

LIBRARY

Michigan State University

PLACE IN RETURN BOX to remove this checkout from your record.
 TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
MAR 23 1992 9000004		

**BIOSTRATIGRAPHY AND PALEOECOLOGY OF
MID-CRETACEOUS SEDIMENTARY ROCKS, EASTERN UTAH
AND WESTERN COLORADO: A PALYNOLOGICAL INTERPRETATION**

By

Richard Edmond Carroll

Volume I

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Geological Sciences

1992

AND

FOR

THE

THE

THE

THE

A

THE

THE

THE

THE

THE

CO

THE

THE

THE

THE

THE

ABSTRACT

BIOSTRATIGRAPHY AND PALEOECOLOGY OF MID-CRETACEOUS SEDIMENTARY ROCKS, EASTERN UTAH AND WESTERN COLORADO: A PALYNOLOGICAL INTERPRETATION

By

Richard Edmond Carroll

Five sections and two sets of cores of mid-Cretaceous (Albian - Turonian) rocks from eastern Utah and western Colorado were examined for palynomorphs. Stratigraphic units represented by these samples are the Cedar Mountain Formation, Mowry Shale, Dakota Sandstone, and the Tununk Shale, Ferron Sandstone and Blue Gate Shale members of the Mancos Shale.

A palynoflora of 270 different forms were differentiated from 169 samples. These include 38 referable to the angiosperms, 31 to the gymnosperms, 100 to spore-bearing ferns, bryophytes and lycopods, 69 to dinoflagellate cysts, 13 to acritarchs, six to other algae, five of fungal origin, and eight of unknown origin. Palynomorphs from each sample were counted and relative percent for each form, and relative percent and absolute abundances were calculated for each major taxonomic group.

Comparison with known ranges of these palynomorphs indicate: the Cedar Mountain Formation is latest Albian in age in east-central Utah and middle Albian in northeastern Utah; the Mowry Shale is early Cenomanian; the Dakota Sandstone is middle to late Cenomanian; the Tununk Shale is late Cenomanian to middle Turonian; the Ferron Sandstone is middle to late Turonian; and the Blue Gate Shale is late Turonian in age at its base.

The graphic method of correlation resulted in good correlation between three closely spaced sections in east-central Utah. Correlations between these and the sections studied from northeastern Utah and western Colorado were not made.

The Tununk Shale was divided into lower and upper units. The upper unit is identified by the occurrence of *Chatangiella granulifera*, *Alterbidinium* sp. A, and Tricolpate Pollen Form D.

Techniques for estimating distance from paleoshoreline, and correlating environmental changes between areas, such as diversity measurements, absolute abundances, relative percentage of terrestrial materials and percent smooth-walled and spined microplankton, were used as indicators of shoreline transgression and regression within the homogeneous marine Tununk Shale.

Reciprocal averaging, a multivariate ordination technique, was used to attempt to differentiate the relative contributions of the principal deltas supplying the main body of sediments to the Ferron Sandstone in east-central Utah. This analysis of the spores and pollen from southern and northern regions of the Ferron Sandstone, i.e., from the Last Chance and Price River (Vernal) deltas, indicates that the source floras in those two areas must have been very similar.

ACKNOWLEDGEMENTS

I would like to express my appreciation to those people without whose help the completion of this study would not have been possible. My deepest thanks go to Dr. Aureal T. Cross for assistance with field studies and collection and directing this dissertation and for patiently encouraging; Dr. Ralph E. Taggart also for directing and counseling; and to Dr. Robert L. Anstey and Dr. Michael A. Velbel for their help as committee members.

Financial assistance for this study came from many sources. The Department of Geological Sciences and the College of Natural Sciences, Michigan State University, provided teaching and research assistantships. Standard Oil of California provided two Chevron Field-Oriented Thesis Research awards for costs incurred in field research, and Chevron USA provided money to help pay the cost of manuscript preparation and reproduction. A University Graduate Travel Fellowship was awarded by the College of Natural Sciences, Michigan State University. Thanks go to each of these institutions and organizations.

Fellow students, Myung Yi, Pat Fields, Dave Huber and Jim Carr, offered constructive criticism and encouragement when they were needed. Special thanks go to the Department of Geological Sciences office staff, Cathy Caswell, Mona Kendal, Jackie Bennett and Loretta Knudson for help and encouragement in many ways, and for providing technical and administrative assistance, and to Diane Baclawski for cheerful and competent help in the Geology Library.

07

07.07.2020

07.07.2020

07.07.2020

07.07.2020

07.07.2020

Of course, none of this would have been possible without the selfless support of my loving wife, Linda, who worked hard while I studied, offered endless encouragement when I was discouraged, and put up with my time-consuming love of geology. My children, Allan, Arwyn, Patrick, Julianna and Suzanne, helped in ways only a parent can appreciate. My parents, Don and Myrna Carroll, gave love and financial support in times of greatest need.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	viii
LIST OF FIGURES	ix
INTRODUCTION	1
Scope	1
Objectives	2
METHODS	3
Field Collection of Samples	3
Sample Preparation	8
Maceration Schedule for Shales, Siltstones, Sandstones and Limestones	8
Maceration Schedule for Coal and Organic Shales	10
Microscope Slide Preparation	12
Photographic Techniques	12
Data Acquisition	13
Statistical Methods	14
PREVIOUS WORK	19
Geology	19
Palynology	20
STRATIGRAPHY	31
Regional Geologic Setting	31
Cedar Mountain and Burro Canyon Formations	35
Mowry Shale	39
Dakota Sandstone	41
Mancos Shale	43
Tununk Shale Member	43
Ferron Sandstone Member and Frontier Formation	45
Blue Gate Shale Member	51
SYSTEMATIC PALYNOLOGY	53
General Remarks	53
Systematic Descriptions	65
Angiospermous Pollen -- Porate	65
Angiospermous Pollen -- Monocolpate	66
Angiospermous Pollen -- Dicolpate	70

RESU

CONC
APPEN
EELJO
PLATE

	<u>Page</u>
Angiospermous Pollen -- Tricolpate	71
Angiospermous Pollen -- Colpate >3	78
Angiospermous Pollen -- Tricolporate	80
Angiospermous Pollen -- Obligate Tetrads	82
Gymnospermous Pollen -- Alete	83
Gymnospermous Pollen -- Saccate	88
Gymnospermous Pollen -- Plicate	96
Microspores -- Trilete	98
Microspores -- Monolete	136
Microspores -- Hilate	140
Megaspores	142
Miscellaneous Terrestrial Material	145
Dinoflagellate Cysts -- Proximate Cavate	152
Dinoflagellate Cysts -- Proximate Acavate	165
Dinoflagellate Cysts -- Spinifera	175
Dinoflagellate Cysts -- Chorata	178
Acritarchs -- Without Processes	186
Acritarchs -- With Processes	188
Miscellaneous Marine Material	194
Forms of Uncertain Origin	194
RESULTS	196
Distribution of Palynomorphs	196
Cedar Mountain Formation	196
Mowry Shale	224
Dakota Sandstone	225
Tununk Shale	226
Ferron Sandstone	227
Blue Gate Shale	227
Correlation	228
Geologic Age	232
Cedar Mountain Formation	232
Mowry Shale	237
Dakota Sandstone	240
Tununk Shale	241
Ferron Sandstone	242
Blue Gate Shale	242
Paleoecology	243
Cedar Mountain Formation	243
Mowry Shale	246
Dakota Sandstone	246
Tununk Shale	254
Ferron Sandstone	261
Blue Gate Shale	264
CONCLUSIONS	265
APPENDIX: MEASURED SECTIONS	268
BIBLIOGRAPHY	280
PLATES	326

Page 1. Gen
for

Page 2. St
the

Page 3. L
de

Page 4. A

Page 5. Ma
St

Page 6. Co
in

LIST OF TABLES

		<u>Page</u>
Table 1.	Geographic and stratigraphic distribution of samples available for this study	4
Table 2.	Stratigraphical chronology of palynological reports dealing with the mid-Cretaceous of North America	21
Table 3.	List of ecological/systematic/morphologic codes used in computer data storage and statistical calculations	55
Table 4.	Alphabetical list of palynomorphs	58
Table 5.	Master list of numbers assigned to each of the palynomorphs in Stratigraphic Range Charts	197
Table 6.	Composite stratigraphic range of palynomorphs found in this study	204

Figure 1. In

Figure 2. In
m

Figure 3. To

Figure 4. Pa
at

Figure 5. C
at

Figure 6. D
fr

Figure 7. D

Figure 8. A

Figure 9. C
V

Figure 10. L

Figure 11. L

LIST OF FIGURES

	<u>Page</u>
Figure 1. Index map of study area	7
Figure 2. Index map of palynological studies dealing with the mid-Cretaceous of North America	28
Figure 3. Tectonic setting of North America during the Sevier orogeny	32
Figure 4. Paleogeography of North America during the early Cenomanian and late early Turonian	33
Figure 5. Correlation and age of mid-Cretaceous units of eastern Utah and western Colorado	36
Figure 6. Diagrammatic cross-section of Cretaceous strata extending from western Utah to western Colorado	37
Figure 7. Delta systems attributed to the Turonian Ferron Sandstone	47
Figure 8. Map of the Ferron Sandstone outcrop in Castle Valley	48
Figure 9. Cross-section of the Ferron Sandstone in outcrop in Castle Valley	48
Figure 10. Local range chart of palynomorphs in the Ivie Creek section	211
Figure 11. Local range chart of palynomorphs in the Molen section	214

Figure 12. Lo
se

Figure 13. Lo
Ra

Figure 14. Lo
se

Figure 15a. G
se

Figure 15b. G
D

Figure 16. C

Figure 17. C
S

Figure 18. Te
M
tr

Figure 19. S
C

Figure 20. Re
P
of

Figure 21. D
sp
Tr

	<u>Page</u>
Figure 12. Local range chart of palynomorphs in the Farnham Dome section	217
Figure 13. Local range chart of palynomorphs in the Horsethief Canyon Ranch section	220
Figure 14. Local range chart of palynomorphs in the Steinaker Draw section	222
Figure 15a. Graphic model for the correlation of the Ivie Creek and Molen sections	230
Figure 15b. Graphic model for the correlation of the Molen and Farnham Dome sections	231
Figure 16. Correlation of the Ivie Creek, Molen and Farnham Dome sections	233
Figure 17. Correlation of the Farnham Dome, Horsethief Canyon Ranch and Steinaker Draw sections	234
Figure 18. Ternary diagram showing palynofloral composition of the Cedar Mountain Formation in percent of species for four samples including two from Tschudy <i>et al.</i> (1984)	244
Figure 19. Stratigraphic section of the Dakota Sandstone at the Horsethief Canyon Ranch section	247
Figure 20. Relative percentage of spores of ferns and other spore-bearing plants to pollen (angiosperms and gymnosperms) in samples of the Dakota Sandstone at the Horsethief Canyon Ranch section.	249
Figure 21. Diagram showing relation between iridium abundance and fern spike from a Cretaceous/Tertiary boundary interval near Trinidad, Colorado	250

Fig. 22. S

Fig. 23. I

Fig. 24. C

Fig. 25. C

Fig. 26. C

Fig. 27. I

	<u>Page</u>
Figure 22. Stratigraphic correlation within the Dakota Sandstone in the Ivie Creek, Dry Wash and Molen sections.	253
Figure 23. Marine/terrestrial ratio curves for the Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch sections	257
Figure 24. Cumulative percent curves for marine/terrestrial palynomorphs for the Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch sections	259
Figure 25. Cumulative percent curves for angiosperms, gymnosperms and spores for the Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch sections	260
Figure 26. Cumulative percent curves for spined and smooth-walled microplankton for the Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch sections	262
Figure 27. Results of reciprocal averaging of samples from the Ferron Sandstone	263

XIX

The se

United States

systems of

and which a

and so on

and so on

and so on

and so on

The en

and so on

and so on

and so on

and so on

and so on

and so on

and so on

and so on

and so on

and so on

INTRODUCTION

SCOPE

The sedimentary rocks of mid-Cretaceous age in eastern Utah and western Colorado represent a record of the maximum transgression and subsequent, but temporary, regressions of the Cretaceous epicontinental seaway in this area. Clastic deposition in the basin, which accompanied these episodes of regression, was transported from the north, west and southwest from the rising Sevier orogenic belt to the west. This cyclicity of sedimentation, due to transgression/regression and concomitant lateral shifting of coastal environments, continued into the uppermost Cretaceous, at which time the terminal regression of the sea from this area occurred.

The environments in which these sedimentary rocks were deposited are reflected in their lithologic composition, sedimentary structures and biogenic contents. Study of these aspects of the rocks gives some understanding of their environments of deposition, and may help to interpret paleogeographic patterns of the region during this time. A principal aim of this study is to add to the understanding of these depositional environments and paleogeographic patterns by studying the palynomorph assemblages found in these rocks.

Economic interests in the rocks of this age and region focus on coal that occurs within coastal sedimentary environments, and in the possibility of oil generation from marine shales and entrapment within associated sandstones.

ACCOUNTS

The s

various o

document

been that

The fo

.

.

.

.

.

.

.

.

Res.

more cha

the same

OBJECTIVES

This study is directed toward determining lateral and vertical changes in the palynofloras of successive strata at several localities within the study area which may help in documenting some of the paleogeographic patterns and depositional environments of eastern Utah and western Colorado during the mid-Cretaceous.

The following objectives have been included in this study:

- Identify, systematically treat and illustrate the pollen, spores and algae indigenous to the sedimentary rocks within the study area.
- Determine stratigraphic ranges of species within the study area.
- Determine geologic ages based on palynological assemblages, and compare the palynological assemblages found in this study to those of comparable age previously recorded.
- Determine changes and dynamics in the floral composition of the plant communities that contributed to the palynomorph assemblages.

Results of this study should amplify existing knowledge regarding the lateral and temporal changes in palynomorph assemblages and the plant communities associated with the accumulation of mid-Cretaceous sediments in eastern Utah and western Colorado.

METHODS

FIELD COLLECTION OF SAMPLES

Twenty localities where mid-Cretaceous rocks are exposed from the area of eastern Utah and western Colorado, were visited, studied and sampled by the author during the summers of 1985 and 1986 for possible inclusion in this study. A total of 562 samples were collected from these sections. Prior to 1985, 167 samples had been collected from several of these localities by Dr. A.T. Cross. In addition, subsurface samples of Ferron Sandstone coals were made available for this and other studies from the United States Steel, Provo, Utah office (21 samples; Gray, Patalski and Schapiro, 1966) and the Branch of Coal Resources, U.S. Geological Survey, Reston, Virginia (212 samples; Dufek, 1987; Crowley, 1987; Crowley, Simon and Stanton, 1988). A total of 932 samples have been curated for palynological analysis of mid-Cretaceous rocks within the study area.

The representation of palynological samples by locality and stratigraphic unit is listed in Table 1. Due to time constraints, of the 932 samples available for study, only 418 were macerated using the procedures outlined below. Of these, 253 were deemed productive on the basis of palynomorph preservation and abundance. Samples from only five stratigraphic sections and two sets of cores were selected to be the basis of this study based on superior outcrop exposure and palynomorph recovery, including 169 of the 253 productive samples.

Table 1	Categorical variable and corresponding distribution of responses available for this study	Frequency	Percentage	Section Total

Table 1. Geographic and stratigraphic distribution of samples available for this study.

Map No.	Section Name	Cedar Mountain	Mowry	Dakota	Tununk	Ferron/ Frontier	Blue Gate	Section Total
1.	Blind Trail Wash		-	4/3/3/0	10/1/1/0	9/0/0/0	1/0/0/0	24/4/4/0
2.	Ivie Creek *		-	2/2/2/2	22/21/16/16	21/17/7/7	1/1/1/1	46/41/26/26
3.	Browning Mine		-			21/12/2/0		21/12/2/0
4.	Quitchupah Cores *		-			212/20/14/14		212/20/14/14
5.	Dry Wash *	1/1/0/0	-	2/2/2/2	24/14/13/2	11/6/3/0	1/0/0/0	39/23/18/4
6.	Molen *	8/4/1/1	-	2/2/1/1	46/31/25/19	9/9/7/4	1/1/0/0	66/47/34/25
7.	Castle Dale-Woodside Road		-		16/4/2/0	15/1/0/0		31/5/2/0
8.	Elmo Road	2/0/0/0	-		12/0/0/0	4/2/0/0		18/2/0/0
9.	Castle Valley Coal Cores *		-			31/31/18/18		31/31/18/18
10.	Farnham Dome *		-		27/26/17/17	14/13/5/5		41/39/22/22
11.	Sylvania Ranch	4/0/0/0	-		7/4/3/0	15/9/6/0	6/5/5/0	32/18/14/0

Key: # Samples Available / # Samples Prepared / # Samples Productive / # Samples Studied.

Note: Sections from which samples have been utilized for this study are marked by an asterisk. For location of sections, see Figure 1 and Appendix - Measured Sections.

Map No.	Section Name	Cedar Mountain	Mowry	Dakota	Tumuk	Frontier	Blue Gate	Section Total
---------	--------------	----------------	-------	--------	-------	----------	-----------	---------------

Table 1 (cont'd.)

Map No.	Section Name	Cedar Mountain	Mowry	Dakota	Tununk	Ferron/ Frontier	Blue Gate	Section Total
12.	Cliff Siding		-	1/0/0/0	1/1/1/0	11/1/1/0	1/1/1/0	14/3/3/0
13.	Green River West	2/0/0/0	-		4/0/0/0	7/0/0/0		13/0/0/0
14.	Valley City	1/1/0/0	-		9/2/1/0	2/2/1/0		12/5/2/0
15.	Cisco		-	2/0/0/0	4/0/0/0			6/0/0/0
16.	Westwater Wash		-	51/6/0/0	18/4/2/0	9/2/0/0	1/0/0/0	79/12/2/0
17.	East Flank Harley Dome		-	25/3/0/0	10/6/2/0	5/3/2/0	3/2/2/0	43/14/6/0
18.	Milepost Nine		-	39/17/1/0	7/0/0/0	4/0/0/0		50/17/1/0
19.	Horsethief Canyon Ranch *		-	23/23/18/18	11/11/10/10	5/5/2/2		39/39/30/30
20.	Delta Colorado	1/1/0/0	-	7/7/0/0	8/8/6/0	15/9/5/0		31/25/11/0
21.	Steinaker Draw *	2/2/1/1	61/53/41/27		3/3/2/2	4/2/0/0	2/1/0/0	72/61/44/30
22.	Stinking Water Creek		3/0/0/0	1/0/0/0	3/0/0/0		5/0/0/0	12/0/0/0
	Unit Total	21/9/2/2	64/53/41/27	159/65/27/23	242/136/101/66	424/144/73/50	22/11/9/1	932/418/253/169

Key: # Samples Available / # Samples Prepared / # Samples Productive / # Samples Studied.

Note: Sections from which samples have been utilized for this study are marked by an asterisk. For location of sections, see Figure 1 and Appendix – Measured Sections.

Figure 1

and those

men by sq-

business no.

fact, and

location of e

in paymen

Rocks

metamorph

water 0 and

metamorph

In the th

skied every

size were a

not deep an

metamorph

ment were c

Samples

fringe with

Wedge of the

area thick

are. In some

last section

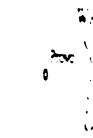
metamorph

Figure 1 is an index map of the study area showing the location of all sections visited. Those sections included in the analyses of this study are marked by circles, the others by squares. Section numbers on the map refer to those listed in Table 1. The Localities included in this study are: Ivie Creek, Molen, Farnham Dome, Horsethief Canyon Ranch, and Steinaker Draw sections, and Quitchupah and Castle Valley coal cores. Location of each section is listed in the appendix, and those sections which were examined for palynomorphs are described in detail.

Rock samples were collected for palynological study while measuring and describing the stratigraphic sections. Because the structural dip of the strata in the area studied varies between 0 and 30 degrees, a Jacob's staff and Brunton compass were used to determine stratigraphic thickness.

In the thick sections of Tununk Shale with relatively uniform lithology, samples were collected every 6 to 9 m depending on exposure. Intervals showing abrupt lithologic change were also sampled. Samples in the Tununk Shale were obtained by digging a trench deep and long enough to expose less-weathered rock one to two meters thick, stratigraphically. Generally, 0.5 to 1.0 kg of rock chips representing the entire stratigraphic interval, were collected from each trench.

Samples were collected over the entire thickness of shale, siltstone and coal lithologic units from measured sections in the Dakota Sandstone and the Ferron Sandstone Member of the Mancos Shale. No quartzose sandstone units were sampled. If a lithologic unit was thicker than about two meters, generally it was subdivided, and two samples were taken. In some instances, as in parts of the Dakota Sandstone at the Horsethief Canyon Ranch section, samples were taken over 1.0 to 15 cm intervals for study of short term ecological changes.



SECTION

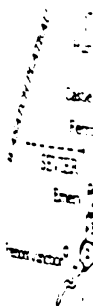


Fig. 1. In
the sections
were stud
in this stu

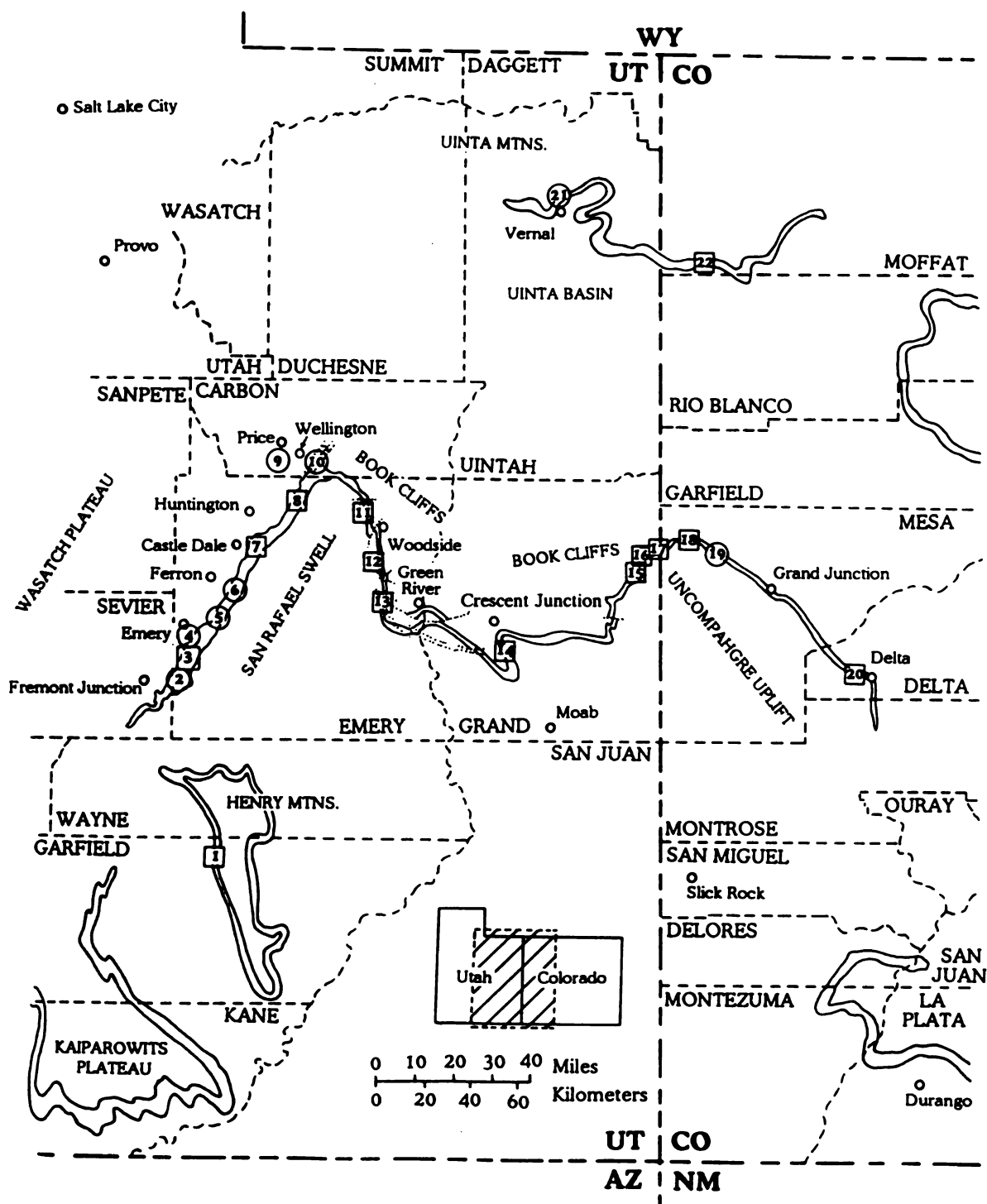


Figure 1. Index map of study area.

Note: Sections from samples included in this study are indicated by circles; those that were studied in the field and from which samples were collected but not included in this study are indicated by squares. For section names see Table 1.

100

101

102

103

104

105

106

107

108

109

110

111

112

113

Palynological samples were collected in plastic bags with sample and stratigraphic information written on the outside of each bag with an indelible marker. These were then wrapped in newspaper until the samples were ready for preparation.

SAMPLE PREPARATION

Samples collected in the field for palynological study were logged into the Michigan State University paleobotanical and palynological collections with Pb series accession numbers. A list of all samples used in this study is included in the appendix.

After a sample was catalogued, it was processed using standard palynological techniques. An effort was made to keep preparation techniques as uniform as possible so that absolute palynomorph abundances could be compared between samples. However, some modification of procedures was necessary due to the varied lithologic and mineralogical composition of the samples. The two basic maceration techniques used for concentration of palynomorphs were as follows:

Maceration Schedule for Shales, Siltstones, Sandstones and Limestones

1. Crush entire sample so that the largest particles are not larger than 5 mm in diameter, but avoid powdering.
2. Mix crushed sample thoroughly and portion off a 5 to 25 g aliquot for maceration. The amount of sample used was based subjectively on the grain size, calcareous nature and carbonaceous appearance of the rock.
3. Transfer weighed subsample portion into 90 ml polypropylene centrifuge tube. Add 40 ml of 10% hydrochloric acid (HCl) to remove carbonates. Stir occasionally, adding more HCl if necessary, until reaction ceases. Centrifuge at 1800 rpm for four minutes and decant supernatant fluid. Wash once with distilled water.

4. Pack centrifuge tube in ice and slowly (over a five to ten minute period) add 20 to 30 ml of 52% hydrofluoric acid (HF) for the removal of silicates. Stir often during the first hour. After the first hour, remove from ice water and add an additional 40 ml of HF. Allow reaction to continue for 24 hours, stirring occasionally. After 24 hours, place centrifuge tube in a steam bath for 10 minutes, stirring often. Remove from steam bath, and allow reaction to continue for an additional 30 minutes; then centrifuge and decant the partially spent HF.
5. Add 30 ml of 10% HCl and place centrifuge tube in a steam bath for 5 minutes, stirring occasionally. Dilute sink fraction with water, centrifuge and decant. Dilute again with water, centrifuge and decant.
6. Add 30 ml of Schulze's solution (five parts nitric acid (HNO_3) to one part potassium chlorate (KClO_3)). Allow to react for ten minutes, stirring frequently. Dilute with water, stir thoroughly, centrifuge and decant. Repeat washing twice with water.
7. Add 50 ml of 5% Potassium Hydroxide (KOH), place in steam bath for 1 1/2 minutes, stirring often. Dilute with water, centrifuge and decant. Wash with water twice or until supernatant fluid becomes clear (some samples may require three to five washes). Wash with 5% HCl for one to five minutes if sample does not clear.
- 7A. Samples which are extremely bentonitic or contain abundant amorphous organic material may require the following additional step (outlined by Balme and Hassell, 1962) to remove complex clay minerals: Add 10 ml of concentrated HNO_3 , stir and immediately dilute with water. Centrifuge, decant and then repeat washing twice with water. Next add 20 ml of 5% Sodium Hydroxide (NaOH), stir and immediately dilute with water. Centrifuge, decant and repeat washing twice with water.

1. Trans
and d
chem
for 10
Agar
tract
pain
Add
then
with

9. Dilute
hydro
added
seven
is clear

10. Pour
vial
available
gram
was o
assess

Verification S
Crash
as pos

8. Transfer residue to a 40 ml glass centrifuge tube and wash in 10% HCl. Centrifuge and decant removing as much of the HCl solution as possible. Add 10 ml of zinc chloride (ZnCl_2) of specific gravity 1.95, mix thoroughly, and centrifuge at 1800 rpm for 10 minutes. Decant light fraction into 90 ml polypropylene centrifuge tube. Again add 10 ml of ZnCl_2 to sink fraction, and again centrifuge and decant light fraction into the same 90 ml tube. Check heavy fraction for palynomorphs. If palynomorphs are present, repeat this step again; if not, discard heavy fraction. Add 20 ml of 5% HCl to the light fraction and dilute with water. Stir thoroughly, then centrifuge for four minutes at 1800 rpm. Decant supernatant fluid and dilute with water. Stir well, centrifuge and decant. Wash once or twice with water.
9. Dilute with water and stir well. Stain residue by adding three drops of ammonium hydroxide (NH_4OH) and a one to three drops of Safranin O (number of drops added depends on the amount of residue to stain). Stir well and allow to stain for several minutes. Centrifuge and decant. Wash with water until supernatant fluid is clear.
10. Pour residue into one dram vial. Centrifuge and pipette off supernatant fluid. Fill vial to base of neck with Hydroxyethyl Cellulose (HEC, a patented chemical available from Virginia Cellulose Department, Hercules Powder Company). A one dram vial filled to this level contains, on the average, 180 pipette drops. This value was determined after experimentation with HEC diluted residues, and was used in assessing approximate absolute palynomorph abundances.

Maceration Schedule for Coal and Organic Shales

1. Crush entire sample to approximately 3 mm diameter. Avoid powdering as much as possible.

2. Max crush

3. Place 5 g

to remove

centrifuge

4. Add 30 ml

to react for

and check

of the sam

side. To

under the

dissolved

residue is

Schulze's s

5. Transfer w

ml of 10%

often. Rem

Repeat wa

four to six

6. Add 20-30

water, cen

again with

7. Stir and c

and limesto

2. **Mix crushed sample thoroughly and remove a 5 g aliquot.**
3. **Place 5 g aliquot of sample in 45 ml glass centrifuge tube, and add 20-30 ml of HCl to remove any carbonate components. After reaction ceases, dilute with water, centrifuge and decant. Repeat washing once with water.**
4. **Add 30 ml of Schulze's solution and put centrifuge tube into steam bath and allow to react for 20 minutes, stirring often. After 20 minutes remove from steam bath and check for sufficient maceration. (This is done by siphoning off a small portion of the sample, and after washing with water, putting a few drops on a microscope slide. To the residue on the slide, add one drop of NaOH. If, when observed under the microscope, most of the amorphous organic materials are dispersed or dissolved and the palynomorphs are freed, the maceration is sufficient.) When the residue is determined to be sufficiently macerated, centrifuge and decant waste Schulze's solution. Repeat washing twice with water.**
5. **Transfer washed residue to a clean 90 ml polypropylene centrifuge tube. Add 50 ml of 10% KOH, and place centrifuge tube in steam bath for three minutes stirring often. Remove from steam bath, dilute contents with water, centrifuge, and decant. Repeat washing with water until supernatant fluid is nearly clear (this may require four to six washes; however, fewer washes are needed if warm water is used).**
6. **Add 20-30 ml of HF to residue for removal of silicates. After two hours, dilute with water, centrifuge and decant. Wash twice with water, once with 5% NaOH, then again with water.**
7. **Stain and concentrate residue as in steps 9 and 10 for shales, siltstones, sandstones, and limestones described above.**

MICROSCOPE SLIDES

Organic re-

agent that will

allow proceed-

1. Thorough-

2. Prepare of

column of

3. Onto a ch-

produce a

or unuse-

residue is

drops of r-

4. Place the

solution in

5. Invert and

Keenmo-

available

catalog n-

mountant

or unmen-

MICROGRAPHIC

Photograp-

tion Micro-

MICROSCOPE SLIDE PREPARATION

Organic residues were mounted on microscope slides for palynologic study in a manner that would enable absolute palynomorph abundance to be calculated. the following procedure was used:

1. Thoroughly shake vial containing organic residue suspended in HEC.
2. Pipette off an amount of the suspended residue, sampling as much of the entire column of suspended residue as possible.
3. Onto a clean 22 mm² coverslip, place enough of the residue drop by drop to produce an adequate but uncrowded dispersal. Using a clean dissecting needle, or unused round toothpick, pull the residue gently out to the edges so that the residue is evenly distributed across the entire coverslip. Record the number of drops of residue used.
4. Place the coverslip on a slide warmer until all of the water and solvent of the HEC solution has evaporated from the residue and the coverslip is completely dry.
5. Invert and mount the coverslip onto a 25 x 75 mm microscope slide using Kleermount (a patented artificial resin produced by Cabisco Chemicals, and available from Carolina Biological Supply Company), and label the slide with the Pb catalog number of the sample. Place the slide on a slide warmer and allow the mountant to set for five to seven days before attempting to examine the slide with oil-immersion objectives.

PHOTOGRAPHIC TECHNIQUES

Photographs of palynomorphs were taken with a Nikon UFX-IIA automatic camera on a Nikon Microphot microscope. Photos were taken using Kodak Panatomic-X film, and

were printed on Kodak Polycontrast rapid III RC paper. Original magnification of the palynomorphs was 1000X, 600X or 400X. Prints were made so that the magnification for the final plates was 1000X, 750X or 500X.

DATA ACQUISITION

Before any counts were made, a reconnaissance of several samples from differing lithologies was made to become familiar with the palynoflora.

In order to achieve the goals of this study as set out in the introduction, the following data were collected from each productive sample examined:

- Approximate absolute palynomorph abundance
- Occurrence or non-occurrence of palynomorph species
- Relative abundance of palynomorph species

These data were collected by counting 500 palynomorphs from each sample, and recording the number of each species encountered and the total distance traversed on the slide. Thompson (1969) plotted experimental palynomorph counts showing the number of taxa identified versus the number of specimens examined. The resultant curves showed that the number of new taxa encountered leveled off significantly after about 300 specimens had been examined. He concluded that a count of 500 specimens generally included most of the taxa present. However, Patterson and Fishbain (1989) have cautioned that, although most taxa will be represented in a count of 500, ecological differentiation based on species with relative abundance of less than 5% may be questionable.

A predetermined method of counting the 500 specimens was utilized in an attempt to produce a random sample. Ten random numbers were selected using a random number table to determine the order of vertical axis traverses. These positions were used

consecutively until 250 specimens were examined on a slide. No more than 75 grains were counted per traverse. The total distance traversed for each slide was recorded. Fungal spores and unidentifiable forms were not included in the counts.

Approximate absolute palynomorph abundances were calculated using a method outlined by Traverse and Ginsburg (1966). The following equation gives a relatively good estimate of absolute palynomorph abundance:

Palynomorphs/gram of sediment =

$$(N * 484 * P * 180) / (T * 0.218 * S * D)$$

where:

N	number of slides examined
484	area of coverslip in mm ²
P	palynomorphs counted
180	drops of residue in vial
T	distance traversed in mm
0.218	field of view in mm ² (540X)
D	total number of drops of residue on all slide examined
S	grams of sediment used in preparation

In order to determine occurrence/non-occurrence for palynomorphs which are present in very low percentages, slides were further studied to note the presence of forms that were not included in the 500 count. This process was used to help establish first and last occurrences. All data were stored, and calculations for relative percentage and absolute abundance were done on an IBM-XT compatible personal computer using R:BASE for DOS data base programming language.

STATISTICAL METHODS

In the study of natural plant communities, two theories have been developed to describe interspecific relationships. The earlier, community-unit theory, states that plant

communities are discrete, well-defined units consisting of populations of co-evolved species. The continuum theory of community ecology, which was introduced later (Gleason, 1926) due to accumulating evidence against the validity of the community-unit theory, states that plant communities are groups of species defined or circumscribed by physical requirements (i.e., moisture, light, soil, nutrients, topography, temperature) of each species (Austin, 1985), and that the gradual blending of communities is due to gradual changes in ecological conditions which in turn control the distribution of the physical requirements of the constituent species. These changing ecological conditions are termed "environmental gradients."

Analysis of natural plant communities according to the continuum theory is, in essence, the study of interrelationships between gradients in community composition and gradients in environmental factors. This type of study, referred to as "gradient analysis", goes beyond simple classification and descriptions of community types, which is the aim of cluster analysis; it integrates the study of gradients with species populations, environmental factors and community structure (Springer and Bambach, 1985).

Cisne and Rabe (1978) have adapted gradient analysis to paleontological and stratigraphic problems in a concept they term "coenocorrelation." In their words, coenocorrelation is "the correlation of positions in a stratigraphic sequence with corresponding positions along a paleoenvironmental gradient through gradient analysis of fossil communities" (p. 341). One must recognize the basic differences in the controlling gradients between extant plant communities and fossil plant assemblages. In living plant communities, environmental gradients control the distribution of the species with respect to other species as they grow together; whereas in fossil assemblages, environmental gradients control which species will be brought together after the death of the organism.

Dear assembly

However, Wam

Dear assembly

is a study of mo

Stratigra

is a trace evolution

for environme

environmental c

used the use

invertebrates ab

rate. They fo

agreement with

The term

ordinium analys

regional per

samples or spec

hyperspace, alon

samples corresp

regional gra

in identifying co

base upon which

Anderson

Olson (1978), G

the numerous m

Death assemblages may or may not represent the way the organisms interrelated in life. However, Warne *et al.* (1976), recognizing this difference, found a higher correlation of death assemblages than that of life assemblages with surrounding environmental conditions in a study of mollusks and foraminifera from Yucatan, Mexico.

Stratigraphic analysis is important in paleontological studies of evolution. In order to trace evolutionary patterns within a lineage, it is critical to distinguish temporal changes from environmental changes. To do so, it is necessary to have a highly accurate time and environmental correlation within the rock sequence being studied. Cisne and Rabe (1978) tested the use of gradient analysis on marine benthic invertebrates (trilobites and brachiopods) along ten isochronous transects down an Ordovician basin slope in New York state. They found that time-lines established by gradient analysis were in very close agreement with bentonite marker beds, which represented natural time-lines in their study.

The term "ordination," referring to mathematical techniques used in vegetation continuum analysis, was first used by Goodall (1954). It is the process of reducing complex vegetational patterns to a simple and more interpretable form. This technique arranges samples or species or both, which are identified by coordinates in an n-dimensional hyperspace, along two or more continuous axes, so that the ecological relationship between samples corresponds to their relative position on the axes. These axes, which represent vegetational gradients, should, under the continuum theory of community ecology, reflect an underlying complex environmental gradient. Ordination, therefore, is the mathematical base upon which the concept of gradient analysis rests.

Anderson (1971), Gauch and Whittaker (1972), and Whittaker and Gauch (1978), Orloci (1978), Greig-Smith (1980, 1983), Gauch (1982), and Pielou (1969) have reviewed the numerous methods of ordination as they apply to plant communities. Kovach (1989)

compared the use of ordination and cluster analysis methods in applications in plant paleoecology. Austin (1985) noted a similarity between the continuum role in plant communities and animal species niche theory, and presented the role of ordination in both of these. Ordination has been used in gradient analyses in such paleontological studies as those of Cisne and Rabe (1978), Springer and Bambach (1985), Kovach (1988) and Wolfe and Schorn (1989).

Two approaches to ordination are possible: direct or environmental ordination, and indirect or vegetational ordination. Direct ordination displays patterns of species or samples in relation to two or more environmental factors, or gradients, which are believed to be important in the distribution of the species or samples (Austin, 1985). Indirect ordination arranges the samples with respect to maximum variance within the data collected (Cisne and Rabe, 1978). Indirect methods of ordination have been chosen for paleontological studies because they do not assume previous knowledge of the important environmental gradients, which information may not be accessible at all.

Several techniques for indirect ordination exist: principle components analysis (PCA), principle coordinates analysis (PCO), polar ordination (PO), detrended correspondence analysis (DCA), non-metric multidimensional scaling (MDS) and reciprocal averaging (RA). Kovach (1989) described the advantages and disadvantages for each of these techniques. Reciprocal averaging was selected for this study because: (1) RA ordines species and samples simultaneously so that both scores are scaled similarly and are comparable, and (2) a program was available for personal computers (Kovach, 1986). In RA, as the name implies, species ordinations are averages of the sample which include the species, and reciprocally, sample ordinations are averages of the species that are included within the sample. Hill (1973) showed how, over several iterations of averaging and recalibrating,

scores for species and samples sooner or later approach equilibrium. Results of RA are plotted out in scatter diagrams where the dimensionless axes represent major complex environmental gradients or trends of variation.

PREVIOUS WORK

GEOLOGY

The Cretaceous rocks of the Western Interior have long been the subject of geologic investigation because of their exceptionally good exposure and economic potential. Early geological studies in the Utah, Colorado and Wyoming area (Clark, 1919, 1928; Fisher, 1936; Gale, 1910; Lupton, 1914, 1916; Taff, 1906; Walton, 1944) dealt mainly with general stratigraphic relationships and mineral and fuel resource reserve estimation. Later work focused on the evident cyclic nature of the sedimentary rocks (Abbott and Liscomb, 1956; Bartram, 1937; Fisher *et al.*, 1960; Katich, 1954; Spieker, 1949; Spieker and Reeside, 1925; Weimer, 1960; Young, 1955, 1957, 1966). Eaton *et al.* (1990), Fouch *et al.* (1983), Hale and Van De Graaff (1964) Kauffman (1977) and Ryer and McPhillips (1983) discussed regional patterns and timing of synorogenic sedimentation and paleogeography of the Utah, Colorado and Wyoming area.

Katich (1951), Stokes (1944, 1952), Young (1960, 1970, 1973) and Eaton *et al.* (1990) have studied regional depositional patterns of the basal Cretaceous rocks of the Colorado Plateau, which include the Cedar Mountain Formation and Dakota Sandstone and equivalent units.

The Tununk Shale Member of the Mancos Shale has been studied mainly from the point of view of invertebrate paleontology. Cobban (1976) reported on the ammonite record from the Tununk Shale from the vicinity of the Castle Valley-Price-Woodside area,

and Bagshaw (1977), Lessard (1973) and Maxfield (1976) have studied the foraminifera of this shale unit.

The Ferron Sandstone Member of the Mancos Shale has been studied extensively from a sedimentological perspective. Cleavinger (1974), Cotter (1971, 1975a, 1975b, 1976), Davis (1954), Hale (1972), Hill (1982), Katich (1953), Ryer (1981a, 1981b, 1981c, 1982a, 1982b), Thompson (1985) and Uresk (1979) have all contributed to our understanding of the paleoecology and sedimentation patterns in the Ferron Sandstone.

PALYNOLOGY

A list of studies that deal with the palynology of mid-Cretaceous rocks in North America is given in stratigraphic order in Table 2. This list is not meant to be exhaustive, but contains most of the significant published work done in this area. Some abstracts and unpublished theses have also been included. Those works dealing with specific geographic areas are plotted in Figure 2.

Palynological studies that are locally important to the eastern Utah and western Colorado area for the mid-Cretaceous are few in number. Sarmiento (1957) developed a broad zonation for the Mancos Shale interval for Castle Valley based on large groups of palynomorphs. However, he found plant microfossils in the lower part of the section (from the Dakota Sandstone to the lower part of the Blue Gate Shale Member of the Mancos Shale) to be quite rare, and defined this interval as Zone A on this basis.

May and Traverse (1973) and May (1975) studied the pollen and spore palynoflora from the Dakota Sandstone, and May (1972) did a reconnaissance of many of the Upper Cretaceous coals of central Utah, including those from the Dakota Sandstone and Ferron Sandstone.

Table 2. Stratigraphical chronology of palynological reports dealing with the mid-Cretaceous of North America.
(See key at end of table for abbreviations)

C R E T A C E O U S																
LOWER CRETACEOUS UPPER CRETACEOUS																
MID-CRET.																
B V H B A A C T C S C M																
E A A A P L E U O A A A																
R L U R T B N R N N M E																
LOCATION																
DESCRIPTION																
NO.	AUTHOR(S)	DATE	X	X	X	X	X	X	X	X	X	X	X	X	LOCATION	DESCRIPTION
1.	Brideaux	1977	X	X	X	X	X	X	X	X	X	X	X	X	CAN DM Richardson Mountains	dino acri
2.	Lachlar et al.	1989	?	?	?										MEX,ae Chiapas	poll spor assembl
3.	Habib	1975	X	X	X	X	X	X	X	X	X	X	X	X	USA Atlantic coast,w Bahamas	dino strat zone
4.	Habib and Drugg	1983	X	X	X	X	X	X	X	X	X	X	X	X	USA Atlantic coast Bahamas	dino strat
5.	Burden and Hills	1989	X	X	X	X	X	X	X	X	X	X	X	X	CAN,w BC AT	spor poll key to genera
6.	Hughes	1969	X	X	X	X	X	X	X	X	X	X	X	X	NA	poll spor general
7.	Pocock	1976	X	X	X	X	X	X	X	X	X	X	X	X	CAN Canadian Arctic	dino strat corr
8.	Habib	1977	X	X	X	X	X	X	X	X	X	X	X	X	USA CAN Atlantic Ocean,w	strat poll spor dino zone
9.	Habib and Knapp	1982	X	X	X	X	X	X	X	X	X	X	X	X	USA CAN Atlantic Ocean,w	dino strat
10.	Riley and Fenton	1984	X	X	X	X	X	X	X	X	X	X	X	X	USA FL,w Gulf of Mexico	strat poll spor
11.	Bebout	1981	X	X	X	X	X	X	X	X	X	X	X	X	USA Atlantic coast	strat poll spor
12.	Bujak and Williams	1978	X	X	X	X	X	X	X	X	X	X	X	X	CAN,ae Atlantic Coast	dino review
13.	Jansonius	1986	X	X	X	X	X	X	X	X	X	X	X	X	USA CAN	dino morph Fromeet system
14.	Jansonius	1989	X	X	X	X	X	X	X	X	X	X	X	X	USA CAN	megasp occur strat
15.	Kovach and Batten	1989	X	X	X	X	X	X	X	X	X	X	X	X	USA MT	megasp occur strat
16.	Newman	1972	X	X	X	X	X	X	X	X	X	X	X	X	CAN USA	dino spor poll strat
17.	Sweet	1979	X	X	X	X	X	X	X	X	X	X	X	X	CAN USA	strat poll spor assembl
18.	Williams	1974	X	X	X	X	X	X	X	X	X	X	X	X	CAN Atlantic coast	dino Ludaradnum dissolutum syst morph
19.	Burden	1984	X	X	X	X	X	X	X	X	X	X	X	X	CAN AT,s USA MT,n	poll spor assembl
20.	Brideaux and McIntyre	1973	X	X	X	X	X	X	X	X	X	X	X	X	CAN YU DM,n Mackenzie River	poll spor assembl
21.	Brenner	1963	X	X	X	X	X	X	X	X	X	X	X	X	USA MD	spor assembl strat
22.	Steeves and Wilkins	1967	X	X	X	X	X	X	X	X	X	X	X	X	CAN SS	poll angio evol
23.	Steeves and Wilkins	1969	X	X	X	X	X	X	X	X	X	X	X	X	USA MD NJ Atlantic coast	poll angio review
24.	Doyle	1977	X	X	X	X	X	X	X	X	X	X	X	X	USA MD,w VA,ne	strat megaf angio evol
25.	Hickey	1984	X	X	X	X	X	X	X	X	X	X	X	X	GRE CAN Arctic	dino strat
26.	Nehr-Hanson and McIntyre	1990	X	X	X	X	X	X	X	X	X	X	X	X	USA MD DE	poll spor assembl
27.	Groot and Penny	1960	X	X	X	X	X	X	X	X	X	X	X	X	CAN Labrador Shelf	dino acri spor strat
28.	Bujak et al.	1989	X	X	X	X	X	X	X	X	X	X	X	X	CAN NT	poll spor assembl
29.	Doerenkamp et al.	1976	X	X	X	X	X	X	X	X	X	X	X	X	CAN DM	poll spor dino acri assembl
30.	Brideaux and McIntyre	1975	X	X	X	X	X	X	X	X	X	X	X	X	CAN ON,c Moose River Basin	poll spor assembl zone Matitagami Fm
31.	Norris	1982	X	X	X	X	X	X	X	X	X	X	X	X		

Table 2 (cont'd).

C R E T A C E O U S									
LOWER CRETACEOUS					UPPER CRETACEOUS				
					MID-CRET.				
					B	V	H	A	A
					E	A	A	P	L
					E	U	O	A	A
					R	L	U	R	T
					B	N	R	N	M
					E				
NO.	AUTHOR(S)	DATE	LOCATION					DESCRIPTION	
96.	Kimyai	1966	X	X	X	X	X	X	poll spor assemb
97.	Nichols and Jacobson	1982a	X	X	X	X	X	X	strat poll spor dino
98.	Nichols and Jacobson	1982b	X	X	X	X	X	X	strat poll spor dino
99.	Nichols <i>et al.</i>	1983	X	X	X	X	X	X	poll spor dino zone
100.	Norris <i>et al.</i>	1975	X	X	X	X	X	X	poll assemb
101.	Ryder and Ames	1970	X	X	X	X	X	X	strat poll spor
102.	Ryder and Ames	1971	X	X	X	X	X	X	poll strat
103.	Tschudy, R.H.	1976b	X	X	X	X	X	X	strat megasp <i>Minerisporites</i>
104.	Williams and Brideaux	1972	X	X	X	X	X	X	strat
105.	Williams and Brideaux	1975	X	X	X	X	X	X	strat
106.	Rouse and Srivastava	1972	X	-	-	-	-	-	strat poll spor
107.	Agasie	1967	X	X	X	X	X	X	poll spor assemb
108.	Agasie	1969	X	X	X	X	X	X	poll spor dino acri assemb Dakota Ss
109.	Agasie and Kremp	1967	X	X	X	X	X	X	poll spor dino
110.	Carter and Cannight	1977	X	X	X	X	X	X	poll spor assemb
111.	Crane <i>et al.</i>	1986	X	X	X	X	X	X	megaf angio dicots flowers occur
112.	Davey	1969	X	X	X	X	X	X	dino acri assemb
113.	Davey	1970	X	X	X	X	X	X	dino acri assemb
114.	Ellis and Tschudy	1964	X	X	X	X	X	X	megasp <i>Arcellites</i>
115.	Farley	1982	X	X	X	X	X	X	poll spor assemb
116.	Farley and Dilcher	1986	X	X	X	X	X	X	poll spor assemb
117.	Hall	1963	X	X	X	X	X	X	megasp
118.	Hall	1970	X	X	X	X	X	X	spor megasp
119.	Hall	1971	X	X	X	X	X	X	spor morph
120.	Hall and Peake	1968	X	X	X	X	X	X	spor megasp
121.	Hedlund	1963	X	X	X	X	X	X	poll spor assemb
122.	Hedlund	1966	X	X	X	X	X	X	spor poll assemb
123.	Hedlund	1967	X	X	X	X	X	X	spor syst
124.	Kovach	1988	X	X	X	X	X	X	megasp paleoec
125.	Kovach and Dilcher	1985	X	X	X	X	X	X	megasp <i>Paritrimetes vittatus</i>
126.	Kovach and Dilcher	1988	X	X	X	X	X	X	megasp seeds assemb
127.	May and Traverse	1973	X	X	X	X	X	X	poll spor assemb

Table 2 (cont'd).

NO. AUTHOR(S)	C R E T A C E O U S												DATE	LOCATION	DESCRIPTION	
	LOWER CRETACEOUS UPPER CRETACEOUS															
	MID-CRET.															
	B	V	H	B	A	A	C	T	C	S	C	M				
	E	A	A	P	L	E	U	O	A	A						
	R	L	U	R	T	B										
160. Hall							X	X	X	X	X		1975	NA	megasp	
161. Penny							X	X	X	X	X		1969	NA	poll spor general	
162. Scott and Srivastava							X	X	X	X	X		1984	USA CO,c	reworted palynomorphs	
163. Srivastava							X	X	X	X	X		1967	NA	review	
164. Techudy, R.H.							X	X	X	X	X		1961	USA CO WY	strat paleoec	
165. Techudy, R.H.							X	X	X	X	X		1973	USA IL, MO, LA, AL, MS	strat Comptenopolis	
166. Techudy, R.H.							X	X	X	X	X		1975	USA MS, AL, TN, GA, LA	poll strat Normapollis	
167. Techudy, R.H.							X	X	X	X	X		1981	CAN,w USA,w	poll Normapollis paleog	
168. Dufek							X	X	X	X	X		1987	USA UT,c Emery County	poll spore disturbance succession	
169. Gray et al.							X	X	X	X	X		1966	USA UT,c	assemb corr	
170. Griebach							X	X	X	X	X		1956	USA WY,sw	poll spor dino acri	
171. McIntyre and Sweet							X	X	X	X	X		1986	CAN AT	poll spor dino acri	
172. Stone							X	X	X	X	X		1967	USA TX,ne	strat	
173. Valentine							X	X	X	X	X		1984	USA TX Atlantic coast	strat regional	
174. Orlansky							X	X	X	X	X		1971	USA UT,s Garfield County	strat assemb	
175. Griggs							X	X	X	X	X		1970a	USA WY,nc Bighorn Basin	poll spor dino acri	
176. Techudy, R.H.							X	X	X	X	X		1965	USA PA Appalachian Mtns	poll spor assemb	
177. Hall							X	X	X	X	X		1967	NA USA MT MD	megasp morph	
178. Techudy, R.H.							X	X	X	X	X		1980	USA,w CAN,w	angio Aquilapollis	
179. Jacobson and Nichols							X	X	X	X	X		1980	USA WY,sw	dino Dinogymnium morph	
180. Techudy, R.H.							X	X	X	X	X		1976a	CAN NM,nw	assemb strat	
181. McIntyre							X	X	X	X	X		1974	CAN NWT DM Horton River	poll spor dino acri	
							X	X	X	X	X				assemb strat	

Table 2 (cont'd.)

Key to Abbreviations:	
Location:	Description:
NA	acri
SA	angio
EU	assemb
AS	biblio
AF	corr
AU	dino
USA	evol
CAN	megaf
MEX	megasp
GRE	morph
ENG	occur
FRA	paleoec
50 U.S. states use U.S. state postal code abbreviations	paleog
AT	poll
BC	spor
DM	strat
MB	syst
NF	ultra
NT	zone
ON	
SS	
YU	
,n	acritarchs
,s	angiosperms
,e	assemblages
,w	bibliography
,c	correlation
,nc	dinoflagellates
,sc	evolution
,ec	megafl
,wc	megaspores
	morphology
	occurrences
	paleoecology
	paleogeography
	pollen
	spores
	stratigraphy, bio-
	systematics
	ultrastructure
	zonation

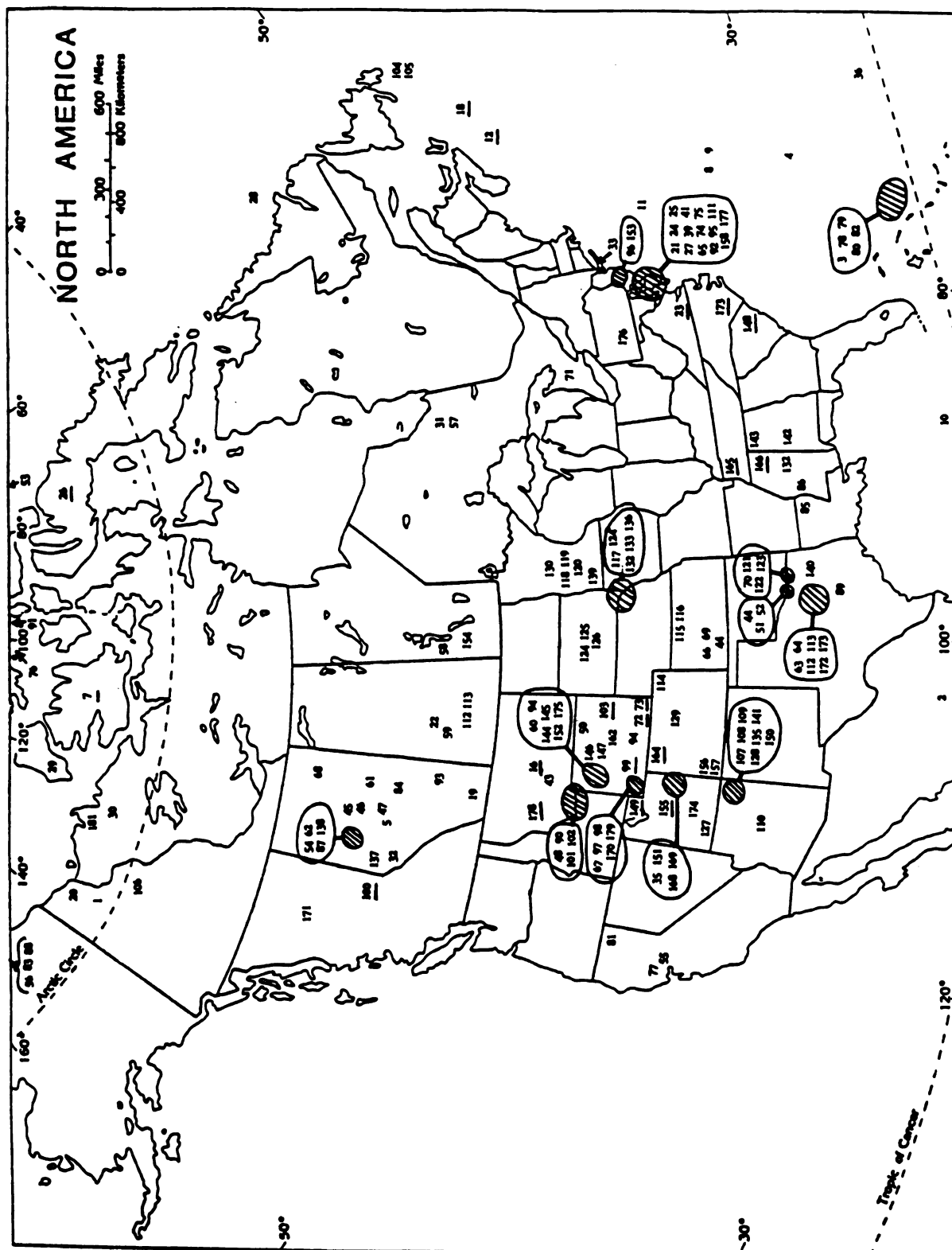


Figure 2. Index map of palynological studies dealing with the mid-Cretaceous of North America.

Note: Locations are approximate. Underlined numerals represent studies of a more regional nature. See Table 2 for list of studies.

Thompson (1969, 1972) investigated the utility of terrestrial pollen and spores and marine dinoflagellates and acritarchs for correlation; identification of faulted or missing stratigraphic units; and paleoenvironmental analysis, particularly proximity or distance from shore of depositional units. Gray *et al.* (1966) studied the palynoflora of the Ferron Sandstone coals, and correlation of Ferron coal splits in the northern part of Castle Valley. Dufek (1987) studied changes in pollen and spore assemblages in the coals and associated rocks of the Ferron Sandstone in the central part of Castle Valley, and effects of volcanic deposits on plant succession, particularly peat-forming floras.

This study represents a continuing effort at Michigan State University to investigate the palynostratigraphy of the Cretaceous rocks of the Western Interior. Previous studies have included the Albian of southwest Wyoming (Tingey, 1978); the Cenomanian-Santonian interval of southwest Colorado (Thompson, 1969); the Cenomanian-Santonian interval of northern Wyoming (Griggs, 1970a); the Turonian of central Utah (Dufek, 1987); the Campanian of eastern Utah (Kidson, 1971), southern Wyoming (Stone, 1971), and northwest New Mexico (Jameosanaie, 1983, 1987); the Campanian-Maestrichtian interval of western Colorado (Gies, 1972); and the Maestrichtian-Paleocene interval of central Utah (Yi, 1989).

Other published reports that have been especially useful in this study include: Brenner (1963) in which the palynology of the Potomac Group in Maryland is described; Hedland (1963, 1966), and Hedland and Norris (1968, 1986) in which palynomorphs from the Albian and Cenomanian in southern Oklahoma were described; Romans (1975), in which the palynology of coals from the Cenomanian-Coniacian interval of Black Mesa, Arizona were described; Singh (1964, 1971, 1983) in which palynomorph assemblages from Albian and Cenomanian rocks in Alberta, Canada were described; and Wingate (1980) in

with A

peirson

n. 1242

Jacobson

which Albian palynomorph assemblages of southern Oklahoma were described. A palynostratigraphic zonation for Albian through Maestrichtian rocks of the overthrust area in Utah, Wyoming and Colorado was developed by Nichols *et al.* (1983) and Nichols and Jacobson (1982a, 1982b).

STRATIGRAPHY

REGIONAL GEOLOGIC SETTING

During the late Early Cretaceous, uplift and deformation of the Sevier Orogeny began in the area of eastern Nevada and western Utah. This deformation, which consisted chiefly of eastward thrusting sheets of early to mid-Paleozoic rocks, continued through the Cretaceous and into the lowermost Tertiary (Armstrong, 1968). Parallel to this north/south trending orogenic belt, an elongate, asymmetrical foreland basin developed to the east which received the detrital material being shed off the highlands to the west. This basin became a depression into which the Cretaceous epicontinental seaway transgressed. A depocenter was already present to the east. The transgression extended westward during the Early Cretaceous, and also connected northward to the embayment from the Arctic. Figure 3 depicts the tectonic setting of North America during the Sevier Orogeny. As can be seen from this diagram, the region of eastern Utah and western Colorado was an area of very active deposition at this time. At its maximum development, the basin extended from Arctic Canada to the Gulf of Mexico, a distance of approximately 3,000 mi (4,800 km), and from south-central Utah to southwestern Minnesota, a distance of more than 1,000 mi (1,600 km) (Kauffman, 1977). Figure 4 depicts generalized representations of the paleogeography of North America during early Cenomanian and late early Turonian times.

An early fluvial phase (Barremian through early Albian) dominated sedimentation within the foreland basin with streams flowing eastward off the rising uplands, then turning northward to empty into the Arctic Sea (Young, 1970). The Cedar Mountain Formation

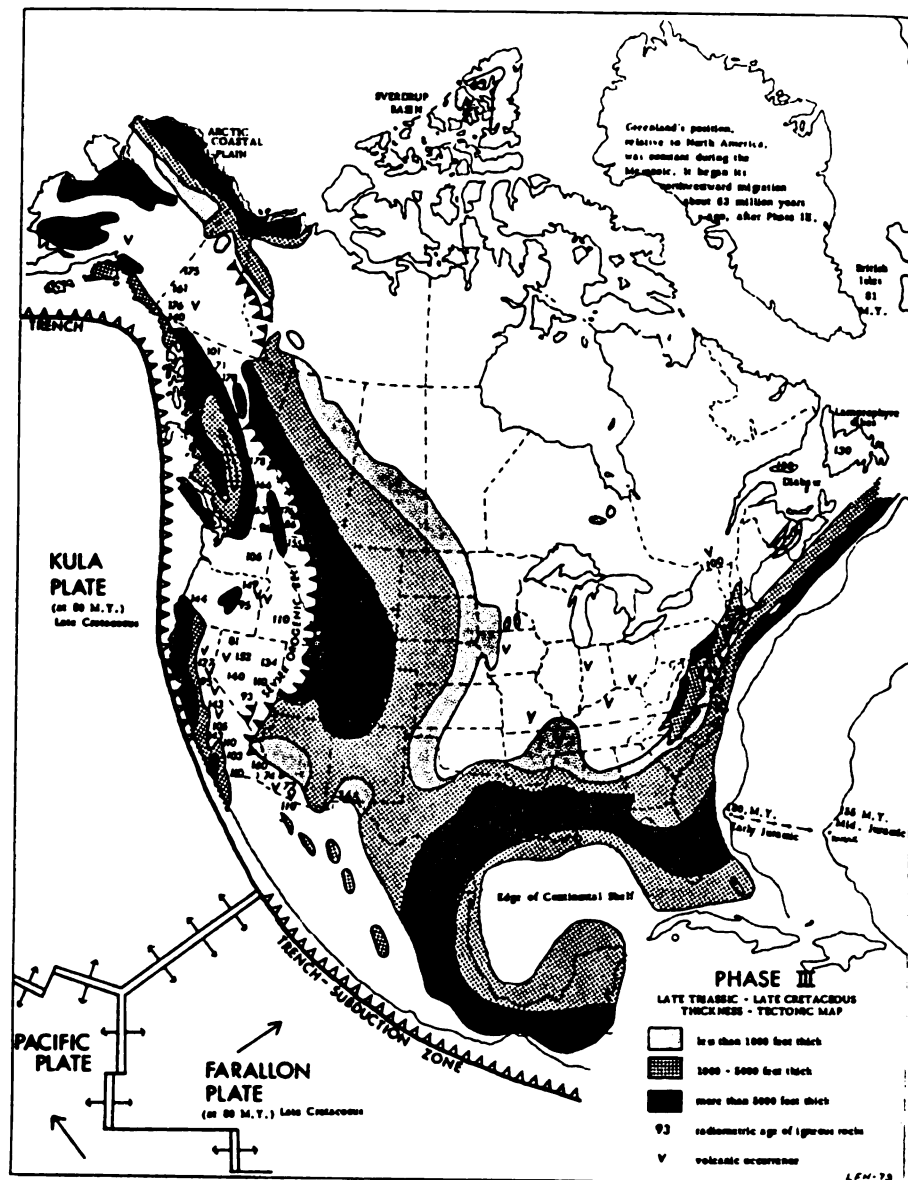


Figure 3. Tectonic setting of North America during the Sevier orogeny.

Source: From Hintze (1973).

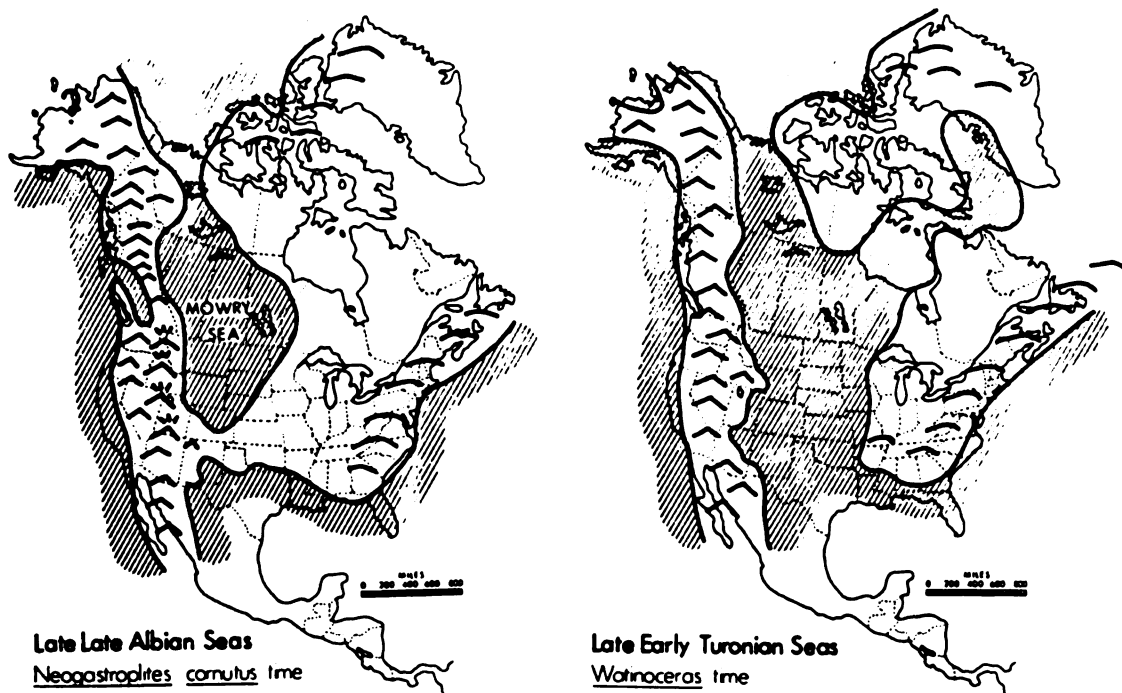


Figure 4. Paleogeography of North America during the early Cenomanian and late early Turonian.

Note: Although Williams and Stelck indicate that the Mowry Sea transgressed into northern Utah during the latest Albian, palynological assemblages from the Steinaker Draw section in the current study suggest that the Mowry Shale is early Cenomanian in age in northeastern Utah.

Source: From Williams and Stelck (1975).

and Burro Canyon Formation of eastern Utah and western Colorado are attributed to this fluvial phase.

This early fluvial phase was followed by a period (middle Albian to early Cenomanian) of broad warping and erosion of the fluvial sediments to produce an unconformity in the area of eastern Utah and western Colorado. To the north during this period, however, the Mowry Sea was gradually extending southward, reaching the Uinta Basin by the end of the Albian or early Cenomanian. A southern extension of the sea spread northward over what is now Texas and New Mexico, so that only a divide of very low topography remained in Colorado and Utah. By this time, the area of thrusting had shifted eastward into western Utah. Volcanism, with sources in Idaho, Montana and western Canada, was increasingly prevalent in the Early Cretaceous. Regionally, it reached its peak during the late Albian and Cenomanian (Kauffman, 1977).

Associated with the slowly transgressing seas, broad, low-lying coastal plain and shallow marine shelf environments developed that shifted laterally with rising or falling sea levels. The Mowry Shale of northeastern Utah, and the Dakota Sandstone of southern and east-central Utah and west-central Colorado were deposited in this setting during the early to late Cenomanian.

Beginning about mid-Cenomanian time, a period of subsidence in the area of eastern Utah and western Colorado resulted in the transgression and deepening of the Mancos Seaway. The Tununk Shale was deposited under transgressional conditions, followed by regression from middle Cenomanian to late Turonian time. At maximum transgression, the Tununk Shale extended as far west as Sanpete Valley on the western side of the Wasatch Plateau (Fouch *et al.*, 1983). Regression of the Mancos Sea during the late Turonian was initiated by renewed tectonic uplift to the west which produced a cycle of

progradational clastic sedimentation (Weimer, 1983b). The Ferron Sandstone Member of the Mancos Shale in Castle Valley and in eastern Utah and western Colorado, and the Frontier Sandstone in the Uinta Basin were deposited during this period of regression. The mid-Cretaceous culminated in the latest Turonian or early Coniacian transgression of the Mancos Sea, and the deposition of the Blue Gate Shale Member of the Mancos Shale conformably on top of the Ferron Sandstone.

Stratigraphic correlation of the Cretaceous units of the San Rafael Swell area, western Colorado and the Uinta Basin are shown together with the Western Interior Standard Reference Section, selected ammonite fossil zones, and the palynological zonation for the Wyoming-Colorado-Utah area in Figure 5. Figure 6 is a diagrammatic cross-section of Cretaceous strata extending from western Utah to western Colorado.

CEDAR MOUNTAIN AND BURRO CANYON FORMATIONS

The Cedar Mountain Formation was named by Stokes (1944) for variegated, bentonitic mudstones occurring stratigraphically between the Upper Jurassic Brushy Basin Member of the Morrison Formation and the Dakota Sandstone on the southwest flank of Cedar Mountain in Emery County, northwest of Green River, Utah. It currently consists of the thin, lower Buckhorn Conglomerate Member, which had previously been assigned formational status, and a thicker, upper shale member (Stokes, 1952). In some places the basal conglomerate may be missing, and in other areas, more than one conglomerate or conglomeratic sandstone may be present (Young, 1960, 1973). The Cedar Mountain Formation is recognized throughout south-central and northeastern Utah and northwestern Colorado.

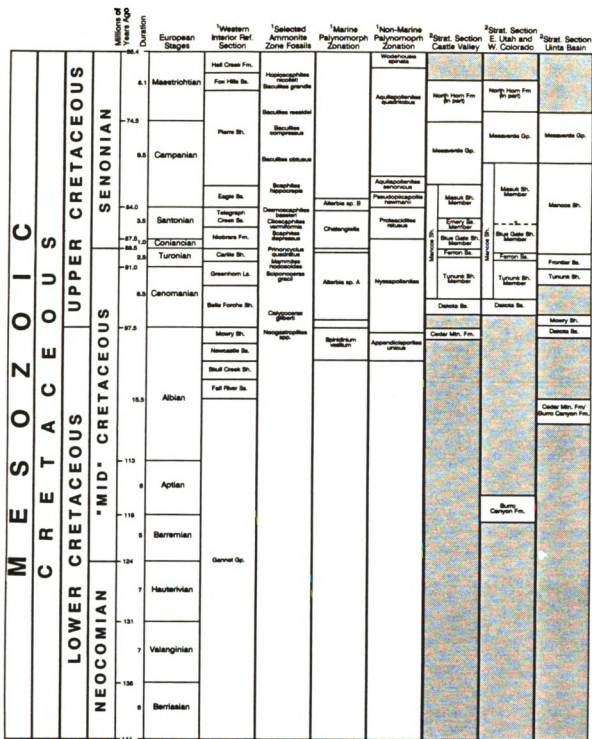


Figure 5. Correlation and age of mid-Cretaceous units of eastern Utah and western Colorado.

Sources: ¹Modified from Nichols and Jacobson, 1982b. ²Modified from Hintze, (1973).

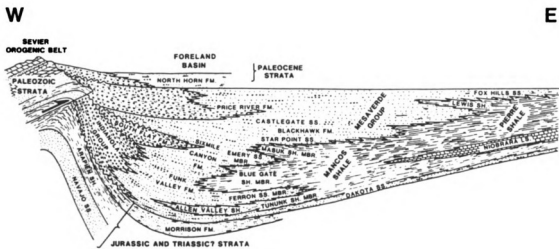


Figure 6. Diagrammatic cross-section of Cretaceous strata extending from western Utah to western Colorado.

Sources: From Ryer (1981b). Modified from Armstrong (1968).

Fossils other than pollen and spores that have been reported from the Cedar Mountain Formation include the wood of conifers, *Tempskya* (a tree fern) and cycadeoids (Furniss and Tidwell, 1972; Tidwell and Herbert, 1976; Tidwell *et al.*, 1976; Thayn *et al.*, 1973), dinosaur egg shells and bones (Bodily, 1969). Thayn and Tidwell (1984a, 1984b) and Thayn *et al.* (1983, 1985) have recognized at least three genera of angiospermous wood from the Cedar Mountain Formation in Castle Valley.

The Burro Canyon Formation was proposed for variegated, non-bentonitic shales alternating with conglomerate, sandstone, limestone and chert in Burro Canyon, San Miguel County, Colorado (Stokes and Phoenix, 1948). The Burro Canyon Formation can be traced from southeastern Utah and southwestern Colorado northward into west-central and northwest Colorado.

There has been some debate concerning the age and stratigraphic relations between these two units (Young, 1960; Craig *et al.*, 1961), but most have agreed that the Cedar Mountain Formation and the Burro Canyon Formation are physically continuous and grade laterally into each other to some extent. With this debate in mind, Tschudy *et al.* (1984) conducted a palynological study of these units in order to more precisely determine the age relationships. Only three productive samples (two from the Burro Canyon Formation and one from the Cedar Mountain Formation) were found among those collected. They were able to suggest that the lower part of the Cedar Mountain Formation lacking invertebrate fossils may be equivalent to the upper part of the Burro Canyon Formation.

Young (1960) proposed that the name Burro Canyon Formation be dropped because of the physical continuity of the two units. However, the use of the two names continues in the literature because each unit has proved to be recognizable and mappable.

An art

Canyon

Jurass

gradat

Forma

makes

thick se

"lower"

compa

stilar

Cedar

would

Mount

MOWA

northw

expos

lamin

easy

West

Colora

An arbitrary lateral boundary between the Cedar Mountain Formation and the Burro Canyon Formation has been placed along the Colorado River in Utah (Stokes, 1952).

These units were deposited unconformably on the Morrison Formation of Late Jurassic age. Craig *et al.* (1961) interpreted the Morrison/Burro Canyon contact as gradational and intertonguing, but an age assignment of Albian for the Cedar Mountain Formation and Barremian-Aptian for the Burro Canyon Formation (Tschudy *et al.*, 1984) makes this interpretation unlikely.

In the Uinta Basin, a shale unit, which lies between the Morrison Formation and a thick sandstone referred to as "upper" Dakota Sandstone, has been mapped in the past as "lower" Dakota Sandstone (Kinney, 1955; Hanson, 1965). Lithologically, this "lower Dakota" compares well with the Cedar Mountain Formation; however, this unit is probably more similar in age and correlates more closely to the Burro Canyon Formation than to the Cedar Mountain Formation based on palynological evidence presented in this study. This would support the conclusion of Tschudy *et al.* (1984) regarding the age of the Cedar Mountain and Burro Canyon formations.

MOWRY SHALE

The Mowry Shale was named by Darton (1904) for exposures on Mowry Creek, northwest of Buffalo, Wyoming, but was given formational status by Hares (1916) based on exposures in the Wind River Basin. The Mowry Shale is a hard, siliceous, dark gray, laminated shale, interbedded with thin sandstones and bentonites, and weathers to an easily recognizable silvery-grey color. During the time of Mowry Shale deposition, the Western Interior Seaway extended as far south as northeastern Utah and northwestern Colorado. The southern limit is well exposed in Colorado, but south of the exposures in the

Uinta Basin of northeastern Utah, the unit is deeply buried and its limits are uncertain (Davis, 1970; Hale and Van De Graaff, 1964).

Byers and Larson (1979) recognized three facies in the Mowry Shale of Wyoming: laminated mudstone, bioturbated mudstone and bioturbated sandstone. These facies represent deposition in areas of increasing amounts of free oxygen and are probably indicators of water depth and circulation in the basin. In the Uinta Basin, only the laminated mudstone facies is present. This facies is interpreted as representing sedimentation within a restricted embayment of the Western Interior Seaway under anoxic conditions, probably at a depth of more than 15 m (Byers and Larson, 1979). Under these conditions, except for nektonic and planktonic forms, fossil remains found in these rocks were probably transported, and do not represent indigenous biota.

Slaughter and Earley (1965) made an extensive study of numerous bentonite beds located within the Mowry Shale. They found that each major bentonite had a characteristic mineralogy that is similar over great distances. Using the mineralogical information and electric logs, they were able to correlate the bentonites over large areas. They concluded that these bentonite beds were deposited as volcanic ash, and transported to the site of deposition by wind originating from the west and northwest. By examining the sand-sized fraction, they were able to determine that the igneous source rock was rhyolitic to andesitic.

The source of the silica cement in the Mowry Shale has been debated. Ruby (1929) hypothesized that the silica was derived directly from volcanic ash. However, this interpretation was challenged by both Davis (1970) and Cluff (1976) who suggested that the silica was derived from the degradation of radiolarian tests. However, the high rate of

radiolarian productivity was due, at least in part, to the constant supply of silica to the seaway from the western margin (Davis, 1970).

Disarticulated fish scales and bones are common throughout the unit, but the rarity of other diagnostic megafossils has led to some question regarding the time-stratigraphic relations of the Mowry Shale (Nixon, 1973). Reeside and Cobban (1960), collected ammonites of the genus *Neogastrolites* from the Mowry of central Wyoming, and assigned an age of late Albian to the unit in this area. However, Cobban and Kennedy (1989) now consider, the ammonite *Neogastrolites americanus*, which was collected from the Mowry, to indicate an early Cenomanian age. Tschudy and Veach (1965) illustrated pollen, spores and dinocysts from the Mowry Shale in a U.S. Geological Survey Open-File Report, but offered no age determination. Sulkoske (1975) described dinocysts from the Mowry Shale in south-central and western Wyoming, and suggested a late Albian age.

DAKOTA SANDSTONE

The Dakota Sandstone is a widespread time-transgressive unit, which was originally named by Meek and Hayden (1862) for basal Cretaceous rocks near the town of Dakota in northwest Nebraska. It is late Albian in age at the type locality (Cobban and Reeside, 1952), but becomes progressively younger in a westerly direction. Agasie (1969) and May and Traverse (1973) assigned an age of Cenomanian to the Dakota Sandstone of the southern Colorado Plateau on the basis of pollen and spores. An age of late Cenomanian was assigned by Eaton *et al.* (1990) in Castle Valley, near the Molen section, on the basis of ammonites and bivalves.

Many variants on this name (Dakota Group, Dakota Formation, Dakota Sandstone, Dakota (?)) have been applied to basal Cretaceous rocks throughout the Western Interior.

This pract

Young (1)

the Manc

Natural

Mountain

Stokes an

the simi

between

upper be

part of th

T

of these

the Ced

Cedar M

underly

Sandst

two fo

confus

Forma

Sandst

Valle

Cree

from

This practice has led to considerable confusion regarding the proper usage of the term. Young (1960) proposed that the carbonaceous beds and associated sandstones beneath the Mancos Shale of the eastern Utah and western Colorado area be referred as the Naturita Formation; and that together with the underlying noncarbonaceous Cedar Mountain Formation (Cedar Mountain and Burro Canyon Formation of Stokes, 1944, and Stokes and Phoenix, 1948) be included in the Dakota Group. This assignment is based on the similar fluvial origin of the two units, and an apparent transgressive facies relationship between the Cedar Mountain Formation and the Dakota Sandstone. He indicated that the upper beds of the Cedar Mountain Formation in the west passed laterally into the lower part of the Dakota Sandstone in the eastern part of the study area.

The problematic nature of the nomenclature and interpretation of the relationships of these rocks is exemplified by Craig *et al.* (1961). They maintain that the contact between the Cedar Mountain Formation and the Dakota Sandstone is unconformable, and that the Cedar Mountain Formation and Burro Canyon Formation are more closely related to the underlying Brushy Basin Member of the Morrison Formation than to the overlying Dakota Sandstone. Due to this questionable relationship, Craig *et al.* (1961) felt that combining the two formations into a group, yet retaining the name Dakota would be inappropriate and confusing. In this study, the names Cedar Mountain Formation and Burro Canyon Formation will be used for the lower noncarbonaceous units and the name Dakota Sandstone will be used to refer to the overlying carbonaceous unit.

The Dakota Sandstone in the area of study is quite diverse in nature. In Castle Valley it ranges in thickness from 12 ft (4 m) at Farnham Dome to 29 ft (9 m) at Ivie Creek. It is predominately a medium- to coarse-grained, cross-bedded sandstone that thins northward. But in some localities, a few feet of the overlying carbonaceous shale can be

assigned to the Dakota. At Molen, a 3 ft (1 m) sandstone is overlain by 8.5 ft (2.5 m) of dark grey shale which yields only terrestrial palynomorphs. The upper contact at this locality is placed at a 6 inch (15 cm) gravel zone composed of black quartzite pebbles. Above this zone, a mixed terrestrial/marine palynomorph assemblage, typical of the Tununk Shale, is found. To the south, at Ivie Creek, the Dakota consists of carbonaceous shales and a thin coal bed overlain by a 20 ft (6 m) sandstone.

On the east side of the San Rafael Swell, the Dakota Sandstone is composed only of a 3 ft (1 m) or less pebble conglomerate, and near Green River, Utah, the Cedar Mountain Formation is directly overlain by the Mancos Shale. Farther east, at Westwater Wash and Horsethief Canyon Ranch, several thick sandstones and coals are present in the Dakota. The thickness is greater than 90 ft (27 m) at these eastern localities.

In the Uinta Basin, a sandstone referred to as the Dakota Sandstone is divided disconformably into a "lower" shale unit and an "upper" sandstone unit. The shale unit, as mentioned earlier, is probably correlatable to the Cedar Mountain or Burro Canyon formation. The "upper" sandstone of the Dakota Sandstone in the Uinta Basin is also older than the Dakota to the south, because it lies beneath the early Cenomanian Mowry Shale. It may represent a time-transgressive unit correlative to the Dakota Sandstone to the south, or it may be a unit entirely unrelated to Dakota deposition.

MANCOS SHALE

Tununk Shale Member

The Tununk Shale is the lowermost member of the Mancos Shale in eastern Utah and western Colorado. It was named by Gilbert (1877) for outcrops of shale on the Tununk Plateau in the Henry Mountains of Utah. It is composed of silty marine shales and

mudstones. It overlies the Cenomanian Dakota Sandstone abruptly and disconformably. Ryer and McPhillips (1983) attribute the disconformity to rapid transgression of the Mancos Sea. It grades into the overlying Ferron Sandstone through a series of alternating sandstone and shale layers.

The age of the Tununk Shale is late Cenomanian to middle Turonian. The oyster *Pycnodonta newberryi*, which appears near the base of the Tununk Shale on the west side of the San Rafael Swell, is an indicator of late Cenomanian age. Obradovich and Cobban (1975) dated the *P. newberryi* zone at 90 my. Eaton *et al.* (1990) indicated that the age of the lower part of the Tununk Shale in Castle Valley is of latest Cenomanian to early Turonian.

In Castle Valley, the Tununk Shale ranges in thickness from approximately 300 ft (91 m) near Farnham Dome at the north, to over 700 ft (213 m) south of Emery, Utah. In the area of eastern Utah and western Colorado, it is notably thinner. This is due, in part, to the fact that the Ferron Sandstone in that area is represented by a unit that is stratigraphically lower in the section than the Ferron Sandstone of Castle Valley (Cotter, 1976). It thins eastward to only 140 ft (43 m) at Sylvania Ranch and 165 ft (50 m) at Harley Dome at the Utah-Colorado border, but it thickens again eastward into Colorado.

In the Uinta Basin, the Tununk Shale is probably represented by a 56 ft (17 m) thick silty shale that lies disconformably upon the Mowry Shale and that has been referred to as the "lower" Frontier Sandstone. This transition from silicic shales of the Mowry Shale to silty shales of the Tununk Shale may represent the transition from a closed embayment to open marine conditions at the time when transgressing seas from the north and south connected. Reeside (1955) and Hale and Van De Graaff (1964) recognized the disconformity between

the M

Turkey

Fern

for co

Vale,

condo

In Cal

of En

ess s

that

Size

of am

of the

need

Don

the P

the

bee

Has

and

the Mowry Shale and the Tununk Shale, and concluded that the Cenomanian to middle Turonian time unit is missing in this area.

