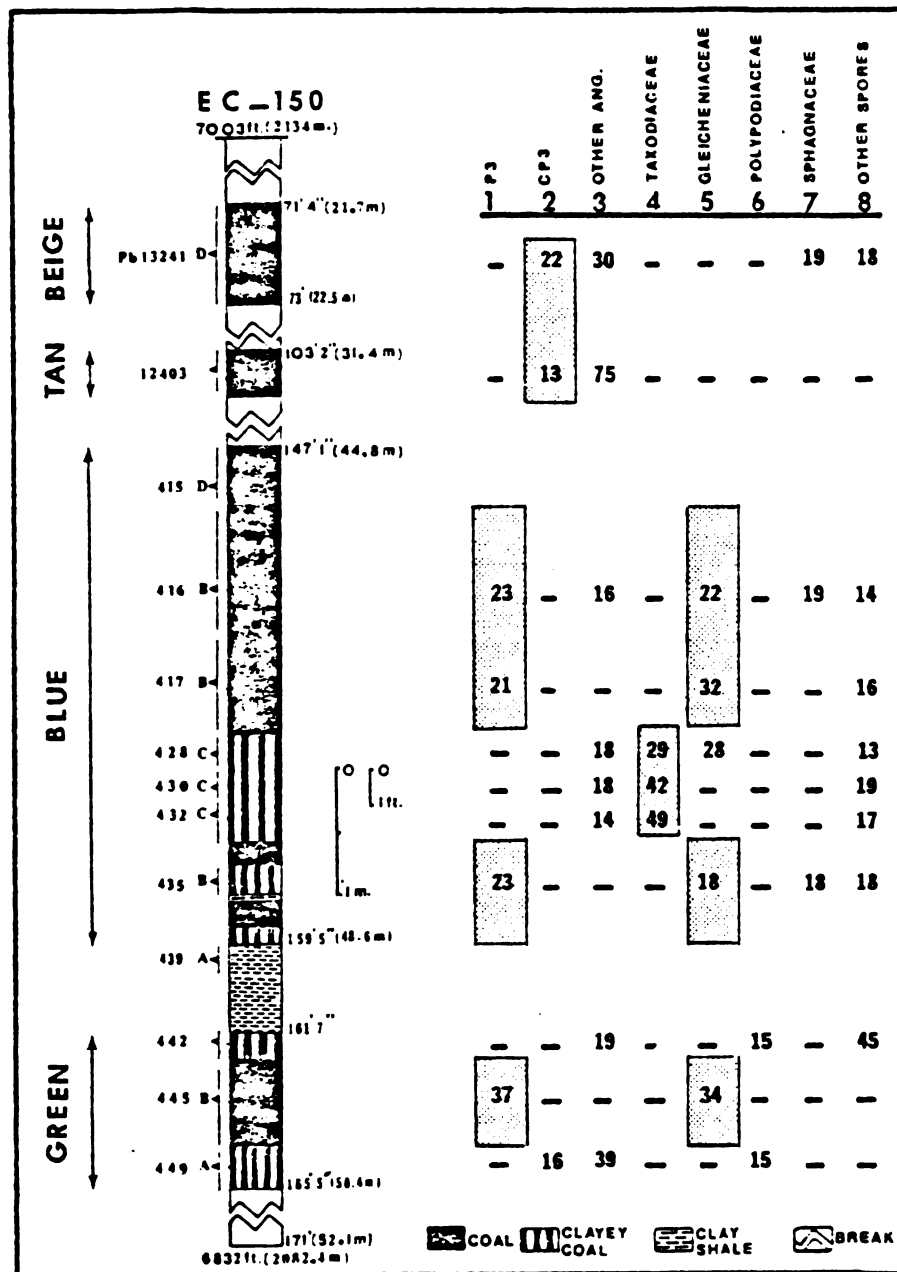


Figure 11: Relative Frequencies of Eight Major Palynomorph Groups in Core Section EC-150.

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The pollen flora type "C" is characterized by having an exceptionally high relative frequency of taxodiaceous pollen. This flora is confined to the clay shale and clayey coal zones of the "Blue" coal or the clay shale parting between the "Blue" and the underlying "Green" coal.

The occurrence of this assemblage at these levels suggests that the deepening of the water must have been, at least partially, responsible for the formation of the partings within the "Blue" coal and between the "Blue" and the "Green" coal, resulting in exclusion of most of the characteristic swamp plants and ephemeral dominance by cypress analogs and other taxa that are capable of tolerating deeper water.

The palynological composition of the "Blue" coal and the underlying "Green" coal is generally very similar. They have probably formed in a similar depositional environment under comparable local site conditions. The partings between the two coals in all core sections is comprised of organic clay shales. No sandstone was deposited between the "Blue" and "Green" coals. This interruption in the otherwise uniform and steady accumulation of peat does not seem to have taken place as a result of any major shift in the pattern of the deltaic regime. A slight increase in the water level could have killed the marsh or swamp vegetation and interrupted the accumulation of peat. One of the numerous modern examples of this situation can be seen in the Mississippi deltaic swamp complex between New Orleans and Baton Rouge, Louisiana. The local deepening of water in this area is marked by scattered dead stumps of Taxodium trees which are the last plants to be eliminated as the water level

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rises. The increase in the relative frequency of taxodiaceous pollen in the zones of type "C" flora may be the result of this kind of selective elimination of other vegetation as a result of deepening of the water.

It should be noted that the relative percentage of taxodiaceous pollen never exceeds 4% in any "pure" coal beds, although this pollen becomes important in some non-coal-producing organic shales at a few points along the section. This observation leads to the speculation that taxodiaceous gymnosperms, although abundant at some levels in the South Hospah section, did not contribute significantly to the peat. It seems that the type of swamp vegetation suggested by the South Hospah palynological assemblages is different in one major aspect from those contributing to the late Paleocene coals of Powder River Basin in Wyoming where the taxodiaceous pollen is dominant throughout the woody coal beds (Loretta Satchell, personal communication).

The pollen flora type "D" can be distinguished by exceptionally high relative frequency of Nyssa-type pollen. This flora is dominated by other angiospermous pollen and the spores of understory vegetation (Figure 6). Gymnospermous pollen has a very low relative frequency in this palynofloral type. With a few exceptions, this palynoflora is restricted to the "Beige/Bronze" coal zone. This pollen flora reflects a major contrast between the local environment of "Blue/Green" coal complex and the overlying "Beige/Bronze" coal zone. The latter seems to have formed in a swamp dominated by members of the family Nyssaceae. Other minor coal beds above the "Blue" coal have also different palynological composition from the

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"Blue" coal. This represents a pronounced change in the environment of deposition reflected by a change in the peat-forming plant community.

Environments of Deposition and Paleoclimate:

Primary examination of the overall composition of the South Hospah palynological assemblages reveals some significant characters from the standpoint of paleoenvironmental and paleoecological interpretations.

The first significant feature of this assemblage is the absence of acid-resistant marine phytoplankton such as dinoflagellates and acritarchs. The presence of these entities in palynological preparations has long been used as an indication of marine, or brackish environments.

The absence of marine phytoplankton from the South Hospah palynological assemblages and the absence of any marine invertebrates from the rock samples throughout the section indicate that the sediments were deposited in a freshwater environment.

The second significant character of the South Hospah palynological assemblages is the virtual absence or relative insignificance of gymnospermous bisaccate pollen. Where present in a sample, the relative percentage of these palynomorphs rarely exceeds 0.3% of the total count.

Bisaccate pollen grains occur more regularly in some Upper Cretaceous sections of the Rocky Mountain Area. Examples are the late Campanian Almond Formation in Wyoming (Stone, 1973) and the Crevasse Canyon Formation (Santonian) in New Mexico (Tschudy, 1976). Bisaccate gymnospermous pollen is found only rarely in the Upper

Cretaceous Mancos Shale (Upper Cenomanian-Campanian) in Colorado (Thompson, 1969; Gies, 1972).

Among the coniferous bisaccate pollen, Pinus is well-known to palynologists for having aerodynamic characteristics which give it the potential for wide distribution by wind. Such pollen grains may be over-represented in environments far from source populations as a result of long-distance transport, relatively small size, prolific production, relatively high durability factor and the ecological amplitude of their parent plants. An abundance of bisaccate pollen, therefore, does not necessarily indicate the presence of coniferous gymnosperms in the immediate vicinity of or proximity to the depositional site. Factors involved in over-representation of the pollen of various coniferous plants in various types of depositional sites, including offshore marine environments, have been discussed in many studies (Davis, 1963; Cross, Thompson, and Zaitzeff, 1966; Chaloner & Muir, 1968; Erdtman, 1969).

It should be emphasized that some conifers producing bisaccate pollen, such as fir (Abies) and some species of spruce (Picea), have generally more restricted habitats. Also, the large size of the pollen of these gymnosperms makes them less suitable for long-distance transport (Leopold, 1964; King, 1967; Cross & Taggart, 1982). In their study of pollen rain at different altitudes of Mt. Mitchell in Blue Ridge Mountains of North Carolina Taggart (Cross & Taggart, 1982) demonstrated a sharp decrease in the relative percentage of fir and spruce pollen in samples from the deciduous forest only 274 meters below the zone of montane conifer forests, despite the fact that these species are still common or occasional components

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of the deciduous forests at lower elevations. Fir and spruce pollen make up only 4% to 5% of the pollen spectrum at lower elevations in that area.

Considering the foregoing discussion, the scarcity or absence of the bisaccate pollen from the South Hospah assemblages indicates that the number of coastal plain, delta plain or swampland conifers producing this pollen type must have been extremely low in or near the depositional site. It also suggests that any upland conifers of this type must have been located at a considerable distance from the depositional site.

Other palynological evidence also supports the lowland habitat of the plants contributing to the palynoflora of this site. Members of taxodiaceous plants are represented in the South Hospah assemblages by Sequoiapollenites, Taxodiaceapollenites and Inaperturopollenites. Four living species of this family native to North America are Sequoia sempervirens (Coastal redwood), and Sequoiadendron giganteum (Giant sequoia or Sierra redwood), Taxodium distichum (bald cypress), Taxodium mucronatum, (Montezuma bald and cypress)(Elias, 1980).

The Coastal redwood grows along a narrow, moist, lowland belt in the Pacific coastal region of southwestern Oregon and central to northern California (Lawrence, 1951; Elias, 1980). Fossil leaves assignable to Sequoia were found in the study area (Cross, et al., in progress). Occasional papillate pollen grains found in the South Hospah samples may be assigned to this genus.

The Giant sequoia is an upland tree that grows at 1500-2500 m elevation in isolated groves scattered along the western slopes of

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the Sierra Nevada in central California (Elias, 1980). This genus has not been reported from Mesozoic (Taylor, 1981, p. 453).

Bald cypress is a deciduous conifer of low, wet areas, primarily of the coastal regions of the southeastern United States from Maryland to Florida, west to southern Texas, and the Mississippi embayment as far north as southern Illinois and Indiana (Elias, 1980).

Montezuma bald cypress occurs in low, wet, swampy areas of lower latitudes from Guatemala to the northeastern state of Coahuila, Mexico, and southern and southwestern Texas.