Ferron Sandstone Member and Frontier Formation

The Ferron Sandstone Member of the Mancos Shale was named by Lupton (1914) for coal-bearing sandstones, siltstones and shales exposed east of Ferron, Utah in Castle Valley. The contact between the Ferron Sandstone and the underlying Tununk Shale is conformable and gradational. The Blue Gate Shale Member overlies the Ferron Sandstone. In Castle Valley, the Ferron Sandstone ranges in thickness from over 800 ft (240 m) south of Emery at Ivie Creek to about 75 ft (23 m) east of Price at Farnham Dome. From the east side of the San Rafael Swell eastward into Colorado, the physical aspect of the Ferron changes and is composed of two thin sandstones separated by a thin tongue of the Tununk Shale.

The age interpretation of the Ferron sandstone is based primarily on the occurrence of ammonites found in marine sandstones in the Ferron and in the bounding marine shales of the Tununk and Blue Gate. Cobban (1976) found the ammonites, *Prionocyclus hyatti*, near the base of the Ferron, and *Scaphites warreni* near the top of the Ferron at Farnham Dome. On this evidence, he assigned an age of late middle to late Turonian (Figure 5).

It has been recognized (Cotter, 1975a, 1975b, 1976; Davis, 1954; Katich, 1954,) that the Ferron Sandstone exposed in Castle Valley is comprised of sediments deposited by two different deltas. In the northern part of the valley, thin, sheet-like marine sandstones have been attributed to the Vernal Delta that had a source to the north and west (Cotter, 1975b; Hale and Van De Graaff, 1964). The Last Chance Delta, that had a source to the south and southwest, was responsible for the deposition of a thick clastic wedge which pinches

out northward and eastward (Hale, 1972; Katich, 1953). Figure 7 shows the approximate location of the Vernal and Last Chance Deltas. Detailed mapping and correlation of these units in outcrop show that the two depositional systems were not entirely contemporaneous. The northern units lie in part stratigraphically lower than the southern unit; and therefore, the lower strata are slightly older.

Figures 8 and 9 show the stratigraphic and geographic distribution of the different units of the Ferron Sandstone as described by Cotter (1975b). He divided the sedimentary rocks attributable to the Vernal Delta into four units: the Clawson unit, the Washboard unit, the Farnham unit and the Woodside unit. He proposed that the environments of deposition for these units would have been similar to the modern-day Georgia coast of the Atlantic ocean which is characterized by low wave energy and tidal domination.

The Clawson unit is a poorly sorted, fine-grained silty sandstone that is bioturbated throughout its entire thickness. Cotter (1975b) attributes most of the bioturbation to the teichichnians, as seen by the trace fossil known as retusive *Teichichnus*, although other, less identifiable burrows are discernable. One of the most striking features of the Clawson unit is the presence of massive carbonate concretions, some up to 8 ft (2.5 m) in diameter, scattered throughout the unit. These concretions sometimes have septarian calcite at their centers, and may form at several levels within the unit. At Elmo Road, these concretions can be seen weathering out at the surface just above the top of the Clawson unit. The Clawson unit thins southward and becomes finer, so that east of Emery it gradually blends into the Tununk Shale, while its northern limit is lost in cover north of Elmo Road. The maximum thickness is about 45 ft (14 m) near Ferron. This unit has been interpreted by Cotter (1975b, 1976) as an offshore-shelf environment that accumulated slowly seaward of the shoreface. This is indicated primarily by the intense bioturbation and very fine grain

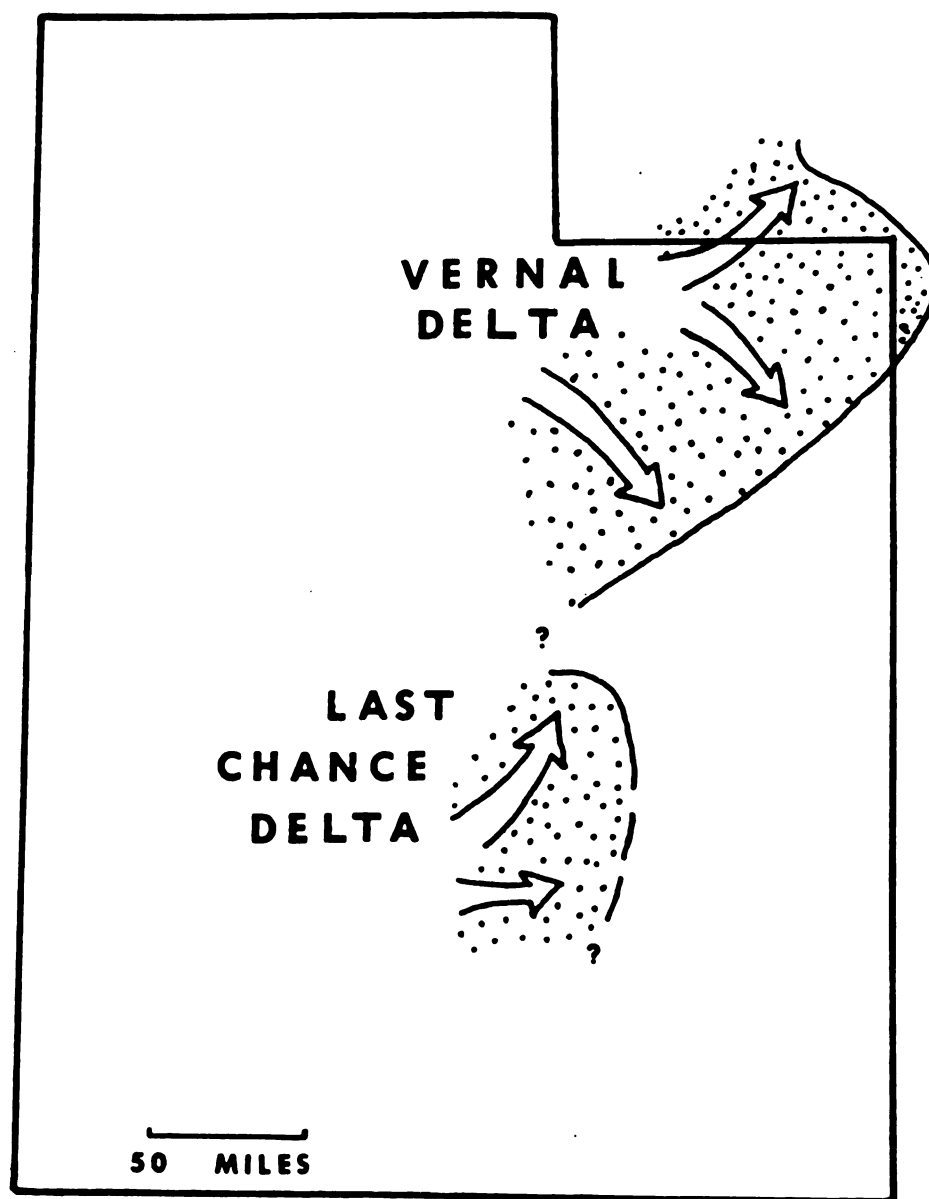


Figure 7. Delta systems attributed to the Turonian Ferron Sandstone.

Source: From Cotter (1976).

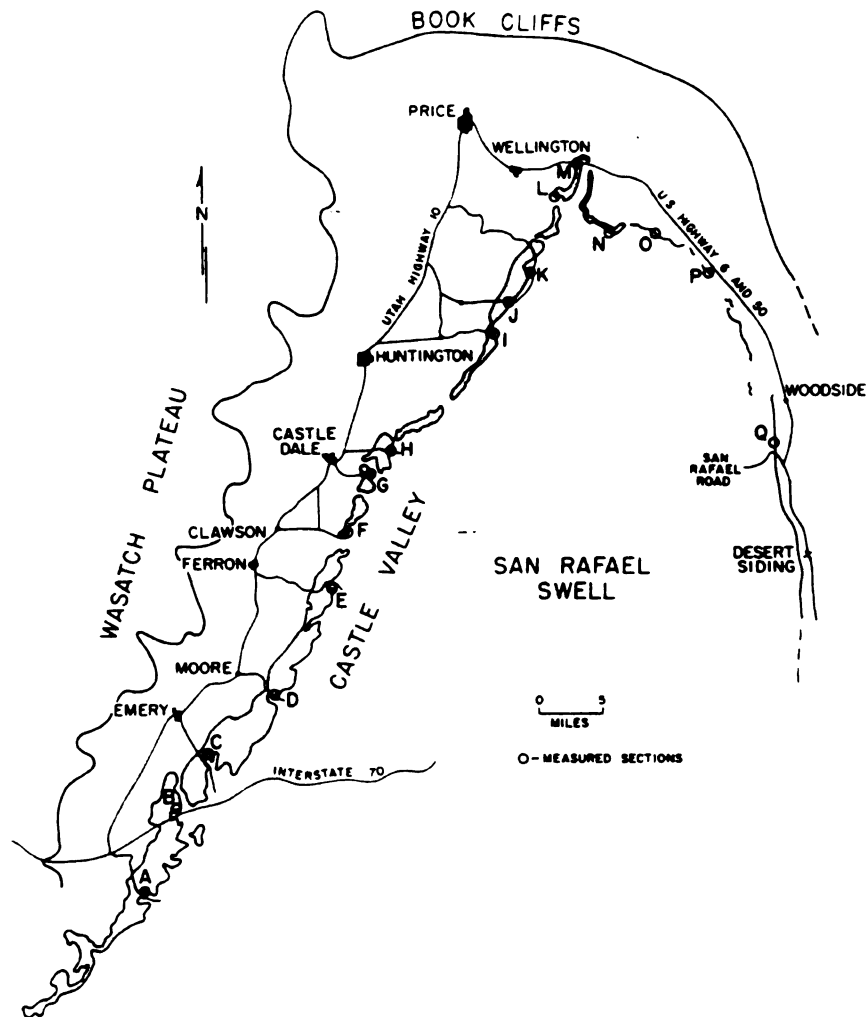


Figure 8. Map of the Ferron Sandstone outcrop in Castle Valley.

Source: From Cotter (1975b).

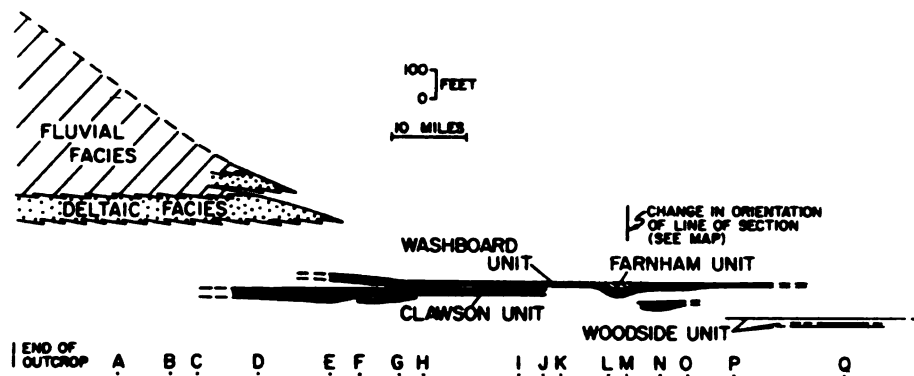


Figure 9. Cross-section of Ferron Sandstone in outcrop in Castle Valley.

Source: From Cotter (1975b).

size. Land (1972), Paull (1962) and Young (1955, 1957) have previously noted similar large concretions in offshore deposits.

The Washboard unit is the most extensive of the northern units. It is exposed from south of Dry Wash northward around the northern tip of the San Rafael Swell, and south again to the Woodside-Desert Siding area. It is composed of laminated, fine-grained sandstone and bioturbated fine-grained sandstone in varying proportions (Cotter, 1975b), and has a maximum thickness of 30 ft (9 m). The laminated sandstone contains identifiable trace fossils such as *Ophiomorpha*, *Thalassinoides*, *Rosselia* and *Teichichnus*. The bioturbated sandstone is similar in nature to that of the Clawson unit. Large concretions are also common in this unit. Beds of laminated sandstone with an overall coarser texture, interbedded with intensely bioturbated silty sandstones indicate that the Washboard unit was deposited in a similar environment to that of the Clawson unit, but slightly closer to the shoreface. In such an environment, occasional storms introduced laminated sand bodies, the upper portions of which were then affected by post-storm feeding activity.

The Farnham unit is a laterally-limited unit that is enclosed within the Washboard unit at Farnham Dome. It reaches a maximum of 25 ft (7.5 m) and is exposed only for about 3 miles. It is composed of cross-bedded fine-grained sandstone. Shell fragments of bivalves and gastropods, which show little sign of abrasion, are commonly abundant. The unit has a sharp basal contact with the underlying part of the Washboard unit. The only common trace fossil is protrusive *Teichichnus*, which is uncommon in all of the other units (Cotter, 1975b). Cotter (1975b) attributes these deposits to erosion and sedimentation associated with a tidal inlet.

The Woodside unit is composed of about 15 ft (4.5 m) of thin, fine-grained sandstones and siltstones interbedded with dark gray, bioturbated carbonaceous shale.

Center

along

Howe

traced

Green

the

unit w

From

near

Base

A: S

the

(19

198

He

an

M

H

S

C

T

Cotter (1975b) noted that this unit could be traced along outcrops from Grassy Creek south along the eastern flank of the San Rafael Swell to the Woodside-Desert Siding area. However, this unit, and a similar sandstone which lies about 100 ft (30 m) above it, can be traced as a low lying cuesta south to Green River and as far east as Delta, Colorado. From Green River eastward, concretions of about 4 to 5 ft (1.5 m) can be seen associated with this unit. Cotter (1975b) concluded that the environment of deposition of the Woodside unit was a submerged, offshore marine sandstone bar in a shallow shelf sea.

In the Uinta Basin, deposits attributable to the Vernal Delta are referred to as the Frontier Formation. The Frontier Formation was named by Knight (1902) for exposures near Kemmerer, Wyoming. Richter (1983) studied the Frontier Formation of the Uinta Basin and concluded that it resulted from deposition in a wave-dominated delta system. At Steinaker Draw, the unit consists of several massive, cross-bedded sandstones, interbedded with siltstones and carbonaceous shales. A thin coal occurs near the top.

The sediments attributed to the Last Chance Delta have been studied by Cleavinger (1974), Cotter (1975a, 1976), Dufek (1987), Ryer (1981a, 1981b, 1981c, 1982a, 1982b, 1983) and Thompson (1985). This unit is well exposed south of Emery, Utah, at Ivie Creek. Here, the unit consists of over 800 ft (240 m) of sandstone, mudstone, carbonaceous shale and coal. It thins rapidly to the north and east, so that, in outcrop, it grades laterally into Mancos Shale just north of Ferron. Unlike the offshore marine shelf setting of the northern units of the Vernal Delta described by Cotter (1975b), the southern beds of the Ferron Sandstone are attributed to deposition associated with a river-dominated, or low energy delta. Thompson (1985) outlined three phases of deposition to the unit: progradational facies represented by bioturbated, upward-coarsening shelf and delta-front sandstones, siltstones and shales; aggradational facies represented by upward-fining sandstones,

normal

bio-ber

Vernal L

reaches

of econo

of the l

explorat

peat acc

Katchi

Blue Ga

stratega

It is com

character

Valley.

Sandsto

Garzey C

Sandsto

unifrag

Fisher

E

nonmarine siltstones and coals of the delta plain; and transgressive facies represented by bioturbated sandy mudstone and carbonaceous mudstone.

Coal has been mined from sediments attributable to both the Last Chance and Vernal Deltas. In the Vernal Coal Field, in the Uinta Basin, west of Steinaker Draw, coal reaches economic thickness within the Frontier Sandstone. The Ferron Sandstone has coal of economic thickness south of Emery in the Emery Coal Field in a northeastern portion of the Last Chance delta. Coals of economic interest have also been identified in exploration cores in Castle Valley near Price, Utah. These coals have been attributed to peat accumulation within a southern lobe of the Vernal Delta (Cotter, 1975b; Hale, 1972; Katich, 1954).

Blue Gate Shale Member

The Blue Gate Shale Member of the Mancos Shale was named for shales stratigraphically above the Ferron Member in the Henry Mountains by G.K. Gilbert (1877). It is comprised of marine shales and siltstones, and closely resembles the general physical character of the Tununk Shale Member, but is typically less bentonitic. In the area of Castle Valley, it is approximately 2000 ft (610 m) thick, being bounded below by the Ferron Sandstone Member and above by the Emery Sandstone Member in the south and the Garley Canyon Sandstone Member in the Price area. The contact between the Ferron Sandstone and the Blue Gate Shale appears to be conformable, but rather abrupt. The unit ranges in age from late Turonian to Santonian in the Castle Valley area (Cobban, 1976; Fisher *et al.*, 1960; Peterson *et al.*, 1980).

Eastward and northeastward of Castle Valley, the Blue Gate Shale is not differentiated because the Emery Sandstone which separates it from the Masuk Shale

Member is not present. Therefore, shales and silty shales found above the Ferron Sandstone and Frontier Sandstone in eastern Utah and in the Uinta Basin are simply referred to as Mancos Shale.

02

sys

gene

tem

gou

with

post

rem

nom

are

know

104

100

stat

com

SYSTEMATIC PALYNOLOGY

GENERAL REMARKS

The palynomorphs identified in this study have been documented in the following systematic treatment. The palynomorphs are categorized into six main groups representing generalized botanical affinities: angiospermous pollen, gymnospermous pollen, spores of ferns, lycopods and bryophytes, dinoflagellate cysts, acritarchs and miscellaneous. These groups are further subdivided on simple morphological characteristics. Genera and species within each morphological group are listed alphabetically.

Descriptions of palynomorphs are given only for those forms that have not been positively referred to a published species or where additional or circumscriptive descriptive remarks are considered appropriate. In some cases, synonymies are given to help clarify nomenclature. Occurrences outside the geographic and stratigraphic range of this study are given only for those forms for which the observed range is an extension of its previously known range.

Qualitative terms in describing the occurrence of species include: rare (less than 1.0%), common (1.0% to 3.0%), frequent (3.0% to 10.0%), and abundant (greater than 10.0%).

In order to utilize readily available computer programs for data storage and statistical evaluation, each form species was given a species code. A species code is composed of three parts: a four numeral ecological/systematic/morphologic code, followed

by a four letter ge

code for Anisopoli

Dist Letter

1 1

2 1

3 8

4 2

5-8 ART

9-10 01

Table 3 is
with a short expla
in this study with

by a four letter generic code and a two numeral specific code. For example, the species code for *Artiopollis indivisus*, which is 1182ARTI01, is explained as follows:

<u>Digit#</u>	<u>Letter/Num.</u>	<u>Meaning</u>
1	1	Terrestrial Palynomorph (2=Marine Palynomorph)
2	1	Angiosperm Pollen (2=Gymno., 3=Spore producing plants)
3	8	Obligate Tetrad (1-7=Individual Pollen)
4	2	Colpate Obligate Tetrads (1=Porate, 3=Colporate)
5-8	ARTI	Generic Abbreviation
9-10	01	Species Number (02= <i>Artiopollis praecox</i>)

Table 3 is a listing of the ecological/systematic/morphologic part of the species code with a short explanation, and Table 4 lists, in alphabetical order, all palynomorphs reported in this study with their species code, page, and plate and figure information.

Table

Code

1000
1100
1110
1120
1121
1123
1125
1129
1130
1131
1132
1133
1134
1135
1139
1140
1143
1145
1149
1150
1180
1181
1182
1183
1184
1190
1200
1210
1211
1212
121
122
122
122
122
122
122
122

Table 3. List of ecological/systematic/morphologic codes used in computer data storage and statistical calculations.

<u>Code</u>	<u>Description</u>
1000	Terrestrial palynomorphs
1100	Angiosperm pollen
1110	Inaperturate angiosperm pollen
1120	Porate angiosperm pollen
1121	Monoporate angiosperm pollen
1123	Triporate angiosperm pollen
1125	Periporate angiosperm pollen
1129	Other or unknown porate angiosperm pollen
1130	Colpate angiosperm pollen
1131	Monocolpate angiosperm pollen
1132	Dicolpate angiosperm pollen
1133	Tricolpate angiosperm pollen
1134	Tetracolpate angiosperm pollen
1135	Trichotomosulcate angiosperm pollen
1139	Other or unknown colpate angiosperm pollen
1140	Colporate angiosperm pollen
1143	Tricolporate angiosperm pollen
1145	Multicolporate angiosperm pollen
1149	Other or unknown colporate angiosperm pollen
1150	Fenestrate angiosperm pollen
1180	Angiosperm pollen in obligate tetrads
1181	Inaperturate angiosperm pollen in obligate tetrads
1182	Colpate angiosperm pollen in obligate tetrads
1183	Porate angiosperm pollen in obligate tetrads
1184	Colporate angiosperm pollen in obligate tetrads
1190	Other or unknown angiosperm pollen
1200	Gymnosperm pollen
1210	Alete gymnosperm pollen
1211	Inaperturate alete gymnosperm pollen
1212	Monosulcate alete gymnosperm pollen
1213	Porate alete gymnosperm pollen
1219	Other alete gymnosperm pollen
1220	Saccate gymnosperm pollen
1221	Monosaccate gymnosperm pollen
1222	Bisaccate gymnosperm pollen
1223	Multisaccate gymnosperm pollen
1229	Other or unknown saccate gymnosperm pollen
1230	Plicate gymnosperm pollen
1290	Other or unknown gymnosperm pollen

Table 2

Code

1000
1300
1310
1311
1312
1320
1321
1322
1330
1331
1332
1390
1400
1410
1420
1500
1510
1520
1530
1590
1900
2000
2100
2110
2111
2112
2113
2114
2115
212
212
212
212
212
212
213
21
21

Table 3 (cont'd).

<u>Code</u>	<u>Description</u>
1000	Terrestrial palynomorphs (continued)
1300	Fern and lycopod spores
1310	Trilete spores
1311	Trilete microspores
1312	Trilete megaspores
1320	Monolete spores
1321	Monolete microspores
1322	Monolete megaspores
1330	Hilate spores
1331	Hilate microspores
1332	Hilate megaspores
1390	Other or unknown spores
1400	Fungal material
1410	Fungal spores
1420	Fungal tissue
1500	Other terrestrial plant tissue
1510	Cuticle
1520	Seed tissue
1530	Vascular tissue
1590	Other or unknown terrestrial plant tissue
1900	Other or unknown terrestrial palynomorphs
2000	Marine palynomorphs
2100	Dinoflagellate cysts
2110	Proximate cavate
2111	Apical archeopyle
2112	Intercalary archeopyle
2113	Precingular archeopyle
2114	Combination archeopyle
2115	Archeopyle absent or uncertain
2120	Proximate acavate
2121	Apical archeopyle
2122	Intercalary archeopyle
2123	Precingular archeopyle
2124	Combination archeopyle
2125	Archeopyle absent or uncertain
2130	Apteate
2131	Apical archeopyle
2135	Archeopyle absent or uncertain

Table

Code

2000
2100
2140
2140
2143
2145
2150
2151
2153
2154
2155
2190
2200
2210
2220
2300
2900
9000

Table 3 (cont'd).

<u>Code</u>	<u>Description</u>
2000	Marine palynomorphs (continued)
2100	Dinoflagellate cysts (continued)
2140	Spiniferate
2140	Apical archeopyle
2143	Precingular archeopyle
2145	Archeopyle absent or uncertain
2150	Chorate
2151	Apical archeopyle
2153	Precingular archeopyle
2154	Combination archeopyle
2155	Archeopyle absent or uncertain
2190	Other or unknown dinoflagellate cysts
2200	Acritarchs
2210	Acritarchs without processes
2220	Acritarchs with processes
2300	Microforaminiferal linings
2900	Other or unknown marine palynomorphs
9000	Other or unknown palynomorphs

Table

Farm

Answer

Agri:

Also

Also

At the

Amide

Appendix

472

42

422

App

Appa

474

Appendix

452

Appz

Apies

ATL
App:

452

170

Am.

22

Re-

Brain

Br...

By

10

Be

Butter

Big

But

Boy

Ca

تاریخ

Com

Cam.

Carm

Case

Case

Cereb

Chico

Chico

Table 4. Alphabetical list of palynomorphs.

<u>Form</u>	<u>Code</u>	<u>Page</u>	<u>Plate:Figure</u>
Acritarch Form A	2210FORM_A	188	34:8
Aequitriradites ornatus	1331AEQU01	140	18:2
Alisporites bilateralis	1222ALIS01	89	4:11
Alisporites sp. A	1222ALIS_A	89	5:1
Alterbidinium sp. A	2112ALTE_A	153	23:1
Amber Spherules	1590AMBE01	145	19:5
Appendicisporites auritus	1311APPE02	99	7:7
Appendicisporites dentimarginatus	1311APPE08	99	7:8
Appendicisporites insignis	1311APPE12	99	7:9
Appendicisporites potomacensis	1311APPE15	100	8:1
Appendicisporites sp. A	1311APPE_A	100	8:2
Appendicisporites sp. B	1311APPE_B	101	8:3
Appendicisporites sp. C	1311APPE_C	101	8:4
Appendicisporites sp. D	1311APPE_D	101	8:5
Appendicisporites sp. E	1311APPE_B	102	8:6
Appendicisporites sp. F	1311APPE_F	102	8:7
Apteodinium maculatum	2123APTE01	165	27:4-5
Araucariacites australis	1211ARAU01	83	3:12
Arcellites disciformis	1312ARCE01	142	18:6
Artiopollis indivisus	1182ARTI01	82	3:10
Ascostomocystis giganteus	2111ASCO01	153	23:2
Asteropollis asteroides	1135ASTE01	78	3:1
Bacutriteles greenlandicus	1312BACU01	143	19:1
Balmeisporites glenglenensis	1312BALM01	144	19:2
Balmula ?pentaradiata	2114BALM_A	154	23:3
Baltisphaeridium multispinosum	2220BALTO4	189	34:9
Baltisphaeridium whitei	2220BALTO5	189	35:1
Baltisphaeridium sp. A	2220BALT_A	190	35:2
Baltisphaeridium sp. B	2220BALT_B	190	35:3
Batioladinium jaegeri	2121BATI01	166	27:6-7
Bipatellifera ?clathrata	2210BIPE01	187	34:5
Biretisporites potoniaei	1311BIRE02	103	9:1
Bourkidinium granulatum	2151BOUR01	178	31:7
Caligodinium aceras	2121CALI01	166	28:1
Callialasporites ?dampieri	1221CALLO2	90	5:2
Camarozonosporites insignis	1311CAMA02	103	9:2
Camarozonosporites sp. A	1311CAMA_A	104	9:3
Canningia sp. A	2124CANN_A	167	28:2
Catastomocystis sp. A	2113CATA_A	154	23:4
Cedripites sp. A	1222CEDR_A	90	5:3
Cerebropollenites mesozoicus	1223CERE02	91	5:4
Chatangiella ?granulifera	2112CHAT01	155	23:5
Chatangiella sp. A	2112CHAT_A	155	24:1

Table 4 (cont'd).

Form	Code	Page	Plate:Figure
<i>Chlamydophorella nyei</i>	2111CHLA01	156	24:2-3
<i>Chomotriletes minor</i>	1311CHOM02	104	9:4
<i>Cibotiumspora juncta</i>	1311CIBO01	105	9:5
<i>Cicatricosisporites crassiterminatus</i>	1311CICA10	105	9:6
<i>Cicatricosisporites dorogensis</i>	1311CICA13	106	9:7
<i>Cicatricosisporites hallei</i>	1311CICA16	106	9:8
<i>Cicatricosisporites potomacensis</i>	1311CICA25	106	9:9
<i>Cicatricosisporites venustus</i>	1311CICA30	107	10:1
<i>Cicatricosisporites</i> sp. A	1311CICA_A	107	10:2
<i>Cicatricosisporites</i> sp. A	1321CICA_A	137	17:3
<i>Cingutritiles congruens</i>	1311CINU01	108	10:3
<i>Cingutritiles</i> sp. A	1311CINU_A	108	10:4
<i>Cingutritiles</i> sp. B	1311CINU_B	108	10:5
<i>Clavatipollenites hughesii</i>	1131CLAV01	66	1:3
<i>Cleistosphaeridium</i> ?multispinosum	2151CLEI01	179	32:1
<i>Cleistosphaeridium</i> sp. A	2151CLEI_A	179	32:2
<i>Conbaculatisporites</i> sp. A	1311CONB_A	109	10:6
<i>Concavisporites lamontis</i>	1311CONC03	109	10:7
<i>Concavissimisporites variuerrucatus</i>	1311CONA06	110	10:8
<i>Corollina meyeriana</i>	1213CORO01	84	3:13
<i>Corollina torosus</i>	1213CORO02	84	3:14; 4:1
<i>Coronifera oceanica</i>	2153CORO01	180	32:3
<i>Cribroperidinium edwardsii</i>	2113CRIB01	156	24:4-5
<i>Cribroperidinium</i> ?exilicristatum	2113CRIB02	157	24:6
<i>Crybelosporites brenneri</i>	1311CRYB02	110	10:9-10
<i>Crybelosporites pannuceus</i>	1311CRYB03	110	10:11
<i>Cyathidites concavus</i>	1311CYAT07	111	10:12
<i>Cyathidites minor</i>	1311CYAT04	111	10:13
<i>Cycadopites carpentieri</i>	1212CYCA01	85	4:2
<i>Cyclonephelium vannophorum</i>	2121CYCL01	167	28:3
<i>Cyclonephelium</i> sp. A	2121CYCL_A	168	28:4
<i>Cyclonephelium</i> sp. B	2121CYCL_B	168	28:5
<i>Dapsilidinium marinum</i>	2151DAPS01	180	32:4
<i>Deltoidospora hallii</i>	1311DELT01	112	11:1-2
<i>Densoisporites microrugulatus</i>	1311DENS01	112	11:3
<i>Densoisporites velatus</i>	1311DENS03	113	11:4
<i>Dichastopollenites dunveganensis</i>	1132DICH01	70	1:11-12
<i>Dichastopollenites reticulatus</i>	1132DICH02	70	1:13-16
<i>Dichastopollenites</i> sp. A	1132DICH_A	71	1:17-18
<i>Dictyophyllidites impensus</i>	1311DICT03	113	11:5
Dinoflagellate Form A	2122FORM_A	174	30:3-4
Dinoflagellate Form B	2111FORM_B	165	27:2-3
Dinoflagellate Form C	2155FORM_C	186	34:3

Table 4 (cont.)

Form

Dinoflagellate
Dinoflagellate
Dinoflagellate
Dinoflagellate
Dinoflagellate
Echinatosporis
Endoscrinium
Equisetosporites
Equisetosporites
Equisetosporites
Equisetosporites
Equisetosporites
Eucommidites
Eusporulites
Forentina coe
Foraminisporis
Foucaiticoipites
Foucaiticoipites
Fromea amph
Fromea frag.
Fromea sp. A
Fromea sp. B
Fromea sp. C
Fungal Spore
Fungal Spore
Fungal Spore
Fungal Spore
Fungal Spore
Gemmarietes
Gleichenioidites
Gleichenioidites
Heisporites
Hexagonifer
Hexagonifer
Hystichodites
Inaperturop
Inaperturop
Inaperturop
Kohansium
Kuisporites
Kuisporites
Kuisporites
Laeng-gatos
Laeng-gatos
Larconites

Table 4 (cont'd).

Form	Code	Page	Plate:Figure
Dinoflagellate Form D	2151FORM_D	186	34:4
Dinoflagellate Form E	2123FORM_E	174	30:5
Dinoflagellate Form F	2122FORM_F	174	31:1
Dinoflagellate Form G	2122FORM_G	175	31:2
Dinoflagellate Form H	2125FORM_H	175	31:3
<i>Echinatisporis varispinosus</i>	1311ECHI01	114	11:6
<i>Endoscrinium campanula</i>	2113ENDO01	157	24:7
<i>Equisetosporites ambiguus</i>	1230EQUI01	97	7:1-2
<i>Equisetosporites</i> sp. A	1230EQUI_A	97	7:3
<i>Equisetosporites</i> sp. C	1230EQUI_C	97	7:4
<i>Equisetosporites</i> sp. D	1230EQUI_D	97	7:5
<i>Equisetosporites</i> sp. E	1230EQUI_E	97	7:6
<i>Eucommiidites minor</i>	1212EUCO03	85	4:3-4
<i>Exesipollenites tumulus</i>	1213EXES01	86	4:5
<i>Florentinia cooksoniae</i>	2153FLOR01	181	32:5
<i>Foraminisporis dailyi</i>	1311FORA01	114	11:7
<i>Foveotricolpites robustus</i>	1133FOVE02	71	2:1
<i>Foveotricolporites callosus</i>	1143FOVE01	80	3:4
<i>Fromea amphora</i>	2121FROM01	169	28:6
<i>Fromea</i> ? <i>fragilis</i>	2121FROM03	169	29:1
<i>Fromea</i> sp. A	2121FROM_A	170	29:2
<i>Fromea</i> sp. B	2121FROM_B	170	29:3
<i>Fromea</i> sp. C	2121FROM_C	170	29:4
Fungal Spore Form A	1410FORM_A	146	20:1
Fungal Spore Form B	1410FORM_B	146	20:2
Fungal Spore Form C	1410FORM_C	146	20:3
Fungal Spore Form D	1410FORM_D	147	20:4
Fungal Spore Form E	1410FORM_E	147	20:5
<i>Gemmatriletes</i> ? <i>morulus</i>	1311GEMM02	115	11:8
<i>Gleicheniidites circinidites</i>	1311GLEI03	115	11:9
<i>Gleicheniidites senonicus</i>	1311GLEI05	116	11:10
<i>Heliosporites kemensis</i>	1311HELI02	117	11:11
<i>Hexagonifera</i> sp. A	2112HEXA_A	158	25:1-2
<i>Hexagonifera</i> sp. B	2112HEXA_B	158	25:3
<i>Hystriodinium oligacanthum</i>	2143HYST01	176	31:4
<i>Inaperturopollenites dubius</i>	1211INAP01	86	4:6
<i>Inaperturopollenites limbatus</i>	1211INAP02	87	4:7
<i>Kiokansium polypes</i>	2151KIOK01	181	32:6
<i>Khukisporites foveolatus</i>	1311KLUK01	117	11:12
<i>Khukisporites pseudoreticulatus</i>	1311KLUK02	117	12:1
<i>Laevigatosporites belfordii</i>	1321LAEV01	137	17:4
<i>Laevigatosporites ovatus</i>	1321LAEV06	137	17:5
<i>Laricoidites</i> sp. A	1211LARI_A	87	4:8

Table 4 (cont'd).

<u>Form</u>	<u>Code</u>	<u>Page</u>	<u>Plate:Figure</u>
<i>Leberidocysta</i> sp. A	2111LEBE_A	159	25:4
<i>Leiofusa jurassica</i>	2220LEIO01	191	35:4
<i>Leiofusa</i> sp. A	2220LEIO_A	191	35:5
<i>Leptolepidites major</i>	1311LEPT06	118	12:2
<i>Leptolepidites</i> sp. A	1311LEPT_A	118	12:3
<i>Liliacidites dividuus</i>	1131LILI03	67	1:4
<i>Liliacidites</i> sp. A	1131LILI_A	67	1:5
<i>Liliacidites</i> sp. B	1131LILI_B	68	1:6
? <i>Litosphaeridium</i> sp. A	2151LITO_A	182	32:7
<i>Luxadinium propatulum</i>	2114LUXA01	159	25:5-6
<i>Lycopodiacidites cerniidites</i>	1311LYCO03	119	12:4
? <i>Lycopodiacidites</i> sp. A	1311LYCO_A	119	12:5
<i>Matonisporites phlebopteroides</i>	1311MATO04	120	12:6
<i>Micrhystridium fragile</i>	2220MICR02	192	35:6
<i>Micrhystridium stellatum</i>	2220MICR01	192	35:7
<i>Micrhystridium</i> sp. A	2220MICR_A	192	35:8
Microforaminiferal Lining Form A	2300FORM_A	194	35:11
<i>Microfoveolatisporis pseudoreticulatus</i>	1321MICR01	138	17:6
<i>Microreticulatosporites sacalii</i>	1311MICR02	120	12:7
<i>Minerisporites dissimilis</i>	1312MINE01	144	19:3
<i>Molaspora lobata</i>	1312MOLA02	144	19:4
Monocolpate Pollen Form A	1131FORM_A	69	1:8
Monocolpate Pollen Form B	1131FORM_B	69	1:10
Monocolpate Pollen Form C	1131FORM_C	69	1:9
<i>Monocolpopollenites</i> sp. A	1131MONO_A	68	1:7
Monolete Spore Form A	1321FORM_A	139	12:9
Monolete Spore Form B	1321FORM_B	140	17:10
Monolete Spore Form C	1321FORM_C	140	18:1
<i>Neoraistrickia</i> sp. A	1311NEOR_A	121	12:8
<i>Nyssapollenites nigricolpus</i>	1143NYSS02	80	3:5-7
<i>Nyssapollenites</i> sp. A	1143NYSS_A	81	3:8
<i>Odontochitina operculata</i>	2114ODON02	160	25:7
<i>Odontochitina singhii</i>	2114ODON03	160	26:1
<i>Oligosphaeridium complex</i>	2151OLIG01	183	33:1
<i>Oligosphaeridium pulcherrimum</i>	2151OLIG02	183	33:2
<i>Oligosphaeridium tenuiprocessum</i>	2151OLIG03	184	33:3
<i>Oligosphaeridium</i> sp. A	2151OLIG_A	184	33:4
<i>Osmundacidites wellmanii</i>	1311OSMU03	121	12:9
<i>Ovoidinium verrucosum</i>	2114OVOI01	161	26:6
<i>Ovoidites</i> sp. A	1900VOI_A	147	20:6
<i>Palaeohystrichophora infusorioides</i>	2112PALA01	161	26:3
<i>Palambages canadiana</i>	1900PALA01	148	20:7
<i>Palambages</i> sp. A	1900PALA_A	148	20:8

Table 4 (cont'd).

Form	Code	Page	Plate:Figure
<i>Pareodinia</i> sp. A	2122PARE_A	171	29:5
<i>Parvisaccites rugulatus</i>	1222PARV04	91	5:5
<i>Penetetrapites mollis</i>	1124PENE01	65	1:1
<i>Perinopollenites elatoides</i>	1211PERI01	88	4:9
<i>Periporopollenites</i> sp. A	1125PERI_A	65	1:2
<i>Perotriletes</i> sp. A	1311PERO_A	122	13:1
<i>Perotriletes</i> sp. C	1311PERO_C	122	13:2
<i>Perotriletes</i> sp. D	1311PERO_D	122	13:3
<i>Petalosporites quadrangulus</i>	1321PETA01	138	17:7
<i>Phimopollenites pannosus</i>	1133PHIM01	72	2:2
<i>Pilosisorites trichopapillosus</i>	1311PILO03	123	13:4
<i>Pilosisorites</i> sp. A	1311PILO_A	123	13:5
<i>Pinuspollenites</i> sp. A	1222PINU_A	92	5:6
<i>Pistillipollenites mcgregorii</i>	1133PIST01	72	2:3
<i>Pityosporites</i> sp. A	1222PITY_A	93	5:7
<i>Podocarpidites</i> sp. A	1222PODO_A	93	5:8
<i>Podocarpidites</i> sp. B	1222PODO_B	94	5:9
<i>Podocarpidites</i> sp. C	1222PODO_C	94	6:1
<i>Polycingulatisporites radiatus</i>	1311POLY01	124	13:6
<i>Pristinuspollenites elongatus</i>	1222PRIS01	95	6:2
<i>Pseudoceratium polymorphum</i>	2121PSEU01	171	29:6
<i>Psilatrilites ?circumundulatus</i>	1311DENS_A	124	13:7
<i>Pterodinium cingulatum</i>	2123PTER01	171	29:7
<i>Pterodinium</i> sp. A	2123PTER_A	172	29:8
<i>Pterospermella aureolata</i>	2210PTER04	187	34:6
<i>Pterospermella eurypteris</i>	2210PTER02	187	34:7
<i>Reticulatasporites dupliexinuous</i>	1311RETU01	125	13:8
<i>Reticulatasporites</i> sp. A	1311RETU_A	125	13:9
<i>Reticulatisporites</i> sp. A	1311RETC_A	126	14:1
<i>Reticulosporis foveolatus</i>	1321RETC01	139	17:8
<i>Rugubivesiculites reductus</i>	1222RUGU02	95	6:3
<i>Rugubivesiculites rugosus</i>	1222RUGU03	95	6:4-5
<i>Rugulatisporites</i> sp. A	1311RUGU_A	126	14:2
<i>Schizosporis parvus</i>	1900SCHIO3	149	20:9
<i>Schizosporis reticulatus</i>	1900SCHIO4	149	21:1
<i>Scopusporis excavatus</i>	1311SCOP01	127	14:3
<i>Spermatites ellipticus</i>	1520SPER01	150	21:2
<i>Spermatites</i> sp. A	1520SPER_A	150	21:3
<i>Spermatites</i> sp. B	1520SPER_B	150	21:4
<i>Spiniferites ramosus</i> ssp. <i>gracilis</i>	2143SPIN02	177	31:5
<i>Spiniferites ramosus</i> ssp. <i>ramosus</i>	2143SPIN01	177	31:6
<i>Stephanocolpites tectorius</i>	1138STEP02	79	3:2
<i>Stereisporites antiquasporites</i>	1311STER01	127	14:4

Table 4 (cont'd).

Form	Code	Page	Plate:Figure
<i>Subtilisphaera inaffecta</i>	2115SUBT01	162	26:4
<i>Subtilisphaera</i> sp. A	2115SUBT_A	162	26:5
<i>Subtilisphaera</i> sp. B	2115SUBT_B	163	26:6
<i>Subtilisphaera</i> sp. C	2115SUBT_C	163	26:7
<i>Subtilisphaera</i> sp. D	2115SUBT_D	164	26:8
<i>Tanyosphaeridium salpinx</i>	2151TANY01	185	34:1
<i>Tanyosphaeridium</i> sp. A	2151TANY_A	185	34:2
<i>Taxodiaceapollenites hiatus</i>	1211TAXO01	88	4:10
Terrestrial Unknown Form A	1900FORM_A	151	22:2
Terrestrial Unknown Form B	1900FORM_B	152	22:3
Terrestrial Unknown Form C	1900FORM_C	152	22:4
Terrestrial Unknown Form D	1900FORM_D	152	22:5
<i>Tetracolpites reticulatus</i>	1134TETR02	79	3:3
<i>Thalassiphora microcysta</i>	2113THAL01	164	27:1
<i>Tigrisporites reticulatus</i>	1311TIGR01	128	14:5
<i>Todisporites minor</i>	1311TODI01	128	14:6
<i>Trichodinium castaneum</i>	2123TRIC01	173	30:1
<i>Trichopeltinites</i> sp. A	1420TRIC_A	151	21:5-6; 22:1
Tricolpate Pollen Form A	1133FORM_A	76	2:14
Tricolpate Pollen Form B	1133FORM_B	76	2:15
Tricolpate Pollen Form D	1133FORM_D	77	2:16
Tricolpate Pollen Form E	1133FORM_E	77	2:17
Tricolpate Pollen Form F	1133FORM_F	78	2:18
<i>Tricolpites anguloluminosus</i>	1133TRIC03	73	2:4
<i>Tricolpites crassimurus</i>	1133TRIC08	73	2:5-6
<i>Tricolpites eragatus</i>	1133TRIC11	74	2:7-8
<i>Tricolpites geranioides</i>	1133TRIC12	74	2:9
<i>Tricolpites minutus</i>	1133TRIC22	74	2:10-11
<i>Tricolpites reticulatus</i>	1133TRIC28	75	2:12
<i>Tricolpites virgeus</i>	1133TRIC32	75	2:13
<i>Tricolporoidites minimus</i>	1143TRIO03	81	3:9
Trilete Spore Form A	1311FORM_A	131	15:4
Trilete Spore Form B	1311FORM_B	132	15:5-7
Trilete Spore Form C	1311FORM_C	132	15:8-9
Trilete Spore Form D	1311FORM_D	132	15:10-11
Trilete Spore Form E	1311FORM_E	133	16:1
Trilete Spore Form G	1311FORM_G	133	16:2
Trilete Spore Form J	1311FORM_J	133	16:3
Trilete Spore Form K	1311FORM_K	134	16:4
Trilete Spore Form L	1311FORM_L	134	16:5
Trilete Spore Form M	1311FORM_M	134	16:6
Trilete Spore Form N	1311FORM_N	135	16:7
Trilete Spore Form O	1311FORM_O	135	16:8

Table 4 (cont'd).

<u>Form</u>	<u>Code</u>	<u>Page</u>	<u>Plate:Figure</u>
Trilete Spore Form P	1311FORM_P	136	17:1
Trilete Spore Form Q	1311FORM_Q	136	17:2
Trilete Spore Genus 1 sp. A	1311FORM1A	131	15:1
Trilete Spore Genus 1 sp. B	1311FORM1B	131	15:2
Trilete Spore Genus 1 sp. C	1311FORM1C	131	15:3
<i>Trilobosporites crassus</i>	1311TRIO05	129	14:7
<i>Triporeletes cenomanianus</i>	1331TRIP01	141	18:3
<i>Triporeletes involucratus</i>	1331TRIP02	142	18:4
<i>Triporeletes radiatus</i>	1311TRIP03	142	18:5
<i>Undulatisporites pannuceus</i>	1311UNDU02	129	14:8
<i>Undulatisporites undulapulus</i>	1311UNDU03	130	14:9
<i>Undulatisporites</i> sp. A	1311UNDU_A	130	14:10
Unknown Form A	9000FORM_A	194	36:1-2
Unknown Form B	9000FORM_B	195	36:3
Unknown Form C	9000FORM_C	195	36:4
Unknown Form D	9000FORM_D	195	36:5
<i>Veryhachium irregulare forma subtetraedron</i>	2220VERY01	193	35:9
<i>Veryhachium lairdi</i>	2220VERY02	193	35:10
<i>Virgo amiantopollis</i>	1184VIRG01	82	3:11
<i>Vitreisporites pallidus</i>	1222VITR01	96	6:6
<i>Wigginsella canadense</i>	2123WIGG01	173	30:2

SYSTEM

Address

1968

per

17

(19

17

0

1

SYSTEMATIC DESCRIPTIONS

Angiospermous Pollen -- Porate**Genus *Penetetrapites* Hedland and Norris, 1968**

TYPE SPECIES: *Penetetrapites mollis* Hedland and Norris, 1968.

COMMENTS: See Hedland and Norris (1968, p. 152) for generic diagnosis.

***Penetetrapites mollis* Hedland and Norris, 1968**

[Plate 1, Figure 1]

1968 *Penetetrapites mollis* Hedland and Norris, p. 152, pl. 7, fig. 6-12.

SIZE RANGE: 24 μ m to 27 μ m equatorial, 5 specimens measured.

OCCURRENCE: Common; in the Cedar Mountain at Molen.

COMMENTS: See Hedland and Norris (1968, p. 152) for description. This form seems to be restricted to the mid-Cretaceous of North America. The botanical affinity of this pollen type is unknown, however, Hedland and Norris (1968), Davies and Norris (1976), and Wingate (1980) tentatively include it with other angiospermous pollen.

Genus *Periporopollenites* Pflug & Thomson in Thomson and Pflug, 1953

TYPE SPECIES: *Periporopollenites stigmosus* (Potonié, 1931a) Pflug & Thomson in Thomson and Pflug, 1953.

COMMENTS: This genus was established for fossil pollen with more than three pores distributed over the whole body of the grain with various symmetry. The concept of *Liquidambarpollenites* Raatz, 1937 ex Potonié, 1960, an obligate junior synonym, is included within this diagnosis. Pollen of this type is produced by the modern genus *Liquidambar*, and differs from that produced by the *Amaranthaceae* and *Chenodpodaceae* by lacking thickened pore borders.

***Periporopollenites* sp. A**

[Plate 1, Figure 2]

1966 *Liquidambarpollenites* sp. of Hedlund, p. 31, pl. 9, fig. 7.

DESCRIPTION: Pollen grain; amb circular; periporate, number of pores many and variable (35 to 60, 4 grains), pores $1.5\mu\text{m}$ to $2\mu\text{m}$ in diameter; exine psilate to finely punctate; dimensions $21\mu\text{m}$ to $28\mu\text{m}$ diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: The possibility exists that these grains represent modern pollen contamination, however, the condition of the grains and the way in which they take stain supports the conclusion that they are probably indigenous. Hedlund (1966) also considered the possibility of field or laboratory contamination of sediments of Cenomanian age with periporate pollen.

Angiospermous Pollen -- Monocolpate**Genus *Clavatipollenites* Couper, 1958**

TYPE SPECIES: *Clavatipollenites hughesii* Couper, 1958

COMMENTS: See Couper (1958, p. 159) for generic diagnosis.

***Clavatipollenites hughesii* Couper, 1958**

[Plate 1, Figure 3]

1958 *Clavatipollenites hughesii* Couper, p. 159, pl. 31, fig. 19-22.

SIZE RANGE: $17\mu\text{m}$ to $20\mu\text{m}$ polar, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain and Dakota at Molen; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Couper (1958, p. 159) for description.

Genus *Liliacidites* Couper, 1953

TYPE SPECIES: *Liliacidites kaitangataensis* Couper, 1953.

COMMENTS: See Couper (1953, p. 56) for generic diagnosis. *Liliacidites* is probably of monocotyledonous affinity.

***Liliacidites dividuus* (Pierce, 1961) Brenner, 1963**

[Plate 1, Figure 4]

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

1963 *Liliacidites dividuus* (Pierce, 1961) Brenner, p. 93, pl. 40, fig. 7-10.

SIZE RANGE: 30 μ m to 32 μ m polar; 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota and lower Tununk at Horsethief Canyon Ranch.

COMMENTS: For description see Brenner (1963, p. 93).

***Liliacidites* sp. A**

[Plate 1, Figure 5]

DESCRIPTION: Pollen grain; monocolpate, colpus indistinct; amb circular; exine coarsely reticulate, muri thick (0.5 μ m to 1.0 μ m), lumina irregularly shaped, 2 μ m to 3 μ m diameter; dimensions: 19 μ m to 24 μ m by 15 μ m to 17 μ m equatorial, 5 specimens measured.

OCCURRENCE: Rare; in the upper Tununk and Ferron at Farnham Dome and Molen and in the Ferron and Blue Gate at Ivie Creek.

***Liliacidites* sp. B**

[Plate 1, Figure 6]

DESCRIPTION: Pollen grain; monocolpate; amb elongate oval; exine finely reticulate, muri thin ($0.25\mu\text{m}$ to $0.5\mu\text{m}$), lumina polygonal ($1.0\mu\text{m}$ to $2.0\mu\text{m}$ diameter); dimensions: $40\mu\text{m}$ to $51\mu\text{m}$ by $22\mu\text{m}$ to $25\mu\text{m}$ equatorial, 3 specimens measured.

OCCURRENCE: Rare to common; in the Dakota and Tununk at Horsethief Canyon Ranch; in the Ferron at Farnham Dome, Molen and Ivie Creek.

Genus *Monocolpopollenites* Pflug & Thomson in Thomson and Pflug, 1953**emend. Nichols, Ames & Traverse, 1973**

TYPE SPECIES: *Monocolpopollenites tranquillus* (Potonié, 1934b) Jansonius and Hills, 1976.

COMMENTS: See Jansonius and Hills (1976, card 4297) and Nichols *et al.* (1973, p. 251) for generic diagnosis and discussion. The affinity of monocolpopollenites is uncertain, but may be with the Monocotyledonae or Cycadales.

***Monocolpopollenites* sp. A**

[Plate 1, Figure 7]

DESCRIPTION: Pollen grain; monocolpate, colpus $1\mu\text{m}$ wide at center to $5\mu\text{m}$ near ends; amb circular or nearly so; exine densely covered with low baculae; dimensions: $25\mu\text{m}$ to $30\mu\text{m}$ equatorial, 6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota, Tununk and Ferron at Horsethief Canyon Ranch; in the Tununk at Ferron at Molen and Ivie Creek; and in the Tununk at Farnham Dome.

Monocolpate Pollen Form A

[Plate 1, Figure 8]

DESCRIPTION: Pollen grain; monocolpate, colpus $1\mu\text{m}$ to $2\mu\text{m}$ wide entire length of grain; amb circular; exine finely granulate; dimensions: $13\mu\text{m}$ to $17\mu\text{m}$ equatorial, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota and lower Tununk at Horsethief Canyon Ranch; in the upper Tununk and Ferron at Ivie Creek, Molen and Farnham Dome.

Monocolpate Pollen Form B

[Plate 1, Figure 10]

DESCRIPTION: Pollen grain; monocolpate, colpus $1\mu\text{m}$ wide $3/4$ length of grain; amb elongate oval; exine scabrate; dimensions: $50\mu\text{m}$ to $70\mu\text{m}$ by $29\mu\text{m}$ to $37\mu\text{m}$ equatorial, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota through Ferron at Molen; in the Dakota through Blue Gate at Ivie Creek; in the Tununk and Ferron at Farnham Dome.

Monocolpate Pollen Form C

[Plate 1, Figure 9]

DESCRIPTION: Pollen grain; monocolpate, colpus $1\mu\text{m}$ wide entire length of grain; shape subprolate; exine scabrate; dimensions $14\mu\text{m}$ to $18\mu\text{m}$ equatorial, 10 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

Angiospermous Pollen – Dicolpate**Genus *Dichastopollenites* May, 1975**

TYPE SPECIES: *Dichastopollenites reticulatus* May, 1975.

COMMENTS: See May (1975, p. 531) for generic description. Affinity is angiospermous.

***Dichastopollenites dunveganensis* Singh, 1983**

[Plate 1, Figure 11-12]

1983 *Dichastopollenites dunveganensis* Singh, p. 70, pl. 15, fig. 3-8.

SIZE RANGE: 26 μ m to 36 μ m equatorial, 7 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain and Dakota at Molen; in the Molen and lower Tununk at Ivie Creek.

COMMENTS: See Singh (1983, p. 70) for description.

***Dichastopollenites reticulatus* May, 1975**

[Plate 1, Figure 13-16]

1972 Pollen type A – May, pl. 1, fig. 16, 17; pl. 4, fig. 3; pl. 5, fig. 19-21.

1973 Pollen type A – May and Traverse, pl. 1, fig. 3.

1975 *Dichastopollenites reticulatus* May, p. 532, pl. 1, fig. 1-9; pl. 2, fig. 1-6.

SIZE RANGE: 22 μ m to 29 μ m equatorial, 12 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain and Dakota at Molen; in the Mowry at Steinaker Draw; in the Dakota and lower Tununk at Ivie Creek and Molen; in the lower Tununk at Farnham Dome.

COMMENTS: See May (1975, p. 532 for description. May (1975) described this species as having a zonosulcate germinal apparatus, however, specimens from the Cedar

Mountain Formation at Molen indicate that this species is dicolpate. D.L. Dilcher (in Farley, 1982) suggested that the type specimen is dicolpate.

***Dichastopollenites* sp. A**

[Plate 1, Figure 17-18]

DESCRIPTION: Pollen grain; dicolpate, colpi thin ($0.5\mu\text{m}$ to $1.0\mu\text{m}$) extending 7/8 length of grain; amb subcircular with a pseudo-diad appearance; exine very finely reticulate; dimensions: $17\mu\text{m}$ to $19\mu\text{m}$ polar, $20\mu\text{m}$ to $23\mu\text{m}$ equatorial, 7 specimens.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENTS: *Dichastopollenites* sp. A differs from both *D. dunveganensis* and *D. reticulatus* by being smaller in dimensions and by having a much finer reticulate sculpturing.

Angiospermous Pollen -- Tricolpate

Genus *Foveotricolpites* Pierce, 1961

TYPE SPECIES: *Foveotricolpites sphaeroides* Pierce, 1961.

COMMENTS: See Pierce (1961, p. 49) for generic diagnosis. The affinity of *Foveotricolpites* is with the dicotyledonous angiosperms.

***Foveotricolpites robustus* Singh, 1983**

[Plate 2, Figure 1]

1972 *Tricolpites* cf. sp. 2 — May, p. 514, pl. 4, fig. 10.

1983 *Foveotricolpites robustus* Singh, p. 80, pl. 18, fig. 7-9.

SIZE RANGE: $27\mu\text{m}$ to $33\mu\text{m}$ equatorial, 4 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek; in the Dakota and lower Tununk at Molen; in the lower Tununk at Farnham Dome.

COMMENTS: See Singh (1983, p. 80) for description.

Genus *Phimopollenites* Dettmann, 1973

TYPE SPECIES: *Phimopollenites pannosus* (Dettmann & Playford, 1968) Dettmann, 1973.

COMMENTS: See Dettmann (1973, p. 16) for generic diagnosis. *Fothergilla* and *Tetracentron* produce pollen similar to *Phimopollenites* (Dettmann, 1973).

***Phimopollenites pannosus* (Dettmann & Playford, 1968) Dettmann, 1973**

[Plate 2, Figure 2]

1968 *Tricolpites pannosus* Dettmann & Playford, p. 84, pl. 8, fig. 6.

1973 *Phimopollenites pannosus* (Dettmann & Playford, 1968) Dettmann, p. 16, pl. 3, fig. 1-2.

SIZE RANGE: 17 μ m to 21 μ m equatorial, 7 specimens measured.

OCCURRENCE: Rare to frequent; in the upper Tununk and Ferron at Molen; in the Ferron at Farnham Dome; in the Ferron and Blue Gate at Ivie Creek.

COMMENTS: For description see Dettmann (1973, p. 16).

Genus *Pistillipollenites* Rouse, 1962

TYPE SPECIES: *Pistillipollenites mcgregorii* Rouse, 1962.

COMMENTS: See Rouse (1962, p. 206) for generic diagnosis.

***Pistillipollenites mcgregorii* Rouse, 1962**

[Plate 2, Figure 3]

1962 *Pistillipollenites mcgregorii* Rouse, p. 206, pl. 1, fig. 8-12.

SIZE RANGE: 18 μ m to 33 μ m diameter, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota and Tununk at Horsethief Canyon Ranch; in the Dakota through Ferron at Molen; in the Tununk and Ferron at Farnham Dome; in the Dakota through Blue Gate at Ivie Creek.

COMMENTS: Rouse (1962) reported extracting pollen grains similar to *Pistillipollenites mcgregorii* from flowers of the genus *Rusbyanthus*, a member of the Gentianaceae.

Genus *Tricolpites* Cookson, 1947a ex Couper, 1953

TYPE SPECIES: *Tricolpites reticulatus* Cookson, 1947a.

COMMENTS: See Couper (1953, p. 61) for generic diagnosis. Numerous species of dicotyledonous angiosperms produce pollen of the form genus *Tricolpites*.

***Tricolpites anguloluminosus* Anderson, 1960**

[Plate 2, Figure 4]

1960 *Tricolpites anguloluminosus* Anderson, p. 26, p. 6, fig. 15-17; p. 8, fig. 17-18.

SIZE RANGE: 21 μ m to 27 μ m equatorial, 26 μ m to 42 μ m polar, 7 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Anderson (1960, p. 21) for description.

***Tricolpites crassimurus* (Groot & Penney, 1960) Singh, 1971**

[Plate 2, Figure 5-6]

1960 *Tricolpopollenites crassimurus* Groot & Penney, p. 232, pl. 2, fig. 4-5.

1971 *Tricolpites crassimurus* (Groot & Penney, 1960) Singh, p. 207, pl. 32, fig. 4-6.

SIZE RANGE: 30 μ m to 39 μ m equatorial, 2 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Cedar Mountain, Dakota and lower Tununk at Molen; in the lower Tununk at Ivie Creek and Farnham Dome.

COMMENTS: For description see Singh (1971, p. 207).

***Tricolpites erugatus* Hedlund, 1966**

[Plate 2, Figure 7-8]

1966 *Tricolpites erugatus* Hedlund, p. 30, pl. 9, fig. 2a-2b.

SIZE RANGE: 12 μ m to 17 μ m polar, 13 μ m to 19 μ m equatorial, 10 specimens measured.

OCCURRENCE: Rare to common; throughout all sections.

COMMENTS: For description see Hedlund (1966, p. 30).

***Tricolpites geranioides* Couper, 1960**

[Plate 2, Figure 9]

1960 *Tricolpites geranioides* Couper, p. 66, pl. 11, fig. 5-8.

1963 *Retitricolpites geranioides* (Couper, 1960) Brenner, p. 91, pl. 38, fig. 9; pl. 39, fig. 1.

SIZE RANGE: 33 μ m to 37 μ m equatorial, 4 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Dakota at Molen.

COMMENTS: See Brenner (1963, p. 91) for description.

***Tricolpites minutus* (Brenner, 1963) Dettmann, 1973**

[Plate 2, Figure 10-11]

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

1973 *Tricolpites minutus* (Brenner, 1963) Dettmann, p. 12, pl. 4, fig. 1-4.

SIZE RANGE: 8 μ m to 12 μ m polar, 6 μ m to 10 μ m equatorial, 15 specimens measured.

OCCURRENCE: Rare to abundant; throughout all sections.

COMMENTS: See Brenner (1963, p. 39) and Dettmann (1973, p. 12) for description.

***Tricolpites reticulatus* Cookson, 1947a**

[Plate 2, Figure 12]

1947a *Tricolpites reticulatus* Cookson, p. 134, pl. 15, fig. 45.

SIZE RANGE: 28 μ m to 40 μ m polar, 20 μ m to 26 μ m equatorial, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: For description see Cookson (1947a, p. 134).

***Tricolpites virgeus* (Groot, Penney & Groot, 1961) Brenner, 1963**

[Plate 2, Figure 13]

1961 *Tricolpopollenites virgeus* Groot, Penney & Groot, p. 133, pl. 26, fig. 16-17.

1963 *Tricolpites virgeus* (Groot, Penney & Groot, 1961) Brenner, p. 92, pl. 39, fig. 4-5.

SIZE RANGE: 22 μ m to 34 μ m equatorial, 7 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Dakota and lower Tununk at Horsethief Canyon Ranch and Ivie Creek; in the Cedar Mountain, Dakota and lower Tununk at Molen.

COMMENTS: See Brenner (1963, p. 92) for description.

Tricolpate Pollen Form A

[Plate 2, Figure 14]

DESCRIPTION: Pollen grain; tricolpate, colpi wide, margins ragged; amb subtriangular; exine psilate to finely foveolate; dimensions: 15 μ m to 21 μ m equatorial, 10 specimens measured.

OCCURRENCE: Rare to common; in the Dakota, Tununk, and Ferron at Horsethief Canyon Ranch, Ivie Creek and Molen; in the Tununk and Ferron at Farnham Dome.

COMMENTS: This species is distinguished from other tricolpate pollen by its shape (nearly straight equatorial sides as compared to *T. eragatus*) and ragged colpi margins.

Tricolpate Pollen Form B

[Plate 2, Figure 15]

DESCRIPTION: Pollen grain; tricolpate; shape spheroidal; exine reticulate; dimensions: 11 μ m to 16 μ m diameter, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain and Mowry at Steinaker Draw; in the Cedar Mountain, Dakota and lower Tununk at Molen; in the Dakota and lower Tununk at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: This species is distinguished from *Tricolpites minutus* by its reticulate exine and its slightly larger size, and from *Tricolpites eragatus* by its nearly straight equatorial sides.

Tricolpate Pollen Form D

[Plate 2, Figure 16a, 16b]

DESCRIPTION: Pollen grain; tricolpate; shape subprolate; exine heterobrochate reticulate with reticulum finer near colpi and poles; dimensions: 18 μ m to 24 μ m polar, 5 specimens measured.

OCCURRENCE: Rare; in the upper Tununk and Ferron at Farnham Dome and Molen; in the upper Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: This species is distinguished from other tricolpate forms by its heterobrochate reticulate exine.

Tricolpate Pollen Form E

[Plate 2, Figure 17a,b]

DESCRIPTION: Pollen grain; tricolpate; shape subprolate to prolate; exine homobrochate reticulate; dimensions: 18 μ m to 24 μ m polar, 5 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain at Molen; in the Dakota and lower Tununk at Horsethief Canyon Ranch and Ivie Creek; in the lower Tununk at Farnham Dome.

COMMENTS: Tricolpate Pollen Form E is distinguished from *Tricolpites reticulatus* by its nearly circular outline, its smaller size and finer reticulate exine, and from Tricolpate Form D by its evenly sized reticulum.

Tricolpate Pollen Form F

[Plate 2, Figure 18]

DESCRIPTION: Pollen grain; tricolpate, colpi distinguished by longitudinal folding; shape prolate to subprolate; exine very thin, finely reticulate; dimensions: 22 μ m to 26 μ m polar, 17 μ m to 20 μ m equatorial, 9 specimens measured.

OCCURRENCE: Rare to common; in the Dakota at Ivie Creek and Molen.

COMMENTS: This species is distinguished from other tricolpate forms by its very thin, finely reticulate exine.

Angiospermous Pollen -- Colpate >3

Genus *Asteropollis* Hedlund & Norris, 1968

TYPE SPECIES: *Asteropollis asteroides* Hedlund & Norris, 1968.

COMMENTS: See Hedlund and Norris (1968, p. 152) for generic diagnosis. The affinity of *Asteropollis* is with an unknown angiosperm.

***Asteropollis asteroides* Hedlund & Norris, 1968**

[Plate 3, Figure 1]

1968 *Asteropollis asteroides* Hedlund & Norris, p. 153, pl. 6, fig. 18-20; pl. 7, fig. 1-3.

SIZE RANGE: 22 μ m diameter, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch; in the Mowry at Steinaker Draw.

COMMENTS: See Hedlund and Norris (1968, p. 153) for description.

Genus *Stephanocolpites* Van der Hammen, 1954

TYPE SPECIES: *Stephanocolpites costatus* Van der Hammen, 1954.

COMMENTS: See Jansonius and Hills (1976, card 2698) for generic diagnosis and comments. Affinity of *Stephanocolpites* is with the angiosperms.

***Stephanocolpites tectorius* Hedlund, 1966**

[Plate 3, Figure 2]

1966 *Stephanocolpites tectorius* Hedlund, p. 30 pl. 9, fig. 8a, 8b.

SIZE RANGE: 58 μ m to 70 μ m polar, 31 μ m to 38 μ m equatorial, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Hedlund (1966, p. 30) for description.

Genus *Tetracolpites* Vimal, 1952 ex Srivastava, 1966

TYPE SPECIES: *Tetracolpites reticulatus* Srivastava, 1966.

COMMENTS: See Srivastava (1966, p. 545) for generic diagnosis.

***Tetracolpites reticulatus* Srivastava, 1966**

[Plate 3, Figure 3]

1966 *Tetracolpites reticulatus* Srivastava, p. 546, pl. 7, fig. 27.

SIZE RANGE: 17 μ m to 18 μ m equatorial, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Srivastava (1966, p. 546) for description. Specimens encountered in this study are smaller than those described by Srivastava (39 μ m).

Angiospermous Pollen -- Tricolporate**Genus *Foveotricolporites* Pierce, 1961**

TYPE SPECIES: *Foveotricolporites rhombohedralis* Pierce, 1961.

COMMENTS: See Pierce (1961, p. 52) for generic diagnosis.

***Foveotricolporites callosus* Singh, 1983**

[Plate 3, Figure 4]

1972 cf. *Tricolporopollenites* sp. 2 – May, p. 516, pl. 6, fig. 14.

1983 *Foveotricolporites callosus* Singh, p. 87, pl. 19, fig. 12-17; pl. 20, fig. 1-8.

SIZE RANGE: 24 μ m to 29 μ m equatorial, 9 specimens measured.

OCCURRENCE: Rare to frequent; in the upper Tununk and Ferron at Molen and Ivie Creek; in the Ferron at Farnham Dome.

COMMENTS: See Singh (1983, p. 87) for description,

Genus *Nyssapollenites* Thiergart, (1937) 1938 ex Potonié, 1960

TYPE SPECIES: *Nyssapollenites pseudocruciatus* (Potonié, 1931a) Thiergart, 1937.

COMMENTS: See Jansonius and Hills (1976, card 1794) for generic diagnosis.

Nyssapollenites is similar to pollen produced by the modern angiosperm genus *Nyssa*.

***Nyssapollenites nigricolpus* Singh, 1983**

[Plate 3, Figure 5-7]

1969 *Tricolporopollenites aliquantulus* auct. non Hedlund – Agasie, 1969, p. 28, pl. 4, fig. 11.

1983 *Nyssapollenites nigricolpus* Singh, p. 83, pl. 19, fig. 1-4.

SIZE RANGE: 15 μ m to 21 μ m equatorial, 12 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw, in the Dakota, Tununk and Ferron at Molen, Ivie Creek and Horsethief Canyon Ranch; in the Tununk and Ferron at Farnham Dome.

COMMENTS: See Singh (1983, p. 83) for description.

***Nyssapollenites* sp. A**

[Plate 3, Figure 8]

DESCRIPTION: Pollen grain; tricolporate, colpi extending 2/3 to 3/4 distance to pole, slightly opened, pore distinct, margins of colpi deeply stained; amb circular; dimensions: 13 μ m to 18 μ m equatorial, 7 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch; in the Dakota and Ferron at Ivie Creek, in the Dakota, Tununk and Ferron at Molen; in the Ferron at Farnham Dome.

COMMENTS: *Nyssapollenites* sp. A differs from *Nyssapollenites nigricolpus* by its circular amb.

Genus *Tricolporoidites* Paclová, 1971

TYPE SPECIES: *Tricolporoidites bohemicus* Paclová, 1971.

COMMENTS: See Paclová (1971, p. 115) or Jansonius and Hills (1976, card 2998) for generic diagnosis.

***Tricolporoidites minimus* Paclová, 1971**

[Plate 3, Figure 9]

1971 *Tricolporoidites minimus* Paclová, p. 116, pl. 11, fig. 1-4.

SIZE RANGE: 12 μ m to 15 μ m polar, 9 μ m to 11 μ m equatorial, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

COMMENTS: See Pacltová (1971, p. 116) for description, and Singh (1983, p. 82) for discussion.

Angiospermous Pollen -- Obligate Tetrads

Genus *Artiopollis* Agasie, 1969 emend. Singh, 1983

TYPE SPECIES: *Artiopollis indivisus* Agasie, 1969.

COMMENTS: See Singh (1983, p. 89) for emended generic diagnosis. The affinity of *Artiopollis* is with the non-magnoliid dicotyledonous angiosperms.

***Artiopollis indivisus* Agasie, 1969**

[Plate 3, Figure 10]

1969 *Artiopollis indivisus* Agasie, p. 28, pl. 4, fig. 6-8.

SIZE RANGE: 30 μ m to 47 μ m diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch and Molen

COMMENTS: For description see Agasie (1969, p. 28).

Genus *Virgo* Ward, 1986

TYPE SPECIES: *Virgo amiantopollis* (Srivastava, 1975b) Ward, 1986.

COMMENTS: For generic diagnosis see Ward (1986, p. 65). Pollen of the form genus *Virgo* has affinity with the non-magnoliid dicotyledonous angiosperms.

***Virgo amiantopollis* (Srivastava, 1975b) Ward, 1986**

[Plate 3, Figure 11a-d]

1975b *Senectotetradites amiantopollis* Srivastava, p. 95, pl. 44, fig. 4-15.

1986 *Virgo amiantopollis* (Srivastava, 1975b) Ward, p. 65, pl. 19, fig. 10-15.

SIZE RANGE: 18 μ m to 24 μ m diameter, 13 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Ward (1986, p. 65) for description.

Gymnospermous Pollen – Alete

Genus *Araucariacites* Cookson, 1947a ex Couper, 1953

TYPE SPECIES: *Araucariacites australis* Cookson, 1947a.

COMMENTS: See Couper (1953, p. 39) for generic diagnosis.

***Araucariacites australis* (Cookson, 1947a) Couper, 1953**

[Plate 3, Figure 12]

1947a *Granulanopites australis* Cookson, p. 130 pl. 13, fig. 3.

1953 *Araucariacites australis* (Cookson, 1947a) Couper, p. 39.

1958 *Araucariacites australis* (Cookson, 1947a) Couper, 1953 – Couper, p. 151, pl. 27, fig. 3-5.

SIZE RANGE: 57 μ m to 72 μ m diameter, 7 specimens measured.

OCCURRENCE: Rare; throughout all sections.

COMMENTS: See Couper (1953, p. 151) for description.

Genus *Corollina* Malyavkina, 1949 emend. Cornet & Traverse, 1975

TYPE SPECIES: *Corollina compacta* Malyavkina, 1949.

COMMENTS: See Cornet and Traverse (1975, p. 15) for the emended generic description and a discussion of the nomenclatural problems concerning *Circulina*, *Corollina* and *Classopollis*.

***Corollina meyeriana* (Klaus, 1960) Venkatachala & Goczan, 1964**

[Plate 3, Figure 13]

- 1960 *Circulina meyeriana* Klaus, p. 165, pl. 36, fig. 57-60.
- 1963 *Circulina parva* Brenner, p. 84, pl. 34, fig. 2, 3.
- 1964 *Corollina meyeriana* (Klaus, 1960) Venkatachala & Goczan, p. 217, pl. 3, fig. 1-15.
- 1966 *Gliscopollis meyeriana* (Klaus, 1960) Venkatachala, p. 99.

SIZE RANGE: 21 μ m to 31 μ m diameter, 11 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Cornet and Traverse (1975, p. 19) for description.

Corollina torosus* (Reissinger, 1950) Klaus, 1960*emend. Cornet & Traverse, 1975**

[Plate 3, Figure 4; Plate 4, Figure 1]

- 1950 *Pollenites torosus* Reissinger, p. 115, pl. 14, fig. 14.
- 1953 *Classopollis classoides* Pflug, pl. 14, fig. 20; text-fig. 4j-4m.
- 1960 *Corollina torosus* (Reissinger, 1950) Klaus, 1960, p. 168.

SIZE RANGE: 24 μ m to 37 μ m diameter, 9 specimens measured.

OCCURRENCE: Rare to abundant; in the Cedar Mountain, Mowry and Tununk at Steinaker Draw; in the Cedar Mountain, Dakota and Tununk at Molen; in the Tununk at Horsethief Canyon Ranch; in the Tununk at Ivie Creek and Farnham Dome.

COMMENTS: See Cornet and Traverse (1975, p. 17) for emended description.

Genus *Cycadopites* Wodehouse, 1933 ex Wilson & Webster, 1946

TYPE SPECIES: *Cycadopites follicularis* Wilson & Webster, 1946 ex Potonié, 1958.

COMMENTS: See Cornet and Traverse (1975, p. 21) for generic diagnosis.

***Cycadopites carpentieri* (Delcourt & Sprumont, 1955) Singh, 1964**

[Plate 4, Figure 2]

1955 *Monosulcites carpentieri* Delcourt & Sprumont, p. 15, fig. 14.

1964 *Cycadopites carpentieri* (Delcourt & Sprumont, 1955) Singh, 1964, p. 104, pl. 14, fig. 3.

SIZE RANGE: 49 μ m to 58 μ m long equatorial axis, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Molen and Horsethief Canyon Ranch; in the Dakota and Ferron at Ivie Creek.

COMMENTS: See Singh (1964, p. 104) for description.

Genus *Eucommiidites* Erdtman, 1948 ex Potonié, 1958 emend. Hughes, 1961

TYPE SPECIES: *Eucommiidites troedssonii* Erdtman, 1948.

COMMENTS: See Hughes (1961, p. 292) for emended generic description.

***Eucommiidites minor* Groot & Penny, 1960**

[Plate 4, Figure 3-4]

1961 *Eucommiidites minor* Groot & Penny, 1960 – Hughes, p. 296, pl. 17-18.

SIZE RANGE: 19 μ m to 24 μ m diameter, 14 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Hughes (1961, p. 296) for description and discussion.

Genus *Exesipollenites* Balme, 1957

TYPE SPECIES: *Exesipollenites tumulus* Balme, 1957.

COMMENTS: See Balme (1957, p. 39) for generic diagnosis.

***Exesipollenites tumulus* Balme, 1957**

[Plate 4, Figure 5]

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

SIZE RANGE: 16 μ m to 20 μ m diameter, 7 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain at Molen and Steinaker Draw.

COMMENTS: For description see Balme (1957, p. 39).

**Genus *Inaperturopollenites* Pflug & Thomson in Thomson and Pflug, 1953
emend. Potonié, 1958**

TYPE SPECIES: *Inaperturopollenites dubius* (Potonié & Venitz, 1934) Thomson & Pflug, 1953.

COMMENTS: See Jansonius and Hills (1976, card 3985) for generic diagnosis.

***Inaperturopollenites dubius* (Potonié & Venitz, 1934) Thomson & Pflug, 1953**

[Plate 4, Figure 6]

1934 *Pollenites magnus dubius* Potonié & Venitz, p.17, pl. 2, fig. 21.

1953 *Inaperturopollenites dubius* (Potonié & Venitz, 1934) Thomson & Pflug, p. 65, pl. 4, fig. 89; pl. 5, fig. 1-13.

SIZE RANGE: 28 μ m to 40 μ m diameter, 15 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections, except Cedar Mountain at Molen and Steinaker Draw.

COMMENTS: See Jansonius and Hills (1976, card 3985) for description. The affinity of this species is probably with Cupressaceae or Taxodiaceae.

***Inaperturopollenites limbatus* Balme, 1957**

[Plate 4, Figure 7]

1957 *Inaperturopollenites limbatus* Balme, p. 25, pl. 17, fig. 1-2.

SIZE RANGE: 80 μ m to 97 μ m diameter, 7 specimens measured.

OCCURRENCE: Rare to frequent; in the lower Tununk in all sections.

COMMENTS: See Balme (1957, p. 25) for description.

Genus *Laricoidites* Potonié, Thomson & Thiergart ex Potonié, 1958

TYPE SPECIES: *Laricoidites magnus* (Potonié, 1931d) Potonié, Thomson & Thiergart, 1950 ex Potonié, 1958.

COMMENTS: See Jansonius and Hills (1976, card 1450) for generic diagnosis.

***Laricoidites* sp. A**

[Plate 4, Figure 8]

DESCRIPTION: Pollen grain; alete; shape spherical to subspherical; exine finely granulate, thin and easily folded; measurements: 48 μ m to 72 μ m diameter, 7 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch; in the Tununk and Ferron at Ivie Creek, Molen and Farnham Dome.

Genus *Perinopollenites* Couper, 1958

TYPE SPECIES: *Perinopollenites elatoides* Couper, 1958.

COMMENTS: See Couper (1958, p. 152) for synonymy and generic diagnosis.

***Perinopollenites elatoides* Couper, 1958**

[Plate 4, Figure 9]

1958 *Perinopollenites elatoides* Couper, p. 152, pl. 27, fig. 9-11.SIZE RANGE: 26 μ m to 31 μ m diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Dakota, Tununk and Ferron at Molen; in the Dakota and Ferron at Ivie Creek.

COMMENTS: See Couper (1958, p. 152) for description. Pollen of the *Perinopollenites elatoides* form were extracted from the cones of *Elatides williamsonii*, a fossil gymnosperm referable to the Taxodiaceae.**Genus *Taxodiaceapollenites* Kremp, 1949 ex Potonié, 1958**TYPE SPECIES: *Taxodiaceapollenites hiatus* (Potonié, 1931c) Kremp, 1949.

COMMENTS: See Jansonius and Hills (1976, card 2839) for generic diagnosis.

***Taxodiaceapollenites hiatus* (Potonié, 1931c) Kremp, 1949**

[Plate 4, Figure 10]

1931c *Pollenites hiatus* Potonié, p. 5, fig. 27.1949 *Taxodiaceapollenites hiatus* (Potonié, 1931c) Kremp, p. 59.1965 *Thuja ? hiatus* (Potonié, 1931c) Stanley, p. 273, pl. 38, fig. 1-3.SIZE RANGE: 24 μ m to 31 μ m diameter, 15 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Stanley (1965, p. 273) for description.

Gymnospermous Pollen -- Saccate**Genus *Alisporites* Daugherty, 1941 emend. Potonié & Kremp, 1956**TYPE SPECIES: *Alisporites opii* Daugherty, 1941.

COMMENTS: See Singh (1964, p. 107) for discussion and synonymy.

***Alisporites bilateralis* Rouse, 1959**

[Plate 4, Figure 11]

1959 *Alisporites bilateralis* Rouse, p. 316, pl. 1, fig. 10-11.

SIZE RANGE: 53 μ m to 61 μ m total breadth of grain, 7 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Rouse (1959, p. 316) for description.

***Alisporites* sp. A**

[Plate 5, Figure 1]

DESCRIPTION: Pollen grain, bisaccate; central body oval in polar view, approximately 50 μ m to 57 μ m in length and 39 μ m to 45 μ m diameter normal to long axis; bladders attached to entire length of body, 20 μ m to 26 μ m wide, exine of bladders finely granulate; distal furrow 6 μ m to 11 μ m wide entire length; dimensions: 54 μ m to 63 μ m total diameter of grain, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain and Mowry at Steinaker Draw; in the Dakota and Tununk at Ivie Creek and Molen; in the Tununk at Farnham Dome; in the Tununk and Ferron at Horsethief Canyon Ranch.

Genus *Callialasporites* Dev, 1961

TYPE SPECIES: *Callialasporites trilobatus* (Balme, 1957) Dev, 1961.

COMMENTS: See Dev (1961, p. 48) for generic diagnosis.

1957 Zone

1957 Zone

1961 Call.

1963 Tsug

text f

SIZE F

OCCU

COMM

Cretaceous in

p. 478, for de

TYPE SE

COMME

DESCR

approximately

17 μ m to 23 μ m

expanding to

dimension of

***Callialasporites ?dampieri* (Balme, 1957) Dev, 1961**

[Plate 5, Figure 2]

- 1957 *Zonalapollenites dampieri* Balme, p. 32, pl. 8, fig. 88-90.
- 1957 *Zonalapollenites segmentatus* Balme, p. 33, pl. 8, fig. 91-92.
- 1961 *Callialasporites dampieri* (Balme, 1957) Dev, p. 48, pl. 4, fig. 26-27.
- 1963 *Tsugaepollenites segmentatus* (Balme, 1957) Dettmann, p. 101, pl. 24, fig. 11-16; text fig. 6f.

SIZE RANGE: 55 μ m diameter, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: As this genus is most commonly found in rocks of Jurassic and Lower Cretaceous in age, this specimen may be reworked from older rocks. See Fensome (1983, p. 478) for description and complete synonymy.

Genus *Cedripites* Wodehouse, 1933

TYPE SPECIES: *Cedripites eocenicus* Wodehouse, 1933.

COMMENTS: For generic diagnosis see Wodehouse (1933, p. 490).

***Cedripites* sp. A**

[Plate 5, Figure 3]

DESCRIPTION: Pollen grain, bisaccate; central body circular in polar view, psilate, approximately 31 μ m to 41 μ m in diameter; bladders attached three fourths length of body, 17 μ m to 23 μ m wide, exine of bladders psilate; distal furrow 4 μ m to 6 μ m wide at pole and expanding to approximately 12 μ m nearer equator; dimensions: 43 μ m to 53 μ m total long dimension of grain, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota and Tununk at Molen; in the Tununk at Ivie Creek; in the Tununk and Ferron at Farnham Dome.

Genus *Cerebropollenites* Nilsson, 1958

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

COMMENTS: See Nilsson (1958, p. 72) or Jansonius and Hills (1976, card 442) for generic description.

***Cerebropollenites mesozoicus* (Couper, 1958) Nilsson, 1958**

[Plate 5, Figure 4]

SYNONYMY:

1958 *Tsugaepollenites mesozoicus* Couper, 1958, p. 155, pl. 30, fig. 8-10.

1958 *Cerebropollenites mesozoicus* (Couper, 1958) Nilsson, p. 72, pl. 6, figs. 10-12.

SIZE RANGE: 40µm diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Burger (1966, p. 261) for description.

Genus *Parvisaccites* Couper, 1958

TYPE SPECIES: *Parvisaccites radiatus* Couper, 1958.

COMMENTS: See Couper (1958, p. 154) for description, and Singh (1964, p. 112) for synonymy. Pollen similar to *Parvisaccites* is produced by the modern species *Dacrydium*.

***Parvisaccites rugulatus* Brenner, 1963**

[Plate 5, Figure 5]

1963 *Parvisaccites rugulatus* Brenner, p. 79, pl. 30, fig. 1-2.

SIZE RANGE: 31 μ m to 40 μ m total diameter perpendicular to bladders, 35 μ m to 46 μ m diameter parallel to bladder, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Brenner (1963, p. 79) for description.

Genus *Pinuspollenites* Raatz, 1937 ex Potonié, 1958

TYPE SPECIES: *Pinuspollenites labdacus* (Potonié, 1931c) Raatz, 1937 ex Potonié, 1958.

COMMENTS: See Jansonius and Hills (1976, card 2012) for generic diagnosis.

***Pinuspollenites* sp. A**

[Plate 5, Figure 6]

DESCRIPTION: Pollen grain, bisaccate; central body oval in polar view, approximately 30 μ m to 55 μ m in length and 46 μ m to 62 μ m in diameter (short axis); bladders attached three fourths length of body, 25 μ m to 32 μ m wide, exine of bladders scabrate to finely granulate; distal furrow 12 μ m to 18 μ m wide entire length; dimensions: 54 μ m to 71 μ m total long dimension of grain, 15 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

Genus *Pityosporites* Seward, 1914

TYPE SPECIES: *Pityosporites antarcticus* Seward, 1914.

COMMENTS: See Seward (1914, p. 23) for generic diagnosis.

***Pityosporites* sp. A**

[Plate 5, Figure 7]

DESCRIPTION: Pollen grain, bisaccate; central body oval in polar view, finely granulate, approximately $40\mu\text{m}$ to $51\mu\text{m}$ in length and $33\mu\text{m}$ to $35\mu\text{m}$ in width; bladders attached to entire length of body, but not extending past margins of central body, $12\mu\text{m}$ to $17\mu\text{m}$ wide, exine of bladders finely to coarsely granulate; distal furrow $12\mu\text{m}$ to $15\mu\text{m}$ wide entire length; dimensions: $40\mu\text{m}$ to $51\mu\text{m}$ total length of grain, 6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Podocarpidites* Cookson, 1947a ex Couper, 1953

TYPE SPECIES: *Podocarpidites ellipticus* Cookson, 1947a.

COMMENTS: See Couper (1953, p. 35) for generic diagnosis.

***Podocarpidites* sp. A.**

[Plate 5, Figure 8]

DESCRIPTION: Pollen grain, bisaccate; central body circular in polar view, finely granulate, approximately $41\mu\text{m}$ to $49\mu\text{m}$ in diameter; bladders attached to entire length and extending slightly beyond body, $36\mu\text{m}$ to $44\mu\text{m}$ in breadth and $47\mu\text{m}$ to $54\mu\text{m}$ in length, exine of bladders coarsely granulate; distal furrow $6\mu\text{m}$ to $12\mu\text{m}$ wide entire length; dimensions: $70\mu\text{m}$ to $84\mu\text{m}$ total dimension of long axis of grain, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Molen, Ivie Creek and Farnham Dome.

6

10

25

30

35

S.

67

68

45

2

91

17

***Podocarpidites* sp. B**

[Plate 5, Figure 9]

DESCRIPTION: Pollen grain, bisaccate; central body oval in polar view, coarsely granulate, approximately $36\mu\text{m}$ to $41\mu\text{m}$ perpendicular to long axis and $41\mu\text{m}$ to $48\mu\text{m}$ in long axis; bladders attached along entire length and extending beyond body, $24\mu\text{m}$ to $29\mu\text{m}$ in breadth and $42\mu\text{m}$ to $51\mu\text{m}$ in length, exine of bladders thin and finely granulate; distal furrow $9\mu\text{m}$ to $12\mu\text{m}$ wide entire length; dimensions: $58\mu\text{m}$ to $70\mu\text{m}$ total long dimension of grain, 7 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain, Mowry and Tununk at Steinaker Draw.

***Podocarpidites* sp. C**

[Plate 6, Figure 1]

DESCRIPTION: Pollen grain, bisaccate; central body broadly oval in polar view, psilate, approximately $37\mu\text{m}$ to $47\mu\text{m}$ in long dimension; bladders attached along entire width and extending beyond body, $27\mu\text{m}$ to $35\mu\text{m}$ perpendicular to long axis of grain and $37\mu\text{m}$ to $48\mu\text{m}$ parallel with long axis in length, exine of bladders coarsely reticulate; distal furrow $9\mu\text{m}$ to $12\mu\text{m}$ wide entire width of central body; dimensions: $65\mu\text{m}$ to $78\mu\text{m}$ total breadth of grain, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek; in the Tununk and Ferron at Horsethief Canyon Ranch.

Genus *Pristinuspollenites* B.D. Tschudy, 1973

TYPE SPECIES: *Pristinuspollenites microsaccus* (Couper, 1958) B.D. Tschudy, 1973.

COMMENTS: For generic diagnosis see B.D. Tschudy (1973, p. 16).

***Pristinuspollenites elongatus* (Kemp, 1970) Singh, 1983**

[Plate 6, Figure 2]

1970 *Alisporites elongatus* Kemp, p. 120, pl. 27, fig. 2-7.

1983 *Pristinuspollenites elongatus* (Kemp, 1970) Singh, p. 54, pl. 10, fig. 1.

SIZE RANGE: 40 μ m to 58 μ m total breadth, 56 μ m to 75 μ m height, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota and Ferron at Ivie Creek; in the Tununk at Molen.

COMMENTS: See Singh (1983, p. 54) for description.

Genus *Rugubivesiculites* Pierce, 1961

TYPE SPECIES: *Rugubivesiculites convolutus* Pierce, 1961.

COMMENTS: See Pierce (1961, p. 22) for generic diagnosis.

***Rugubivesiculites reductus* Pierce, 1961**

[Plate 6, Figure 3]

1961 *Rugubivesiculites reductus* Pierce, p. 41, pl. 2, fig. 64-65.

SIZE RANGE: 43 μ m to 47 μ m total breadth, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch; in the Tununk at Molen; in the Tununk and Ferron at Farnham Dome; in the Ferron at Ivie Creek.

COMMENTS: See Pierce (1961, p. 41) for description and Singh (1971, p. 167) for discussion.

***Rugubivesiculites rugosus* Pierce, 1961**

[Plate 6, Figure 4-5]

1961 *Rugubivesiculites rugosus* Pierce, p. 40, pl. 2, fig. 59-60.

SIZE RANGE: 85 μ m to 101 μ m breadth, 6 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota and Tununk at Molen; in the Mowry and Tununk at Steinaker Draw; in the Dakota and Tununk at Horsethief Canyon Ranch and Ivie Creek; in the Tununk at Farnham Dome.

COMMENTS: See Pierce (1961, p. 40) for description.

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

TYPE SPECIES: *Vitreisporites signatus* Leschik, 1955.

COMMENTS: See Jansonius (1962, p. 55) for emended generic diagnosis.

***Vitreisporites pallidus* (Reissinger, 1938) Nilsson, 1958**

[Plate 6, Figure 6]

1938 *Pityosporites pallidus* Reissinger, p. 14.

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

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

1958 *Vitreisporites pallidus* (Reissinger, 1938) Nilsson, p. 77, pl. 7, fig. 12-14.

SIZE RANGE: 26 μ m to 34 μ m total breadth, 7 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain and Mowry at Steinaker Draw; in the Dakota and Tununk at Molen; in the Tununk at Ivie Creek and Farnham Dome.

COMMENTS: See Singh (1964, p. 102) for description.

Gymnospermous Pollen -- Plicate

Genus *Equisetosporites* Daugherty, 1941 emend. Singh, 1964

TYPE SPECIES: *Equisetosporites chinleana* Daugherty, 1941.

COMMENTS: See Singh (1964, p. 129) for emended generic diagnosis.

1

1

ap

wx

app

sam

mea

Cre

cou

***Equisetosporites ambiguus* (Hedlund, 1966) Singh, 1983**

[Plate 7, Figure 1-2a,b]

1966 *Ephedripites ambiguus* Hedlund, p. 27, pl. 8, fig. 3a-3b.1983 *Equisetosporites ambiguus* (Hedlund, 1966) Singh, p. 57, pl. 10, fig. 9-11.SIZE RANGE: 29 μ m to 36 μ m polar, 5 specimens measured.

OCCURRENCE: Rare; in the Ferron at Molen and Ivie Creek.

COMMENTS: For description see Singh (1983, p. 57).

***Equisetosporites* sp. A**

[Plate 7, Figure 3]

DESCRIPTION: Pollen grain, polyplicate; shape perprolate; surface ornamented with approximately 30 plicae, each 0.5 μ m wide separated by furrows of approximately the same width; dimensions: 31 μ m to 40 μ m polar, 13 μ m to 16 μ m equatorial, 8 specimens measured.

OCCURRENCE: Rare; throughout all sections, except Steinaker Draw.

***Equisetosporites* sp. C**

[Plate 7, Figure 4]

DESCRIPTION: Pollen grain, polyplicate; shape prolate; surface ornamented with approximately 9 to 11 plicae, each 1.5 μ m wide separated by furrows of approximately the same width; dimensions: 28 μ m to 33 μ m polar, 16 μ m to 24 μ m equatorial, 5 specimens measured.

OCCURRENCE: Rare; in the Dakota at Molen; in the Dakota and lower Tununk at Ivie Creek; in the lower Tununk at Farnham Dome.

COMMENTS: *Equisetosporites* sp. C is different from other forms by having fairly course plicae.

***Equisetosporites* sp. D**

[Plate 7, Figure 5]

DESCRIPTION: Pollen grain, polyplicate, shape perprolate; surface ornamented with approximately 20 to 25 plicae, each $0.25\mu\text{m}$ to $0.5\mu\text{m}$ wide separated by furrows of approximately the same width; dimensions: $20\mu\text{m}$ to $25\mu\text{m}$ polar, $8\mu\text{m}$ to $11\mu\text{m}$ equatorial, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek and Molen.

COMMENTS: This form of *Equisetosporites* is distinguished by its small size.

***Equisetosporites* sp. E**

[Plate 7, Figure 6]

DESCRIPTION: Pollen grain, polyplicate, shape perprolate; surface ornamented with approximately 30 plicae, each $1.0\mu\text{m}$ to $1.5\mu\text{m}$ wide separated by furrows $0.5\mu\text{m}$ to $1.0\mu\text{m}$ wide; surface of plicae are finely scabrate; dimensions: $72\mu\text{m}$ to $88\mu\text{m}$ polar, $26\mu\text{m}$ to $33\mu\text{m}$ equatorial, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENTS: This form of *Equisetosporites* is distinct in its large size.

Microspores -- Trilete**Genus *Appendicisporites* Weyland & Krieger, 1953**

TYPE SPECIES: *Appendicisporites tricuspidatus* Weyland & Krieger, 1953.

COMMENTS: See Srivastava (1972, p. 4) for synonymy and Pocock (1964, p. 161) for generic diagnosis and discussion. Spores similar to the form genus *Appendicisporites* are known from the modern schizaeaceous fern genera *Anemia* and *Mohria*.

1

C

1965

Draw

1961

1966

1976

1985

***Appendicisporites auritus* Agasie, 1969**

[Plate 7, Figure 7]

1969 *Appendicisporites auritus* Agasie, p. 17, pl. 1, fig. 1-2.SIZE RANGE: 42 μ m to 51 μ m, 5 specimens measured.

OCCURRENCE: Rare to common; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

COMMENTS: For description see Agasie (1969, p. 17).

***Appendicisporites dentimarginatus* Brenner, 1963**

[Plate 7, Figure 8]

1963 *Appendicisporites dentimarginatus* Brenner, p. 45, pl. 6, fig. 2-3.SIZE RANGE: 48 μ m to 58 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Brenner (1963, p. 45) for description.

Appendicisporites insignis**(Markova in Ivanova and Markova, 1961) Chlonova, 1976**

[Plate 7, Figure 9]

1961 *Anemia insignis* Markova in Ivanova and Markova, p. 76, pl. 19, fig. 4a, 4b,; pl. 33, fig. 13, 14.1966 *Cicatricosisporites insignis* (Markova in Ivanova and Markova, 1961) Döring, p. 67.1976 *Appendicisporites insignis* (Markova in Ivanova and Markova, 1961) Chlonova, p. 42, pl. 7, fig. 1, 2.1985 *Plicatella insignis* (Markova in Ivanova and Markova, 1961) Davies, 1985, p. A47.

SIZE RANGE: 58 μ m to 70 μ m, 11 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Singh (1983, p. 36) for description.

***Appendicisporites potomacensis* Brenner, 1963**

[Plate 8, Figure 1]

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

SIZE RANGE: 44 μ m to 56 μ m, 7 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota and lower Tununk at Molen; in the Mowry at Steinaker Draw; in the Dakota and lower Tununk at Ivie Creek; in the lower Tununk at Farnham Dome.

COMMENTS: For description see Brenner (1963, p. 46).

***Appendicisporites* sp. A**

[Plate 8, Figure 2a, 8b]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae approximately 3/4 radius; ribs numerous, thin and flat-topped, approximately 1.0 μ m wide separated by furrows of about the same width; appendices approximately 13 μ m in length and 4 μ m wide, decreasing in length towards distal side; dimensions: 46 μ m to 61 μ m total diameter including appendices, 12 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek.

COMMENTS: *Appendicisporites* sp. A is similar to *Appendicisporites insignis*, but differs in having thinner and more numerous ribs.

***Appendicisporites* sp. B**

[Plate 8, Figure 3]

DESCRIPTION: Spore, trilete; amb triangular with concave sides; laesurae approximately $2/3$ radius; ribs few, thin and triangular in cross-section, approximately $3.0\mu\text{m}$ wide separated by furrows of about $2\mu\text{m}$; appendices approximately $10\mu\text{m}$ in length and $5\mu\text{m}$ to $2\mu\text{m}$ wide; dimensions: $52\mu\text{m}$ to $63\mu\text{m}$ total diameter including appendices, 3 specimens measured.

OCCURRENCE: Frequent; in the Dakota at Molen.

***Appendicisporites* sp. C**

[Plate 8, Figure 4]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae approximately $7/8$ radius, raised and undulating; ribs few, thick and flat-topped, approximately $2.0\mu\text{m}$ wide separated by furrows of about the same width; appendices reduced to thickened areas at apices; dimensions: $28\mu\text{m}$ to $34\mu\text{m}$ total diameter including appendices, 5 specimens measured.

OCCURRENCE: Common; in the Cedar Mountain at Steinaker Draw.

***Appendicisporites* sp. D**

[Plate 8, Figure 5]

DESCRIPTION: Spore, trilete; amb triangular with convex sides to sub-circular; laesurae approximately $3/4$ radius; ribs numerous, thin and triangular in cross-section, approximately $2.0\mu\text{m}$ wide separated by furrows $2\mu\text{m}$ to $4\mu\text{m}$ thick; appendices approximately $7\mu\text{m}$ in length and $6\mu\text{m}$ to $8\mu\text{m}$ wide; dimensions: $44\mu\text{m}$ to $50\mu\text{m}$ total diameter including appendices, 3 specimens measured.

app:

sepa

leng

diam

small

appro:

irregul

separa

3.4m in

append

the Fem.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

***Appendicisporites* sp. E**

[Plate 8, Figure 6]

DESCRIPTION: Spore, trilete; amb triangular with straight to convex sides; laesurae approximately 3/4 radius; ribs numerous, thin and flat-topped, approximately 1.0 μ m wide separated by furrows of about the same width; appendices approximately 3 μ m to 5 μ m in length and 4 μ m wide; thin flange-like ridge at equator; dimensions: 44 μ m to 55 μ m total diameter including appendices, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENTS: This form differs from *Appendicisporites* sp. A, in having fewer ribs, smaller appendices and in having a flange-like equatorial ridge.

***Appendicisporites* sp. F**

[Plate 8, Figure 7]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae approximately 3/4 radius; ribs numerous, thin discontinuous, made up of ribs with small, irregular shaped clavae projecting up from the ribs, approximately 1.0 μ m to 1.5 μ m wide separated by furrows of about 1 μ m to 3 μ m in width; appendices reduced, approximately 3 μ m in length and 5 μ m wide; dimensions: 45 μ m to 54 μ m total diameter including appendices, 5 specimens measured.

OCCURRENCE: Rare; in the upper Tununk, Ferron and Blue Gate at Ivie Creek; in the Ferron at Molen and Farnham Dome.

day

195

57

19

19

57

7

Genus *Biretisporites* Delcourt & Sprumont, 1955

emend. Delcourt, Dettmann & Hughes, 1963

TYPE SPECIES: *Biretisporites potoniaei* Delcourt & Sprumont, 1955.

COMMENTS: See Delcourt, Dettmann and Hughes (1963, p. 283) for generic diagnosis and synonymy.

***Biretisporites potoniaei* Delcourt & Sprumont, 1955**

[Plate 9, Figure 1]

1955 *Biretisporites potoniaei* Delcourt & Sprumont, p. 40, fig. 10.

SIZE RANGE: 31 μ m to 43 μ m, 7 specimens measured.

OCCURRENCE: Rare to common; throughout all sections.

COMMENTS: See Delcourt, Dettmann and Hughes (1963, p. 284) for description and synonymy.

Genus *Camarozonosporites* Pant, 1954 ex Potonié, 1956 emend. Klaus, 1960

TYPE SPECIES: *Camarozonosporites cretaceus* (Weyland & Krieger, 1953) Potonié, 1956.

COMMENTS: See Jansonius and Hills (1976, card 366) for generic diagnosis.

***Camarozonosporites insignis* Norris, 1967**

[Plate 9, Figure 2]

1967 *Camarozonosporites insignis* Norris, p. 96, pl. 13, fig. 12-16.

SIZE RANGE: 27 μ m to 40 μ m, 15 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Dakota, Tununk and Ferron at Molen and Horsethief Canyon Ranch; in the Dakota, Tununk, Ferron and Blue Gate at Ivie Creek; in the Tununk and Ferron at Farnham Dome.

COMMENTS: See Norris (1967, p. 96) for description.

***Camarozonosporites* sp. A**

[Plate 9, Figure 3]

DESCRIPTION: Spore, trilete; amb circular; distal surface sculptured with rugulae; dimensions: 19 μ m to 27 μ m, 12 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: This form differs from *Camarozonosporites insignis* by the smaller size and the coarser distal rugulae.

Genus *Chomotriletes* Naumova, 1939 ex Naumova, 1953

TYPE SPECIES: *Chomotriletes vedugensis* Naumova, 1953.

COMMENTS: See Singh (1964, p. 61) for generic diagnosis.

***Chomotriletes minor* (Kedves, 1961) Pocock, 1970**

[Plate 9, Figure 4]

1961 *Schizaeoisporites minor* Kedves, p. 129, pl. 6, fig. 11-16.

1970 *Chomotriletes minor* (Kedves, 1961) Pocock, p. 61, pl. 11, fig. 14.

SIZE: 42 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: For description see Pocock (1970, p. 61).

Genus *Cibotiumspora* Chang, 1965

TYPE SPECIES: *Cibotiumspora paradoxa* (Malyavkina, 1949) Chang, 1965.

COMMENTS: See Filatoff (1975, p. 60) for generic diagnosis.

1

1

1

1

C

19

Ca

at

***Cibotiumspora juncta* (Kara-Murza, 1954) Singh, 1983**

[Plate 9, Figure 5]

- 1954 *Cibotium juncta* Kara-Murza, p. 35, pl. 1, fig. 4-9.
- 1964 *Deltoidospora junctum* (Kara-Murza, 1954) Singh, p. 81, pl. 9, fig. 16.
- 1970 *Obtusisporis juncta* (Kara-Murza, 1954) Pocock, p. 35, pl. 5, fig. 26,29.
- 1983 *Cibotiumspora junctum* (Kara-Murza, 1954) Singh, 1983, p. 30.

SIZE RANGE: 30 μ m to 35 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch and Ivie Creek; in the Dakota and lower Tununk at Molen.

COMMENTS: See Singh (1964, p. 81) for description.

***Genus Cicatricosisporites* Potonié & Gelletich, 1933**

TYPE SPECIES: *Cicatricosisporites dorogensis* Potonié & Gelletich, 1933.

COMMENTS: See Dettmann (1963, p. 52) for generic diagnosis and discussion.

***Cicatricosisporites crassiterminatus* Hedlund, 1966**

[Plate 9, Figure 6]

- 1966 *Cicatricosisporites crassiterminatus* Hedlund, p. 19, pl. 4, fig. 1a-1c.

SIZE RANGE: 45 μ m to 56 μ m; 13 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch; in the Dakota, Tununk and Ferron at Ivie Creek and Molen; in the Ferron at Farnham Dome.

COMMENTS: See Hedlund (1966, p. 19) for description.

193

195

195

196

Mo

live

195

196

196

Cicatricosisporites dorigensis* Potonié & Gelletich, 1933*emend. Kedves, 1961**

[Plate 9, Figure 7]

1933 *Cicatricosisporites dorigensis* Potonié & Gelletich, p. 523, pl. 1, fig. 1-3.1951b *Mohriosporites dorigensis* (Potonié & Gelletich, 1933) Potonié, pl. 20, fig. 14.1955 *Cicatricosisporites sewardi* Delcourt and Sprumont, p. 19, text-fig. 2.1961 *Cicatricosisporites dorigensis* ssp. *major* Kedves, p. 126, pl. 5, fig. 10.SIZE RANGE: 42 μ m to 66 μ m, 9 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain, Dakota and Tununk at Molen; in the Mowry at Steinaker Draw; in the Dakota, Tununk, Ferron and Blue Gate at Ivie Creek; in the Tununk at Farnham Dome.

COMMENTS: See Couper (1958, p. 136) for description.

***Cicatricosisporites hallei* Delcourt & Sprumont, 1955**

[Plate 9, Figure 8]

1955 *Cicatricosisporites hallei* Delcourt & Sprumont, p. 17, pl. 1, fig. 1; text fig. 1.1961 *Cicatricosisporites dorigensis* ssp. *minor* Kedves, p. 126, pl. 6, fig. 1-4.SIZE RANGE: 45 μ m to 57 μ m, 7 specimens measured.

OCCURRENCE: Rare to common; throughout all sections.

COMMENTS: See Delcourt, Dettmann and Sprumont (1963, p. 287) for description.

***Cicatricosisporites potomacensis* Brenner, 1963**

[Plate 9, Figure 9]

1963 *Cicatricosisporites potomacensis* Brenner, p. 50, pl. 9, fig. 4-5.SIZE RANGE: 63 μ m to 75 μ m, 4 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: For description see Brenner (1963, p. 50).

***Cicatricosisporites venustus* Deák, 1963**

[Plate 10, Figure 1]

1963 *Cicatricosisporites venustus* Deák, p. 252, pl. 2, fig. 8, 9, 12, 13.

1984 *Cicatricosisporites venustus* Deák — Tschudy *et al.*, pl. 2, fig. 8.

SIZE RANGE: 28 μ m to 34 μ m, 8 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain at Molen; in the Cedar Mountain and Mowry at Steinaker Draw.

COMMENTS: For description see Deák (1963, p. 252).

***Cicatricosisporites* sp. A**

[Plate 10, Figure 2]

DESCRIPTION: Spore, trilete; amb triangular with broadly rounded apices; laesurae 2/3 distance to equator; surface ribbed, ribs 2 μ m to 3 μ m wide separated by canals of approximately equal width; wall thick; dimensions: 60 μ m to 71 μ m diameter, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Molen and Horsethief Canyon Ranch.

COMMENTS: This is distinguished from other forms of *Cicatricosisporites* by its thick wall, triangular shape and large size.

Genus *Cingutritetes* Pierce, 1961

TYPE SPECIES: *Cingutritetes congruens* Pierce, 1961.

COMMENTS: For generic diagnosis see Pierce (1961, p. 25).

***Cingutriletes congruens* Pierce, 1961**

[Plate 10, Figure 3]

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

SIZE RANGE: 29 μ m to 37 μ m, 7 specimens measured.

OCCURRENCE: Rare to frequent; in the upper Tununk at Farnham Dome; in the upper Tununk and Ferron at Molen; in the upper Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Pierce (1961, p. 25) for description.

***Cingutriletes* sp. A**

[Plate 10, Figure 4]

DESCRIPTION: Spore, trilete; amb subcircular; laesurae extending entire distance to equator; equatorial cingulum 2 μ m to 4 μ m wide, wider where laesurae extends onto cingulum; surface psilate; dimensions: 29 μ m to 34 μ m diameter, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Ivie Creek.

COMMENTS: This form is distinguished from *Cingutriletes congruens* by its narrower cingulum.

***Cingutriletes* sp. B**

[Plate 10, Figure 5]

DESCRIPTION: Spore, trilete; amb circular to subcircular; laesurae extending 1/2 distance to equator; equatorial cingulum 1 μ m to 2 μ m wide; distal surface covered with low verrucae; dimensions: 24 μ m diameter, 1 specimen measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Conbaculatisporites* Klaus, 1960

TYPE SPECIES: *Conbaculatisporites mesozoicus* Klaus, 1960

COMMENTS: See Jansonius and Hills (1976, card 544) for generic diagnosis.

***Conbaculatisporites* sp. A**

[Plate 10, Figure 6]

DESCRIPTION: Spore, trilete; amb subcircular; laesurae extending entire distance to equator; proximal and distal surface densely covered with verrucae $1\mu\text{m}$ to $2\mu\text{m}$ in diameter; dimensions: $22\mu\text{m}$ to $26\mu\text{m}$ diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

Genus *Concavisporites* Pflug in Thomson and Pflug, 1953

emend. Delcourt & Sprumont, 1955

TYPE SPECIES: *Concavisporites rugulatus* Pflug in Thomson and Pflug, 1953.

COMMENTS: See Delcourt and Sprumont (1955, p. 22) or Jansonius and Hills (1976, card 546) for emended generic diagnosis.

***Concavisporites lamontis* Habib, 1969**

[Plate 10, Figure 7]

1966 *Concavisporites* sp. — Hedlund, p. 13, pl. 1, fig. 8.

1969 *Concavisporites lamontis* Habib, p. 91, pl. 1, fig. 15-16.

SIZE RANGE: $23\mu\text{m}$ to $40\mu\text{m}$, 15 specimens measured.

OCCURRENCE: Rare to abundant; throughout all sections.

COMMENTS: See Habib (1969, p. 91) for description.

Genus *Concavissimisorites* Delcourt & Sprumont, 1955, emend

Delcourt, Dettmann & Hughes, 1963

TYPE SPECIES: *Concavissimisorites verrucosus* Delcourt & Sprumont, 1955.

COMMENTS: See Delcourt, Dettmann and Hughes (1963, p. 284) for emended generic diagnosis.

***Concavissimisorites vari verrucatus* Brenner, 1963**

[Plate 10, Figure 8]

1963 *Concavissimisorites vari verrucatus* Brenner, p. 59, pl. 14, fig. 4.

SIZE RANGE: 42 μ m to 61 μ m, 9 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain and Dakota at Molen; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek and Horsethief Canyon Ranch.

COMMENTS: See Brenner (1963, p. 59) for description.

Genus *Crybelosporites* Dettmann, 1963

TYPE SPECIES: *Crybelosporites striatus* (Cookson & Dettmann) Dettmann, 1963.

COMMENTS: For generic diagnosis see Dettmann (1963, p. 80).

***Crybelosporites brenneri* Playford, 1971**

[Plate 10, Figure 9-10]

1971 *Crybelosporites brenneri* Playford, p. 555, pl. 105, fig. 18-20.

SIZE RANGE: 34 μ m to 45 μ m inner body, 46 μ m to 68 μ m total including perisporium, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

COMMENTS: See Playford (1971, p. 555) for description.

***Crybelosporites pannuceus* (Brenner, 1963) Wingate, 1980**

[Plate 10, Figure 11]

1963 *Perotriletes pannuceus* Brenner, p. 66, pl. 18, fig. 3; pl. 19, fig. 1.

1980 *Crybelosporites pannuceus* (Brenner, 1963) Wingate, p. 23, pl. 9, fig. 4-5.

SIZE: 60 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Molen.

COMMENTS: See Brenner (1963, p. 66) for description.

Genus *Cyathidites* Couper, 1953

TYPE SPECIES: *Cyathidites australis* Couper, 1953.

COMMENTS: See Couper (1953, p. 27) for generic diagnosis.

***Cyathidites concavus* (Bolkhovitina, 1953) Dettmann, 1963**

[Plate 10, Figure 12]

1953 *Stenozonotriletes concavus* Bolkhovitina, p. 46, pl. 1, fig. 7.

1963 *Cyathidites concavus* (Bolkhovitina, 1953) Dettmann, p. 24, pl. 1, fig. 17-19.

SIZE RANGE: 23 μ m to 29 μ m, 12 specimens measured.

OCCURRENCE: Rare; in the Dakota and Tununk at Ivie Creek and Molen; in the Dakota, Tununk and Ferron at Horsethief Canyon Ranch; in the Tununk at Farnham Dome.

COMMENTS: See Dettmann (1963, p. 24) for description.

***Cyathidites minor* Couper, 1953**

[Plate 10, Figure 13]

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

SIZE RANGE: 29 μ m to 36 μ m, 8 specimens measured.

OCCURRENCE: Rare to common; throughout all sections.

COMMENTS: See Couper (1953, p. 28) for description.

Genus *Deltoidospora* Miner, 1935 emend. Potonié, 1956

TYPE SPECIES: *Deltoidospora hallii* Miner, 1935.

COMMENTS: See Singh (1964, p. 80) for synonymy and generic diagnosis.

***Deltoidospora hallii* Miner, 1935**

[Plate 11, Figure 1-2]

1935 *Deltoidospora hallii* Miner, p. 618, pl. 24, fig. 7.

SIZE RANGE: 23 μ m to 30 μ m, 15 specimens measured.

OCCURRENCE: Rare to abundant; throughout all sections.

COMMENTS: See Miner (1935, p. 618) and Singh (1964, p. 80) for synonymy and description.

Genus *Densoisporites* Weyland & Krieger, 1953

emend. Dettmann, 1963

TYPE SPECIES: *Densoisporites velatus* Weyland & Krieger, 1953.

COMMENTS: See Dettmann (1963, p. 83) for emended generic diagnosis.

***Densoisporites microrugulatus* Brenner, 1963**

[Plate 11, Figure 3]

1963 *Densoisporites microrugulatus* Brenner, p. 61, pl. 15, fig. 6; pl. 16, fig. 1.

SIZE RANGE: 47 μ m to 57 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Brenner (1963, p. 61) for description.

***Densoisporites velatus* Weyland & Krieger, 1953**

emend. Krasnova in Samoilovitch et al., 1961

[Plate 11, Figure 4]

1953 *Densoisporites velatus* Weyland & Krieger, p. 12, pl. 4, fig. 12-14.

1958 *Densoisporites perinatus* Couper, p. 145, pl. 23, fig. 6-9.

1961 *Selaginella velata* (Weyland & Krieger, 1953) Krasnova in Samoilovitch et al., p. 35, pl. 7, fig. 5, 6.

SIZE RANGE: 30 μ m to 42 μ m, 6 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Dettmann (1963, p. 84) for description.

Genus *Dictyophyllidites* Couper, 1958 emend. Dettmann, 1963

TYPE SPECIES: *Dictyophyllidites harrisii* Couper, 1958.

COMMENTS: For emended generic diagnosis see Dettmann (1963, p. 27).

***Dictyophyllidites impensus* (Hedlund, 1966) Singh, 1983**

[Plate 11, Figure 5]

1966 *Matonisporites impensus* Hedlund, p. 13., pl. 2, fig. 1a-1b.

1983 *Dictyophyllidites impensus* Singh, 1983, p. 29, pl. 1, fig. 1.

SIZE RANGE: 42 μ m to 67 μ m, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain and Mowry at Steinaker Draw; in the Cedar Mountain, Dakota and Tununk at Molen; in the Dakota at Horsethief

Canyon Ranch; in the Dakota, Tununk and Ferron at Ivie Creek; in the Tununk at Farnham Dome.

COMMENTS: See Singh (1983, p. 29) for description.

Genus *Echinatisporis* Krutzsch, 1959

TYPE SPECIES: *Echinatisporis longechinus* Krutzsch, 1959.

COMMENTS: See Srivastava (1975b, p. 38) for discussion and generic diagnosis.

***Echinatisporis varispinosus* (Pocock, 1962) Srivastava, 1975b**

[Plate 11, Figure 6]

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

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

1975b *Echinatisporis varispinosus* (Pocock, 1962) Srivastava, p. 39, pl. 17, fig. 8-14; pl. 18, fig. 1-4.

SIZE RANGE: 23 μ m to 29 μ m, 9 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Srivastava (1975b, p. 39) for description and discussion.

Genus *Foraminisporis* Krutzsch, 1959

TYPE SPECIES: *Foraminisporis foraminis* Krutzsch, 1959.

COMMENTS: See Wingate (1980, p. 8) for short description and discussion.

***Foraminisporis dailyi* (Cookson & Dettmann, 1958a) Dettmann, 1963**

[Plate 11, Figure 7]

1958a *Granulatisporites dailyi* Cookson & Dettmann, p. 99, pl. 14, fig. 2-4.

- 1963 *Foraminisporis dailyi* (Cookson & Dettmann, 1958a) Dettmann, 1963, p. 72, pl. 14, fig. 15-18.

SIZE RANGE: 36 μ m to 43 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Molen and Ivie Creek.

COMMENTS: See Dettmann (1963, p. 72) for description.

Genus *Gemmatriletes* Pierce, 1961

TYPE SPECIES: *Gemmatriletes morulus* Pierce, 1961.

COMMENTS: See Pierce (1961, p. 27) for generic diagnosis.

***Gemmatriletes ?morulus* Pierce, 1961**

[Plate 11, Figure 8]

- 1961 *Gemmatriletes morulus* Pierce, p. 27, pl. 1, fig. 7.

SIZE RANGE: 33 μ m to 39 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Pierce (1961, p. 17) for description.

Genus *Gleicheniidites* Ross, 1949 ex Delcourt & Sprumont, 1955

emend. Dettmann, 1963

TYPE SPECIES: *Gleicheniidites senonicus* Ross, 1949.

COMMENTS: For emended generic diagnosis see Dettmann (1963, p. 64).

***Gleicheniidites circinidites* (Cookson, 1953) Dettmann, 1963**

[Plate 11, Figure 9]

- 1953 *Gleichenia circinidites* Cookson, p. 464, pl. 1, fig. 6.

- 1953 *Gleichenia umbonata* Bolkhovitina, p. 53, pl. 8, fig. 4-7.
- 1961 *Cingutrites interruptus* Pierce, p. 26, pl. 1, fig. 5.
- 1963 *Gleicheniidites* cf. *G. cercinidites* [sic] (Cookson, 1953) Dettmann, p. 65, pl. 13, fig. 6-10.

- 1963 *Gleicheniidites circinidites* (Cookson, 1953) Brenner, p. 53, pl. 11, fig. 4-5.

SIZE RANGE: 24 μ m to 34 μ m, 11 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek; in the Dakota, Tununk and Ferron at Horsethief Canyon Ranch; and in the Tununk at Farnham Dome.

COMMENTS: See Dettmann (1963, p. 65) for description.

***Gleicheniidites senonicus* Ross, 1949**

[Plate 11, Figure 10]

- 1949 *Gleicheniidites senonicus* Ross, p. 31, pl. 1, fig. 3.

SIZE RANGE: 26 μ m to 32 μ m, 15 specimens measured.

OCCURRENCE: Rare to abundant; throughout all sections.

COMMENTS: See Ross (1949, p. 31) for description.

Genus *Heliosporites* Schulz, 1962 emend. Srivastava, 1972

TYPE SPECIES: *Heliosporites altmarkensis* Schulz, 1962.

COMMENTS: See Srivastava (1972, p. 18) for generic diagnosis. It has been noted that spores similar to the form genus *Heliosporites* are produced by the extant *Selaginella selaginoides* (Srivastava, 1972, p. 19).

***Heliosporites kemensis* (Chlonova, 1960) Srivastava, 1972**

[Plate 11, Figure 11]

1960 *Selaginella kemensis* Chlonova, p. 29, pl. 3, fig. 81972 *Heliosporites kemensis* (Chlonova, 1960) Srivastava, p. 19, pl. 14, fig. 3-13; pl. 15, fig. 1-13.SIZE RANGE: 42 μ m to 49 μ m total for tetrad, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENTS: See Srivastava (1972, p. 19) for description.

Genus *Klukisporites* Couper, 1958 emend. Pocock, 1965TYPE SPECIES: *Klukisporites variegatus* Couper, 1958.

COMMENTS: For emended generic diagnosis see Pocock (1965, p. 193).

***Klukisporites foveolatus* Pocock, 1965**

[Plate 11, Figure 12]

1965 *Klukisporites foveolatus* Pocock, p. 194, pl. 7, fig. 5-6.SIZE RANGE: 32 μ m to 37 μ m, 6 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Pocock (1965, p. 194) for description and Singh (1971, p. 95) for synonymy.

***Klukisporites pseudoreticulatus* Couper, 1958**

[Plate 12, Figure 1a,b]

1958 *Klukisporites pseudoreticulatus* Couper, p. 138, pl. 19, fig. 8-10.SIZE RANGE: 49 μ m to 60 μ m, 10 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota and Tununk at Molen; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek and Horsethief Canyon Ranch.

COMMENTS: See Couper (1958, p. 138) for description and Singh (1971, p. 96) for discussion.

Genus *Leptolepidites* Couper, 1953

TYPE SPECIES: *Leptolepidites verrucatus* Couper, 1953.

COMMENTS: See Couper (1953, p. 28) for generic description.

***Leptolepidites major* Couper, 1958**

[Plate 12, Figure 2]

1958 *Leptolepidites major* Couper, p. 141, pl. 21, fig. 7-8.

SIZE RANGE: 35 μ m to 40 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: For description see Couper (1958, p. 141).

***Leptolepidites* sp. A**

[Plate 12, Figure 3]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending 1/2 distance to equator; proximal and distal surfaces verrucate, verrucae approximately 1.5 μ m in diameter; dimensions: 26 μ m to 33 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This form differs from *Leptolepidites major* by having smaller verrucae and by being somewhat smaller.

Genus *Lycopodiacidites* Couper, 1953

TYPE SPECIES: *Lycopodiacidites bullerensis* Couper, 1953.

COMMENTS: See Couper (1953, p. 26) for generic diagnosis.

***Lycopodiacidites cerniidites* (Ross, 1949) Brenner, 1963**

[Plate 12, Figure 4a,b]

1949 *Lycopodium cerniidites* Ross, p. 30, pl. 1, fig. 1-2.

1955 *Lycopodiumsporites cerniidites* (Ross, 1949) Delcourt & Sprumont, p. 32.

1963 *Lycopodiacidites cerniidites* (Ross, 1949) Brenner, p. 43, pl. 5, fig. 2a-2b.

1969 *Camazonosporites dakotaensis* Agasie, p. 19, pl. 2, fig. 9-10.

SIZE RANGE: 37 μ m to 44 μ m, 9 specimens measured.

OCCURRENCE: Rare to common; in the Dakota and Tununk at Horsethief Canyon Ranch and Molen; in the Dakota, Tununk, Ferron and Blue Gate at Ivie Creek; in the Ferron at Farnham Dome.

COMMENTS: See Brenner (1963, p. 43) for description.

?*Lycopodiacidites* sp. A

[Plate 12, Figure 5a,b]

DESCRIPTION: Spore, trilete; amb subcircular to triangular with convex sides; laesurae extending 3/4 distance to equator with raised and thickened margins 2 μ m to 3 μ m wide, distal surface rugulate; spore enclosed in perisporium; dimensions: 35 μ m to 37 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Ferron at Farnham Dome.

Genus *Matonisporites* Couper, 1958 emend. Dettmann, 1963

TYPE SPECIES: *Matonisporites phlebopteroides* Couper, 1958.

COMMENTS: For emended generic diagnosis see Dettmann (1963, p. 58).

***Matonisorites phlebopteroides* Couper, 1958**

[Plate 12, Figure 6]

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

SIZE RANGE: 53 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Couper (1958, p. 140) for description.

Genus *Microreticulatisporites* Knox, 1950 emend. Potonié & Kremp, 1954

TYPE SPECIES: *Microreticulatisporites lacunosus* (Ibrahim, 1933) Knox, 1950.

COMMENTS: See Singh (1964, p. 97) for generic diagnosis.

***Microreticulatisporites sacalii* (Deák & Combaz, 1967) Ravn, 1986**

[Plate 12, Figure 7]

1967 *Vadaszisorites sacali* (err. orth. pro *sacalii*) Deák & Combaz, p. 79, pl. 1, fig. 14.

1986 *Microreticulatisporites sacalii* (Deák & Combaz, 1967) Ravn, p. 774, fig. 1.

SIZE RANGE: 39 μ m to 44 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Ravn (1986, p. 774) for description.

Genus *Neoraistrickia* Potonié, 1956

TYPE SPECIES: *Neoraistrickia truncatus* (Cookson, 1953) Potonié, 1956.

COMMENTS: See Dettmann (1963, p. 35) for discussion and generic diagnosis.

***Neoraistrickia* sp. A**

[Plate 12, Figure 8]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending entire distance to equator; equatorial margin and distal surface sparsely covered with clavae $1\mu\text{m}$ to $3\mu\text{m}$ in height; dimensions: $30\mu\text{m}$ to $37\mu\text{m}$ diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

Genus *Osmundacidites* Couper, 1953

TYPE SPECIES: *Osmundacidites wellmanii* Couper, 1953.

COMMENTS: See Couper (1953, p. 20) for generic diagnosis and Dettmann (1963, p. 31) for synonymy and discussion.

***Osmundacidites wellmanii* Couper, 1953**

[Plate 12, Figure 9]

1953 *Osmundacidites wellmanii* Couper, p. 20, pl. 1, fig. 5.

SIZE RANGE: $35\mu\text{m}$ to $45\mu\text{m}$, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Dakota at Ivie Creek and Molen; in the Dakota, Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: For description see Couper (1953, p. 20).

Genus *Perotriletes* Couper, 1953

TYPE SPECIES: *Perotriletes granulatus* Couper, 1953

COMMENTS: See Couper (1953, p. 31) for generic diagnosis.

Perotriletes sp. A

[Plate 13, Figure 1]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae extending 3/4 distance to equator; surface psilate; spore enclosed in thin perisporium, perisporium finely punctate 3-4 μ m wide; dimensions: 26 μ m to 33 μ m total diameter including perisporium, 8 specimens measured.

OCCURRENCE: Rare to common; in the Dakota at Horsethief Canyon Ranch; in the Dakota and Tununk at Molen; in the Dakota, Tununk, Ferron and Blue Gate at Ivie Creek; and in the Tununk and Ferron at Farnham Dome.

Perotriletes sp. C

[Plate 13, Figure 2]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending entire distance to equator, laesurae undulating, generally tapering radially; surface psilate; spore enclosed in thin perisporium, perisporium psilate up to 6 μ m wide; dimensions: 24 μ m to 33 μ m total diameter including perisporium, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

Perotriletes sp. D

[Plate 13, Figure 3]

DESCRIPTION: Spore, trilete; amb triangular with convex to straight sides; laesurae extending almost entire distance to equator; surface psilate; spore enclosed in thin perisporium, perisporium finely granulate with some coarser, almost knobby grana showing on margins as scalloped or undulating rim 5 to 6 μ m wide; dimensions: 35 μ m to 41 μ m total diameter including perisporium, 3 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain at Steinaker Draw and Molen.

Genus *Pilosisorites* Delcourt & Sprumont, 1955

TYPE SPECIES: *Pilosisorites labdacus* Delcourt & Sprumont, 1955.

COMMENTS: See Singh (1964, p. 75) for synonymy and generic diagnosis.

***Pilosisorites trichopapillosus* (Thiergart, 1949) Delcourt & Sprumont, 1955**

[Plate 13, Figure 4]

- 1949 *Sporites trichopapillosus* Thiergart, p. 22, pl. 4, fig. 18
- 1955 *Pilosisorites trichopapillosus* (Thiergart, 1949) Delcourt & Sprumont, p. 35, pl. 3, fig. 3.
- 1961 *Lygodium trichopapillosus* (Thiergart, 1949) Bolkhovitina, p. 102, pl. 38, fig. 1a, 1b.
- 1965 *Trilobosporites spinosus* Pocock, p. 191, pl. 6, fig. 9.

SIZE RANGE: 43 μ m to 69 μ m, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Cedar Mountain at Molen; in the Cedar Mountain and Mowry at Steinaker Draw.

COMMENTS: See Singh (1964, p. 75) for synonymy and description.

***Pilosisorites* sp. A**

[Plate 13, Figure 5a,b]

DESCRIPTION: Spore, trilete; amb triangular with slightly convex sides; laesurae extending 1/2 to 2/3 distance to equator, laesurae with thickened margins; proximal and distal surfaces densely covered with echinae 3 μ m to 5 μ m in height and 2 μ m to 3 μ m in width at base; dimensions: 50 μ m to 62 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This form differs from *Pilosporites trichopapillosus* by its fewer, but thicker echinae, its subtriangular amb and its interradianal segments of the amb being convex.

Genus *Polycingulatisporites* Simoncsics & Kedves, 1961

emend. Playford & Dettmann, 1965

TYPE SPECIES: *Polycingulatisporites circulus* Simoncsics & Kedves, 1961.

COMMENTS: For generic diagnosis see Playford and Dettmann (1965, p. 143).

***Polycingulatisporites radiatus* Singh, 1971**

[Plate 13, Figure 6]

1971 *Polycingulatisporites radiatus* Singh, p. 130, pl. 18, fig. 4-7.

SIZE RANGE: 38 μ m to 41 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1971, p. 130) for description.

Genus *Psilatriletes* Van der Hammen, 1954 ex Potonié, 1956

TYPE SPECIES: *Psilatriletes detortus* (Weyland & Krieger, 1953) Potonié, 1956.

COMMENTS: See Jansonius and Hills (1976, card 2236) for generic diagnosis.

***Psilatriletes ?circumundulatus* Brenner, 1963**

[Plate 13, Figure 7a,b]

1963 *Psilatriletes circumundulatus* Brenner, p. 67, pl. 20, fig. 4-5.

SIZE RANGE: 46 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota and Ferron at Molen.

COMMENTS: See Brenner (1963, p. 67) for description.

Genus *Reticulatasporites* Ibrahim, 1933 emend. Potonié & Kremp, 1954

TYPE SPECIES: *Reticulatasporites facetus* Ibrahim, 1933.

COMMENTS: See Jansonius and Hills (1976, card 2362) for generic diagnosis.

***Reticulatasporites dupliexinous* Brenner, 1963**

[Plate 13, Figure 8]

1963 *Reticulatasporites dupliexinous* Brenner, p. 72, pl. 24, fig. 3-5.

SIZE RANGE: 34 μ m to 42 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota and Ferron at Molen.

COMMENTS: See Brenner (1963, p. 72) for description.

***Reticulatasporites* sp. A**

[Plate 13, Figure 9a,b]

DESCRIPTION: Spore, trilete; amb circular; short laesurae extending 1/4 to 1/3 distance to equator; entire surface ornamented with pseudoreticulum except for a small interradian (contact) area, muri 1 μ m to 3 μ m in width and approximately 2 μ m high, lumina irregularly shaped 3 μ m to 13 μ m in diameter; dimensions: 48 μ m to 55 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Reticulatisporites* Ibrahim, 1933

TYPE SPECIES: *Reticulatisporites reticulatus* Ibrahim, 1933.

COMMENTS: See Jansonius and Hills (1976, card 2365) for generic diagnosis.

***Reticulatisporites* sp. A**

[Plate 14, Figure 1]

DESCRIPTION: Spore, trilete; amb circular; laesurae indistinct, extending about 1/3 distance to equator, usually obscured by ornamentation; surface ornamented with pseudo reticulum, muri very thin, less than $0.5\mu\text{m}$ in width, $3\mu\text{m}$ to $8\mu\text{m}$ in height, lumina of variable shape $2\mu\text{m}$ to $5\mu\text{m}$ in diameter; dimensions: $40\mu\text{m}$ to $46\mu\text{m}$ diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Rugulatisporites* Pflug in Thomson and Pflug, 1953

TYPE SPECIES: *Rugulatisporites quintus* Pflug in Thomson and Pflug, 1953.

COMMENTS: See Thomson and Pflug (1953, p. 56) and Jansonius and Hills (1976, card 2460) for generic diagnosis.

***Rugulatisporites* sp. A**

[Plate 14, Figure 2]

DESCRIPTION: Spore, trilete; amb subtriangular; laesurae extend 7/8 distance to equator; wall $2\mu\text{m}$ to $3\mu\text{m}$ thick; entire surface covered with minute rugulae; dimensions: $45\mu\text{m}$ to $54\mu\text{m}$, 2 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

Genus *Scopusporis* Wingate, 1980

TYPE SPECIES: *Scopusporis lautus* Wingate, 1980.

COMMENTS: See Wingate (1980, p. 32) for genetic diagnosis.

***Scopusporis excavatus* (Brenner, 1963) Wingate, 1980**

[Plate 14, Figure 3a,b]

1963 *Matonisporites excavatus* Brenner, p. 54, pl. 12, fig. 2-3.1980 *Scopusporis excavatus* (Brenner, 1963) Wingate, p. 32, pl. 12, fig. 5-6.SIZE RANGE: 40 μ m to 49 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Cedar Mountain and Mowry at Steinaker Draw.

COMMENTS: See Brenner (1963, p. 54) for description and Wingate (1980, p. 33) for discussion.

Genus *Stereisporites* Pflug in Thomson and Pflug, 1953TYPE SPECIES: *Stereisporites stereoides* (Potonié & Venitz, 1934) Pflug in Thomson and Pflug, 1953.

COMMENTS: See Singh (1971, p. 33) for generic diagnosis and discussion.

***Stereisporites antiquasporites* (Wilson & Webster, 1946) Dettmann, 1963**

[Plate 14, Figure 4]

1946 *Sphagnum antiquasporites* Wilson & Webster, p. 273, fig. 2.1962 *Sphagnumsporites antiquasporites* (Wilson & Webster, 1946) Pocock, p. 32, pl. 1, fig. 1-3.1963 *Stereisporites antiquasporites* (Wilson & Webster, 1946) Dettmann, p. 25, pl. 1, fig. 20-21.SIZE RANGE: 22 μ m to 26 μ m, 15 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Dettmann (1963, p. 25) for description.

Genus *Tigrisporites* Klaus, 1960 emend. Singh, 1971

TYPE SPECIES: *Tigrisporites halleinis* Klaus, 1960.

COMMENTS: See Singh (1971, p. 138) for generic diagnosis.

***Tigrisporites reticulatus* Singh, 1971**

[Plate 14, Figure 5a,b]

1971 *Tigrisporites reticulatus* Singh, p. 139, pl. 18, fig. 17-19.

SIZE RANGE: 30µm to 36µm, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: For description see Singh (1971, p. 139).

Genus *Todisporites* Couper, 1958

TYPE SPECIES: *Todisporites major* Couper, 1958.

COMMENTS: See Couper (1958, p. 134) for generic diagnosis.

***Todisporites minor* Couper, 1958**

[Plate 14, Figure 6]

1958 *Todisporites minor* Couper, p. 135, pl. 16, fig. 9-10.

SIZE RANGE: 40µm to 54µm, 13 specimens measured.

OCCURRENCE: Rare to common; throughout all sections

COMMENTS: See Couper (1958, p. 135) for description.

Genus *Trilobosporites* Pant, 1954 ex Potonié, 1956

TYPE SPECIES: *Trilobosporites hannonicus* (Delcourt & Sprumont, 1955) Potonié, 1956.

COMMENTS: See Delcourt, Dettmann, and Hughes (1963, p. 288) for synonymy and generic diagnosis.

***Trilobosporites crassus* Brenner, 1963.**

[Plate 14, Figure 7]

1963 *Trilobosporites crassus* Brenner, p. 70, pl. 23, fig. 2.

SIZE RANGE: 42 μ m to 59 μ m, 7 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain and Mowry at Steinaker Draw; in the Cedar Mountain and Dakota at Molen; in the Dakota at Horsethief Canyon Ranch; in the Dakota and lower Tununk at Ivie Creek.

COMMENTS: For description see Brenner (1963, p. 70).

Genus *Undulatisporites* Pflug in Thomson and Pflug, 1953

TYPE SPECIES: *Undulatisporites microcutis* Pflug in Thomson and Pflug, 1953.

COMMENTS: See Potonié (1956, p. 19) for generic diagnosis.

***Undulatisporites pannuceus* (Brenner, 1963) Singh, 1971**

[Plate 14, Figure 8a,b]

1963 *Alsophilidites pannuceus* Brenner, p. 56, pl. 12, fig. 5-6.

1971 *Undulatisporites pannuceus* (Brenner, 1963) Singh, p. 147, pl. 20, fig. 9-10.

SIZE RANGE: 38 μ m to 43 μ m, 2 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Brenner, p. 56 for description.

***Undulatisporites undulapolus* Brenner, 1963**

[Plate 14, Figure 9]

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

SIZE RANGE: 22 μ m to 28 μ m, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw and in the Dakota at Molen.

COMMENTS: For description see Brenner (1963, p. 72).

***Undulatisporites* sp. A**

[Plate 14, Figure 10]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending almost to equator, thin and gently undulating; surface finely granulate; wall approximately 2 μ m thick, but thicker at equator around ends of laesurae which causes characteristic folding in this area; dimensions: 36 μ m to 41 μ m diameter, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Steinaker Draw.

COMMENTS: *Undulatisporites* sp. is distinguished from *Undulatisporites undulapolus* by its thinner laesurae and its slightly larger size, and from *Undulatisporites pannuceus* by its circular amb and thinner wall.

Trilete Spore Genus 1

DESCRIPTION: Spores, trilete; amb circular; laesurae simple extending approximately 2/3 distance to equator; surface ornamented with spinae or coni which are united at their bases forming ridges or rows of cristae, and which may parallel the equator more or less.

Trilete Spore Genus 1 sp. A

[Plate 15, Figure 1]

DESCRIPTION: As per the generic description; cristae $0.5\mu\text{m}$ to $1.0\mu\text{m}$ in width, approximately $1.0\mu\text{m}$ high; dimensions: $53\mu\text{m}$ to $58\mu\text{m}$ diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

Trilete Spore Genus 1 sp. B

[Plate 15, Figure 2]

DESCRIPTION: As per the generic description; cristae approximately $0.5\mu\text{m}$ in width, $1.0\mu\text{m}$ to 3 in height; dimensions: $38\mu\text{m}$ to $44\mu\text{m}$ diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Ivie Creek and Horsethief Canyon Ranch.

Trilete Spore Genus 1 sp. C

[Plate 15, Figure 3]

DESCRIPTION: As per the generic description; cristae $2\mu\text{m}$ to $3\mu\text{m}$ in width, approximately $3\mu\text{m}$ to $4\mu\text{m}$ high; dimensions: $33\mu\text{m}$ to $40\mu\text{m}$ diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Dakota and lower Tununk at Horsethief Canyon Ranch.

Trilete Spore Form A

[Plate 15, Figure 4]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae extending entire distance to equator, somewhat undulating; surface scabrate to granulate; dimensions: $17\mu\text{m}$ to $23\mu\text{m}$ diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

Trilete Spore Form B

[Plate 15, Figure 5-7]

DESCRIPTION: Spore, trilete; laesurae extending $\frac{3}{4}$ distance to equator; wall $2\mu\text{m}$ to $4\mu\text{m}$ thick, pseudoreticulate with muri $2\mu\text{m}$ to $5\mu\text{m}$ wide and approximately $3\mu\text{m}$ high and 4 to 7 polygonal lumina with from 4 to 6 sides, $11\mu\text{m}$ to $25\mu\text{m}$ in diameter; dimensions: $55\mu\text{m}$ to $67\mu\text{m}$ diameter, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota and lower Tununk at Horsethief Canyon Ranch.

Trilete Spore Form C

[Plate 15, Figure 8-9]

DESCRIPTION: Spore, trilete; amb circular; laesurae $2\mu\text{m}$ to $8\mu\text{m}$ in width, extending $\frac{4}{5}$ distance to equator; surface psilate to finely scabrate; wall thickened around equator; dimensions: $28\mu\text{m}$ to $33\mu\text{m}$ diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

Trilete Spore Form D

[Plate 15, Figure 10-11]

1987 Unidentified Spore B — Jameossanaie, p. 22, pl. 11, fig. 14.

DESCRIPTION: Spore, trilete; amb circular; laesurae $3\mu\text{m}$ in width extending $\frac{1}{3}$ to $\frac{1}{2}$ distance to equator; wall thickened around laesurae producing a darkening in the interradian area; surface scabrate; dimensions: $32\mu\text{m}$ to $42\mu\text{m}$ diameter, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Ferron at Ivie Creek.

COMMENTS: Specimens illustrated by Jameossanaie (1987) are from lower Campanian Menefee Formation of northwestern New Mexico.

Trilete Spore Form E

[Plate 16, Figure 1]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending 2/3 to 3/4 distance to equator; surface ornamented with small gemmae or baculae which are connected to produce a fine pseudoreticulate pattern, muri 0.5 μ m wide and 0.5 μ m-1.5 μ m high, lumina polygonal with 4 to 8 sides 2 μ m to 4 μ m in diameter; dimensions: 55 μ m diameter, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

Trilete Spore Form G

[Plate 16, Figure 2a,b]

DESCRIPTION: Spore, trilete; amb circular; laesurae very thin, extending 1/3 to 4/5 distance to equator; distal surface ornamented with pseudoreticulum, muri 0.5 μ m to 1.0 μ m wide and 1.0 μ m high; lumina variable in shape 3 μ m to 5 μ m wide; dimensions: 40 μ m to 44 μ m diameter; 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Trilete Spore Form J

[Plate 16, Figure 3]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending 4/5 distance to equator; wall thick (3 μ m to 4 μ m); surface ornamented with gemmae 0.5 μ m to 1.0 μ m in diameter; dimensions: 32 μ m to 37 μ m diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Dakota at Molen.

COMMENTS: This form is distinguished from *Osmundacidites wellmanii* by its much thicker wall and longer coni.

Trilete Spore Form K

[Plate 16, Figure 4]

DESCRIPTION: Spore, trilete; found in obligate tetrads; laesurae extending 2/3 distance to equator; wall very thin; surface scabrate to granulate; dimensions: 27 μ m to 32 μ m diameter individual spore, 47 μ m to 55 μ m total diameter of tetrad, 6 specimens measured.

OCCURRENCE: Rare; in the Ferron at Farnham Dome.

Trilete Spore Form L

[Plate 16, Figure 5]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending 4/5 distance to equator; surface psilate; spore wall very thin and either extremely folded or having a fine verrucate pattern; dimensions: 46 μ m to 51 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Ferron at Molen and Farnham Dome.

Trilete Spore Form M

[Plate 16, Figure 6a,b]

1987 *Triletes* sp. I — Kelly, pl. 4, fig. 10.

DESCRIPTION: Spore, trilete; amb subcircular; laesurae 5 μ m to 6 μ m wide extending entire distance to equator with thickened borders 3 μ m wide; surface ornamented with 10 μ m to 15 μ m radially extended linear thickenings, 2 μ m to 5 μ m in width, which coalesce

at the center of the distal face and radiate outward to the equator; dimensions: 64 μ m to 79 μ m diameter, 6 specimens measured.

OCCURRENCE: Rare; in the Ferron at Ivie Creek.

Trilete Spore Form N

[Plate 16, Figure 7]

DESCRIPTION: Spore, trilete; amb triangular with convex sides; laesurae extending entire distance to equator, usually entirely ruptured; surface psilate to finely scabrate; spore enclosed in thin perisporium; dimensions: 23 μ m to 27 μ m; 10 specimens measured.

OCCURRENCE: Rare to common; in the Ferron at Ivie Creek and Molen.

Trilete Spore Form O

[Plate 16, Figure 8]

DESCRIPTION: Spore, trilete; amb circular; laesurae extending almost entire distance to equator with a pattern of thickening on either side of the laesurae similar to stitchwork; distal surface ornamented with 5 pits located radially about the pole 4 μ m to 6 μ m in diameter; dimensions: 40 μ m to 45 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Ferron at Ivie Creek.

COMMENTS: The stitchwork or zipper-like thickening associated with the laesurae is similar to that in spores illustrated by Yi (1989) as *Genus et sp. nov. 1*; by Kelly (1987) as *Nevesisporites simiscalaris*, and by Norton and Hall (1969) as *Taurocusporites sp.* The specimens of Yi (1989) and Norton and Hall (1969) are both probably *Nevesisporites simiscalaris*. *Taurocusporites* has a similar pattern, but the thickening on either side of the laesurae are randomly oriented, while in this form the thickening are in associated pairs on

either side of the laesurae. The distal pits are similar to those found in *Kuylisporites lunaris* Cookson & Dettmann, 1958.

Trilete Spore Form P

[Plate 17, Figure 1]

DESCRIPTION: Spore, trilete; occurring in obligate tetrads; surface scabrate; wall thick; laesurae $5\mu\text{m}$ to $7\mu\text{m}$ thick, each side thickened $2\frac{1}{2}\mu\text{m}$ to $3\frac{1}{2}\mu\text{m}$ in an irregular coarse rolled edge; dimensions: $38\mu\text{m}$ to $45\mu\text{m}$ diameter single grains, $62\mu\text{m}$ to $78\mu\text{m}$ total diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENT: Except for size, this is closely similar to Trilete Spore Form K which is about 3/5 as large.

Trilete Spore Form Q

[Plate 17, Figure 2]

DESCRIPTION: Spore, trilete; amb triangular with concave sides and rounded apices; laesurae extending $4/5$ distance to equator, slightly undulating; surface psilate; dimensions: $14\mu\text{m}$ to $17\mu\text{m}$ diameter, 8 specimens measured.

OCCURRENCE: Common; in the Cedar Mountain at Steinaker Draw.

Microspores -- Monolete

Genus *Cicatricosisporites* Pflug & Thomson in Thomson and Pflug, 1953

TYPE SPECIES: *Cicatricosisporites eocenicus* (Selling, 1944) Pflug & Thomson in Thomson and Pflug, 1953.

COMMENTS: See Jansonius and Hills (1976, card 4391) for generic diagnosis and discussion.

***Cicatricosporites* sp. A**

[Plate 17, Figure 3]

DESCRIPTION: Spore, monolete; amb bean-shaped; laesurae extending 1/3 length of proximal surface; surface ribbed with ribs approximately 2 μ m wide and 2 μ m high separated by grooves of approximately the same width; dimensions: 56 μ m to 76 μ m length by 38 μ m to 43 μ m width, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Molen and Horsethief Canyon Ranch.

Genus *Laevigatosporites* Ibrahim, 1933**emend. Schopf, Wilson & Bentall, 1944**

TYPE SPECIES: *Laevigatosporites vulgaris* (Ibrahim in Potonié, Ibrahim and Loose, 1932) Ibrahim, 1933.

COMMENTS: See Schopf, Wilson and Bentall (1944, p. 36) for generic diagnosis.

***Laevigatosporites belfordii* Burger, 1976**

[Plate 17, Figure 4]

1976 *Laevigatosporites belfordii* Burger, p. 13, pl. 9, fig. 3-4.

SIZE RANGE: 48 μ m to 57 μ m, 6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: For description see Burger (1976, p. 13).

***Laevigatosporites ovatus* Wilson & Webster, 1946**

[Plate 17, Figure 5]

1946 *Laevigatosporites ovatus* Wilson & Webster, p. 273, pl. 5, fig. 2a, 2b.

SIZE RANGE: 25 μ m to 40 μ m, 15 specimens measured.

OCCURRENCE: Rare to frequent; throughout all sections.

COMMENTS: See Wilson and Webster (1946, p. 273) for description.

Genus *Microfoveolatosporis* Krutzsch, 1959

TYPE SPECIES: *Microfoveolatosporis pseudodentatus* Krutzsch, 1959.

COMMENTS: See Singh (1983, p. 48) for generic diagnosis and discussion.

***Microfoveolatosporis pseudoreticulatus* (Hedlund, 1966) Singh, 1983**

[Plate 17, Figure 6]

1966 *Verrucatosporites pseudoreticulatus* Hedlund, p. 21, pl. 5, fig. 1-6.

1983 *Microfoveolatosporis pseudoreticulatus* (Hedlund, 1966) Singh, p. 49, pl. 7, fig. 4-10:
pl. 8, fig. 1-6.

SIZE RANGE: 47 μ m to 72 μ m, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

COMMENTS: See Singh (1983, p. 49) for description.

Genus *Petalosporites* Agasie, 1969

TYPE SPECIES: *Petalosporites quadrangulus* Agasie, 1969.

COMMENTS: See Agasie (1969, p. 24) for generic diagnosis.

***Petalosporites quadrangulus* Agasie, 1969**

[Plate 17, Figure 7]

1969 *Petalosporites quadrangulus* Agasie, p. 24, pl. 3, fig. 5-7.

SIZE RANGE: 38 μ m to 45 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch, Ivie Creek and Molen.

COMMENTS: See Agasie (1969, p. 24) for description.

Genus *Reticulosporis* Krutzsch, 1959

TYPE SPECIES: *Reticulosporis miocenicus* (Selling, 1944) Krutzsch, 1959.

COMMENTS: For generic diagnosis see Singh (1983, p. 49).

***Reticulosporis foveolatus* (Pierce, 1961) Skarby, 1978**

[Plate 17, Figure 8]

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

1966 *Microfoveolatosporis foveolatus* (Pierce, 1961) Potonié, pl. 9, fig. 107.

1978 *Reticulosporis foveolatus* (Pierce, 1961) Skarby, p. 122, fig. 1J-L, 4C1-C6.

SIZE RANGE: 95 μ m to 110 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch; in the Ferron at Ivie Creek and from Quichupah core 5.

COMMENTS: Spores similar to *Reticulosporis foveolatus* are produced by the recent fern *Schizaea pusilla* (Singh, 1983). See Singh (1983, p. 50) for description.

Monolete Spore Form A

[Plate 17, Figure 9]

DESCRIPTION: Spore, monolete; amb oval with slightly attenuated tips; laesurae extending almost entire length of proximal surface; surface pseudoreticulate, muri made up of baculae which are connected to form polygonal lumina approximately 1 μ m in diameter; dimensions: 58 μ m to 71 μ m length by 36 μ m to 48 μ m width, 9 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

Monolete Spore Form B

[Plate 17, Figure 10]

DESCRIPTION: Spore, monolete; amb bean-shaped; laesurae extending 1/3 to 1/2 length of proximal surface; surface densely ornamented with coni or echinae; dimensions: 35 μ m to 50 μ m length by 20 μ m to 30 μ m width, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Dakota at Horsethief Canyon Ranch.

Monolete Spore Form C

[Plate 18, Figure 1]

DESCRIPTION: Spore, monolete; amb oval; laesurae extending 1/3 length of proximal surface; surface finely granulate; dimensions: 58 μ m to 66 μ m length by 42 μ m to 50 μ m width; 2 specimens measured.

OCCURRENCE: Rare; in the Castle Valley coal cores.

Microspores – Hilate

Genus *Aequitriradites* Delcourt & Sprumont, 1955

emend. Cookson & Dettmann, 1961

TYPE SPECIES: *Aequitriradites dubius* Delcourt & Sprumont, 1955.

COMMENTS: See Cookson and Dettmann (1961, p. 426) for emended generic diagnosis.

***Aequitriradites ornatus* Upshaw, 1963**

[Plate 18, Figure 2]

1963 *Aequitriradites ornatus* Upshaw, p. 428, pl. 1-6, 9-14; text fig. 1.

SIZE RANGE: 68 μ m to 75 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Mowry at Steinaker Draw.

COMMENTS: See Upshaw (1963, p. 428) for description.

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

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

COMMENTS: See Playford (1971, p. 551) for emended generic diagnosis, and Dettmann (1963, p. 96) and Srivastava (1975b, p. 68) for discussion.

***Triporoletes cenomanianus* (Agasie, 1969) Srivastava, 1975**

[Plate 18, Figure 3]

1969 *Retitriletes cenomanianus* Agasie, p. 24, pl. 3, fig. 9, 10.

1971 *Inaperturopollenites cenomanianus* (Agasie, 1969) Orlansky, p. 44, pl. 6, fig. 15-18.

1972 *Triporoletes tomatilis* Srivastava, p. 35, pl. 31, fig. 7-11; pl. 32, fig. 1.

1973 *Seductisporites eminens* B.D. Tschudy, p. 12, pl. 4, fig. 1-3.

1975b *Triporoletes cenomanianus* (Agasie, 1969) Srivastava, p. 68.

SIZE RANGE: 49 μ m to 65 μ m, 8 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch; in the Dakota and Tununk at Ivie Creek and Molen; in the Tununk at Farnham Dome.

COMMENTS: See Agasie (1969, p. 24) for description.

***Triporoletes involucratus* (Chlonova, 1969) Playford, 1971**

[Plate 18, Figure 4]

1969 *Rouseisporites involucratus* Chlonova, p. 55, pl. 9, fig. 8-12.1971 *Triporoletes involucratus* (Chlonova, 1969) Playford, p. 553, pl. 105, fig. 13-15.1987 *Lobatia involucrata* (Chlonova, 1969) Chlonova, p. 12.SIZE RANGE: 35 μ m to 46 μ m, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Playford (1971, p. 553) for description.

***Triporoletes radiatus* (Dettmann, 1963) Playford, 1971**

[Plate 18, Figure 5a,b]

1963 *Rouseisporites radiatus* Dettmann, p. 98, pl. 23, fig. 13-17.1971 *Triporoletes radiatus* (Dettmann, 1963) Playford, p. 552, pl. 106, fig. 3-4.SIZE RANGE: 56 μ m to 67 μ m, 8 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

COMMENTS: See Dettmann (1963, p. 98) for description.

Megaspores**Genus *Arcellites* Miner, 1935 emend. Ellis & Tschudy, 1964**TYPE SPECIES: *Arcellites disciformis* Miner, 1935 emend. Ellis & Tschudy, 1964.

COMMENTS: See Singh (1964, p. 162) for generic diagnosis and synonymy.

***Arcellites disciformis* Miner, 1935 emend. Ellis & Tschudy, 1964**

[Plate 18, Figure 6]

1935 *Arcellites disciformis* Miner, p. 600, p. 20, fig. 61,64-66.

1964 *Arcellites disciformis* Miner, emend. Ellis & Tschudy, p. 75, pl. 1, fig. 1-12; text fig. 1.

SIZE RANGE: 580 μ m to 650 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch and Molen; in the Dakota and Ferron at Ivie Creek.

COMMENTS: See Singh (1964, p. 167) and Ellis and Tschudy (1964, p. 75) for description.

Genus *Bacutriletes* Potonié, 1956

TYPE SPECIES: *Bacutriletes tylotus* (Harris, 1935) Potonié, 1956.

COMMENTS: See Potonié (1956, p. 35) or Jansonius and Hills (1976, card 229) for generic diagnosis.

***Bacutriletes greenlandicus* (Miner, 1932) Potonié, 1956**

[Plate 19, Figure 1]

1932 *Selaginellites greenlandicus* Miner, p. 500, fig. 10-11.

1956 *Bacutriletes greenlandicus* (Miner, 1932) Potonié, p. 35.

SIZE RANGE: 531 μ m to 562 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Miner (1932, p. 500) for description.

Genus *Balmeisporites* Cookson & Dettmann, 1958b

TYPE SPECIES: *Balmeisporites holodictyus* Cookson & Dettmann, 1958b.

COMMENTS: For generic diagnosis see Cookson and Dettmann (1958b, p. 42).

***Balmeisporites glenglenensis* Cookson & Dettmann, 1958b**

[Plate 19, Figure 2]

1958b *Balmeisporites glenglenensis* Cookson & Dettmann, p. 43, pl. 2, fig. 9, 10.

SIZE: 170 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Ferron at Ivie Creek.

COMMENTS: See Cookson and Dettmann (1958, p. 43) for description.

Genus *Minerisporites* Potonié, 1956

TYPE SPECIES: *Minerisporites mirabilis* (Miner, 1935) Potonié, 1956.

COMMENTS: See Tschudy (1976b, p. E5) for generic description.

***Minerisporites dissimilis* Tschudy, 1976b**

[Plate 19, Figure 3]

1976b *Minerisporites dissimilis* Tschudy, p. E6, pl. 2, fig. 1-6.

SIZE RANGE: 315 μ m to 332 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Castle Valley coal cores.

COMMENTS: See Tschudy (1976b, p. E6) for description.

Genus *Molaspora* Schemel, 1950 emend. Hall, 1963

TYPE SPECIES: *Molaspora lobata* (Dijkstra, 1949) Hall, 1963.

COMMENTS: For emended generic diagnosis see Hall (1963, p. 430).

***Molaspora lobata* (Dijkstra, 1949) Hall, 1963**

[Plate 19, Figure 4]

1949 *Triletes lobatus* Dijkstra, p. 25, pl. 2, fig. 9.

1950 *Molaspora rugosa* Schemel, p. 753, fig. 12.

1963 *Arcellites lobatus* (Dijkstra, 1949) Potter, p. 228.

1963 *Molaspora lobata* (Schemel, 1950) Hall, p. 432, pl. 85, fig. 7; pl. 86, fig. 10-11.

1968 *Molaspora lobata* (Dijkstra, 1949) Hall in Hall and Peake, p. 459, pl. 1, fig. 4.

SIZE RANGE: 515 μ m to 564 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: For description see Hall (1963, p 432).

Miscellaneous Terrestrial Material

Amber Spherules

[Plate 19, Figure 5]

DESCRIPTION: Solid, subspherical bodies without any apparent wall structure; inclusions of unknown material is apparent in larger specimens; unstained specimens were typically a yellow-brown color; dimensions 30 μ m to 130 μ m diameter, 7 specimens measured.

OCCURRENCE: Though not included in counts, amber spherules were very abundant in coals and coaly shales in the Dakota and Ferron.

COMMENTS: Although amber may have many sources, Dilcher and Crane (1984, p. 360) noted that carpels, receptacles and branches of *Archaeanthus linnenbergeri*, an angiosperm, from the Dakota Formation of Kansas, contain "numerous, yellow-brown lustrous resin-bodies," ranging from 60 μ m to 120 μ m in diameter. In examining the large fraction of some coal preparations, some amber spherules have been noted in connection with leaf tissue (plate 19, figure 5).

Fungal Spore Form A

[Plate 20, Figure 1]

DESCRIPTION: Fungal spore, multicellate, multiseptate, uniserial arranged in a straight chain, with six to twelve cells; dimensions: individual cells $20\mu\text{m}$ by $33\mu\text{m}$, total form $28\mu\text{m}$ to $36\mu\text{m}$ by $100\mu\text{m}$ to $154\mu\text{m}$, 4 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota, Tununk and Ferron at Molen, in the Dakota, Tununk and Ferron at Ivie Creek; in the Tununk and Ferron at Farnham Dome.

Fungal Spore Form B

[Plate 20, Figure 2]

DESCRIPTION: Fungal spore; multicellate, multiseptate, uniserial arranged in a straight chain, with three to four cells; dimensions: individual cells $18\mu\text{m}$ by $26\mu\text{m}$, total form $18\mu\text{m}$ to $21\mu\text{m}$ by $40\mu\text{m}$ to $54\mu\text{m}$, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota, Tununk and Ferron at Molen; in the Dakota at Horsethief Canyon Ranch; in the Dakota, Tununk and Ferron at Ivie Creek.

Fungal Spore Form C

[Plate 20, Figure 3]

DESCRIPTION: Fungal spore; multicellate, aggregate of approximately 12 to 20 spores, individual spores button-shaped and monoporate, approximately $8\mu\text{m}$ to $11\mu\text{m}$ in diameter; dimensions: aggregate $19\mu\text{m}$ to $34\mu\text{m}$ diameter, 9 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Fungal Spore Form D

[Plate 20, Figure 4]

DESCRIPTION: Fungal spore; multicellate, with four cells, individual cells inaperturate, wall approximately $1\mu\text{m}$ thick, $12\mu\text{m}$ to $15\mu\text{m}$ in diameter; dimensions: $18\mu\text{m}$ to $32\mu\text{m}$ diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Ferron at Ivie Creek and Molen.

Fungal Spore Form E

[Plate 20, Figure 5]

DESCRIPTION: Fungal spore; unicellular, cell wall $2\mu\text{m}$ to $3\mu\text{m}$ thick, inaperturate; dimensions: $8\mu\text{m}$ to $12\mu\text{m}$ in diameter, 10 specimens measured.

OCCURRENCE: Rare to common; in the Cedar Mountain, Dakota, Tununk and Ferron at Molen; in the Dakota, Tununk and Ferron at Ivie Creek and Horsethief Canyon Ranch; in the Tununk and Ferron at Farnham Dome.

Genus *Ovoidites* Potonié, 1951b ex Krutzsch, 1959

TYPE SPECIES: *Ovoidites ligneolus* Potonié 1951b ex Krutzsch, 1959.

COMMENTS: See Jansonius and Hills (1976, card 1841) for generic diagnosis and Rich, Kuehn and Davies (1982, p. 20) for discussion. *Ovoidites* is probably a zygospore of zygnemataceous algae (Rich, Kuehn and Davies, 1982, p. 26).

***Ovoidites* sp. A**

[Plate 20, Figure 6]

DESCRIPTION: Palynomorph, probably algal; body prolate in shape, exine approximately $1\mu\text{m}$ thick, scabrate; aperture consists of a single line of rupture which runs

parallel to the long axis beginning 1/6 the length of the body from one pole, through the other pole and back again to within 1/6 the length of the body to the first pole; dimensions: 135 μ m to 150 μ m by 65 μ m to 75 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

Genus *Palambages* Wetzel, 1961

TYPE SPECIES: *Palambages morulosa* Wetzel, 1961.

COMMENTS: See Wetzel (1961, p. 338) for generic diagnosis.

***Palambages canadiana* Srivastava, 1968**

[Plate 20, Figure 7]

1968 *Palambages canadiana* Srivastava, p. 1117, pl. 1, fig. 11.

SIZE RANGE: 84 μ m to 107 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: For description see Srivastava (1968, p. 1117).

***Palambages* sp. A**

[Plate 20, Figure 8]

DESCRIPTION: Palynomorph, probably algal; irregular colony of spheroidal, inaperturate, very thin-walled, psilate folded cells; dimensions: individual cells 12 μ m to 16 μ m in diameter, colony 55 μ m to 72 μ m, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This form differs from *Palambages canadiana* in having fewer but larger individual cells.

Genus *Schizosporis* Cookson & Dettmann, 1959

TYPE SPECIES: *Schizosporis reticulatus* Cookson & Dettmann, 1959.

COMMENTS: For generic diagnosis see Cookson and Dettmann (1959, p. 213).

***Schizosporis parvus* Cookson & Dettmann, 1959**

[Plate 20, Figure 9]

1959 *Schizosporis parvus* Cookson & Dettmann, p. 216, pl. 1, fig. 15-20.

1975 *Psilospora parvus* (Cookson & Dettmann, 1959) Filatoff, p. 92, pl. 30, fig. 3.

SIZE RANGE: 44 μ m to 62 μ m, 7 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain, Dakota, Tununk and Ferron at Molen; in the Dakota, Tununk and Ferron at Ivie Creek; in the Dakota and Tununk at Horsethief Canyon Ranch; in the Ferron at Farnham Dome.

COMMENTS: See Cookson and Dettmann (1959, p. 216) for description.

***Schizosporis reticulatus* Cookson & Dettmann, 1959**

[Plate 21, Figure 1]

1959 *Schizosporis reticulatus* Cookson & Dettmann, p. 213, pl. 1, fig. 1-4.

SIZE RANGE: 135 μ m to 166 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen; in the Dakota at Horsethief Canyon Ranch; in the Ferron at Ivie Creek.

COMMENTS: See Cookson and Dettmann (1959, p. 213) for description.

Genus *Spermatites* Miner, 1935

TYPE SPECIES: *Spermatites ellipticus* Miner, 1935.

COMMENTS: See Miner (1935, p. 597) for generic diagnosis.

***Spermatites ellipticus* Miner, 1935**

[Plate 21, Figure 2]

1935 *Spermatites ellipticus* Miner, p. 599, pl. 19, fig. 41-47.SIZE RANGE: 735 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

COMMENTS: See Miner (1935, p. 599) for description.

***Spermatites* sp. A**

[Plate 21, Figure 3]

DESCRIPTION: Seed coat; wall made up of a rectangular cell pattern with individual cells 50 μ m by 20 μ m; dimensions: 690 μ m by 290 μ m, 1 specimen measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

***Spermatites* sp. B**

[Plate 21, Figure 4]

DESCRIPTION: Seed coat; wall thin, smooth and folded; dimensions: 1079 μ m by 640 μ m.

OCCURRENCE: Rare; in the Ferron at Ivie Creek.

Genus *Trichopeltinites* Cookson, 1947bTYPE SPECIES: *Trichopeltinites pulcher* Cookson, 1947b.

COMMENTS: Cookson (1947b, p. 211) erected the genus *Trichopeltinites* for fossil fungal thalli similar to those of the Trichopeltineae, and *Trichopeltis* in particular. See Dilcher (1965, p. 21) for generic diagnosis.

***Trichopeltinites* sp. A**

[Plate 21, Figure 5-6; Plate 22, Figure 1]

DESCRIPTION: Fungal stroma and ascomata; circular to elongate with irregular margins; dimensions: variable, 50 μ m to 440 μ m, 6 specimens measured.

OCCURRENCE: Rare; in the Dakota at Molen and Dry Wash.

COMMENTS: *Trichopeltinites* sp. A is similar to both *T. pulcher* and *T. fusilis* Dilcher (1965, p. 21). However, these species are recovered from Eocene and younger deposits only, so that assigning forms here to either of these species would be tentative. This may be the first record of this genus from pre-Tertiary deposits. The host plants for modern forms of this fungi are various species of *Sapindus* (Dilcher, 1965), *Drimys* and *Nothofagus* (Cookson, 1947b), and which Cookson indicated are plants found in rain forest communities.

Terrestrial Unknown Form A

[Plate 22, Figure 2]

DESCRIPTION: Palynomorph; circular amb, exine perforate with holes irregularly shaped and approximately 1 μ m to 2 μ m in diameter near the edge and circular and less than 0.5 μ m near the center; dimensions: 24 μ m to 28 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

COMMENTS: These forms may represent disarticulated, compressed halves of an entire sphere.

Terrestrial Unknown Form B

[Plate 22, Figure 3]

DESCRIPTION: Palynomorph; inaperturate, circular amb, exine fairly thick and punctate; dimensions: 41 μ m to 45 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

Terrestrial Unknown Form C

[Plate 22, Figure 4]

DESCRIPTION: Palynomorph; possible monoporate with circular thinning of exine 15 μ m in diameter, amb circular, exine thin psilate to finely scabrate and slightly folded; dimensions: 42 μ m to 45 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Dakota at Horsethief Canyon Ranch.

Terrestrial Unknown Form D

[Plate 22, Figure 5]

DESCRIPTION: Palynomorphs, possibly pollen grain; amb circular, exine psilate, very thin and wrinkled; dimensions: 81 μ m diameter, 1 specimen measured.

OCCURRENCE: Rare; in the Cedar Mountain at Molen.

Dinoflagellate Cysts -- Proximate Cavate

Genus *Alterbidinium* Lentin & Williams, 1985

TYPE SPECIES: *Alterbidinium acutulum* (Wilson, 1967) Lentin & Williams, 1985.

COMMENTS: See Lentin and Williams (1976, p. 47) for generic diagnosis. See also Lentin and Williams (1985, p. 11; 1989 p. 10) for discussion of the usage of *Alterbia* and *Alterbidinium*.

***Alterbidinium* sp. A**

[Plate 23, Figure 1]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; endocyst circular to subcircular, pericyst compressed, ellipsoidal with apical and eight antapical horns well developed, left antapical weakly developed; paratabulation features represented by archeopyle and paracingulum, archeopyle intercalary 6-sided isodeltaform, paracingulum represented by low transverse equatorial folds; dimensions: 47 μ m to 57 μ m length, 38 μ m to 43 μ m width, 9 specimens measured.

OCCURRENCE: Rare to frequent; in the upper Tununk and Ferron at Ivie Creek, Molen and Farnham Dome.

Genus *Ascostomocystis* Drugg & Loeblich, 1967

TYPE SPECIES: *Ascostomocystis hydria* Drugg & Loeblich, 1967.

COMMENTS: See Drugg and Loeblich (1967, p. 187) for generic diagnosis. Stover and Evitt (1978) considered this to be an acritarch genus.

***Ascostomocystis giganteus* Singh, 1983**

[Plate 23, Figure 2]

1983 *Ascostomocystis giganteus* Singh, p. 129, pl. 45, fig. 1, 2.

SIZE RANGE: 160 μ m to 184 μ m length, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: For description see Singh (1983, p. 129).

Genus *Balmula* Bint, 1986

TYPE SPECIES: *Balmula tripenta* Bint, 1986.

COMMENTS: See Bint (1986, p. 158) for generic diagnosis.

***Balmula ?pentaradiata* (Singh, 1983) Bint, 1986**

[Plate 23, Figure 3]

- 1978 *Muderongia* sp. 1 — Tingey, p. 80, pl. 8, fig. 7, 10.
 1983 *Muderongia pentaradiata* Singh, p. 123, pl. 43, fig. 5.
 1986 *Balmula pentaradiata* (Singh, 1983) Bint, p. 158.

SIZE RANGE: 125 μ m to 155 μ m length, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1983, p. 123) for description.

Genus *Catastomocystis* Singh, 1983

TYPE SPECIES: *Catastomocystis spinosa* Singh, 1983.

COMMENTS: See Singh (1983, p. 151) for generic diagnosis.

***Catastomocystis* sp. A**

[Plate 23, Figure 4]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; endocyst circular, pericyst ellipsoidal, apical region rounded, antapical region open, pericyst surface smooth; paratabulation not evident; archeopyle precingular; dimensions: 51 μ m to 67 μ m length of pericyst, 42 μ m to 58 μ m width of pericyst, 5 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

COMMENTS: *Catastomocystis* sp. A differs from *Catastomocystis spinosa* in lacking gonal spines, and from *Catastomocystis microreticulata* in having a smooth pericyst.

Genus *Chatangiella* Vozzhennikova, 1967 emend. Marshall, 1988

TYPE SPECIES: *Chatangiella niiga* Vozzhennikova, 1967.

COMMENTS: See Marshall (1988, p. 199) for emended generic diagnosis.

***Chatangiella ?granulifera* (Manum, 1963) Lentin & Williams, 1976**

[Plate 23, Figure 5]

1963 *Deflandrea granulifera* Manum, p. 61, pl. 3, fig. 5-9.1967 *Australiella granulifera* (Manum, 1963) Vozzhennikova, p. 61, pl. 3, fig. 5-9.1976 *Chatangiella granulifera* (Manum) Lentin & Williams, p. 54.

SIZE RANGE: 84 μ m to 98 μ m in length, 60 μ m to 78 μ m in width, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Tununk at Steinaker Draw; in the upper Tununk and Ferron at Farnham Dome and Molen; in the upper Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Manum (1963, p. 61) for description.

***Chatangiella* sp. A**

[Plate 24, Figure 1]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; dorsoventral outline fusiform with slightly expanded mid-area; paracingulum not well developed; epicyst conical with slight sometimes narrowing to form shoulders; hypocyst with two antapical horns of unequal length, one is often very much reduced; archeopyle intercalary; periphram wall smooth, thin and often folded with no apparent paratabulation; endophram circular to subcircular in outline; dimensions: 70 μ m to 85 μ m in length and 45 μ m to 60 μ m in width, 9 specimens measured.