The family Nyssaceae (tupelo or gum tree family) is represented in the assemblages by the pollen genera Nyassapollenites and Margocolporites. Only one living genus (Nyssa) is native to the eastern North America. Nyssa aquatica (water tupelo or sour gum) follows almost the same pattern of distribution as bald cypress in the United States, but it only extends into the northeastern and northwestern edges of Florida. Nyssa ogeche (ogeche tupelo) is much more restricted in distribution and occupies the stream banks and river swamps of the Coastal Plain of southeastern South Carolina, Georgia, and northern Florida. Nyssa sylvatica (black gum or tupelo) is widely distributed throughout the eastern North America. Typical black tupelo (Nyssa sylvatica var. sylvatica) occurs in uplands and stream bottoms in cooler climates, but swamp tupelo (N. sylvatica var. biflora) is almost exclusively restricted to wet bottomlands, ponds, and swamps of the Coastal Plain (Elias, 1980, p. 708).

The members of the family Arecaceae (Palmae) are represented in the South Hoshpah samples by the pollen genus Monocolpopollenites.

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All nine modern genera of palms native to North America occur in lowland and coastal areas of Florida and the southern Coastal Plain except for the California washingtonia (Washingtonia filifera) which is native to the southwestern United States and grows at 150-1000 m elevation.

Some of the members of Taxodiaceae, Nyssaceae, and Arecaceae grow in upland areas as isolated stands or associated with other upland vegetation, but the association of their representatives in the South Hospah section suggests a lowland habitat.

The constituents of the South Hospah palynoflora represent a diversity of wet, tropical-subtropical vegetation in this area in Lower Campanian time. Modern representatives of the fern families Matoniaceae and Gleicheniaceae and also the cycads and palms are all restricted to tropical and subtropical zones, today (Lawrence, 1951). Paleoenvironmental studies suggest that the members of the extinct family Cheirolepidiaceae were also restricted to tropical and subtropical climatic zones (Srivastava, 1976; Upchurch & Doyle, 1981). Nevertheless, other paleontological studies on the Cretaceous, Foraminifera (Bergquist, 1971) and gastropods (Sohl, 1971) suggest a mild but not necessarily subtropical climatic regime in the study area. It seems that the maritime climate, moderated by the interior seaway, prevailing in the area for most part of the Upper Cretaceous provided a high level of equability in which a wide range of plant populations could flourish simultaneously.

Palynological data provide some indirect evidences for interpretation of dynamic energy of the depositional environments (Kuyl, Muller & Waterbolk, 1955; Muller, 1959; Cross, Thompson &

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Zaitzeff, 1966; Thompson, 1969). Some palynological evidence suggests that, for the most part, the South Hospah sediments were deposited in relatively low-energy environments. Members of the Zygnemataceae family of green algae are generally indicative of stagnant, shallow, and more or less mesotrophic fresh-water habitats (Van Geel, 1976, 1979; Van Geel & Van der Hammen, 1978, Pals et al., 1980; Rich et al., 1982). A number of megaspores and seeds have also been found at different levels of the section. The large size of these palynomorphs usually limits the transport of large members of them to sites close to the source plants. The megaspores probably were produced by heterosporous lycopods such as Selaginellaceae and Isoetaceae. The number of megaspores produced in the sporangia of these plants is, of course, much less than microspores. The presence of megaspores in a sample is thus normally an indication of proximity of the parent plant to the sample site, although short distance transport and occasional concentrations often occur locally as a result of water transport. Although the question of autochthonous vs. allochthonous accumulation of coal should be approached through direct examination of the coal beds and the underlying clay shales, the palynological information indirectly indicates in situ accumulation of the coal beds in the South Hospah area.

In summary, the palynological evidence suggests that the coal-bearing sediments of the South Hospah area were deposited in a low energy, fresh water environment under maritime warm-temperate climate of high equability; ecological conditions which can be approximated to those prevailing in the modern swamps of the southeastern United States (Figure 12).

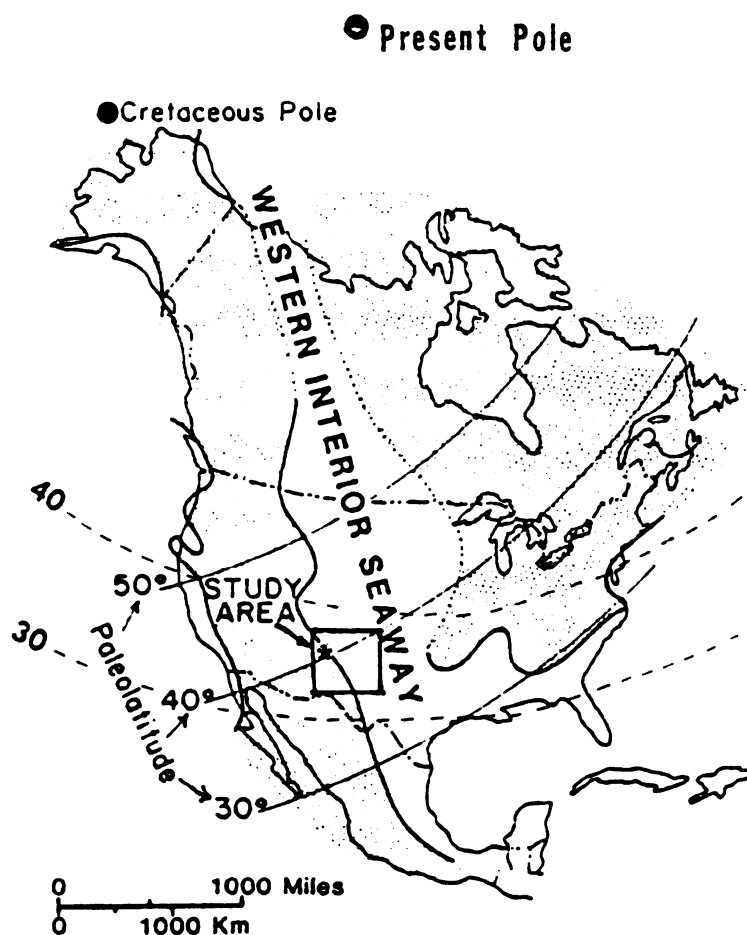


Figure 12: Postulated Paleogeographic Position of the South Hospah Area During the Late Cretaceous. (After Boyle & Scott, 1982, with some modification).

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Sedimentological and palynological characters of the strata above the "Blue" coal suggest that the deltaic plain swamp environments in which "Green" and "Blue" coals were deposited were subsequently occupied by the distal deposits of an alluvial plain regime. The supporting evidence for this interpretation are:

1. A general increase in the energy of the sedimentary environment is evident by introduction of fine to medium-sized sandstone deposits into the site where mainly coal and clay shale had been accumulating (Fig. 7). The presence of cross-bedding in sandstones also suggests a higher energy in the environment of deposition.

2. If the sandstone layers above the "Blue" coal were considered off-shore near-beach sand deposits, then marine microplankton should be expected in the thin, gray-shale interbeds (samples Pbl2413, 12484, and 12494, Fig. 7 are some examples). Examination of these interbeds and all other samples from the South Hospah section revealed no trace of marine phytoplankton.

3. Ferric iron oxide (hematite) has been locally accumulated in the white, cross-bedded sandstone above the "Blue" coal. Differential weathering has exposed these iron oxide-cemented concretions in form of elongated sausage-like promontories and ridges at the outcrops. The accumulation of hematite suggests a partially emergent, oxidizing environment.

4. General decrease in thickness and lateral continuity of coal beds which suggests a more limited environment for accumulation of peat between alluvial distributaries, and also more frequent

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interruptions in the process of peat accumulation.

5. At least partial erosion of the "Blue" coal deposits is evidenced by deposition of a clean, white sandstone immediately on top of this coal in section EC-50 with no trace of any clay or mud shale in between. The overlying sandstone in this section contains brecciated, sharply angular debris of gray or mottled shale which indicates distortion of the underlying shale bed and rapid deposition of the brecciated material in a very short distance from the source. This type of brecciation is also evident in another sandstone bed, ten feet above the "Blue" coal in the same section, and 23 feet above the "Blue" coal in section EC-150. Still another erosional contact is evident in section EC-100 on top of a thin layer of coal (unnamed) at the depth of 56 feet from the surface. This coal is overlain by 14 feet of white sandstone with a clearly defined abrupt lithologic change at the boundary. This situation is more likely to have occurred in a prograding delta in which the alluvial plain deposits scour and partially erode the underlying sediments as they accumulate on the scoured surface of the remaining deposits.

6. The marked contrast between the palynological assemblages in the "Blue/Green" coal complex and all other overlying coal beds in all sections indicates a change in the physical environments of deposition which affected the structure of the plant communities.

7. In a gray clay shale immediately above the "Blue Coal" in sections EC-150 and EC-100, the assemblage is characterized by a sudden increase in the relative frequency of Classopollis and ephedra-type pollen. This shift in the spectrum was noted in samples Pb12522 (core section EC-100, Fig. 7) and Pb12414 (core section

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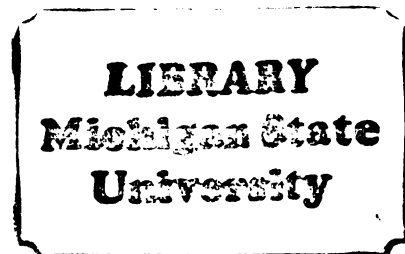
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EC-150, Fig. 7). The occurrence of ephedralean pollen in the above samples (5% and 2%, respectively) is especially notable. This pollen rarely occurs in the South Hospah samples, and usually at frequency of 1% or less.

Two other zones with high percentages of Classopollis were also found, both above the "Blue Coal", one in section EC-50 (Pb12494, Fig. 7), 14 feet above the coal, and the other in section EC-150 (Pb12384) which is a second peak of Classopollis in this section. This pollen represents extinct xeromorphic gymnospermous family Cheirolepidiaceae living in arid regions at low paleolatitudes, with fossil occurrences in sediments which show evidence of aridity (Hughes, 1973; Brenner, 1976; Upchurch and Doyle, 1981). Moreover, samples with more than 3% of cycadalean and araucarian pollen, and schizaeaceous spores (representatives of drier habitats) are located above the "Blue" coal. This implies that relatively drier conditions prevailed after the deposition of "Blue" coal.

This pattern is consistent with the general trend of migration of the prograding Menefee delta towards east and northeast. In other words, the evidence supports the notion that the deposition of sediments over the "Blue" coal was associated with further regression of the seashore from its previous position.

THESIS





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VI. GEOLOGIC AGE AND CORRELATION

In the following discussion, the South Hospah palynological assemblage is compared with other assemblages reported previously from Upper Cretaceous sections in the San Juan Basin and other localities in the Rocky Mountain area. The presence or absence of more advanced angiosperm pollen in a given assemblage forms the basis for this comparison.

The oldest Upper Cretaceous coal-bearing rock unit in most parts of the Rocky Mountain area is Dakota Sandstone (Figure 3). Palynological studies on this unit and its equivalent units in Minnesota (Pierce, 1961), Iowa (Hall, 1963), Oklahoma (Hedlund, 1966, 1968), Arizona (Agasie & Kremp, 1967; Agasie, 1969; Romans, 1972), Utah (May and Traverse, 1973), and Colorado (Panella, 1966) have established a Cenomanian age for the Dakota. No triporate pollen have been reported from Cenomanian strata of western United States. Although triporate forms appear as early as middle Cenomanian in the eastern United States, the first appearance in the San Juan Basin area is in the Coniacian (R. H. Tschudy, 1976a). The South Hospah section is thus definitely younger than the Dakota Sandstone and equivalent rock units in western United States.