OCCURRENCE: Common to frequent; in the Tununk at Steinaker Draw.

COMMENTS: This species differs from *Chatangiella ?granulifera* in being somewhat smaller, less wide in dorsoventral view and in having a conical epicyst.

Genus *Chlamydothorella* Cookson & Eisenack, 1958 emend. Duxbury, 1983

TYPE SPECIES: *Chlamydothorella nyei* Cookson & Eisenack, 1958.

COMMENTS: For emended generic diagnosis see Duxbury (1983, p. 41).

***Chlamydothorella nyei* Cookson & Eisenack, 1958**

[Plate 24, Figure 2-3]

1958 *Chlamydothorella nyei* Cookson & Eisenack, p. 56, pl. 11, fig. 1-3.

1970 *Chlamydothorella apiculata* Cookson & Eisenack, p. 150, pl. 13, fig. 3.

1970 *Chlamydothorella lagena* Cookson & Eisenack, p. 151, pl. 13, fig. 4.

SIZE RANGE: 45 μ m to 58 μ m, 13 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Ivie Creek, Molen and Farnham Dome; in the Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: See Cookson and Eisenack (1958, p. 56) for description. The specimen illustrated in Figure 3 of Plate 24 is a rare dorsoventral view rather than the more typical apical or antapical view.

Genus *Cribroperidinium* Neale & Sarjeant, 1962 emend. Davey, 1969

TYPE SPECIES: *Cribroperidinium sepimentum* Neale & Sarjeant, 1962.

COMMENTS: See Davey (1969, p. 125) for emended generic description.

***Cribroperidinium edwardsii* (Cookson & Eisenack, 1958) Davey, 1969**

[Plate 24, Figure 4-5]

1958 *Gonyaulax edwardsii* Cookson & Eisenack, p. 32, pl. 3, fig. 5-6; text-fig. 7.

1967 *Gonyaulacysta edwardsii* (Cookson & Eisenack, 1958) Clark & Verdier, p. 31.

1969 *Cribroperidinium edwardsii* (Cookson & Eisenack, 1958) Davey, p. 128.

SIZE RANGE: 123 μ m to 147 μ m, 15 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Cookson and Eisenack (1958, p. 32) for description.

***Cribroperidinium ?exilicristatum* (Davey, 1969) Stover & Evitt, 1978**

[Plate 24, Figure 6]

1969 *Gonyaulacysta exilicristatum* Davey, p. 121, pl. 1, fig. 1-2; text fig. 9A-9B.

1978 *Cribroperidinium exilicristatum* (Davey, 1969) Stover & Evitt, p. 150.

SIZE RANGE: 84 μ m to 97 μ m, 7 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Davey (1969, p. 121) for description.

Genus *Endoscrinium* (Klement, 1960) Vozzhennikova, 1967

TYPE SPECIES: *Endoscrinium galeritum* (Deflandre, 1938) Vozzhennikova, 1967.

COMMENTS: See Vozzhennikova (1967, p. 175) for emended generic diagnosis.

***Endoscrinium campanula* (Gocht, 1959) Vozzhennikova, 1967**

[Plate 24, Figure 7]

1959 *Scriniodinium campanula* Gocht, p. 61, pl. 4, fig. 6; pl. 5, fig. 1.

1967 *Endoscrinium campanula* (Gocht, 1959) Vozzhennikova, p. 175.

1971 *Gonyaulacysta fragosa* Brideaux, p. 83, pl. 23, fig. 42; pl. 24, fig. 44-45; text fig. 8c-8d.

SIZE RANGE: 103 μ m to 119 μ m total, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Vozzhennikova (1967, p. 175) for description.

Genus *Hexagonifera* Cookson & Eisenack, 1961 emend. Stover & Evitt, 1978

TYPE SPECIES: *Hexagonifera glabra* Cookson & Eisenack, 1961.

COMMENTS: See Stover and Evitt (1978, p. 107) for emended generic diagnosis.

***Hexagonifera* sp. A**

[Plate 25, Figure 1-2]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; shape subspherical; no parasutural features, cyst wall smooth; paratabulations indicated by intercalary archeopyle only, paracingulum not apparent; dimensions: 42 μ m to 58 μ m length, 37 μ m to 54 μ m width, 15 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Ivie Creek; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: In some samples of Mowry Shale, this form is found in isospecific clumps with numbers of cysts ranging from 8 into the hundreds (plate 25, figure 2).

***Hexagonifera* sp. B**

[Plate 25, Figure 3]

1969 non *Hexagonifera suspecta* Manum and Cookson, 1964 – Thompson, p. 43, p. 10, fig. 4.

DESCRIPTION: Dinoflagellate cyst, proximate acavate; shape subspherical; no parasutural features, cyst wall scabrate; paratabulations indicated by intercalary archeopyle only, paracingulum not apparent; dimensions: 36 μ m to 50 μ m length, 28 μ m to 35 μ m width, 10 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Farnham Dome and Molen; in the Tununk and Ferron at Horsethief Canyon Ranch; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: This form is different from *Hexagonifera* sp. A in having a scabrate surface.

Genus *Leberidocysta* Stover & Evitt, 1978

TYPE SPECIES: *Leberidocysta chlamydata* (Cookson & Eisenack, 1962b) Stover & Evitt, 1978.

COMMENTS: See Stover and Evitt (1978, p. 59) for generic diagnosis.

***Leberidocysta* sp. A**

[Plate 25, Figure 4]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; endocyst ellipsoidal, pericyst wall thin and very folded; paratabulation indicated by apical archeopyle only; dimensions: 45 μ m to 60 μ m length, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the lower Tununk at Horsethief Canyon Ranch, Molen, Ivie Creek and Farnham Dome.

Genus *Luxadinium* Brideaux & McIntyre, 1975

TYPE SPECIES: *Luxadinium primulum* Brideaux & McIntyre, 1975.

COMMENTS: See Brideaux and McIntyre (1975, p. 36) for generic diagnosis.

***Luxadinium propatulum* Brideaux & McIntyre, 1975**

[Plate 25, Figure 5-6]

1975 *Luxadinium propatulum* Brideaux & McIntyre, p. 37, pl. 13, fig. 9-12; pl. 14, fig. 1,2.

des

19

19

19

19

th

Tu

19

SIZE RANGE: 75 μ m to 91 μ m total length, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw.

COMMENTS: See Brideaux and McIntyre (1975, p. 37) and Singh (1983, p. 157) for description, and Singh (1983, p. 158) for discussion.

Genus *Odontochitina* Deflandre, 1935 emend. Bint, 1986

TYPE SPECIES: *Odontochitina operculata* (Wetzel, 1933a) Deflandre & Cookson, 1955.

COMMENTS: For emended generic diagnosis see Bint (1986, p. 138).

***Odontochitina operculata* (Wetzel, 1933a) Deflandre & Cookson, 1955**

[Plate 25, Figure 7]

1933a *Ceratium operculata* Wetzel, p. 170, pl. 2 fig. 21-22, text-fig. 3.

1935 *Odontochitina silicorum* Deflandre, p. 234, pl. 9, fig. 8-10.

1955 *Odontochitina operculata* (Wetzel, 1933a) Deflandre & Cookson, p. 291.

SIZE RANGE: 220 μ m to 290 μ m total length, 9 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Wetzel (1933a, p. 170) for description.

***Odontochitina singhii* Morgan, 1980**

[Plate 26, Figure 1]

1980 *Odontochitina singhii* Morgan, p. 29, pl. 20, fig. 12-15.

SIZE RANGE: 320 μ m to 355 μ m total length, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMME

G

TYPE SPE

COMME

Ovoid

1964 Ascodin

1970 Ovoidin

SIZE RA

OCCUR

Horsethief Car

COMME

Genus Pal

1955

TYPE S

COMME

257).

1935 Palae

SIZE P

COMMENTS: See Morgan (1980, p. 29) for description.

Genus *Ovoidinium* Davey, 1970 emend. Duxbury, 1983

TYPE SPECIES: *Ovoidinium verrucosum* (Cookson & Hughes, 1964) Davey, 1970.

COMMENTS: See Duxbury (1983, p. 61) for emended generic diagnosis.

***Ovoidinium verrucosum* (Cookson & Hughes, 1964) Davey, 1970**

[Plate 26, Figure 2]

1964 *Ascodinium verrucosum* Cookson & Hughes, p. 41, pl. 5, fig. 4-8.

1970 *Ovoidinium verrucosum* (Cookson & Hughes, 1964) Davey, p. 351.

SIZE RANGE: 54 μ m to 76 μ m total length, 15 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch, Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Cookson and Hughes (1964, p. 41) for description.

Genus *Palaeohystrichophora* Deflandre, 1935 emend. Deflandre & Cookson, 1955

TYPE SPECIES: *Palaeohystrichophora infusorioides* Deflandre, 1935.

COMMENTS: For emended generic diagnosis see Deflandre and Cookson (1955, p. 257).

***Palaeohystrichophora infusorioides* Deflandre, 1935**

[Plate 26, Figure 3]

1935 *Palaeohystrichophora infusorioides* Deflandre, p. 230, pl. 8, fig. 4.

SIZE RANGE: 52 μ m to 80 μ m total length of pericyst, 15 specimens measured.

OCCURRENCE: Rare to abundant; in the Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Singh (1983, p.) for description and discussion.

Genus *Subtilisphaera* Jain & Millepied, 1973 emend. Lentin & Williams, 1976

TYPE SPECIES: *Subtilisphaera senegalensis* Jain & Millepied, 1973.

COMMENTS: See Lentin and Williams (1976, p. 117) for emended generic diagnosis.

***Subtilisphaera inaffecta* (Drugg, 1978) Bujak & Davies, 1983**

[Plate 26, Figure 4]

1978 *Geiselodinium inaffectum* Drugg, p. 68, pl. 3, fig. 10-12.

1983 *Subtilisphaera inaffecta* (Drugg, 1978) Bujak & Davies, p. 163.

SIZE RANGE: 41 μ m to 49 μ m total length, 10 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Ivie Creek and Molen; in the Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: See Drugg (1978, p. 68) for description.

***Subtilisphaera* sp. A**

[Plate 26, Figure 5]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; pericyst compressed and subspherical to somewhat peridinioid, apical horn and one or two antapical horns developed, endocyst outline imitating pericyst, surface smooth or faintly ornamented; paratabulation and archeopyle not indicated; dimensions: 48 μ m to 59 μ m length, 32 μ m to 40 μ m, length/width approximately 1.5, 12 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Molen and Ivie Creek; in the Tununk and Ferron at Farnham Dome and Horsethief Canyon Ranch.

COMMENTS: *Subtilisphaera* sp. A, B, C, and D were differentiated based on size and length/width ratios.

***Subtilisphaera* sp. B.**

[Plate 26, Figure 6]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; same as for *Subtilisphaera* sp. A; dimensions: 48 μ m to 56 μ m length, 39 μ m to 52 μ m, length/width approximately 1.1, 10 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Molen and Ivie Creek and Horsethief Canyon Ranch; in the Tununk and Ferron at Farnham Dome.

***Subtilisphaera* sp. C**

[Plate 26, Figure 7]

1982a *Alterbia* sp. A — Nichols and Jacobson, p. 130, pl. 2, fig. 5.

DESCRIPTION: Dinoflagellate cyst, proximate cavate; same as for *Subtilisphaera* sp. A; dimensions: 82 μ m to 95 μ m length, 50 μ m to 61 μ m, length/width approximately 1.6, 15 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch; in the Tununk and Ferron at Molen; in the Tununk and Blue Gate at Ivie Creek.

COMMENTS: This species is very similar to *Alterbia* sp. A of Nichols and Jacobson (1982a) and Nichols, Jacobson and Tschudy (1983) in outward size and morphology. However, because no operculum has been observed in the specimens of this study, this species has been placed in the genus *Subtilisphaera*.

***Subtilisphaera* sp. D**

[Plate 26, Figure 8]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; same as for *Subtilisphaera* sp. A; dimensions: 85 μ m to 100 μ m length, 68 μ m to 79 μ m, length/width approximately 1.3, 13 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch; in the Tununk and Ferron at Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Horsethief Canyon Ranch.

Genus *Thalassiphora* Eisenack & Gocht, 1960 emend. Gocht, 1968

TYPE SPECIES: *Thalassiphora pelagica* (Eisenack, 1954) Eisenack & Gocht, 1960.

COMMENTS: See Gocht (1968, p. 153) for generic diagnosis.

***Thalassiphora microcysta* Singh, 1983**

[Plate 27, Figure 1]

1983 *Thalassiphora microcysta* Singh, p. 153, pl. 56, fig. 7-8; pl. 57, fig. 1.

SIZE RANGE: 64 μ m to 81 μ m total width, 26 μ m to 30 μ m width of endocyst; 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1983, p. 153) for description.

Dinoflagellate Form B

[Plate 27, Figure 2-3]

DESCRIPTION: Dinoflagellate cyst, proximate cavate; shape spherical to subspherical, endocyst approximating the shape of the pericyst, pericyst surface thin, smooth and wrinkled; no paratabulation indicated; some specimens show an apical archeopyle; dimensions: 43 μ m to 60 μ m length, 14 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

COMMENTS: *Hexagonifera* sp. A and B and species of *Fromea* differ from this form in being singled walled.

Dinoflagellate Cysts -- Proximate Acavate

Genus *Apteodinium* Eisenack, 1958 emend. Lucas-Clark, 1987

TYPE SPECIES: *Apteodinium granulatum* Eisenack, 1958.

COMMENTS: See Lucas-Clark (1987, p. 168) for emended generic diagnosis.

***Apteodinium maculatum* Eisenack & Cookson, 1960**

[Plate 27, Figure 4-5]

1960 *Apteodinium conjunctum* Eisenack & Cookson, p. 5, pl. 1, fig. 7-8.

1960 *Apteodinium maculatum* Eisenack & Cookson, p. 4, pl. 2, fig. 1.

1984 *Cribroperidinium conjunctum* (Eisenack & Cookson, 1960) Helenes, p. 121.

SIZE RANGE: 84 μ m to 110 μ m length, 13 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry at Steinaker Draw; in the lower Tununk at Horsethief Canyon Ranch, Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Eisenack and Cookson (1960, p. 4) for description.

Genus *Batioladinium* Brideaux, 1975 emend. Pourtoy, 1988

TYPE SPECIES: *Batioladinium jaegeri* (Alberti, 1961) Brideaux, 1975.

COMMENTS: See Pourtoy (1988, p. 390) for emended generic diagnosis.

***Batioladinium jaegeri* (Alberti, 1961) Brideaux, 1975**

[Plate 27, Figure 6-7]

1961 *Broomea jaegeri* Alberti, p. 26, pl. 5, fig. 1-7.

1975 *Batioladinium jaegeri* (Alberti, 1961) Brideaux, p. 1241.

1975 *Necrobroomea jaegeri* (Alberti, 1961) Wiggins, p. 111.

1980 *Imbatodinium jaegeri* (Alberti, 1961) Dörhöfer & Davies, p. 37.

SIZE RANGE: 142 μ m to 185 μ m total length, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Brideaux (1975, p. 1242) for description.

Genus *Caligodinium* Drugg, 1970

TYPE SPECIES: *Caligodinium amiculum* Drugg, 1970.

COMMENTS: See Drugg (1970, p. 814) for generic diagnosis.

***Caligodinium aceras* (Manum & Cookson, 1964) Lentin & Williams, 1973**

[Plate 28, Figure 1]

1964 *Kalyptea aceras* Manum & Cookson, p. 27, pl. 6, fig. 9-11.

1973 *Caligodinium aceras* (Manum & Cookson, 1964) Lentin & Williams, p. 21.

SIZE RANGE: 91 μ m to 117 μ m total width, 54 μ m to 63 μ m endocyst width; 6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Manum and Cookson (1964, p. 27) for description.

Genus *Canningia* Cookson & Eisenack, 1960 emend. Helby, 1987

TYPE SPECIES: *Canningia reticulata* Cookson & Eisenack, 1960.

COMMENTS: For emended generic diagnosis see Helby (1987, p. 321).

***Canningia* sp. A**

[Plate 28, Figure 2]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; circular to subcircular in outline; epicyst faintly conical; hypocyst lacks horns and with a rounded antapical region; archeopyle apical; periphram wall thick with a dense pseudoreticulate sculpture 4 μ m to 6 μ m high and with no apparent paratabulation; dimensions: 80 μ m to 93 μ m in height, 11 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Tununk at Molen and Farnham Dome; in the Tununk and Ferron at Farnham Dome.

COMMENTS: This species of *Canningia* differs from the species of *Cyclonephelium* by its lack of antapical horns.

Genus *Cyclonephelium* Deflandre & Cookson, 1955

emend. Ioannides, Stavrinos and Downie, 1977

TYPE SPECIES: *Cyclonephelium compactum* Deflandre & Cookson, 1955.

COMMENTS: For emended generic diagnosis see Ioannides, Stavrinos and Downie (1977, p. 450).

***Cyclonephelium vannophorum* Davey, 1969**

[Plate 28, Figure 3]

1969 *Cyclonephelium vannophorum* Davey, p. 168, pl. 9, fig. 3; pl. 11, fig. 11-12; text fig. 16E.

SIZE RANGE: 65 μ m to 84 μ m total length, 12 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Tununk at Farnham Dome, Molen and Ivie Creek; in the Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: For description see Davey (1969, p. 168).

***Cyclonephelium* sp. A**

[Plate 28, Figure 4]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; circular to subcircular in outline; epicyst broadly conical with small apical horn; hypocyst with two reduced horns of approximately equal size; archeopyle apical; periphram wall with a granulate sculpture and with paratabulation expressed somewhat in archeopyle; dimensions: 73 μ m to 94 μ m in height, 13 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw.

***Cyclonephelium* sp. B**

[Plate 28, Figure 5]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; subcircular to ellipsoidal in outline; epicyst faintly conical; hypocyst with two reduced horns of unequal size, one of which may be absent, with a rounded antapical region; archeopyle apical; periphram wall with a pseudoreticulate sculpture 2 μ m to 4 μ m high and with no apparent paratabulation; dimensions: 73 μ m to 88 μ m in height, 9 specimens measured.

OCCURRENCE: Rare; in the lower Tununk at Horsethief Canyon Ranch, Ivie Creek, Molen, and Farnham Dome.

Genus *Fromea* Cookson & Eisenack, 1958 emend. Yun, 1981

TYPE SPECIES: *Fromea amphora* Cookson & Eisenack, 1958.

COMMENTS: See Jansonius (1989, p. 63) for generic diagnosis.

***Fromea amphora* Cookson & Eisenack, 1958**

[Plate 28, Figure 6]

1958 *Fromea amphora* Cookson & Eisenack, p. 56, pl. 5, fig. 10.

1972 *Fromea warlinghamensis* Gitmez & Sarjeant, p. 188, pl. 1, fig. 6, 8, pl. 9, fig. 5, 6.

SIZE RANGE: 68 μ m to 90 μ m total length, 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch, Ivie Creek, Molen, and Farnham Dome.

COMMENTS: See Cookson and Eisenack (1958, p. 56) for description.

***Fromea ?fragilis* (Cookson & Eisenack, 1962b) Stover & Evitt, 1978**

[Plate 29, Figure 1]

1962b *Palaeostomocystis fragilis* Cookson & Eisenack, p. 496, pl. 7, fig. 10-11.

1978 *Fromea fragilis* (Cookson & Eisenack, 1962b) Stover & Evitt, p. 48.

SIZE RANGE: 61 μ m to 112 μ m total length; 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek.

COMMENTS: See Cookson and Eisenack (1962b, p. 496) for description.

***Fromea* sp. A**

[Plate 29, Figure 2]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; ellipsoidal in outline with a somewhat rectangular base; periphram wall coarsely granulate, thin and often folded; archeopyle apical with operculum often still loosely attached; paracingulum not present; dimensions: 80 μ m to 91 μ m, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

***Fromea* sp. B**

[Plate 29, Figure 3]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; prolate ellipsoidal in outline with a somewhat rectangular base; periphram wall granulate, and thick; archeopyle apical; paracingulum not present; dimensions: 50 μ m to 68 μ m, 6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

***Fromea* sp. C**

[Plate 29, Figure 4]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; elongate ellipsoidal in outline; periphram wall somewhat scabrate and thin; archeopyle apical; paracingulum not present; dimensions: 90 μ m to 111 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Pareodinia* Deflandre, 1947 emend. Stover & Evitt, 1978

TYPE SPECIES: *Pareodinia ceratophora* Deflandre, 1947 emend. Gocht, 1970.

COMMENTS: See Stover and Evitt (1978, p. 116) for emended generic diagnosis.

***Pareodinia* sp. A**

[Plate 29, Figure 5]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; oval in outline; epicyst with a stout apical horn; hypocyst with rounded antapical region and without horns; periphram covered with a dense, minute rugulae; paracingulum and paratabulation not expressed; archeopyle intercalary; dimensions: 48 μ m to 55 μ m in length, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Genus *Pseudoceratium* Gocht, 1957 emend. Helby, 1987

TYPE SPECIES: *Pseudoceratium pelliferum* Gocht, 1957.

COMMENTS: See Helby (1987, p. 313) for emended generic diagnosis.

***Pseudoceratium polymorphum* (Eisenack, 1958) Bint, 1986**

[Plate 29, Figure 6]

1958 *Aptea polymorpha* Eisenack, p. 394, pl. 22, fig. 5-12, pl. 24, fig. 5.

1986 *Pseudoceratium polymorphum* (Eisenack, 1958) Bint, p. 145.

SIZE RANGE: 54 μ m to 71 μ m total length; 11 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw.

Genus *Pterodinium* Eisenack, 1958 emend. Sarjeant, 1985

TYPE SPECIES: *Pterodinium aliferum* Eisenack, 1958.

COMMENTS: For emended generic diagnosis see Sarjeant (1985, p. 70).

***Pterodinium cingulatum* (Wetzel, 1933b) Below, 1981**

[Plate 29, Figure 7]

1933b *Cymatiosphaera cingulata* Wetzel, p. 28, pl. 4, fig. 10.

1955 *Hystriosphera cingulata* (Wetzel, 1933b) Deflandre & Cookson, p. 267.

1958 *Cymatiosphaera pterota* Cookson & Eisenack, p. 50, pl. 11, fig. 7.

1966a *Hystriosphera crassimurata* Davey & Williams, p. 39, pl. 1, fig. 11.

1970 *Spiniferites cingulatus* (Wetzel, 1933b) Sarjeant, p. 76.

1970 *Spiniferites pterotus* (Cookson & Eisenack) Sarjeant, p. 76.

1981 *Pterodinium cingulatum* (Wetzel, 1933b) Below, p. 114.

SIZE RANGE: 38 μ m to 49 μ m total length; 7 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Tununk at Molen and Farnham Dome; in the Tununk and Ferron at Horsethief Canyon Ranch and Ivie Creek.

COMMENTS: See Wetzel (1933b, p. 28) for description.

***Pterodinium* sp. A**

[Plate 29, Figure 8]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; ellipsoidal in outline; body with high (5 μ m) sutural crests marking the paratabulation; paracingulum and parasulcus present; archeopyle precingular; dimensions: 51 μ m to 57 μ m, 6 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch.

Genus *Trichodinium* Eisenack & Cookson, 1960 emend. Clark & Verdier, 1967

TYPE SPECIES: *Trichodinium pellitum* Eisenack & Cookson, 1960.

COMMENTS: See Clark and Verdier (1967, p. 18) for emended generic diagnosis.

***Trichodinium castaneum* (Deflandre, 1935) Clark & Verdier, 1967**

[Plate 30, Figure 1]

1935 *Palaeoperidinium castaneum* Deflandre, p. 229, pl. 6, fig. 8.

1959 *Apteodinium ciliatum* Gocht, p. 65, pl. 8, fig. 5-6.

1964 *Trichodinium ciliatum* (Gocht, 1959) Eisenack, p. 811.

1967 *Trichodinium castaneum* (Deflandre, 1935) Clark & Verdier, p. 19.

SIZE RANGE: 50 μ m to 59 μ m total length, 9 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the lower Tununk at Farnham Dome and Ivie Creek.

COMMENTS: See Davey (1969, p. 131) for description.

Genus *Wigginsiella* Lucas-Clark, 1987

TYPE SPECIES: *Wigginsiella grandstandica* Lucas-Clark, 1987.

COMMENTS: For generic diagnosis, see Lucas-Clark (1987, p. 160).

***Wigginsiella canadensis* Singh, 1983 emend. Lucas-Clark, 1987**

[Plate 30, Figure 2]

1983 *Spongodinium canadense* Singh, p. 141, pl. 49, fig. 1-3.

1987 *Wigginsiella canadensis* (Singh, 1983) Lucas-Clark, p. 164.

SIZE RANGE: 99 μ m to 110 μ m total length; 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1983, p. 141) for description.

Dinoflagellate Form A

[Plate 30, Figure 3-4]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; body subspherical in outline; periphram with a low reticulate sculpture; paratabulation, parasulcus and paracingulum not apparent; archeopyle appears intercalary; the periphram wall appears to be much thicker, or the reticulate sculpture is denser in the antapical region of the hypocyst than in other areas; dimensions: 64 μ m to 75 μ m; 15 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: The thickened antapical region of this dinocyst makes it easily identifiable.

Dinoflagellate Form E

[Plate 30, Figure 5]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; circular in outline; periphram covered with dense hair-like spines 6 μ m to 11 μ m long; archeopyle precingular; dimensions: 60 μ m to 65 μ m total; 3 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

Dinoflagellate Form F

[Plate 31, Figure 1]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; circular in outline; periphram wall covered with dense short (1 μ m) hair-like spines; paratabulation expressed as lines of periphram wall thinning; archeopyle intercalary?; dimensions: 58 to 63 μ m, 4 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

Dinoflagellate Form G

[Plate 31, Figure 2]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; circular in outline; periphram wall covered with dense 4 μ m to 8 μ m long hair-like spines; paratabulation expressed as lines of wall thinning in the periphram; archeopyle intercalary?; dimensions: 69 to 73 μ m, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This species is very similar to Dinoflagellate Form F, but it is slightly larger, and the hair-like processes are longer.

Dinoflagellate Form H

[Plate 31, Figure 3]

DESCRIPTION: Dinoflagellate cyst, proximate acavate; ellipsoidal in outline; periphram wall very thin, smooth and folded; paracingulum may be indicated by a presence of a lateral fold found in most specimens; paratabulation and archeopyle not expressed; dimensions: 48 μ m to 50 μ m, 3 specimens measured.

OCCURRENCE: Rare; in the Tununk at Ivie Creek.

Dinoflagellate Cysts -- Spiniferate**Genus *Hystrichodinium* Deflandre, 1935 emend. Clark & Verdier, 1967**

TYPE SPECIES: *Hystrichodinium pulchrum* Deflandre, 1935.

COMMENTS: See Clark and Verdier (1967, p. 37) for emended generic diagnosis.

***Hystrichodinium oligacanthum* Deflandre & Cookson, 1955**

[Plate 31, Figure 4]

- 1955 *Hystrichodinium oligacanthum* Deflandre & Cookson, p. 255, pl. 1, fig. 1, text-fig. 2-3.

SIZE RANGE: 89 μ m to 100 μ m total length including processes, 52 μ m to 55 μ m length of exocyst; 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Deflandre and Cookson (1955, p. 255) for description.

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

TYPE SPECIES: *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich & Loeblich, 1966.

COMMENTS: For emended generic diagnosis, see Sarjeant (1970, p. 75).

Spiniferites ramosus (Ehrenberg, 1838) Loeblich & Loeblich, 1966.

- 1838 *Xanthidium ramosum* Ehrenberg, pl. 1, fig. 1, 2, 5.
- 1838 *Xanthidium furcata* Ehrenberg, pl. 1, fig. 12, 14.
- 1933b *Hystrichosphaera furcata* (Ehrenberg, 1838) Wetzel, p. 34.
- 1959 *Areoligera birama* Maier, p. 304, pl. 29, fig. 2.
- 1959 *Areoligera dermatica* Maier, p. 305, pl. 29, fig. 3.
- 1959 *Galea koryka* Maier, p. 310, pl. 30, fig. 7, 8.
- 1959 *Hystrichosphaeridium echinoides* Maier, p. 318, pl. 32, fig. 5, 6.
- 1966 *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich & Loeblich, p. 56.

***Spiniferites ramosus* ssp. *gracilis* (Davey & Williams, 1966a)**

Lentin & Williams, 1973

[Plate 31, Figure 5]

1955 *Hystriosphera ramosa* Ehrenberg, 1838 – Deflandre & Cookson, p. 263, pl. 5, fig. 8.

1966a *Hystriosphera ramosa* ssp. *gracilis* Davey & Williams, p. 34, pl. 1, fig. 5; pl 5, fig. 6.

1973 *Spiniferites ramosus* ssp. *gracilis* (Davey & Williams, 1966a) Lentin & Williams, p. 130.

SIZE RANGE: 48µm to 59µm total including processes, 34µm to 41µm central body;

13 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Davey and Williams (1966a, p. 34) for description.

***Spiniferites ramosus* ssp. *ramosus* (Ehrenberg, 1838) Loeblich & Loeblich, 1966**

[Plate 31, Figure 6]

1838 *Xanthidium ramosum* Ehrenberg, pl. 1, fig. 1, 2, 5.

1966 *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich & Loeblich, p. 56.

1981 *Homotryblium distinctum* Saluja & Kindra, p. 51, pl. 2, fig. 45.

SIZE RANGE: 48µm to 65µm total including processes, 32µm to 52µm endocyst; 10 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Loeblich and Loeblich (1966, p. 56) for description.

Dinoflagellate Cysts -- Chorates

Genus *Bourkidinium* Morgan, 1975

TYPE SPECIES: *Bourkidinium granulatum* Morgan, 1975.

COMMENTS: See Morgan (1975, p. 160) for generic description.

***Bourkidinium granulatum* Morgan, 1975**

[Plate 31, Figure 7]

1975 *Bourkidinium granulatum* Morgan, p. 160, pl. 2, fig. 2a-c.

1980 *Bourkidinium granulatum* Morgan, 1975 — Morgan, pl. 2, fig. 15-16.

1983 *Bourkidinium granulatum* Morgan, 1975 — Singh, p. 124, pl. 42, fig. 6-7.

SIZE RANGE: Overall length 75-81 μ m, central body length 55-58 μ m, two specimens.

OCCURRENCE: Rare; in Mowry at Steinaker Draw.

COMMENTS: See Morgan (1975, p. 160) for description. Specimens encountered in this study are more similar to the specimen illustrated by Morgan in 1980 than the type specimen in that there are fewer processes at the antapical end (6-8), and the number of processes are the same in the apical and antapical areas. The type material show 4-7 apical processes and 9-15 antapical processes. Specimens illustrated by Singh (1983) are smaller than those encountered in this study.

Genus *Cleistosphaeridium* Davey et al., 1966

TYPE SPECIES: *Cleistosphaeridium diversispinosum* Davey et al., 1966.

COMMENTS: See Davey et al. (1966, p. 166) for generic diagnosis.

***Cleistosphaeridium ?multispinosum* (Singh, 1964) Brideaux, 1971**

[Plate 32, Figure 1]

1971 *Cleistosphaeridium multispinosum* Brideaux, p. 93.

SIZE RANGE: 47 μ m to 58 μ m total including processes, 33 μ m to 41 μ m central body;
8 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw and in the lower
Tununk at Horsethief Canyon Ranch, Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Singh (1964, p. 141) for description.

***Cleistosphaeridium* sp. A**

[Plate 32, Figure 2]

1983 *Cleistosphaeridium* sp. — Singh, p. 120, pl. 41, fig. 6.

SIZE: 46 μ m body, 55 μ m total; 1 specimen measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: Singh (1983) assigned this form to *Cleistosphaeridium* on a tentative
basis. See Singh (1983, p. 120) for description.

Genus *Coronifera* Cookson & Eisenack, 1958 emend. May, 1980

TYPE SPECIES: *Coronifera oceanica* Cookson & Eisenack, 1958 emend. May, 1980.

COMMENTS: See May (1980, p. 48) for emended generic diagnosis.

***Coronifera oceanica* Cookson & Eisenack, 1958 emend. May, 1980**

[Plate 32, Figure 3]

- 1958 *Coronifera oceanica* Cookson & Eisenack, p. 45, pl. 12, fig. 5, 6.
- 1964 *Hystrichosphaeridium monstrosa* Tasch in Tasch, McClure and Oftedahl, p. 195, pl. 1, fig. 12.
- 1978 *Coronifera monstrosa* (Tasch in Tasch, McClure and Oftedahl, 1964) Stover & Evitt, p. 148.

SIZE RANGE: 77 μ m to 94 μ m total including processes, 53 μ m to 62 μ m central body;
6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Cookson and Eisenack (1958, p. 45) for description.

Genus *Dapsilidinium* Bujak et al., 1980

TYPE SPECIES: *Dapsilidinium pastielsii* (Davey & Williams, 1966b) Bujak et al., 1980.

COMMENTS: See Bujak et al. (1980, p. 27) for generic diagnosis.

***Dapsilidinium marinum* Singh, 1983**

[Plate 32, Figure 4]

- 1983 *Dapsilidinium marinum* Singh, p. 121, pl. 41, fig. 7-9.

SIZE RANGE: 39 μ m to 46 μ m total including processes, 27 μ m to 34 μ m central body;
10 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the lower Tununk at Farnham Dome.

COMMENTS: See Singh (1983, p. 121) for description.

Genus *Florentinia* Davey & Verdier, 1973 emend. Duxbury, 1980

TYPE SPECIES: *Florentinia cooksoniae* Davey & Verdier, 1973.

COMMENTS: For emended generic diagnosis, see Duxbury (1980, p. 119).

***Florentinia cooksoniae* (Singh, 1971) Duxbury, 1980**

[Plate 32, Figure 5]

1971 *Hystriosphæridium cooksoniae* Singh, p. 329, pl. 51, fig. 7-8; pl. 52, fig. 1-4.

1980 *Florentinia cooksoniae* (Singh, 1971) Duxbury, p. 120.

SIZE RANGE: 64µm to 70µm total including processes, 38µm to 42µm central body;
6 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1971, p. 329) for description.

Genus *Kiokansium* Stover & Evitt, 1978 emend. Duxbury, 1983

TYPE SPECIES: *Kiokansium polypes* (Cookson & Eisenack, 1962b) Below, 1982.

COMMENTS: For emended generic diagnosis see Duxbury (1983, p. 48).

***Kiokansium polypes* (Cookson & Eisenack, 1962b) Below, 1982**

[Plate 32, Figure 6]

1962b *Hystriosphæridium recurvatum* ssp. *polypes* Cookson & Eisenack, p. 491, pl. 4,
fig. 11-13.

1964 *Hystriosphæridium unituberculatum* Tasch in Tasch, McClure and Oftedahl, p.
194, pl. 3, fig. 8.

1978 *Kiokansium unituberculatum* (Tasch in Tasch, McClure and Oftedahl, 1964) Stover
& Evitt, p. 167.

1982 *Kiokansium polypes* (Cookson & Eisenack, 1962b) Below, p. 56.

1969 *Cleistosphaeridium polypes* (Cookson & Eisenack, 1962b) Davey, p. 154.

1979 *Bacchidinium polypes* (Cookson & Eisenack, 1962b) Davey, p. 555.

SIZE RANGE: 35 μ m to 39 μ m total including processes, 28 μ m to 31 μ m central body;
9 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch.

COMMENTS: See Cookson and Eisenack (1962b, p. 49) for description.

Genus *Litosphaeridium* Davey & Williams, 1966b emend. Lucas-Clark, 1984

TYPE SPECIES: *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) Davey & Williams, 1966b.

COMMENTS: See Lucas-Clark (1984, p. 181) for emended generic diagnosis.

?*Litosphaeridium* sp. A

[Plate 32, Figure 7]

DESCRIPTION: Dinoflagellate cyst, chorate; central body spherical to ellipsoidal; periphram finely granular with about 12 evenly spaced processes which open distally and are all approximately the same size (9 μ m to 12 μ m long and 13 μ m to 18 μ m wide); archeopyle type unknown; dimensions: 50 μ m to 56 μ m body, 74 μ m to 81 μ m total; 15 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the lower Tununk at Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch.

Genus *Oligosphaeridium* Davey & Williams, 1966b emend. Davey, 1982b

TYPE SPECIES: *Oligosphaeridium complex* (White, 1842) Davey & Williams, 1966b.

COMMENTS: See Davey (1982, p. 13) for emended generic diagnosis.

***Oligosphaeridium complex* (White) Davey & Williams, 1966(b)**

[Plate 33, Figure 1]

- 1842 *Xanthidium tubiferum complex* White, p. 39, pl. 4 fig. 11.
 1940 *Hystichosphaeridium elegantulum* Lejeune-Carpentier, p. 22, text-fig. 11, 12.
 1946 *Hystichosphaeridium complex* (White, 1842) Deflandre, p. 111.
 1966b *Oligosphaeridium complex* (White, 1842) Davey & Williams, p. 71.
 1970 *Oligosphaeridium cephalum* Sah et al., p. 147, pl. 2, fig. 22, 23.
 1981 *Hystichosphaeridium himalayense* Mehrotra & Sinha, p. 152, pl. 1, fig. 7-9.

SIZE RANGE: 47 μ m to 72 μ m total including processes, 22 μ m to 39 μ m central body;
 12 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Molen, Farnham Dome and Horsethief Canyon Ranch; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: For description see Davey and Williams (1966b, p. 71).

***Oligosphaeridium pulcherrimum* (Deflandre & Cookson, 1955)**

Davey & Williams, 1966b

[Plate 33, Figure 2]

- 1955 *Hystichosphaeridium pulcherrimum* Deflandre & Cookson, p. 270, pl. 1, fig. 8, text-fig. 21, 22.
 1966b *Oligosphaeridium pulcherrimum* (Deflandre & Cookson, 1955) Davey & Williams, p. 75.

SIZE RANGE: 71 μ m to 110 μ m total including processes, 45 μ m to 65 μ m central body;
 13 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Ivie Creek; in the Tununk and Ferron at Molen, Farnham Dome and Horsethief Canyon Ranch.

COMMENTS: See Davey and Williams (1966b, p. 75) for description.

***Oligosphaeridium tenuiprocessum* Singh, 1983**

[Plate 33, Figure 3]

1983 *Oligosphaeridium tenuiprocessum* Singh, p. 123, pl. 42, fig. 1-4.

SIZE RANGE: 74 μ m to 112 μ m total including processes, 39 to 64 μ m central body; 5 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw.

COMMENTS: See Singh (1983, p. 123) for description.

***Oligosphaeridium* sp. A**

[Plate 33, Figure 4]

DESCRIPTION: Dinoflagellate cyst, chorate; central body spherical to ellipsoidal; periphram covered with approximately 16 to 22 processes 12 μ m to 18 μ m long, which open and widen distally into 15 μ m to 23 μ m wide funnel-shaped expansions; the stems and expansions of the processes are perforated from within 5 μ m of the central body to the distal expansion forming a reticulate wall and discontinuous rim; dimensions: 60 μ m to 67 μ m body, 93 μ m to 110 μ m total, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This species is similar to *Oligosphaeridium pulcherrimum*, but differs in having shorter processes which open wider distally and are more fully perforated.

Genus *Tanyosphaeridium* Davey & Williams, 1966b

TYPE SPECIES: *Tanyosphaeridium variecalamus* Davey & Williams, 1966b.

COMMENTS: See Davey and Williams (1966b, p. 98) for generic diagnosis.

***Tanyosphaeridium salpinx* Norvick in Norvick and Burger, 1976**

[Plate 34, Figure 1]

1976 *Tanyosphaeridium salpinx* Norvick in Norvick and Burger, p. 63, pl. 9, fig. 10.

SIZE RANGE: 52 μ m to 57 μ m total including processes, 32 μ m to 39 μ m length of central body; 7 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the lower Tununk at Horsethief Canyon Ranch, Farnham Dome, Molen and Ivie Creek.

COMMENTS: For description, see Norvick and Burger (1976, p. 63).

***Tanyosphaeridium* sp. A**

[Plate 34, Figure 2]

DESCRIPTION: Dinoflagellate cyst, chorate; long oval in outline; periphram covered by numerous processes 8 μ m to 10 μ m in length and approximately 1.5 μ m in diameter which flare slightly at the distal end; dimensions: 40 μ m to 46 μ m inner body length, 51 μ m to 60 μ m total length, 5 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: This species differs from *Tanyosphaeridium salpinx* in having approximately half as many processes.

Dinoflagellate Form C

[Plate 34, Figure 3]

DESCRIPTION: Dinoflagellate cyst, chorate; periphram covered with hollow processes approximately 10 μ m long, 10 μ m to 13 μ m wide proximally, 12 μ m to 18 μ m distally, and are constricted somewhat in the middle part; the wall at the distal end of the process forms a somewhat jagged rim; dimensions: 40 μ m to 44 μ m inner body, 57 μ m to 63 μ m total, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Molen, Farnham Dome and Ivie Creek; in the Tununk and Ferron at Horsethief Canyon Ranch.

Dinoflagellate Form D

[Plate 34, Figure 4]

DESCRIPTION: Dinoflagellate cyst, chorate; periphram covered with approximately 13 to 17 processes 8 μ m to 10 μ m in length and 1 μ m in width terminating in four to six recurved spines; dimensions: 25 μ m to 30 μ m inner body 40 μ m to 46 total, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Molen, Farnham Dome and Ivie Creek and Horsethief Canyon Ranch.

Acritarchs -- Without Processes

Genus *Bipatellifera* Singh, 1983

TYPE SPECIES: *Bipatellifera clathrata* Singh, 1983.

COMMENTS: See Singh (1983, p. 168) for generic diagnosis.

***Bipatellifera ?clathrata* Singh, 1983**

[Plate 34, Figure 5]

1983 *Bipatellifera clathrata* Singh, p. 168, pl. 62, fig. 5-9.SIZE RANGE: 21 μ m to 29 μ m total length; 8 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Ivie Creek and Farnham Dome; in the Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: See Singh (1983, p. 168) for description.

Genus *Pterospermella* Eisenack, 1972TYPE SPECIES: *Pterospermella aureolata* (Cookson & Eisenack, 1958) Eisenack, 1972.

COMMENTS: See Norris and Sarjeant (1965, p. 52) for generic diagnosis.

***Pterospermella aureolata* (Cookson & Eisenack, 1958) Eisenack, 1972**

[Plate 34, Figure 6]

1958 *Pterospermopsis aureolata* Cookson & Eisenack, p. 49, pl. 9, fig. 10-12.1972 *Pterospermella aureolata* (Cookson & Eisenack, 1958) Eisenack, p. 597, text fig. 1-3.SIZE RANGE: 69 μ m to 117 μ m total including outer sac, 40 μ m to 74 μ m central body; 11 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome, and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Cookson and Eisenack (1958, p. 49) for description.

Pterospermella eurypteris* (Cookson & Eisenack, 1958)*Eisenack, Cramer & Diez, 1973**

[Plate 34, Figure 7]

1958 *Pterospermopsis eurypteris* Cookson & Eisenack, p. 49, pl. 9, fig. 13.

1973 *Pterospermella eurypteris* (Cookson & Eisenack, 1958) Eisenack, Cramer & Diez, p. 977.

DESCRIPTION: The sac of this species is more or less the same width as the diameter of the central body, wall of outer sac smooth on outside and coarsely granular to pebbly on inner surface; dimensions: 65 μ m to 103 μ m total including outer sac, 27 μ m to 52 μ m central body; 9 specimens measured.

OCCURRENCE: Rare to common; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Ivie Creek; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome, and Molen.

COMMENTS: See Cookson and Eisenack (1958, p. 49) for description.

Acritarch Form A

[Plate 34, Figure 8]

DESCRIPTION: Acritarch, smooth-walled; body circular, densely covered with minute, very short, cone-shaped spines 0.25 μ m to 0.5 μ m in length; dimensions: 23 μ m to 25 μ m diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Acritarchs -- With Processes

Genus *Baltisphaeridium* Eisenack, 1958 emend. Downie & Sarjeant, 1963

TYPE SPECIES: *Baltisphaeridium longispinosum* (Eisenack) Eisenack, 1958.

COMMENTS: See Downie and Sarjeant (1963, p. 89) for emended generic diagnosis.

***Baltisphaeridium multispinosum* Singh, 1964**

[Plate 34, Figure 8]

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

SIZE RANGE: 50 μ m to 67 μ m total including processes, 37 μ m to 44 μ m central body;
15 specimens measured.

OCCURRENCE: Rare to abundant; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome, and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Singh (1964, p. 141) for description, and Singh (1971, p. 395) for discussion.

***Baltisphaeridium whitei* (Deflandre & Courteville, 1939) Sarjeant, 1959**

[Plate 35, Figure 1]

1939 *Hystrichosphaeridium whitei* Deflandre & Courteville, p. 103, pl. 3, fig. 5-6.1959 *Baltisphaeridium whitei* (Deflandre & Courteville, 1939) Sarjeant, p. 339.

SIZE RANGE: 52 μ m to 68 μ m total including processes, 38 μ m to 43 μ m central body,
7 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch, Farnham Dome, Molen and Ivie Creek.

COMMENTS: See Singh (1971, p. 396) for description and Clark and Verdier for extended synonymy.

***Baltisphaeridium* sp. A**

[Plate 35, Figure 2]

DESCRIPTION: Acritarch, spined; spherical inner body covered with many broad-based spines 10 μ m to 14 μ m long, generally $> 1/4$ the radius of the inner body; spines hollow, $1/3$ to $1/2$ radius of inner body; dimensions: 33 μ m to 40 μ m inner body, 51 μ m to 65 μ m total including spines, 10 specimens measured.

OCCURRENCE: Rare to common; in the Mowry at Steinaker Draw; in the Tununk at Farnham Dome, Molen and Ivie Creek; in the Tununk and Ferron at Horsethief Canyon Ranch.

COMMENTS: This form differs from *Baltisphaeridium multispinosum* and *Baltisphaeridium whitei* in having fewer and thicker spines.

***Baltisphaeridium* sp. B**

[Plate 35, Figure 3]

DESCRIPTION: Acritarch, spined; spherical inner body covered with many broad-based spines 8 μ m to 11 μ m long; dimensions: 22 μ m to 27 μ m inner body, 36 μ m to 42 μ m total including spines, 7 specimens measured.

OCCURRENCE: Rare to common; in the Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: *Baltisphaeridium* sp. B differs from other species of *Baltisphaeridium* in being smaller and having a thinner wall.

Genus *Leiofusa* Eisenack, 1938

TYPE SPECIES: *Leiofusa fusiformis* (Eisenack) Eisenack, 1938

COMMENTS: See Norris and Sarjeant (1965, p. 35) for generic diagnosis.

***Leiofusa jurassica* Cookson & Eisenack, 1958**

[Plate 35, Figure 4]

1958 *Leiofusa jurassica* Cookson & Eisenack, p. 51, pl. 10, fig. 3-4.SIZE RANGE: 53 μ m to 78 μ m total length including processes; 5 specimens measured.

OCCURRENCE: Rare; in the Mowry and Tununk at Steinaker Draw; in the Tununk at Horsethief Canyon Ranch, Farnham Dome, Molen and Ivie Creek.

COMMENTS: See Cookson and Eisenack (1958, p. 51) for description.

***Leiofusa* sp. A**

[Plate 35, Figure 5]

DESCRIPTION: Acritarch, short-spined; body 24 μ m to 26 μ m in length and 16 μ m to 19 μ m in width; two spines projecting at 180 degrees from each other and at ends of long axis of central body, 5 μ m to 8 μ m long; dimensions 37 μ m to 45 μ m total length including spines, 4 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: This form differs from *Leiofusa jurassica* in having shorter spines in relation to its body length.**Genus *Micrhystridium* Deflandre, 1937 emend. Downie & Sarjeant, 1963**TYPE SPECIES: *Micrhystridium inconspicuum* (Deflandre) Deflandre, 1937.

COMMENTS: For emended generic diagnosis see Downie and Sarjeant (1963, p. 92).

***Micrhystridium fragile* Deflandre, 1947**

[Plate 35, Figure 6]

1947 *Micrhystridium fragile* Deflandre, p. 8, fig. 13-18.

SIZE RANGE: 11 μ m to 18 μ m total including processes, 9 μ m to 15 μ m central body;
8 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Singh (1971, p. 398) for description.

***Micrhystridium stellatum* Deflandre, 1945**

[Plate 35, Figure 7]

1945 *Micrhystridium stellatum* Deflandre, p. 65, pl. 3, fig. 16-19.

SIZE RANGE: 21 μ m to 41 μ m total including processes, 17 μ m to 34 μ m central body;
9 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry and Tununk at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Singh (1971, p. 400) for description.

***Micrhystridium* sp. A**

[Plate 35, Figure 8]

DESCRIPTION: Acritarch, spined; body spherical, covered with numerous very short spines, 0.5 μ m to 1.5 μ m in length; dimensions: 5 μ m to 7 μ m in diameter including spines,
7 specimens measured.

OCCURRENCE: Rare to frequent; in the Mowry at Steinaker Draw; in the Tununk and Ferron at Horsethief Canyon Ranch, Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: This form is differentiated from *Micrhystridium fragile* in being smaller and in having smaller and more numerous spines.

Genus *Veryhachium* Deunff, 1954 emend. Downie & Sarjeant, 1963

TYPE SPECIES: *Veryhachium trisulcum* (Deunff) Deunff, 1954.

COMMENTS: See Norris and Sarjeant (1965, p. 62) for generic diagnosis.

***Veryhachium irregulare* forma *subtetraedron* Jekhowsky, 1961**

[Plate 35, Figure 9]

1961 *Veryhachium irregulare* forma *subtetraedron* Jekhowsky, p. 208, pl. 1, fig. 4-9.

SIZE RANGE: 28 μ m to 48 μ m total including processes, 20 μ m to 29 μ m central body; 6 specimens measured.

OCCURRENCE: Rare to frequent; in the Tununk at Steinaker Draw and Horsethief Canyon Ranch; in the Tununk and Ferron at Farnham Dome and Molen; in the Tununk, Ferron and Blue Gate at Ivie Creek.

COMMENTS: See Singh (1971, p. 407) for description.

***Veryhachium lairdi* (Deflandre, 1946) Deunff, 1954**

[Plate 35, Figure 10]

1946 *Hystriosphæridium lairdi* Deflandre, card no. 1112.

1954 *Veryhachium lairdi* (Deflandre, 1946) Deunff, p. 306.

SIZE RANGE: 57 μ m to 68 μ m total including processes, 32 μ m to 45 μ m central body; 3 specimens measured.

OCCURRENCE: Rare; in the Tununk at Ivie Creek, Molen and Farnham Dome.

COMMENTS: See Singh (1971, p. 408) for description.

Miscellaneous Marine Material

Microforaminiferal Lining Form A

[Plate 35, Figure 11]

DESCRIPTION: Palynomorph, 7 to 11 planispiral spherical chambers ranging from 12 μ m to 25 μ m in diameter; dimensions: 63 μ m to 86 μ m largest diameter, 4 specimens measured.

OCCURRENCE: Rare; in the Tununk at Horsethief Canyon Ranch, Farnham Dome, Molen and Ivie Creek.

Forms of Uncertain Origin

Unknown Form A

[Plate 36, Figure 1-2]

1980 Algal Systs [sic] of unknown affinity – Pocock, pl. 4, fig. 12.

DESCRIPTION: Palynomorph, possible acritarch or other algal cyst; cell wall two-layered, inner layer composed of an oval inner body 80 μ m to 93 μ m in length and 40 μ m to 55 μ m in width, psilate to finely scabrate, outer layer composed of a loose, thin netting or reticulum which is constricted at the ends of the long axis of the oval inner body to produce terminal, deflated or collapsed, sac-like appendages; dimensions: 110 μ m to 132 μ m total length, 40 μ m to 55 μ m total width, 8 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

COMMENTS: The specimen figured by Pocock (1980) is similar to the forms found in the Mowry Sh. He states (p. 424) that these are abundant in the Aptian of Alberta.

ps

19

un

50

ver

cin

me

Unknown Form B

[Plate 36, Figure 3]

DESCRIPTION: Palynomorph, possibly spore; circular amb; wall thick ($2\mu\text{m}$ to $4\mu\text{m}$), psilate; dimensions: $42\mu\text{m}$ to $47\mu\text{m}$ diameter, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw; in the Tununk at Ivie Creek.

Unknown Form C

[Plate 36, Figure 4]

1984 Undetermined of Tschudy, Tschudy and Craig, pl. 2, fig. 18.

DESCRIPTION: Palynomorph, amb circular to oval, equatorial? margin gently undulating or scalloped wall $2\mu\text{m}$ to $3\mu\text{m}$, psilate or finely granulate; dimensions: $46\mu\text{m}$ to $50\mu\text{m}$, 2 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

Unknown Form D

[Plate 36, Figure 5]

DESCRIPTION: Palynomorph, possibly spore; obligate tetrad in tetrahedral unit, wall very thick ($4\mu\text{m}$ to $6\mu\text{m}$), surface marked with small holes which may be degradation; dimensions: $35\mu\text{m}$ to $42\mu\text{m}$ diameter for individual spore, $68\mu\text{m}$ to $78\mu\text{m}$ total, 3 specimens measured.

OCCURRENCE: Rare; in the Mowry at Steinaker Draw.

DISTR

sample

5 is a n

range

The stu

Cedar

well-p

their

an o

same

(198

Tsch

at the

gray-g

from th

Mountai

was barre

RESULTS

DISTRIBUTION OF PALYNOMORPHS

The distribution of 270 form species of palynomorphs was determined from 169 samples collected from five measured stratigraphic sections and two sets of cores. Table 5 is a master list of all palynomorphs found in these sections and Table 6 summarizes the range data for all sections and shows the total range of each species noted in this study. The stratigraphic ranges of the 270 form species are presented in Figures 10 through 14.

Cedar Mountain Formation

Of the nine prepared samples from the Cedar Mountain, only two had sufficiently well-preserved palynomorphs to study. Tschudy *et al.* (1984, p. 6) had similar results in their study of the Cedar Mountain and Burro Canyon Formations. One sample, taken from an organic-rich mudstone interval at the Molen Section, appears to be from nearly the same level as the productive sample of the Cedar Mountain studied by Tschudy *et al.* (1984). The Molen section is nine miles to the southwest of the locality from which Tschudy's sole productive sample was collected. The other productive sample was taken at the Steinaker Draw section. Palynomorphs from this sample were recovered from light gray-green, clay, rip-up clasts of Cedar Mountain shale found in a coarse-grained sandstone from the lower eight inches of the overlying Dakota Sandstone. A sample of the Cedar Mountain Shale, taken just below the Cedar Mountain/Dakota contact at Steinaker Draw, was barren of palynomorphs.

Table 5. Master list of numbers assigned to each of the palynomorphs in stratigraphic range charts.

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Tab 6
<i>Acritarch</i> Form A					135	78
<i>Aequitriradites ornatus</i>		31			90	19
<i>Alisporites bilateralis</i>	33	53	14	112	20	51
<i>Alisporites</i> sp. A	72	97	11	113	11	233
<i>Alterbidinium</i> sp. A	142	163	95	140		257
<i>Appendicisporites auritus</i>	13	78		56		207
<i>Appendicisporites dentimarginatus</i>	62	8		52	145	30
<i>Appendicisporites insignis</i>				19	32	122
<i>Appendicisporites potomacensis</i>	27	50	69		97	52
<i>Appendicisporites</i> sp. A	14				33	123
<i>Appendicisporites</i> sp. B		79				208
<i>Appendicisporites</i> sp. C					2	1
<i>Appendicisporites</i> sp. D		9				2
<i>Appendicisporites</i> sp. E		10				3
<i>Appendicisporites</i> sp. F	146	173	112			259
<i>Apteodinium maculatum</i>	110	113	52	100	40	139
<i>Araucariacites australis</i>	42	120	26	34	64	187
<i>Arcellites disciformis</i>	76	86		4		242
<i>Artiopollis indivisus</i>		74		14		209
<i>Ascostomocystis giganteus</i>					146	79
<i>Asteropollis asteroides</i>				86	144	124
<i>Bacutritiles greenlandicus</i>	67			5		210
<i>Balmeisporites glenglenensis</i>	155					264
<i>Balmula</i> ?pentaradiata					111	80
<i>Baltisphaeridium multispinosum</i>	104	126	46	128	55	193
<i>Baltisphaeridium whitei</i>	128	137	59	138	101	154
<i>Baltisphaeridium</i> sp. A	121	147	76	129	171	173
<i>Baltisphaeridium</i> sp. B	105	153	20			252
<i>Batioladinium jaegeri</i>					96	81
<i>Bipatellifera</i> ?clathrata	132		90	110	166	174
<i>Biretisporites potoniaei</i>	47	55	30		14	64
<i>Bourkidinium granulatum</i>	119		74	131	160	140
<i>Caligodinium aceras</i>					152	82
<i>Callialasporites</i> ?dampieri				66		211
<i>Camazonosporites insignis</i>	48	107	17	39	108	188
<i>Camazonosporites</i> sp. A				27	114	150
<i>Canningia</i> sp. A	143	169	92		153	175
<i>Catastomocystis</i> sp. A					81	83

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Cedripites</i> sp. A	93	47	16			57
<i>Cerebropollenites mesozoicus</i>				87		212
<i>Chatangiella</i> ? <i>granulifera</i>	141	164	96		181	260
<i>Chatangiella</i> sp. A					182	255
<i>Chlamydophorella nyei</i>	91	132	10	115	42	176
<i>Chomotriletes minor</i>					127	84
<i>Cibotiumspora juncta</i>	2	94		64	143	136
<i>Cicatricosisporites crassiterminatus</i>	34	101	109	15	63	165
<i>Cicatricosisporites dorogensis</i>	80	46	57		61	65
<i>Cicatricosisporites hallei</i>	35	63	18	40	34	53
<i>Cicatricosisporites potomacensis</i>		11		58	124	31
<i>Cicatricosisporites venustus</i>		12			8	20
<i>Cicatricosisporites</i> sp. A		87		89	142	125
<i>Cingutritiles congruens</i>	144	158	91			253
<i>Cingutritiles</i> sp. A	3					213
<i>Cingutritiles</i> sp. B					86	85
<i>Clavatipollenites hughesii</i>	8	36		13		35
<i>Cleistosphaeridium</i> ? <i>multispinosum</i>	85	139	58	98	76	141
<i>Cleistosphaeridium</i> sp. A					132	86
<i>Conbaculatisporites</i> sp. A		13			69	21
<i>Concavisporites lamontis</i>	49	108	31	41	22	66
<i>Concavissimisporites variuerrucatus</i>	15	39		20	154	32
<i>Corollina meyeriana</i>	45	61	15	37	30	67
<i>Corollina torosus</i>	90	48	13	111	19	54
<i>Coronifera oceanica</i>	83	134	2		107	142
<i>Cribroperidinium edwardsii</i>	92	150	85		75	155
<i>Cribroperidinium</i> ? <i>exilicristatum</i>	114	146	60	139	103	156
<i>Crybelosporites brenneri</i>	63	80		21	87	126
<i>Crybelosporites pannuceus</i>		14				4
<i>Cyathidites concavus</i>	21	92	73	77		234
<i>Cyathidites minor</i>	50	64	64	28	23	68
<i>Cycadopites carpentieri</i>	75	75		12		248
<i>Cyclonephelium vannophorum</i>	113	131	6	121	74	176
<i>Cyclonephelium</i> sp. A					38	87
<i>Cyclonephelium</i> sp. B	88	143	55	96		243
<i>Dapsilidinium marinum</i>			83		156	143
<i>Deltoidospora hallii</i>	51	109	32	42	24	69
<i>Densoisporites microrugulatus</i>		15			118	22
<i>Densoisporites velatus</i>		16			60	23

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Dichastopollenites dunveganensis</i>	19	37				45
<i>Dichastopollenites reticulatus</i>	59	38	50	53	71	39
<i>Dichastopollenites</i> sp. A		2				5
<i>Dictyophyllidites impensus</i>	36	51	7	22	10	55
Dinoflagellate Form A					82	88
Dinoflagellate Form B					91	89
Dinoflagellate Form C	112	114	53	124	104	178
Dinoflagellate Form D	133	152	88	133	172	157
Dinoflagellate Form E					141	90
Dinoflagellate Form F					117	91
Dinoflagellate Form G					130	92
Dinoflagellate Form H	82					249
<i>Echinatisporis varispinosus</i>	52	65	19	95	180	77
<i>Endoscrinium campanula</i>					120	93
<i>Equisetosporites ambiguus</i>	157	177				265
<i>Equisetosporites</i> sp. A	30	54	79	62		58
<i>Equisetosporites</i> sp. C	70	76	84			244
<i>Equisetosporites</i> sp. D	12	77			136	127
<i>Equisetosporites</i> sp. E		7				6
<i>Eucommiidites minor</i>	24	43	1	36	16	56
<i>Exesipollenites tumulus</i>		5			1	7
<i>Florentinia cooksoniae</i>					147	94
<i>Foraminisporis dailyi</i>	16	81				214
<i>Foveotricolpites robustus</i>	9	96	75		100	151
<i>Foveotricolporites callosus</i>	138	166	108			258
<i>Fromea amphora</i>	131	156	67	132	62	158
<i>Fromea</i> ? <i>fragilis</i>	111				95	144
<i>Fromea</i> sp. A					126	95
<i>Fromea</i> sp. B					129	96
<i>Fromea</i> sp. C					68	97
Fungal Spore Form A	78	69	36			59
Fungal Spore Form B	77	56		10		60
Fungal Spore Form D	153	178			125	185
Fungal Spore Form E	37	57	37	47		61
<i>Gemmatriletes</i> ? <i>morulus</i>		17			139	24
<i>Gleicheniidites circinidites</i>	64		8	43	29	166
<i>Gleicheniidites senonicus</i>	81	110	33	44	72	189
<i>Heliosporites kemensis</i>		18				8
<i>Hexagonifera</i> sp. A	96	151	38	116	47	194

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

T

F

—

H

Hj

In

In

K

K

K

K

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

L

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Hexagonifera</i> sp. B	97	135	82	117	170	195
<i>Hystriodinium oligacanthum</i>					131	98
<i>Inaperturopollenites dubius</i>	43	117	27	35	44	190
<i>Inaperturopollenites limbatus</i>	87	145	66	102	179	250
<i>Kiokansium polypes</i>	86	138	5	97	168	145
<i>Klukisporites foveolatus</i>		19		81	73	33
<i>Klukisporites pseudoreticulatus</i>	17	44		16	99	40
<i>Laevigatosporites belfordii</i>					79	99
<i>Laevigatosporites ovatus</i>	57	68	35	46	25	70
<i>Laricoidites</i> sp. A	136	171	89	57		235
<i>Leberidocysta</i> sp. A	84	144	4	101	167	146
<i>Leiofusa jurassica</i>	124	157	62	137	175	159
<i>Leiofusa</i> sp. A	129	161	86		27	160
<i>Leptolepidites major</i>					150	100
<i>Leptolepidites</i> sp. A					67	101
<i>Liliacidites dividuus</i>				94	102	136
<i>Liliacidites</i> sp. A	149	172	100			261
<i>Liliacidites</i> sp. B	158	175	111	93		236
? <i>Litosphaeridium</i> sp. A	126	136	3		105	147
<i>Luxadinium propatulum</i>					36	102
<i>Lycopodiacidites cerniidites</i>	53	98	105	23		191
? <i>Lycopodiacidites</i> sp. A			106			266
<i>Micrhystridium fragile</i>	106	127	47	130	56	196
<i>Micrhystridium stellatum</i>	108	129	49	136	57	197
<i>Micrhystridium</i> sp. A	107	128	48		158	198
Microforaminiferal Lining Form A	134	154	61	134		251
<i>Microfoveolatosporis pseudoreticulatus</i>	5	88		71	88	128
<i>Microreticulatisporites sacalii</i>				73		215
<i>Molaspora lobata</i>		29		48		36
Monocolpate Pollen Form A	145	168	102	92		237
Monocolpate Pollen Form B	79	104	22		98	192
Monocolpate Pollen Form C	58			6		216
<i>Monocolpopollenites</i> sp. A	23	91	54	78	159	167
Monolete Spore Form A				80		217
Monolete Spore Form B		30		65		37
<i>Neoraistrickia</i> sp. A				2	78	129
<i>Nyssapollenites nigricolpus</i>	31	103	63	33	123	168
<i>Nyssapollenites</i> sp. A	73	106	104	55		238
<i>Odontochitina operculata</i>	99	141	65	119	48	199

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Odontochitina singhii</i>					116	103
<i>Oligosphaeridium complex</i>	102	118	42	125	53	200
<i>Oligosphaeridium pulcherrimum</i>	94	124	43	126	54	179
<i>Oligosphaeridium tenuiprocessum</i>					83	104
<i>Oligosphaeridium</i> sp. A					112	105
<i>Osmundacidites wellmanii</i>	4	82		29	155	169
<i>Ovoidinium verrucosum</i>	115	148	12	104	37	161
<i>Ovoidites</i> sp. A				51		218
<i>Palaeohystrichophora infusorioides</i>	98	121	39	118	183	254
<i>Palambages canadiana</i>					28	106
<i>Palambages</i> sp. A					89	107
<i>Pareodinia</i> sp. A					157	108
<i>Parvisaccites rugulatus</i>		6			93	25
<i>Penetetrapites mollis</i>		1				9
<i>Perinopollenites elatoides</i>	74	100				239
<i>Periporopollenites</i> sp. A				72		219
<i>Perotriletes</i> sp. A	54	99	80	11		246
<i>Perotriletes</i> sp. C		20				10
<i>Perotriletes</i> sp. D		21			3	11
<i>Petalosporites quadrangulus</i>	68	89		84		220
<i>Phimopollenites pannosus</i>	154	170	103			262
<i>Pilosisorites trichopapillosus</i>		22			15	26
<i>Pilosisorites</i> sp. A					110	109
<i>Pinuspollenites</i> sp. A	46	62	29	38	46	71
<i>Pistillipollenites mcgregorii</i>	39	102	71	74		247
<i>Pityosporites</i> sp. A					165	110
<i>Podocarpidites</i> sp. A	117	140	99		113	162
<i>Podocarpidites</i> sp. B					21	50
<i>Podocarpidites</i> sp. C	11			114	178	170
<i>Polycingulatisporites radiatus</i>		23			162	27
<i>Pristinuspollenites elongatus</i>	29	162			92	171
<i>Pseudoceratium polymorphum</i>					39	111
<i>Psilatrilites ?circumundulatus</i>		111				245
<i>Pterodinium cingulatum</i>	137	159	98	141	161	180
<i>Pterodinium</i> sp. A				103	70	163
<i>Pterospermella aureolata</i>	103	133	44	127	176	201
<i>Pterospermella eurypteris</i>	123	125	45	135	66	181
<i>Reticulatasporites dupliexinus</i>		112			140	172
<i>Reticulatasporites</i> sp. A					138	112

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Note

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Reticulatisporites</i> sp. A					149	113
<i>Reticulosporis foveolatus</i>	6			70		221
<i>Rugubivesiculites reductus</i>	151	167	101	1		240
<i>Rugubivesiculites rugosus</i>	28	49	70	75	41	48
<i>Schizosporis parvus</i>	38	52	110	26		62
<i>Schizosporis reticulatus</i>	156	32		85		63
<i>Scopusporis excavatus</i>		24			7	28
<i>Spermatites ellipticus</i>				49		222
<i>Spermatites</i> sp. A				67		223
<i>Spermatites</i> sp. B	152					267
<i>Spiniferites ramosus</i> ssp. <i>gracilis</i>	100	119	40	122	51	202
<i>Spiniferites ramosus</i> ssp. <i>ramosus</i>	101	123	41	123	52	203
<i>Stephanocolpites tectorius</i>				54		224
<i>Stereisporites antiquasporites</i>	55	66	34	45	109	72
<i>Subtilisphaera inaffecta</i>	120	115		120	77	182
<i>Subtilisphaera</i> sp. A	116	116	87	109	49	183
<i>Subtilisphaera</i> sp. B	130	149	78	105	163	184
<i>Subtilisphaera</i> sp. C	118	122		107	50	204
<i>Subtilisphaera</i> sp. D	95	142	72	108	65	205
<i>Tanyosphaeridium salpinx</i>	127	155	68	99	106	148
<i>Tanyosphaeridium</i> sp. A					174	114
<i>Taxodiaceapollenites hiatus</i>	44	60	28	63	45	73
Terrestrial Unknown Form A		33				12
Terrestrial Unknown Form B		34				13
Terrestrial Unknown Form C				91		225
Terrestrial Unknown Form D		35				14
<i>Tetracolpites reticulatus</i>	10	72		8		226
<i>Thalassiphora microcysta</i>					151	115
<i>Tigrisporites reticulatus</i>		25			122	29
<i>Todisporites minor</i>	56	67	77	76	169	74
<i>Trichodinium castaneum</i>	135		93		26	164
<i>Trichopeltinites</i> sp. A		90				227
Tricolpate Pollen Form A	32	105	23	30		241
Tricolpate Pollen Form B	71	45		25	12	41
Tricolpate Pollen Form D	140	165	94			263
Tricolpate Pollen Form E	22	3	56	61		47
Tricolpate Pollen Form F	60	70				228
<i>Tricolpites anguloluminosus</i>	1	4		9	148	34
<i>Tricolpites crassimurus</i>	89	41	51	50	80	42

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Table 5 (cont'd.)

Form	IC Fig 10	M Fig 11	FD Fig 12	HCR Fig 13	SD Fig 14	Table 6
<i>Tricolpites eragatus</i>	40	58	24	31	17	75
<i>Tricolpites geranioides</i>		71			137	130
<i>Tricolpites minutus</i>	41	59	25	32	18	76
<i>Tricolpites reticulatus</i>				7	115	131
<i>Tricolpites virgeus</i>	25	42		24	84	43
<i>Tricolporoidites minimus</i>	61	73		17	43	152
Trilete Spore Form A	18	83		3	173	132
Trilete Spore Form B				59	85	138
Trilete Spore Form C				69		229
Trilete Spore Form D	147				128	186
Trilete Spore Form E	65			82		230
Trilete Spore Form G					58	116
Trilete Spore Form J		84				231
Trilete Spore Form L		174	107			268
Trilete Spore Form M	150					269
Trilete Spore Form N	148	176				270
Trilete Spore Form P		26				15
Trilete Spore Form Q					4	16
Trilete Spore Genus 1 species A		27				17
Trilete Spore Genus 1 species B	66			79		232
Trilete Spore Genus 1 species C		28		60		46
<i>Trilobosporites crassus</i>	20	40		83	9	44
<i>Triporoletes cenomanianus</i>	26	95	81	68	177	153
<i>Triporoletes involucratus</i>	7			90	94	133
<i>Triporoletes radiatus</i>					119	117
<i>Undulatisporites pannuceus</i>				88	5	38
<i>Undulatisporites undulapolus</i>		85			35	134
<i>Undulatisporites</i> sp. A					6	18
Unknown Form A					164	118
Unknown Form B	125				133	149
Unknown Form C					59	119
Unknown Form D					134	120
<i>Veryhachium irregulare forma subtetraedron</i>	109	130	21	106	184	206
<i>Veryhachium lairdi</i>	139	160	97			256
<i>Virgo amiantopollis</i>	69			18	31	135
<i>Vitreisporites pallidus</i>	122	93	9		13	49
<i>Wigginsella canadense</i>					121	121

Note: Numbers in first five columns indicate the chronological number of each palynomorph in Figures 10 through 14. The last column lists the reference number for each palynomorph in the composite range table (Table 6). (IC = Ivie Creek Section, M = Molen Section, FD = Farnham Dome Section, HCR = Horsethief Canyon Ranch Section, SD = Steinaker Draw Section).

Table 6. Composite stratigraphic range of palynomorphs found in this study.

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
1.	<i>Appendicisporites</i> sp. C	X						
2.	<i>Appendicisporites</i> sp. D	X						
3.	<i>Appendicisporites</i> sp. E	X						
4.	<i>Crybelosporites pannuceus</i>	X						
5.	<i>Dichastopollenites</i> sp. A	X						
6.	<i>Equisetosporites</i> sp. E	X						
7.	<i>Exesipollenites tumulus</i>	X						
8.	<i>Heliosporites kemensis</i>	X						
9.	<i>Penetetrapites mollis</i>	X						
10.	<i>Perotriletes</i> sp. C	X						
11.	<i>Perotriletes</i> sp. D	X						
12.	Terrestrial Unknown Form A	X						
13.	Terrestrial Unknown Form B	X						
14.	Terrestrial Unknown Form D	X						
15.	Trilete Spore Form P	X						
16.	Trilete Spore Form Q	X						
17.	Trilete Spore Genus 1 species A	X						
18.	<i>Undulatisporites</i> sp. A	X						
19.	<i>Aequitriradites ornatus</i>	X	X					
20.	<i>Cicatricosisporites venustus</i>	X	X					
21.	<i>Conbaculatisporites</i> sp. A	X	X					
22.	<i>Densoisporites microrugulatus</i>	X	X					
23.	<i>Densoisporites uelatus</i>	X	X					
24.	<i>Gemmatriletes ?morulus</i>	X	X					
25.	<i>Parvisaccites rugulatus</i>	X	X					
26.	<i>Pilosporites trichopapillosus</i>	X	X					
27.	<i>Polycingulatisporites radiatus</i>	X	X					
28.	<i>Scopusporis excavatus</i>	X	X					
29.	<i>Tigrisporites reticulatus</i>	X	X					
30.	<i>Appendicisporites dentimarginatus</i>	X	X	X				
31.	<i>Cicatricosisporites potomacensis</i>	X	X	X				
32.	<i>Concavissimisporites variiverrucatus</i>	X	X	X				
33.	<i>Klukisporites foveolatus</i>	X	X	X				
34.	<i>Tricolpites anguloluminosus</i>	X	X	X				
35.	<i>Clavatipollenites hughesii</i>	X		X				
36.	<i>Molaspora lobata</i>	X		X				
37.	Monolete Spore Form B	X		X				
38.	<i>Undulatisporites pannuceus</i>	X		X				
39.	<i>Dichastopollenites reticulatus</i>	X	X	X	X			
40.	<i>Klukisporites pseudoreticulatus</i>	X	X	X	X			

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
41.	Tricolpate Pollen Form B	X	X	X	X			
42.	<i>Tricolpites crassimurus</i>	X	X	X	X			
43.	<i>Tricolpites virgeus</i>	X	X	X	X			
44.	<i>Trilobosporites crassus</i>	X	X	X	X			
45.	<i>Dichastopollenites dunveganensis</i>	X		X	X			
46.	Trilete Spore Genus 1 species C	X		X	X			
47.	Tricolpate Pollen Form E	X		X	X			
48.	<i>Rugubivesiculites rugosus</i>	X	X	X	X	X		
49.	<i>Vitreisporites pallidus</i>	X	X	X	X	X		
50.	<i>Podocarpidites</i> sp. B	X	X			X		
51.	<i>Alisporites bilateralis</i>	X	X	X	X	X	X	
52.	<i>Appendicisporites potomacensis</i>	X	X	X	X	X	X	
53.	<i>Cicatricosisporites hallei</i>	X	X	X	X	X	X	
54.	<i>Corollina torosus</i>	X	X	X	X	X	X	
55.	<i>Dictyophyllidites impensus</i>	X	X	X	X	X	X	
56.	<i>Eucommiidites minor</i>	X	X	X	X	X	X	
57.	<i>Cedripites</i> sp. A	X		X	X	X	X	
58.	<i>Equisetosporites</i> sp. A	X		X	X	X	X	
59.	Fungal Spore Form A	X		X	X	X	X	
60.	Fungal Spore Form B	X		X	X	X	X	
61.	Fungal Spore Form E	X		X	X	X	X	
62.	<i>Schizosporis parvus</i>	X		X	X	X	X	
63.	<i>Schizosporis reticulatus</i>	X		X			X	
64.	<i>Biretisporites potoniaei</i>	X	X	X	X	X	X	X
65.	<i>Cicatricosisporites dorogensis</i>	X	X	X	X	X	X	X
66.	<i>Concavisporites lamontis</i>	X	X	X	X	X	X	X
67.	<i>Corollina meyeriana</i>	X	X	X	X	X	X	X
68.	<i>Cyathidites minor</i>	X	X	X	X	X	X	X
69.	<i>Deltoidospora hallii</i>	X	X	X	X	X	X	X
70.	<i>Laevigatosporites ovatus</i>	X	X	X	X	X	X	X
71.	<i>Pinuspollenites</i> sp. A	X	X	X	X	X	X	X
72.	<i>Stereisporites antiquasporites</i>	X	X	X	X	X	X	X
73.	<i>Taxodiaceapollenites hiatus</i>	X	X	X	X	X	X	X
74.	<i>Todisporites minor</i>	X	X	X	X	X	X	X
75.	<i>Tricolpites eragatus</i>	X	X	X	X	X	X	X
76.	<i>Tricolpites minutus</i>	X	X	X	X	X	X	X
77.	<i>Echinatisporis varispinosus</i>	X		X	X	X	X	X
78.	Acritarch Form A		X					
79.	<i>Ascostomocystis giganteus</i>		X					
80.	<i>Balmula ?pentaradiata</i>		X					

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Table

No.

—

81.
82.
83.
84.
85.
86.
87.
88.
89.
90.
91.
92.
93.
94.
95.
96.
97.
98.
99.
100.
101.
102.
103.
104.
105.
106.
107.
108.
109.
110.
111.
112.
113.
114.
115.
116.
117.
118.
119.
120.

Note

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
81.	<i>Batioladinium jaegeri</i>		X					
82.	<i>Caligodinium aceras</i>		X					
83.	<i>Catastomocystis</i> sp. A		X					
84.	<i>Chomotriletes minor</i>		X					
85.	<i>Cingutriletes</i> sp. B		X					
86.	<i>Cleistosphaeridium</i> sp. A		X					
87.	<i>Cyclonephelium</i> sp. A		X					
88.	Dinoflagellate Form A		X					
89.	Dinoflagellate Form B		X					
90.	Dinoflagellate Form E		X					
91.	Dinoflagellate Form F		X					
92.	Dinoflagellate Form G		X					
93.	<i>Endoscrinium campanula</i>		X					
94.	<i>Florentinia cooksoniae</i>		X					
95.	<i>Fromea</i> sp. A		X					
96.	<i>Fromea</i> sp. B		X					
97.	<i>Fromea</i> sp. C		X					
98.	<i>Hystrichodinium oligacanthum</i>		X					
99.	<i>Laevigatosporites belfordii</i>		X					
100.	<i>Leptolepidites major</i>		X					
101.	<i>Leptolepidites</i> sp. A		X					
102.	<i>Luxadinium propatulum</i>		X					
103.	<i>Odontochitina singhii</i>		X					
104.	<i>Oligosphaeridium tenuiprocessum</i>		X					
105.	<i>Oligosphaeridium</i> sp. A		X					
106.	<i>Palambages canadiana</i>		X					
107.	<i>Palambages</i> sp. A		X					
108.	<i>Pareodinia</i> sp. A		X					
109.	<i>Pilosporites</i> sp. A		X					
110.	<i>Pityosporites</i> sp. A		X					
111.	<i>Pseudoceratium polymorphum</i>		X					
112.	<i>Reticulatasporites</i> sp. A		X					
113.	<i>Reticulatisporites</i> sp. A		X					
114.	<i>Tanyosphaeridium</i> sp. A		X					
115.	<i>Thalassiphora microcysta</i>		X					
116.	Trilete Spore Form G		X					
117.	<i>Triporoletes radiatus</i>		X					
118.	Unknown Form A		X					
119.	Unknown Form C		X					
120.	Unknown Form D		X					

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Table

No.

121.

122.

123.

124.

125.

126.

127.

128.

129.

130.

131.

132.

133.

134.

135.

136.

137.

138.

139.

140.

141.

142.

143.

144.

145.

146.

147.

148.

149.

150.

151.

152.

153.

154.

155.

156.

157.

158.

159.

160.

No.

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
121.	<i>Wigginsella canadense</i>		X					
122.	<i>Appendicisporites insignis</i>		X	X				
123.	<i>Appendicisporites</i> sp. A		X	X				
124.	<i>Asteropollis asteroides</i>		X	X				
125.	<i>Cicatricosporites</i> sp. A		X	X				
126.	<i>Crybelosporites brenneri</i>		X	X				
127.	<i>Equisetosporites</i> sp. D		X	X				
128.	<i>Microfoveolatosporis pseudoreticulatus</i>		X	X				
129.	<i>Neoraistrickia</i> sp. A		X	X				
130.	<i>Tricolpites geranioides</i>		X	X				
131.	<i>Tricolpites reticulatus</i>		X	X				
132.	Trilete Spore Form A		X	X				
133.	<i>Triporoletes involucratus</i>		X	X				
134.	<i>Undulatisporites undulapolus</i>		X	X				
135.	<i>Virgo amiantopollis</i>		X	X				
136.	<i>Cibotiumspora juncta</i>		X	X	X			
137.	<i>Liliacidites dividuus</i>		X	X	X			
138.	Trilete Spore Form B		X	X	X			
139.	<i>Apteodinium maculatum</i>		X		X			
140.	<i>Bourkidinium granulatum</i>		X		X			
141.	<i>Cleistosphaeridium</i> ?multispinosum		X		X			
142.	<i>Coronifera oceanica</i>		X		X			
143.	<i>Dapsilidinium marinum</i>		X		X			
144.	<i>Fromea</i> ?fragilis		X		X			
145.	<i>Kiokansium polypes</i>		X		X			
146.	<i>Leberidocysta</i> sp. A		X		X			
147.	? <i>Litosphaeridium</i> sp. A		X		X			
148.	<i>Tanyosphaeridium salpinx</i>		X		X			
149.	Unknown Form B		X		X			
150.	<i>Camarozonosporites</i> sp. A		X	X	X	X		
151.	<i>Foveotricolpites robustus</i>		X	X	X	X		
152.	<i>Tricolporoidites minimus</i>		X	X	X	X		
153.	<i>Triporoletes cenomanianus</i>		X	X	X	X		
154.	<i>Baltisphaeridium whitei</i>		X		X	X		
155.	<i>Cribroperidinium edwardsii</i>		X		X	X		
156.	<i>Cribroperidinium</i> ?exilicristatum		X		X	X		
157.	Dinoflagellate Form D		X		X	X		
158.	<i>Fromea amphora</i>		X		X	X		
159.	<i>Leiofusa jurassica</i>		X		X	X		
160.	<i>Leiofusa</i> sp. A		X		X	X		

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Table 6 (cont'd)

No. Form

161.	Ovoidin
162.	Podoca
163.	Pterodin
164.	Trichod
165.	Cicatric
166.	Gleichen
167.	Monoco
168.	Nyssap
169.	Osmun
170.	Podoca
171.	Pristinu
172.	Reticula
173.	Baltispl
174.	Bipatel
175.	Cannin
176.	Chlamy
177.	Cyclon
178.	Dinofla
179.	Oligosp
180.	Pterod
181.	Pterosp
182.	Subtili
183.	Subtili
184.	Subtili
185.	Funga
186.	Trilete
187.	Arauc
188.	Cama
189.	Gleich
190.	Inape
191.	Lycop
192.	Monc
193.	Baltis
194.	Hexa
195.	Hexa
196.	Micrt
197.	Micrt
198.	Micrt
199.	Odon
200.	Oligo

Note: CM =
TUL
Sand

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
161.	<i>Ovoidinium verrucosum</i>		X		X	X		
162.	<i>Podocarpidites</i> sp. A		X		X	X		
163.	<i>Pterodinium</i> sp. A		X		X	X		
164.	<i>Trichodinium castaneum</i>		X		X	X		
165.	<i>Cicatricosisporites crassiterminatus</i>		X	X	X	X	X	
166.	<i>Gleicheniidites circinidites</i>		X	X	X	X	X	
167.	<i>Monocolpopollenites</i> sp. A		X	X	X	X	X	
168.	<i>Nyssapollenites nigricolpus</i>		X	X	X	X	X	
169.	<i>Osmundacidites wellmanii</i>		X	X	X	X	X	
170.	<i>Podocarpidites</i> sp. C		X	X	X	X	X	
171.	<i>Pristinuspollenites elongatus</i>		X	X	X	X	X	
172.	<i>Reticulatasporites dupliexinuous</i>		X	X			X	
173.	<i>Baltisphaeridium</i> sp. A		X		X	X	X	
174.	<i>Bipatellifera</i> ?clathrata		X		X	X	X	
175.	<i>Canningia</i> sp. A		X		X	X	X	
176.	<i>Chlamydophorella nyei</i>		X		X	X	X	
177.	<i>Cyclonephelium vannophorum</i>		X		X	X	X	
178.	Dinoflagellate Form C		X		X	X	X	
179.	<i>Oligosphaeridium pulcherrimum</i>		X		X	X	X	
180.	<i>Pterodinium cingulatum</i>		X		X	X	X	
181.	<i>Pterospermella eurypteris</i>		X		X	X	X	
182.	<i>Subtilisphaera inaffecta</i>		X		X	X	X	
183.	<i>Subtilisphaera</i> sp. A		X		X	X	X	
184.	<i>Subtilisphaera</i> sp. B		X		X	X	X	
185.	Fungal Spore Form D		X				X	
186.	Trilete Spore Form D		X				X	
187.	<i>Araucariacites australis</i>		X	X	X	X	X	X
188.	<i>Camerozonosporites insignis</i>		X	X	X	X	X	X
189.	<i>Gleicheniidites senonicus</i>		X	X	X	X	X	X
190.	<i>Inaperturopollenites dubius</i>		X	X	X	X	X	X
191.	<i>Lycopodiacidites cerniidites</i>		X	X	X	X	X	X
192.	Monocolpate Pollen Form B		X	X	X	X	X	X
193.	<i>Baltisphaeridium multispinosum</i>		X		X	X	X	X
194.	<i>Hexagonifera</i> sp. A		X		X	X	X	X
195.	<i>Hexagonifera</i> sp. B		X		X	X	X	X
196.	<i>Micrhystridium fragile</i>		X		X	X	X	X
197.	<i>Micrhystridium stellatum</i>		X		X	X	X	X
198.	<i>Micrhystridium</i> sp. A		X		X	X	X	X
199.	<i>Odontochitina operculata</i>		X		X	X	X	X
200.	<i>Oligosphaeridium complex</i>		X		X	X	X	X

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
201.	<i>Pterospermella aureolata</i>		X		X	X	X	X
202.	<i>Spiniferites ramosus</i> ssp. <i>gracilis</i>		X		X	X	X	X
203.	<i>Spiniferites ramosus</i> ssp. <i>ramosus</i>		X		X	X	X	X
204.	<i>Subtilisphaera</i> sp. C		X		X	X	X	X
205.	<i>Subtilisphaera</i> sp. D		X		X	X	X	X
206.	<i>Veryhachium irregulare</i> forma subtetraedron		X		X	X	X	X
207.	<i>Appendicisporites auritus</i>			X				
208.	<i>Appendicisporites</i> sp. B			X				
209.	<i>Artiopollis indivisus</i>			X				
210.	<i>Bacutritiles greenlandicus</i>			X				
211.	<i>Callialasporites ?dampieri</i>			X				
212.	<i>Cerebropollenites mesozoicus</i>			X				
213.	<i>Cingutritiles</i> sp. A			X				
214.	<i>Foraminisporis dailyi</i>			X				
215.	<i>Microreticulatisporites sacalii</i>			X				
216.	Monocolpate Pollen Form C			X				
217.	Monolete Spore Form A			X				
218.	Ovoidites sp. A			X				
219.	<i>Periporopollenites</i> sp. A			X				
220.	<i>Petalosporites quadrangulus</i>			X				
221.	<i>Reticulosporis foveolatus</i>			X				
222.	<i>Spermatites ellipticus</i>			X				
223.	<i>Spermatites</i> sp. A			X				
224.	<i>Stephanocolpites tectorius</i>			X				
225.	Terrestrial Unknown Form C			X				
226.	<i>Tetracolpites reticulatus</i>			X				
227.	<i>Trichopeltinites</i> sp. A			X				
228.	Tricolpate Pollen Form F			X				
229.	Trilete Spore Form C			X				
230.	Trilete Spore Form E			X				
231.	Trilete Spore Form J			X				
232.	Trilete Spore Genus 1 species B			X				
233.	<i>Alisporites</i> sp. A			X	X	X	X	
234.	<i>Cyathidites concavus</i>			X	X	X	X	
235.	<i>Laricoidites</i> sp. A			X	X	X	X	
236.	<i>Liliacidites</i> sp. B			X	X	X	X	
237.	Monocolpate Pollen Form A			X	X	X	X	
238.	<i>Nyssapollenites</i> sp. A			X	X	X	X	
239.	<i>Perinopollenites elatoides</i>			X	X	X	X	
240.	<i>Rugubivesiculites reductus</i>			X	X	X	X	

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

Tabl

No.

241.

242.

243.

244.

245.

246.

247.

248.

249.

250.

251.

252.

253.

254.

255.

256.

257.

258.

259.

260.

261.

262.

263.

264.

265.

266.

267.

268.

269.

270.

TOTAL

Note:

Table 6 (cont'd).

No.	Form	CM	MO	DA	TUL	TUU	FE	BL
241.	Tricolpate Pollen Form A			X	X	X	X	
242.	<i>Arcellites disciformis</i>			X			X	
243.	<i>Cycadopites carpentieri</i>			X			X	
244.	<i>Equisetosporites</i> sp. C			X			X	
245.	<i>Psilatriletes ?circumundulatus</i>			X			X	
246.	<i>Perotriletes</i> sp. A			X	X	X	X	X
247.	<i>Pistillipollenites mcgregorii</i>			X	X	X	X	X
248.	<i>Cyclonephelium</i> sp. B				X			
249.	Dinoflagellate Form H				X			
250.	<i>Inaperturopollenites limbatus</i>				X			
251.	Microforaminiferal Lining Form A				X	X		
252.	<i>Baltisphaeridium</i> sp. B				X	X	X	X
253.	<i>Cingutriletes congruens</i>				X	X	X	X
254.	<i>Palaeohystrichophora infusorioides</i>				X	X	X	X
255.	<i>Chatangiella</i> sp. A					X		
256.	<i>Verhachium lairdi</i>					X		
257.	<i>Alterbidinium</i> sp. A					X	X	
258.	<i>Foveotricolporites callosus</i>					X	X	
259.	<i>Appendicisporites</i> sp. F					X	X	X
260.	<i>Chatangiella ?granulifera</i>					X	X	X
261.	<i>Liliacidites</i> sp. A					X	X	X
262.	<i>Phimopollenites pannosus</i>					X	X	X
263.	Tricolpate Pollen Form D					X	X	X
264.	<i>Balmeisporites glenglenensis</i>						X	
265.	<i>Equisetosporites ambiguus</i>						X	
266.	<i>?Lycopodiacidites</i> sp. A						X	
267.	<i>Spermatites</i> sp. B						X	
268.	Trilete Spore Form L						X	
269.	Trilete Spore Form M						X	
270.	Trilete Spore Form N						X	
TOTAL		77	173	123	123	106	101	44

Note: CM = Cedar Mountain Formation, MO = Mowry Shale, DA = Dakota Sandstone, TUL = Lower Tununk Shale, TUU = Upper Tununk Shale, FE = Ferron Sandstone, BL = Blue Gate Shale.

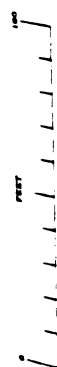
1 Tetractylinae
 2 Ctenactinae
 3 Ctenactinae
 4 Ctenactinae
 5 Microdactylinae
 6 Pseudodactylinae
 7 Pseudodactylinae
 8 Pseudodactylinae
 9 Pseudodactylinae
 10 Pseudodactylinae
 11 Pseudodactylinae
 12 Pseudodactylinae
 13 Pseudodactylinae
 14 Pseudodactylinae
 15 Pseudodactylinae
 16 Pseudodactylinae
 17 Pseudodactylinae
 18 Pseudodactylinae
 19 Pseudodactylinae
 20 Pseudodactylinae
 21 Pseudodactylinae
 22 Pseudodactylinae
 23 Pseudodactylinae
 24 Pseudodactylinae
 25 Pseudodactylinae
 26 Pseudodactylinae
 27 Pseudodactylinae
 28 Pseudodactylinae
 29 Pseudodactylinae
 30 Pseudodactylinae
 31 Pseudodactylinae
 32 Pseudodactylinae
 33 Pseudodactylinae
 34 Pseudodactylinae
 35 Pseudodactylinae
 36 Pseudodactylinae
 37 Pseudodactylinae
 38 Pseudodactylinae
 39 Pseudodactylinae
 40 Pseudodactylinae
 41 Pseudodactylinae
 42 Pseudodactylinae
 43 Pseudodactylinae
 44 Pseudodactylinae
 45 Pseudodactylinae
 46 Pseudodactylinae
 47 Pseudodactylinae
 48 Pseudodactylinae
 49 Pseudodactylinae
 50 Pseudodactylinae
 51 Pseudodactylinae
 52 Pseudodactylinae
 53 Pseudodactylinae
 54 Pseudodactylinae
 55 Pseudodactylinae
 56 Pseudodactylinae
 57 Pseudodactylinae
 58 Pseudodactylinae
 59 Pseudodactylinae
 60 Pseudodactylinae
 61 Pseudodactylinae
 62 Pseudodactylinae
 63 Pseudodactylinae
 64 Pseudodactylinae
 65 Pseudodactylinae
 66 Pseudodactylinae
 67 Pseudodactylinae
 68 Pseudodactylinae
 69 Pseudodactylinae
 70 Pseudodactylinae
 71 Pseudodactylinae
 72 Pseudodactylinae
 73 Pseudodactylinae
 74 Pseudodactylinae
 75 Pseudodactylinae
 76 Pseudodactylinae
 77 Pseudodactylinae
 78 Pseudodactylinae
 79 Pseudodactylinae
 80 Pseudodactylinae
 81 Pseudodactylinae
 82 Pseudodactylinae
 83 Pseudodactylinae
 84 Pseudodactylinae
 85 Pseudodactylinae
 86 Pseudodactylinae
 87 Pseudodactylinae
 88 Pseudodactylinae
 89 Pseudodactylinae
 90 Pseudodactylinae
 91 Pseudodactylinae
 92 Pseudodactylinae
 93 Pseudodactylinae
 94 Pseudodactylinae
 95 Pseudodactylinae
 96 Pseudodactylinae
 97 Pseudodactylinae
 98 Pseudodactylinae
 99 Pseudodactylinae
 100 Pseudodactylinae

Figure 10

1	<i>Tricolpites anguloluminosus</i>	54	<i>Perotriletes</i> sp. A	107	<i>Microhystridium</i> sp. A
2	<i>Cibotiumspora juncta</i>	55	<i>Stereosporites antiquasporites</i>	108	<i>Microhystridium stellatum</i>
3	<i>Cingutrites</i> sp. A	56	<i>Toditesporites minor</i>	109	<i>Veryhachium irregulare</i> forma substraedron
4	<i>Osmundacidites wellmanii</i>	57	<i>Laevigatosporites ovatus</i>	110	<i>Aptodinium maculatum</i>
5	<i>Microfoveolatosporites pseudoreticulatus</i>	58	<i>Monocolpate Pollen Form C</i>	111	<i>Fromea ?fragilis</i>
6	<i>Reticulatosporites foveolatus</i>	59	<i>Dichastopollenites reticulatus</i>	112	<i>Dinoflagellate Form C</i>
7	<i>Triporolites involucreatus</i>	60	<i>Tricolpate Pollen Form F</i>	113	<i>Cyclonephellium vannophorum</i>
8	<i>Clavetipollenites hugheii</i>	61	<i>Tricolporoidites minimus</i>	114	<i>Cribroperidinium ?exilicristatum</i>
9	<i>Foveotricolpites robustus</i>	62	<i>Appendicisporites dentimarginatus</i>	115	<i>Ovoidinium verrucosum</i>
10	<i>Tetracolpites reticulatus</i>	63	<i>Crybelosporites breneri</i>	116	<i>Subtilisphaera</i> sp. A
11	<i>Podocarpidites</i> sp. C	64	<i>Gleicheniidites circinidites</i>	117	<i>Podocarpidites</i> sp. A
12	<i>Equisetisporites</i> sp. D	65	<i>Trilete Spore Form E</i>	118	<i>Subtilisphaera</i> sp. C
13	<i>Appendicisporites auritus</i>	66	<i>Trilete Spore Genus 1 species B</i>	119	<i>Bourkidinium granulosum</i>
14	<i>Appendicisporites</i> sp. A	67	<i>Bacutrites greenlandicus</i>	120	<i>Subtilisphaera inaeffecta</i>
15	<i>Concavissimisporites variverrucatus</i>	68	<i>Petalosporites quadrangulus</i>	121	<i>Baltisphaeridium</i> sp. A
16	<i>Foraminisporites dallyi</i>	69	<i>Virgo amiantopollis</i>	122	<i>Vitreosporites pallidus</i>
17	<i>Kukisporites pseudoreticulatus</i>	70	<i>Equisetisporites</i> sp. C	123	<i>Pteropermella euryptaris</i>
18	<i>Trilete Spore Form A</i>	71	<i>Tricolpate Pollen Form B</i>	124	<i>Leiofusa jurassica</i>
19	<i>Dichastopollenites dumveganensis</i>	72	<i>Alloporites</i> sp. A	125	<i>Unknown Form B</i>
20	<i>Tricobosporites crassus</i>	73	<i>Nyseeipollenites</i> sp. A	126	<i>?Urtosphaeridium</i> sp. A
21	<i>Cyathidites concavus</i>	74	<i>Perinopollenites elatoides</i>	127	<i>Tanyosphaeridium aspinx</i>
22	<i>Tricolpate Pollen Form E</i>	75	<i>Cycadoides carpenterii</i>	128	<i>Baltisphaeridium whitei</i>
23	<i>Monocolpopollenites</i> sp. A	76	<i>Arceutites disciformis</i>	129	<i>Leiofusa</i> sp. A
24	<i>Eucommiidites minor</i>	77	<i>Fungal Spore Form B</i>	130	<i>Subtilisphaera</i> sp. B
25	<i>Tricolpites virgeus</i>	78	<i>Fungal Spore Form A</i>	131	<i>Fromea amphora</i>
26	<i>Triporolites canomanianus</i>	79	<i>Monocolpate Pollen Form B</i>	132	<i>Bipatellifera ?clathrata</i>
27	<i>Appendicisporites potomacensis</i>	80	<i>Cicatricosporites dorgensis</i>	133	<i>Dinoflagellate Form D</i>
28	<i>Rugubivesiculites rugosus</i>	81	<i>Gleicheniidites senonicus</i>	134	<i>Microforaminiferal Lining Form A</i>
29	<i>Pristinuspollenites elongatus</i>	82	<i>Dinoflagellate Form H</i>	135	<i>Trichodinium castaneum</i>
30	<i>Equisetisporites</i> sp. A	83	<i>Coronifera oceanica</i>	136	<i>Laricoidites</i> sp. A
31	<i>Nyseeipollenites nigricolpus</i>	84	<i>Leberidocysta</i> sp. A	137	<i>Pterodinium cingulatum</i>
32	<i>Tricolpate Pollen Form A</i>	85	<i>Cleistosphaeridium ?multispinosum</i>	138	<i>Foveotricolpites callosus</i>
33	<i>Alloporites bilateralis</i>	86	<i>Kokansium polypes</i>	139	<i>Veryhachium lairdi</i>
34	<i>Cicatricosporites crasseiterminatus</i>	87	<i>Inaperturopollenites limbatu</i>	140	<i>Tricolpate Pollen Form D</i>
35	<i>Cicatricosporites hallei</i>	88	<i>Cyclonephellium</i> sp. B	141	<i>Chatangiella ?granulifera</i>
36	<i>Dictyophyllidites impenus</i>	89	<i>Tricolpites crassimurus</i>	142	<i>Alterbidinium</i> sp. A
37	<i>Fungal Spore Form E</i>	90	<i>Corollina torosus</i>	143	<i>Canningia</i> sp. A
38	<i>Schizosporites parvus</i>	91	<i>Chlamydothorella nyel</i>	144	<i>Cingutrites congruens</i>
39	<i>Pistillipollenites mcgregorii</i>	92	<i>Cribroperidinium edwardii</i>	145	<i>Monocolpate Pollen Form A</i>
40	<i>Tricolpites eragatus</i>	93	<i>Cedripites</i> sp. A	146	<i>Appendicisporites</i> sp. F
41	<i>Tricolpites minutus</i>	94	<i>Oligosphaeridium pulcherrimum</i>	147	<i>Trilete Spore Form D</i>
42	<i>Araucariacites australis</i>	95	<i>Subtilisphaera</i> sp. D	148	<i>Trilete Spore Form N</i>
43	<i>Inaperturopollenites dubius</i>	96	<i>Hexagonifera</i> sp. A	149	<i>Liliacidites</i> sp. A
44	<i>Taxodiaceosporites hieatus</i>	97	<i>Hexagonifera</i> sp. B	150	<i>Trilete Spore Form M</i>
45	<i>Corollina meyeriana</i>	98	<i>Palaeohystrichophora infusoroides</i>	151	<i>Rugubivesiculites reductus</i>
46	<i>Pinuspollenites</i> sp. A	99	<i>Odontochitina operculata</i>	152	<i>Spermatites</i> sp. B
47	<i>Biretisporites potoniensis</i>	100	<i>Spiniferites ramosus</i> esp. gracilis	153	<i>Fungal Spore Form D</i>
48	<i>Camerozonosporites insignis</i>	101	<i>Spiniferites ramosus</i> esp. ramosus	154	<i>Phimopollenites pannosus</i>
49	<i>Concavosporites lemontis</i>	102	<i>Oligosphaeridium complex</i>	155	<i>Balmesporites glenglenensis</i>
50	<i>Cyathidites minor</i>	103	<i>Pteropermella aureolata</i>	156	<i>Schizosporites reticulatus</i>
51	<i>Deltoidospora hallii</i>	104	<i>Baltisphaeridium multispinosum</i>	157	<i>Equisetisporites ambiguus</i>
52	<i>Echinatlesporites varispinosus</i>	105	<i>Baltisphaeridium</i> sp. B	158	<i>Liliacidites</i> sp. B
53	<i>Lyopodiadites cernidites</i>	106	<i>Microhystridium fragile</i>		

Figure 10

0 RICHES



Figure

Note:

Note

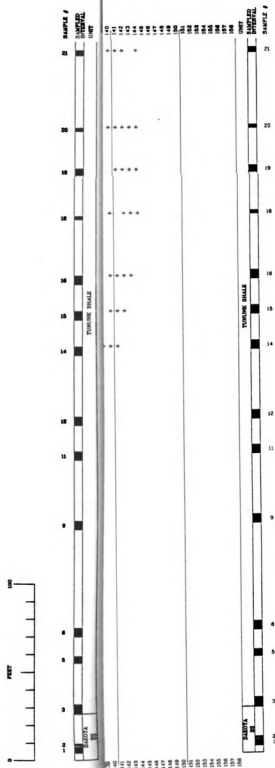


Figure 10.

Note:

1	<i>Penetstrepites mollis</i>	61	<i>Corollina meyeriana</i>	120	<i>Anaerolacites australis</i>
2	<i>Dicliostopollenites</i> sp. A	62	<i>Pinuspollenites</i> sp. A	121	<i>Palaeohystriophora infusorioides</i>
3	<i>Tricolpate Pollen Form E</i>	63	<i>Cicatricoseporites hallii</i>	122	<i>Subtillephaera</i> sp. C
4	<i>Tricolpites anguloluminosus</i>	64	<i>Cyathidites minor</i>	123	<i>Spiniferites ramosus</i> sep. ramosus
5	<i>Esseipollenites tumulus</i>	65	<i>Echinatleporia variegatus</i>	124	<i>Oligosphaeridium pulcherrimum</i>
6	<i>Parvesaccites rugulatus</i>	66	<i>Stereosporites antiquasporites</i>	125	<i>Pterospemella euryptera</i>
7	<i>Equisetopollenites</i> sp. E	67	<i>Todolporites minor</i>	126	<i>Baltisphaeridium multipinosum</i>
8	<i>Appendiciopollenites dentimarginatus</i>	68	<i>Laevigatopollenites ovestus</i>	127	<i>Microhystridium fragile</i>
9	<i>Appendiciopollenites</i> sp. D	69	<i>Fungal Spore Form A</i>	128	<i>Microhystridium</i> sp. A
10	<i>Appendiciopollenites</i> sp. E	70	<i>Tricolpate Pollen Form F</i>	129	<i>Microhystridium stellatum</i>
11	<i>Cicatricoseporites potomacensis</i>	71	<i>Tricolpites geranioides</i>	130	<i>Verhachium irregulare</i> forma sublaedron
12	<i>Cicatricoseporites venustus</i>	72	<i>Tetracolpites reticulatus</i>	131	<i>Cyclonephelium vannophorum</i>
13	<i>Conbaculapollenites</i> sp. A	73	<i>Tricolporoidites minimus</i>	132	<i>Chlamydocophorella nyel</i>
14	<i>Crybelosporites pennuolus</i>	74	<i>Artipollis indivius</i>	133	<i>Pterospemella aureolata</i>
15	<i>Densolapollenites microrugulatus</i>	75	<i>Cycadopites carpentieri</i>	134	<i>Coronifera oceanica</i>
16	<i>Densolapollenites velatus</i>	76	<i>Equisetopollenites</i> sp. C	135	<i>Hexagonifera</i> sp. B
17	<i>Gemmatriletes ?morulus</i>	77	<i>Equisetopollenites</i> sp. D	136	<i>?Ulosphaeridium</i> sp. A
18	<i>Heliopollenites lemaneale</i>	78	<i>Appendiciopollenites auritus</i>	137	<i>Baltisphaeridium whist</i>
19	<i>Kuldeporites foveolatus</i>	79	<i>Appendiciopollenites</i> sp. B	138	<i>Kokanekum polypes</i>
20	<i>Perotritates</i> sp. C	80	<i>Crybelosporites breunneri</i>	139	<i>Cleatlophaeridium ?multipinosum</i>
21	<i>Perotritates</i> sp. D	81	<i>Foraminisporia dalyi</i>	140	<i>Podocarpidites</i> sp. A
22	<i>Ptilosporites trichocapillatus</i>	82	<i>Osmundacidites wellmanii</i>	141	<i>Odontochitina operculata</i>
23	<i>Polycingulapollenites radiatus</i>	83	<i>Trilete Spore Form A</i>	142	<i>Subtillephaera</i> sp. D
24	<i>Scoposporia excavatus</i>	84	<i>Trilete Spore Form J</i>	143	<i>Cyclonephelium</i> sp. B
25	<i>Tigridopollenites reticulatus</i>	85	<i>Undulapollenites undulapollus</i>	144	<i>Leberidocysta</i> sp. A
26	<i>Trilete Spore Form P</i>	86	<i>Arcellites disciformis</i>	145	<i>Inaperturopollenites limbus</i>
27	<i>Trilete Spore Genus 1 species A</i>	87	<i>Cicatricoseporites</i> sp. A	146	<i>Cribroperidinium ?edricristatum</i>
28	<i>Trilete Spore Genus 1 species C</i>	88	<i>Microfoveolapollenites</i>	147	<i>Baltisphaeridium</i> sp. A
29	<i>Molaspora lobata</i>	89	<i>pseudoreticulatus</i>	148	<i>Ovoidinium verrucosum</i>
30	<i>Monolete Spore Form B</i>	90	<i>Petalosporites quadrangulus</i>	149	<i>Subtillephaera</i> sp. B
31	<i>Aquilatridites ornatus</i>	91	<i>Trichopeltinites</i> sp. A	150	<i>Cribroperidinium edwardii</i>
32	<i>Schizosporia reticulatus</i>	92	<i>Monocolpoidipollenites</i> sp. A	151	<i>Hexagonifera</i> sp. A
33	<i>Terrestrial Unknown Form A</i>	93	<i>Cyathidites concavus</i>	152	<i>Dinoflagellate Form D</i>
34	<i>Terrestrial Unknown Form B</i>	94	<i>Vitreporites pallidus</i>	153	<i>Baltisphaeridium</i> sp. B
35	<i>Terrestrial Unknown Form D</i>	95	<i>Cibotumapora juncta</i>	154	<i>Microforaminiferal Lining Form A</i>
36	<i>Clavatiipollenites hugheii</i>	96	<i>Triporolites canomanius</i>	155	<i>Tanyosphaeridium aspinx</i>
37	<i>Dicliostopollenites dunveganensis</i>	97	<i>Foveotricolpites robustus</i>	156	<i>Fromea amphora</i>
38	<i>Dicliostopollenites reticulatus</i>	98	<i>Alloporites</i> sp. A	157	<i>Lecofusa jurassica</i>
39	<i>Concavissimipollenites varverrucatus</i>	99	<i>Lycopodioidites cerniidites</i>	158	<i>Cingulitites congruens</i>
40	<i>Trifolopollenites crassus</i>	100	<i>Perinopollenites elatoides</i>	159	<i>Pterodinium cingulatum</i>
41	<i>Tricolpites crassimurus</i>	101	<i>Cicatricoseporites crassiterminatus</i>	160	<i>Verhachium lairdi</i>
42	<i>Tricolpites virgeus</i>	102	<i>Pistillipollenites mcgregorii</i>	161	<i>Lecofusa</i> sp. A
43	<i>Eucommidites minor</i>	103	<i>Nyssaepollenites nigricolpus</i>	162	<i>Pristinusapollenites elongatus</i>
44	<i>Kuldeporites pseudoreticulatus</i>	104	<i>Monocolpate Pollen Form B</i>	163	<i>Alterbidinium</i> sp. A
45	<i>Tricolpate Pollen Form B</i>	105	<i>Tricolpate Pollen Form A</i>	164	<i>Chatangiella ?granulifera</i>
46	<i>Cicatricoseporites dorogensis</i>	106	<i>Nyssaepollenites</i> sp. A	165	<i>Tricolpate Pollen Form D</i>
47	<i>Cedripites</i> sp. A	107	<i>Camerozonosporites insignis</i>	166	<i>Foveotricolpites callosus</i>
48	<i>Corollina torosus</i>	108	<i>Concavipollenites lamontis</i>	167	<i>Rugubivisculites reductus</i>
49	<i>Rugubivisculites rugosus</i>	109	<i>Deltoidospora hallii</i>	168	<i>Monocolpate Pollen Form A</i>
50	<i>Appendiciopollenites potomacensis</i>	110	<i>Gleicheniidites senonicus</i>	169	<i>Canningia</i> sp. A
51	<i>Dictyophyllidites impensus</i>	111	<i>Pallatritates ?circumundulatus</i>	170	<i>Phimopollenites pannosus</i>
52	<i>Schizosporia parvus</i>	112	<i>Reticulapollenites duplesinus</i>	171	<i>Laricoidites</i> sp. A
53	<i>Alloporites bilateralis</i>	113	<i>Aptodinium maculatum</i>	172	<i>Ullacoidites</i> sp. A
54	<i>Equisetopollenites</i> sp. A	114	<i>Dinoflagellate Form C</i>	173	<i>Appendiciopollenites</i> sp. F
55	<i>Biretloporites potonilae</i>	115	<i>Subtillephaera inaeffecta</i>	174	<i>Trilete Spore Form L</i>
56	<i>Fungal Spore Form B</i>	116	<i>Subtillephaera</i> sp. A	175	<i>Ullacoidites</i> sp. B
57	<i>Fungal Spore Form E</i>	117	<i>Inaperturopollenites dubius</i>	176	<i>Trilete Spore Form N</i>
58	<i>Tricolpites eragatus</i>	118	<i>Oligosphaeridium complex</i>	177	<i>Equisetopollenites ambiguus</i>
59	<i>Tricolpites minutus</i>	119	<i>Spiniferites ramosus</i> sep. gracilis	178	<i>Fungal Spore Form D</i>
60	<i>Taxodiaceapollenites histus</i>				

Figure 11



Figure 11.

Note:

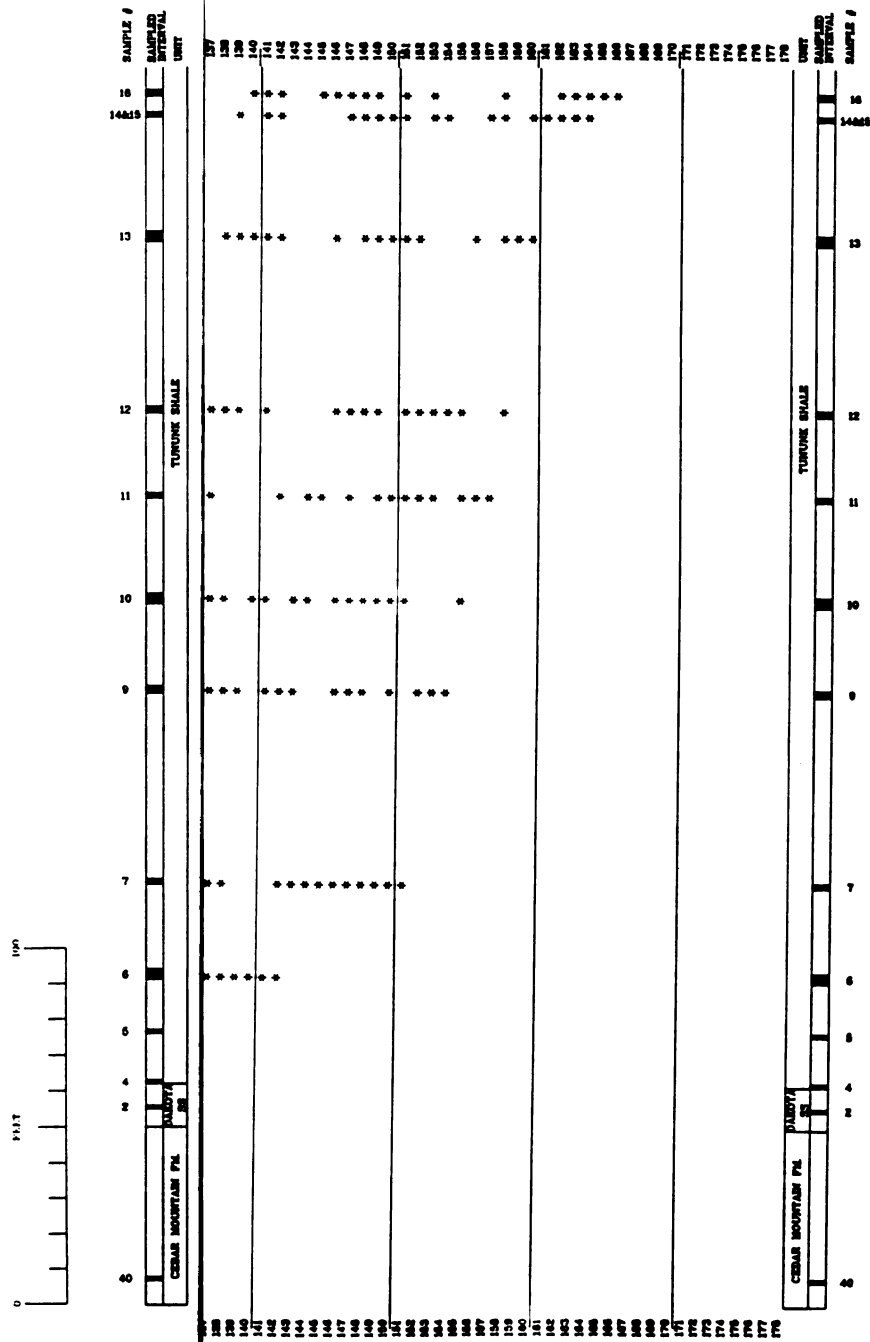


Figure 11.

Note:

1	Eucommiidites minor	38	Hexagonifera sp. A	76	Baltapheeridium sp. A
2	Coronifera oceanica	39	Palaeohystriophora infusorioides	77	Todtaportites minor
3	?Litosphaeridium sp. A	40	Spiniferites ramosus esp. gracilis	78	Subtilisphaera sp. B
4	Labridocysta sp. A	41	Spiniferites ramosus esp. ramosus	79	Equisetosporites sp. A
5	Kolansium polytes	42	Oligosphaeridium complex	80	Perotritates sp. A
6	Cyclonophellum vannophorum	43	Oligosphaeridium pulcherrimum	81	Triporotates cenomanicus
7	Dictyophyllidites impaneus	44	Pteropermella aureolata	82	Hexagonifera sp. B
8	Gleicheniidites circinidites	45	Pteropermella euryptera	83	Dapilidinium maritimum
9	Vitreosporites pallidus	46	Baltapheeridium multispinosum	84	Equisetosporites sp. C
10	Chlamydophorella nyel	47	Michrystidium fragile	85	Cribroperidinium edwardsii
11	Alisporites sp. A	48	Michrystidium sp. A	86	Lelofusa sp. A
12	Ovoidinium verrucosum	49	Michrystidium stellatum	87	Subtilisphaera sp. A
13	Corollina torosus	50	Dichestopollenites reticulatus	88	Dinoflagellate Form D
14	Alisporites bilateralis	51	Tricolpites crassimurus	89	Laricoidites sp. A
15	Corollina meyeriana	52	Aptodinium maculatum	90	Bipetalifera ?clathrata
16	Cedripites sp. A	53	Dinoflagellate Form C	91	Cingulitites congruens
17	Camerozonosporites insignis	54	Monocolpopollenites sp. A	92	Canningia sp. A
18	Cicatricosisporites hallii	55	Cyclonophellum sp. B	93	Trichodinium castaneum
19	Echinatlesporia variispinosus	56	Tricolpate Pollen Form E	94	Tricolpate Pollen Form D
20	Baltapheeridium sp. B	57	Cicatricosisporites dorogensis	95	Alterbidinium sp. A
21	Veryhachium irregulare forma subtetradron	58	Cicatricosisporites ?multispinosum	96	Chetangiella ?granulifera
22	Monocolpate Pollen Form B	59	Baltapheeridium whitii	97	Veryhachium lairdi
23	Tricolpate Pollen Form A	60	Cribroperidinium ?exilicristatum	98	Pterodinium cingulatum
24	Tricolpites eragatus	61	Microforaminiferal Lining Form A	99	Podocarpidites sp. A
25	Tricolpites minutus	62	Lelofusa jurassica	100	Liliacidites sp. A
26	Araucariacites australis	63	Nyssaepollenites nigricolpus	101	Rugubivesiculites reductus
27	Inaperturopollenites dubius	64	Cyathidites minor	102	Monocolpate Pollen Form A
28	Taxodiaceapollenites hiatus	65	Odontochitina operculata	103	Phimopollenites pannosus
29	Pinuspollenites sp. A	66	Inaperturopollenites limbatas	104	Nyssaepollenites sp. A
30	Biretisporites potoniensis	67	Fromea amphora	105	Lycopodiadites cernidites
31	Concaviporites lamontis	68	Tanyosphaeridium salpinx	106	?Lycopodiadites sp. A
32	Deltoidospora hallii	69	Appendicisporites potomacensis	107	Trilete Spore Form L
33	Gleicheniidites senonicus	70	Rugubivesiculites rugosus	108	Foveotricolporites callosus
34	Stereisporites antiquasporites	71	Pistillipollenites mgregorii	109	Cicatricosisporites crasseiterminatus
35	Laevigatosporites ovatus	72	Subtilisphaera sp. D	110	Schizosporia parvus
36	Fungal Spore Form A	73	Cyathidites concavus	111	Liliacidites sp. B
37	Fungal Spore Form E	74	Bourkiddinium granulosum	112	Appendicisporites sp. F
		75	Foveotricolpites robustus		

Figure 12



Figure 12.

Note:

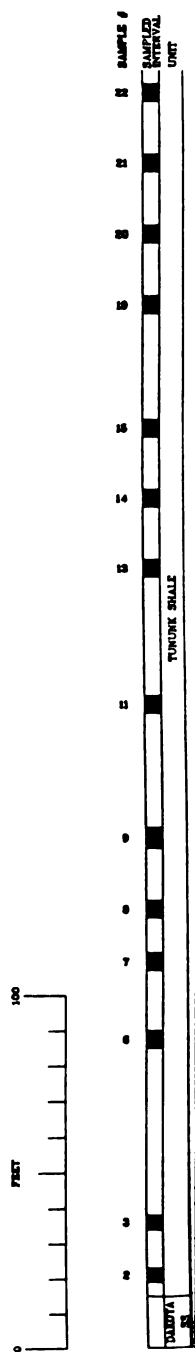


Figure 12.

Note:

1	<i>Rugubivesiculites reductus</i>	49	<i>Spermatites ellipticus</i>	96	<i>Cyclonephelium</i> sp. B
2	<i>Neoraetrickia</i> sp. A	50	<i>Tricolpites crassimurus</i>	97	<i>Kokanelum polytypus</i>
3	Trilete Spore Form A	51	<i>Ovoidites</i> sp. A	98	<i>Cleistocepharidium</i> ?multipinosum
4	<i>Arcellites disciformis</i>	52	<i>Appendicisporites dentimarginatus</i>	99	<i>Tanyosphaeridium aspinx</i>
5	<i>Baculitites greenlandicus</i>	53	<i>Dicliastopollenites reticulatus</i>	100	<i>Aptodinium maculatum</i>
6	Monocolpate Pollen Form C	54	<i>Stephanocolpites tectorius</i>	101	<i>Leberidocysta</i> sp. A
7	<i>Tricolpites reticulatus</i>	55	<i>Nyseapollenites</i> sp. A	102	<i>Inaperturopollenites limbatus</i>
8	<i>Tetracolpites reticulatus</i>	56	<i>Appendicisporites auritus</i>	103	<i>Pterodinium</i> sp. A
9	<i>Tricolpites anguloluminosus</i>	57	<i>Laricoidites</i> sp. A	104	<i>Ovoidinium verrucosum</i>
10	Fungal Spore Form B	58	<i>Cicatricoseporites potomacensis</i>	105	<i>Subtilisphaera</i> sp. B
11	<i>Perotrilites</i> sp. A	59	Trilete Spore Form B	106	<i>Veryhachium irregulare</i> forma subtetradron
12	<i>Cycadopolites carpentieri</i>	60	Trilete Spore Genus 1 species C	107	<i>Subtilisphaera</i> sp. C
13	<i>Cleavipollenites hugheii</i>	61	Tricolpate Pollen Form E	108	<i>Subtilisphaera</i> sp. D
14	<i>Artipollis indivisus</i>	62	<i>Equilestesporites</i> sp. A	109	<i>Subtilisphaera</i> sp. A
15	<i>Cicatricoseporites crassiterminatus</i>	63	<i>Taxodiceaeapollenites hiatus</i>	110	<i>Bipalaeifera</i> ?clathrata
16	<i>Kukisporites pseudoreticulatus</i>	64	<i>Cibotiumspora juncta</i>	111	<i>Corollina torosus</i>
17	<i>Tricolporoidites minimus</i>	65	Monolete Spore Form B	112	<i>Alloporites bilateralis</i>
18	<i>Virgo amiantopolis</i>	66	<i>Callialasporites</i> ?dampieri	113	<i>Alloporites</i> sp. A
19	<i>Appendicisporites insignis</i>	67	<i>Spermatites</i> sp. A	114	<i>Podocarpidites</i> sp. C
20	<i>Concaviesimisporites variverrucatus</i>	68	<i>Triporolites canomanianus</i>	115	<i>Chlamydophorella nyel</i>
21	<i>Crybelosporites brenneri</i>	69	Trilete Spore Form C	116	<i>Hexagonifera</i> sp. A
22	<i>Dictyophyllidites impaneus</i>	70	<i>Reticuloseporis foveolatus</i>	117	<i>Hexagonifera</i> sp. B
23	<i>Lyopodolacoidites cerniidites</i>	71	<i>Microfoveolatesporites pseudoreticulatus</i>	118	<i>Palaeohystrichophora infusorioides</i>
24	<i>Tricolpites virgeus</i>	72	<i>Periporopollenites</i> sp. A	119	<i>Odontochitina operculata</i>
25	Tricolpate Pollen Form B	73	<i>Microreticulatisporites sacali</i>	120	<i>Subtilisphaera inaeffecta</i>
26	<i>Schizosporites parvus</i>	74	<i>Pistillipollenites mcgregorii</i>	121	<i>Cyclonephelium vannophorum</i>
27	<i>Camerozonosporites</i> sp. A	75	<i>Rugubivesiculites rugosus</i>	122	<i>Spiniferites ramosus</i> esp. gracilis
28	<i>Cyathidites minor</i>	76	<i>Todisporites minor</i>	123	<i>Spiniferites ramosus</i> esp. ramosus
29	<i>Osmundacidites wellmanii</i>	77	<i>Cyathidites concavus</i>	124	<i>Dinoflagellate</i> Form C
30	Tricolpate Pollen Form A	78	<i>Monocolpopollenites</i> sp. A	125	<i>Oligosphaeridium complex</i>
31	<i>Tricolpites eragatus</i>	79	Trilete Spore Genus 1 species B	126	<i>Oligosphaeridium pulcherrimum</i>
32	<i>Tricolpites minutus</i>	80	Monolete Spore Form A	127	<i>Pterospermella aureolata</i>
33	<i>Nyseapollenites nigricolpus</i>	81	<i>Kukisporites foveolatus</i>	128	<i>Baltisphaeridium multipinosum</i>
34	<i>Araucariacites australis</i>	82	Trilete Spore Form E	129	<i>Baltisphaeridium</i> sp. A
35	<i>Inaperturopollenites dubius</i>	83	<i>Triobosporites crassus</i>	130	<i>Microthyridium fragile</i>
36	<i>Eucommiidites minor</i>	84	<i>Petalosporites quadrangulus</i>	131	<i>Bourkidinium granulosum</i>
37	<i>Corollina meyeriana</i>	85	<i>Schizosporites reticulatus</i>	132	<i>Fromea amphora</i>
38	<i>Pinuspollenites</i> sp. A	86	<i>Asteropollis asteroides</i>	133	<i>Dinoflagellate</i> Form D
39	<i>Camerozonosporites insignis</i>	87	<i>Cerebropollenites mesozoicus</i>	134	<i>Microforaminiferal</i> Lining Form A
40	<i>Cicatricoseporites hallii</i>	88	<i>Undulatisporites pannucosus</i>	135	<i>Pterospermella eurypteria</i>
41	<i>Concaviporites lamontis</i>	89	<i>Cicatricoseporites</i> sp. A	136	<i>Microthyridium stellatum</i>
42	<i>Deftoidospora hallii</i>	90	<i>Triporolites involuatus</i>	137	<i>Lelofusa jurassica</i>
43	<i>Gleicheniidites circinidites</i>	91	Terrestrial Unknown Form C	138	<i>Baltisphaeridium whitei</i>
44	<i>Gleicheniidites senonicus</i>	92	Monocolpate Pollen Form A	139	<i>Cribroperidinium</i> ?exilicristatum
45	<i>Stereosporites antiquasporites</i>	93	<i>Liliacidites</i> sp. B	140	<i>Alterbidinium</i> sp. A
46	<i>Laevigatesporites ovatus</i>	94	<i>Liliacidites dividius</i>	141	<i>Pterodinium cingulatum</i>
47	Fungal Spore Form E	95	<i>Echinatesporis varispinosus</i>		
48	<i>Molasporea lobata</i>				

Figure 13



Figure 13.
Note:

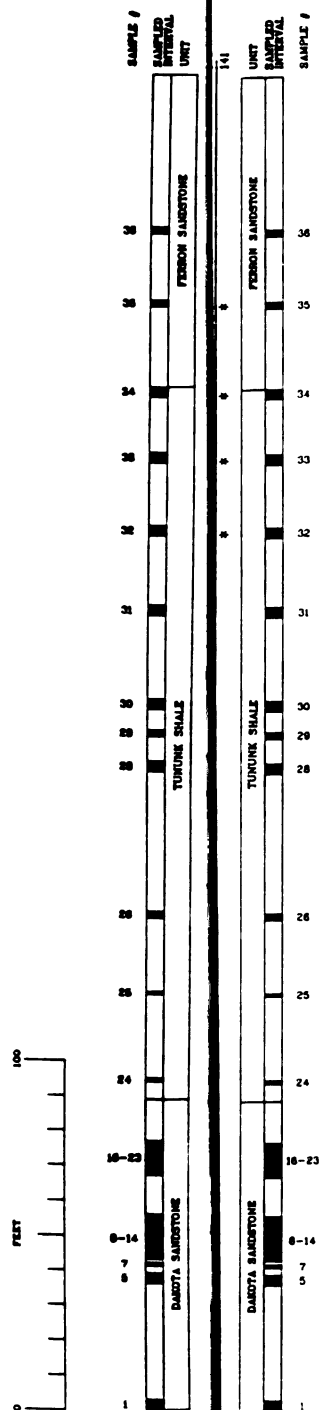


Figure 13.

Note:

1	<i>Exseipollenites tumulus</i>	63	<i>Cicatricoseporites crasseiterminatus</i>	124	<i>Cicatricoseporites potomacensis</i>
2	<i>Appendicoseporites</i> sp. C	64	<i>Arucariacites australis</i>	125	Fungal Spore Form D
3	<i>Pterotriletes</i> sp. D	65	<i>Subtillephaera</i> sp. D	126	<i>Fromea</i> sp. A
4	Trilete Spore Form Q	66	<i>Pterospermella euryptera</i>	127	<i>Chomotriletes minor</i>
5	<i>Undulatisporites pannuceus</i>	67	<i>Leptolepidites</i> sp. A	128	Trilete Spore Form D
6	<i>Undulatisporites</i> sp. A	68	<i>Fromea</i> sp. C	129	<i>Fromea</i> sp. B
7	<i>Scoposporis excavatus</i>	69	<i>Conbaculatisporites</i> sp. A	130	Dinoflagellate Form G
8	<i>Cicatricoseporites venustus</i>	70	<i>Pterodinium</i> sp. A	131	<i>Hystriodinium oligacanthum</i>
9	<i>Trilobosporites crassus</i>	71	<i>Dicliostephanites reticulatus</i>	132	<i>Ciclostephanidium</i> sp. A
10	<i>Dictyophyllidites impensus</i>	72	<i>Gleichenidites senonicus</i>	133	Unknown Form B
11	<i>Allepites</i> sp. A	73	<i>Kuldesporites foveolatus</i>	134	Unknown Form D
12	Tricolpate Pollen Form B	74	<i>Cyclonephellium vannophorum</i>	135	Acritarch Form A
13	<i>Vitreosporites pallidus</i>	75	<i>Cribroperidinium edwardii</i>	136	<i>Equisetoseporites</i> sp. D
14	<i>Biretisporites potonensis</i>	76	<i>Ciclostephanidium ?multipinosum</i>	137	<i>Tricolpites geranioides</i>
15	<i>Pileoseporites trichopapillosum</i>	77	<i>Subtillephaera inaeffecta</i>	138	<i>Reticulatisporites</i> sp. A
16	<i>Eucommidites minor</i>	78	<i>Neorotricidia</i> sp. A	139	<i>Gemmastriletes ?morulus</i>
17	<i>Tricolpites eragatus</i>	79	<i>Laevigatoseporites bellfordii</i>	140	<i>Reticulatisporites dupliednosus</i>
18	<i>Tricolpites minutus</i>	80	<i>Tricolpites crassimurus</i>	141	Dinoflagellate Form E
19	<i>Corollina torosus</i>	81	<i>Ciclastomocystis</i> sp. A	142	<i>Cicatricoseporites</i> sp. A
20	<i>Allepites bilateralis</i>	82	Dinoflagellate Form A	143	<i>Cibicidespora juncea</i>
21	<i>Podocarpidites</i> sp. B	83	<i>Oligosphaeridium tenuiprocessum</i>	144	<i>Asteropollis asteroides</i>
22	<i>Concavosporites lemontis</i>	84	<i>Tricolpites virgeus</i>	145	<i>Appendicoseporites dentimarginatus</i>
23	<i>Cyathidites minor</i>	85	Trilete Spore Form B	146	<i>Aecostomocystis gigantis</i>
24	<i>Deltoidospora hallii</i>	86	<i>Cingulitrites</i> sp. B	147	<i>Florentinia cooksoniae</i>
25	<i>Laevigatoseporites ovatus</i>	87	<i>Crybelosporites brenneri</i>	148	<i>Tricolpites anguloluminosus</i>
26	<i>Trichodinium castaneum</i>	88	<i>Microfoveolatosporis pseudoreticulatus</i>	149	<i>Reticulatisporites</i> sp. A
27	<i>Lalofusa</i> sp. A	89	<i>Palambages</i> sp. A	150	<i>Leptolepidites major</i>
28	<i>Palambages canadensis</i>	90	<i>Aequitriletes ornatus</i>	151	<i>Thalassipora microcysta</i>
29	<i>Gleichenidites circinidites</i>	91	Dinoflagellate Form B	152	<i>Caligodinium aceras</i>
30	<i>Corollina meyeriana</i>	92	<i>Prietrusapollenites elongatus</i>	153	<i>Canningia</i> sp. A
31	<i>Virgo amiantopollis</i>	93	<i>Parvisaccites rugulatus</i>	154	<i>Concavosporites variverrucatus</i>
32	<i>Appendicoseporites insignis</i>	94	<i>Triporoletes involuatus</i>	155	<i>Osmundacidites weilmanii</i>
33	<i>Appendicoseporites</i> sp. A	95	<i>Fromea ?fragilis</i>	156	<i>Depelidinium marinum</i>
34	<i>Cicatricoseporites hallii</i>	96	<i>Bellodinium jaegeri</i>	157	<i>Parosodina</i> sp. A
35	<i>Undulatisporites undulapokus</i>	97	<i>Appendicoseporites potomacensis</i>	158	<i>Microhystridium</i> sp. A
36	<i>Luxodinium propatum</i>	98	<i>Monocolpate Pollen Form B</i>	159	<i>Monocolpopollenites</i> sp. A
37	<i>Ovoidinium verrucosum</i>	99	<i>Kuldesporites pseudoreticulatus</i>	160	<i>Bouriddinium granulatum</i>
38	<i>Cyclonephellium</i> sp. A	100	<i>Foveotricolpites robustus</i>	161	<i>Pterodinium cingulatum</i>
39	<i>Pseudocerasium polymorphum</i>	101	<i>Bellisphaeridium whitei</i>	162	<i>Polycingulatisporites radiatus</i>
40	<i>Aptodinium maculatum</i>	102	<i>Ullacidites divivus</i>	163	<i>Subtillephaera</i> sp. B
41	<i>Rugubivisculites rugosus</i>	103	<i>Cribroperidinium ?exilicristatum</i>	164	Unknown Form A
42	<i>Chlamydomorphella nyel</i>	104	Dinoflagellate Form C	165	<i>Pityosporites</i> sp. A
43	<i>Tricolporoidites minimus</i>	105	<i>?Utophaeridium</i> sp. A	166	<i>Bipatellifera ?clathrata</i>
44	<i>Inaperturopollenites dubius</i>	106	<i>Tanyosphaeridium saipinx</i>	167	<i>Labridocysta</i> sp. A
45	<i>Taxodiaceapollenites hiatus</i>	107	<i>Coronifera oceanica</i>	168	<i>Kolaneium</i> polypes
46	<i>Pinuspollenites</i> sp. A	108	<i>Camerozonosporites insignis</i>	169	<i>Todisporites minor</i>
47	<i>Hexagonifera</i> sp. A	109	<i>Stereosporites antiquasporites</i>	170	<i>Hexagonifera</i> sp. B
48	<i>Odontochitina operculata</i>	110	<i>Pileosporites</i> sp. A	171	<i>Bellisphaeridium</i> sp. A
49	<i>Subtillephaera</i> sp. A	111	<i>Balmula ?pentaradiata</i>	172	Dinoflagellate Form D
50	<i>Subtillephaera</i> sp. C	112	<i>Oligosphaeridium</i> sp. A	173	Trilete Spore Form A
51	<i>Spiniferites ramosus</i> sep. gracilis	113	<i>Podocarpidites</i> sp. A	174	<i>Tanyosphaeridium</i> sp. A
52	<i>Spiniferites ramosus</i> sep. ramosus	114	<i>Camerozonosporites</i> sp. A	175	<i>Lalofusa jurassica</i>
53	<i>Oligosphaeridium complex</i>	115	<i>Tricolpites reticulatus</i>	176	<i>Pterospermella aureolata</i>
54	<i>Oligosphaeridium putcherrimum</i>	116	<i>Odontochitina singhii</i>	177	<i>Triporoletes cenomanianus</i>
55	<i>Bellisphaeridium multipinosum</i>	117	Dinoflagellate Form F	178	<i>Podocarpidites</i> sp. C
56	<i>Microhystridium fragile</i>	118	<i>Densosporites microrugulatus</i>	179	<i>Inaperturopollenites limbatus</i>
57	<i>Microhystridium stellatum</i>	119	<i>Triporoletes radiatus</i>	180	<i>Echinatisporis varispinosus</i>
58	Trilete Spore Form G	120	<i>Endocrinium campanula</i>	181	<i>Chatangiella ?granulifera</i>
59	Unknown Form C	121	<i>Wigginsiella canadensis</i>	182	<i>Chatangiella</i> sp. A
60	<i>Densosporites velatus</i>	122	<i>Tigrisporites reticulatus</i>	183	<i>Palaehystrichophora infusorioides</i>
61	<i>Cicatricoseporites dorogensis</i>	123	<i>Nyssaepollenites nigricolpus</i>	184	<i>Veryhachium irregulare</i> forma subtriadron
62	<i>Fromea amphora</i>				

Figure 14

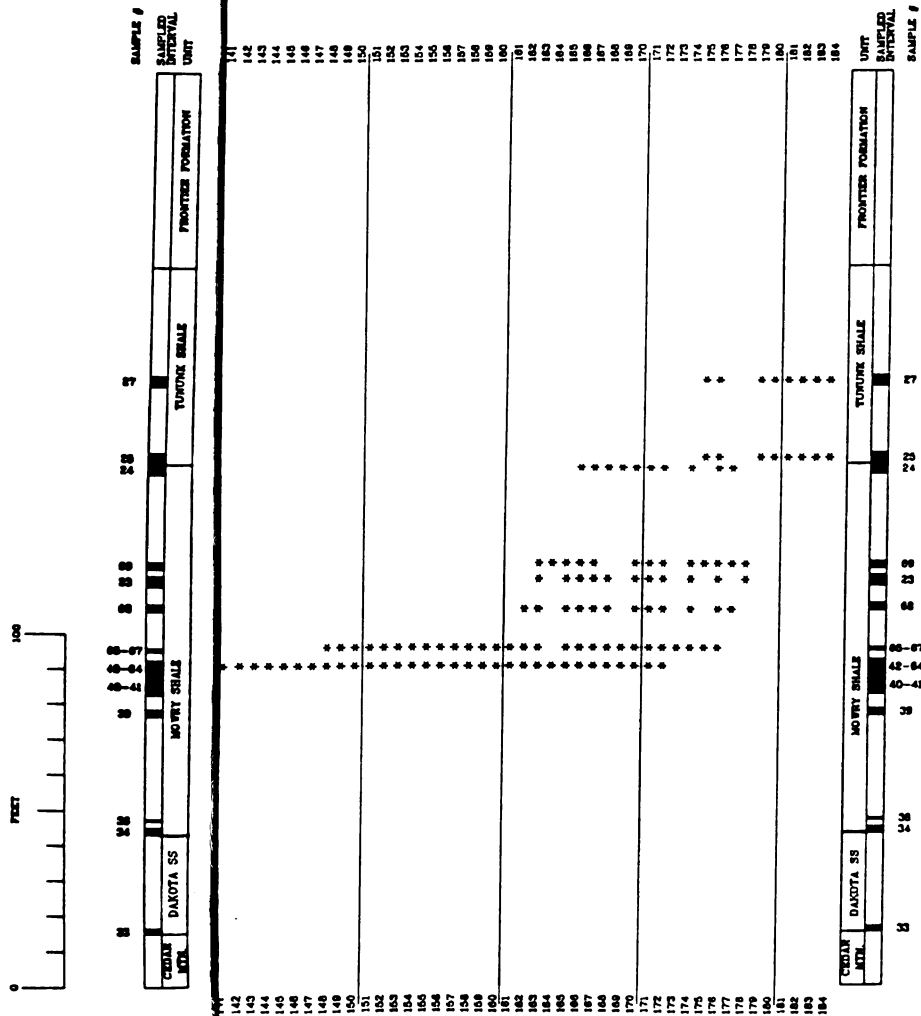


Figure 14.

Note:

Palynomorph assemblages from the two Cedar Mountain samples were quite different. Sixty-nine different forms were differentiated in the Molen assemblage and, not surprisingly, this was similar to the assemblage of Cedar Mountain described by Tschudy *et al.* (1984). Twenty-five species were identified in the Steinaker Draw sample, 16 of which were in common with the Cedar Mountain assemblage in the Molen sample. This assemblage appears to be intermediate in age between the Molen sample and assemblages recovered from samples of Burro Canyon by Tschudy *et al.* (1984). The two samples that yielded palynomorphs produced forms with fairly good preservation, but not in great quantities. The recovery was about 7,000 grains per gram of sediment from the Molen sample and 1,000 grains per gram from the Steinaker Draw sample. All palynomorphs identified from the Cedar Mountain samples are pollen or spores of vascular land plants, except Fungal Form A and *Schizosporis*, a freshwater alga. Tschudy *et al.* (1984) did not mention finding any palynomorphs, such as dinoflagellates or acritarchs, that would indicate marine conditions.

Of the 77 different forms differentiated in the Cedar Mountain samples, 18 are confined to this unit; 11 are found in both the Cedar Mountain and Mowry Shale only; four are found in the Cedar Mountain and Dakota Sandstone only; five are found in the Cedar Mountain, Mowry and Dakota; 39 range into the Tununk Shale or higher; and 14 range into the Blue Gate Shale.

Mowry Shale

Twenty-seven productive samples were studied from the Mowry Shale collected only at the Steinaker Draw section. The lithology of the samples from the Mowry was predominantly bentonitic shale. However, at a finer scale, this was seen to be made up of alternating intervals of soft gray fissile shale, hard black non-fissile shale, and bentonitic

shale. Palynomorphs were recovered from both types of shale, but not from any of the bentonites processed.

Preservation of the palynomorphs from the Mowry Shale ranged from good to excellent. The best preservation was found in the hard black non-fissile shale. The quality of preservation diminished with increasing bentonitic content of the shale. Productivity of the samples was very high, generally ranging from 85,000 to 300,000 grains per gram of sediment, but one sample contained over 2 million grains per gram.

Of the 172 palynomorph forms found in the Mowry, 44, mostly dinoflagellates or acritarchs, were found only in the Mowry; 14 were common to the Mowry and Dakota only, all pollen or spores; 22 were found in Mowry, Dakota and Tununk only; 71 ranged from the Mowry into the Tununk or higher; and 20 ranged through the Ferron into the Blue Gate.

Dakota Sandstone

Samples were collected from four sections of the Dakota Sandstone: Horsethief Canyon Ranch, Ivie Creek, Dry Wash, and Molen. Eighteen samples from the Horsethief Canyon Ranch section of western Colorado were collected at short intervals (1 to 10 cm) through the coal-bearing section to study floristic changes through time. Most samples from the Horsethief Canyon Ranch section were coal, but several coaly, silty, or bentonitic shales were also included. The remaining five samples, which came from the Ivie Creek, Dry Wash and Molen sections located in the Castle Valley area of east-central Utah, included one coal and four carbonaceous shales.

Palynomorph recovery from the Dakota Sandstone was quite variable. Preservation ranged from poor to good. No definite correlation to lithology was apparent, but in many cases, the plant fossils from coals tended to be less well-preserved than from the shales.

Productivity also varied greatly. One bentonitic shale produced only about 230 grains per gram of sediment; whereas, some coal samples contained as many as 100,000 to 750,000 grains per gram.

Of the 76 forms differentiated from the Dakota samples, 26 pollen and spore species were confined to the Dakota. Fifteen pollen and spore species, whose range begins in the Dakota here, were found sporadically in the Tununk, and in the Ferron above. Only two ranged upward into the Blue Gate.

Tununk Shale

Sixty-six samples were studied for palynomorphs from five stratigraphic sections of the Tununk Shale Member of the Mancos Shale. The Tununk Shale is predominantly a medium gray, silty shale or mudstone and most samples are of this lithology. However, a few dark gray shales and siltstones were also sampled and studied. Palynomorphs were not recovered from the two limestone samples collected from the Tununk.

The condition of preservation of palynomorphs recovered from the Tununk generally ranged from poor to fair. However, a few samples contained well-preserved dinoflagellates, pollen and spores. The most common form of degradation in the Tununk Shale is penetration of palynomorph walls by crystals of authigenic pyrite, resulting in exines defaced and distorted by a few, to many, polygonal holes. Palynomorph abundance is low but fairly consistent in Tununk samples. Values range up to 28,000 grains per gram of sediment, but average about 3,000 grains per gram.

Of the 95 forms differentiated from the Tununk samples, only six were restricted to the Tununk. Of these, four were confined to the lower Tununk and two to the upper Tununk. The termination of stratigraphic range of 17 is in the lower Tununk, and the first

appearance of nine is in the upper Tununk. Two forms were found only in the Tununk Shale and Ferron Sandstone; and 30 range upwards from the Tununk into the Blue Gate.

Ferron Sandstone

Fifty samples were studied from four stratigraphic sections and two sets of cores of the Ferron Sandstone. Four samples are represented by coal or terrestrial carbonaceous shale, and one by a marine, silty shale from the Ivie Creek section. The samples of Ferron Sandstone from the Molen, Farnham Dome and Horsethief Canyon Ranch sections are all marine in nature. Samples from the Quichupah and Castle Valley cores are all from terrestrial strata and include 21 coals and 13 shales or coaly shales. Samples collected and macerated from the Frontier Sandstone at the Steinaker Draw section were all barren of palynomorphs.

Preservation of palynomorphs studied in the Ferron samples ranges from poor to good. Most of the marine samples tended to have the same types of corrosion seen in the Tununk Shale. Also, as in the Dakota Sandstone samples, preservation was typically better in the shales than in the coals. As with the Tununk, sample productivity tended to be fairly low in the marine samples with one exception, that being the single marine sample from Ivie Creek which contained about 45,000 grains per gram of sediment.

Of the 101 forms differentiated from the Ferron, seven were found only in Ferron samples. The last occurrence within the samples examined for this study of 50 palynomorphs, is in the Ferron; and 44 continue upwards into the Blue Gate Member of the Mancos Shale.

Blue Gate Shale

One sample from the Blue Gate Shale from the Ivie Creek section and one from the Farnham Dome section were studied. Both were medium gray silty shales very similar in

nature to most of the Tununk samples. Palynomorph preservation and recovery was fair, as in most of the Tununk Shale samples, with about 8,000 grains per gram of sediment. Most grains showed slight corrosion and damage due to pyrite crystal growth. Only 44 forms were found in the Blue Gate Shale member, and none were confined to this unit.

CORRELATION

Correlation of units above the Dakota Sandstone was attempted using the graphic correlation method introduced by Shaw (1964), as modified by Edwards (1984, 1989). Explained briefly, the stratigraphically lowest and highest occurrences of taxa (local range base and top) are plotted on a graph where the abscissa is the stratigraphic thickness in feet of one measured section and the ordinate is that of a second measured section. A species whose range base is at 150 feet in the first section, and at 300 feet in the second section would be plotted as a point at the coordinates (150,300). After a number of species range bases and tops are plotted in a similar manner, and being fairly confident that the observed bases and tops are approximately equivalent to their true bases and tops, a "line of correlation" can be fitted to these points. Then, any level of one section can be approximately correlated with its assumed time-correlative level in the other section.

An attempt was made to correlate the five stratigraphic sections using this technique. The following correlations were made: Ivie Creek with Molen, Molen with Farnham Dome, Horsethief Canyon Ranch with Ivie Creek, Horsethief Canyon Ranch with Farnham Dome, Steinaker Draw with Farnham Dome and Steinaker Draw with Horsethief Canyon Ranch. Of these, only two produced reasonably good correlation coefficients: Ivie Creek with Molen ($r^2 = 0.81$) and Molen with Farnham Dome ($r^2 = 0.85$). The coefficients from the correlations involving Horsethief Canyon Ranch and other sections and Steinaker

Draw and other sections were all less than 0.25. The reason for this low degree of correlation may be due to the short stratigraphic thickness of the Horsethief Canyon Ranch and Steinaker Draw sections. Short stratigraphic thickness of a section reduces the degree of confidence in assessing true range bases and tops. However, the lack of correlation may have a paleoecological basis and indicate completely different source areas (provenance) for the sediments, including the palynomorphs. The lack of correlation may also indicate that previously assumed stratigraphic correlations are in error. The results of the plots with good correlation coefficients are shown in Figures 15a and 15b.

The following 27 species were used to construct the lines of correlation between the three sections that yielded good correlations (dinoflagellates indicated by an asterisk):

<u>FORM</u>	<u>BASE</u>	<u>TOP</u>
<i>Alterbidinium</i> sp. A *	X	
<i>Appendicisporites</i> sp. F	X	
<i>Apteodinium maculatum</i> *		X
<i>Baltisphaeridium whitei</i> *		X
<i>Chatangiella granulifera</i> *	X	
<i>Cingulriletes congruens</i>	X	
<i>Coronifera oceanica</i> *		X
<i>Cribroperidinium edwardsii</i> *		X
<i>Cribroperidinium ?exilicristatum</i> *		X
<i>Cyclonephelium</i> sp. B *	X	X
<i>Equisetosporites ambiguus</i>	X	
<i>Foveotricolpites robustus</i>		X
<i>Foveotricolporites callosus</i>	X	
<i>Fromea amphora</i> *		X
<i>Inaperturopollenites limbatus</i>		X
<i>Kiokansium polypes</i> *		X
<i>Leberidocysta</i> sp. A *		X
<i>Liliacidites</i> sp. A	X	
<i>Ovoidinium verrucosum</i> *		X
<i>Phimopollenites pannosus</i>	X	
<i>Tanyosphaeridium salpinx</i> *		X
Tricolpate Pollen Form D	X	
Trilete Spore Form L	X	
Trilete Spore Form N	X	
<i>Triporoletes cenomanianus</i>		X

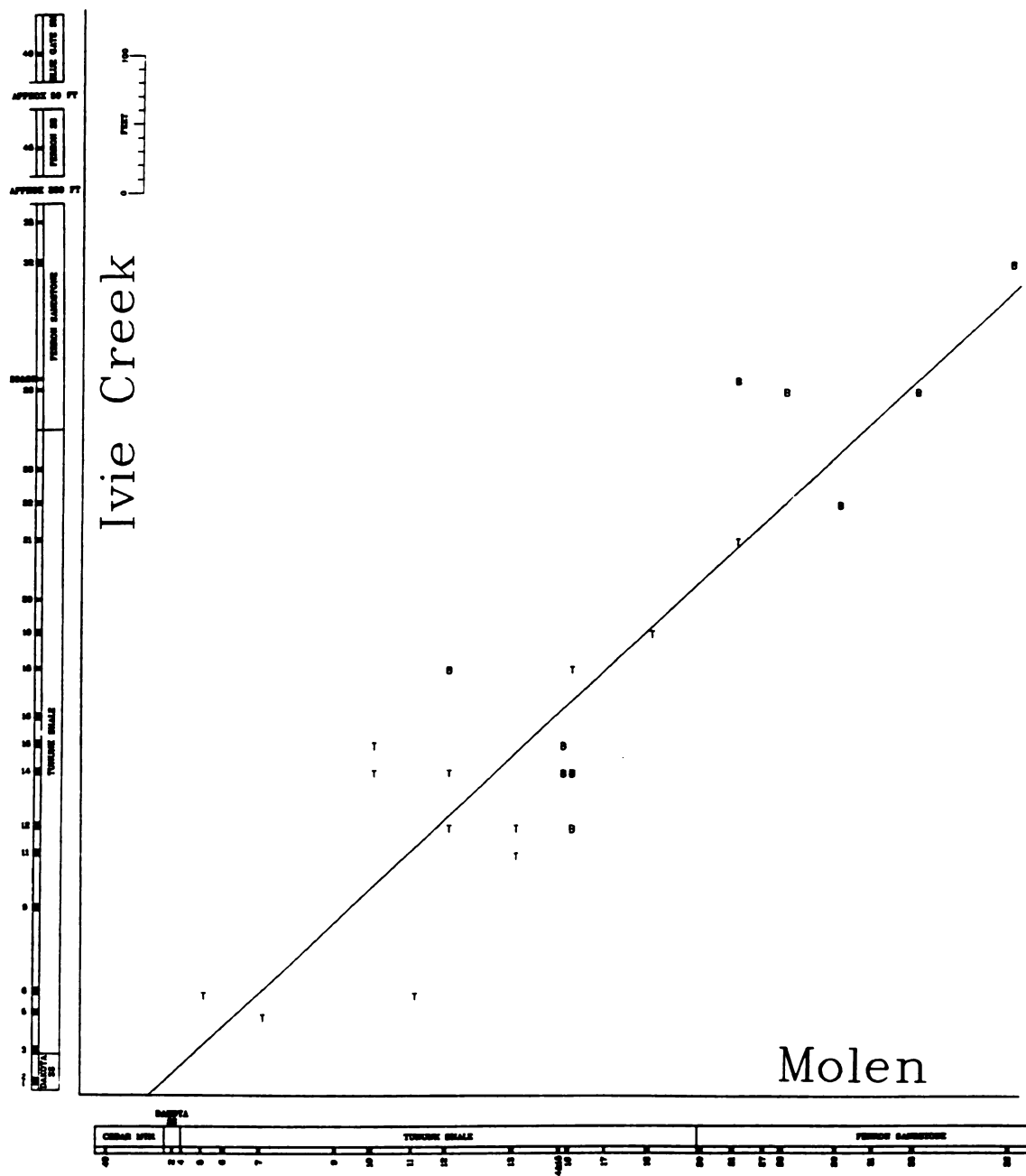


Figure 15a. Graphic model for the correlation of the Ivie Creek and Molen sections.

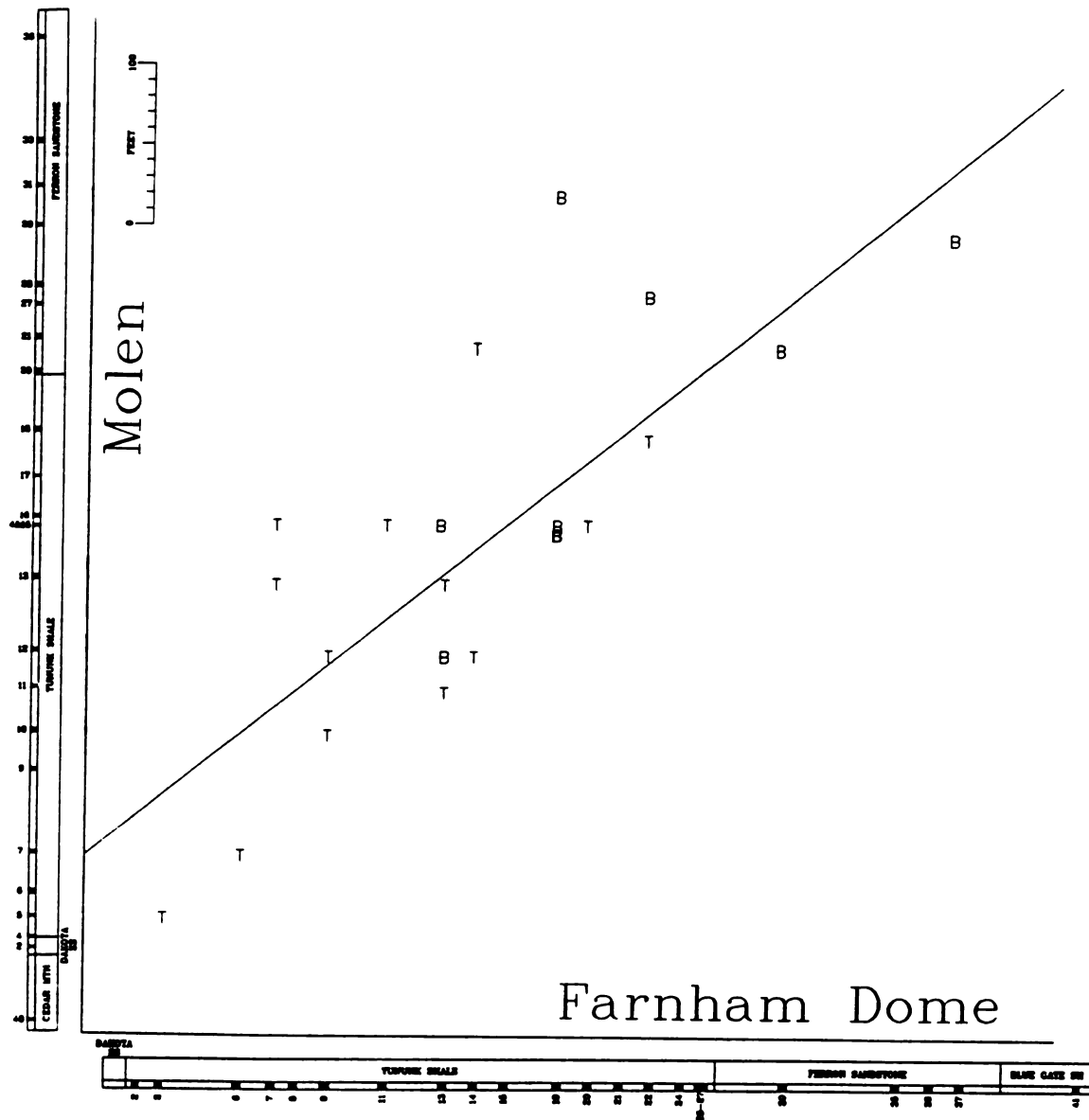


Figure 15b. Graphic model for the correlation of the Molen and Farnham Dome sections.

Figures 16 and 17 represent the final interpretation of the correlations. Solid correlation lines between Ivie Creek and Molen and between Molen and Farnham Dome are based on the results of the graphic correlations. Dashed lines between the other sections indicate less confidence, and are based on stratigraphic ranges of one to several of the above species.

On the basis of these correlations, several observations can be noted. First, the lower middle Ferron at Farnham Dome and lower Ferron at Molen correlate in part with the uppermost Tununk at Ivie Creek. Second, the Tununk can be divided into a lower and upper Tununk at Farnham Dome and Molen near the "Molen" bed. This also correlates closely with the first appearance of *Chatangiella granulifera*, *Alterbidinium* sp. A and Tricolpate Pollen Form D. Based on the ranges of these forms, the approximate boundary between the upper and lower Tununk can be identified in the Ivie Creek and Horsethief Canyon Ranch sections. Third, the Tununk at Steinaker Draw is entirely upper Tununk, and is separated from the underlying Mowry by an unconformity equivalent in age to part of the Dakota and all of the lower Tununk deposited in western Colorado and east-central Utah.

GEOLOGIC AGE

Cedar Mountain Formation

The Cedar Mountain Formation is clearly of Lower Cretaceous age, and the horizons sampled in this study probably range from middle late to latest Albian. This assignment is based primarily on the occurrence of angiosperm pollen. Angiosperm pollen first appear in mid-Cretaceous (Aptian to Cenomanian) rocks world-wide (Drinnan *et al.*,

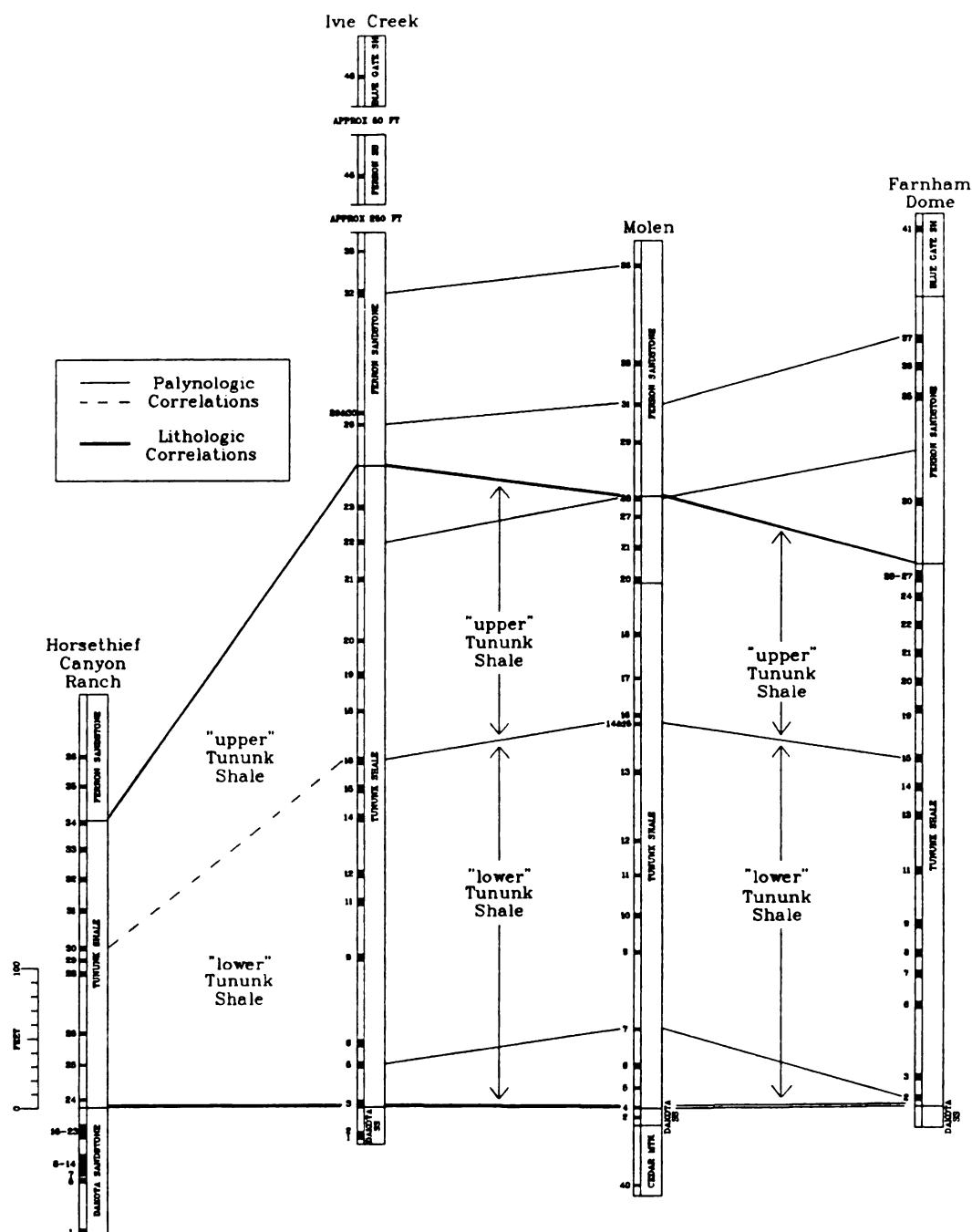


Figure 16. Correlation of the Ivie Creek, Molen and Farnham Dome sections.

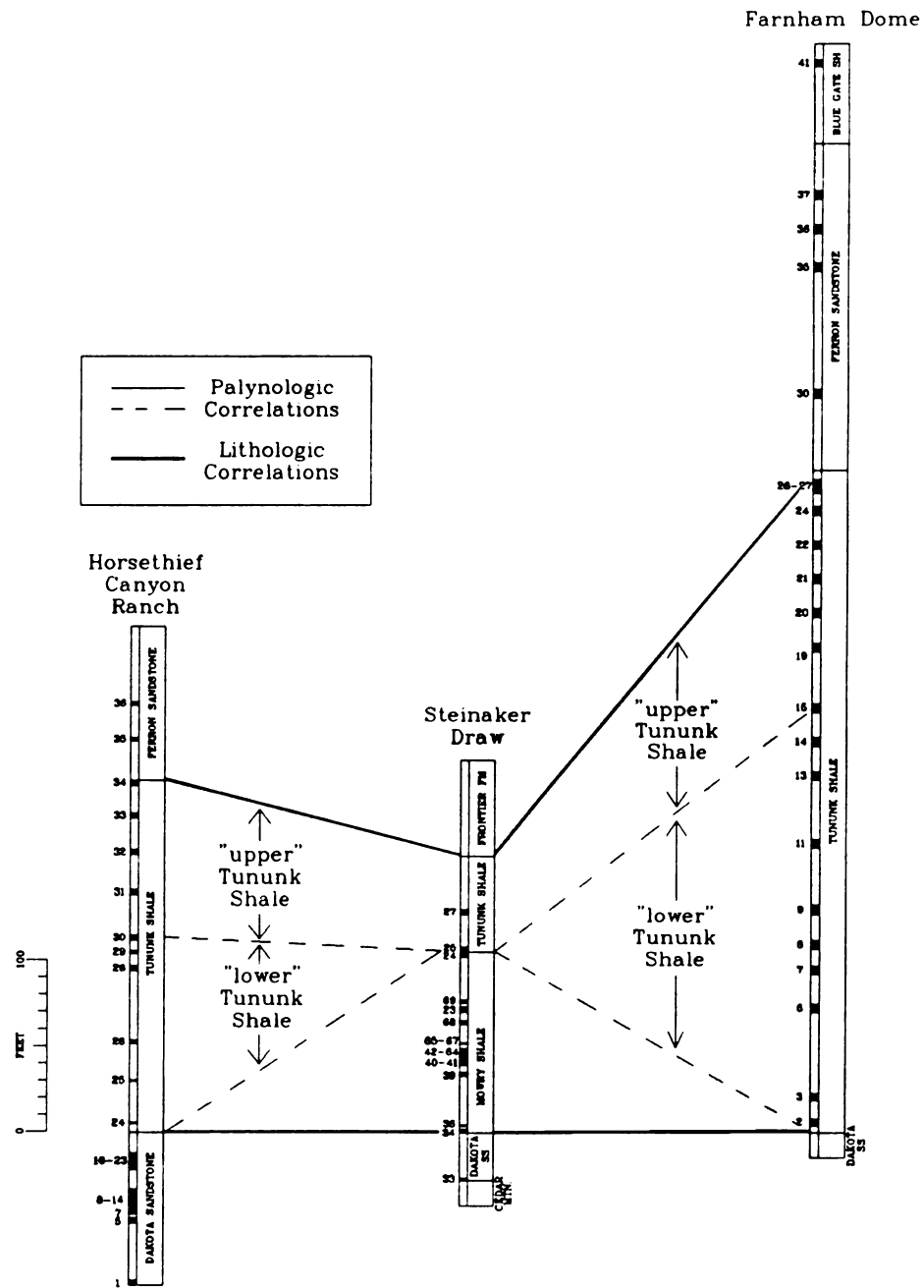


Figure 17. Correlation of the Farnham Dome, Horsethief Canyon Ranch and Steinaker Draw sections.

1991). In North America, tricolpate pollen first appear in the Albian. North American documentation of this is provided by Singh (1971), Brenner (1963), Panella (1966), Norris (1967), Hedlund and Norris (1968), Srivastava (1975b), Tschudy *et al.* (1984) and Ward (1986). Tricolporate pollen, however, are first found in rocks of latest Albian or earliest Cenomanian age in western North America. The genus *Nyssapollenites* first occurs at or near the Albian/Cenomanian boundary, but has been identified twice from the latest Albian (Singh, 1971; Panella, 1966). Tschudy *et al.* (1984) consider the first occurrence of *Nyssapollenites* to be a fairly reliable indicator of the boundary between the Early and Late Cretaceous.

The sample of black to gray bentonitic shale of the Cedar Mountain Formation taken at the Molen section contains 12 species referable to angiosperms, seven of which are tricolpate forms. No tricolporate pollen were identified in that sample. *Penetetrapites mollis*, a distinct pollen form with four or five pores, is found in the Molen sample, and has been recognized only from late Albian sediments of North America (Phillips and Felix, 1971b; Srivastava, 1975b; Ward, 1986). It also contains two species of *Dichastopollenites*, *D. reticulatus* and *D. sp. A.* *D. reticulatus* described by May (1975) from the Dakota of southern Utah as a possible guide palynomorph for the Cenomanian. Since the Cedar Mountain Formation is clearly latest Albian, the stratigraphic range for *Dichastopollenites reticulatus* is here extended downward to include this earlier age, i.e., latest Albian. Two other previously described species, *Crybelosporites pannuceus* and *Heliosporites kemensis*, are confined to the Cedar Mountain at Molen. *Crybelosporites pannuceus* has been identified from Albian deposits of Maryland (Brenner, 1963) and Oklahoma (Hedlund and Norris, 1968). *Heliosporites kemensis* has been recognized from the earliest Cretaceous of England (Norris, 1969), the Albian-Cenomanian of the U.S.S.R. (Chlonova, 1969) and the

Maestrichtian of Alberta (Srivastava, 1972). Ten undescribed forms assignable to five spore genera, one gymnosperm genus, one angiosperm genus and three unidentified forms have been found only in this sample from the Molen section. *Exesipollenites tumulus*, which is common in Jurassic and Lower Cretaceous sediments worldwide, is found only in the two samples from the Cedar Mountain. The Cedar Mountain Formation at the Molen section is here assigned to an age of late late Albian. This agrees with Tschudy *et al.* (1984), who assigned an age of late or latest Albian to a single sample collected from approximately the same horizon, but nine miles to the northeast.

The sample of Cedar Mountain from the Steinaker Draw section contains only three species of angiospermous pollen, all of which are tricolpate, and which also occur in the Molen sample. Only three spore species, *Appendicisporites* sp. C, Trilete Spore Form Q and *Undulatisporites* sp. A, occur only in the Cedar Mountain Formation of Steinaker Draw. No species occur in this sample that would indicate a precise age, but the absence of tricolporate angiosperm pollen, the general paucity of other angiospermous pollen and the occurrence of *Exesipollenites tumulus* definitely indicate an Early Cretaceous age. These occurrences also indicate that the Cedar Mountain at Steinaker Draw is older than that at Molen which contains a fairly diverse angiosperm assemblage, and perhaps could be late middle or early late Albian. Tschudy *et al.* (1984) assign an age of late Barremian to early Albian to palynomorph assemblages found in the Burro Canyon Formation of western Colorado which contain no angiosperm pollen. If it is true that the Cedar Mountain and Burro Canyon formations are physically continuous, at least in part, as Tschudy *et al.* (1984) and others have suggested, then the Cedar Mountain at Steinaker Draw may represent an intermediate, and as yet unstudied interval of these units.

Mowry Shale

The Mowry Shale at Steinaker Draw is early Cenomanian in age. This assignment is based primarily on dinoflagellate ranges. The Mowry contains well-preserved and very diverse microplankton assemblages. Results of this study indicate that it compares very favorably with the lower Cenomanian Upper Shaftsbury Formation of the Peace River area of Alberta (Singh, 1983).

Though no comprehensive study relating to complete palynomorph assemblages from the Mowry Shale has been published, there are four references that do address the palynology of the Mowry Shale. Tschudy and Veach (1965) produced a U.S. Geological Survey Open-File Report illustrating pollen, spores and microplankton from the Mowry and Thermopolis shales from Montana, but did not discuss an age assignment. Sulkoske's unpublished master's thesis (1975) on the microplankton of the Albian through Campanian interval from two sections in southern and western Wyoming demonstrates an Albian age for the Mowry Shale based on the occurrence of *Chichaouadinium vestitum* (described as *Spinidinium vestitum*) and *Ovoidinium verrucosum* (described as *Ovoidinium ostium*). Nichols and Jacobson (1982a) constructed a palynostratigraphic zonation for the Cretaceous of the Rocky Mountain overthrust belt of southwestern Wyoming north of the Uinta Mountains, which included the Aspen Shale, a Mowry equivalent north of the Uinta Mountains. They assigned an age of late Albian to this unit, and used three selected species as indicators of this interval: *Chichaouadinium vestitum* (described as *Spinidinium vestitum*), *Januasporites spiniferus* and *Appendicisporites unicus*. A study of the fossil Ceratiaceae from the mid-Cretaceous of the Western Interior (Bint, 1986) included samples of the Mowry Shale from South Dakota, which he considered to be late late Albian based on radiometric data presented by Kauffman (1977).