Romans (1975) reported two Normapolles-type triporate pollen species from Toreva and Wepo Formations of the Black Mesa, Arizona. These are Plicapollis sarta Pflug and Triporopollenites scabroporus Newman¹. The geologic age of the Toreva and Wepo Formations in the Black Mesa section was estimated by R. H. Tschudy (1980) to be Turonian and Santonian, respectively. The stratigraphic position

¹ I consider this form to belong in the genus Vacuopollis.

of Wepo Formation, as interpreted by R. H. Tschudy, is below the Gibson Coal member of the Crevasse Canyon Formation. Romans did not report any Proteacidites, nor any other non-Normapolles triporate pollen from either the Toreva or the Wepo Formations. The absence of these taxa in the South Hospah coal indicates that it is younger than the Toreva or Wepo.

Tschudy (1976a) reported a high percentage of non-Normapolles triporate pollen grains (including Proteacidites) from the Gibson Coal in San Juan County, New Mexico, along with a number of Normapolles pollen (Complexiopollis, Plicapollis, Pseudoplicapollis, Trudopollis). Except for the genus Complexiopollis, he did not find any of these palynomorphs in the underlying Dilco Coal in the same locality. He mentioned that only one specimen of Proteacidites was found in the lower part of Gibson Coal. Pollen of this genus occurs with a relative frequency of one percent of the total angiosperm pollen in the uppermost part of the Gibson coal and is common in the overlying sample from the basal Menefee Formation. He did not find Complexiopollis in strata above the Gibson Coal. The available reports indicate that the Gibson Coal is the latest known occurrence of this genus in the strata of western North America (R. H. Tschudy, 1980, fig. 2).

Complexiopollis was not found in any of the South Hospah samples. Proteacidites and several other non-Normapolles triporate pollen grains are common, however, in the South Hospah samples. Orlansky (1971) reported Plicapollis¹, Pseudoplicapollis², Vacuopollis³, and Proteacidites from the Upper Cretaceous of Utah.

¹Orlansky's Sporopollis, pl. 10, figs. 31,32.

²Orlansky's Cupanieidites, pl. 10, fig. 37.

³Orlansky's Tricolporites, pl. 10, figs. 34,35.

Tschudy (1980) estimated the stratigraphic position of this section to be above the Gibson Coal and below the basal Menefee.

Thompson (1969) reported some Normapolles pollen from the Upper Mancos Shale in southwest Colorado. The genera Vacuopollis¹, Pseudoplicapollis², Labrapollis (Thompson's pl. 19, fig. 6), Plicapollis³, and the genus Proteacidites which were reported by Thompson, are all present in the South Hospah samples, as well. The identity of the form genus illustrated by Thompson (pl. 19, fig. 29) as ?Extratriporepollenites is questionable. He did not report any Aquilapollenites from these sediments. The non-Normapolles grains which supposedly belong to such modern plant taxa as Juglandaceae, Betulaceae, Casuarinaceae, and Myricaceae are virtually absent from Thompson's samples, but have been reported from the stratigraphically higher levels of Mancos Shale by Gies (1972) in Campanian-Maestrichtian strata from northwestern Colorado. Representatives of these four modern families are common and morphologically diverse in the South Hospah samples. Palynological evidence indicates that the South Hospah sediments are younger than the Mancos Shale section studied by Thompson (1969).

¹Thompson's Triporepollenites cf. T. scabroporus, pl. 18, figs. 26, 28, non-fig. 27, and Conclavipollis cf. C. wolfcreekensis, pl. 19, fig. 5.

²Thompson's ?Plicapollis silicatus, pl. 19, fig. 3, and Triporepollenites cf. T. tectus, pl. 19, fig. 8.

³Thompson's Sporopollis cf. S. laqueaeformis, pl. 19, fig. 7.

May (1972) illustrated the successive appearance of pollen of more recent angiosperms towards the higher stratigraphic levels of Upper Cretaceous coals from Utah. The occurrence of a polyporate pollen form identified by May as Liquidambar sp. (May, 1972, pl. 23, figs. 10, 11) from the Blackhawk Formation indicates that this rock unit is probably younger than the South Hospah Coal. Comparison of the palynomorph assemblages suggests that the South Hospah coal is older than the Blackhawk Formation and younger than Emery Sandstone. The relative stratigraphic position of Emery Sandstone was interpreted by Tschudy (1980) to be lower Campanian.

Aquilapollenites is absent from the South Hospah samples and it was not observed by May (1972) in the rocks below the Price River Formation. This form first appeared in Turonian and flourished principally in Siberia, the Far East, northeastern China, and western North America throughout the remainder of Late Cretaceous time (Srivastava, 1981, p. 155). The stratigraphic range of this form in the Southern Rocky Mountain area is apparently shorter than its total range elsewhere.

Aquilapollenites was not reported from any rocks interpreted as Santonian by Tschudy (1980), nor has it been reported from any rock formations dated Santonian in the southern Rocky Mountain area. Species of this genus have been reported from Judith River Formation in north-central Montana by B. Tschudy (1973), and from the Mesaverde Group in Colorado by Martinez (1983?). The two formations are considered by R. Tschudy (1980) to be older than Price River Formation but younger than Blackhawk Formation. The absence of this genus from the rocks older than Mesaverde Group may indicate that the

actual time of appearance of this genus in the Rocky Mountain area is the early, but not the earliest, Campanian.

Aquilapollenites has been reported consistently from the younger strata in several localities of the Rockies. In San Juan Basin, R. Tschudy (1973) reported this genus from the Lewis Shale, Pictured Cliffs Sandstone and Fruitland Formation in Rio Arriba County, New Mexico. He assigned an Upper Campanian age (Didymoceras stvensoni to Baculites jenseni zones) for the entire section. Delfel

(1979) reported Aquilapollenites from the La Ventana Sandstone (a sedimentary "tongue" of the regressive Cliff House Sandstone) in the vicinity of La Ventana, Sandoval County, New Mexico. She assigned a Maestrichtian age to this unit "...based on the well-established presence of 12 indisputably Maestrichtian species, along with the relatively high percentage of triporate pollen...". She summarized the 12 species in her Table III, page 31. This age determination does not seem to be conclusive and should await further investigation. None of the exclusively Upper Campanian and Maestrichtian pollen taxa previously reported from New Mexico (Anderson, 1960; Tschudy, 1973), Colorado (Tschudy, 1973; Clarke, 1969), Wyoming (Stone, 1972; Leffingwell, 1970), South Dakota (Stanley, 1965), and California (Drugg, 1967; Chmura, 1973) are present in the La Ventana assemblage studied by Delfel (1979). The significant taxa, which are not present in her study, include Erdtmanipollis, Cranwellia, Alnipollenites, Ulmipollenites, Periporopollenites, Thomsonipollis, Kurtzipites, Ilexpollenites, Pulcheripollenites, and Wodehousia. Also, it should be noted that Aquilapollenites spp., Proteacidites thalmanii, and P. retusus are

not restricted to Maestrichtian as she has indicated. It is my opinion that the age of La Ventana cannot be younger than the early Campanian based on the palynomorphs presented by Delfel (1979). The above-mentioned palynomorphs (except Proteacidites, which extends down to Santonian in range) are also absent from the South Hospah samples. The presence of Aquilapollenites in the La Ventana Sandstone indicates that it is younger in age than the South Hospah coal.

Newman (1972) extended the range of Aquilapollenites as low as the Upper Santonian in Montana. The same range was tentatively suggested by Jarzen & Norris (1975) for the Western Canadian Interior. This may suggest that Aquilapollenites probably appeared in the northern latitudes earlier than in the southern latitudes. Except for some unusual occurrences of this genus in India (Baksi and Deb, 1976) and Senegal (Jardine and Magloire, 1965), the Aquilapollenites province was generally to the north of Normapolles province (Srivastava, 1981, p. 165, fig. 5), and their occurrence in the lower latitudes beyond the provincial boundary seems to indicate southward migration along the Mesocordilleran land mass.

In summary, the overall palynological composition of the South Hospah samples strongly suggest that the stratigraphic position of this section is above the Gibson Coal Member of Crevasse Canyon Formation (see Figure 3). In other words, the palynological evidence supports the assignment of these strata to the Menefee Formation. Core drilling information indicates that the coal-bearing strata in the South Hospah lease area overlie a sandstone which has been called Point Lookout Sandstone by the geologists of Chaco Energy Company.

The palynological information confirms this assignment. This also indicates that only the lower coal-bearing member (Cleary Coal Member) of the Menefee Formation is involved in the lease area and in this study. The South Hospah deposits are probably younger than the "basal Menefee" coal bed west of Farmington, San Juan Basin, which was studied by Tschudy (1976) and dated as Santonian. A lower Campanian age is suggested for the South Hospah section based on this palynologic study.

The South Hospah coal seams can be locally correlated by palynological zonation. The Gleicheniidites assemblage zone is distinguished by high relative frequency of both gleicheniaceus spores and non-Normapolles triporate pollen. It corresponds to the palynoflora type "B" established by cluster analysis. The "Blue/Green" coal complex can be correlated in all sections by this assemblage zone. The top of the "Blue" coal can be clearly depicted in sections EC-100 and EC-150. Immediately above the "Blue" coal in these two sections, lies a gray shale (samples Pb12522 and Pb12414, respectively, Fig. 7) with a contrasting high percentage of Classopollis/ Exesipollenites complex and ephedralean pollen. The relative frequency of the former pollen group does not exceed 6% in any other sample, but it appears as 11% and 23%, respectively in those two samples in cores EC100 and EC150, at this level.

Palynological analysis indicates that "Beige" and "Bronze" coals are comparable and probably correlative. They both contain type "D" pollen flora. Moreover, sample Pb12516 from the "Bronze" coal in section EC-100 and sample Pb13241 from the "Beige" coal in section EC-150 are closely associated in having comparable percentages of tricolporate and tricolpate pollen, and bryophytic and fungal spores.

Similarly, sample Pbl2515 from a gray shale within the "Bronze" coal in section EC-100 (Fig. 7) and sample Pbl2386 from a gray shale four inches above the "Beige" coal in section EC-150 (Fig. 7) closely correlate by having exceptionally high percentage of Araucariacites. The relative percentage of this pollen grain does not exceed 4% in any other sample, but it is 8% in Pbl2386 and 15% in Pbl2515. The ratio of the Inaperturopollenites/Taxodiaceapollenites complex, triporate and tricolporate pollen, and polypodiaceous and algal spores is also comparable in these two samples. Sample Pbl2460 from the "Beige" coal in section EC-75 and Pbl2387 from the "Beige" coal in section EC-150 (Fig. 7) are comparable in having a high percentage of bryophytic spores and triporate pollen.

Figure 13: Known Range of Some Upper Cretaceous Pollen Grains
in the Rocky Mountains of the United States.
(Stratigraphic position of rock units after R. H.
Tschudy, 1980, with some modification; estimated
ages from Berggren, et al., 1975).

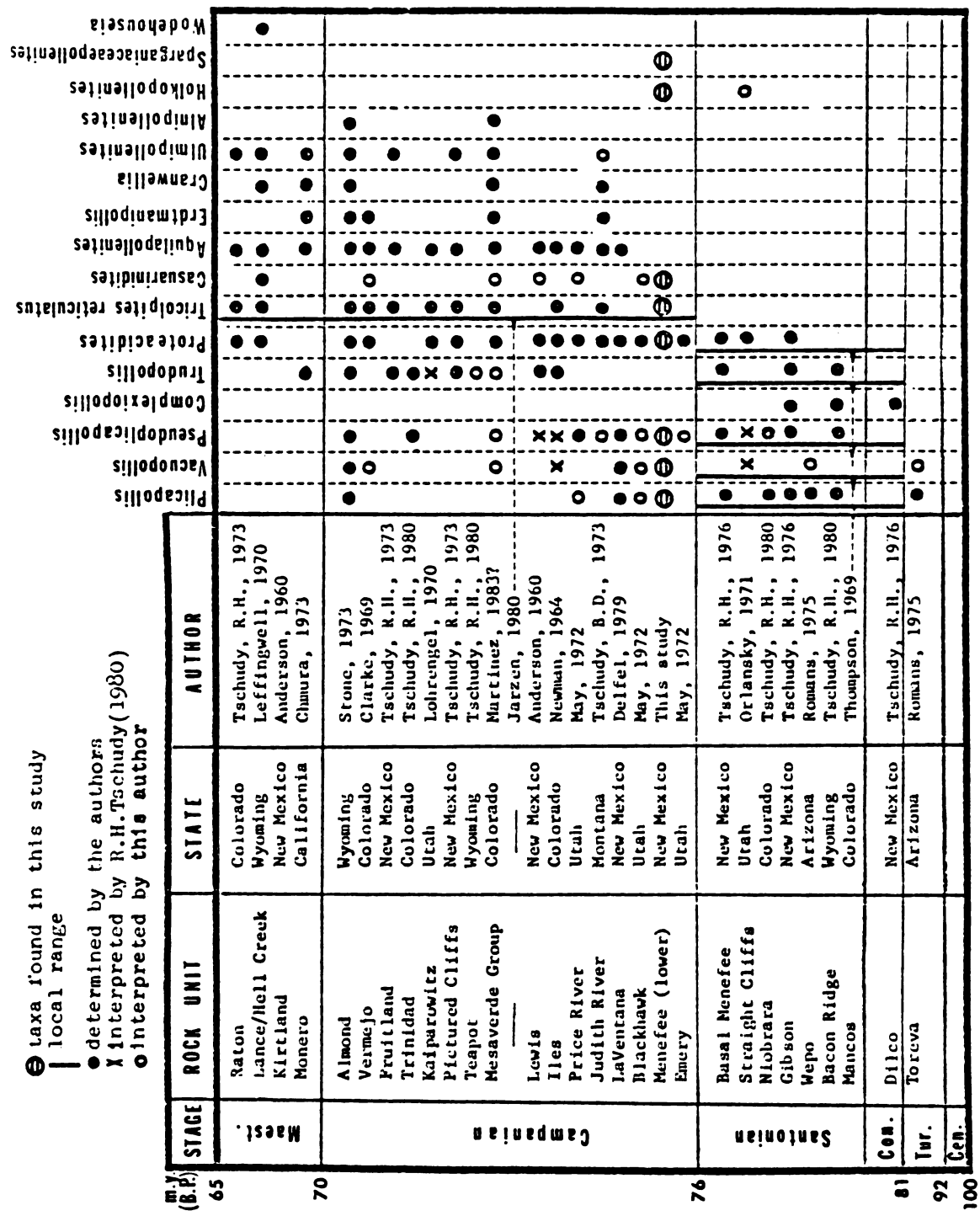


Figure 13

VII. CONCLUSIONS

One of the major contributions of this study is the identification and illustration of 263 palynomorph taxa from the South Hospah coal-bearing rocks. Four new genera, six new species, eight new combinations, one new rank, and one emended genus are tentatively designated. Taxonomic treatment of palynomorphs is desirable for scientific analysis, but accurate differentiation, identification and careful assignment of these forms to appropriate taxonomic categories is crucial for developing a reliable and meaningful information base. This report adds to the knowledge of the Upper Cretaceous palynology, paleobotany, and biostratigraphy of the western North America.

The new statistical technique used in this analysis proved to be useful in differentiating major palynomorph communities which, in turn, reflect different local environments of the lowland, freshwater marsh-swamp complex in which the South Hospah coals were deposited. The advantage of the "similarity index" proposed in this study over the other conventional indices is that the relative percentage of each element is taken into consideration as well as its presence or absence in different samples. This "weighted" index seems to provide a stronger statistic for the purpose of paleoenvironmental analysis. Accurate identification of palynomorphs and carefully designed counts are essential in obtaining useful clusters. Reducing the number of elements in each sample by lumping the counted entities into major taxonomic groups would eliminate undesirable dispersion of elements into numerous small clusters. The best results are obtained by

pre-designating groups which have presumed ecological and/or environmental significance. Various arrangements and combinations of taxa can be tested with the aid of digital computers in order to visualize different patterns of clustering. The dendrograms plotted by computer can then be analysed for paleoenvironmental interpretations.

This similarity index combined with cluster analysis seem to be useful in biostratigraphic correlation, as well. Assemblage zones could be established by using this technique because samples with comparable frequency of taxa would apparently tend to unite into the same cluster.

A useful extension of the present study would involve coal petrographic analysis (either transmitted-light-study of thin sections, or reflected-light-study of polished blocks) in order to correlate the palynological data with the lithological and mineralogical characters of the coal.

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APPENDIX

Appendix A

Systematic list of the South Hospah palynomorphs
 Dicotyledonous pollen grains have been artificially
 grouped into morphological categories.

TAXA	PLATE	FIGURE
Division Eumycophyta (True Fungi)		
Fungal Spore Type A	1	1
Fungal Spore Type B	1	2-4
Fungal Spore Type C-1	1	5
Fungal Spore Type C-2	1	6
Fungal Spore Type D-1	1	7
Fungal Spore Type D-2	1	8
Fungal Spore Type D-3	1	9-10
Fungal Spore Type D-4	1	11-14
Fungal Spore Type D-5	1	15
Fungal Spore Type D-6	1	16
Fungal Spore Type E-1	1	17
Fungal Spore Type E-2	1	18,19
Fungal Spore Type F	1	20
Fungal Spore Type G	1	21
Fungal Spore Type H-1	1	22-23
Fungal Spore Type H-2	1	24-25
Fungal Spore Type H-3	1	26
Fungal Spore Type H-4	1	27
Fungal Spore Type I	1	28-31
Fungal Spore Type J	2	1-13
Fungal Spore Type K	2	14
Fungal Spore Type L	2	15
Fungal Spore Type M	2	16
Fungal Spore Type N	2,3	17,1,2
Fungal Spore Type O	3	3
Fungal Spore Type P	3	4
Division Chlorophyta (Green Algae)		
Genus <u>Ovoidites</u>		
<u>O. ligneolus</u>	3	5,6
Genus <u>Palambages</u>		
<u>P. sp. 1</u>	3	7
<u>P. sp. 2</u>	3	8
Genus <u>Schizosporis</u>		
<u>S. cooksoni</u>	3	9,10
<u>S. parvus</u>	4	3,4
<u>S. scabratus</u>	4	5-8
<u>S. sp.</u>	4	1,2
Algal Spore? Type A	4	9-11
Algal Spore? Type B	4	12
Division Bryophyta		
Class Musci (Mosses)		
Family Sphagnaceae		
Genus <u>Stereisporites</u>		
<u>S. sp. 1</u>	5	1
<u>S. sp. 2</u>	5	2-7
<u>S. sp. 3</u>	5	8

Appendix A (cont.)

TAXA	PLATE	FIGURE
Genus <u>Cingutrilletes</u>		
<u>C. congruens</u>	5	9
<u>C. sp.</u>	5	10,11
Genus <u>Distverrusporis</u>		
<u>D. antiquasporites</u>	5	12,13
<u>D. clavus</u>	5	14,15
<u>D. sp.</u>	5	16
Genus <u>Tripunctisporis</u>		
<u>T. sp. 1</u>	5	17,18
<u>T. sp. 2</u>	5	19
Genus <u>Distancorisporis</u>		
<u>D. dakotaensis</u>	5	20,21
<u>D. sp. 1</u>	6	1,2
<u>D. sp. 2</u>	6	3
<u>D. sp. 3</u>	6	4
<u>D. sp. 4</u>	6	5
Class Hepaticae (Liverworts)		
Genus <u>Aequitriradites</u>		
<u>A. ornatus</u>	6	6
<u>A. spinulosus</u>	6	7
Genus <u>Triporoletes</u>		
<u>T. novomexicanus</u>	6	8-10
Division Lycophyta		
Family Lycopodiaceae		
Genus <u>Camarozonosporites</u>		
<u>C. hammenii</u>	6	11-14
<u>C. imberbis</u>	6	15-17
Genus <u>Ceratosporites</u>		
<u>C. sp.</u>	7	1
Genus <u>Echinatisporis</u>		
<u>E. varispinosus</u>	7	2,3
Genus <u>Hamulatisporites</u>		
<u>H. rugulatus</u>	7	4
Genus <u>Minerisporites</u>		
<u>M. mirabilis</u>	7	5
Genus <u>Neoraistrickia</u>		
<u>N. sp. cf N. speciosa</u>	7	6-7
Genus <u>Peromonolites</u>		
<u>P. sp.</u>	7	8-9
Genus <u>Perotrilites</u>		
<u>P. sp. 1</u>	7	10-11
<u>P. sp. 2</u>	7	12-13
Genus <u>Sestrosporites</u>		
<u>S. pseudoalveolatus</u>	7	14
Genus <u>Velosporites</u>		
<u>V. triquetrus</u> (Lantz) Dettmann 1963	7	15

Appendix A (cont.)

TAXA	PLATE	FIGURE
Division Pterophyta (Ferns)		
Order Filicales		
Family Osmundaceae		
Genus <u>Baculatisporites</u>		
<u>B. sp.</u>	8	1
Genus <u>Osmundacidites</u>		
<u>O. sp.</u>	8	2
Genus <u>Todisporites</u>		
<u>T. major</u>	8	3
<u>T. minor</u>	8	4,5
Family Schizaeaceae		
Genus <u>Appendicisporites</u>		
<u>A. cristatus</u>	8	6-10
<u>A. cf A. pschekhaensis</u>	9	1
<u>A. stellantis</u>	9	3
<u>A. tricornitatus</u>	9	2
Genus <u>Chomotriletes</u>		
<u>C. fragilis</u>	9	4,5
Genus <u>Cicatricosisporites</u>		
<u>C. australiensis</u>	9	6
<u>C. cuneiformis</u>	9	7
<u>C. hallei</u>	9	8-11
Genus <u>Microfoveolatosporis</u>		
<u>M. foveolatus</u>	10	1,2
Genus <u>Microreticulatisporites</u>		
<u>M. uniformis</u>	10	3
Genus <u>Soccorosporites</u>		
<u>S. reticulatus</u>	10	4,5
Family Gleicheniaceae		
Genus <u>Deltoidospora</u>		
<u>D. Hallii</u>	10	6
Genus <u>Gleicheniidites</u>		
<u>G. senonicus</u>	10	7,8
Genus <u>Ornamentifera</u>		
<u>O. tuberculata</u>	10	9
<u>O. sp.</u>	10	10
Family Matoniaceae		
Genus <u>Biretisporites</u>		
<u>B. sp. 1</u>	10	11
<u>B. sp. 2</u>	10	12,13
<u>B. sp. 3</u>	10	14,15
<u>B. sp. 4</u>	11	1
Genus <u>Matonisporites</u>		
<u>M. sp. 1</u>	11	2
<u>M. sp. 2</u>	11	3
Family Cheiroleuriaceae		
Genus <u>Dictyophyllidites</u>		
<u>D. harrissii</u>	11	4
Family Polypodiaceae		
Genus <u>Laevigatosporites</u>		

Appendix A (cont.)