The early Cenomanian age assigned here to the Mowry Shale of Steinaker Draw is based on the occurrence of the dinoflagellates, *Ascostomocystis giganteus*, *Balmula pentaradiata*, *Thalassiphora microcysta*, and *Wigginsella canadense* of which the ranges are restricted to the early Cenomanian. There are a number of other species that occur in the Mowry Shale at Steinaker Draw whose first appearance is considered by Singh (1983) to be early Cenomanian or later. These include the dinoflagellates, *Caligodinium aceras*, *Dapsilidinium marinum*, *Spiniferites ramosus* ssp. *gracilis*, and *Spiniferites ramosus* ssp. *ramosus*; the spores, *Appendicisporites insignis*, *Cicatricosisporites crassiterminatus*, and *Microfoveolatosporis pseudoreticulatus*; and the pollen, *Foveotricolpites robustus*, *Nyssapollenites nigricolpus*, and *Tricolporoidites minimus*.

Several species which Nichols and Jacobson (1982b) indicated to be characteristic of the Albian were also found in samples of Mowry Shale at Steinaker Draw. These include: *Batioladinium jaegeri*, *Cleistosphaeridium multispinosum*, *Luxadinium propatulum*, and *Pseudoceratium polymorphum* (*Aptea polymorpha*). However, other specialists have identified each of these in rocks younger than Albian. Cookson and Hughes (1964) indicated that the range of *Batioladinium jaegeri* extended into the early Cenomanian, and Lentin and Williams (1989) assigned an early Cenomanian age as the top of the range for *Cleistosphaeridium multispinosum*. Singh (1983) has reported *Luxadinium propatulum* from the early Cenomanian Upper Shaftsbury Formation of Alberta. The upper limit of the stratigraphic range for two other species of dinoflagellates tentatively identified from Steinaker Draw, *Pseudoceratium polymorphum* and *Hystriodinium oligacanthum*, is Albian. Either these forms have been misidentified here, or these occurrences represent an extension of their stratigraphic ranges. Another range discrepancy lies with the dinoflagellate identified as *Subtilisphaera* sp. C in this study. Here it is believed to be

conspecific with *Alterbidinium* sp. A of Nichols and Jacobson (1982b), the base of the range of which is middle Cenomanian. Again, this may be a misidentification, or an extension of its previously known range.

The palynomorphs, *Chichaouadinium vestitum* (*Spinidinium vestitum*), *Januasporites spiniferus* and *Appendicisporites unicus*, considered by Nichols and Jacobson (1982b) as noted above, as indicator species for the latest Albian, were not found in samples of Mowry Shale at Steinaker Draw. Also missing from the Steinaker Draw palynoflora are three key fossils for dating the late Albian Cedar Mountain Formation: *Penetetrapites mollis*, *Exesipollenites tumulus* and *Crybelosporites pannuceus*. Although, the Mowry Shale has a diverse terrestrial flora, these species may be absent due to paleoecological factors. *Palaeohystrichophora infusorioides*, an indicator species for the middle Cenomanian through Santonian, was not found in the Mowry Shale. This may be a negative evidence for the age being no older than early Cenomanian.

The early Cenomanian age here assigned to the Mowry Shale is in agreement with Molenaar and Wilson (1990) who collected the ammonite, *Neogastrolites americanus*, from the middle of the Mowry at Steinaker Draw. This ammonite is now considered to be early Cenomanian by Cobban and Kennedy (1989). A possible explanation for the late Albian age for the Mowry northward is that the base of the Mowry may be time transgressive from south to north. The "lethal isostrate", or laminated mudstone, facies described by Byers and Larson (1979), which is the black, organic, and palynomorph-rich facies present at Steinaker Draw, may be time equivalent to a possibly palynomorph poor "vital isostrate" or "vital heterostrate", or bioturbated mudstones and sandstones that are higher in the Mowry Shale to the north.

Dakota Sandstone

The Dakota Sandstone is of Cenomanian age in the study area, and is probably middle to late Cenomanian. It contains species of *Nyssapollenites* and *Tricolporoidites*, tricolporate forms that do not appear in North America until after the end of the Albian. Therefore, the Dakota strata are probably not older than Cenomanian. The angiosperm pollen, *Artiopollis indivisus*, *Foveotricolpites robustus*, *Nyssapollenites nigricolpus*, and *Stephanocolpites tectorius*, and the spores, *Triporoletes involucratus*, *Microreticulatisporites sacalii*, and *Petalosporites quadrangulus*, all occur in the Dakota, and have stratigraphic distributions which range through the Cenomanian. The middle Cenomanian age is suggested by the previously known stratigraphic ranges of the following five species: *Appendicisporites insignis* ranges early to middle Cenomanian; *Crybelosporites brenneri* middle Albian to middle Cenomanian; *Virgo amiantopollis* middle Albian to early Cenomanian; *Appendicisporites auritus* middle Cenomanian to Turonian; and *Bacutritetes greenlandicus* ranges from middle Cenomanian to Coniacian.

The palynomorph assemblages from the two areas where the Dakota Sandstone was studied (western Colorado at Horsethief Canyon Ranch, and east-central Utah at Ivie Creek, Molen, and Dry Wash) are very similar, and no age distinction could be made between them. Because the total assemblage diversity was somewhat lower for the samples in central Utah, less certainty is placed on the age of the Dakota in that area.

The Cenomanian or middle Cenomanian age assigned here to the Dakota Sandstone is consistent with the views of Agasie (1969), and May and Traverse (1973) who studied the palynology of the Dakota Sandstone in southern Utah and northern Arizona. It also compares well with the Cenomanian age assigned to the Red Branch Member of the Woodbine Formation (Hedlund, 1966, 1967), which has many species in common with the

Dakota Sandstone in the area of this study. Eaton, Kirkland and Kauffman (1990) collected invertebrate fossils from the Dakota Sandstone in Castle Valley near the Dry Wash section. This fauna was interpreted as late Cenomanian in age. On the basis of the palynology, it is reasonable to assign the Dakota Sandstone an age of middle Cenomanian at Horsethief Canyon Ranch to the east while assigning an age of late Cenomanian in central Utah, because the time-transgressive nature of the Dakota is clearly shown in the fact that to the north, at Steinaker Draw, the Dakota Sandstone underlies the Mowry Shale, and is probably older than early Cenomanian, if not much older.

Tununk Shale

The age of the Tununk Shale, based on palynomorphs, appears to range from middle or late Cenomanian to middle or late Turonian. The difficulty in determining the age of the Tununk is due to the very few age-diagnostic dinoflagellates that occur in this unit. The age for the base of the Tununk is restricted to middle or late Cenomanian by its stratigraphic position above the middle to late Cenomanian Dakota Sandstone. In addition, the presence of the dinoflagellate, *Palaeohystrichophora infusorioides*, from the base of the Tununk, indicates that this unit is no older than early Turonian (Nichols and Jacobson, 1982b). However, several species of dinoflagellates that occur in the lower Tununk, indicate a Cenomanian age. Four such species are *Apteodinium maculatum*, *Kiokansium polypes*, *Fromea fragilis*, and *Tanyosphaeridium salpinx*. The age of the upper Tununk appears to be middle Turonian, based on the occurrence of *Cribroperidinium edwardsii* and *Ovoidinium verrucosum*. These are considered to be typical of middle Turonian by Nichols and Jacobson (1982b). Both of these dinoflagellates have their local stratigraphic tops in the upper Tununk, as they do not occur in the marine intervals of the Ferron above or in the Blue Gate Shale in the two samples studied from Ivie Creek and Farnham Dome.

Therefore, the age of the lowermost part of the Tununk Shale here is considered to be late Cenomanian, and the upper part is early to middle Turonian. This agrees fairly well with a latest Cenomanian to early Turonian age assigned by Eaton *et al.* (1990) to the base of the Tununk near the Molen section, and late middle Turonian age assigned by Cobban (1976) to the uppermost Tununk at the Farnham Dome section. Both age assignments are based on ammonite occurrences. The Tununk Shale at Steinaker Draw, which correlates to the upper part of the Tununk at Farnham dome based on the occurrence of *Chatangiella granulifera*, has been assigned an age of late middle Turonian by Molenaar and Wilson (1990).

Ferron Sandstone

The age of the Ferron Sandstone is based primarily on stratigraphic position and it appears to be of different ages in the several areas under study. It overlies the middle Turonian age upper Tununk Shale Member and is overlain by the late Turonian Blue Gate Shale Member of the Mancos Shale. Nichols and Jacobson's palynologic zonation of the Rocky Mountain Cretaceous (1982b) indicated that the terrestrial Turonian section is probably the least recognizable. Only one form, *Tricolpites* sp. A, was used as an indicator for that part of the section, and it was not recognized in the Ferron of central Utah in this study. Ammonite records by Cobban (1976) indicate that the Ferron is of upper middle to middle upper Turonian age.

Blue Gate Shale

Based on the palynomorphs in the two samples of the Blue Gate Shale studied, no definite age determination could be made. Microplankton present in the sample of Blue Gate are generally long-ranging species, and terrestrial palynomorphs found are also not age diagnostic. However, the occurrence of *Palaeohystrichophora infusorioides* indicates

the lower boundary of the Blue Gate to be about middle Cenomanian. If *Subtilisphaera* sp. C of this study is the same as *Alterbia* sp. A of Nichols and Jacobson (1982b), then the upper limit would be late Turonian. This age assignment, however loose, is in agreement with a late Turonian age assigned by Cobban (1976). He reported the ammonites, *Scaphites whitfieldi* and *Prionocyclus wyomingensis elegans*, from beds just above the Ferron Sandstone at Farnham Dome, and a species of *Scaphites* intermediate between *Scaphites whitfieldi* and *Scaphites warreni* from beds a few feet above the Ferron Sandstone near the town of Ferron, which is within 10 miles of the Molen section.

PALEOECOLOGY

Cedar Mountain Formation

Based on two productive samples, fossil pollen and spore assemblages indicate that the sediments of the Cedar Mountain Formation were deposited in a terrestrial environment, and the surrounding vegetation consisted of a mixed community of gymnosperms, ferns and angiosperms. The relative percentages of abundance of each of these groups are plotted on a ternary diagram in Figure 18.

The Cedar Mountain at Molen plots nearly at the center of the diagram indicating a nearly equal palynomorph contribution of each of these groups to the accumulating sediment. However, the diversity of the plants representing these groups is not equal, with 46 species of spores and 12 each of angiosperms and gymnosperms. Because most spore species have very low frequencies, they constitute only about 28 percent of the grains counted, yet they make up nearly half of the species represented. This may indicate that the plant community was richer in fern species than in gymnosperms and angiosperms, but that the site of deposition was at greater distance from the area of where ferns were growing, or that the higher plants were dominant in number in the flora. Climatic or habitat conditions may not have favored dense stands of ferns. Plants such as the

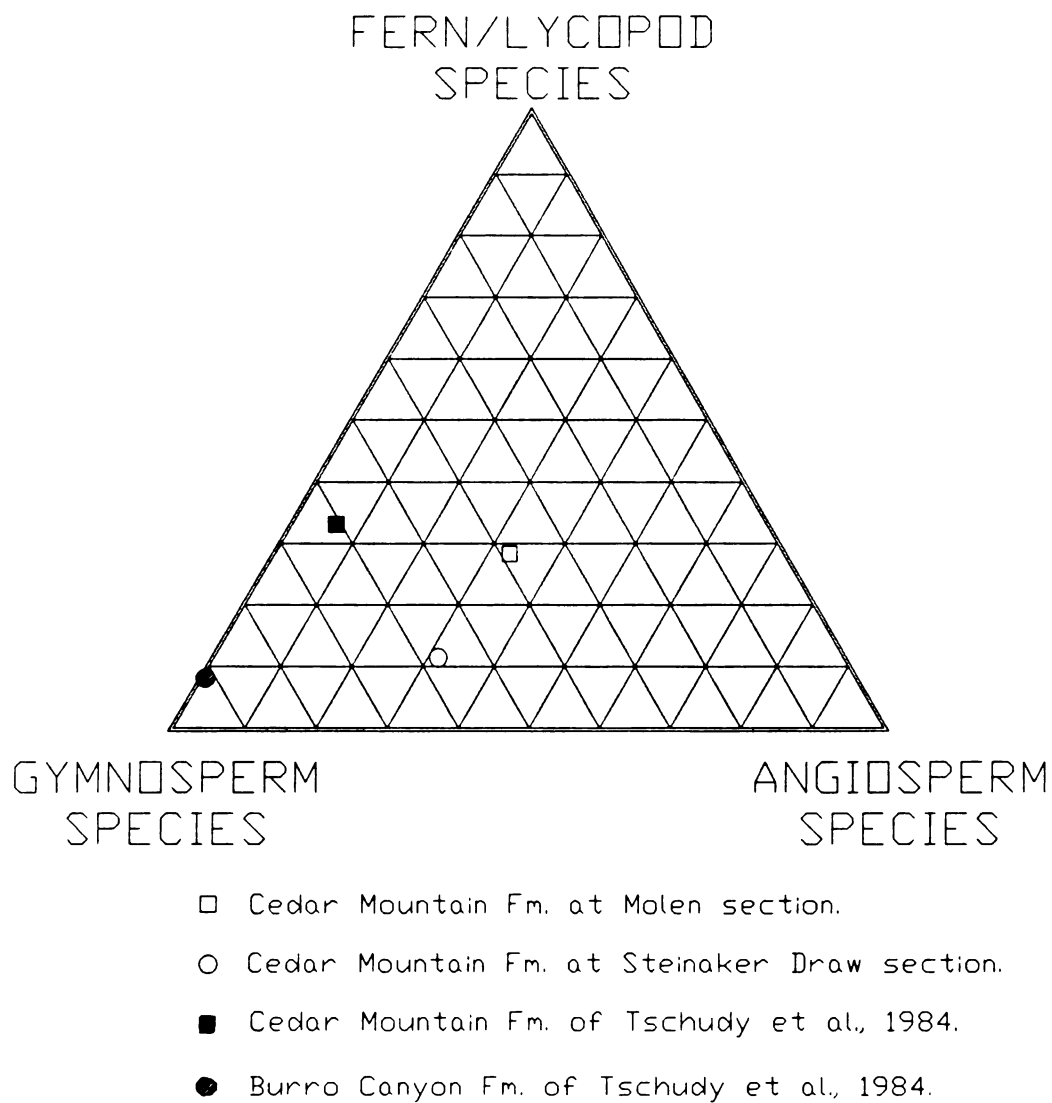


Figure 18. Ternary diagram showing palynofloral composition of the Cedar Mountain Formation in percent of species abundance for four samples including two samples from Tschudy et al. (1984).

gymnosperms, and probably many of the angiosperms, may contribute greater amounts of pollen to the sediments because of their proximity to the depositional site or to a main distributary mouth, or they may simply produce much larger numbers of pollen per plant than the spores of the fern plants. The dominant species recognized in the Cedar Mountain at Molen were: *Tricolpites minutus*, *Dichastopollenites reticulatus*, *Eucommiidites minor*, *Corollina meyeriana*, *Rugubivesiculites reductus*, and *Biretisporites potoniaei*.

The plot for the Steinaker Draw sample in Figure 18 indicates that the surrounding vegetation was dominated by gymnosperms and ferns. Common forms found in this sample include: *Alisporites bilateralis*, *Corollina torosus*, *Eucommiidites minor*, *Exesipollenites tumulus*, *Cyathidites minor*, and *Tricolpites erugatus*. The diversity of species in this sample is much less for this sample than for the Molen sample, with only three species of angiosperms, seven gymnosperms and 15 ferns. This lower diversity and shift to a more gymnosperm/spore dominated assemblage may be partially age-controlled as well as environmental. Estimates for the samples of Cedar Mountain and Burro Canyon from Tschudy *et al.* (1984), also plotted on Figure 18, show the relationship of these samples to those of the Steinaker Draw sample. The significant factor in the Burro Canyon plot is that the flora represented is almost entirely made up of gymnosperms. No angiosperms are present. This may be indicative of a pre-angiosperm time of sedimentation, or in a very dense stand of gymnosperms. The flora indicated for the Cedar Mountain sample from Steinaker Draw is more similar to the Burro Canyon in respects to gymnosperm and angiosperm pollen percentages, probably because of age (Aptian). However, the spore percentage indicates there is a greater mix of ferns in the Cedar Mountain flora at Molen (late Albian). This may be due to proximity to a fern-rich habitat.

Mowry Shale

The diverse and well-preserved palynomorph assemblages recovered from samples of the Mowry Shale indicate that the depositional environment of the Mowry was conducive to the accumulation and preservation of organic matter as well as the production of indigenous floras (dinoflagellates, acritarchs, etc.). These conditions probably included a stratified marine environment with nutrient-rich surface waters with progressively anoxic conditions at greater depth. This would account for the abundance and diversity of planktonic fossils (dinoflagellates and acritarchs) which were subjected to limited degradation by burrowing filter feeders rather than oxygenated bottom environments. Leckie, *et al.* (1990) suggested that assemblages which are very diverse in dinoflagellates (22 to 42 species in their study) represent open marine conditions in the outer neritic environment. Samples from the Mowry range from 19 to 44 species of dinoflagellates, yet also contain 25 to 38 percent terrestrially derived pollen and spores. This may indicate that the sediments in the Mowry at Steinaker Draw were deposited in a large unrestricted embayment, with near normal salinity, but with extensive terrestrial plant communities nearby or in headlands draining into the embayment. The absence of thick siltstones or sandstones, and the high absolute abundances of palynomorphs (20,000 to 2,000,000 palynomorphs per gram of sediment) within the Mowry probably indicate a relatively slow rate of sedimentation perhaps some distance in front of a major delta system.

Dakota Sandstone

Horsethief Canyon Ranch Section. The Dakota at Horsethief Canyon Ranch was sampled in detail to study paleoecological changes within coals and the consequences of ashfall disturbances. Figure 19 is a stratigraphic section of the Dakota at Horsethief Canyon

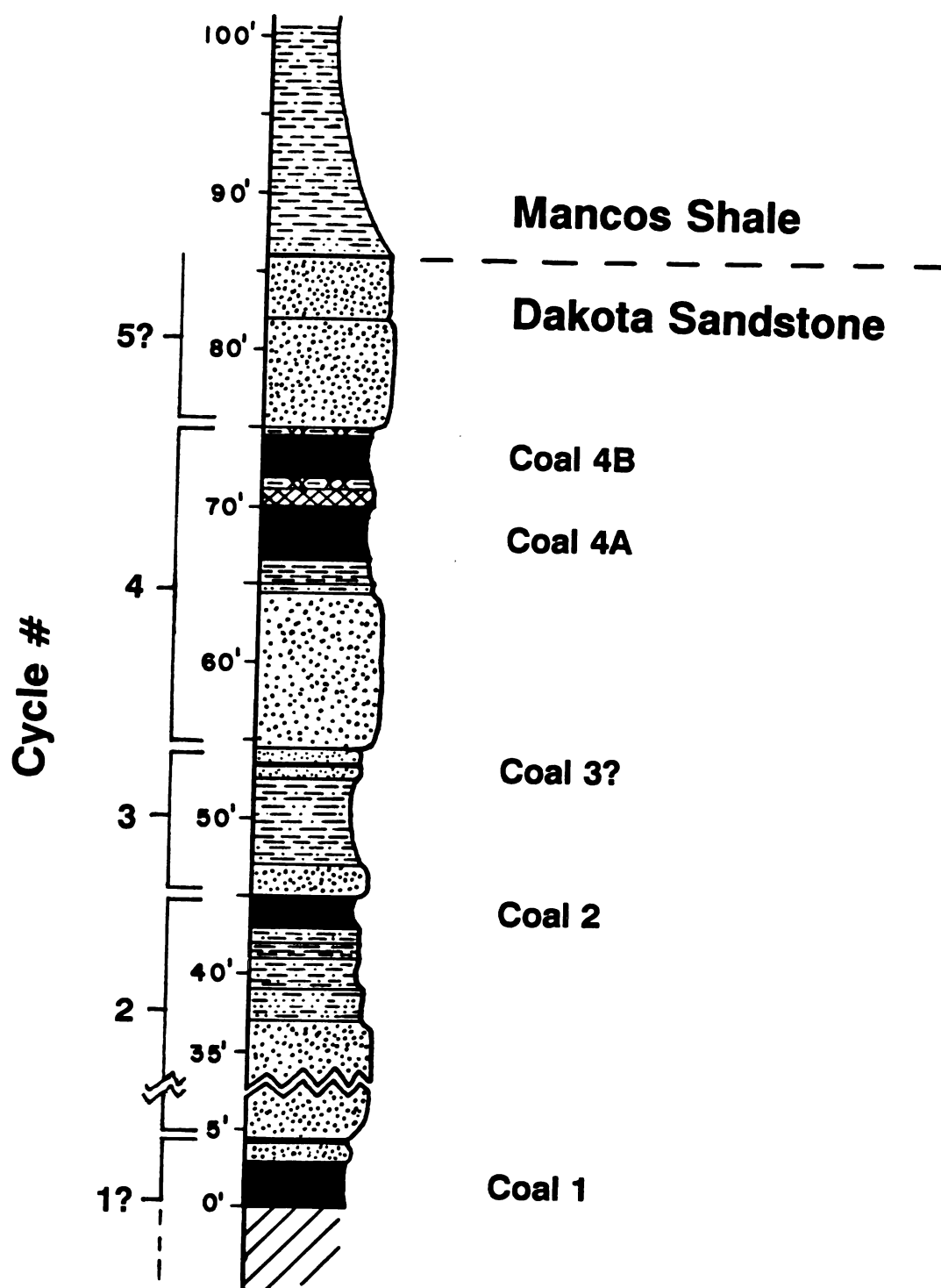


Figure 19. Stratigraphic section of the Dakota Sandstone at the Horsethief Canyon Ranch section.

Ranch and shows the position of the three main coals. The base of the Dakota at this section is not exposed. The total thickness is not known, but about 86 feet of the upper part of this section was measured and sampled. The section includes three to five fining-upward sequences (Figure 19), with lenticular sandstones at the base of each and carbonaceous shale or coal at the top of each of these sequences. The top of sequence 1 is probably represented by the basal Coal 1, and the top of sequence 5 may have been truncated by erosion at the base of the Mancos Shale. These are interpreted to be channel sands fining-upward into overbank, floodplain and peat-forming environments.

Coals and shales from cycles 1, 2 and 4 were sampled. Coal from cycle 4 is split into a lower and upper seam by a one foot thick bentonite. The coal from just below the bentonite and the bentonitic shale and coal above this bentonite were sampled at close intervals to determine the extent and magnitude of floristic changes that occurred in this disturbance interval. Figure 20 shows the relative percentage of ferns (represented by spores) compared to the pollen of seed plants (angiosperms/gymnosperms). Spores in the coal samples range from 53 to 75 percent. This is compared to values of 39 and 43 percent for carbonaceous shales not associated with bentonites; 63 to 71 percent for bentonitic shales above the main bentonite; and 84 to 93 percent for bentonitic shales below the main bentonite.

Figure 21 is an illustration from Tschudy and Tschudy (1984) showing the relationship between spore percentages and iridium abundances at the Cretaceous/Tertiary boundary in the Raton Basin, Colorado. It shows an abrupt increase in relative percent of fern spores, or "fern-spike", which has been referred to as the "Tschudy effect" (Flemming and Nichols, 1988), in the shale and basal coal associated with the iridium anomaly. This fern-spike has been interpreted as a result of catastrophic disruption of vegetation in

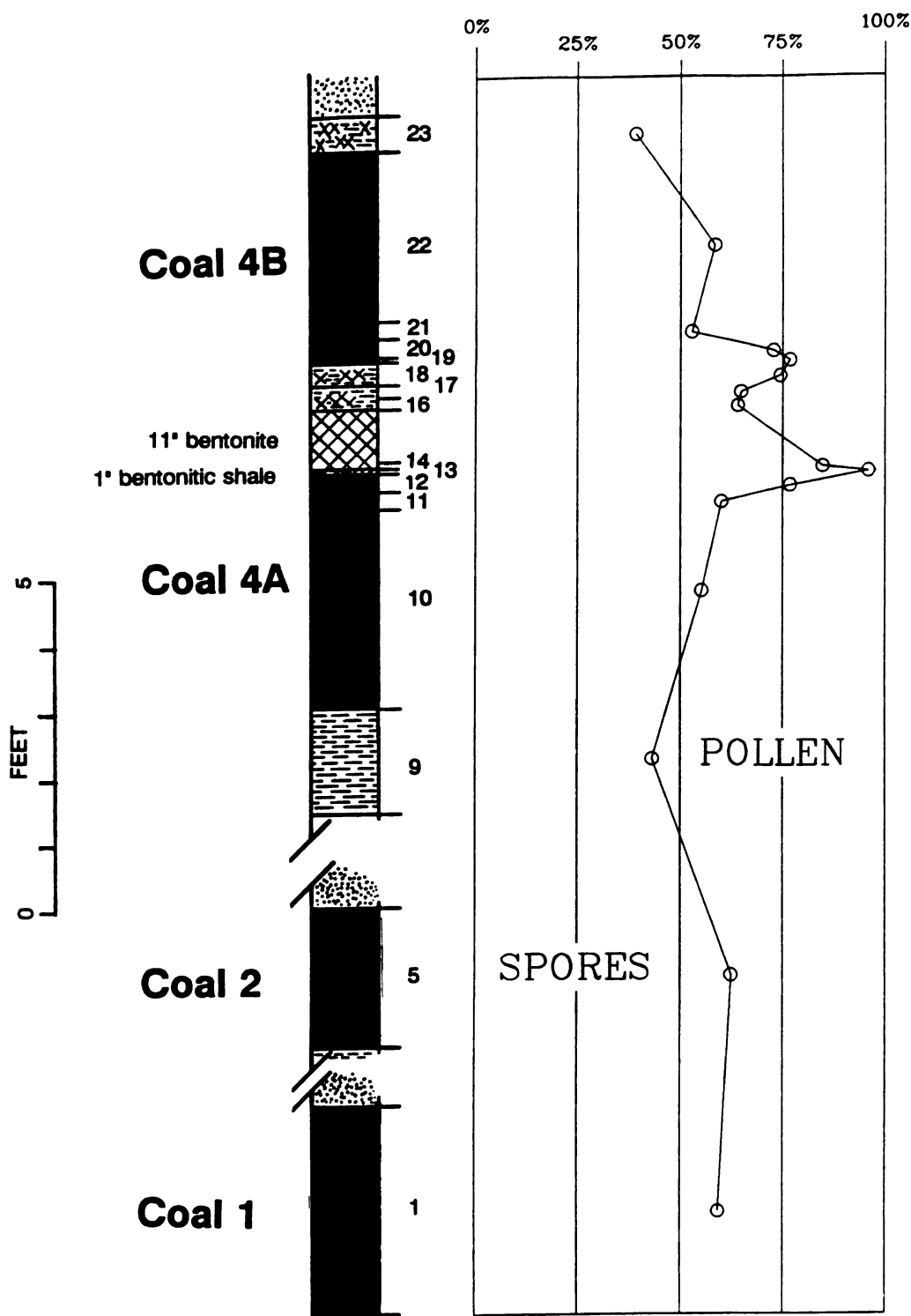


Figure 20. Relative percentage of spores of ferns and other spore-bearing plants to pollen (angiosperms and gymnosperms) in samples of the Dakota Sandstone at the Horsethief Canyon Ranch section.

Note: Samples are numbered to the right of the column.

F

S

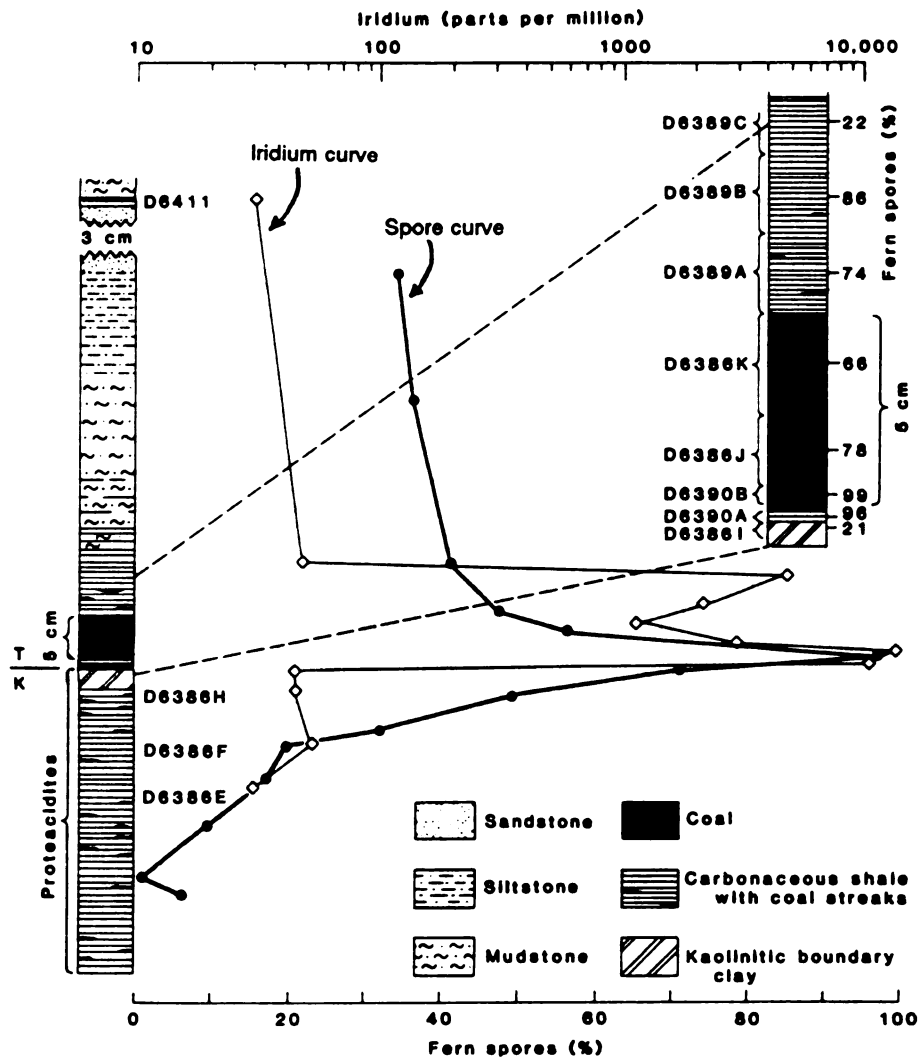


Figure 21. Diagram showing relation between iridium abundance and fern spike from a Cretaceous/Tertiary boundary interval near Trinidad, Colorado.

Source: From Tschudy et al. (1984).

resp

stud

sec

ind

spe

ob

effi

Su

Ta

wi

co

of

pe

ov

D

se

th

T

T

a

v

a

response to the terminal Cretaceous event (Tschudy and Tschudy, 1986). From further study, Flemming and Nichols (1988) noted that this effect was regional in nature. In the sections they studied, it generally occurs within 0 to 15 cm of the K-T boundary, is independent of lithology, and the spore assemblage is dominated by one of only a few species of fern spores.

The early recolonization by ferns of areas devastated by volcanic eruptions was observed after the eruption of Krakatoa in 1883 (Went, 1949; Francis and Self, 1983). The effects of periodic volcanic eruptions on paleofloras have been studied in the Miocene Succor Creek Formation of Oregon and Idaho (Taggart and Cross, 1980; Cross and Taggart, 1983; and Taggart *et al.*, 1982). They noted several volcanic events associated with disrupted floristic successional cycles. Dufek (1987) observed fern spikes in several coals of the Ferron Sandstone in east-central Utah. She noted that the level of disturbance of the flora was related to thickness of the ash-fall (bentonite). In one such disturbance, 60 percent of angiosperms and 30 percent of gymnosperms temporarily disappeared from overlying sediments. Rushforth (1971) documented ferns preserved in a bentonite in the Dakota Sandstone of eastern Utah about 25 miles west of the Horsethief Canyon Ranch section.

Figure 20 shows two increases in spore percentages, one just prior to and including the base of the bentonite and one in the base of the coal overlying the bentonitic shales. The lower, but more prominent spike, is clearly above the range of normal values for coals. This high value (93 percent) is from a sample of black bentonitic shale (sample 13) just above the top of the coal. The absolute abundance of palynomorphs from this sample is very low, about 63 grains per gram of sediment, but the sample also contained a high amount of fusain in the residue. This may indicate an early fire burning over the swamp

vegetation coincident with the initial ash fall or outgassing, and very short term recovery just prior to the main ashfall disturbance. The second spike is harder to explain, but may represent a slow, rather than rapid transition from an open marsh to a peat-forming swamp. During this temporary recovery episode (samples 16 - 17) a greater amount of angiosperm pollen was preserved in the coal swamp than in the two associated fern pulses below and above. The cause of this is unknown, but may be due to extensive angiosperm recovery on adjoining sites peripheral to the peat-forming swamp. One factor which complicates the interpretations of fern-spikes in the lower Upper Cretaceous is the fact that at the K-T boundary, average values for ferns in the total palynoflora are generally about 20 percent; whereas, in the Cenomanian they appear to be about 60 percent. This high background fern representation will tend to mask all but the largest variations in fern spore abundances.

Castle Valley Sections. While in the field measuring and sampling the sections, field observations indicated that the tops of the thick sandstones of the Dakota Sandstone at the Ivie Creek, Dry Wash and Molen sections were correlatable. After palynological analysis of the samples below the major sandstone at Ivie Creek, and the samples from just above the thick sandstones at Dry Wash and Molen, the correlation postulated in Figure 22 seems to be more logical. At Ivie Creek, the two samples produced terrestrial palynomorphs as expected, the palynomorph assemblage of the lower shale being very similar to that of the uppermost shale sample at Horsethief Canyon Ranch. At Dry Wash and Molen, samples between the sandstone of the Dakota and a 6 inch black chert pebble conglomerate also produced assemblages of entirely terrestrial origin. The shales associated with the conglomerate itself yielded a mixed marine/terrestrial assemblage. Eaton *et al.* (1990), who studied the Dakota in the area of Ivie Creek and Molen, referred to these continental shales

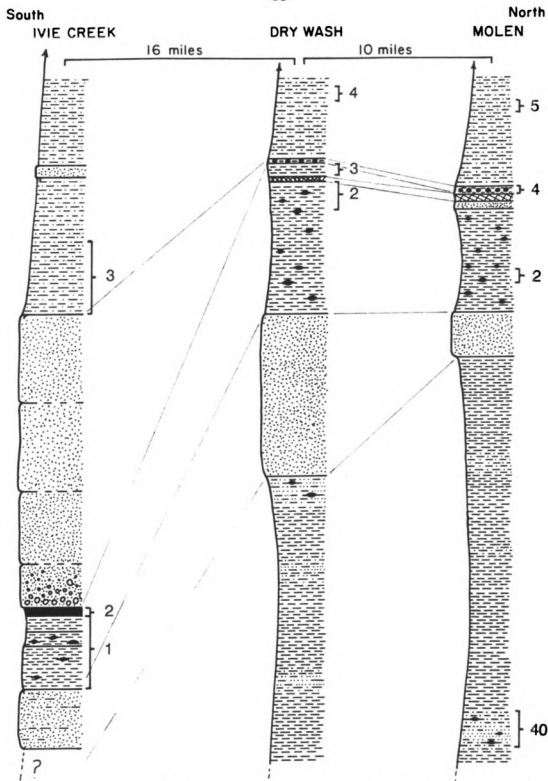


Figure 22. Stratigraphic correlation within the Dakota Sandstone in the Ivie Creek, Dry Wash and Molen sections.

Note: Numbers to the right of the columns are sample numbers.

as r

sanc

sed

paly

evic

epip

the

nea

Tur

of t

pat

dis

are

ap

19

to

po

an

sm

sh

ch

de

as mudstones which separate the lower nonmarine sandstone from an upper marine sandstone that is not present at either Dry Wash or Ivie Creek. They suggested that these sediments were formed in quiet waters of a bay or estuary. Actually, on the basis of this palynological study, these sediments were probably laid down in relatively fresh water as evidenced by the lack of any marine palynomorphs. The presence of *Trichopeltinites*, an epiphyllous fungi, and very abundant cuticular material and amber spherules, suggests that the environment was one in which a great deal of plant litter accumulated, possibly nearshore in an interdistributary swamp or bay.

Tununk Shale

Determining the linear distance from the paleoshoreline of a sample, i.e. the position of the sampling site at time of sediment deposit, is useful in reconstructing paleogeographic patterns and shoreline features. Determining which parameters best identify or define this distance, and using this as a means of zonation and correlation of environments from one area to another, has been the focus of several studies dealing with the Mancos Shale of approximately the same age as the Tununk (Sarmiento, 1957; Thompson, 1969; Jones, 1977; Kelly, 1987). Some of these techniques include using the following: ratio of marine to terrestrial forms; absolute abundance of terrestrial organic detritus; diversity of terrestrial pollen and spores and marine microplankton; relative abundance of gymnosperm pollen; and the ratio of microplankton with spines or more elaborate external ornaments to smooth-walled microplankton. Values in determining distance of samples from paleo-shoreline include identification of paleogeographic patterns and shoreline features as they change sequentially due to relative rise and fall of sea level (transgressive-regressive cycles).

Thompson (1969, 1972) was able to determine approximate distance offshore of deposition of sediments forming the rocks of two sections of Mancos Shale in southwestern

Colon

as we

vario

relati

abso

dista

abun

with

abun

theo

mic

to v

with

wat

con

acti

enc

lim

Sar

sec

cor

acc

Colorado, using some background information on shoreline positions determined by others, as well as palynologic distribution and frequency patterns. From these data, he plotted various parameters against the known distance offshore. His results indicated that the relative frequency of *Classopollis* spp., microplankton diversity, and relative frequency and absolute abundance of microplankton with spines, all tend to increase with increased distance from the paleoshoreline. Other factors, such as terrestrial diversity, and absolute abundance of total palynomorphs, fusain particles and cuticle fragments tend to decrease with increased distance from the shore.

Staplin (1961) was one of the first to investigate the trend of increasing relative abundances of spined microplankton to increasing distance from shoreline. The main theory for this is that with increasing distance from shore, and in increasingly quiet water, microplankton forms with spines or processes, which have higher surface area compared to volume, will have a greater drag in a viscous medium, thus enabling them to remain within the photic zone. Microplankton living closer to shore in increasingly turbulent waters, need less surface area to remain near the surface. Furthermore, forms with complex external appendages would not survive as well, turbulence of near-shore wave action. Wall *et al.* (1967) have shown that it is important for microplankton, after encystment into a floating, non-motile state, to remain within certain light and temperature limits for germination to take place. Studies by Downie *et al.* (1971) and Williams and Sarjeant (1967) indicate that zonation of fossil dinoflagellates by distance from shore exists.

In this study, four of the methods mentioned above were plotted for each of the sections, Ivie Creek, Molen, Farnham Dome and Horsethief Canyon Ranch. These were compared to determine whether correlation and zonation of the Tununk Shale could be accomplished by these methods.

Thompson (1969) showed a positive correlation for marine diversity and an inverse correlation for terrestrial diversity with increasing distance offshore. In using a ratio of the two indices, the resulting value may amplify subtle differences between the two. A marine/terrestrial diversity index (M/T) can be computed by dividing the marine diversity of a sample by the sum of the marine and terrestrial diversities. This results in values ranging from zero to one. A value of zero would reflect a completely terrestrial environment, while a value of one would indicate a marine environment with no terrestrial input. Values of zero were common for coals and coaly shales, but no values greater than 0.87 were encountered in any sample, so that even in marine samples, there was always a terrestrial component, however small. Intermediate values may represent environments of increasing distance from shoreline or increasing distance from sediment source due to delta distributary switching. From Thompson's (1969) plots of terrestrial and marine diversity, some ambiguity is evident in samples from 1 to 100 miles offshore. The average M/T ratio for samples ranging from 1 to 50 miles offshore is about 0.49, while values for 50 to 100 miles average about 0.25. This may reflect complex environmental interactions or high variability in part due to the configuration of the paleoshoreline. For samples over 100 miles offshore, values range from 0.73 to greater than 0.83, and show a trend of increasing values for increasing distance offshore.

Figure 23 gives the results for the ratio of marine/terrestrial (M/T) diversities for the four sections. All sections show increasing M/T values near the base of the Tununk, indicating transgression of the sea and increasing distance from the shore. The graphs also indicate that during the time of deposition of the Tununk Shale, three to five transgressive shifts in shoreline occurred, with peak M/T values over 0.75. These show up in the Ivie

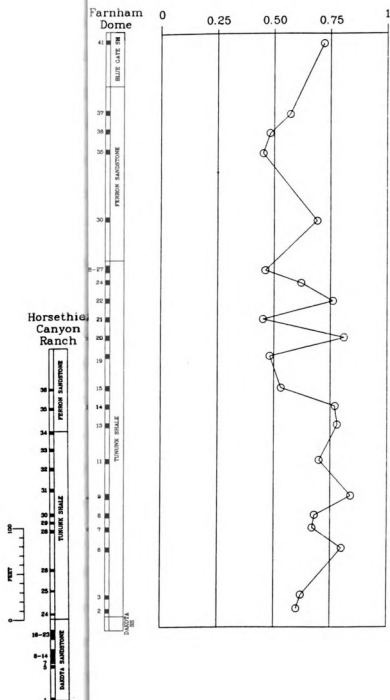


Figure 23.

Creek, Molen and Farnham Dome sections. The Horsethief Canyon Ranch section, though also showing fluctuations, does not show as much detail as the other three sections.

A single major regressional shift is indicated by M/T values of 0.50 and less near the approximate boundary of the lower and upper Tununk. In the Molen and Farnham Dome sections this shift occurs at or just below the boundary, and just above in the Ivie Creek section. Samples from within the Ferron Sandstone show a decrease in M/T values. In four samples of coals and coaly shales at Ivie Creek, M/T values are zero. At Molen, Farnham Dome and Horsethief Canyon Ranch, Ferron sample M/T values decrease, but do not fall to zero indicating the near-shore marine depositional environment of this unit in these areas. However, no coal samples were present in the Tununk and Ferron samples of the three latter sections.

Figure 24 shows the results of plotting relative percent marine terrestrial values against stratigraphic position. Values for percent terrestrial material show no major fluctuation within the Tununk Shale except for an increase near the lower/upper Tununk boundary. This is at the same position as the regressional shift indicated by M/T values.

Figure 25 is a plot of cumulative percent of spores, gymnosperms and angiosperms against stratigraphic position. The major trend indicated in this diagram is the increased percentage of gymnosperm pollen in marine samples compared with samples from terrestrial or nearshore environments. This increase is due primarily to increased abundances of *Corollina* spp., *Pinuspollenites* sp. A and *Alisporites* sp. A. This trend has also been shown to occur with *Classopollis* from Turonian sediments from New Mexico (Kelley, 1987), with pine pollen from recent sediments from the Gulf of Mexico (Cross *et al.*, 1966), and with mangrove pollen from recent sediments offshore of the Orinoco delta (Muller, 1959).

Horsethief,
Canyon
Ranch



Figure 24.

Figure 26 shows the plot for relative percentages of smooth-walled microplankton and spined microplankton. Samples from within the Tununk Shale show a great variability in these values. There is a general trend of increasing percentages of smooth-walled microplankton through time, especially in the Farnham Dome and Horsethief Canyon Ranch sections, but this is not as evident in the Ivie Creek and Molen sections. Peaks of smooth-walled microplankton occur at approximately the same elevation as the regressive shift in M/T ratios near the boundary between the upper and lower Tununk. Whether these peaks of smooth-walled microplankton are due to a higher energy marine environment or just occur coincidentally is difficult to determine. Jones (1977) showed a similar high variability of M/T ratios in samples from the lower Mancos from Arizona.

Ferron Sandstone

Abundances for 45 pollen, spore and microplankton species from 45 samples from the Ferron Sandstone were used in ordination calculations to determine if different environments of deposition within the Ferron, and different floral source areas, could be recognized using this technique. Twenty-one samples were coals, 12 were terrestrial shales or coaly shales, and 12 were marine shales from within the Ferron Sandstone. Figure 27 gives the results of two plots of the values generated for these samples using Reciprocal Averaging.

When axis one is plotted against axis 2 (Figure 27, upper plot), samples from marine environments were set off (grouped between 0 and 50 on axis one), from the terrestrial shales and coals (grouped between 50 and 100). The two samples of marine shale from the Horsethief Canyon Ranch section are set off from the other marine samples from Castle Valley by differences in axis 2 values. Apparently, the marine palynofloras from Horsethief Canyon Ranch share little similarity with those from Castle Valley. The

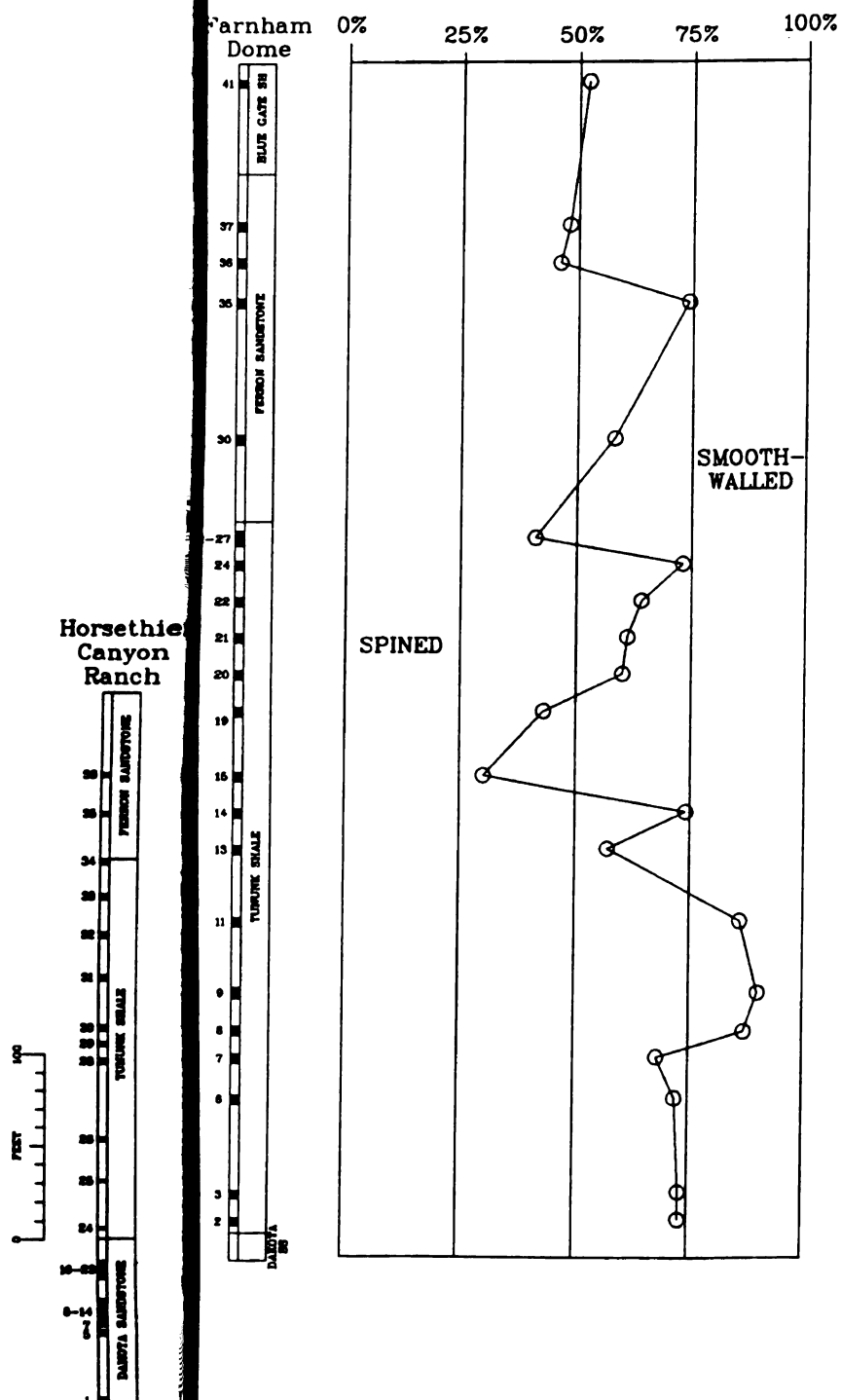
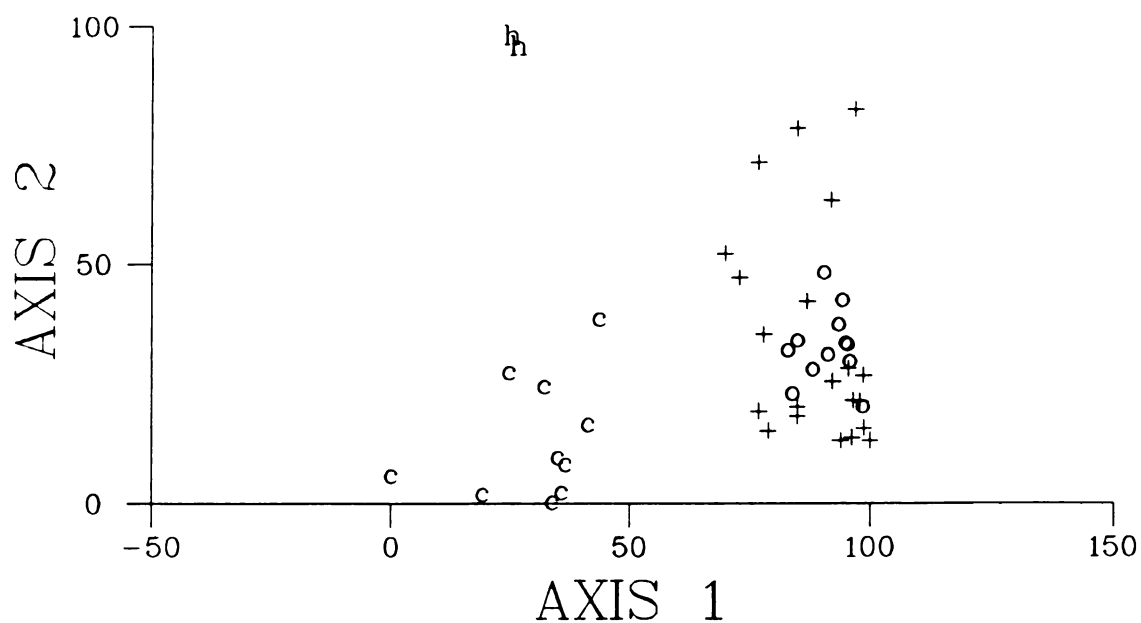


Figure 26.



c - marine shales from Castle Valley
 h - marine shales from Horsethief Canyon Ranch
 o - shales or coaly shales from Castle Valley
 + - coals from Castle Valley

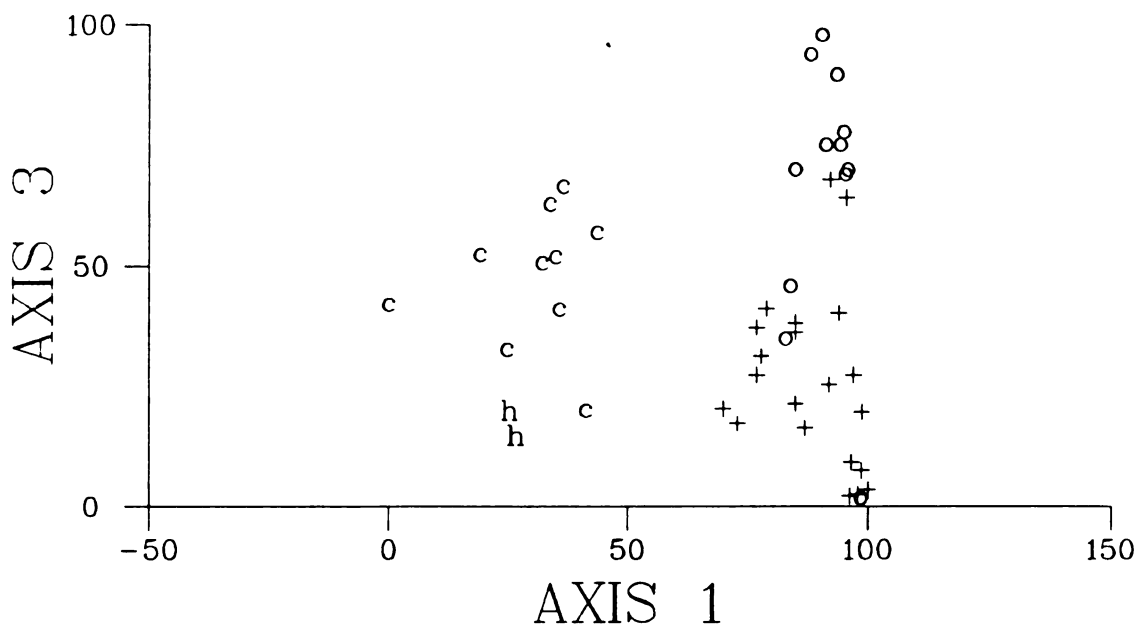


Figure 27. Results of reciprocal averaging of samples from the Ferron Sandstone.

cluster of samples representing terrestrial coals and shales are mixed and no clear interpretation can be made.

When axis 1 is plotted against axis 3 (Figure 27, lower plot), groups of coals and shales are partially distinguishable. In this plot, shales have clearly higher axis 3 values. However, in this plot, the two marine groups are not distinguishable. When axes 2 and 3 are used (not figured), most samples plot nearly in the center of the graph, and none of the groups are recognizable.

Axis 1 might be interpreted as representing a shoreline gradient where values less than 50 are marine, and those greater than 50 are terrestrial. Axis 2 may represent a pronounced paleofloral difference between the marine Ferron Sandstone samples from the Horsethief Canyon Ranch Section and those from Castle Valley. Axis 3 may reflect a moisture gradient that would differentiate a peat-forming swamp palynoflora community from the somewhat dryer autochthonous flood plain or allochthonous upland palynoflora communities.

Although through this technique, different environments, based on lithology, are separable into groups, samples from the same environment, but different locality, were not distinguishable. These same environments seemed to have existed both in the southern terrestrial deposits of the Last Chance delta at the Ivie Creek section and Quichupah cores and in the northern terrestrial deposits of the Vernal delta from the Castle Valley cores with little difference in floristic character.

Blue Gate Shale

Increasing M/T values, relative percent marine material and relative percent gymnosperm pollen from samples at the top of Ivie Creek and Farnham Dome sections all indicate that the Blue Gate Shale represents deposition in increasingly marine conditions following the termination of sedimentation in the Ferron Sandstone.

MICHIGAN STATE UNIV. LIBRARIES



31293008975066

**LIBRARY
Michigan State
University**

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
MAR 23 1994 7805504		

MSU Is An Affirmative Action/Equal Opportunity Institution

c:\circ\datedue.pm3-p.1

**BIOSTRATIGRAPHY AND PALEOECOLOGY OF
MID-CRETACEOUS SEDIMENTARY ROCKS, EASTERN UTAH
AND WESTERN COLORADO: A PALYNOLOGICAL INTERPRETATION**

By

Richard Edmond Carroll

Volume II

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Geological Sciences

1992

CONCLUSIONS

The following conclusions were derived from the study of 169 samples of mid-Cretaceous (Albian - Turonian) sediments from five measured stratigraphic sections and two sets of cores, and the palynomorph assemblages they contained:

1. The Cedar Mountain Formation is latest Albian in age in east-central Utah, and middle Albian in northeast Utah. Sediments of the Cedar Mountain were deposited in a terrestrial environment. The associated flora was fern-rich, but contained angiosperms and gymnosperms which contributed abundant pollen to the sediments.
2. The Mowry Shale in northeastern Utah is early Cenomanian in age. The black shales of the Mowry represent deposition in an anoxic marine environment free from bioturbation. A rich and abundant dinoflagellate and acritarch assemblage suggests open marine conditions. However, the frequent occurrence of terrestrially derived pollen and spores, and the absence of siltstones or sandstones, indicate proximity to a stable shoreline.
3. The Dakota Sandstone is middle to late Cenomanian in age in western Colorado and east-central Utah. The depositional environments of the Dakota range from fluvial, floodplain and swamp in western Colorado to interdistributary swamp in east-central Utah. Bentonite beds and associated fern spore abundances indicate that peat formation in the swamps was

occasionally interrupted, and plant community recovery was initiated primarily by ferns.

4. The Tununk Shale Member of the Mancos Shale is late Cenomanian to middle Turonian in age. It was deposited in an open marine environment associated with a fluctuating shoreline to the west, resulting from relative sea level changes. The Tununk Shale can be divided into lower and upper shale units in east-central Utah on the basis of dinoflagellate and pollen ranges.
5. The Ferron Sandstone Member of the Mancos Shale is middle to late Turonian in age, and represents deposition associated with two separate prograding delta systems that were only, in part, contemporaneous. Sediments associated with the Last Chance delta are found at the southern end of Castle Valley and represent fluvial, floodplain and swamp environments. Sediments associated with the Vernal delta are found in central and northern Castle Valley and possibly in western Colorado, and represent upper and lower shoreface environments in the outcrop, and flood and swamp environments in the subsurface. The source vegetation for these two deltas was similar enough that they were not distinguishable using Reciprocal Averaging (a multivariate analysis technique using ordination).
6. The Blue Gate Shale Member of the Mancos Shale is late Turonian in age at its base in east-central Utah, and was deposited under conditions similar in nature to the Tununk Shale Member.

Techniques such as diversity measurements, absolute abundances, relative percentage of terrestrial materials and relative percentages of smooth-walled and spined microplankton for determining distance of a sample from paleoshoreline and correlating

environmental changes between geographic areas, should be used cautiously and in conjunction with what is known about local environmental factors. Ordination, using Reciprocal Averaging or other methods, offers the possibility of relating palynomorph abundances to environmental or geographic factors.

The investigation of fossil pollen, spores and algae can be used effectively and reliably to assist in applications of biostratigraphy and paleoecology. Palynology may also be used to enhance and validate results obtained by other aspects of paleontology and such exploratory techniques as geochemistry, sedimentary petrology and geophysics.

APPENDIX

MEASURED SECTIONS

MEASURED SECTIONS

Location of Sections and Samples Utilized in Study

The following section gives information regarding section location, sample data and stratigraphy of the eight sections in which samples were used for this study. Index map # refers to numbers used in Figure 1 and Table 1. Sample data includes, from left to right: sample number (S#), collection number, PB number (Michigan State University maceration number), formation or unit name, sample thickness (Thk.), sampled interval of unit, and lithology. Only samples which were used in this study are tabulated on the following pages. Samples which were barren of palynomorphs or otherwise not used are not included.

IVIE CREEK SECTION

CODE: UT-EM-IC

INDEX MAP #: 2

LOCATION: Approximately 7.5 miles south of Emery, Emery County, Utah

TWN & RNG: SE 1/4, SEC 23, and SW 1/4, SEC 24, T 23 S, R 6 E

MAPS: Salina 2°; Mesa Butte, Utah 7.5°; Walker Flat, Utah 7.5°

SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
46	7-09-85 I 22	14390	Blue Gate Sh.	2'	at base	Shale, silty, medium gray
45	7-09-85 I 21	14389	Ferron Ss.	2'	near top	Shale, silty, brown
38	7-09-85 I 14	14607	Ferron Ss.	1'	153-154'	Shale, carbonaceous, black
32	7-09-85 I 8	14603	Ferron Ss.	5'	121-126'	Shale, siltstone and thin sandstones
30	7-09-85 I 6	14601	Ferron Ss.	8"	38'4"-31'0"	Coal
29	7-09-85 I 5	14600	Ferron Ss.	1'4"	37-38'4"	Shale, dark gray
26	7-09-85 I 2	14597	Ferron Ss.	1'6"	28'6"-30'	Coal and coaly shale
23	7-08-85 II 7	14595	Tununk Sh.	3'	427-430'	Shale, silty, medium gray
22	7-08-85 II 6	14403	Tununk Sh.	3'	402-405'	Shale, silty, medium gray
21	7-08-85 II 5	14594	Tununk Sh.	3'	374-377'	Shale, silty, medium gray
19	7-08-85 II 3	14593	Tununk Sh.	4'	307-311'	Shale, silty, medium gray
18	7-08-85 II 2	14386	Tununk Sh.	2'	282-284'	Shale, silty, medium gray
16	7-26-70 I 16	6443	Tununk Sh.	5'	245-250'	Shale, silty, medium gray with numerous thin siltstones
15	7-26-70 I 15	6442	Tununk Sh.	5'	225-230'	Shale, silty, medium gray
14	7-26-70 I 14	6441	Tununk Sh.	5'	205-210'	Shale, silty, medium gray, somewhat bentonitic
12	7-26-70 I 12	6439	Tununk Sh.	5'	165-170'	Shale, silty, medium gray
11	7-26-70 I 11	6438	Tununk Sh.	5'	145-150'	Shale, silty, medium gray
9	7-26-70 I 9	6436	Tununk Sh.	5'	105-110'	Shale, silty, medium gray
6	7-26-70 I 6	6433	Tununk Sh.	5'	44-49'	Shale, silty, medium gray
5	7-26-70 I 5	6432	Tununk Sh.	5'	28-33'	Shale with thin sandstones
3	7-26-70 I 3	6430	Tununk Sh.	5'6"	0-5'6"	Shale and silty sandstone
2	7-26-70 I 2	6429	Dakota Ss.	1'6"	8-9'6"	Shale, coaly
1	7-26-70 I 1	6428	Dakota Ss.	4'	4-8'	Shale, coaly shale and coal

QUITCHUPAH CORES

INDEX MAP #: 4
 CODE: UT-EM-Q
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Mesa Butte, Utah 7.5'; Emery East, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quichupah Core 5 (UT-EM-Q5)
 LOCATION: Emery County, Utah
 TWN & RNG: NE 1/4, SEC 33, T 22 S, R 6 E

NAME: Quichupah Core 6 (UT-EM-Q6)
 LOCATION: Emery County, Utah
 TWN & RNG: NW 1/4, SEC 34, T 22 S, R 6 E

NAME: Quichupah Core 8 (UT-EM-Q8)
 LOCATION: Emery County, Utah
 TWN & RNG: SW 1/4, SEC 35, T 22 S, R 6 E

NAME: Quichupah Core 9 (UT-EM-Q9)
 LOCATION: Emery County, Utah
 TWN & RNG: NW 1/4, SEC 35, T 22 S, R 6 E

NAME: Quichupah Core 10A (UT-EM-Q10A)
 LOCATION: Emery County, Utah
 TWN & RNG: NW 1/4, SEC 26, T 22 S, R 6 E

NAME: Quichupah Core 11 (UT-EM-Q11)
 LOCATION: Emery County, Utah
 TWN & RNG: NE 1/4, SEC 23, T 22 S, R 6 E

NAME: Quichupah Core 12 (UT-EM-Q12)
 LOCATION: Emery County, Utah
 TWN & RNG: SW 1/4, SEC 12, T 22 S, R 6 E

SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
12-1	Q12-1	13007	Ferron Ss.			Coal
11-7	Q11-7	12996	Ferron Ss.	14.4"		Coal
10A-2	Q10A-2	12972	Ferron Ss.	5.4"		Shale
9-3	Q9-3	12955	Ferron Ss.	9.0"		Coal
9-2	Q9-2	12954	Ferron Ss.			Coal
8-8	Q8-8	12939	Ferron Ss.	2.4"		Shale
8-1	Q8-1	12932	Ferron Ss.	12.0"		Shale, coaly
6-2	Q6-2	12881	Ferron Ss.			Coal
5-16	Q5-16	12846	Ferron Ss.	0.8"		Shale
5-10	Q5-10	12840	Ferron Ss.			Coal
5-8	Q5-8	12838	Ferron Ss.	4.8"		Shale
5-3	Q5-3	12833	Ferron Ss.	2.4"		Coal, shaly
5-2	Q5-2	12832	Ferron Ss.	12.0"		Coal
5-1	Q5-1	12831	Ferron Ss.	13.2"		Shale, coaly

DRY WASH SECTION**CODE:** UT-EM-DW**INDEX MAP #:** 5**LOCATION:** Approximately 5 miles southeast of Moore, Emery County, Utah**TWN & RNG:** NW 1/4, SEC 12, SW 1/4 SEC 1, AND SE 1/4 SEC 2, T 22 S, R 7 E; AND
SE 1/4, SEC 34, T 21 S, R 7 E**MAPS:** Salina 2° ; Short Canyon, Utah 7.5'; Emery East, Utah 7.5'**SAMPLES:**

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
5	7-12-85 I 5	14566	Tununk Sh.	3'	30-33'	Shale, silty, dark gray, carbonaceous
4	7-12-85 I 4	14398	Tununk Sh.	1'	3-4'	Shale, carbonaceous, black
3	7-12-85 I 3	14565	Dakota Ss.	1'	20'4"-21'4"	Shale, coaly
2	7-12-85 I 2	14376	Dakota Ss.	2'	18-20'	Shale, coaly

MOLEN SECTION

CODE: UT-EM-M

INDEX MAP #: 6

LOCATION: Approximately 7 miles east of Ferron, Emery County, Utah

TWN & RNG: SEC 21, 22 and 23, T 20 S, R 8 E

MAPS: Price 2" ; Molen, Utah 7.5'; Horn Silver Gulch, Utah 7.5'; Ferron, Utah 7.5'

SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
36	8-17-85 I 2	14487	Ferron Ss.	2'	165-167'	Shale, carbonaceous, black
33	7-11-85 I 5	14485	Ferron Ss.	3'	95-98'	Shale, carbonaceous, black, with thin lenses of siltstone and sandstone
31	7-11-85 I 3	14484	Ferron Ss.	2'	66-68'	Interbedded shale, siltstone and thin sandstone
29	7-11-85 I 1	14482	Ferron Ss.	2'	39-41'	Sandstone, carbonaceous with thin beds of shale and siltstone
28	7-10-85 I 23	14374	Tununk Sh.	3'	433-436'	Shale, silty, medium gray
27	7-10-85 I 22	14481	Tununk Sh.	2'	421-423'	Shale, silty, medium gray
21	7-10-85 I 21	14373	Tununk Sh.	3'	398-401'	Shale, silty, medium gray
20	7-10-85 I 20	14475	Tununk Sh.	1'6"	376-377'6"	Shale, silty, medium gray
18	7-10-85 I 18	14474	Tununk Sh.	3'	336-339'	Shale, silty, medium gray
17	7-10-85 I 17	14489	Tununk Sh.	1'	306-307'	Shale, silty, medium gray
16	7-10-85 I 16	14372	Tununk Sh.	2'	279-281'	Shale, bentonitic, silty, light to medium gray
15	7-10-85 I 15	14473	Tununk Sh.	6"	274-274'6"	Siltstone, dark gray, resistant
14	7-10-85 I 14	14472	Tununk Sh.	1'	273-274'	Shale, silty, medium gray
13	7-10-85 I 13	14371	Tununk Sh.	3'	238-241'	Shale, silty, medium gray
12	7-10-85 I 12	14471	Tununk Sh.	2'	190-192'	Shale, silty, medium gray
11	7-10-85 I 11	14470	Tununk Sh.	1'6"	166-167'6"	Shale, silty, medium gray
10	7-10-85 I 10	14311	Tununk Sh.	3'	136-139'	Shale, silty, medium gray
9	7-10-85 I 9	14469	Tununk Sh.	2'	111-113'	Shale, silty, medium gray
7	7-10-85 I 7	14468	Tununk Sh.	1'6"	56-57'6"	Shale, silty, medium gray
6	7-10-85 I 6	14366	Tununk Sh.	3'	29-32'	Shale, silty, medium gray
5	7-10-85 I 5	14370	Tununk Sh.	1'	4-5'	Shale, carbonaceous, black
4	7-10-85 I 4	14467	Tununk Sh.	6"	0-0'6"	Conglomerate, mostly quartzite pebbles .25 to 1 inch in diameter, with black silty shale matrix, very loosely consolidated
2	7-10-85 I 2	14466	Dakota Ss.	1'	5-6'	Shale, carbonaceous, black
40	8-19-86 I 2	14645	Cedar Mtn. Fm.	1'	7-8'	Shale, carbonaceous, bentonitic, black and medium gray

CASTLE VALLEY COAL CORES

CODE: UT-CA-CVCC
 INDEX MAP #: 9
 LOCATION: Near Price, Carbon County, Utah
 TWN & RNG:
 MAPS: Price 2" ; Price, Utah 7.5'
 SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
29	CVA 19-911	9015	Ferron Ss.	0.2'	1773.9-1774.1	Coal
28	CVA 19-907	9014	Ferron Ss.	1.0'	1735.7-1736.7	Coal
27	CVA 18-904	9013	Ferron Ss.	0.7'	2163.0-2163.7	Coal
26	CVA 18-903	9012	Ferron Ss.	4.0'	2158.1-2162.1	Coal, silty
25	CVA 18-899	9011	Ferron Ss.	1.1'	2106.0-2107.1	Shale, coaly
24	CVA 17-896	9010	Ferron Ss.	0.6'	1764.4-1765.0	Coal
23	CVA 17-895	9009	Ferron Ss.	0.5'	1760.7-1761.2	Coal
22	CVA 17-893	9008	Ferron Ss.	0.4'	1658.3-1658.7	Shale, black, carbonaceous
21	CVA 17-892	9007	Ferron Ss.	0.6'	1648.9-1649.5	Coal and shale
19	CVA 16-883	9005	Ferron Ss.	0.5'	1798.4-1798.9	Coal
18	CVA 16-882	9004	Ferron Ss.	0.4'	1795.4-1795.8	Coal
15	CVA 15-87??	9001	Ferron Ss.	1.7'	1783.4-1785.1	Coal
13	CVA 14-872	8999	Ferron Ss.	2.0'	2175.0-2177.0	Coal
12	CVA 14-869	8998	Ferron Ss.	0.3'	2101.1-2102.4	Coal
8	CVA 14-864	8994	Ferron Ss.	0.1'	2087.3-2087.4	Coal and siltstone
7	CVA 14-863	8993	Ferron Ss.	0.9'	2078.7-2079.6	Coal
5	CVA 13-859	8991	Ferron Ss.	0.9'	2414.0-2414.9	Coal
4	CVA 13-858	8990	Ferron Ss.	3.7'	2408.9-2412.6	Coal

FARNHAM DOME SECTION

CODE: UT-CA-FD
 INDEX MAP #: 10
 LOCATION: Approximately 5 miles east of Wellington, Carbon County, Utah
 TWN & RNG: S 1/2, SEC 1, and E 1/2, SEC 2, T 15 S, R 11 E
 MAPS: Price 2" ; Wellington, Utah 7.5"

SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
41	11-11-66 II 11	6727	Blue Gate Sh.	4'	45-49'	Shale, dark gray and tan siltstone
37	11-11-66 II 7	6722	Ferron Ss.	5'	143-148'	Shale, dark gray
36	11-11-66 II 6	6721	Ferron Ss.	5'	123-128'	Shale, dark gray, chippy
35	11-11-66 II 5	6720	Ferron Ss.	5'	101-106'	Shale, dark gray, chippy
30	11-10-66 I 27	6716	Ferron Ss.	5'	27-32'	Shale, silty, light gray to medium tan
27	11-10-66 I 26	6712	Tununk Sh.	5'	382-386'	Shale, silty, dark gray
28	11-11-66 II 1	6714	Tununk Sh.	5'	378-382'	Shale, silty, medium gray, hard
24	11-10-66 I 21	6709	Tununk Sh.	5'	360-365'	Shale, medium gray
22	11-10-66 I 20	6707	Tununk Sh.	5'	340-345'	Shale, silty, medium tan
21	11-10-66 I 19	6706	Tununk Sh.	5'	320-325'	Shale, medium gray
20	11-10-66 I 18	6705	Tununk Sh.	5'	300-305	Shale, medium gray
19	11-10-66 I 17	6704	Tununk Sh.	5'	280-285'	Shale, silty, dark gray
15	11-10-66 I 15	6702	Tununk Sh.	5'	245-250'	Shale, dark gray
14	11-10-66 I 14	6701	Tununk Sh.	5'	225-230'	Shale, dark gray
13	11-10-66 I 13	6368	Tununk Sh.	5'	205-210'	shale and siltstone, gray to green-gray
11	11-10-66 I 11	6366	Tununk Sh.	5'	166-171'	Shale, soft, gray with siltstone above and below
9	11-10-66 I 9	6364	Tununk Sh.	6'	127-133'	Shale, silty, medium gray
8	11-10-66 I 8	6363	Tununk Sh.	5'	107-112'	Shale, dark gray, hard
7	11-10-66 I 7	6362	Tununk Sh.	5'	92-97'	Shale, medium gray with limestone lens
6	11-10-66 I 6	6361	Tununk Sh.	5'	70-75'	Shale, dark gray, hard, chippy
3	11-10-66 I 3	6358	Tununk Sh.	4'	19-23'	Siltstone, shaly, dark gray
2	11-10-66 I 2	6357	Tununk Sh.	4'	4-8'	Shale, very dark gray

HORSETHIEF CANYON RANCH SECTION

CODE: CO-ME-HCR
 INDEX MAP #: 19
 LOCATION: On bank of the Colorado River, near Loma, Mesa County, Colorado
 TWN & RNG: NW 1/4, SEC 10, T 1 N, R 3 W
 MAPS: Grand Junction 2" ; Mack, Colorado 7.5"
 SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
36	8-30-86 IV 35	14801	Ferron Ss.	2'	44-46'	Shale, black and medium tan
35	8-30-86 IV 34	14800	Ferron Ss.	2'	23-26'	Shale, black
34	8-30-86 IV 33	14799	Tununk Sh.	3'	202-205'	Shale, silty, dark gray
33	8-30-86 IV 32	14798	Tununk Sh.	3'	183-186'	Siltstone, medium gray
32	8-30-86 IV 31	14797	Tununk Sh.	3'	162-165'	Shale, silty, medium to dark gray
31	8-30-86 IV 30	14796	Tununk Sh.	3'	139-142'	Shale, dark gray
30	8-30-86 IV 29	14795	Tununk Sh.	3'	112-115'	Shale, dark gray
29	8-30-86 IV 28	14794	Tununk Sh.	2'	104-116'	Siltstone, shaly, medium gray
28	8-30-86 IV 27	14793	Tununk Sh.	3'	94-97'	Siltstone, medium gray to tan
26	8-30-86 IV 25	14791	Tununk Sh.	2'	52-54'	Shale, silty, medium gray
25	8-30-86 IV 24	14790	Tununk Sh.	1'	30-31'	Shale, silty, medium gray
24	8-30-86 IV 23	14789	Tununk Sh.	1'	5-6'	Shale, silty, medium gray
23	8-30-86 IV 22	14788	Dakota Ss.	6"	76'2"-76'8"	Shale, bentonitic, medium gray
22	8-30-86 IV 21	14787	Dakota Ss.	2'5"	73'9"-76'2"	Shale, carbonaceous, siltstone and coal
21	8-30-86 IV 20	14786	Dakota Ss.	3"	73'6"-73'9"	Coal
20	8-30-86 IV 19	14785	Dakota Ss.	3"	73'3"-73'6"	Coal
19	8-30-86 IV 18	14784	Dakota Ss.	1"	73'2"-73'3"	Coal
18	8-30-86 IV 17	14783	Dakota Ss.	5"	72'9"-73'2"	Shale, silty carbonaceous
17	8-30-86 IV 16	14782	Dakota Ss.	3"	72'6"-72'9"	Shale, bentonitic, medium gray
16	8-30-86 IV 15	14781	Dakota Ss.	1"	72'5"-72'6"	Shale, bentonitic, medium gray
14	8-30-86 IV 13	14779	Dakota Ss.	1"	71'6"-71'7"	Shale, bentonitic, light gray
13	8-30-86 IV 12	14778	Dakota Ss.	1"	71'5"-71'6"	Shale, bentonitic, medium gray
12	8-30-86 IV 11	14777	Dakota Ss.	3"	71'2"-71'5"	Coal
11	8-30-86 IV 10	14776	Dakota Ss.	3"	70'11"-71'2"	Coal and carbonaceous shale
10	8-30-86 IV 9.5	14775	Dakota Ss.	2'11"	68-70'11"	Coal
9	8-30-86 IV 9	14774	Dakota Ss.	1'6"	66'6"-68'	Siltstone, carbonaceous and dark gray shale
8	8-30-86 IV 8	14773	Dakota Ss.	1'6"	65-66'6"	Siltstone, carbonaceous
7	8-30-86 IV 7	14772	Dakota Ss.	1'6"	53'6"-55'	Siltstone, carbonaceous and dark gray shale
5	8-30-86 IV 5	14770	Dakota Ss.	2'	44'6"-46'6"	Coal
1	8-30-86 IV 1	14766	Dakota Ss.	3'	0-3'	Coal

STEINAKER DRAW SECTION

CODE: UT-UI-SD
 INDEX MAP #: 21
 LOCATION: Approximately 4 miles north of Vernal, Uintah County, Utah
 TWN & RNG: N 1/2, SE 1/4, SEC 35, T 4 S, R 21 E
 MAPS: Vernal 2" ; Steinaker Reservoir, Utah 7.5'
 SAMPLES:

S#	Collection#	PB#	Unit	Thk.	Interval	Lithology
27	7-17-85 I 9	14358	Tununk Sh.	3'	52-55'	Siltstone and shale
25	7-17-85 I 7	14356	Tununk Sh.	3'	0-3'	Shale and siltstone, med. tan
24	7-17-85 I 6	14355	Mowry Sh.	3'	102'6"-105'6"	Shale, dark gray
69	8-26-86 I 38	14754	Mowry Sh.	2'	75'6"-77'6"	Shale, dark gray
23	7-17-85 I 5	14304	Mowry Sh.	3'	70'6"-73'6"	Shale, dark gray
68	8-26-86 I 37	14753	Mowry Sh.	2'	63'6"-65'6"	Shale, bentonitic, med. to dark gray
67	8-26-86 I 36	14752	Mowry Sh.	4"	57-57'4"	Shale, hard, black
66	8-26-86 I 35	14751	Mowry Sh.	2"	56'10"-57'	Shale, soft, fissile, med. gray
65	8-26-86 I 34	15123	Mowry Sh.	4"	56'6"-56'10"	Shale, hard, black
64	8-26-86 I 33	15122	Mowry Sh.	3"	49'1.5"-49'4.5"	Shale, soft, fissile, med. to dark gray
63	8-26-86 I 32	15121	Mowry Sh.	1"	49'0.5"-49'1.5"	Shale, soft, fissile
62	8-26-86 I 31	15120	Mowry Sh.	0.5"	49-49'0.5"	Shale, bentonitic, soft
60	8-26-86 I 29	15118	Mowry Sh.	2"	48'7"-48'9"	Shale, soft, fissile
59	8-26-86 I 28	15117	Mowry Sh.	1'0.5"	47'6.5"-48'7"	Alternating hard non-fissile and soft fissile shale.
58	8-26-86 I 27	15116	Mowry Sh.	2"	47'4.5"-47'6.5"	Shale, hard, thick-bedded
57	8-26-86 I 26	15115	Mowry Sh.	2"	47'2.5"-47'4.5"	Shale, hard, thick-bedded
56	8-26-86 I 25	15114	Mowry Sh.	1"	47'1.5"-47'2.5"	Shale, hard, thick-bedded
55	8-26-86 I 24	15113	Mowry Sh.	0.5"	47'1"-47'1.5"	Shale, hard, thick-bedded
50	8-26-86 I 19	15108	Mowry Sh.	2"	46-46'2"	Shale, hard, non-fissile
49	8-26-86 I 18	15107	Mowry Sh.	2"	45'10"-46'	Shale, soft, fissile, med. gray
48	8-26-86 I 17	15106	Mowry Sh.	1.5"	45'8.5"-45'10"	Shale, bentonitic, med. gray
44	8-26-86 I 13	15102	Mowry Sh.	0.5"	45'3.5"-45'4"	Shale, bentonitic, med. gray
43	8-26-86 I 12	15101	Mowry Sh.	3"	45'0.5"-45'3.5"	Shale, bentonitic, med. gray
42	8-26-86 I 11	15100	Mowry Sh.	6.5"	44'6"-45'0.5"	Shale, bentonitic, med. gray
41	8-26-86 I 10	15099	Mowry Sh.	3'	41'6"-44'6"	Shale, bentonitic, med. gray
40	8-26-86 I 9	15098	Mowry Sh.	2'	39'6"-41'6"	Shale, bentonitic, med. gray
39	8-26-86 I 8	15097	Mowry Sh.	2'	33'6"-35'6"	Shale, bentonitic, med. gray
36	8-26-86 I 5	15094	Mowry Sh.	6"	4-4'6"	Shale, silty, dense
34	8-26-86 I 3	15092	Mowry Sh.	2'	0-2'	Alternating black, fissile shale and silty shale
33	8-26-86 I 2	15091	Cedar Mtn. Fm.	1'6"	16-17'6"	Sandstone, fine-grained, containing rip-up clasts of underlying med. gray shale

LOCATION OF SECTIONS NOT UTILIZED IN STUDY

This section gives location information for stratigraphic section from which samples were not used. Index map # refers to numbers used in Figure 1 and Table 1.