TAXA	PLATE	FIGURE
<u>L. haardtii</u>	11	5,6
<u>L. ovatus</u>	11	7
<u>L. pseudodiscordatus</u>	11	8,9
<u>L. sp.</u>	11	10
Genus <u>Polypodiidites</u>		
<u>P. prosecundus</u>	11	11-13
<u>P. sp. 1</u>	11	14,15
<u>P. sp. 2</u>	12	1
Genus <u>Polypodiisporonites</u>		
<u>P. sp. 1</u>	12	2-4
<u>P. sp. 2</u>	12	5
Family Cyatheaceae - Dicksoniaceae		
Genus <u>Cyathidites</u>		
<u>C. australis</u>	12	6
<u>C. minor</u>	12	7
Genus <u>Kuylisporites</u>		
<u>K. scutatus</u>	12	8,9
<u>K. sp.</u>	12	10
Division Pterophyta		
Incertae Sedis (Microspores)		
Genus <u>Cardioangulina</u>		
<u>C. sp. 1</u>	12	11
<u>C. sp. 2</u>	12	12
Genus <u>Cirratriradites</u>		
<u>C. teter</u>	12	13
Genus <u>Concavissimisporites</u>		
<u>C. sp.</u>	12	14
Genus <u>Concavisporites</u>		
<u>C. sp.</u>	12	15
Genus <u>Foraminisporis</u>		
<u>F. sp.</u>	13	1
Genus <u>Foveosporites</u>		
<u>F. sp. 1</u>	13	2,3
<u>F. sp. 2</u>	13	4
Genus <u>Granulatisporites</u>		
<u>G. granulatus</u>	13	5
Genus <u>Quadripollis</u>		
<u>Q. sp.</u>	13	6-9
Genus <u>Toroisporis</u>		
<u>T. delicatus</u>	13	10
<u>T. longitorus</u>	13	11-13
Genus <u>Undulatisporites</u>		
<u>U. sinuosis</u>	14	1,2
<u>U. sp. 1</u>	14	3
<u>U. sp. 2</u>	14	4
Genus <u>Verrucatosporites</u>		
<u>V. pseudoreticulatus</u>	14	5
Genus <u>Verrucosisporites</u>		
<u>V. sp. 1</u>	14	6-8

Appendix A (cont.)

TAXA	PLATE	FIGURE
<u>V. sp. 2</u>	14	9,10
<u>V. sp. 3</u>	14	11
Unidentified spore A.	14	12-15
Unidentified Spore B	14	16,17
Unidentified Spore C	14	18
Unidentified Spore D Type 1	15	1-4
Unidentified Spore D Type 2	15	5
Division Pterophyta		
<u>Incertae sedis (megaspores)</u>		
Genus <u>Balmeisporites</u>		
<u>B. glenelgensis</u>	15	6,7
<u>B. rigidus</u>	15	8-11
Genus <u>Dictyothythakos</u>		
<u>D. sp.</u>	15	12-14
Genus <u>Echitriletes</u>		
<u>E. sp.</u>	16	1
Genus <u>Paxillitriletes</u>		
<u>P. fairlightensis</u>	16	2
Unidentified Megaspore A	16	3,4
Unidentified Megaspore B	16	5-7
Division Cycadophyta-Ginkgophyta		
Genus <u>Cycadopites</u>		
<u>C. sp. 1</u>	17	1
<u>C. sp. 2</u>	17	2
<u>C. sp. 3</u>	17	3
<u>C. sp. 4</u>	17	4
Order Bennettitales		
Genus <u>Exesipollenites</u>		
<u>E. tumulus</u>	17	5
Genus <u>Spheripollenites</u>		
<u>S. classopollinoides</u>	17	6
<u>S. scabratus</u>	17	7
Division Coniferophyta		
Family Cheirolepidiaceae		
Genus <u>Classopollis</u>		
<u>C. Classoides</u>	17	8,9
<u>C. martinottii</u>	17	10-12
<u>C. cf. Circulina parva</u>	17	13
Family Taxodiaceae-Cupressaceae		
Genus <u>Inaperturopollenites</u>		
<u>I. dubius</u>	17	14
<u>I. minor</u>	17	15-17
<u>I. tenuis</u>	17	18-20
<u>I. sp.</u>	17	21
Genus <u>Sequoiapollenites</u>		
<u>S. spp.</u>	17	22-24
Genus <u>Taxodiaceapollenites</u>		

Appendix A (cont.)

TAXA	PLATE	FIGURE
<u>T. hiatus</u>	17	25
Family <u>Araucariaceae</u>		
Genus <u>Araucariacites</u>		
<u>A. atlanticus</u>	17	26
<u>A. australis</u>	17	27
<u>A. limbatus</u>	18	1-3
<u>A. sp.</u>	18	4
Genus <u>Inaperturotetradites</u>		
<u>I. sp.</u>	18	5-7
Family <u>Pinaceae</u>		
Genus <u>Alisporites</u>		
<u>A. sp.</u>	18	8
Genus <u>Zonalapollenites</u>		
<u>Z. sp.</u>	18	9,10
Family <u>Podocarpaceae</u>		
Genus <u>Parvisaccites</u>		
<u>P. radiatus</u>	18	11,12
Genus <u>Phyllocladidites</u>		
<u>P. inchoatus</u>	19	1
Genus <u>Rugubivesiculites</u>		
<u>R. rugosus</u>	19	2
Division <u>Gnetophyta</u>		
Order <u>Ephedrales</u>		
Family <u>Ephedraceae</u>		
Genus <u>Equisetosporites</u>		
<u>E. jansonii</u>	19	3,4
<u>E. menakae</u>	19	5
<u>E. rousei</u>	19	6,7
<u>E. sp.</u>	19	8
Genus <u>Steevesipollenites</u>		
<u>S. cf S. binodosus</u>	19	9
Gymnospermae - <u>Incertae sedis</u>		
Genus <u>Callialasporites</u>		
<u>C. dampieri</u>	19	10-13
Genus <u>Eucommiidites</u>		
<u>E. crossii</u>	20	1-10
<u>E. hughesii</u>	20	11-15
<u>E. troedsonii</u>	20	16-20
Genus <u>Perinopollenites</u>		
<u>P. sp.</u>	20	21,22
Genus <u>Spermatites</u> (seed)		
<u>S. ellipticus</u>	20,21	23,24,1,2
<u>S. elongatus</u>	21	3
<u>S. sp. 1</u>	21	4
<u>S. sp. 2</u>	21	5
Division <u>Magnoliophyta</u> (angiosperms)		
Class <u>Liliopsida</u> (monocots)		
Genus <u>Clavatipollenites</u>		
<u>C. minutus</u>	22	1,2

Appendix A (cont.)

TAXA	PLATE	FIGURE
Genus <u>Liliacidites</u>		
<u>L. intermedius</u>	22	3-5
<u>L. sp. 1</u>	22	6
<u>L. sp. 2</u>	22	7,8
<u>L. sp. 3</u>	22	9
<u>L. sp. 4</u>	22	10
<u>L. sp. 5</u>	22	11
<u>L. sp. 6</u>	22	12-15
Genus <u>Monocolpopollenites</u>		
<u>M. reticulatus</u>	22	16-23
<u>M. cf. M. texensis</u>	22	24
<u>M. sp.</u>	22	25,26
Genus <u>Retimonocolpites</u>		
<u>R. sp. 1</u>	22	27-30
<u>R. sp. 2</u>	23	1
Genus <u>Sparganiaceapollenites</u>		
<u>S. hospahensis</u>	23	2-4
Class Magnoliopsida (dicots)		
Tricolpate pollen grains		
Genus <u>Cupuliferoidapollenites</u>		
<u>C. parvulus</u>	23	5
<u>C. sanjuanensis</u>	23	6-15
Genus <u>Fraxinoipollenites</u>		
<u>F. variabilis</u>	23	16-18
Genus <u>Rousea</u>		
<u>R. georgensis</u>	23	19,20
<u>R. sp.</u>	23	21,23
Genus <u>Striatopollis</u>		
<u>S. paraneus</u>	23	24
Genus <u>Tricolpites</u>		
<u>T. aoristus</u>	23	25,26
<u>T. confossipollis</u>	23	27,28
<u>T. crassimurus</u>	23	29-31
<u>T. hians</u>	23	32-36
<u>T. minutus</u>	24	1-5
<u>T. mutabilis</u>	24	6-10
<u>T. reticulatus</u>	24	11,12
<u>T. vulgaris</u>	24	13,14
<u>T. sp. 1</u>	24	15
<u>T. sp. 2</u>	24	16-18
<u>T. sp. 3</u>	24	19
<u>T. sp. 4</u>	24	20,21
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<u>T. sp. 6</u>	24	23-25
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tricolpate pollen grains		
Genus <u>Utriculites</u>		
<u>U. visus</u>	24	28,29
Tricolporate pollen grains		
Genus <u>Holkopollenites</u>		
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<u>M. lihokus</u>	25	7
<u>M. sp. 1</u>	25	8-11
<u>M. sp. 2</u>	25	12, 13
Genus <u>Nyssapollenites</u>		
<u>N. albertensis</u>	25	14-16
<u>N. sp. 1</u>	25	17-19
<u>N. sp. 2</u>	25	20, 21
Genus <u>Perinotricolporites</u>		
<u>P. delicatus</u>	25	22-27
Genus <u>Rhoipites</u>		
<u>R. globosus</u>	25	28-30
<u>R. sp.</u>	25	31-36
Genus <u>Ranunculacidites</u>		
<u>R. sp.</u>	26	1, 2
Tricolporate pollen Forma A	26	3-6
Tricolporate pollen Forma B	26	7-11
Tricolporate pollen Forma C	26	12, 13
Triporate pollen grains		
Genus <u>Casuarinidites</u>		
<u>C. granilabratus</u>	26	14-20
<u>C. microgranulatus</u>	26	21-27
<u>C. sp.</u>	26	28, 29
Genus <u>Labrapollis</u>		
<u>L. sp. 1</u>	26	30-32
<u>L. sp. 2</u>	26	33
Genus <u>Momipites</u>		
<u>M. wyomingensis</u>	26	34, 35
Genus <u>Plicapollis</u>		
<u>?P. rusticus</u>	26	36-38
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<u>P. spp.</u>	27	1-6
Genus <u>Proteacidites</u>		
<u>P. retusus</u>	27	7-9
<u>P. thalmanni</u>	27	10
<u>P. sp. 1</u>	27	11
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Genus <u>Pseudoplicapollis</u>		
<u>P. cuneata</u>	27	13-20
<u>P. newmanii</u>	27	21-23
Genus <u>Pseudovacuopollis</u>		
<u>P. involutus</u>	27	24-25
Genus <u>Triatriopollenites</u>		
<u>T. globosus</u>	27	26-32
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<u>P. sp. 1</u>	28	8
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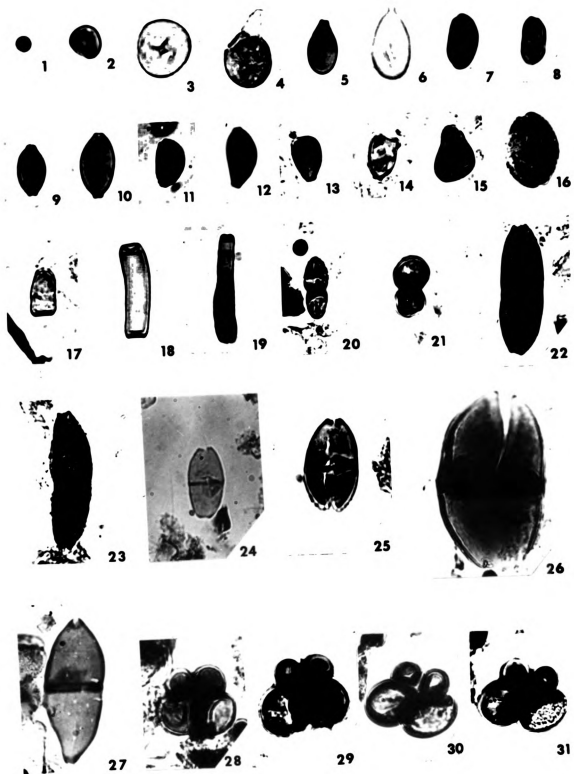


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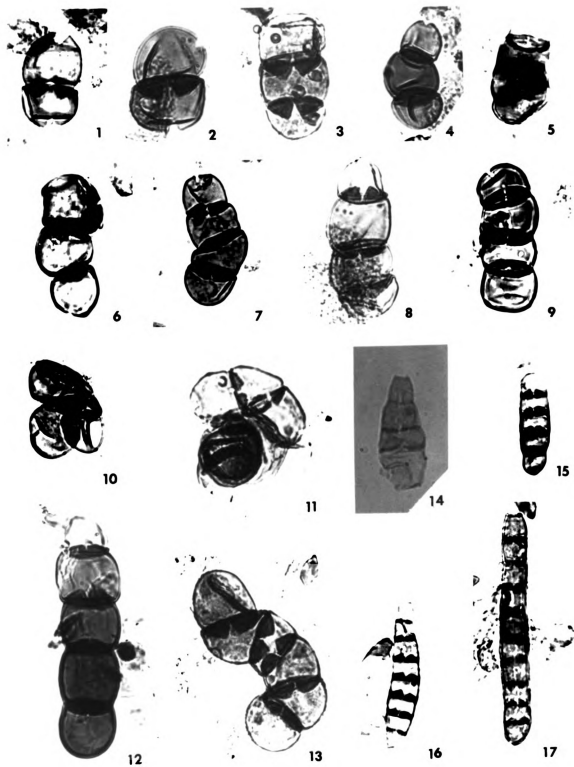


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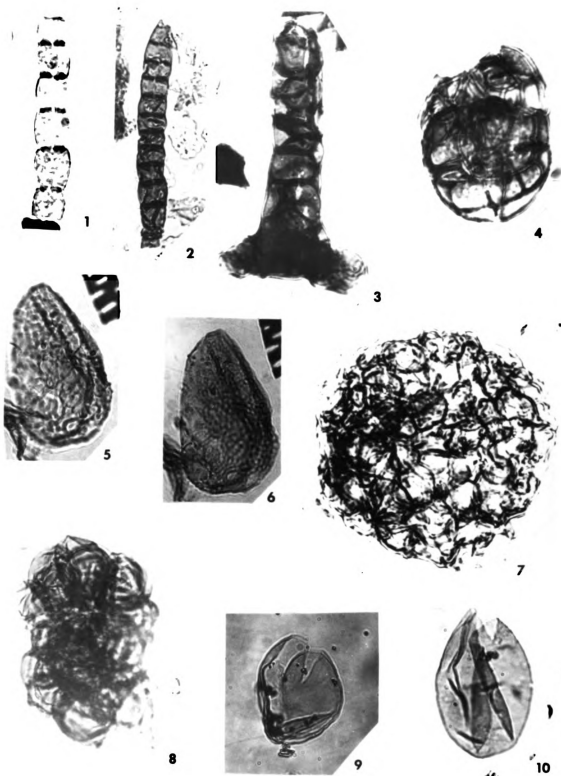


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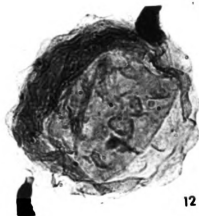
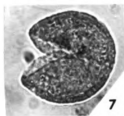
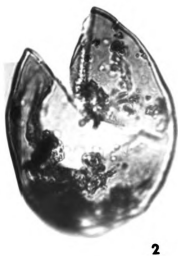
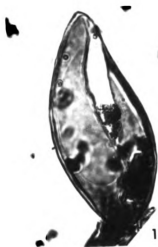


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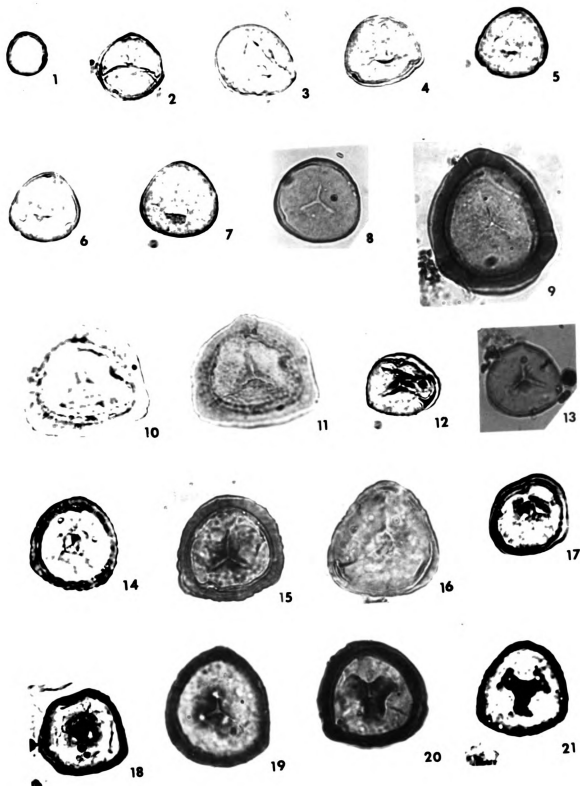


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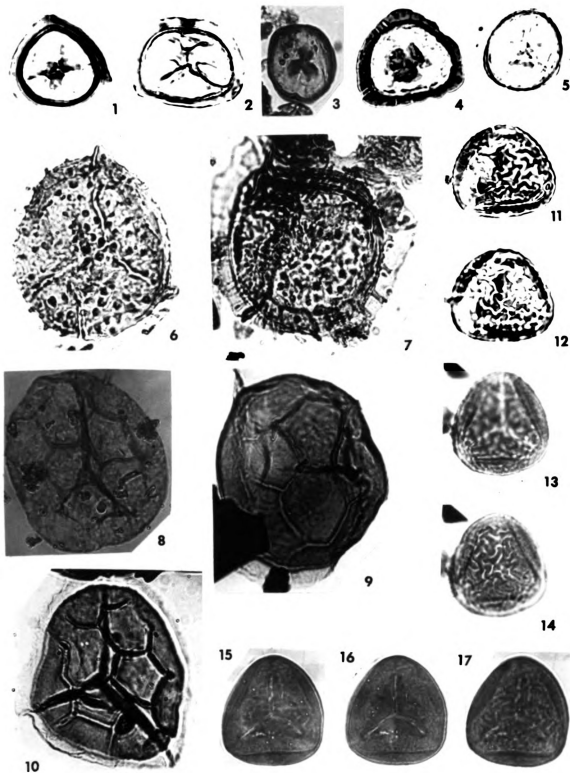


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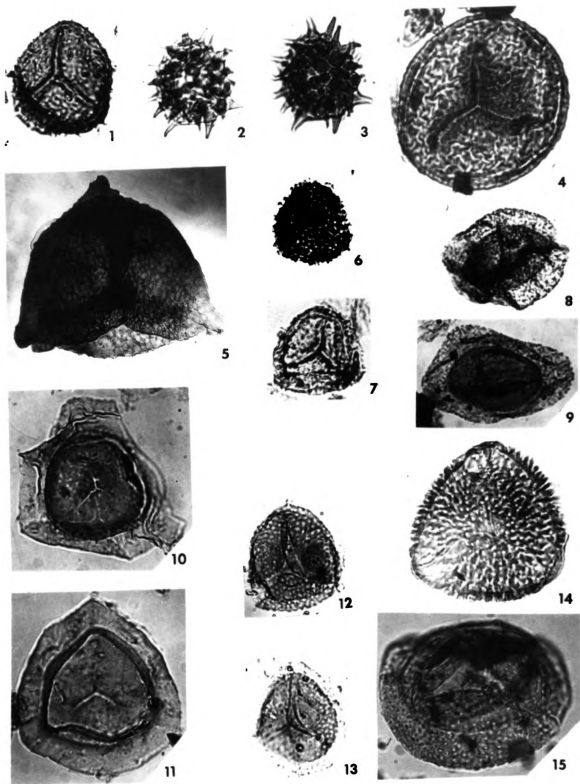
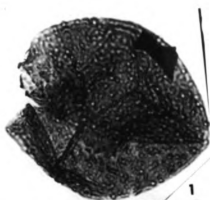


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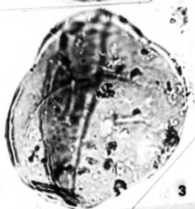
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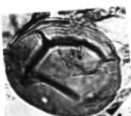
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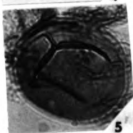
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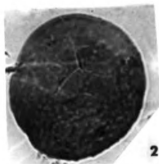
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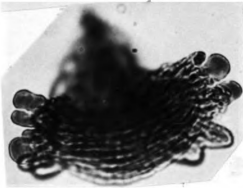
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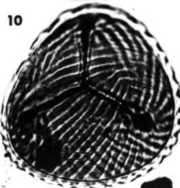
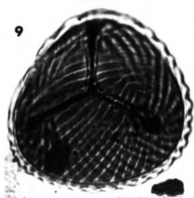
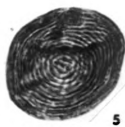
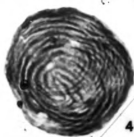
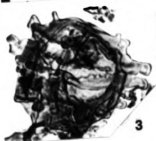


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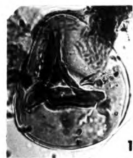
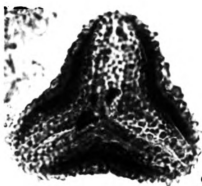
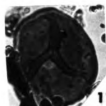
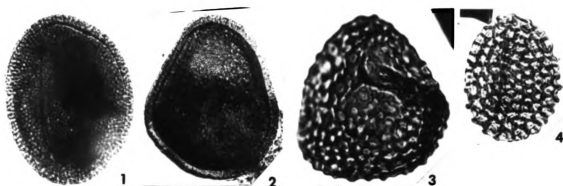