NAME: Blind Trail Wash
 CODE: UT-GA-BTW
 INDEX MAP #: 1
 LOCATION: Approximately 13 miles southeast of Notom, Garfield County, Utah
 TWN & RNG: S 1/2, SEC 28, T 31 S, R 8 E
 MAPS: Salina 2° ; Notom 4 SE, Utah 7.5' Preliminary

NAME: Browning Mine
 CODE: UT-EM-BM
 INDEX MAP #: 3
 LOCATION: Approximately 4.5 miles south of Emery, Emery County, Utah
 TWN & RNG: NE 1/4, SEC 33, T 22 S, R 6 E
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quitchupah Core 2A
 CODE: UT-EM-Q2A
 INDEX MAP #: 4
 LOCATION: Emery County, Utah
 TWN & RNG: NE 1/4, SEC 20, T 23 S, R 6 E
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quitchupah Core 3
 CODE: UT-EM-Q3
 INDEX MAP #: 4
 LOCATION: Emery County, Utah
 TWN & RNG: SE 1/4, SEC 8, T 23 S, R 6 E
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quitchupah Core 4
 CODE: UT-EM-Q4
 INDEX MAP #: 4
 LOCATION: Emery County, Utah
 TWN & RNG: NW 1/4, SEC 4, T 23 S, R 6 E
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quitchupah Core 5A
 CODE: UT-EM-Q5A
 INDEX MAP #: 4
 LOCATION: Emery County, Utah
 TWN & RNG: NE 1/4, SEC 33, T 22 S, R 6 E
 MAPS: Salina 2° ; Walker Flat, Utah 7.5'; Emery West, Utah 7.5'

NAME: Quitchupah Core 7
 CODE: UT-EM-Q7
 INDEX MAP #: 4
 LOCATION: Emery County, Utah
 TWN & RNG: SE 1/4, SEC 3, T 23 S, R 6 E
 MAPS: Salina 2° ; Mesa Butte, Utah 7.5'; Emery West, Utah 7.5'; Walker Flat, Utah 7.5'

NAME: Quitchupah Core 13A

CODE: UT-EM-Q13
INDEX MAP #: 4
LOCATION: Emery County, Utah
TWN & RNG: SE 1/4, SEC 1, T 22 S, R 6 E
MAPS: Salina 2° ; Emery East, Utah 7.5'; Emery West, Utah 7.5'

NAME: Castle Dale-Woodside Road
CODE: UT-EM-CDWR
INDEX MAP #: 7
LOCATION: Approximately 5 miles west of Castle Dale, Emery County, Utah
TWN & RNG: SECS 29, 32, 33, and 34, T 18 S, R 9 E
MAPS: Price 2° ; Hadden Holes, Utah 7.5'; Castle Dale 7.5'

NAME: Elmo Road
CODE: UT-EM-ER
INDEX MAP #: 8
LOCATION: Approximately 4 miles east of Cleveland, Emery County, Utah
TWN & RNG: SW 1/4, SEC 13, and SE 1/4, SEC 14, T 17 S, R 10 E
MAPS: Price 2° ; Cleveland, Utah 7.5'; Huntington, Utah 7.5'

NAME: Sylvania Ranch
CODE: UT-EM-SR
INDEX MAP #: 11
LOCATION: Approximately 1 mile southwest of Grassy railroad siding, Emery County, Utah
TWN & RNG: NW 1/4, NE 1/4, SEC 23, T 17 S, R 13 E
MAPS: Price 2° ; Grassy, Utah 7.5'

NAME: Cliff Siding
CODE: UT-EM-CS
INDEX MAP #: 12
LOCATION: Approximately 5.5 miles south of Woodside, Emery County, Utah
TWN & RNG: SE 1/4, SEC 32, T 18 S, R 14 E
MAPS: Price 2° ; Cliff, Utah 7.5'

NAME: Green River West
CODE: UT-EM-GRW
INDEX MAP #: 13
LOCATION: Approximately 10 miles west of Green River, Emery County, Utah
TWN & RNG: N 1/2, SEC 2, T 22 S, R 14 E; AND SE 1/4, SEC 35, T 21 S, R 14 E
MAPS: Salina 2° ; Jessies Twist, Utah 7.5'

NAME: Valley City
CODE: UT-GR-VC
INDEX MAP #: 14
LOCATION: Grand County, Utah
TWN & RNG: Moab 2° ; Valley City, Utah 7.5'

NAME: Cisco
CODE: UT-GR-C
INDEX MAP #: 15
LOCATION: Grand County, Utah
TWN & RNG: Moab 2° ; Cisco, Utah 7.5'

NAME: Westwater Wash
CODE: UT-GR-WW

INDEX MAP #: 16
LOCATION: Grand County, Utah
TWN & RNG:
MAPS: Grand Junction 2° ; Westwater, Utah-Colorado 7.5'; Agate, Utah 7.5'

NAME: East Flank Harley Dome
CODE: UT-GR-EFHD
INDEX MAP #: 17
LOCATION: At rest area on west-bound I 70, approximately 3.5 miles west of Utah-Colorado state line, Grand County, Utah
TWN & RNG: NW 1/4, NE 1/4, SEC 2, T 19 S, R 26 E and SE 1/4, SE 1/4, SEC 35, T 18 S, R 26 E
MAPS: Grand Junction 2° ; Bitter Creek Well, Utah-Colorado 7.5'

NAME: Mile Post Nine
CODE: CO-ME-MPN
INDEX MAP #: 18
LOCATION: At roadcut, on north side of westbound I 70, nine miles east of the Utah/Colorado border, Mesa County, Colorado
TWN & RNG: N 1/2, NE 1/4, SEC 32, and S 1/2, SE 1/4, SEC 29, T 9 S, R 103 W
MAPS: Grand Junction 2° ; Ruby Canyon, Colorado 7.5'

NAME: Delta Colorado
CODE: CO-DE-DC
INDEX MAP #: 20
LOCATION: Near Delta, Delta County, Colorado
TWN & RNG: NE 1/4, NE 1/4, SEC 14, T 15 S, R 97 W
MAPS: Moab 2° ; Roubideau, Colorado 7.5'; Point Creek, Colorado 7.5'

NAME: Stinking Water Creek
CODE: CO-MO-SWC
INDEX MAP #: 22
LOCATION: East side of Stinking Water Creek, .25 miles north of Blue Mountain, Moffat County, Colorado
TWN & RNG: SE 1/4, SEC 5, T 3 N, R 102 W
MAPS: Vernal 2° ; Lazy Y Point, Colorado 7.5'

BIBLIOGRAPHY

BIBLIOGRAPHY

- Abbott, W.O. and Liscomb, R.L., 1956. Stratigraphy of the Book cliffs in east central Utah. *In Geology and Economic Deposits of East Central Utah*, Intermountain Association of Petroleum Geologists, 7th Annual Field Conference Guidebook, p. 120-124.
- Agasie, J.M., 1967. Upper Cretaceous palynomorphs from Coal Canyon, Coconino County, Arizona. Unpublished M.S. thesis, University of Arizona, Tucson, Arizona, 104 p.
- Agasie, J.M., 1969. Late Cretaceous palynomorphs from northeastern Arizona. *Micropaleontology*, 15(1):13-30.
- Agasie, J.M. and Kremp, G.O.W., 1967. Upper Cretaceous palynomorphs from the Dakota Sandstone of northeastern Arizona. *Proceedings, 43rd Annual Meeting, American Association for the Advancement of Science and Arizona Academy of Science*, (University of Arizona, 1967), p. 22.
- Albert, N.R., Evitt, W.R. and Stein, J.A., 1986. *Lacrymodinium*, n. gen., a gonyaulacoid dinoflagellate with intercalary archeopyle from the Jurassic and Early Cretaceous of California and Alaska. *Micropaleontology*, 32(4):303-315.
- Alberti, G., 1961. Zur Kenntnis mesozoischer und alttertiärer Dinoflagellaten und Hystrichosphaerideen von Nord- und Mitteldeutschland sowie einigen anderen europäischen Gebieten. *Palaeontographica* 116A:1-58.
- Anderson, A.J.B., 1971. Ordination methods in ecology. *Journal of Ecology*, 59:713-726.
- Anderson, R.L., 1960. Cretaceous-Tertiary palynology, eastern side of the San Juan Basin, New Mexico. *New Mexico Institute of Mining and Technology Memoir* 6, 58 p.
- Andrews, H.N. and Pearsall, 1941. On the flora of the Frontier Formation of southwest Wyoming. *Annals of the Missouri Botanical Gardens*, 28:165-192.
- Armstrong, R.L., 1968. Sevier Orogenic Belt in Nevada and Utah. *Geological Society of America Bulletin*, 79:429-458.
- Aurisano, R.W., 1989. Upper Cretaceous dinoflagellate biostratigraphy of the subsurface Atlantic Coastal Plain of New Jersey and Delaware, U.S.A. *Palynology*, 13:143-179.
- Aurisano, R. and Habib, D., 1977. Upper Cretaceous dinoflagellate zonation of the subsurface Toms River section near Toms River, New Jersey. *In Swain, F.M.*,

- editor, *Stratigraphic Micropaleontology of Atlantic Basin and Borderlands*, Elsevier Scientific Publishing Co., p. 369-387.
- Austin, M.P., 1985. Continuum concept, ordination methods and niche theory. *Annual Review of Ecological Systematics*, 16:39-61.
- Bagshaw, R.L., 1977. Foraminiferal abundance related to bentonite ash beds in the Tununk Member of the Mancos Shale (Cretaceous) in southeastern Utah. *Brigham Young University Geology Studies*, 24(2):33-49.
- Balme, B.E., 1957. Spores and pollen grains from the Mesozoic of Western Australia. Australia, Commonwealth Scientific and Industrial Research Organization, Coal Research Section, T.C. 25, 48 p.
- Balme, B.E. and Hassell, C.W., 1962. Upper Devonian spores from the Canning Basin, Western Australia. *Micropaleontology*, 8(1):1-28.
- Bartram, J.G., 1937. Upper Cretaceous of Rocky Mountain area. *American Association of Petroleum Geologists Bulletin*, 21:899-913.
- Beals, E.W., 1984. Bray-Curtis ordination: An effective strategy for analysis of multivariate ecological data. *Advances in Ecological Research*, 14:1-55.
- Bebout, J.W., 1981. An informal palynologic zonation for the Cretaceous System of the United States mid-Atlantic (Baltimore Canyon area) outer continental shelf. *Palynology*, 5:159-194.
- Below, R., 1981. Dinoflagellaten-Zysten aus dem oberen Hauterive bis unteren Cenoman Süd West-Marokkos. *Palaeontographica*, 176A:1-145.
- Below, R., 1982. Scolochorate Zysten der Gonyaulacaceae (Dinophyceae) aus der Unterkreide Marokkos. *Palaeontographica*, 182B:1-51.
- Bergad, R.D., 1973. North American species of the Cretaceous megaspores *Balmeisporites* and *Monophyllosporites*. *Micropaleontology*, 19(1):53-67.
- Bergad, R.D., and Hall, J.W., 1971. A Cretaceous *Azolla* massula with large glochidia. *Botanical Gazette*, 132(3):237-239.
- Bint, A.N., 1983. *Umbodinium crustou* gen. et sp. nov., a peridinioid dinoflagellate with two intercalaries from the Albian of Kansas. *Palynology*, 7:171-182.
- Bint, A.N., 1984. Mid-Cretaceous dinoflagellates from the Western Interior, U.S.A. Unpublished Ph.D. thesis, Stanford University, Palo Alto, California, 373 p.
- Bint, A.N., 1986. Fossil Ceratiaceae: A restudy and new taxa from the mid-Cretaceous of the Western Interior, U.S.A. *Palynology*, 10:135-180.

- Bodily, N.M., 1969. An armored dinosaur from the Lower Cretaceous of Utah. *Brigham Young University Geology Studies*, 16(3):35-60.
- Bolkhovitina, N.A., 1953. Spores and pollen characteristic of the Cretaceous deposits of central regions of the U.S.S.R. *Trans. Acad. Sci. U.S.S.R.*, 145:1-184 (in Russian).
- Bolkhovitina, N.A., 1961. Fossil and Recent spores of the family Schizaeaceae. *Trans. Geol. Inst., Acad. Sci. U.S.S.R.*, 40:1-176 (in Russian).
- Brenner, G.J., 1963. The spores and pollen of the Potomac Group of Maryland. State of Maryland, Board of Natural Resources, Department of Geology, Mines and Water Resources, Bulletin 27, 215 p.
- Brenner, G.J., 1967. Early angiosperm pollen differentiation in the Albian to Cenomanian deposits of Delaware (U.S.A.). *Review of Palaeobotany and Palynology*, 1:219-227.
- Brenner, G.J., 1974. Palynological analysis of cores from Test Hole AA-De 100. Maryland Geological Survey Report, 22:65-75.
- Brenner, G.J., 1976. Middle Cretaceous floral provinces and early migrations of angiosperms. In Beck, C.B., editor, *Origin and Early Evolution of Angiosperms*, Columbia University Press, p. 23-47.
- Brenner, G.J., 1977. Middle Cretaceous floral provinces and early migration of angiosperms [abstract]. *Palynology*, 1:171.
- Brideaux, W.W., 1971. Palynology of the Lower Colorado Group central Alberta, Canada. I. Introductory remarks. *Geology and microplankton studies. Palaeontographica*, 135B:53-114.
- Brideaux, W.W., 1972. Microplankton assemblages from the middle and late Albian of central Alberta, Canada [abstract]. *Geoscience and Man*, 4:127-128.
- Brideaux, W.W., 1975. Taxonomic note: redefinition of the genus *Broomea* and its relationship to *Batioladinium* gen. nov. (Cretaceous). *Canadian Journal of Botany*, 53:1239-1243.
- Brideaux, W.W., 1977. Taxonomy of Upper Jurassic-Lower Cretaceous microplankton from the Richardson Mountains, District of Mackenzie, Canada. *Geological Survey of Canada, Bulletin* 281, 89 p.
- Brideaux, W.W. and McIntyre, D.J., 1973. *Lunatadinium dissolutum* gen. et sp. nov., a dinoflagellate cyst from Lower Cretaceous rocks, Yukon Territory and northern District of Mackenzie. *Canadian Petroleum Geology, Bulletin*, 21(3)395-402.
- Brideaux, W.W. and McIntyre, D.J., 1975. Miospores and microplankton from Aptian-Albian rocks along Horton River, District of Mackenzie. *Geological Survey of Canada, Bulletin* 252, 85 p.

- Brown, C.W. and R.L. Pierce. 1962. Palynologic correlation in Cretaceous Eagle Ford Group, northeast Texas. *American Association of Petroleum Geologists, Bulletin*, 46(12):2133-2147.
- Bujak, J.P. and Davies, E.H., 1983. Modern and fossil Peridiniidae. *American Association of Stratigraphic Palynologists, Contribution Series*, 13:1-203.
- Bujak, J.P., Davies, E.H., Fensome, R.A., Helenes, J. and Williams, G.L., 1989. New insights into the Cretaceous stratigraphy of the Labrador Shelf [abstract]. *Palynology*, 13:280-281.
- Bujak, J.P., Downie, C., Eaton, G.L. and Williams, G.L., 1980. Taxonomy of some Eocene dinoflagellate cyst species from southern England. In Bujak, J.P., Downie, C., Eaton, G.L. and Williams, editors, *Dinoflagellate cysts and acritarchs from the Eocene of southern England*, The Palaeontological Association, Special Papers in Palaeontology, 24:1-9.
- Bujak, J.P. and Williams, G.L., 1978. Cretaceous palynostratigraphy of offshore southeastern Canada. *Geological Survey of Canada, Bulletin*, 297:1-19.
- Burden, E.T., 1982. Lower Cretaceous terrestrial palynomorph biostratigraphy of the McMurray Formation, northeastern Alberta. Unpublished Ph.D. thesis, University of Calgary, Calgary, Alberta, Canada, 442 p.
- Burden, E.T., 1984. Terrestrial palynomorph biostratigraphy of the lower part of the Mannville Group (Lower Cretaceous), Alberta and Montana. In Scott, D.F. and Glass, D.J., editors, *The Mesozoic of Middle North America*, Canadian Society of Petroleum Geologists, Memoir, 9:249-276.
- Burden, E.T. and Hills, L.V., 1989. Illustrated key to genera of Lower Cretaceous terrestrial palynomorphs (excluding megaspores) of western Canada. *American Association of Stratigraphic Palynologists, Contribution Series*, No. 21, 147 p.
- Burger, D., 1966. Palynology of the uppermost Jurassic and lowermost Cretaceous strata in the eastern Netherlands. *Leidse geol. Meded.*, 35:209-276.
- Burger, D., 1975. Cenomanian spores and pollen grains from Bathurst Island. In Norvick, M.S. and Burger, D., editors, *Palynology of the Cenomanian of Bathurst Island*, Northern Territory, Australia. Australian Bureau of Mineral Resources, Geology and Geophysics Bulletin, 151:114-154.
- Burger, D., 1976. Some Early Cretaceous plant microfossils from Queensland. *Australian Bureau of Mineral Resources, Geology and Geophysics Bulletin*, 160:1-22.
- Burgess, J.D., 1970. Palynological correlation and interpretation of Frontier environment in central Wyoming. *Wyoming Geological Association, 22nd Annual Field Conference Guidebook*, p. 133-145.

- Burgess, J.D., 1971. Palynological interpretation of Frontier environments in central Wyoming. *Geoscience and Man*, 3:69-82.
- Byers, C.W. and Larson, D.W., 1979. Paleoenvironments of Mowry Shale (Lower Cretaceous), western and central Wyoming. *American Association of Petroleum Geologists, Bulletin*, 63(3):354-375.
- Carter, F.J. and Canright, J.E., 1977. Palynology of the Pinedale coals (Cenomanian) from central Arizona [abstract]. *Palynology*, 1:172.
- Carter, W.D., 1957. Disconformity between Lower and Upper Cretaceous in western Colorado and eastern Utah. *Geological Society of America, Bulletin*, 68:307-314.
- Chang, L., 1965. Pollen assemblages and their significance in the Yima coal-bearing series from Yinchih-sien, Honan Province. *Acta Palaeontol. Sinica*, 13:160-196 (in Chinese).
- Chlonova, A.F., 1960. Species composition of pollen and spores from Upper Cretaceous and Chulimo-Yenisei depression. *Trudy Inst. Geol. Geofiz., Akad., Nauk, U.S.S.R. Siber. Otd.*, 3:1-104 (in Russian).
- Chlonova, A.F., 1969. Spores and pollen characteristic of Cretaceous deposits of the Zeya-Bureya depression. *Trudy Inst. Geol. Geofiz., Akad. Nauk, U.S.S.R. Siber. Otd.*, 138:52-151 (in Russian).
- Chlonova, A.F., 1976. Palynologic characteristics of Cretaceous deposits, Kya River (west Siberia). *Acad. Sci. U.S.S.R., Trans. Inst. Geol. and Geoph.*, 312:5-103 (in Russian).
- Chlonova, A.F., 1987. Spores of Hepaticae in Lower Cretaceous deposits of Siberia and the Far East. In Verkhovskaya, N.B. et al., editors, *Doklady Nauk SSSR, Dal'nevostochnyi Nauchnyi Tsentr, Biol.-Pochvennyi Inst.; Palinologiya vostoka SSSR, Sbornik Nauchnykh Trudov, Vladivostok* (in Russian).
- Christopher, R.A., 1979. Normapolles and triporate pollen assemblages from the Raritan and Magothy Formations (Upper Cretaceous) of New Jersey. *Palynology*, 3:73-121.
- Cisne, J.L. and Rabe, 1978. Coenocorrelation: Gradient analysis of fossil communities and its applications in stratigraphy. *Lethaia*, 11:341-364.
- Clark, F.R., 1919. The Farnham Anticline, Carbon County Utah. *U.S. Geological Survey, Bulletin*, 71:1-13.
- Clark, F.R., 1928. Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah. *U.S. Geological Survey, Bulletin* 793, 165 p.
- Clark, R.F.A. and Verdier, J.-P., 1967. An investigation of microplankton assemblages from the Chalk of the Isle of Wight, England. *Verhandelingen der Koninklijke*

- Nederlandsche Akademie van Wetenschappen, Afdeling Natuurkunde, Eerste Reeks, 24:1-96.
- Cleavinger, H.B., II, 1974. Paleoenvironments of deposition of the Upper Cretaceous Ferron Sandstone near Emery, Emery County, Utah. Brigham Young University Geology Studies, 21(1):247-274.
- Cluff, R.M., 1976. Paleocology and depositional environment of the Mowry Shale (Albian), Black Hills region. Unpublished M.S. thesis, University of Wisconsin, Madison, Wisconsin, 104 p.
- Cobban, W.A., 1952. Frontier Formation, Wyoming and adjacent areas. American Association of Petroleum Geologists, Bulletin, 36(10):1913-1961.
- Cobban, W.A., 1976. Ammonite record from the Mancos Shale of the Castle Valley-Price-Woodside area, east-central Utah. In Cross, A.T. and Maxfield, E.B., editors, Aspects of Coal Geology, Northwest Colorado Plateau; Some Geologic Aspects of Coal Accumulation, Alteration, and Mining in Western North America: A Symposium. Brigham Young University Geology Studies, 22(3):117-126.
- Cobban, W.A. and Kennedy, W.J., 1989. The ammonite *Metengonoceras* Hyatt, 1903, from the Mowry Shale (Cretaceous) of Montana and Wyoming. U.S. Geological Survey, Bulletin 1787-L, p. 1-11, 5 pl.
- Cobban, W.A. and Reeside, J.B., Jr., 1952. Correlation of the Cretaceous formations of the western interior of the central states. Geological Society of America, Bulletin, 63:1011-1043.
- Cooke, D., Craven, A.H. and Clarke, G.M., 1982. Basic Statistical Computing. Edward Arnold (Publishers) Ltd., London, 156 p.
- Cookson, I.C., 1947a. Plant microfossils of the lignites of Kerguelen Archipelago. British-Australian-New Zealand Antarctica Research Expedition, 1929-1931, Science Reports, Series A, 2(8):127-142.
- Cookson, I.C., 1947b. Fossil fungi from Tertiary deposits in the southern hemisphere. Part I. Linnean Society of New South Wales, Proceedings, 72(3/4):207-214.
- Cookson, I.C., 1953. Difference in microspore composition of some samples from a bore at Carnaam, South Australia. Australian Journal of Botany, 1:462-473.
- Cookson, I.C. and Dettmann, M.E., 1958a. Some trilete spores from Upper Mesozoic deposits in the eastern Australia region. Royal Society of Victoria, Proceedings, 70:95-128.
- Cookson, I.C. and Dettmann, M.E., 1958b. Cretaceous "megaspores" and a closely associated microspore from the Australian region. Micropaleontology, 4:39-49.

- Cookson, I.C. and Dettmann, M.E., 1959. On *Schizosporis*, a new form genus from Australian Cretaceous deposits. *Micropaleontology*, 5:213-216.
- Cookson, I.C. and Dettmann, M.E., 1961. Reappraisal of the Mesozoic microspore genus *Aequitriradites*. *Palaeontology*, 4(3):425-427.
- Cookson, I.C. and Eisenack, A., 1958. Microplankton from Australian and New Guinea Upper Mesozoic sediments. *Royal Society of Victoria, Proceedings*, 70(1):19-79.
- Cookson, I.C. and Eisenack, A., 1960. Upper Mesozoic microplankton from Australia and New Guinea. *Palaeontology*, 2(1):243-261.
- Cookson, I.C. and Eisenack, A., 1961. Upper Cretaceous microplankton from the Belfast No. 4 Bore, south-western Victoria. *Royal Society of Victoria, Proceedings*, 74:69-76.
- Cookson, I.C. and Eisenack, A., 1962a. Some Cretaceous and Tertiary microfossils from Western Australia. *Royal Society of Victoria, Proceedings*, 75:269-273.
- Cookson, I.C. and Eisenack, A., 1962b. Additional microplankton from Australian Cretaceous sediments. *Micropaleontology*, 8(4):485-507.
- Cookson, I.C. and Eisenack, A., 1970. Cretaceous microplankton from the Eucla Basin, Western Australia. *Royal Society of Victoria, Proceedings*, 83(2):137-157.
- Cookson, I.C. and Hughes, N.F., 1964. Microplankton from the Cambridge Greensand (mid-Cretaceous). *Palaeontology*, 7(1):37-59.
- Cornet, B. and Traverse, A., 1975. Palynological contributions to the chronology and stratigraphy of the Hartford Basin in Connecticut and Massachusetts. *Geoscience and Man*, 11:1-33.
- Cotter, E., 1971. Paleoflow characteristics of a Late Cretaceous river in Utah from analysis of sedimentary structures in the Ferron Sandstone. *Journal of Sedimentary Petrology*, 1:129-138.
- Cotter, E., 1975a. Deltaic deposits in the Upper Cretaceous Ferron Sandstone, Utah. In Broussard, M.L.S., editor, *Deltas, Models for Exploration*, Houston Geological Society, p. 471-484.
- Cotter, E., 1975b. Late Cretaceous sedimentation in a low-energy coastal zone: The Ferron Sandstone of Utah. *Journal of Sedimentary Petrology*, 45(3):669-685.
- Cotter, E., 1976. The role of deltas in the evolution of the Ferron Sandstone and its coals, Castle Valley, Utah. In Cross, A.T. and Maxfield, E.B., editors, *Aspects of Coal Geology, Northwest Colorado Plateau; Some Geologic Aspects of Coal Accumulation, Alteration, and Mining in Western North America: A Symposium*.

- Brigham Young University Geology Studies, 22(3):117-126. Brigham Young University Geology Studies, 22(3):15-41.
- Couper, R.A., 1953. Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand. New Zealand Geological Survey, Paleontological Bulletin, 22:1-77.
- Couper, R.A., 1958. British Mesozoic microspores and pollen grains. *Palaeontographica*, 103B:75-179.
- Couper, R.A., 1960. New Zealand Mesozoic and Cainozoic plant microfossils. New Zealand Geological Survey, Paleontological Bulletin, 32:1-88.
- Crabtree, D.R., 1988. Mid-Cretaceous ferns in situ from the Albino Member of the Mowry Shale, Southwestern Montana. *Palaeontographica*, 209B:1-27, 7 pl.
- Craig, L.C., Holmes, C.N., Cadigan, R.A., Freeman, V.L., Mullens, T.E. and Weir, G.W., 1955. Stratigraphy of the Morrison and related formations, Colorado Plateau region, a preliminary report. U.S. Geological Survey, Bulletin, 1009-E:125-168.
- Craig, L.C., Ekren, E.B., Houser, F.N., Shawe, D.R., Simmons, G.C. and Katich, P.J., Jr., 1961. Dakota Group of Colorado Plateau [Discussion]. American Association of Petroleum Geologists, Bulletin, 45(9):1582-1592.
- Crane, P.R., Friis, E.M. and Pedersen, K.R., 1986. Lower Cretaceous angiosperm flowers: Fossil evidence on early radiation of dicotyledons. *Science*, 232:852-854.
- Cross, A.T., Maxfield, E.B., Cotter, E. and Cross, C.C., 1975. Field guide and road log to the western Book Cliffs, Castle Valley, and parts of the Wasatch Plateau. Brigham Young University Geology Studies, 22(2):1-132.
- Cross, A.T. and Taggart, R.E., 1983. Causes of short-term sequential changes in fossil plant assemblages: Some considerations based on a Miocene flora of the northwestern United States. *Annals of the Missouri Botanical Gardens*, 69(3):676-734.
- Cross, A.T., Thompson, G.G. and Zaitzeff, J.B., 1966. Source and distribution of palynomorphs in bottom sediments, southern part of the Gulf of California. *Marine Geology*, 4:467-524.
- Crowley, S.S., 1987. The effects of volcanic ash partings on maceral composition and chemistry of the C coal bed, Ferron Sandstone Member of the Mancos Shale, Utah. Unpublished M.S. thesis, George Washington University, Washington, D.C., 105 p.
- Crowley, S.S., Simon, F.O. and Stanton, R.W., 1988. Selected chemical composition of the C coal bed, Emery field, Utah. U.S. Geological Survey, Open-File Report No. 88-0526, 60 p.

- Darton., N.H., 1904. Comparisons of the stratigraphy of the Black Hills, Bighorn Mountains, and Rocky Mountain Front Range. Geological Society of America, Bulletin, 15:379-448.
- Daugherty, L.H., 1941. The Upper Triassic flora of Arizona, with a discussion of geologic occurrence by H.R. Stagner. Carnegie Institute, Washington, Publication 526, Contributions to Paleontology, 108 p.
- Davey, R.J., 1969. Non-calcareous microplankton from the Cenomanian of England, northern France and North America. Part I. Bulletin, British Museum (Natural History), Geology Series, 17(3):103-180.
- Davey, R.J., 1970. Non-calcareous microplankton from the Cenomanian of England, northern France and North America, Part II. Bulletin, British Museum (Natural History), Geology Series, 18(8):333-397.
- Davey, R.J., 1979. Marine Apto-Albian palynomorphs from Holes 400A and 402A, IPOD Leg 48, northern Bay of Biscay. In Montadert, L. et al., editors, Initial Reports of the Deep Sea Drilling Project, Volume XLVII, Washington, p. 547-577.
- Davey, R.J., 1982. Dinocyst stratigraphy of the latest Jurassic to Early Cretaceous of the Haldager No. 1 borehole, Denmark. Geological Survey of Denmark, Series B, 6:1-57.
- Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., 1966. Fossil dinoflagellate cysts attributed to *Baltisphaeridium*. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., editors, Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Supplement 3, p. 157-175.
- Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., 1969. Generic reallocations. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., editors, Appendix to Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Appendix to Supplement 3, p. 15-17.
- Davey, R.J. and Verdier, J.-P., 1973. An investigation of microplankton assemblages from latest Albian (Vraconian) sediments. Revista Española Micropaleontología, 5:173-212.
- Davey, R.J. and Williams, G.L., 1966a. The genera *Hystrichosphaera* and *Achomosphaera*. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., editors, Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Supplement 3, p. 128-52.
- Davey, R.J. and Williams, G.L., 1966b. The genus *Hystrichosphaeridium* and its allies. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., editors, Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Supplement 3, p. 53-106.

- Davey, R.J. and Williams, G.L., 1969. Generic reallocations. In Davey, R.J., Downie, C., Sarjeant, W.A.S. and Williams, G.L., editors, Appendix to Studies on Mesozoic and Cainozoic dinoflagellate cysts; Bulletin of the British Museum (Natural History) Geology, Appendix to Supplement 3, p. 4-7.
- Davies, E.H., 1985. Anemiacean, schizaeacean and related spores: An index to genera and species. Canadian Technical Report of Hydrography and Ocean Sciences, No. 67, 218 p.
- Davies, E.H. and Norris, G., 1976. Ultrastructural analysis of exine and apertures in angiospermous colpoid pollen (Albian, Oklahoma). Pollen et Spores, 18(1):129-144.
- Davis, J.C., 1970. Petrology of Cretaceous Mowry Shale of Wyoming. American Association of Petroleum Geologists Bulletin, 54(3):487-502.
- Davis, L.J., 1954. Stratigraphy of the Ferron Sandstone. In Geology of Portions of the High Plateaus and Adjacent Canyon Lands, Central and South-Central Utah; Intermountain Association of Petroleum Geologists, 5th Annual Field Conference Guidebook, p. 55-58.
- Davis, P.N., 1963. Palynology and stratigraphy of the Lower Cretaceous rocks of northern Wyoming. Unpublished Ph.D. thesis, University of Oklahoma, Norman, Oklahoma, 199 p.
- Deák, M.H., 1963. Quelques spores striées de l'étage Aptien. Revue de Micropaléontologie, 5:251-256.
- Deák, M.H. and Combaz, A., 1967. "Microfossiles organique" du Wealdien et du Cenomanien dans un sondage de Charente - Maritime. Revue de Micropaléontologie, 10:69-96.
- Deflandre, G., 1935. Considérations biologiques sur les microorganismes d'origine planctonique conservés dans les silex de la craie. Bulletin biologique de la France et de la Belgique, 69:213-244.
- Deflandre, G., 1937. Microfossiles des silex crétacés. Deuxième partie. Flagélles incertae sedis Hystrichosphaeridés. Sarcodinés. Organismes divers, Annales de paléontologie, 26:51-103.
- Deflandre, G., 1938. Microplancton des mers jurassiques conservé dans les marnes de Villers-sur-Mer (Calvados). Etude liminaire et considérations générales. Travaux de la Station Zoologique Wimereux, 13:147-200.
- Deflandre, G., 1945. Microfossiles des calcaires Siluriens de la Montagne Noire. Annales de Paléontologie, 31:41-75.

- Deflandre, G., 1946. Hystrichosphaerides II. Espèces du Secondaire et du Tertiaire. Fich. micropaléont. sér. 6, Archives Originales Serv. Documentation, Centre National de la Recherche Scientifique, no. 235, cards 860-1019.
- Deflandre, G., 1947. Sur quelques microorganismes planctoniques des silex Jurassiques. Bulletin de l'Institut océanographique de Monaco, 921:1-12.
- Deflandre, G. and Cookson, I.C., 1955. Fossil microplankton from Australian Late Mesozoic and Tertiary sediments. Australian Journal of Marine and Freshwater Research, 6:242-313.
- Deflandre, G. and Courteville, H., 1939. Note préliminaire sur les microfossiles des silex Crétacés du Cambrésis. Bulletin de la Société Française de Microscopie, 8:95-106.
- Delcourt, A.F., Dettmann, M.E. and Hughes, N.G., 1963. Revision of some Lower Cretaceous microspores from Belgium. Palaeontology, 6(2):282-292.
- Delcourt, A.F. and Sprumont, G., 1955. Les spores et grains de pollen du Wealdien du Hainaut. Société Belge de Géologie, de Paléontologie et d'Hydrologie, Mémoires, 4(5):1-73.
- Dettmann, M.E., 1963. Upper Mesozoic microfloras from southeastern Australia. Royal Society of Victoria, Proceedings, 77:1-148.
- Dettmann, M.E., 1973. Angiospermous pollen from Albian to Turonian sediments of eastern Australia. In Glover, J.E. and Playford, G., editors, Mesozoic and Cainozoic Palynology: Essays in Honour of Isabel Cookson, Geological Society of Australia, Special Publication, 4:3-34.
- Dettmann, M.E. and Playford, G., 1968. Taxonomy of some Cretaceous spores and pollen grains from eastern Australia. Royal Society of Victoria, Proceedings, 81:69-93.
- Deunff, J., 1954. *Veryhachium*, genre nouveau d'Hystrichosphères du Primaire. Société Géologique de France, Bulletin; Compte rendu sommaire des Séances; Mémoires, 13:305-307.
- Dev, S., 1961. The fossil flora of the Jabalpur Series. 3. Spores and Pollen Grains. Palaeobotanist, 8:43-56.
- Dijkstra, S.J., 1949. Megaspores and some other fossils from the Aachenian (Senonian) in South Limburg, Netherlands. Mededelingen van de Geologische Stichting, Nieuwe Serie, 3:19-32.
- Dilcher, D.L., 1965. Epiphyllous fungi from Eocene deposits in western Tennessee, U.S.A. Palaeontographica, 116B:1-54.

- Dilcher, D.L. and Crane, P.R., 1984. *Archaeanthus*: an early angiosperm from the Cenomanian of the Western Interior of North America. *Annals of the Missouri Botanical Gardens*, 71:351-385.
- Doerenkamp, A.S., Jardiné, S. and Moreau, P., 1976. Cretaceous and Tertiary palynomorph assemblages from Banks Island and adjacent areas (N.W.T.). *Canadian Petroleum Geology, Bulletin*, 24(3):372-417.
- Döring, H., 1966. Die sporenstratigraphische Gliederung der Unterkreide im nördlichen Mitteleuropa. In Döring, H., Krutzsch, W., Mia, D.H. und Schulz, E., editors, *Erläuterungen zu den sporenstratigraphischen Tabellen vom Zechstein bis zum Oligozän*; Abhandlungen des Zentrales Geologisches Institut (Berlin), 5:64-77.
- Dörhöfer, G. and Davies, E.H., 1980. Evolution of archeopyle and tabulation in Rhaetogonyaulacinean dinoflagellate cysts. *Royal Ontario Museum, Canada Life Sciences Miscellaneous Publications*, p. 1-91.
- Downie, C. and Sarjeant, W.A.S., 1963. On the interpretation and status of some hystrichosphere genera. *Palaeontology*, 6:83-96.
- Downie, C., Hussain, M.A. and Williams, G.L., 1971. Dinoflagellate cyst and acritarch associations in the Paleogene of southeast England. *Geoscience and Man*, 3:29-35.
- Doyle, J.A., 1969. Cretaceous angiosperm pollen on the Atlantic Coastal Plain and its evolutionary significance. *Journal of the Arnold Arboretum*, 50(1):1-35.
- Doyle, J.A., 1977. Spores and Pollen: The Potomac Group (Cretaceous) angiosperm sequence. In Kaufmann, E.G. and Hazel, J.E., editors, *Concepts and Methods of Biostratigraphy*, p. 339-363.
- Doyle, J.A. and Robbins, E.I., 1977. Angiosperm pollen zonation of the continental Cretaceous of the Atlantic Coastal Plain and its application to deep wells in the Salisbury Embayment. *Palynology*, 1:43-78.
- Drinnan, A.N., Crane, P.R., Friis, E.M. and Pedersen, K.R., 1991. Angiosperm flowers and tricolpate pollen of Buxaceae affinity from the Potomac Group (mid-Cretaceous) of eastern North America. *American Journal of Botany*, 78:153-176.
- Drugg, W.S., 1967. Palynology of the upper Moreno Formation (Late Cretaceous-Paleocene) Escarpado Canyon, California. *Palaeontographica*, 120B:1-71.
- Drugg, W.S., 1970. Some new genera, species, and combinations of phytoplankton from the Lower Tertiary of the Gulf Coast, U.S.A. *North American Paleontological Convention, Chicago, 1969, Proceedings*, G:809-843.
- Drugg, W.S., 1978. Some Jurassic dinoflagellate cysts from England, France and Germany. *Palaeontographica*, 168B:61-79.

- Drugg, W.S. and Loeblich, A.R., Jr., 1967. Some Eocene and Oligocene phytoplankton from the Gulf Coast, U.S.A. *Tulane Studies in Geology*, 5:181-194.
- Dufek, D.A., 1987. Palynological analysis of floral changes caused by repeated volcanic ash burial of a coal-forming Upper Cretaceous peat swamp, Utah, U.S.A., Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 232 p.
- Duxbury, S., 1980. Barremian phytoplankton from Speeton, East Yorkshire. *Palaeontographica*, 173B:107-146.
- Duxbury, S., 1983. A study of dinoflagellate cysts and acritarchs from the Lower Greensand (Aptian to lower Albian) of the Isle of Wight, southern England. *Palaeontographica*, 186B:18-80.
- Eaton, J.G., Kirkland, J.I. and Kauffman, E.G., 1990. Evidence and dating of mid-Cretaceous tectonic activity in the San Rafael Swell, Emery County, Utah. *Mountain Geologist*, 27(2):39-45.
- Edwards, L.E., 1984. Insights on why graphic correlation (Shaw's method) works. *Journal of Geology*, 92:583-587.
- Edwards, L.E., 1989. Supplemented graphic correlation: a powerful new tool for paleontologists and non paleontologists. *Palaios*, 4(2):127-143.
- Ehrenberg, C.G., 1838. Über das Massenverhältniss der jetzt lebenden Kiesel-Infusorien und über ein neues Infusorien-Conglomerat als Polishiefer von Jastraba in Ungarn. *Abhandlungen der Preussischen Akademie der Wissenschaften*, 1836, p. 109-135.
- Eisenack, A., 1938. Die Phosphoritknollen der Bernsteinformation als Überlieferer tertiären Planktons. *Schriften der Physikalisch-ökonomischen Gesellschaft zu Königsberg*, 70:181-188.
- Eisenack, A., 1954. Mikrofossilien aus Phosphoriten des samländischen Unteroligozäns und über die Einheitlichkeit der Hystrichosphaerideen. *Palaeontographica*, 105A:49-95.
- Eisenack, A., 1958. Mikroplankton aus dem norddeutschen Apt nebst einigen Bemerkungen über fossile Dinoflagellaten. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 106:383-422.
- Eisenack, A., 1964. Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien. Band I. Dinoflagellaten. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1964, 888 p.
- Eisenack, A., 1969. Zur Systematik einiger paläozoischer Hystrichosphären (Acritarcha) des baltischen Gebietes. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 133:245-266.

- Eisenack, A., 1972. Kritische Bemerkung zur Gattung *Pterospermopsis* (Chlorophyta, Prasinophyceae). Neues Jahrbuch für Geologie und Paläontologie, Monatshefte, Heft 10, p. 596-601.
- Eisenack, A. and Cookson, I.C., 1960. Microplankton from Australian Lower Cretaceous sediments. Royal Society of Victoria, Proceedings, 72:1-11.
- Eisenack, A., Cramer, F.H. and Diez, M. del C.R., 1973. Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien. Band III. Acritarcha, 1. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1104 p.
- Eisenack, A. and Gocht, H., 1960. Neue Namen für einige Hystrichosphären und verwandten Mikrofossilien. Band II. Dinoflagellaten. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1971, 1130 p.
- Ellis, C.H. and Tschudy, R.H., 1964. The Cretaceous megaspore genus *Arcellites* Miner. Micropaleontology, 10(1):73-79.
- Erdtman, G., 1948. Did dicotyledonous plants exist in Early Jurassic times? Geologiska Föreningen Stockholm, Förhandlingar, 70:265-271.
- Evitt, W.R., 1973. Maestrichtian *Aquilapollenites* in Texas, Maryland, and New Jersey. Geoscience and Man, 7:31-38.
- Farabee, M.J. and Skvarla, J.J., 1988. Examination of a pollen tetrad of *Integricarpus reticulatus* (Mchedlishvili) Stanley from the Maestrichtian of North Dakota, U.S.A., Palynology, 12:43-48.
- Farley, M.B., 1982. An assessment of the correlation between miospores and depositional environments of the Dakota Formation (Cretaceous) north-central Kansas and adjacent Nebraska. Unpublished A.M. thesis, Indiana University, Bloomington, Indiana, 181 p.
- Farley, M.B. and Dilcher, D.L., 1986. Correlation between miospores and depositional environments of the Dakota Formation (mid-Cretaceous) of north-central Kansas and adjacent Nebraska, U.S.A. Palynology, 10:117-133.
- Fasola, A., 1983. Upper Cretaceous dinocyst zonation in Manitoba; correlation with coeval zones in the north Atlantic and the Arctic [abstract]. Palynology, 7:239.
- Felix, C.J. and Burbridge, P.P. 1976. Age of microplankton studied by Manum and Cookson from Graham and Ellef Ringnes Islands. Geoscience and Man, 15:83-86.
- Felsenstein, J., 1985. Confidence limits on phylogenies: An approach using the bootstrap. Evolution, 39:783-791.

- Fensome, R.A., 1983. Miospores from the Jurassic-Cretaceous boundary beds, Aklavik Range, Northwest Territories, Canada. Unpublished Ph.D. dissertation, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, 761 p.
- Filatoff, J., 1975. Jurassic palynology of the Perth Basin, Western Australia. *Palaeontographica*, 154B:1-113.
- Fisher, D.J., 1936. The Book Cliffs coal field in Emery and Grand Counties, Utah. U.S. Geological Survey, Bulletin 852, 104 p.
- Fisher, D.J., Erdmann, D.E. and Reeside, J.R., 1960. Cretaceous and Tertiary formations of the Book Cliffs, Carbon, Emery and Grand Counties, Utah, and Garfield and Mesa Counties, Colorado. U.S. Geological Survey, Professional Paper 332, 80 p.
- Flemming, R.F., 1989. Fossil *Scenedesmus* (Chlorococcales) from the Raton Formation, Colorado and New Mexico, U.S.A., Review of Palaeobotany and Palynology, 59(1-4):1-6.
- Flemming, R.F. and Nichols, D.J., 1988. The "Tschudy effect": fern-spore abundance anomaly at the Cretaceous-Tertiary boundary [abstract]. *Palynology*, 12:238.
- Fouch, T.D., Lawton, T.F., Nichols, D.J., Cashion, W.B. and Cobban, W.A., 1983. Patterns and timing of synorogenic sedimentation in Upper Cretaceous rocks of central and northeast Utah. In Reynolds, M.W. and Dolly, E.D., editors, Mesozoic Paleogeography of West-Central United States, Rocky Mountain Section. Society of Economic Paleontologists and Mineralogists, Denver, Colorado, p. 305-336.
- Francis, P. and Self, S., 1983. The eruption of Krakatoa. *Scientific American*, 249(5):172-187.
- Frederiksen, N.O. and Krafft, K., 1984. Cretaceous and Tertiary stratigraphy, paleontology, and structure, southwestern Maryland and northeastern Virginia. American Association of Stratigraphic Palynologists, Field trip volume and guidebook, 1984, 248 p.
- Furniss, B. and Tidwell, W.D., 1972. Cycadioidales from the Cedar Mountain Formation near Moab, Utah [abstract]. Geological Society of America, Programs with Abstracts, 4(6):377.
- Gale, H.S., 1910. Coal fields of northwestern Colorado and northeastern Utah. U.S. Geological Survey, Bulletin 316-E, p. 264-301.
- Gauch, H.G., Jr., 1982. Multivariate Analysis in Community Ecology. Cambridge University Press, New York, 298 p.
- Gauch, H.G., Jr. and Whittaker, R.H., 1972. Comparison of ordination techniques. *Ecology*, 53(5):868-875.

- Gies, T.F., 1972. Palynology of sediments bordering some Upper Cretaceous strand lines in northwestern Colorado. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 356 p.
- Gilbert, G.K., 1877. Report on the geology of the Henry Mountains, Utah. U.S. Geological Survey, Rocky Mountain Region Report, 160 p.
- Gitmez, G.U. and Sarjeant, W.A.S., 1972. Dinoflagellate cysts and acritarchs from the Kimmeridgian (Upper Jurassic) of England, Scotland and France. Bulletin of the British Museum (Natural History) Geology, 18:231-331.
- Gleason, H.A., 1926. The individualistic concept of the plant association. Torrey Botanical Club, Bulletin, 53:7-26.
- Gocht, H., 1957. Mikroplankton aus dem nordwestdeutschen Neokom (Teil I). Paläontologische Zeitschrift, 31:163-185.
- Gocht, H., 1959. Mikroplankton aus dem nordwestdeutschen Neokom (Teil II). Paläontologische Zeitschrift, 33:50-89.
- Gocht, H., 1968. Zur Morphologie und Ontogenie von *Thalassiphora* (Dinoflagellata). Palaeontographica, 129A:149-156.
- Gocht, H., 1970. Dinoflagellaten-Zysten aus dem Bathonium des Erdölfeldes Aldorf (NW-Deutschland). Palaeontographica, 129B:125-165.
- Goodall, D.W., 1954. Objective methods for the classification of vegetation. III. An essay in the use of factor analysis. Australian Journal of Botany, 2:304-324.
- Goodman, D.K. and Evitt, W.R., 1981. The dinoflagellate *Angustidinium acribes* (Davey & Verdier) gen. et comb. nov. from the mid-Cretaceous of northern California Coast Ranges. Grana, 20(1):43-54.
- Gray, R.J., Patalski, R.M. and Schapiro, N., 1966. Correlation of coal deposits from central Utah. In Central Utah Coals, Hamblin, W.K. and Rigby, J.K., editors, Utah Geological and Mineral Survey, Bulletin, 80:81-86.
- Greig-Smith, P., 1980. The development of numerical classification and ordination. Vegetatio, 42:1-9.
- Greig-Smith, P., 1983. Quaternary Plant Ecology. University of California Press, Los Angeles, 359 p.
- Gries, J.P., 1952. Mesozoic stratigraphy of the Dakota Basin. Billings Geological Society, 3rd Annual Field Conference Guidebook, p. 73-78.

- Griesbach, F.R., 1956. Preliminary palynology of the Lower Frontier Formation, southwestern Wyoming. Unpublished M.S. thesis, University of Utah, Salt Lake City, Utah, 54 p.
- Griggs, P.H., 1970a. Stratigraphy and palynology of the Frontier Formation (Upper Cretaceous), Bighorn Basin, Wyoming. Unpublished. Ph.D. thesis, Michigan State University, East Lansing, Michigan, 232 p.
- Griggs, P.H., 1970b. Palynological interpretation of the type section, Chuckanut Formation, Northwestern Washington. In Kosanke, R.M. and Cross, A.T., editors, Symposium on Palynology of the Late Cretaceous and Early Tertiary. Geological Society of America Special Paper, 127:169-212.
- Groot, J.J. and Penny, J.S., 1960. Plant Microfossils and age of nonmarine Cretaceous sediments of Maryland and Delaware. *Micropaleontology*, 6(2):225-236.
- Groot, J.J., Penny, J.S. and Groot, C.R. 1961. Plant microfossils and age of the Raritan, Tuscaloosa, and Magothy Formations of the eastern United States. *Palaeontographica*, 108B:121-140.
- Habib, D., 1969. Middle Cretaceous palynomorphs in a deep-sea core from the Seismic Reflector Horizon A outcrop area. *Micropaleontology*, 15(1):85-101.
- Habib, D., 1970a. Morphological affinity of selected palynomorphs from the Horizon Beta outcrop [abstract]. *Geoscience and Man*, 1:134.
- Habib, D., 1970b. Middle Cretaceous palynomorph assemblages from clays near the Horizon Beta deep-sea outcrop. *Micropaleontology*, 16(3):345-379.
- Habib, D., 1975. Neocomian dinoflagellate zonation in the western North Atlantic. *Micropaleontology*, 21(4):373-392.
- Habib, D., 1977. Comparison of Lower and middle Cretaceous palynostratigraphic zonations in the western North Atlantic. In Swain, F.M., editor, *Stratigraphic Micropaleontology of the Atlantic Basin and Borderlands*, p. 341-367.
- Habib, D. and Drugg, W.S., 1983. Dinoflagellate age of Middle Jurassic-Early Cretaceous sediments in the Blake-Bahama Basin. *Initial Reports of the Deep Sea Drilling Project*, 76:623-638.
- Habib, D. and Knapp, S.D., 1982. Stratigraphic utility of Cretaceous small acritarchs. *Micropaleontology*, 28(4):335-371.
- Hale, L.A., 1972. Depositional history of the Ferron Formation, central Utah. In Baer, J.L. and Callaghan, editors, *Plateau, Basin and Range Transition Zone, Central Utah*. Utah Geological Association, Publication, 2:29-40.

- Hale, L.A. and Van De Graaff, F.R., 1964. Cretaceous stratigraphy and facies patterns-northeastern Utah and adjacent areas. In Guidebook to the Geology and Mineral Resources of the Uintah Basin -- Utah's Hydrocarbon Storehouse, Intermountain Association of Petroleum Geologists, 13th Annual Field Conference Guidebook, p. 115-138.
- Hall, J.W., 1963. Megaspores and other fossils in the Dakota Formation (Cenomanian) of Iowa (U.S.A.). *Pollen et Spores*, 5(2):425-443.
- Hall, J.W., 1967. Two new species of *Ariadnaesporites*. *Pollen et Spores*, 9(3):425-443.
- Hall, J.W., 1969. Trends in the evolution of fossil Salviniaceae [abstract]. 11th International Botanical Congress, Seattle, Washington, Proceedings with Abstracts, p. 83.
- Hall, J.W., 1970. Megaspores as indicators of habitat [abstract]. *Geoscience and Man*, 1:133.
- Hall, J.W., 1971. A spore with cytoplasm-like contents from the Cretaceous of Minnesota, USA. *Pollen et Spores*, 13(1):163-168.
- Hall, J.W., 1974. Cretaceous Salviniaceae. *Annals of the Missouri Botanical Gardens*, 61(2):354-367.
- Hall, J.W., 1975. *Ariadnaesporites* and *Glomerisporites* in the Late Cretaceous: Ancestral Salviniaceae. *American Journal of Botany*, 62(4):359-369.
- Hall, J.W. and Peake, N.M., 1968. Megaspore assemblages in the Cretaceous of Minnesota. *Micropaleontology*, 14(4):456-464.
- Hanson, W.R., 1965. Geology of the Flaming Gorge area, Utah-Colorado-Wyoming. U.S. Geological Survey, Professional Paper 490, 196 p.
- Hares, C.J., 1916. Anticlines in central Wyoming. U.S. Geological Survey, Bulletin 641-I, 46 p.
- Harker, S.D. and Sarjeant, W.A.S., 1975. The stratigraphic distribution of organic-walled dinoflagellate cysts in the Cretaceous and Tertiary. *Review of Palaeobotany and Palynology*, 20:217-315.
- Harris, T.M., 1935. The fossil flora of Scoresby Sound, east Greenland. Part 4. Ginkgoales, Coniferales, Lycopodiales, and isolated fructifications. *Medd. Gron.*, 112(1):153-167.
- Hazenbush, G.C., 1973. Stratigraphy and depositional environments of the Mancos Shale (Cretaceous), Black Mesa, Arizona. In Fassett, J.E., editor, *Cretaceous and Tertiary Rocks of the Southern Colorado Plateau*. Four Corners Geological Society Memoir, p. 57-71.

- Hedlund, R.W., 1963. Palynology of the Red Branch Member of the Woodbine Formation (Upper Cretaceous) in Bryan County, Oklahoma. Unpublished Ph.D. thesis, University of Oklahoma, Norman, Oklahoma.
- Hedlund, R.W., 1966. Palynology of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County, Oklahoma. Oklahoma Geological Survey, Bulletin 112, 69 p.
- Hedlund, R.W., 1967. Taxonomic reevaluation of spore taxa from the Cenomanian of Oklahoma. *Pollen et Spores*, 9(3):579-582.
- Hedlund, R.W. and Norris, G., 1968. Spores and pollen grains from Fredricksburgian (Albian) strata, Marshall County, Oklahoma. *Pollen et Spores*, 10(1):129-159.
- Hedlund, R.W. and Norris, G., 1986. Dinoflagellate cyst assemblage from middle Albian strata of Marshall County, Oklahoma, U.S.A. *Review of Palaeobotany and Palynology*, 46:293-309.
- Helby, R., 1987. *Muderongia* and related dinoflagellates of the latest Jurassic to Early Cretaceous of Australia. In *Jell, P.A., editor, Studies in Australian Mesozoic Palynology, Association of Australian Palaeontologists, Memoir 4*, p. 297-336.
- Helenes, J., 1984. Morphological analysis of Mesozoic-Cenozoic *Cribroperidinium* (Dinophyceae), and taxonomic implications. *Palynology*, 8:107-137.
- Hickey, L.J., 1984. Summary and implications of the fossil plant record of the Potomac Group. In *Frederiksen, N.O. and Krafft, K, editors, Cretaceous and Tertiary Stratigraphy, Paleontology, and Structure, Southeast Maryland and Northeastern Virginia. American Association of Stratigraphic Palynologists, Fieldtrip Volume and Guidebook, 1984*, p. 213-248.
- Hill, M.O., 1973. Reciprocal averaging: An eigenvector method of ordination. *Journal of Ecology*, 61:237-249.
- Hill, M.O. and Gauch, H.G., Jr., 1980. Detrended correspondence analysis: An improved ordination technique. *Vegitatio*, 42:47-58.
- Hill, R.B., 1982. Depositional environments of the Upper Cretaceous Ferron Sandstone south of Notom, Wayne County, Utah. *Brigham Young University Geology Studies*, 29(2):59-83.
- Hintze, L.F., 1973. Geologic history of Utah. *Brigham Young University Geology Studies*, 20(3):1-181.
- Hochuli, P. and Kelts, K., 1980. Palynology of middle Cretaceous black clay facies from Deep Sea Drilling Project Sites 417 and 418 of the western north Atlantic. *Initial Reports of the Deep Sea Drilling Project*, 51-53(2):897-935.

- Hopkins, W.S., 1972. An Albian spore-pollen flora from the Sverdrup Basin, Northwest Territories [abstract]. *Geoscience and Man*, 4:131-132.
- Hotton, C., 1984. Palynofloral changes across the Cretaceous-Tertiary boundary in east central Montana [abstract]. Sixth International Palynological Conference, Calgary, Abstracts, p. 66.
- Hughes, N.F., 1961. Further interpretation of *Eucommiidites* Erdtman, 1948. *Palaeontology*, 4(2):292-299.
- Hughes, N.F., 1969. Jurassic and Early Cretaceous pollen and spores. In Tschudy, R.H. and Scott, R.A., editors, *Aspects of Palynology*. Wiley Interscience Publishers, New York, p. 311-329.
- Ibrahim, A.C., 1933. Sporenformen des Aegirhorizonts des Ruhrreviers. Dissertation, Technische Hochschule zu Berlin, Konrad Triltsch, Wurzburg, 48 p.
- Ioannides, N.S., Stavrinos, G.N. and Downie, C., 1977. Kimmeridgian microplankton from Clavel's Hard, Dorset, England. *Micropaleontology*, 22:443-478.
- Ivanova, E.A. and Markova, L.G., 1961. Schizaeaceae. In Samolovitch, S.R. and Mtchedlishvili, N.D., editors, *Pollen and Spores of western Siberia, Jurassic to Paleocene (Pyitsai Spory zapadney Sibiri, Yura-Paletsen)*. Trudy Vsesyuznyi Neftanoi Nauchno-issledovatel'skii Geologorazvedochnyi Institut, 177:64-112 (in Russian).
- Jacobson, S.R. and Nichols, D.J., 1980. Application of cingulum index to *Dinogymnium* in Hilliard Shale, southwestern Wyoming [abstract]. *American Association of Petroleum Geologists, Bulletin*, 64(5):728.
- Jacobson, S.R. and Nichols, D.J. 1982. Palynological dating of syntectonic units in the Utah-Wyoming thrust belt: The Evanston Formation, Echo Canyon Conglomerate. In Powers, R.B., editor, *Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists*, Denver, Colorado, p. 735-750.
- Jain, K.P. and Millepied, P., 1973. Cretaceous microplankton from Senegal Basin, N.W. Africa. 1. Some new genera, species and combinations of dinoflagellates. *Palaeobotanist*, 20:22-32.
- Jameossanaie, A., 1983. Palynology and environments of deposition of the lower Menefee Formation (lower Campanian), South Hospah, McKinley County, New Mexico. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 294 p.
- Jameossanaie, A., 1986. Paleoenvironments of the South Hospah coal deposits, McKinley County, New Mexico. *New Mexico Geology*, 8(2):30-33.
- Jameossanaie, A., Lindsey-Griffin, N. and Griffin, J.R., 1986. Significance of palynological studies in revealing earliest post-accretion age of the Hornbrook successor basin, northern California. *Palynology*, 10:250.

- Jameossanaie, A., 1987. Palynology and age of South Hospah coal-bearing deposits, McKinley County, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Bulletin 112, 65 p.
- Jansonius, J., 1962. Palynology of Permian and Triassic sediments, Peace River area, western Canada. *Palaeontographica*, 110B:35-98.
- Jansonius, J., 1971. Emended diagnosis of *Alisporites* Daugherty 1941. *Pollen et Spores*, 13(2):25-357.
- Jansonius, J., 1986. Reexamination of Mesozoic Canadian dinoflagellate cysts published by S.A.J. Pocock (1962, 1972). *Palynology*, 10:201-223.
- Jansonius, J., 1989. The species of *Fromea* (fossil dinoflagellates). Review of Palaeobotany and Palynology. 61:68.
- Jansonius, J. and Hills, L.V., 1976, et seq. Genera file of fossil spores and pollen. Special Publication, Department of Geology, University of Calgary, Canada, cards 1-4811.
- Jansonius, J., Dijkstra, S.J. and Elsik, W.C., 1981. *Geleenites* Dijkstra 1949 a Cretaceous fungal fructification. *Pollen et Spores*, 23:557-562.
- Jarzen, D.M. and G. Norris. 1975. Evolutionary significance and botanical relationships of Cretaceous angiosperm pollen in the western Canadian interior. *Geoscience and Man*, 11:47-60.
- Jekhowsky, B. de, 1961. Sur quelques hystrichosphaeres permo-triasiques d'Europe et d'Africa. *Revue du Micropaléontologie*, 3(4):207-212.
- Jones, R.E., 1977. Taxonomic treatment of dinoflagellates and acritarchs from the Mancos Shale (Upper Cretaceous) of the southwestern United States. Unpublished Ph.D. thesis, University of Arizona, Tucson, Arizona, 225 p.
- Kara-Murza, E.N., 1954. Spores and pollen of the Mesozoic deposits of the Yenisei-Lena region. *Science Research Institute of Arctic Geology*, 54:1-191 (in Russian).
- Katich, P.J., Jr., 1951. Recent evidence for Lower Cretaceous deposits in Colorado Plateau. *American Association of Petroleum Geologists, Bulletin*, 35(9):2093-2094.
- Katich, P.J., Jr., 1953. Source direction of Ferron Sandstone in Utah. *American Association of Petroleum Geologists, Bulletin*, 37(4):858-862.
- Katich, P.J., Jr., 1954. Cretaceous and Early Tertiary stratigraphy of central and south-central Utah with emphasis on the Wasatch Plateau area. *Intermountain Association of Petroleum Geologists, 5th Annual Field Conference Guidebook*, p. 42-55.

- Katich, P.J., Jr., 1956. Some notes on the Cretaceous faunas of eastern Utah and western Colorado. Intermountain Association of Petroleum Geologists, 7th Annual Field Conference Guidebook, p. 116-119.
- Katich, P.J., Jr., 1959. Late Cretaceous faunal zones, western Colorado. Rocky Mountain Association of Geologists, 11th Annual Field Conference Guidebook, p. 26-29.
- Kauffman, E.G., 1967. Coloradoan macroinvertebrate assemblages, central Western Interior, United States. In *Paleoenvironments of the Cretaceous Seaway in the Western Interior - A Symposium*. Colorado School of Mines, Golden, Colorado, p. 977-995.
- Kauffman, E.G., 1977. Geological and biological overview: Western Interior Cretaceous Basin. *Mountain Geologist*, 14(3/4):75-99.
- Kauffman, E.G., 1984. Paleobiogeography and evolutionary response dynamic in the Cretaceous Western Interior Seaway of North America. In Westermann, G.E.G., editor, *Jurassic-Cretaceous Biochronology and Paleoecology of North America*, Geological Association of Canada Special Paper, 27:273-306.
- Kedves, M., 1961. Études palynologiques dans le bassin de Dorog, II. Pollen et Spores, 3(1):101-153.
- Kelly, C., 1987. Palynologic investigation of the Moreno Hill Formation (Upper Cretaceous), west-central New Mexico. Unpublished M.S. thesis, Michigan State University, East Lansing, Michigan, 116 p.
- Kemp, E., 1970. Aptian and Albian miospores from southern England. *Palaeontographica*, 131B:73-143.
- Kidson, E.J., 1971. Palynology and paleoecology of the Buck Tongue of the Mancos Shale (Upper Cretaceous) from east central Utah and western Colorado. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 244 p.
- Kinney, D.M., 1955. Geology of the Uinta River-Brush Creek area, Duchesne and Uintah Counties, Utah. U.S. Geological Survey, Bulletin 1007, 185 p.
- Klaus, W., 1960. Sporen der karnischen Stufe der ostalpinen Trias. *Jahrbuch der Geologischen Bundesanstalt (Austria)*, Sonderband, 5:107-183.
- Klement, K.W., 1960. Dinoflagellaten und Hystrichosphaerideen aus dem Unteren und Mittleren Malm Südwestdeutschlands. *Palaeontographica*, 114A:1-104.
- Kimyai, A., 1966. New plant microfossils from the Raritan Formation (Cretaceous) in New Jersey. *Micropaleontology*, 12(4):461-476.
- Knight, W.C., 1902. The petroleum fields of Wyoming. *Engineering and Mining Journal*, 73:720-723.

- Knox, E.M., 1950. The spores of *Lycopodium*, *Phylloglossum*, *Selaginella*, and *Isoetes* and their value in the study of microfossils of Palaeozoic age. Botanical Society of Edinburgh, Transactions of Proceedings, 35(3):211-257.
- Kovach, W.L., 1986. A Multivariate Statistics Package for the IBM PC and Compatibles, Version 1.3. Copyright Warren L. Kovach, 1986, Department of Biology, Indiana University, Bloomington, Indiana.
- Kovach, W.L., 1986. Multivariate statistical package for the IBM-PC now available. Plant Science Bulletin, 32(2):2.
- Kovach, W.L., 1988. Quantitative paleoecology of a Cretaceous megaspore flora, using multivariate methods. Cretaceous Research, 9:265-283.
- Kovach, W.L., 1989. Comparisons of multivariate analytical techniques for use in pre-Quaternary plant paleoecology. Review of Palaeobotany and Palynology, 60:255-282.
- Kovach, W.L. and Batten, D.J., 1989. Worldwide stratigraphic occurrences of Mesozoic and Tertiary megaspores. Palynology, 13:247-277.
- Kovach, W.L. and Dilcher, D.L., 1985. Morphology, ultrastructure, and paleoecology of *Paxillitrites vittatus* sp. nov. from the mid-Cretaceous (Cenomanian) of Kansas. Palynology, 9:85-94.
- Kovach, W.L. and Dilcher, D.L., 1988. Megaspores and other dispersed plant remains from the Dakota Formation (Cenomanian) of Kansas, U.S.A. Palynology, 12:89-119.
- Kremp, G.O.W., 1949. Pollen analytische Untersuchung des miozanen Braunkohlenlager con Konin an der Warthe. Palaeontographica, B90:53-93.
- Krutzsch, W., 1959. Einige neue Formgattungen und - Arten von Sporen und Pollen aus der mitteleuropäischen Oberkreide und dem Tertiär. Palaeontographica, 105B:125-157.
- Kuehnert, H.A., 1954. Huntington Anticline, Emery County, Utah. Intermountain Association of Petroleum Geologists, 5th Annual Field Conference Guidebook, pl 94-95.
- Lachkar, G., Michaud, F. and Fourcade, E., 1989. Nouvelles données palynologiques sur le Jurassique supérieur et le Crétacé inférieur du Sud-Est du Mexique (Formation Jerico, Chiapas). Review of Palaeobotany and Palynology, 59(1-4):93-107.
- Land, C.B. Jr., 1972. Stratigraphy of the Fox Hills Sandstone and associated formations, Rock Springs Uplift and Wamsutter Arch area, Sweetwater County, Wyoming: A shoreline-estuary sandstone model for the Late Cretaceous. Colorado School of Mines Quarterly, 67(2):1-69.

- Leckie, D.A., Singh, C., Goodarzi, F. and Wall, J.H., 1990. Organic-rich, radioactive marine shale: A case study of a shallow-water condensed section, Cretaceous Shaftesbury Formation, Alberta, Canada. *Journal of Sedimentary Petrology*, 60(1):101-117.
- Legendre, L. and Legendre, F., 1983. *Numerical Ecology*. Elsevier Scientific Publishing Company, New York.
- Lejeune-Carpentier, M., 1940. L'étude microscopique des silex. Systématique et morphologie des "Tubifères" (Huitième note). *Annales de la Société géologique de Belgique*, 63:B216-B236.
- Lentin, J.K. and Williams, G.L., 1973. Fossil dinoflagellates: Index to genera and species. Geological Survey of Canada, Paper 73-42, 176 p.
- Lentin, J.K. and Williams, G.L., 1975. Fossil dinoflagellates: Index to genera and species. Supplement 1. *Canadian Journal of Botany*, 53:2147-2157.
- Lentin, J.K. and Williams, G.L., 1976. A monograph of fossil peridinioid dinoflagellate cysts. Bedford Institute of Oceanography, Report Series BI-R-77-8, 209 p.
- Lentin, J.K. and Williams, G.L., 1980. Dinoflagellate provincialism with emphasis on Campanian peridiniaceans. *American Association of Stratigraphic Palynologists, Contribution Series No. 7*, 47 p.
- Lentin, J.K. and Williams, G.L., 1985. Fossil dinoflagellates: Index to genera and species, 1985 edition. *Canadian Technical Report of Hydrography and Ocean Sciences*, 60:1-449.
- Lentin, J.K. and Williams, G.L., 1989. Fossil dinoflagellates: Index to genera and species, 1989 edition. *American Association of Stratigraphic Palynologists, Contribution Series No. 20*, 473 p.
- Leopold, E.B. and Pakiser, H.M., 1964. A preliminary report on the pollen and spores of the pre-Selma Upper Cretaceous strata of western Alabama. *U.S. Geological Survey, Bulletin*, 1160-E:71-95.
- Lerbekmo, J.F., Sweet, A.R. and St. Louis, R.M., 1987. The relationship between the iridium anomaly and palynological flora events at three Cretaceous-Tertiary boundary localities in western Canada. *Geological Society of America, Bulletin*, 99:325-330.
- Leschik, G., 1955. Die Keuperflora von Neuwelt bei Basel, II. Iso- und Mikrosporen. *Schweizerische Paläontologische Abhandlungen - Mémoires Suisses de Paléontologie*, 72:9-70.
- Lessard, R.H., 1973. Micropaleontology and paleoecology of the Tununk Member of the Mancos Shale. *Utah Geological and Mineral Survey, Special Studies No. 45*, 28 p.

- Loeblich, A.R., Jr. and Loeblich, A.R., III, 1966. Index to the genera, subgenera, and sections of the Pyrrhophyta. *Studies in Tropical Oceanography*, Miami, 3:1-94.
- Lucas-Clark, J., 1984. Morphology of species of *Litosphaeridium* (Cretaceous, Dinophyceae). *Palynology*, 8:165-193.
- Lucas-Clark, J., 1986. Late Albian dinoflagellate assemblages from outliers of the Great Valley Sequence and the Central Belt Franciscan Complex, Northern California. In Abbot, P.L. editor, *Cretaceous Stratigraphy Western North America*, Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 223-233.
- Lucas-Clark, J., 1987. *Wigginsella* n. gen., *Spongodinium*, and *Apteodinium* as members of the *Aptiana-Ventriosum* complex (fossil Dinophyceae). *Palynology*, 11:155-184.
- Lupton, C.T., 1914. Oil and gas near Green River, Grand County, Utah. U.S. Geological Survey, Bulletin, 541:115-133.
- Lupton, C.T., 1916. Geology and coal resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah. U.S. Geological Survey, Bulletin 628, 88 p.
- Maier, D., 1959. Planktonuntersuchungen in tertiären und quartären marinen Sedimenten. Ein Beitrag zur Systematik, Stratigraphie und Ökologie der Coccolithophorideen, Dinoflagellaten und Hystriosphaeideen vom Oligozän bis zum Pleistozän. *Neues Jahrbuch für Geologie und Paläontologie*, Abhandlungen, 107:278-340.
- Malyavkina, V.S., 1949. Identification of spores and pollen of the Jurassic and Cretaceous deposits. Naphta-Institute, Leningrad, Moscow, 138 p. (in Russian).
- Mantell, G.A., 1850. A pictorial atlas of fossil remains, consisting of coloured illustrations selected from Parkinson's "Organic remains of a former world", and Artis's "Antediluvian phytology". Henry G. Bohn, London, 207 p.
- Manum, S., 1963. Some new species of *Deflandre* and their probable affinity with *Peridinium*. *Norsk Polarinstitut, Årbok* 1962, p. 55-67.
- Manum, S. and Cookson, I.C., 1964. Cretaceous microplankton in a sample from Graham Island, Arctic Canada, collected during the second "Fram"-expedition (1898-1902) with notes on microplankton from the Hassel Formation, Ellef Ringnes Is. *Skrifter utgitt av Det Norske Videnskaps-Akademi i Oslo, I. Mat-Naturv. Klasse, Ny Series*, 17:1-35.
- Marshall, N.G., 1988. A Santonian dinoflagellate assemblage from the Gippsland Basin, southern Australia. In Jell, P.A. and Playford, G., editors, *Palynological and Palaeobotanical Studies in Honour of Basil E. Balme*. *Memoir 5, Association of Australian Palaeontologists*, p. 195-215.

- Masure, E., 1988. Albian-Cenomanian dinoflagellate cysts from Sites 627 and 635, Leg 101, Bahamas. *Proceedings of the Ocean Drilling Project, Scientific Results*, 101:121-138.
- Maxfield, E.B., 1976. Foraminifera from the Mancos Shale of east central Utah. *Brigham Young University Geology Studies*, 23(3):67-162.
- May, F.E., 1972. A survey of palynomorphs from several coal-bearing horizons of Utah. In Doelling, H.H., editor, *Central Utah Coal Fields*. Utah Geological and Mineralogical Survey, Monograph Series No. 3, p. 497-542.
- May, F.E., 1975. *Dichastopollenites reticulatus*, gen. et sp. nov.,—potential Cenomanian guide fossil from southern Utah and northeast Arizona. *Journal of Paleontology*, 49(3):528-533.
- May, F.E., 1976. Dinoflagellates: Fossil motile-stage tests from the Upper Cretaceous of the Northern New Jersey coastal plain. *Science*, 193(4258):1128-1131.
- May, F.E., 1979. Dinoflagellate and acritarch assemblages from the Nanushuk Group (Albian-Cenomanian) and the Torok Formation Umiat test well 11, National Petroleum Reserve in Alaska, northern Alaska. U.S. Geological Survey, Circular, 794:113-127.
- May, F.E., 1980. Dinoflagellate cysts of the Gymnodiniaceae, Peridiniaceae, and Gonyaulacaceae from the Upper Cretaceous Monmouth Group, Atlantic Highlands, New Jersey. *Palaeontographica*, 172B:10-116.
- May, F.E. and Stein, J.A., 1979. Dinoflagellate and acritarch assemblages from the Grandstand Formation (middle to upper Albian) of the Nanushuk Group, Simpson Core, Test 25, National Petroleum Reserve in Alaska, northern Alaska. U.S. Geological Survey, Circular, 794:128-145.
- May, F.E. and Traverse, A., 1973. Palynology of the Dakota Sandstone near Bryce Canyon National Park, southern Utah. *Geoscience and Man*, 7:57-64.
- McClammer, J.U., Jr. and Crabtree, D.R., 1989. Post-Berremian (Early Cretaceous) to Paleocene paleobotanical collections in the Western Interior of North America. *Review of Palaeobotany and Palynology*, 57(3/4):221-232.
- McGookey, D.P., et al., 1972. Cretaceous system. In *Geologic Atlas of the Rocky Mountain Region*, Rocky Mountain Association of Geologists, p. 190-228.
- McIntyre, D.J., 1974. Palynology of an Upper Cretaceous section, Horton River, District of Mackenzie, N.W.T., Geological Survey of Canada, Paper 74-14, 57 p.
- McIntyre, D.J. and Sweet, A.R., 1986. Late Turonian marine and nonmarine palynomorphs from the Cardium Formation, north-central Alberta Foothills, Canada [abstract]. *Palynology*, 10:254.

- McLeroy, C.A., 1971. Late Cretaceous angiosperm pollen from the western San Joaquin Valley, California [abstract]. *Geoscience and Man*, 3:95-96.
- Meek, F.B. and Hayden, F.V., 1862. Description of new Lower Silurian (Primordial), Jurassic, Cretaceous, and Tertiary fossils collected in Nebraska Territory with some remarks on the rocks from which they were obtained. *Proceedings of the Academy of Natural Sciences, Philadelphia*, 13:419-420.
- Mehrotra, N.C. and Sinha, A.K., 1981. Further studies on microplanktons from the Sangchamalla Formation (Upper Flysch) of Malla Johar area in the Tethyan zone of Higher Kumaon Himalaya. In Sinha, A.K., editor, *Contemporary Geoscientific Researches in Himalaya, Dehra Dun (India)*, p. 151-160.
- Melchior, R.C., 1965. Pollen and spores of the Shawmut anticline, Montana. Unpublished Ph.D. thesis, University of Minnesota, Minneapolis, Minnesota, 153 p.
- Miner, E.L., 1932. Megaspores ascribed to *Selaginellites*, from the Upper Cretaceous coals of western Greenland. *Journal of the Washington Academy of Sciences*, 22(18/19):497-506.
- Miner, E.L., 1935. Paleobotanical examinations of Cretaceous and Tertiary coals: 1, Cretaceous coals from Greenland, 2, Cretaceous and Tertiary coals from Montana. *American Midland Naturalist*, 16(4):586-625.
- Molenaar, C.M. and Wilson, B.W., 1990. The Frontier Formation and associated rocks of northeastern Utah and northwestern Colorado. U.S. Geological Survey, Bulletin 1787, 21 p.
- Morgan, R., 1975. Some Early Cretaceous organic-walled microplankton from the Great Australian Basin, Australia. *Royal Society of New South Wales, Journal and Proceedings*, 108:157-167.
- Morgan, R., 1980. Palynostratigraphy of the Australian Early and middle Cretaceous. *Geological Survey of New South Wales, Palaeontology Memoir*, 18:1-153.
- Mtchedlishvili, N.D. and Samoilovitch, S.R., 1960. New species of angiosperms. In *New Species of Plants and Invertebrates of the U.S.S.R.* All-Union Scientific Research Geological Institute (U.S.E.G.E.I.), Government Technical Geology Publishers, Moscow, 1:127-134.
- Muller, J., 1959. Palynology of recent Orinoco Delta and shelf sediments: reports of the Orinoco Shelf Expedition. *Micropaleontology*, 5:1-32.
- Naumova, S.N., 1939. Spores and pollen of the coals of the U.S.S.R. *Transactions of the 17th Geological Congress, Moscow*, 1:355-366 (in Russian).

- Naumova, S.N., 1953. Sporo-pollen complexes of the Upper Devonian from the Russian platform and their stratigraphic value. *Trudy Instituta Geologicheskikh Nauk, Akademiya Nauk, U.S.S.R.* 143, *Geologicheskaya Seriya* 60:10154.
- Neale, J.W. and Sarjeant, W.A.S., 1962. Microplankton from the Speeton Clay of Yorkshire. *Geological Magazine*, 99:439-458.
- Newman, K.R., 1961. Micropaleontology and stratigraphy of Late Cretaceous and Paleocene formations, northwestern Colorado. Unpublished Ph.D. thesis, University of Colorado, Boulder, Colorado.
- Newman, K.R., 1964. Palynologic correlations of Late Cretaceous and Paleocene Formations, northwestern Colorado. In Cross, A.T., editor, *Palynology in Oil Exploration*, Society of Economic Paleontologists and Mineralogists, Special Publication No. 11, p. 169-180.
- Newman, K.R., 1965. Upper Cretaceous--Paleocene guide palynomorphs from northwestern Colorado. *University of Colorado Studies, Series in Earth Science* No. 2, 21 p.
- Newman, K.R., 1972. A review of Jurassic, Cretaceous, and Paleocene stratigraphic palynology in Montana. *Montana Geological Society, 21st Annual Field Conference Guidebook*, p. 81-84.
- Newman, K.R., 1987. Biostratigraphic correlation of Cretaceous-Tertiary boundary rocks, Colorado to San Juan Basin, New Mexico. *Geological Society of America, Special Paper*, 209:151-164.
- Nichols, D.J., 1983. Problems in correlation of Upper Cretaceous palynomorph zones of the North American Western Interior and Atlantic margin [abstract]. *Palynology*, 7:244-245.
- Nichols, D.J., Ames, H.T. and Traverse, A., 1973. On *Arecipites* Wodehouse, *Monocolpopollenites* Thomson & Pflug, and the species "*Monocolpopollenites tranquillius*". *Taxon*, 22(2/3):241-256.
- Nichols, D.J. and Jacobson, S.R., 1982a. Palynostratigraphic framework for the Cretaceous (Albian-Maestrichtian) of the overthrust belt of Utah and Wyoming. *Palynology*, 6:119-147.
- Nichols, D.J. and Jacobson, S.R., 1982b. Cretaceous biostratigraphy in the Wyoming thrust belt. *Mountain Geologist*, 19(3):73-78.
- Nichols, D.J., Jacobson, S.R. and Tschudy, R.H., 1983. Cretaceous palynomorph biozones for the central and northern Rocky Mountain region of the United States. In Powers, R.B., editor, *Geologic Studies of the Cordilleran Thrust Belt: Denver, Colorado*, Rocky Mountain Association of Petroleum Geologists, p. 721-733.

- Nichols, D.J., Jarzen, D.M., Orth, C.J. and Oliver, P.Q., 1986. Palynological and iridium anomalies and Cretaceous-Tertiary boundary, south-central Saskatchewan. *Science*, 231:-714-717.
- Nichols, D.J., Perry, W.J., Jr. and Haley, J.C., 1985. Reinterpretation of the palynology and age of Laramide syntectonic deposits, southwestern Montana, and revision of the Beaverhead Group. *Geology*, 13(2):149-153.
- Nichols, D.J. and Warner, M.A., 1978. Palynology, age, and correlation of the Wanship Formation and their implications for the tectonic history of northeastern Utah. *Geology*, 6(7):430-433.
- Nilsson, T., 1958. Über das Vorkommen eines mesozoischen sapropelgesteins in Schonen. *Lunds Univesitets Arsskrift*, N.F., Avd. 2, 54(10):1-111.
- Nixon, R.P., 1973. Oil source beds in Cretaceous Mowry Shale of northwestern interior United States. *American Association of Petroleum Geologists, Bulletin*, 57(1):136-161.
- Nøhr-Hansen, H. and McIntyre, D.J., 1990. Stratigraphic correlation of mid-Cretaceous dinoflagellate cyst assemblages from east Greenland and Arctic Canada [abstract]. *Palynology*, 14:216.
- North American Commission on Statigraphic Nomenclature, 1983. North American Stratigraphic Code. *American Association of Petroleum Geologists, Bulletin*, 67(5):841-875.
- Norris, G., 1967. Spores and pollen from the lower Colorado Group (Albian-?Cenomanian) of central Alberta. *Palaeontographica*, 120B:72-115.
- Norris, G., 1969. Miospores from the Purbeck Beds and marine Upper Jurassic of southern England. *Palaeontology*, 12(4):574-620.
- Norris, G., 1982. Mesozoic palynology of the Moose River Basin. In Telford, P.G. and Verma, H.M., editors, *Mesozoic Geology and Mineral Potential of the Moose River Basin*, Ontario Geological Survey Study, 21:93-133.
- Norris, G., Jarzen, D.M and Awai-Thorne, B.V., 1975. Evolution of the Cretaceous terrestrial palynoflora in western Canada. In Caldwell, W.G.E., editor, *The Cretaceous System in the Western Interior of North America*, Geological Association of Canada, Special Paper, 13:333-364.
- Norris, G. and Sarjeant, W.A.S., 1965. A descriptive index to genera of fossil Dinophyceae and Acritarcha. *New Zealand Geological Survey, Paleontological Bulletin*, 40:1-70.
- Norris, G., Telford, P.G. and Vos, M.A., 1976. An Albian microflora from the Mattagami Formation, James Bay Lowlands, Ontario. *Canadian Journal of Earth Science*, 13:400-403.

- Norton, N.J. and Hall, J.W., 1967. Guide sporomorphae in the Upper Cretaceous-Lower Tertiary of eastern Montana (U.S.A.). *Review of Palaeobotany Palynology*, 2:99-110.
- Norton, N.J. and Hall, J.W., 1969. Palynology of the Upper Cretaceous and Lower Tertiary in the type locality of the Hell Creek Formation, Montana, U.S.A. *Palaeontographica*, 125A:1-64.
- Norvick, M.S. and Burger, D., 1976. Palynology of the Cenomanian of Bathurst Island, Northern Territory, Australia. Bureau of Mineral Resources, Australia, Bulletin 151, 169 p.
- O'Boyle, C.C., 1955. The Cretaceous rocks of northwest Colorado. Rocky Mountain Association of Petroleum Geologists, p. 32-35.
- Obradovich, J.D. and Cobban, W.A., 1975. A time-scale for the Late Cretaceous of the Western Interior of North America. In Caldwell, W.G.E., editor, *The Cretaceous System in the Western Interior of North America*, Geological Association of Canada Special Paper, 13:31-54.
- Orlansky, R., 1971. Palynology of the Upper Cretaceous Straight Cliffs Sandstone, Garfield County, Utah. *Utah Geological and Mineral Survey Bull.* 89, 57 p.
- Orloci, L., 1978. *Multivariate Analysis in Vegetation Research*, 2nd Edition. W. Junk, Boston, Massachusetts.
- Pacitová, B., 1971. Palynological study of Angiospermae from the Peruc Formation (?Albian-Lower Cenomanian) of Bohemia. *Sbornik Geologických Věd, Paleontologie*, P, 13:105-141.
- Pannella, G., 1966. Palynology of the Dakota Group and Graneros Shale of the Denver Basin. Unpublished Ph.D. thesis, University of Colorado, Boulder, Colorado, 173 p.
- Pant, D.D., 1954. Suggestions for the classification and nomenclature of fossil spores and pollen grains. *Botanical Review*, 20:33-60.
- Patterson, R.T. and Fishbain, E., 1989. Re-examination of the statistical methods used to determine the number of point counts needed for micropaleontological quantitative research. *Journal of Paleontology*, 63(2):245-248.
- Paull, R.A., 1962. Depositional history of the Muddy Sandstone, Big Horn Basin, Wyoming. Wyoming Geological Association, 17th Annual Field Conference Guidebook, p. 102-117.
- Penny, J.S., 1969. Late Cretaceous and early Tertiary palynology. In Tschudy, R.H. and Scott, R.A., editors, *Aspects of Palynology*, p. 331-376.
- Peterson, F. and Ryder, R.T., 1975. Cretaceous rocks in the Henry Mountains region, Utah and their relation to neighboring regions. In Fassett, J.E., editor, *Canyonlands*

Country, Four Corners Geological Society, 8th Annual Field Conference Guidebook, p. 167-189.

- Peterson, F., Ryder, R.T. and Law, B.E., 1980. Stratigraphy, sedimentology, and regional relationships of the Cretaceous system in the Henry Mountains region, Utah. In Picard, M.D., editor, Henry Mountains Symposium, Utah Geological Association, p. 152-170.
- Pflug, H.H., 1953. Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte. *Palaeontographica*, 95B:60-171.
- Phillips, P.P. and Felix, C.J., 1971a. A study of Lower and Middle Cretaceous spores and pollen from the southeastern United States. I. Spores. *Pollen et Spores*, 13(2):279-348.
- Phillips, P.P. and Felix, C.J., 1971b. A study of Lower and Middle Cretaceous spores and pollen from the southeastern United States. II. Pollen. *Pollen et Spores*, 13(3):447-473.
- Pielou, E.C., 1969. *An Introduction to Mathematical Ecology*. Wiley-Interscience, New York.
- Pielou, E.C., 1984. *The Interpretation of Ecological Data*. Wiley-interscience, New York, 263 p.
- Pierce, R.L., 1961. Lower Upper Cretaceous plant microfossils from Minnesota. *Minnesota Geological Survey, Bulletin* 42, 86 p.
- Playford, G., 1971. Palynology of Lower Cretaceous (Swan River) strata of Saskatchewan and Manitoba. *Palaeontology*, 14(4):533-565.
- Playford, G. and Dettman, M.E., 1965. Rhaeto-Liassic plant microfossils from the Leigh Green Coal Measures, South Australia. *Senckenbergiana Lethaea*, 46:127-281.
- Pocock, S.A.J., 1962. Microfloral analysis and age determination of strata at the Jurassic-Cretaceous boundary in the western Canadian plains. *Palaeontographica*, 111B:1-195.
- Pocock, S.A.J., 1964. Pollen and spores of the Chlamydospermidae and Schizaeaceae from upper Mannville strata of the Saskatoon area of Saskatchewan. *Grana Palynologica*, 5(2):129-209.
- Pocock, S.A.J., 1967. The Jurassic-Cretaceous boundary in northern Canada. Review of Palaeobotany and Palynology, 5:129-136.
- Pocock, S.A.J., 1970. Palynology of the Jurassic sediments of western Canada. Part I, terrestrial species. *Palaeontographica*, 130B:12-136.

- Pocock, S.A.J., 1976. A preliminary dinoflagellate zonation of the uppermost Jurassic and lower part of the Cretaceous, Canadian Arctic, and possible correlation in the western Canada Basin. *Geoscience and Man*, 15:101-114.
- Pocock, S.A.J., 1980. The Aptian-Albian boundary in Canada. IV International Palynological Conference, Lucknow (1976-1977), 2:419-424.
- Potonié, R., 1931a. Zur Mikroskopie der Braunkohlen. I. *Zeitschrift Braunkohlen*, 30(16):325-333.
- Potonié, R., 1931b. Pollenformen der miozänen Braunkohlen. II. *Gesellschaft Naturforschender Freunde zu Berlin, Sitzungsberichte*, no. 1-3, p. 24-28.
- Potonié, R., 1931c. Pollenformen aus tertiären Braunkohlen. III. *Preussischen Geologischen Landesanstalt*, 52:1-7.
- Potonié, R., 1931d. Zur Mikroskopie der Braunkohlen Tertiary Sporen - und Blütenstaubformen. IV. *Zeitschrift für Gewinnung und Verwertung der Braunkohle*, 30(27):554-556.
- Potonié, R., 1934a. Zur Morphologie der fossilen Pollen und Sporen. *Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennstoffe, Arbeiten*, 4:5-24.
- Potonié, R., 1934b. Zur Mikrobiologie des eozänen Humodils des Geiseltals. *Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennstoffe, Arbeiten*, 4:25-125.
- Potonié, R., 1951a. Pollen- und Sporenformen als Leitfossilien des Tertiärs. *Mikroskopie*, 6:272-383.
- Potonié, R., 1951b. Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs. *Palaeontographica*, 91B:131-151.
- Potonié, R., 1956. Synopsis der Gattungen der Sporae dispersae. Teil I. Sporites. *Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte*, 23:1-103.
- Potonié, R., 1958. Synopsis der Gattungen der Sporae dispersae. Teil II. Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. *Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte*, 31:114.
- Potonié, R., 1960. Synopsis der Gattungen der Sporae dispersae. Teil III. Nachträge Sporites, Fortsetzung Pollenites mit Generalregister. *Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte*, 39:1-189.
- Potonié, R. and Gellertich, J., 1933. Über Pteridophyten-Sporen einer eozänen Braunkohle aus Dorog in Ungarn. *Gesellschaft Naturforschender Freunde zu Berlin Sitzungsberichte*, 33:517-528.