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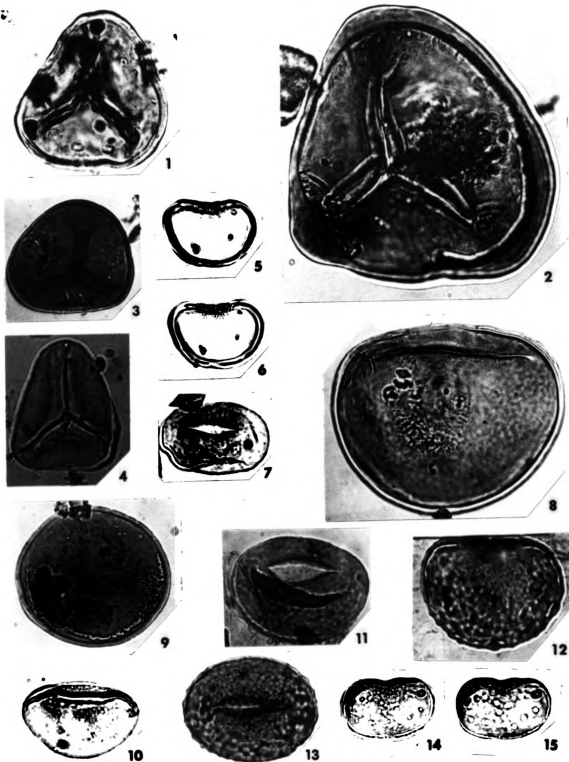


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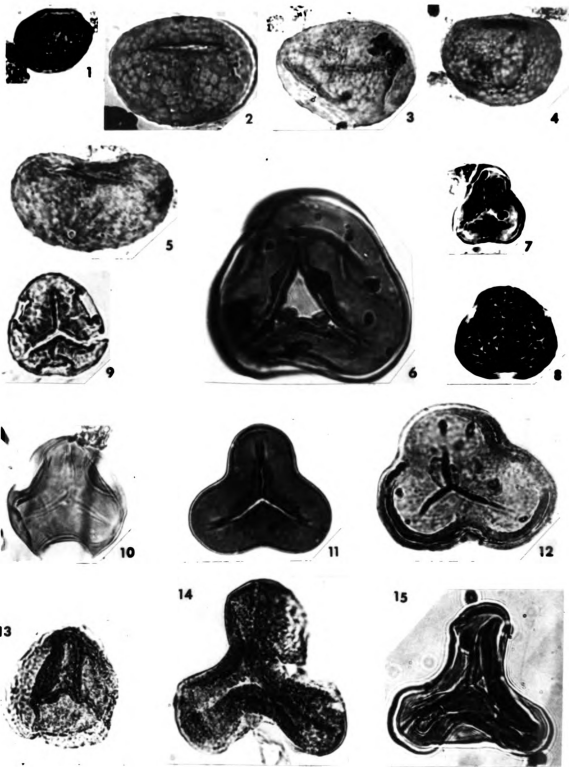


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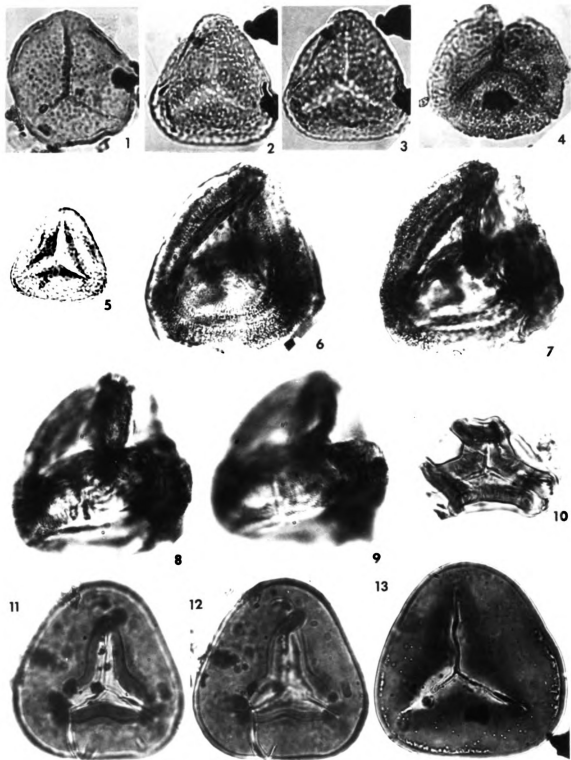


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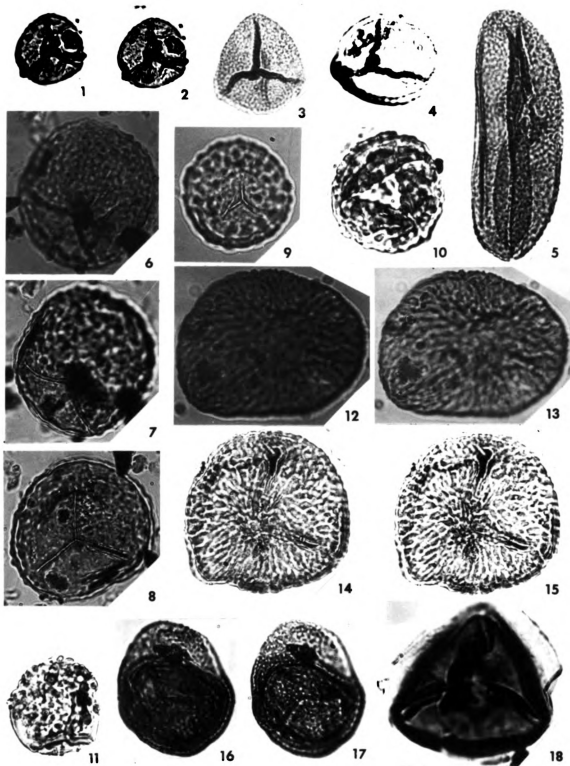


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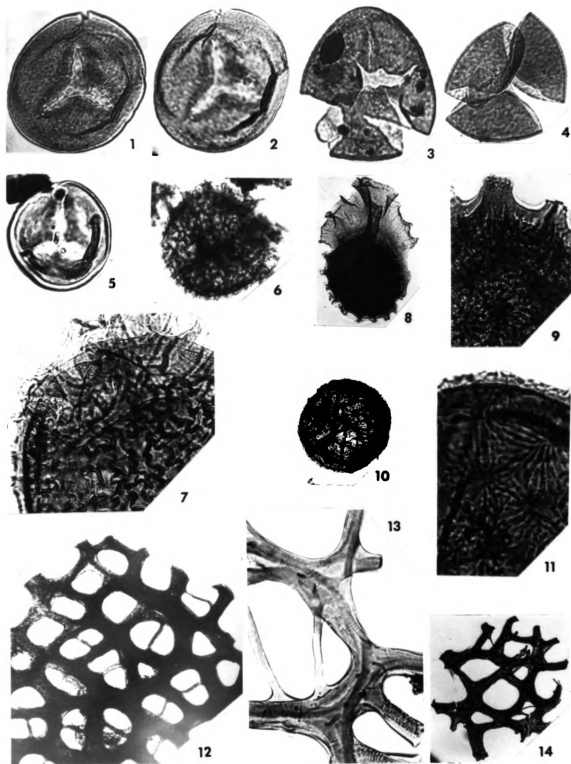


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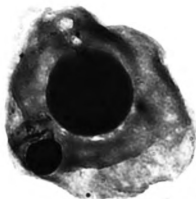
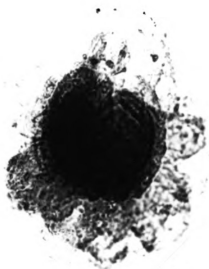
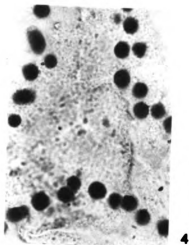
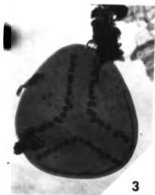
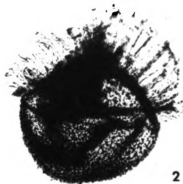
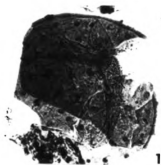


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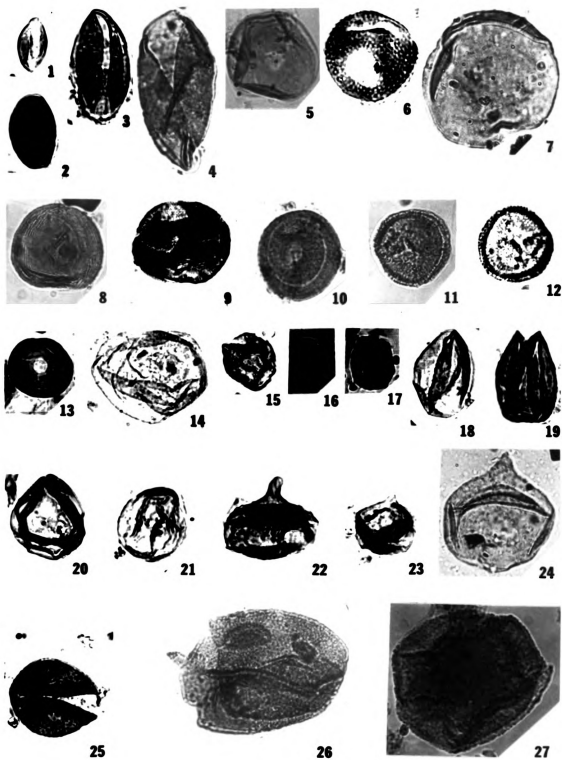


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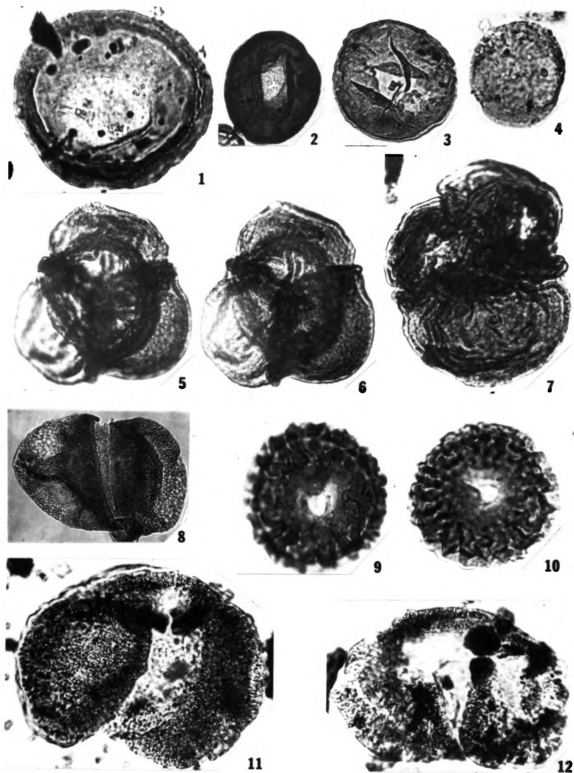


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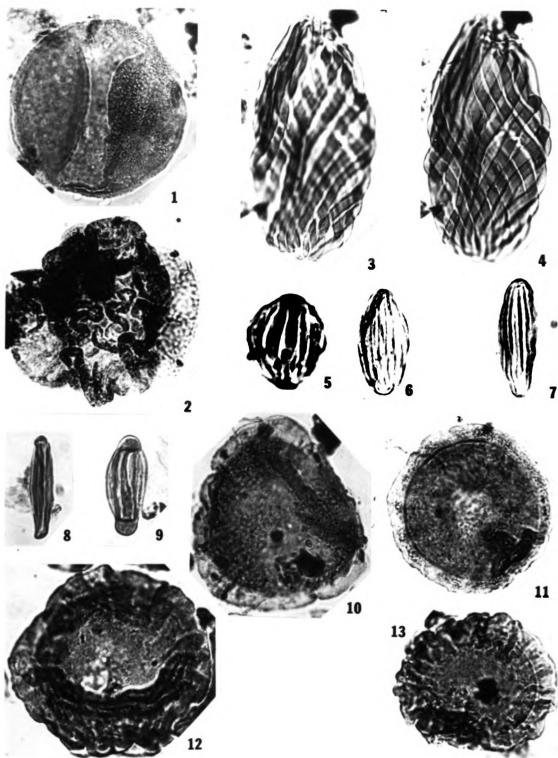


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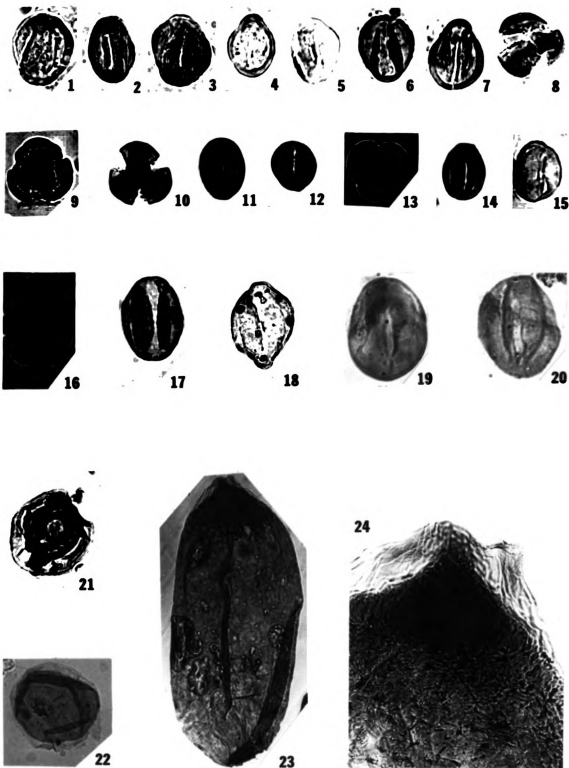


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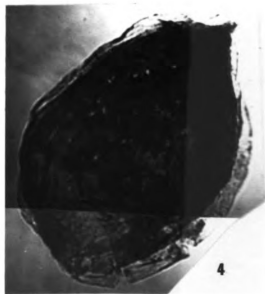
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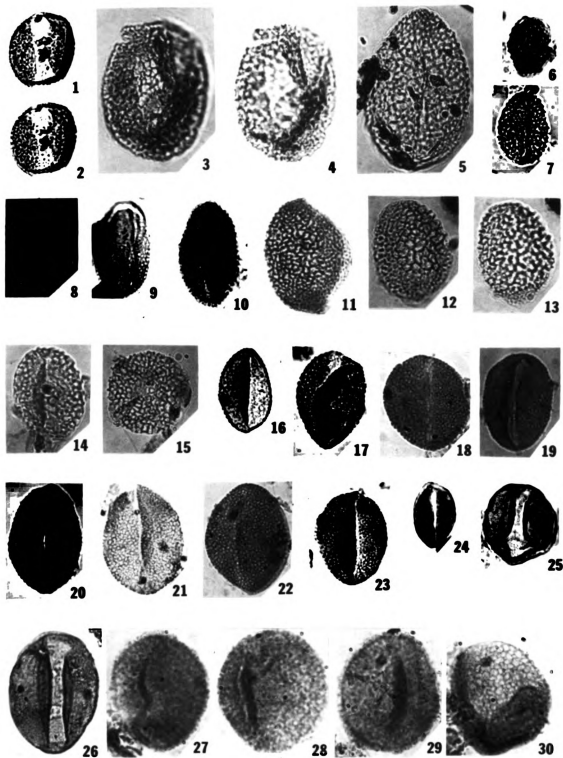


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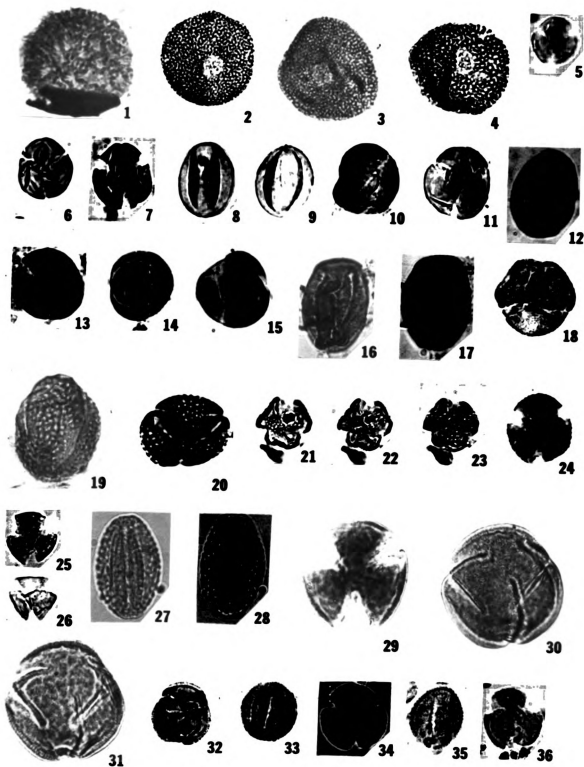


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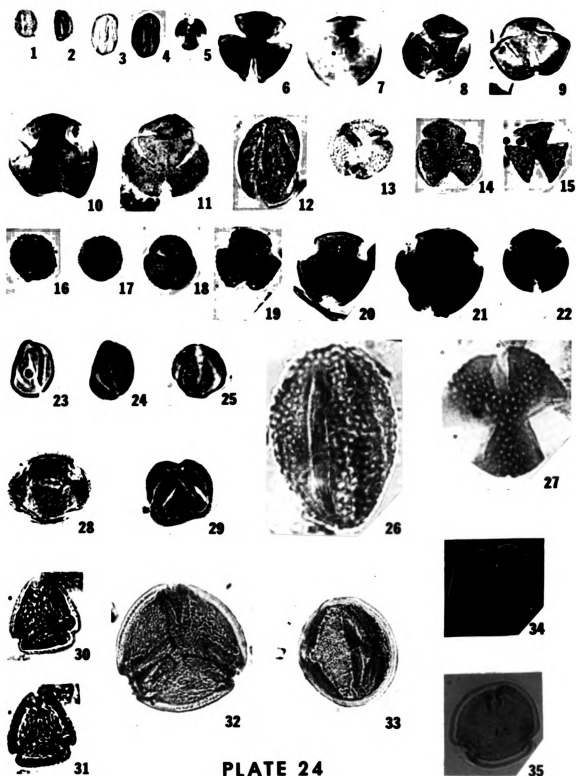


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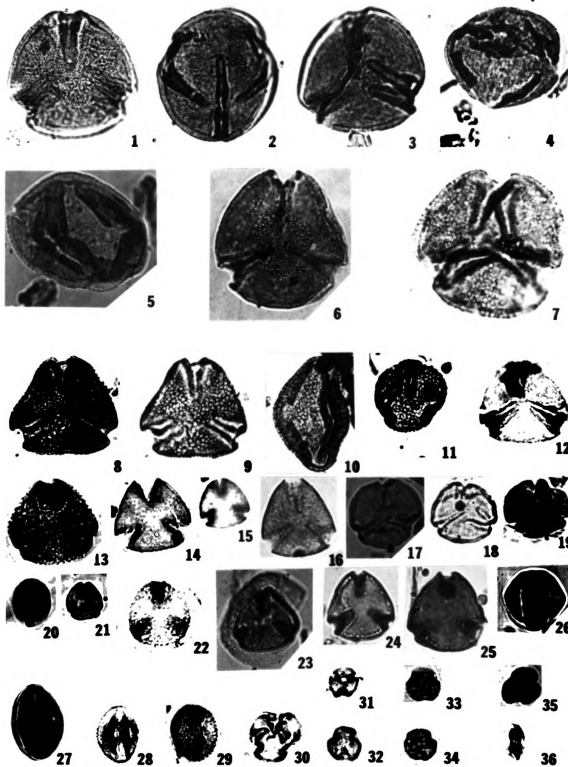


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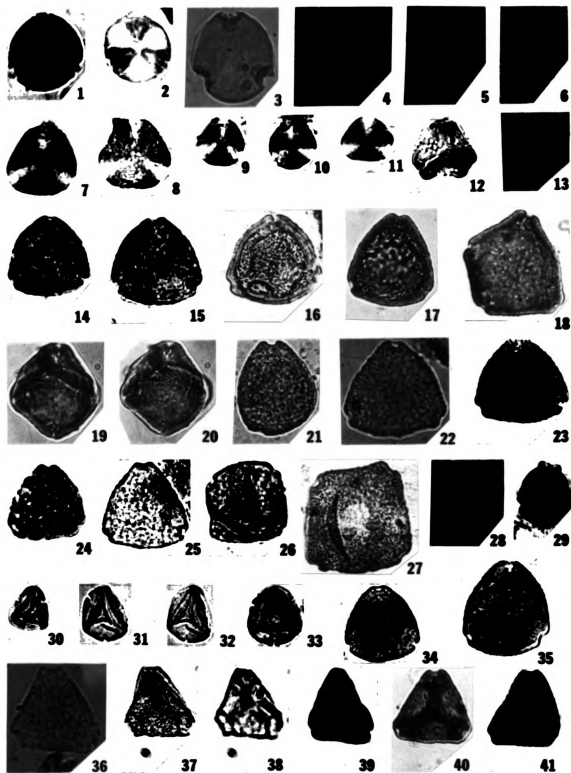


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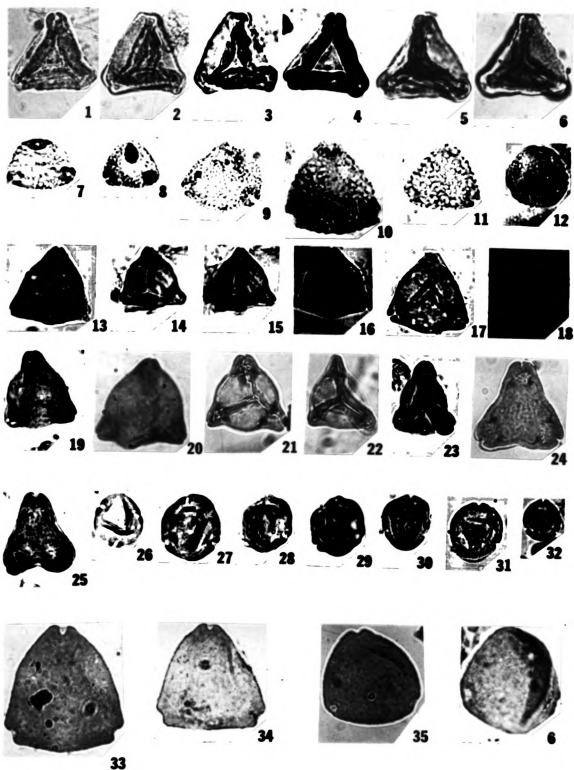


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PLATE 28

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PLATE 28

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