- Potonié, R., Ibrahim, A. and Loose, F., 1932. Sporenformen aus den Flozen Agir und Bismarck des Ruhrgebietes. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage-Band*, 67B:438-454.
- Potonié, R. and Kremp, G., 1954. Die Gattungen der palaozoischen Sporae dispersae und ihre Stratigraphie. *Geologisches Jahrbuch*, 69:111-194.
- Potonié, R. and Kremp, G., 1956. Die Sporae dispersae des Ruhrkarbons. Ihre Morphographie und Stratigraphie mit Ausblicken auf Arten andere Gebiete und Zeitabschnitte. *Palaeontographica*, 100B:65-121.
- Potonié, R., Thomson, P.W. and Thiergart, F., 1950. Zur Nomenklatur und Klassifikation der neogenen Sporomorphae (Pollen und Sporen). *Geologisches Jahrbuch*, 65:53-70.
- Potonié, R. and Venitz, 1934. Zur Mikrobotanik des miozanen Humodils der niederrheinischen Bucht. *Preussischen Geologischen Landesanstalt, Institut für Palaobotanik und Petrographie der Brennsteine Arbeiten*, 5:1-54.
- Potter, D.R., 1963. An emendation of the sporomorph *Arcellites* Miner, 1935. *Oklahoma Geological Notes*, 23(9):227-230.
- Pourtoy, D., 1988. Le genre *Aprobolocysta* Duxbury, 1977, emend.: révision et comparaison avec le genre *Batioladinium* Brideaux, 1975, emend. *Bulletin des Centres de Recherche Exploration-Production Elf-Aquitaine*, 12(1):383-403.
- Prentice, I.C., 1980. Multidimensional scaling as a research tool in Quaternary palynology: A review of theory and methods. *Review of Palaeobotany and Palynology*, 31:71-104.
- Raatz, G., 1937. Mikrobotanisch-Stratigraphische Untersuchung der Braunkohle de Muskauer Bogens. *Abhandlung, Preussische Geologische Landesanstalt, Heft 183*, 48 p.
- Ravn, R.L., 1981. Preliminary observations on the palynology of upper Dakota lignites in northwest Iowa and northeast Nebraska. In Brenner, R.L., et al. (editors), *Cretaceous stratigraphy and sedimentation in northwest Iowa, northeast Nebraska, and southeast South Dakota*, Iowa Geological Survey, Guidebook Series, No. 4, p. 123-127.
- Ravn, R.L., 1986. *Microreticulatisporites sacalii* (Deák and Combaz) n. comb., a stratigraphically significant miospore from the Cenomanian of the United States. *Journal of Paleontology*, 60(3):772-777.
- Ravn, R.L., 1987. *Montiapollis* n. gen., possible Portulacaceae pollen from the Cenomanian of Iowa. *Grana*, 26:243-247.

- Ravn, R.L. and Whitley, D.L., 1982. Palynology of upper Dakota Formation lignites from northwestern Iowa and northeastern Nebraska [abstract]. *Palynology* 6:289-290.
- Reeside, J.B., Jr., 1955. Revised interpretation of the Cretaceous section on Vermilion Creek, Moffat County, Colorado. In Green River Basin, Wyoming Geological Association, 10th Annual Field Conference Guidebook, p. 85-88.
- Reeside, J.B., Jr. and Cobban, W.A., 1960. Studies of the Mowry Shale (Cretaceous) and contemporary formations in the United States and Canada. U.S. Geological Survey, Professional Paper 355, 126 p.
- Reissinger, A., 1938 (1940). Die "Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der Geologischen Vergangenheit. *Paleontographica*, 84B:1-20
- Reissinger, A., 1950. Die "Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der Geologischen Vergangenheit, II. *Palaeontographica*, 90B:99-126.
- Rich, F.J., Kuehn, D. and Davies, T.D., 1982. The paleoecological significance of *Ovoidites*. *Palynology*, 6:19-28.
- Richter, B.E., 1983. Stratigraphy of the Frontier Sandstone (Upper Cretaceous) Vernal area, Uintah County, Utah. Unpublished Master's thesis, Colorado School of Mines, Golden, Colorado, 84 p.
- Riley, L.A. and Fenton, J.P.G., 1984. Palynostratigraphy of the Berriasian to Cenomanian sequence at Deep Sea Drilling Project Site 535, Leg 77, Southeastern Gulf of Mexico. Initial Reports of the Deep Sea Drilling Project, 77:675-690.
- Robbins, E.I. and J.A. Doyle. 1977. Cretaceous palynostratigraphy of four deep wells in the Salisbury Embayment on the Atlantic Coastal Plain [abstract]. *Palynology*, 1:176.
- Roberts, A.E., 1965. Correlation of Cretaceous and lower Tertiary rocks near Livingston, Montana, with those in other areas of Montana and Wyoming. U.S. Geological Survey, Professional Paper, 525-B:54-63.
- Robertson, E.B., 1973. *Marsypiletes cretacea* gen. and sp. nov. from the Hell Creek Formation (Maestrichtian) Montana, U.S.A., *Pollen et Spores*, 15(3/4):511-514.
- Romans, R.C., 1972. Schizaeaceous fern spores from the Cretaceous of Arizona. *Arizona Academy of Science*, 7(3):120-124.
- Romans, R.C., 1975. Palynology of some Upper Cretaceous coals of Black Mesa, Arizona. *Pollen et Spores*, 17(2):273-329.
- Ross, N.E., 1949. On a Cretaceous pollen and spore-bearing clay deposit of Scania. *Geological Institutions, University of Uppsala, Bulletin*, 34:25-43.

- Rouse, G.E., 1959. Plant microfossils from Kootenay coal-measures strata of British Columbia. *Micropaleontology*, 5(3):303-324.
- Rouse, G.E., 1962. Plant fossils from the Burrard Formation of western British Columbia. *Micropaleontology*, 8:187-218.
- Rouse, G.E. and Srivastava, S.K., 1972. Palynological zonation of Cretaceous and early Tertiary rocks of the Bonnet Plume Formation, northeastern Yukon, Canada. *Canadian Journal of Earth Science*, 9(9):1163-1179.
- Rubey, W.W., 1929. Origin of the siliceous Mowry Shale of the Black Hills Region. U.S. Geological Survey, Professional Paper, 154-D:153-170.
- Rushforth, S.R., 1971. A flora from the Dakota Sandstone formation (Cenomanian) near Westwater, Grand County, Utah. *Brigham Young University Science Bulletin, Biological Series*, 14(3):1-44.
- Ryder, R.T. and Ames, H.T., 1970. Palynology and age of Beaverhead Formation and their paleotectonic implications in Lima region, Montana-Idaho. *American Association of Petroleum Geologists, Bulletin*, 54(7):1155-1171.
- Ryder, R.T. and Ames, H.T., 1971. The palynology and age of the Beaverhead Formation and their paleotectonic implications in the Lima region, Montana-Idaho [abstract]. *Geoscience and Man*, 3:97.
- Ryer, T.A., 1977a. Age of Frontier Formation in north-central Utah. *American Association of Petroleum Geologists, Bulletin*, 61(1):112-116.
- Ryer, T.A., 1977b. Patterns of Cretaceous shallow-marine sedimentation, Coalville and Rockport areas, Utah. *Geological Society of America, Bulletin*, 88:177-188.
- Ryer, T.A., 1981a. The Muddy and Quichupah projects: A progress report with descriptions of cores of the I, J, and C coal beds from the Emery coal field, central Utah. U.S. Geological Survey, Open File Report 81-460.
- Ryer, T.A., 1981b. Deltaic coals of the Ferron Sandstone Member of the Mancos Shale: Predictive model for Cretaceous coal-bearing strata of the Western Interior. *American Association of Petroleum Geologists, Bulletin*, 65(11):2323-2340.
- Ryer, T.A., 1981c. Eustatic control of distribution of lower Upper Cretaceous coal beds in Utah: Application in coal exploration [abstract]. *American Association of Petroleum Geologists, Bulletin*, 65(2):984.
- Ryer, T.A., 1982a. Cross-section of the Ferron Sandstone Member of the Mancos Shale in the Emery coal field, Emery and Sevier Counties, central Utah. U.S. Geological Survey, Miscellaneous Field Studies Map MF-1357.

- Ryer, T.A., 1982b. Possible eustatic control on the location of Utah Cretaceous coal fields. In Gurgel, K.D., editor, *Proceedings of the 5th Symposium on the Geology of Rocky Mountain Coal*, Utah Geological and Mineral Survey, Bulletin, 118:89-93.
- Ryer, T.A., 1983. Transgressive-regressive cycles and the occurrence of coal in some Upper Cretaceous strata of Utah. *Geology*, 11:207-210.
- Ryer, T.A. and Langer, A.W., 1980. Thickness change involved in the peat-to-coal transformation for a bituminous coal of Cretaceous age in central Utah. *Journal of Sedimentary Petrology*, 50(3):987-992.
- Ryer, T.A. and Lovekin, J.R., 1986. Upper Cretaceous Vernal Delta of Utah -- depositional or paleotectonic feature? [abstract]. *American Association of Petroleum Geologists, Bulletin*, 69(5):864.
- Ryer, T.A. and McPhillips, M., 1983. Early Late Cretaceous paleogeography of east-central Utah. In Reynolds, M.W. and Dolly, E.D., editors, *Mesozoic Paleogeography of West-Central United States*. Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, Denver, Colorado, p. 253-272.
- Sah, S.C.D., Kar, R.K. and Singh, R.Y., 1970. Fossil microplankton from the Langpar Formation of Therriaghat, south Shillong Plateau, Assam, India. *Palaeobotanist*, Lucknow, 18:143-150.
- Salujha, S.K. and Kindra, G.S., 1981. Palynological fossils from the Langpar Formation exposed along South Shillong front, Meghalaya, India. *Geosciences Journal*, 2:43-62.
- Samoilovitch, S.R. *et al.*, 1961. Pollen and spores of western Siberia, Jurassic-Paleocene. *Transactions of the All-Union Petroleum Science Research and Geological Exploration Institute (U.N.I.G.R.I.)*, 177:1-657 (in Russian).
- Sarjeant, W.A.S., 1959. Microplankton from the Cornbrash of Yorkshire. *Geological Magazine*, 96:329-346.
- Sarjeant, W.A.S., 1970. The genus *Spiniferites* Mantell, 1850 (Dinophyceae). *Grana*, 10:74-78.
- Sarjeant, W.A.S., 1985. The German Aptian dinoflagellate cysts of Eisenack (1958): a re-study. *Review of Palaeobotany and Palynology*. 45:47-106.
- Sarmiento, R., 1957. Microfossil zonation of the Mancos Group. *American Association of Petroleum Geologists, Bulletin*, 41:1683-1693.
- Schemel, M.P., 1950. Cretaceous plant microfossils from Iowa. *American Journal of Botany*, 37:750-754.

- Schopf, J.M., Wilson, L.R. and Bentall, R., 1944. An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. Illinois State Geological Survey, Report of Investigations, 91:1-73.
- Schulz, E., 1962. Sporenpaläontologische Untersuchungen sur Rhat-Lias-Grenze in Thuringen und der Altmark. Geologie, 11:308-319.
- Schulz, E., 1967. Sporenpaläontologische Untersuchungen ratoliassischer Schichten im Zentralteil des Germanischen Beckens. Palaontologische Abh., 28:543-644.
- Schwab, K.W., 1977. Palynology of the lower Thermopolis and Cloverly Formations (Albian), Gros Ventre Mountains, Wyoming [abstract]. Palynology, 1:176.
- Scott, L. and Srivastava, S.K., 1984. Reworked Cretaceous palynomorphs in late Quaternary deposits from central Colorado. Pollen et Spores, 26(2):227-240.
- Selling, O.H., 1944. Studies in the Recent and fossil species of *Schizaea*, with particular reference to their spore characters. Meddelanden fran Götensborgs Botaniska Trädgård, 16:1-113.
- Seward, A.C., 1914. Antarctic fossil plants. British Museum (Natural History) British Antarctic (Terra Nova) Expedition, 1910, Natural History Report, Geology, 1(1):1-49.
- Shaw, A.B., 1964. Time in Stratigraphy. McGraw-Hill, New York, 365 p.
- Simoncsics, P. and Kedves, M., 1961. Palaeobotanical examinations on Manganese Series in Urkut (Hungary, Transdanubia). Acta Mineralogica - Petrographica, Univ. Szeged, 16:3-48.
- Singh, C., 1964. Microflora of the Lower Cretaceous Mannville Group, east-central Alberta. Research Council of Alberta, Bulletin 15, 239 p.
- Singh, C., 1971. Lower Cretaceous microfloras of the Peace River area, northwestern Alberta. Research Council of Alberta, Bulletin 28, 542 p.
- Singh, C., 1975. Stratigraphic significance of early angiosperm pollen in the mid-Cretaceous strata of Alberta. In Caldwell, W.G.E., editor, The Cretaceous System in the Western Interior of North America. Geological Association of Canada Special Paper, 13:365-389.
- Singh, C., 1983. Cenomanian microfloras of the Peace River area, northwestern Alberta. Alberta Research Council, Bulletin 44, 322 p.
- Skarby, A., 1978. Optical properties of fossil *Schizaea* spores from the Upper Cretaceous of Scania. Grana, 17(2):111-123.

- Slaughter, M. and Earley, J.W., 1965. Mineralogy and geological significance of the Mowry bentonites, Wyoming. Geological Society of America, Special Paper 83, 116 p.
- Sneath, D.H. and Sokal, R.R., 1973. Numerical Taxonomy - the principles and practice of numerical classification. W.H. Freeman and Co., San Francisco, 573 p.
- Spicer, R.A. and Hill, C.R., 1979. Principle components and correspondence analysis of quantitative data from a Jurassic plant bed. Review of Palaeobotany and Palynology, 28:273-299.
- Spieker, E.M., 1949. Sedimentary facies and associated diastrophism in the Upper Cretaceous of central and eastern Utah. Geological Society of America Memoir, 39:55-82.
- Spieker, E.M. and Reeside, J.B., Jr., 1925. Cretaceous and Tertiary formations of the Wasatch Plateau, Utah. Geological Society of America, Bulletin, 38:435-454.
- Springer, D.A. and Bambach, R.K., 1985. Gradient versus cluster analysis of fossil assemblages: A comparison from the Ordovician of southwestern Virginia. Lethaia, 18(3):181-198.
- Srivastava, S.K., 1966. Upper Cretaceous microflora (Maestrichtian) from Scollard, Alberta, Canada. Pollen et Spores, 8(3):497-552.
- Srivastava, S.K., 1967. Upper Cretaceous palynology -- A review. Botanical Review, 33(3):260-288.
- Srivastava, S.K., 1968. Fungal elements from the Edmonton Formation (Maestrichtian), Alberta, Canada. Canadian Journal of Botany, 46:1115-1118.
- Srivastava, S.K., 1969a. Pollen genus *Wodehousea* and its stratigraphic significance in the Edmonton Formation (Maestrichtian), Alberta, Canada. Canadian Journal of Earth Science, 6:1307-1311.
- Srivastava, S.K., 1969b. Upper Cretaceous proteaceous pollen from the Edmonton Formation, Alberta (Canada) and their paleoecologic significance. Canadian Journal of Botany, 47:1571-1578.
- Srivastava, S.K., 1972. Systematic description of some spores from the Edmonton Formation (Maestrichtian), Alberta, Canada. Palaeontographica, 139B:1-46.
- Srivastava, S.K., 1975a. Maestrichtian microspore assemblages from the interbasaltic lignites of Mull, Scotland. Palaeontographica, 150B:125-156.
- Srivastava, S.K., 1975b. Microspores from the Fredricksburg Group (Albian) of the southern United States. Paleobiologie Continentale, 6(2):1-119.

- Srivastava, S.K., 1981. Stratigraphic ranges of selected spores and pollen from the Fredericksburg Group (Albian) of the southern United States. *Palynology*, 5:1-28.
- Stanley, E.A., 1965. Upper Cretaceous and Paleocene plant microfossils and Paleocene dinoflagellates and hystrichosphaerids from northeastern South Dakota. *Bulletins of American Paleontology*, 49(222):179-384.
- Stanley, E.A., 1967. Cretaceous pollen and spore assemblages from northern Alaska. *Review of Palaeobotany and Palynology*, 1:229-234.
- Staplin, F.L., 1961. Reef-controlled distribution of Devonian microplankton in Alberta. *Paleontology*, 4(3):392-424.
- Steeves, M.B., 1959. The pollen and spores of the Raritan and Magothy Formations (Cretaceous) of Long Island. Unpublished Ph.D. thesis, Radcliffe College, Cambridge, Massachusetts, 237 p.
- Steeves, W.W. and Wilkins, L.R., 1967. Spores and pollen from the Lower Cretaceous of Saskatchewan, Canada. *Canadian Journal of Botany*, 45:2329-2365.
- Stein, J.A., Ravn, R.L. and Wood, G.D., 1987. Biostratigraphy of Albian-Cenomanian boundary in Texas and implications for middle Cretaceous stratigraphy elsewhere in North America [abstract]. *American Association of Petroleum Geologists, Bulletin*, 71(2):243.
- Stokes, W.L., 1944. Morrison Formation and related deposits in and adjacent to the Colorado Plateau: Geological Society of America, *Bulletin*, 55(8):951-992.
- Stokes, W.L., 1952. Lower Cretaceous in the Colorado Plateau. *American Association of Petroleum Geologists, Bulletin*, 36(9):1766-1776.
- Stokes, W.L., Peterson, J.A. and Picard, M.D., 1955. Correlation of Mesozoic formations of Utah. *American Association of Petroleum Geologists, Bulletin*, 39:2003-2019.
- Stokes, W.L. and Phoenix, D.A., 1948. Geology of the Egnar-Gypsum Valley area, San Miguel and Montrose Counties, Colorado. U.S. Geological Survey, Oil and Gas Investigations Preliminary Map 93.
- Stone, J.F., 1967. Quantitative palynology of a Cretaceous Eagle Ford exposure. *The Compass, Sigma Gamma Epsilon*, 45(1):17-25.
- Stone, J.F., 1971. Palynology of the Almond Formation (Upper Cretaceous), Rock Springs Uplift, Wyoming. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 190 p.
- Stone, J.F., 1973. Palynology of the Almond Formation (Upper Cretaceous), Rock Springs Uplift, Wyoming. *Bulletins of American Paleontology*, 64(278):1-135.

- Stover, L.E., 1962. *Tauropusporites*, a new trilete spore genus from the Lower Cretaceous of Maryland. *Micropaleontology*, 8(1):55-59.
- Stover, L.E., 1964. Comparison of three Cretaceous spore-pollen assemblages from Maryland and England. In Cross, A.T., editor, *Palynology in Oil Exploration*, Society of Economic Paleontologists and Mineralogists, Special Publication, 11:143-152.
- Stover, L.E. and Evitt, W.R., 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. Stanford University Publications, Geological Sciences, 15:1-300.
- Sulkoske, W.C., 1975. Cretaceous microplankton assemblages from the Albian to Campanian of Wyoming. Unpublished M.S. thesis, University of Arizona, Tucson, Arizona, 75 p.
- Sweet, A.R., 1979. Jurassic and Cretaceous megaspores. In Brideaux, W.W., editor, *Contributions of Stratigraphic Palynology (with emphasis on North America)*, Volume 2: Mesozoic Palynology. American Association of Stratigraphic Palynologists Contribution Series, 5B:1-30.
- Taff, J.A., 1906. Book Cliffs coal field, Utah, west of Green River. U.S. Geological Survey, Bulletin, 285:289-302.
- Taggart, R.E. and Cross, A.T., 1980. Vegetation change in the Miocene Succor Creek flora of Oregon and Idaho: A case study in paleosuccession. In Dilcher, D.L. and Taylor, T.N., editors, *Biostratigraphy and fossil plants - Successional and paleoecological analyses*. Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania, p. 185-210.
- Taggart, R.E., Cross, A.T. and Satchell, L., 1982. Effects of periodic volcanism on Miocene vegetation distribution in eastern Oregon and western Idaho. Third North American Paleontological Convention, Proceedings, 2:535-540.
- Tasch, P., McClure, K. and Oftedahl, O., 1964. Biostratigraphy and taxonomy of a hystrichosphere-dinoflagellate assemblage from the Cretaceous of Kansas. *Micropaleontology*, 10(2):189-206.
- Telford, P.G. and Verma, H.M., 1982. Mesozoic Geology and Mineral Potential of the Moose River Basin. Ontario Geological Survey, Study 21, 193 p.
- Thayn, G.F. and Tidwell, W.D., 1984a. A review of the genus *Paraphyllanthoxylon*. *Review of Palaeobotany and Palynology*, 43:321-335.
- Thayn, G.F. and Tidwell, W.D., 1984b. Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado, Part II. *Mesembrioxylon stokesi*. *Great Basin Naturalist*, 44(2):257-262.

- Thayn, G.F., Tidwell, W.D. and Stokes, W.L., 1973. Petrified angiosperm wood from the Lower Cretaceous Cedar Mountain Formation of Utah [abstract]. Geological Society of America, Abstracts with Programs, 5(6):519.
- Thayn, G.F., Tidwell, W.D. and Stokes, W.L., 1983. Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado, Part I. *Paraphyllanthoxylon utahense*. Great Basin Naturalist, 43(3):394-402.
- Thayn, G.F., Tidwell, W.D. and Stokes, W.L., 1985. Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado, Part III. *Isacinoxylon pittense* n. sp. American Journal of Botany, 72(2):175-180.
- Thiergart, F.G., (1937) 1938. Die Pollenflora der Niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Senftenberg. Jahrbuch, Preussische Geologische Landesanstalt, 58:282-351.
- Thiergart, G., 1949. Der stratigraphische Wert mesozoischer Pollen und Sporen. Palaeontographica, 89B:1-34.
- Thomson, P.W. and Pflug, H., 1953. Pollen und Sporen des Mitteleuropaischen Tertiars. Palaeontographica, 94B:1-138.
- Thompson, G.G., 1969. Paleoecology of palynomorphs in the Mancos Shale, southwestern Colorado. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 169 p.
- Thompson, G.G., 1972. Palynologic correlation and environmental analysis within the marine Mancos Shale of southwestern Colorado. Journal of Sedimentary Petrology, 42(2):287-300.
- Thompson, S.L., 1985. Ferron Sandstone Member of the Mancos Shale: A Turonian mixed-energy deltaic system. Unpublished M.S. thesis, University of Texas, Austin, Texas, 164 p.
- Thusu, B., 1968. Angiosperm microflora of the Dunvegan Formation (upper Cenomanian) Peace River, Alberta, Canada [abstract]. Geological Society America, Special Paper, 121:296.
- Tidwell, W.D. and Herbert, N.E., 1976. *Tempskya* from the Lower Cretaceous Cedar Mountain Formation of Utah [abstract]. American Journal of Botany, Abstracts, 63:33.
- Tidwell, W.D., Thayn, G.F. and Roth, J.L., 1976. Cretaceous and early Tertiary floras of the Intermountain area. Brigham Young University Geology Studies, 22:77-98.
- Tingey, J.C., 1978. Palynology of the Lower Cretaceous Bear River Formation in the overthrust belt of southwestern Wyoming. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 167 p.

- Traverse, A. and Ginsburg, R.N., 1966. Palynology of the surface sediments of Great Bahama Bank, as related to water movement and sedimentation. *Marine Geology*, 4(6):417-435.
- Tschudy, B.D., 1973. Palynology of the Upper Campanian (Cretaceous) Judith River Formation, north-central Montana. U.S. Geological Survey, Professional Paper 770, 42 p.
- Tschudy, R.H., 1961. Palynomorphs as indicators of facies environments in Upper Cretaceous and lower Tertiary strata, Colorado and Wyoming. Wyoming Geological Association, 16th Annual Field Conference Guidebook, p. 53-59.
- Tschudy, R.H., 1965. An Upper Cretaceous deposit in the Appalachian Mountains. U.S. Geological Survey, Professional Paper, 525-B:64-68.
- Tschudy, R.H., 1966. Associated megaspores and microspores of the Cretaceous genus *Ariadnaesporites* Potonié, 1956, emend. In Geological Survey Research 1966, U.S. Geological Survey Professional Paper, 550-D:D76-D82.
- Tschudy, R.H., 1970. Two new pollen genera (Late Cretaceous and Paleocene) with possible affinity to the Illiciaceae. U.S. Geological Survey, Professional Paper 643-F, 13 p.
- Tschudy, R.H., 1973. *Complexiopollis* pollen lineage in Mississippi embayment rocks. U.S. Geological Survey, Professional Paper 743-C, 15 p.
- Tschudy, R.H., 1975. *Normapolles* pollen from the Mississippi embayment. U.S. Geological Survey, Professional Paper 865, 42 p.
- Tschudy, R.H., 1976a. Palynology of Crevasse Canyon and Menefee Formations of San Juan Basin, New Mexico. New Mexico Bureau Mines and Mineral Resources, Circular, 154:48-58.
- Tschudy, R.H., 1976b. Stratigraphic distribution of species of the megaspore genus *Minerisporites* in North America. U.S. Geological Survey, Professional Paper 743-E, 11 p.
- Tschudy, R.H., 1980. *Normapolles* pollen from *Aquilapollenites* province, western United States. New Mexico Bureau of Mines and Mineral Resources, Circular 170, 14 p.
- Tschudy, R.H., 1981. Geographic distribution and dispersal of *Normapolles* genera in North America. *Review of Palaeobotany and Palynology*, 35:283-314.
- Tschudy, R.H., Pillmore, C.L., Orth, C.J., Gilmore, J.S. and Knight, J.D., 1984. Disruption of the terrestrial plant ecosystem at the Cretaceous-Tertiary boundary, Western Interior. *Science*, 225(4666):1030-1032.

- Tschudy, R.H. and Tschudy, B.D., 1986. Extinction and survival of plant life following the Cretaceous/Tertiary boundary event, Western Interior, North America. *Geology*, 14:667-670.
- Tschudy, R.H., Tschudy, B.D. and Craig, L.C., 1984. Palynological evaluation of Cedar Mountain and Burro Canyon Formation, Colorado Plateau. U.S. Geological Survey, Professional Paper 1281, 24 p.
- Tschudy, R.H. and Veach, S.D., 1965. Plant and miscellaneous microfossils from the Thermopolis and Mowry shales. U.S. Geological Survey, Open-File Report 65-165, 6 p.
- Tysdal, R.G., Dyman, T.S. and Nichols, D.J., 1989. Lower Cretaceous bentonitic strata in southwestern Montana assigned to Vaughn Member of Mowry Shale (east) and Blackleaf Formation (west). *Mountain Geologist*, 26(2):53-61.
- Upshaw, C.F., 1959. Palynology of the Frontier Formation, northwestern Wind River Basin, Wyoming. Unpublished Ph.D. thesis, University of Missouri, Columbia, Missouri, 458 p.
- Upshaw, C.F., 1963. Occurrence of *Aequitriradites* in the Upper Cretaceous of Wyoming. *Micropaleontology*, 9(4):427-431.
- Upshaw, C.F., 1964. Palynological zonation of the Upper Cretaceous Frontier Formation near Dubois, Wyoming. In Cross, A.T., editor, *Palynology in Oil Exploration*, Society of Economic Paleontologists and Mineralogists, Special Paper, 11:153-168.
- Uresk, J., 1979. Sedimentary environment of the Cretaceous Ferron Sandstone near Cainville, Utah. *Brigham Young University Geology Studies*, 26(2):81-100.
- Vagvolgyi, A.B. and Hills, L.V., 1969. Microflora of the Lower Cretaceous McMurray Formation, northeast Alberta. *Canadian Petroleum Geology, Bulletin*, 17(2):155-181.
- Valentine, P.C., 1984. Turonian (Eaglefordian) stratigraphy of the Atlantic Coastal Plain and Texas. U.S. Geological Survey, Professional Paper 1315, 21 p.
- Van der Hammen, T., 1954. Principos para la nomenclature palinologica sistematica. *Boletin Geol. Bogota*, 2(2):3-24.
- Venkatachala, B.S., 1966. Mesozoic operculate pollen and their morphology. *Palaeobotanist*, 15:98-101.
- Venkatachala, B.S. and Goczan, F., 1964. The spore-pollen flora of the Hungarian "Kossen facies". *Acta Geologica Academia Scientiarum, Hungary*, 8:203-228.
- Vimal, K.P., 1952. Spores and pollen from Tertiary lignites from Dandot, West Punjab (Pakistan). *Indian Academy of Science, Proceedings*, 36:135-147.

- Vozzhennikova, T.F., 1967. Fossil peridinians of the Jurassic, Cretaceous and Paleogene deposits of the U.S.S.R. *Akad. Nauk. SSSR, Sib. Otd., Inst. Geol. Geofiz., Tr.*, 347 p.
- Wall, D., Guillard, R.L.L. and Dale, B., 1967. Marine dinoflagellate cultures from resting spores. *Phycologia*, 6:83-86.
- Walton, P.T., 1944. Geology of the Cretaceous of the Uintah Basin. *Geological Society of America, Bulletin*, 55:91-130.
- Walton, P.T., 1957. Cretaceous stratigraphy of the Uinta Basin. *Intermountain Association of Petroleum Geologists, 8th Annual Field Conference Guidebook*, p. 97-101.
- Walton, P.T., 1966. Gas fields of the Wasatch Plateau. In Hamblin, W.K. and Rigby, J.K., editors, *Central Utah Coals, Utah Geological and Mineral Survey, Bulletin*, 80:341-352.
- Ward, J.V., 1986. Early Cretaceous angiosperm pollen from the Cheyenne and Kiowa Formations (Albian) of Kansas, U.S.A., *Palaeontographica*, 202B:1-81.
- Warne, J.E., Ekdale, A.A., Ekdale, S.F. and Peterson, C.H., 1976. Raw material of the fossil record. In Scott, R.W. and West, R.R., editors, *Classification of Paleocommunities*, Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania, p. 143-169.
- Weimer, R.J., 1960. Upper Cretaceous stratigraphy, Rocky Mountain area. *American Association of Petroleum Geologists, Bulletin*, 44:1-20.
- Weimer, R.J., 1983a. Relation of unconformities, tectonics, and sea-level changes, Cretaceous of Denver basin and adjacent area. In Reynolds, M.W. and Dolly, E.D., editors, *Mesozoic Paleogeography of West-Central United States*. Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, Special Publication, p. 359-376.
- Weimer, R.J., 1983b. Relation of unconformities, tectonics, and sea-level changes, Cretaceous of Western Interior, U.S.A. In Schlee, J.S., editor, *Interregional Unconformities and Hydrocarbon Accumulation*, American Association of Petroleum Geologists, Memoir, 36:7-35.
- Went, F.W., 1949. The plants of Krakatoa. *Scientific American*, 181:52-54.
- Wetzel, O., 1933a. Die in organischer Substanz erhaltenen Mikrofossilien des baltischen Kreide-Feuersteins mit einem sediment-petrographischen und stratigraphischen Anhang. *Palaeontographica*, 77A:141-188.
- Wetzel, O., 1933b. Die in organischer Substanz erhaltenen Mikrofossilien des baltischen Kreide-Feuersteins mit einem sediment-petrographischen und stratigraphischen Anhang. *Palaeontographica*, 78A:1-110.

- Wetzel, O., 1961. New microspores from Baltic Cretaceous flintstones. *Micropaleontology*, 7:337-350.
- Weyland, H. and Krieger, W., 1953. Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung für die Charakterisierung des mittleren Senons. *Palaeontographica*, 95B:6-29.
- White, H.H., 1842. On fossil Xanthidia. *Microscopical Journal*, London, 11:35-40.
- Whittaker, R.H. and Gauch, H.G., Jr., 1978. Evaluation of ordination techniques. In Whittaker, R.H., editor, *Ordination of Plant Communities*, W. Junk, The Hague, p. 277-337.
- Wiggins, V.D., 1975. The dinoflagellate Family Pareodiniaceae: a discussion. *Geoscience and Man*, 11:95-115.
- Wiggins, V.D., 1981. *Noctuiipollis* -- a new Upper Cretaceous (Campanian) pollen genus from arctic Alaska. *Grana*, 20(1):37-41.
- Wiggins, V.D., 1982. *Expressipollis striatus* n. sp. to *Anacolosidites striatus* n. sp. An Upper Cretaceous of suggested pollen aperture evolution. *Grana*, 21(1):39-49.
- Williams, D.B. and Sarjeant, W.A.S., 1967. Organic-walled microfossils as depth and shoreline indicators. *Marine Geology*, 5:389-412.
- Williams, G.D. and Stelck, C.R., 1975. Speculations on the Cretaceous palaeogeography of North America. In Caldwell, W.G.E., editor, *The Cretaceous System in the Western Interior of North America*, Geological Association of Canada, Special Paper, 13:1-20.
- Williams, G.L., 1974. Dinoflagellate and spore stratigraphy of the Mesozoic-Cenozoic offshore eastern Canada. *Geological Survey of Canada, Special Paper*, 74-30:1-81.
- Williams, G.L. and Brideaux, W.W., 1972. Palynologic analysis of cored sediments from the Grand Banks, Newfoundland [abstract]. *Geoscience and Man*, 4:136.
- Williams, G.L. and Brideaux, W.W., 1975. Palynologic analysis of Upper Mesozoic and Cenozoic of the Grand Banks, Atlantic continental margin. *Geological Survey Canada, Bulletin* 236, 162 p.
- Wilson, G.J., 1967. Microplankton from the Garden Cove Formation, Campbell Island. *New Zealand Journal of Botany*, 5:223-240.
- Wilson, L.R. and Webster, R.M., 1946. Plant microfossils from a Fort Union coal of Montana. *American Journal of Botany*, 33:271-278.

- Wingate, F.H., 1980. Plant microfossils from the Denton Shale Member of the Bokchito Formation (Lower Cretaceous, Albian) in southern Oklahoma. Oklahoma Geological Survey, Bulletin 130, 93 p.
- Wodehouse, R.P., 1933. Tertiary pollen. II. The oil shales of the Eocene Green River formation. Torrey Botanical Club Bulletin, 60(7):479-524.
- Wolfe, J.A. and Schorn, H.E., 1989. Paleoecologic, paleoclimatic, and evolutionary significance of the Oligocene Creede flora, Colorado. *Paleobiology*, 15(2):180-198.
- Yi, M.S., 1989. Palynology and paleoecology of Upper Cretaceous-lower Tertiary strata, Price River Canyon, Utah. Unpublished Ph.D. thesis, Michigan State University, East Lansing, Michigan, 348 p.
- Young, R.G., 1955. Sedimentary facies and intertonguing in the Upper Cretaceous of the Book Cliffs, Utah-Colorado. Geological Society of America, Bulletin, 66:177-201.
- Young, R.G., 1957. Late Cretaceous cyclic deposits, Book Cliffs, eastern Utah. American Association of Petroleum Geologists, Bulletin, 41(8):1760-1774.
- Young, R.G., 1960. Dakota Group of Colorado Plateau. American Association of Petroleum Geologists, Bulletin, 44(2):156-194.
- Young, R.G., 1966. Stratigraphy of coal-bearing rocks of the Book Cliffs, Utah-Colorado. In Central Utah Coals, Utah Geological and Mineral Survey, Bulletin, 80:7-21.
- Young, R.G., 1970. Lower Cretaceous of Wyoming and the Southern Rockies. *Mountain Geologist*, 7(3):105-121.
- Young, R.G., 1973. Depositional environments of basal Cretaceous rocks of the Colorado Plateau. In Fassett, J.E., editor, Cretaceous and Tertiary Rocks of the Southern Colorado Plateau. Four Corners Geological Society Memoir Book, p. 10-27.
- Yun, H-S., 1981. Dinoflagellaten aus der Oberkreide (Santon) von Westfalen. *Palaeontographica*, 177B:1-89.
- Zaitzeff, J.B. and Cross, A.T., 1970. The use of dinoflagellates and acritarchs for zonation and correlation of the Navarro Group (Maestrichtian) of Texas. In Kosanke, R.M. and Cross, A.T., editors, Symposium on palynology of the Late Cretaceous and early Tertiary. Geological Society of America, Special Paper, 127:341-377.
- Zavada, M.S. and Dilcher, D.L., 1988. Pollen wall ultrastructure of selected dispersed monosulcate pollen from the Cenomanian Dakota Formation. *American Journal of Botany*, 75(5):669-679.
- Zippi, P.A., 1989. Early Cretaceous angiosperm pollen from the Mattagami Formation, Ontario [abstract]. *Palynology*, 13:290.

PLATES

PLATE 1

ANGIOSPERMOUS POLLEN -- PORATE

Penetetrapites mollis

1 PB 14645-1-1 (UT-EM-M-40), 191X1198; X1000, 26 μ m.

Periporopollenites sp. A

2 PB 14788-4-3 (CO-ME-HCR-23), 276X1235; X1000, 28 μ m.

ANGIOSPERMOUS POLLEN -- MONOCOLPATE

Clavatipollenites hughesii

3 PB 14766-2-4 (CO-ME-HCR-1), 137X1249; X1000, 18 μ m.

Liliacidites dividuus

4a-b PB 15099-1-4 (UT-UI-SD-41), 260X1215; X1000, 29 μ m.
Two levels of focus.

Liliacidites sp. A

5a-b PB 12831-1-6 (UT-EM-Q5-1), 150X1251; X1000, 20 μ m.
Two levels of focus.

Liliacidites sp. B

6 PB 12831-1-6 (UT-EM-Q5-1), 114X1229; X1000, 46 μ m.

Monocolpopollenites sp. A

7 PB 14775-2-4 (CO-ME-HCR-10), 199X1159; X1000, 29 μ m.

Monocolpate Pollen Form A

8 PB 12831-1-5 (UT-EM-Q5-1), 255X1141; X1000, 14 μ m.

Monocolpate Pollen Form B

9 PB 14788-4-1 (CO-ME-HCR-23), 257X1173; X1000, 17 μ m.

Monocolpate Pollen Form C

10 PB 14766-2-4 (CO-ME-HCR-1), 209X1189; X1000, 52 μ m.

ANGIOSPERMOUS POLLEN -- DICOLPATE

Dichastopollenites dunveganensis

11 PB 14645-2-12 (UT-EM-M-40), 136X1233; X1000, 27 μ m.

12a-b PB 14466-1-1 (UT-EM-M-2), 196X1091; X1000, 33 μ m.
Two levels of focus.

PLATE 1 (cont'd)*Dichastopollenites reticulatus*

13a-b PB 14783-2-5 (CO-ME-HCR-18), 269X1192; X1000, 29 μ m.

Two levels of focus.

14 PB 14645-1-1 (UT-EM-M-40), 177X1172; X1000, 25 μ m.

15 PB 14645-1-1 (UT-EM-M-40), 141X1139; X1000, 28 μ m.

16 PB 14645-1-1 (UT-EM-M-40), 143X1125; X1000, 23 μ m.

Dichastopollenites sp. A

17 PB 14645-1-7 (UT-EM-M-40), 131X1182; X1000, 20 μ m.

18 PB 14645-1-7 (UT-EM-M-40), 221X1208; X1000, 19 μ m.

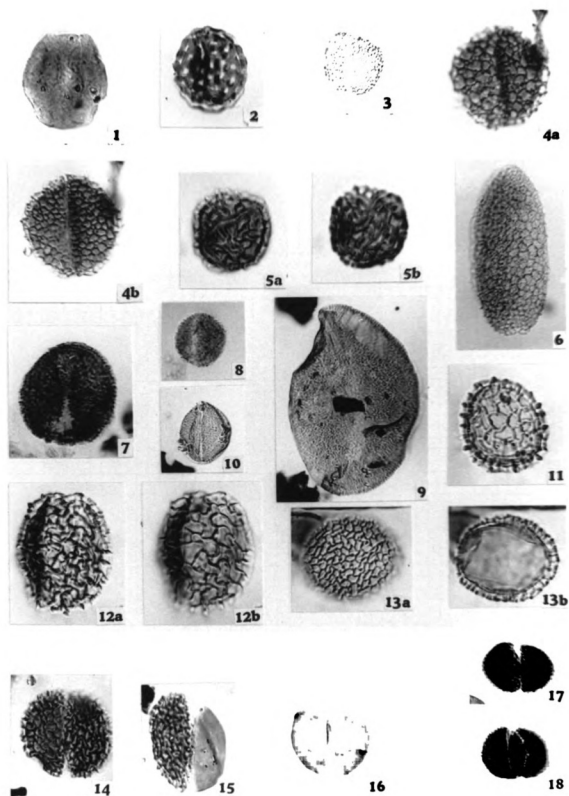


PLATE 1

PLATE 2**ANGIOSPERMOUS POLLEN -- TRICOLPATE***Foveotricolpites robustus*

- 1 PB 14565-1-5 (UT-EM-DW-3), 250X1096; X1000, 32 μ m.

Phimopollenites pannosus

- 2 PB 12831-1-9 (UT-EM-Q5-1), 115X2131; X1000, 17 μ m.

Pistillipollenites mcgregorii

- 3 PB 9008-1-1 (UT-CA-CVCC-22), 304X1164; X1000, 18 μ m.
Three specimens.

Tricolpites anguloluminosus

- 4 PB 14315-2-5 (UT-UI-SD-3), 213X1228; X1000, 42 μ m.

Tricolpites crassimurus

- 5 PB 14315-2-5 (UT-UI-SD-3), 234X1160; X1000, 39 μ m.
6 PB 14770-1-2 (CO-ME-HCR-5), 177X1139; X1000, 31 μ m.

Tricolpites eragatus

- 7 PB 14766-2-3 (CO-ME-HCR-1), 130X1219; X1000, 18 μ m.
8 PB 12831-1-9 (UT-EM-Q5-1), 198X1177; X1000, 15 μ m.

Tricolpites geranioides

- 9a-b PB 15102-2-4 (UT-UI-SD-44), 117X1240; X1000, 36 μ m.
Two levels of focus.

Tricolpites minutus

- 10 PB 14766-2-2 (CO-ME-HCR-1), 313X1224; X1000, 10 μ m by 6 μ m.
11 PB 14788-4-1 (CO-ME-HCR-23), 243X1185; X1000, 11 μ m by 6 μ m.

Tricolpites reticulatus

- 12 PB 14315-2-6 (UT-UI-SD-3), 120X1197; X1000, 42 μ m.

Tricolpites virgeus

- 13 PB 14766-1-3 (CO-ME-HCR-1), 206X1114; X1000, 28 μ m.

Tricolpate Pollen Form A

- 14 PB 14788-4-1 (CO-ME-HCR-23), 287X1210; X1000, 15 μ m.

Tricolpate Pollen Form B

- 15 PB 14788-4-1 (CO-ME-HCR-23), 128X1155; X1000, 14 μ m.

Tricolpate Pollen Form D

- 16a-b PB 12833-1-6 (UT-EM-Q5-3), 275X1146; X1000, 20 μ m.
Two levels of focus.

PLATE 2 (cont'd.)**Tricolpate Pollen Form E**

17a-b PB 14376-3-2 (UT-EM-DW-2), 186X1216; X1000, 27 μ m.

Two levels of focus.

Tricolpate Pollen Form F

18 PB 14376-3-2 (UT-EM-DW-2), 195X1270; X1000, 26 μ m.

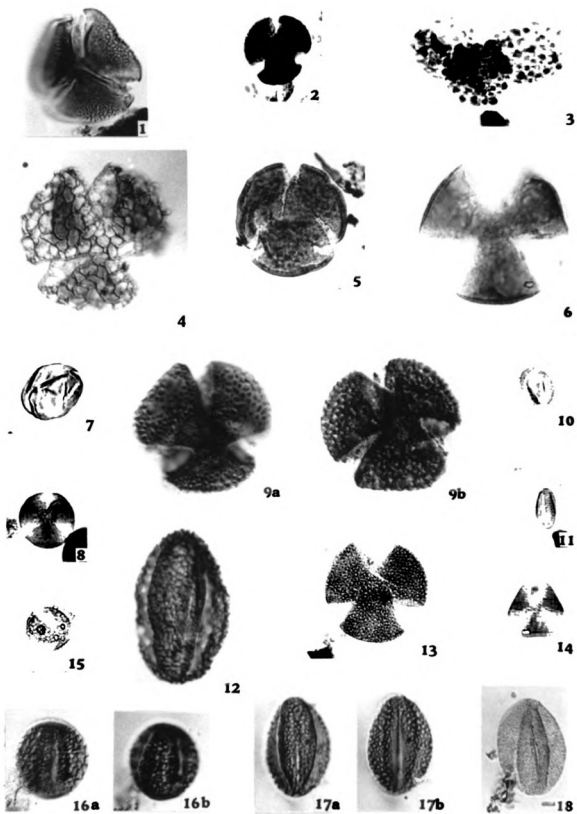


PLATE 2

PLATE 3**ANGIOSPERMOUS POLLEN -- COPATE >3***Asteropollis asteroides*

1 PB 14788-4-1 (CO-ME-HCR-23), 124X1155; X1000, 22 μ m.

Stephanocolpites tectorius

2a-b PB 14770-2-5 (CO-ME-HCR-5), 288X1218; X1000, 67 μ m.
Two levels of focus

Tetracolpites reticulatus

3 PB 14766-2-2 (CO-ME-HCR-1), 288X1230; X1000, 18 μ m.

ANGIOSPERMOUS POLLEN -- TRICOLPORATE*Foveotricolporites callosus*

4 PB 12833-1-6 (UT-EM-Q5-3), 271X1129; X1000, 29 μ m.

Nyssapollenites nigricolpus

5 PB 14775-2-1 (CO-ME-HCR-10), 173X1183; X1000, 16 μ m.

6 PB 14774-1-13 (CO-ME-HCR-9), 174X1145; X1000, 17 μ m.

7a-b PB 14774-1-13 (CO-ME-HCR-9), 223X1221; X1000, 17 μ m.
Two levels of focus

Nyssapollenites sp. A

8 PB 14775-2-1 (CO-ME-HCR-10), 103X1163; X1000, 15 μ m.

Tricolporoidites minimus

9 PB 14766-2-3 (CO-ME-HCR-1), 137X1164; X1000, 14 μ m.

ANGIOSPERMOUS POLLEN -- OBLIGATE TETRADS*Artiopollis indivisus*

10 PB 14766-2-5 (CO-ME-HCR-1), 169X1213; X1000, 48 μ m.

Virgo amiantopollis

11a-d PB 14788-4-1 (CO-ME-HCR-23), 277X1213; X1000, 19 μ m.
Four levels of focus.

GYNOSPERMOUS POLLEN -- ALETE*Araucariacites australis*

12 PB 15122-1-4 (UT-UI-SD-64), 181X1137; X1000, 64 μ m.

Corollina meyeriana

PLATE 3 (cont'd.)

13 PB 14766-2-3 (CO-ME-HCR-1), 133X1200; X1000, 18 μ m.

Corollina torosus

14 PB 15091-1-1 (UT-UI-SD-33), 219X1201; X1000, 24 μ m.

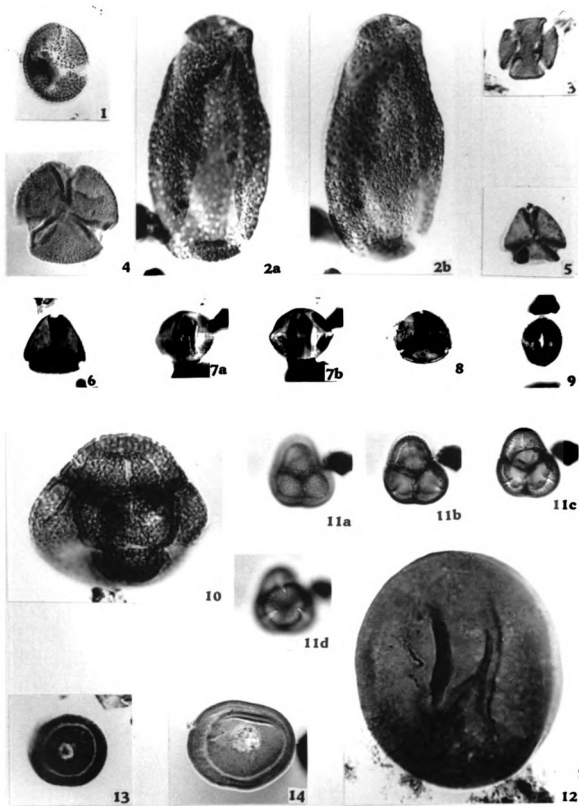


PLATE 3

PLATE 4**GYNOSPERMOUS POLLEN -- ALETE (CONTINUED)***Corollina torosus*

- 1 PB 15106-2-3 (UT-UI-SD-48), 188X1195; X1000, 50 μ m total.

Cycadopites carpentieri

- 2 PB 14766-1-8 (CO-ME-HCR-1), 216X1182; X1000, 52 μ m by 62 μ m.

Eucommiidites minor

- 3 PB 14645-1-7 (UT-EM-M-40), 278X1127; X1000, 23 μ m.
4 PB 14645-1-7 (UT-EM-M-40), 238X1215; X1000, 23 μ m.

Exesipollenites tumulus

- 5 PB 15091-1-2 (UT-UI-SD-33), 149X1168; X1000, 28 μ m.

Inaperturopollenites dubius

- 6 PB 14788-3-2 (CO-ME-HCR-23), 247X1120; X1000, 33 μ m.

Inaperturopollenites limbatus

- 7 PB 14789-2-3 (CO-ME-HCR-24), 230X1290; X750, 90 μ m.

Laricoidites sp. A

- 8 PB 9008-3-4 (UT-CA-CVCC-22), 077X1260; X1000, 68 μ m.

Perinopollenites elatoides

- 9 PB 14466-1-1 (UT-EM-M-2), 227X1102; X1000, 38 μ m.

Taxodiaceaepollentia hiatus

- 10 PB 15122-1-4 (UT-UI-SD-67), 260X1164; X1000, 29 μ m.

GYMNOSPERMOUS POLLEN -- SACCATE*Alisporites bilateralis*

- 11 PB 15108-1-3 (UT-UI-SD-50), 204X1128; X1000, 54 μ m.

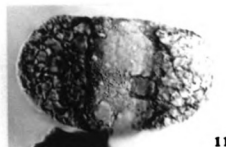
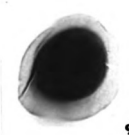
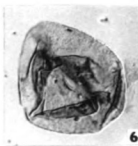
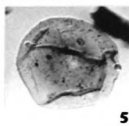
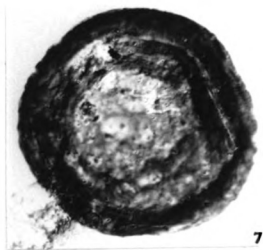
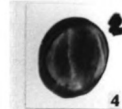
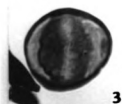


PLATE 5**GYMNOSPERMOUS POLLEN – SACCATE (CONTINUED)***Alisporites* sp. A

- 1 PB 9008-1-1 (UT-CA-CVCC-22), 219X1225; X1000, 56 μ m.

Callialasporites ?dampieri

- 2 PB 14774-1-3 (CO-ME-HCR-9), 203X1204; X1000, 59 μ m.

Cedripites sp. A

- 3 PB 12831-1-6 (UT-EM-Q5-1), 178X1229; X1000, 48 μ m.

Cerebropollenites mesozoicus

- 4 PB 14788-4-3 (CO-ME-HCR-23), 164X1215; X1000, 42 μ m.

Parvisaccites rugulatus

- 5 PB 14645-3-12 (UT-EM-M-40), 204X1237; X1000, 40 μ m.

Pinuspollenites sp. A

- 6 PB 14403-2-4 (UT-EM-IC-22), 184X1292; X1000, 50 μ m.

Pityosporites sp. A

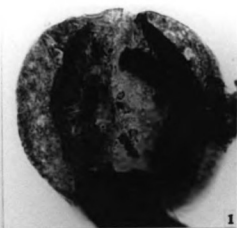
- 7 PB 14754-2-7 (UT-UI-SD-69), 210X1179; X1000, 48 μ m.

Podocarpidites sp. A

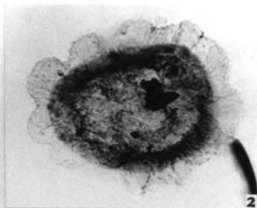
- 8 PB 15102-2-4 (UT-UI-SD-44), 100X1201; X1000, 85 μ m.

Podocarpidites sp. B

- 9 PB 15099-1-4 (UT-UI-SD-41), 211X1235; X1000, 65 μ m.



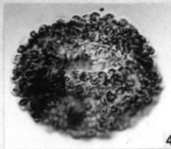
1



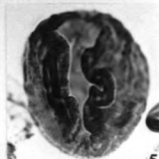
2



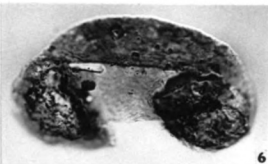
3



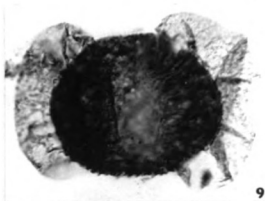
4



5



6



9



8



7

PLATE 6**GYMNOSPERMOUS POLLEN -- SACCATE (CONTINUED)***Podocarpidites* sp. C

1a-b PB 14788-3-2 (CO-ME-HCR-23), 169X1141; X1000, 72 μ m.

Pristinuspollenites elongatus

2 PB 9008-1-3 (UT-CA-CVCC-22), 187X1183; X1000, 53 μ m by 42 μ m.

Rugubivesiculites reductus

3a-b PB 12831-1-5 (UT-EM-Q5-1), 112X1213; X1000, 43 μ m.

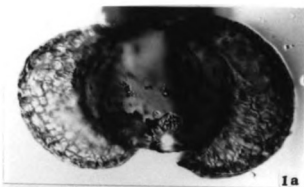
Rugubivesiculites rugosus

4 PB 15108-1-3 (UT-UI-SD-50), 219X1144; X750, 102 μ m.

5 PB 14775-2-3 (CO-ME-HCR-10), 264X1275; X750, 92 μ m.

Vitreisporites pallidus

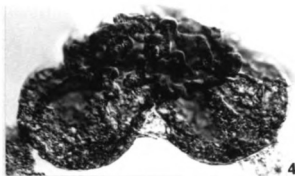
6 PB 15097-1-2 (UT-UI-SD-39), 182X1169; X1000, 27 μ m.



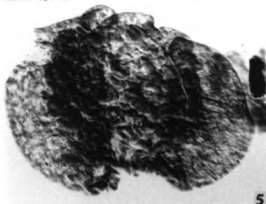
1a



1b



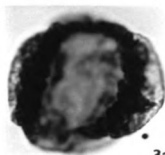
4



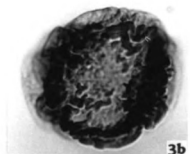
5



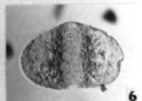
2



3a



3b



6

PLATE 7**GYMNOSPERMOUS POLLEN – PLICATE***Equisetosporites ambiguus*

- 1 PB 12952-1-4 (UT-EM-Q8-8), 154X1181; X1000, 34 μ m.
2a-b PB 12952-1-4 (UT-EM-Q8-8), 186X1104; X1000, 38 μ m.
Two levels of focus.

Equisetosporites sp. A

- 3 PB 15107-2-4 (UT-UI-SD-49), 249X1138; X1000, 36 μ m.

Equisetosporites sp. C

- 4 PB 14774-1-13 (UT-UI-SD-9), 219X1219; X1000, 31 μ m.

Equisetosporites sp. D

- 5 PB 14376-3-2 (UT-EM-DW-2), 187X1176; X1000, 23 μ m by 7 μ m.

Equisetosporites sp. E

- 6 PB 14645-3-13 (UT-EM-M-40), 108X1151; X750, 115 μ m.

MICROSPORES -- TRILETE*Appendicisporites auritus*

- 7 PB 14776-2-4 (CO-ME-HCR-11), 212X1194; X1000, 48 μ m.

Appendicisporites dentimarginatus

- 8 PB 14770-2-5 (CO-ME-HCR-5), 141X1192; X1000, 59 μ m.

Appendicisporites insignis

- 9a-b PB 14766-2-4 (CO-ME-HCR-1), 178X1247; X1000, 62 μ m.
Two levels of focus.

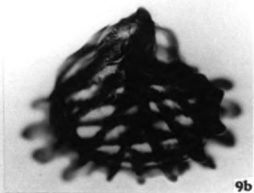
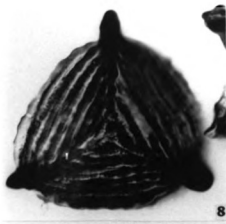
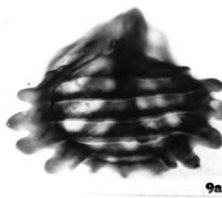
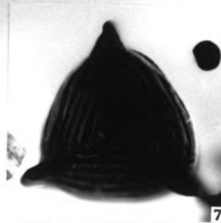
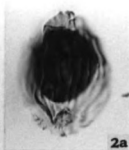


PLATE 8**MICROSPORES -- TRILETE (CONTINUED)***Appendicisporites potomacensis*

1 PB 15101-1-4 (UT-UI-SD-43), 115X1224; X1000, 54 μ m.

Appendicisporites sp. A

2a-b PB 14376-3-4 (UT-EM-DW-2), 220X1176; X1000, 54 μ m.
Two levels of focus.

Appendicisporites sp. B

3 PB 14466-1-1 (UT-EM-M-2), 235X1253; X1000, 48 μ m.

Appendicisporites sp. C

4a-b PB 15091-1-2 (UT-UI-SD-33), 290X1293; X1000, 30 μ m.
Two levels of focus.

Appendicisporites sp. D

5a-b PB 14645-1-3 (UT-EM-M-40), 201X1173; X1000, 46 μ m.
Two levels of focus.

Appendicisporites sp. E

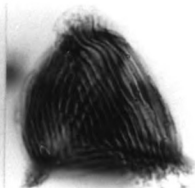
6 PB 14645-1-2 (UT-EM-M-40), 228X1287; X1000, 49 μ m.

Appendicisporites sp. F

7 PB 12831-1-6 (UT-EM-Q5-1), 209X1231; X1000, 49 μ m.



1



2a



3



2b



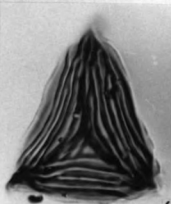
4a



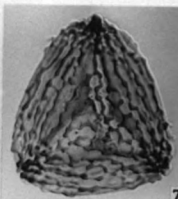
4b



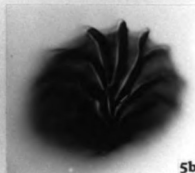
5a



6



7



5b

PLATE 9**MICROSPORES -- TRILETE (CONTINUED)***Biretisporites potoniaei*

- 1 PB 15091-1-2 (UT-UI-SD-33), 278X1125; X1000, 26 μ m.

Camazonosporites insignis

- 2 PB 14766-1-3 (CO-ME-HCR-1), 146X1144; X1000, 37 μ m.

Camazonosporites sp. A

- 3 PB 14783-2-5 (CO-ME-HCR-18), 142X1138; X1000, 25 μ m.

Chomotriletes minor

- 4 PB 15102-1-4 (UT-UI-SD-44), 213X1215; X1000, 42 μ m.

Cibotiumspora juncta

- 5a-b PB 14466-1-1 (UT-EM-M-2), 206X1104; X1000, 32 μ m.

Two levels of focus: a) focus on distal surface;

b) focus on proximal surface.

Cicatricosisporites crassiterminatus

- 6 PB 14776-2-4 (CO-ME-HCR-11), 235X1171; X1000, 51 μ m.

Cicatricosisporites dorogensis

- 7 PB 15094-1-3 (UT-UI-SD-36), 148X1127; X1000, 51 μ m.

Cicatricosisporites hallei

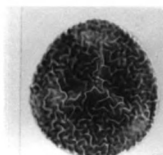
- 8 PB 14788-4-3 (CO-ME-HCR-23), 114X1245; X1000, 48 μ m.

Cicatricosisporites potomacensis

- 9 PB 14645-3-13 (UT-EM-M-40), 235X1247; X1000, 68 μ m.



1



2



3



4



5a



5b



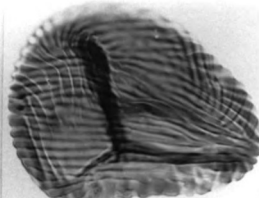
6



7



8



9

PLATE 10**MICROSPORES -- TRILETE (CONTINUED)***Cicatricosisporites venustus*

1 PB 15101-1-4 (UT-UI-SD-43), 233X1134; X1000, 29 μ m.

Cicatricosisporites sp. A

2 PB 14788-3-2 (CO-ME-CHR-23), 243X1163; X1000, 60 μ m.

Cingutritiles congruens

3 PB 12833-1-6 (UT-EM-Q5-3), 228X1217; X1000, 34 μ m.

Cingutritiles sp. A

4 PB 6428-1-4 (UT-EM-IC-1), 185X1175; X1000, 32 μ m.

Cingutritiles sp. B

5 PB 14315-2-2 (UT-UI-SD-3), 112X1185; X1000, 24 μ m.

Conbaculatisporites sp. A

6 PB 15097-1-2 (UT-UI-SD-39), 243X1238; X1000, 25 μ m.

Concavisporites lamontis

7 PB 14766-2-2 (CO-ME-HCR-1), 193X1240; X1000, 28 μ m.

Concavissimisporites vari verrucatus

8 PB 14645-2-12 (UT-EM-M-40), 189X1210; X1000, 44 μ m.

Crybelosporites brenneri

9 PB 14787-2-4 (CO-ME-HCR-22), 205X1190; X1000, 58 μ m total 43 μ m body.

10 PB 14788-3-3 (CO-ME-HCR-23), 300X1244; X1000, 49 μ m.

Crybelosporites pannuceus

11 PB 14645-2-11 (UT-EM-M-40), 171X1227; X1000, 59 μ m.

Cyathidites concavus

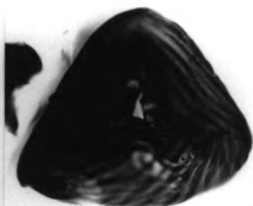
12 PB 14776-2-1 (CO-ME-HCR-11), 185X1247; X1000, 27 μ m.

Cyathidites minor

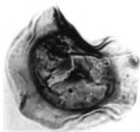
13 PB 14788-4-3 (CO-ME-HCR-23), 125X1136; X1000, 36 μ m.



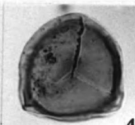
1



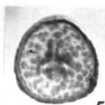
2



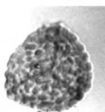
3



4



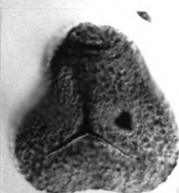
5



6



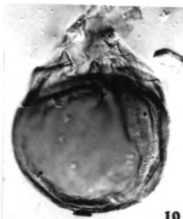
7



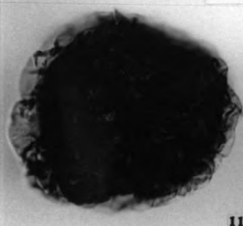
8



9



10



11



12



13

PLATE 11

MICROSPORES -- TRILETE (CONTINUED)

Deltoidospora hallii

- 1 PB 14775-2-1 (CO-ME-HCR-10), 123X1154; X1000, 26 μ m.
 2 PB 14776-1-1 (CO-ME-HCR-11), 144X1257; X150, 457 μ m total.
 Partially ruptured sporangium containing *D. hallii*.

Densoisporites microrugulatus

- 3 PB 14645-2-10 (UT-EM-M-40), 237X1169; X1000, 50 μ m.

Densoisporites velatus

- 4 PB 15091-1-1 (UT-UI-SD-33), 208X1143; X1000, 36 μ m.

Dictyophyllidites impensus

- 5 PB 14565-1-5 (UT-EM-DW-3), 178X1267; X1000, 67 μ m.
 Granular features on proximal surface are artifacts of degradation.

Echinatisporis varispinosus

- 6 PB 6430-2-3 (UT-EM-IC-3), 046X1254; X1000, 30 μ m total 26 μ m body.

Foraminisporis dailyi

- 7 PB 14466-4-3 (UT-EM-M-2), 264X1218; X1000, 38 μ m.

Gemmatriletes ?morulus

- 8 PB 14645-3-12 (UT-EM-M-40), 150X1222; X1000, 32 μ m.

Gleicheniidites circinidites

- 9 PB 14315-2-5 (UT-UI-SD-3), 101X1251; X1000, 17 μ m.

Gleicheniidites senonicus

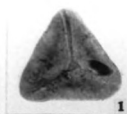
- 10 PB 14766-2-4 (CO-ME-HCR-1), 282X1202; X1000, 28 μ m.

Heliosporites kemensis

- 11a-b PB 14645-3-12 (UT-EM-M-40), 142X1096; X1000, 47 μ m total.
 Two levels of focus.

Klukisporites foveolatus

- 12 PB 14645-2-3 (UT-EM-M-40), 194X1259; X1000, 36 μ m.



1



2



3



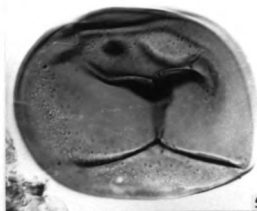
4



6



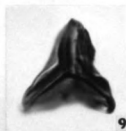
7



5



8



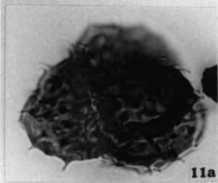
9



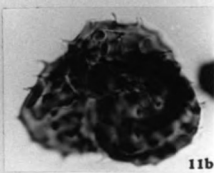
10



12



11a



11b

PLATE 12**MICROSPORES -- TRILETE (CONTINUED)***Klukisporites pseudoreticulatus*

- 1a-b PB 14776-2-3 (CO-ME-HCR-11), 238X1223; X1000, 58 μ m.
Two levels of focus.

Leptolepidites major

- 2 PB 15106-2-4 (UT-UI-SD-48), 204X1146; X1000, 38 μ m.

Leptolepidites sp. A

- 3 PB 15087-1-3 (UT-UI-SD-39), 278X1141; X1000, 31 μ m.

Lycopodiacidites cerniidites

- 4a-b PB 9008-1-1 (UT-CA-CVCC-22), 223X1152; X1000, 42 μ m.
Two levels of focus.

?Lycopodiacidites sp. A

- 5a-b PB 9008-1-3 (UT-CA-CVCC-22), 183X1180; X1000, 37 μ m.
Two levels of focus.

Matonisporites phleboteroides

- 6 PB 14788-3-2 (CO-ME-HCR-23) 212X1107; X1000, 53 μ m.

Microreticulatisporites sacalii

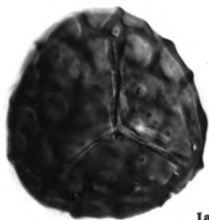
- 7 PB 14788-3-3 (CO-ME-HCR-23), 266X1160; X1000, 42 μ m.

Neoraistrickia sp. A

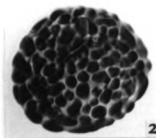
- 8 PB 15099-1-4 (UT-UI-SD-41), 2182X1144; X1000, 30 μ m.

Osmundacidites wellmanii

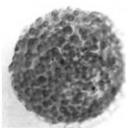
- 9 PB 14776-2-4 (CO-ME-HCR-11), 205X1133; X1000, 46 μ m.



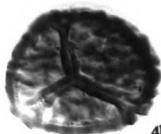
1a



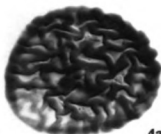
2



3



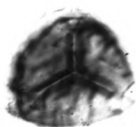
4b



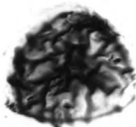
4a



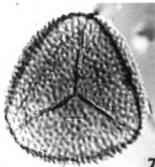
1b



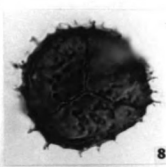
5a



5b



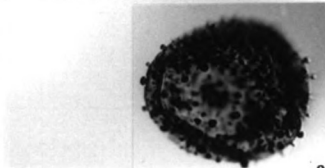
7



8



6



9

PLATE 13**MICROSPORES – TRILETE (CONTINUED)***Perotriletes* sp. A

1 PB 12833-1-6 (UT-EM-Q5-3), 245X1220; X1000, 29 μ m.

Perotriletes sp. C

2 PB 14645-3-12 (UT-EM-M-40), 147X1088; X1000, 29 μ m.

Perotriletes sp. D

3 PB 14645-1-2 (UT-EM-M-40), 137X1211; X1000, 40 μ m.

Pilosiporites trichopapillosus

4 PB 15101-1-4 (UT-UI-SD-43), 274X1219; X750, 72 μ m.

Pilosiporites sp. A

5a-b PB 14315-2-5 (UT-UI-SD-3), 211X1193; X1000, 56 μ m.

Two levels of focus.

Polycingulatisporites radiatus

6 PB 14735-1-8 (UT-UI-SD-68), 155X1152; X1000, 42 μ m.

Psilatrilites circumundulatus

7a-b PB 14645-2-11 (UT-EM-M-40), 176X1279; X1000, 46 μ m.

Two levels of focus: a) focus on proximal surface;

b) focus on distal surface which is convexly caved in.

Reticulatasporites dupliexinous

8 PB 15108-1-3 (UT-UI-SD-50), 091X1168; X1000, 38 μ m.

Reticulatasporites sp. A

9a-b PB 15106-2-3 (UT-UI-SD-48), 149X1207; X1000, 55 μ m.

Two levels of focus.

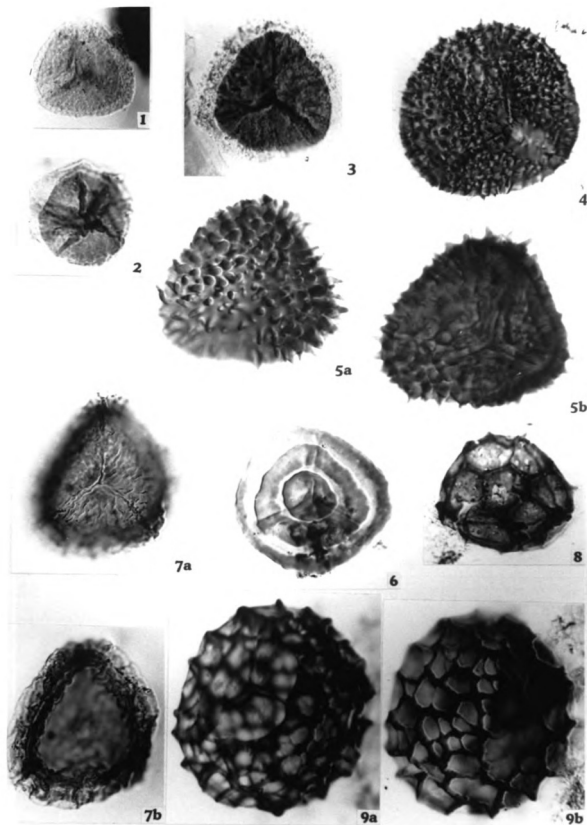


PLATE 13

PLATE 14**MICROSPORES -- TRILETE (CONTINUED)***Reticulatisporites* sp. A

- 1 PB 15102-2-3 (UT-UI-SD-44), 134X1177; X1000, 44 μ m.

Rugulatisporites sp. A

- 2 PB 14788-4-2 (CO-ME-HCR-23), 185X1128; X1000, 54 μ m.
Specimen is somewhat deformed.

Scopusporis excavatus

- 3a-b PB 15094-1-4 (UT-UI-SD-36), 242X1193; X1000, 52 μ m.
Two levels of focus.

Stereisporites antiquasporites

- 4 PB 14645-2-11 (UT-EM-M-40), 233X1127; X1000, 25 μ m.

Tigrisporites reticulatus

- 5a-b PB 15113-1-4 (UT-UI-SD-55), 265X1158; X1000, 35 μ m.
Two levels of focus. Black spot in center of grain is a distal polar thickening.

Todisporites minor

- 6 PB 14788-3-2 (CO-ME-HCR-23), 252X1175; X1000, 52 μ m.

Trilobosporites crassus

- 7 PB 14466-2-4 (UT-EM-M-2), 253X1222; X1000, 42 μ m.

Unulatisporites pannuceus

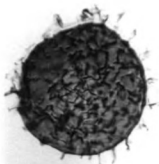
- 8a-b PB 14788-3-2 (CO-ME-HCR-23), 143X1241; X1000, 42 μ m.
Two levels of focus.

Undulatisporites undulapulus

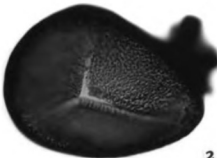
- 9 PB 14466-1-1 (UT-EM-M-2), 182X1140; X1000, 27 μ m.

Undulatisporites sp. A

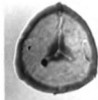
- 10 PB 15091-1-1 (UT-UI-SD-33), 255X1202; X1000, 38 μ m.



1



2



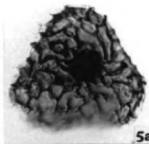
4



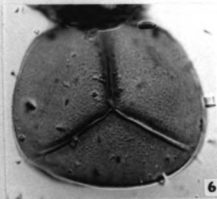
3a



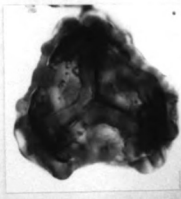
3b



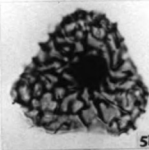
5a



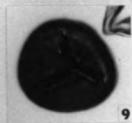
6



7



5b



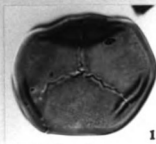
9



8a



8b



10

PLATE 15**MICROSPORES – TRILETE (CONTINUED)****Trilete Spore Genus 1 species A**

- 1 PB 14645-1-3 (UT-EM-M-40), 171X1215; X1000, 53 μ m.

Trilete Spore Genus 1 species B

- 2 PB 14787-2-4 (CO-ME-HCR-22), 191X1203; X1000, 41 μ m.

Trilete Spore Genus 1 species C

- 3a-b PB 14645-2-3 (UT-EM-M-40), 221X1203; X1000, 34 μ m.
Two levels of focus.

Trilete Spore Form A

- 4 PB 14766-2-2 (CO-ME-HCR-1), 306X1239; X1000, 20 μ m.

Trilete Spore Form B

- 5 PB 14770-2-4 (CO-ME-HCR-5), 137X1238; X1000, 63 μ m.
6 PB 14787-2-2 (UT-UI-SD-22), 254X1171; X1000, 64 μ m.
7 PB 14781-2-2 (CO-ME-HCR-16), 146X1260; X1000, 55 μ m.

Trilete Spore Form C

- 8 PB 14783-2-4 (CO-ME-HCR-18), 256X1134; X1000, 33 μ m.
9 PB 14775-2-3 (CO-ME-HCR-10), 228X1192; X1000, 31 μ m.

Trilete Spore Form D

- 10 PB 12952-1-4 (UT-EM-Q8-8), 083X1191; X1000, 32 μ m.
11 PB 15102-1-4 (UT-UI-SD-44); 153X1181; X1000, 42 μ m.

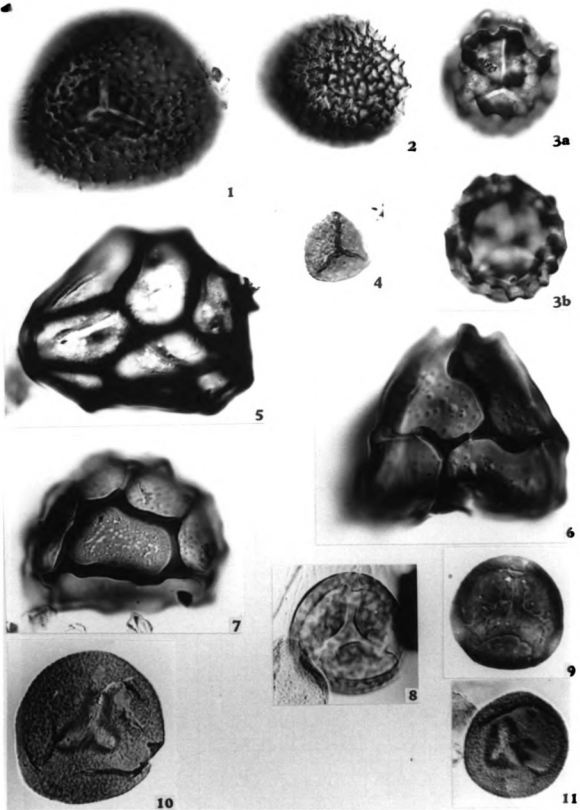


PLATE 15

PLATE 16**MICROSPORES -- TRILETE (CONTINUED)****Trilete Spore Form E**

1 PB 14787-2-4 (CO-ME-HCR-22), 250X1175; X1000, 55 μ m.

Trilete Spore Form G

2a-b PB 15094-1-3 (UT-UI-SD-36), 276X1230; X1000, 40 μ m.
Two levels of focus.

Trilete Spore Form J

3 PB 14466-2-4 (UT-EM-M-2), 212X1114; X1000, 32 μ m.

Trilete Spore Form K

4 PB 9008-1-1 (UT-CA-CVCC-22), 291X1161; X1000, 47 μ m total.

Trilete Spore Form L

5 PB 9008-3-4 (UT-CA-CVCC-22), 190X1269; X1000, 46 μ m.

Trilete Spore Form M

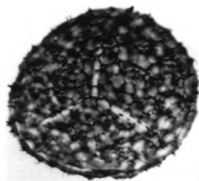
6a-b PB 9008-3-4 (UT-CA-CVCC-22), 067X1129; X1000, 73 μ m.
Two levels of focus.

Trilete Spore Form N

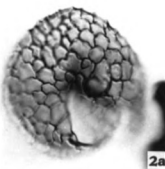
7 PB 12831-1-5 (UT-EM-Q5-1), 221X1784; X1000, 25 μ m.

Trilete Spore Form O

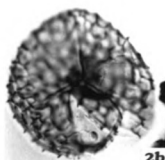
8 PB 9008-3-4 (UT-CA-CVCC-22), 104X1256; X1000, 40 μ m.



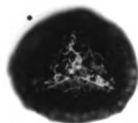
1



2a



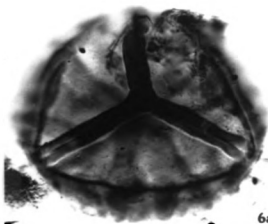
2b



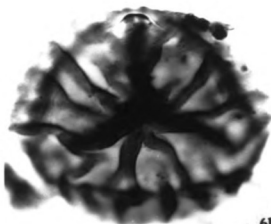
3



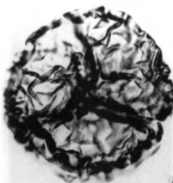
4



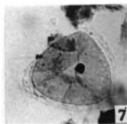
6a



6b



5



7



8

PLATE 17**MICROSPORES -- TRILETE (CONTINUED)****Trilete Spore Form P**

- 1 PB 14645-3-12 (UT-EM-M-40), 270X1202; X1000, 68 μ m total.

Trilete Spore Form Q

- 2 PB 15091-1-2 (UT-UI-SD-33), 176X1200; X1000, 14 μ m.

MICROSPORES -- MONOLETE*Cicatricosporites* sp. A

- 3 PB 14788-3-2 (CO-ME-HCR-23), 256X1216; X1000, 75 μ m.

Laevigatosporites belfordii

- 4 PB 14645-2-12 (UT-EM-M-40), 136X1233; X1000, 58 μ m.

Laevigatosporites ovatus

- 5 PB 14376-3-4 (UT-EM-DW-2), 159X1214; X1000, 30 μ m.

Microfoveolatosporis pseudoreticulatus

- 6 PB 14466-1-1 (UT-EM-M-2), 250X1119; X1000, 53 μ m.

Petalosporites quadrangulus

- 7 PB 14788-4-3 (CO-ME-CHR-23), 170X1256; X1000, 38 μ m.

Reticulosporis foveolatus

- 8 PB 14775-2-3 (CO-ME-HCR-10), 169X1120; X750, 110 μ m by 77 μ m.

Monolete Spore Form A

- 9 PB 14783-2-4 (CO-ME-HCR-18), 154X1214; X1000, 69 μ m.

Monolete Spore Form B

- 10 PB 14645-2-11 (UT-EM-M-40), 192X1108; X1000, 50 μ m.

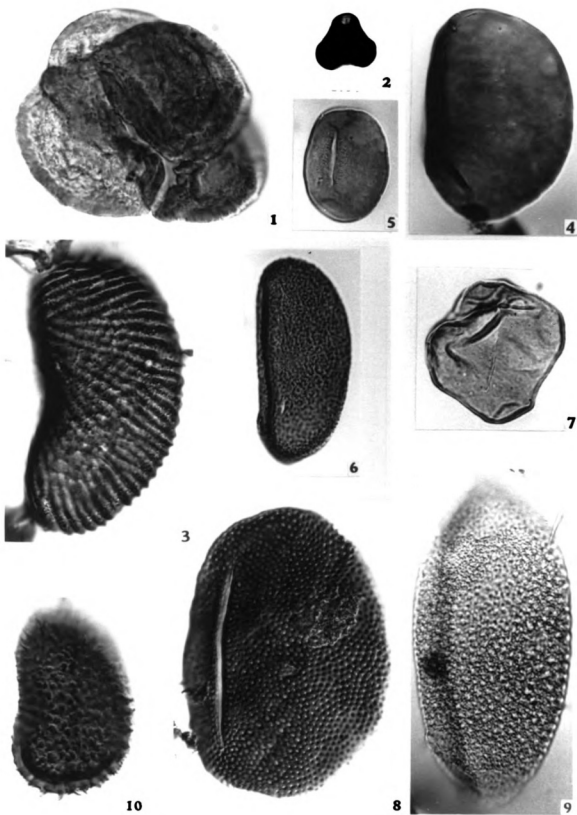


PLATE 17

PLATE 18**MICROSPORES -- MONOLETE (CONTINUED)****Monolete Spore Form C**

- 1 PB 9008-3-3 (UT-CA-CVCC-22), 104X1101; X1000, 66 μ m.

MICROSPORES -- HILATE***Aequitriradites ornatus***

- 2 PB 15102-1-9 (UT-UI-SD-44), 203X1234; X1000, 75 μ m.

Triporoletes cenomanianus

- 3 PB 14787-2-2 (CO-ME-HCR-22), 148X1254; X1000, 53 μ m.

Triporoletes involucratus

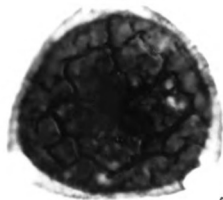
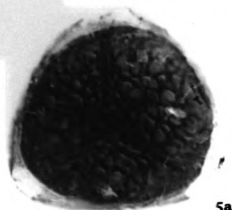
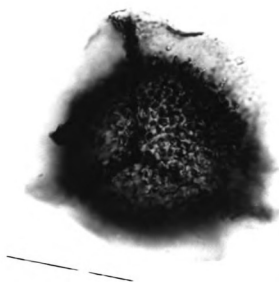
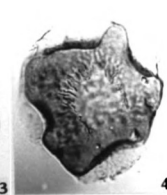
- 4 PB 14788-4-3 (CO-ME-HCR-23), 262X1256; X1000, 47 μ m.

Triporoletes radiatus

- 5a-b PB 15102-1-7 (UT-UI-SD-44), 175X1189; X1000, 60 μ m.
Two levels of focus.

MEGASPORES -- TRILETE***Arcellites disciformis***

- 6 PB 14766-1-1 (CO-ME-HCR-1), 319X1183; X150, 631 μ m total.



1

3

4

2

5a

5b

6

PLATE 19**MEGASPORES – TRILETE (CONTINUED)***Bacutrilletes greenlandicus*

- 1 PB 14766-1-1 (CO-ME-HCR-1), 159X1243; X150, 531 μ m.

Balmeisporites glenglenensis

- 2 PB 14308-1-2 (UT-EM-IC-34), 153X1118; X500, 170 μ m.
Oblique focus of distal surface.

Minerisporites dissimilis

- 3 PB 9007-1-2 (UT-CA-CVCC-21), 212X1255; X150, 332 μ m.

Molaspora lobata

- 4 PB 14770-1-2 (CO-ME-HCR-5), 130X1123; X150, 515 μ m.

MISCELLANEOUS TERRESTRIAL MATERIAL*Amber Spherules*

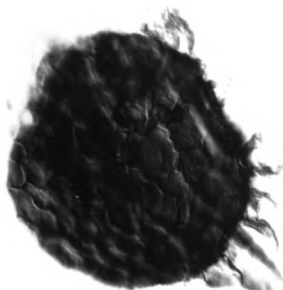
- 5 PB 14376-2-5 (UT-EM-DW-2), 243X1226; X500.



1



4



2



3



5

PLATE 20**MISCELLANEOUS TERRESTRIAL MATERIAL (CONTINUED)****Fungal Spore Form A**

1 PB 12952-1-4 (UT-EM-Q8-8), 143X1195; X750, 146 μ m.

Fungal Spore Form B

2 PB 14766-1-8 (CO-ME-HCR-1), 271X1219, X1000, 46 μ m.

Fungal Spore Form C

3 PB 15102-2-4 (UT-UI-SD-44), 267X1203, X1000, 25 μ m total.

Fungal Spore Form D

4 PB 12831-1-5 (UT-EM-Q5-1), 119X1156; X1000, 28 μ m.

Fungal Spore Form E

5 PB 12831-1-5 (UT-EM-Q5-1); 261X1143; X1000, 9 μ m.

Ovoidites sp. A

6 PB 14774-1-3 (CO-ME-HCR-9), 161X1141; X750, 150 μ m.

Palambages canadiana

7 PB 15102-1-5 (UT-UI-SD-44), 306X1258; X1000, 93 μ m.

***Palambages* sp. A**

8 PB 15099-1-4 (UT-UI-SD-41), 187X1191; X1000, 60 μ m.

Schizosporis parvus

9 PB 14770-2-4 (CO-ME-HCR-5), 146X1268; X1000, 52 μ m.

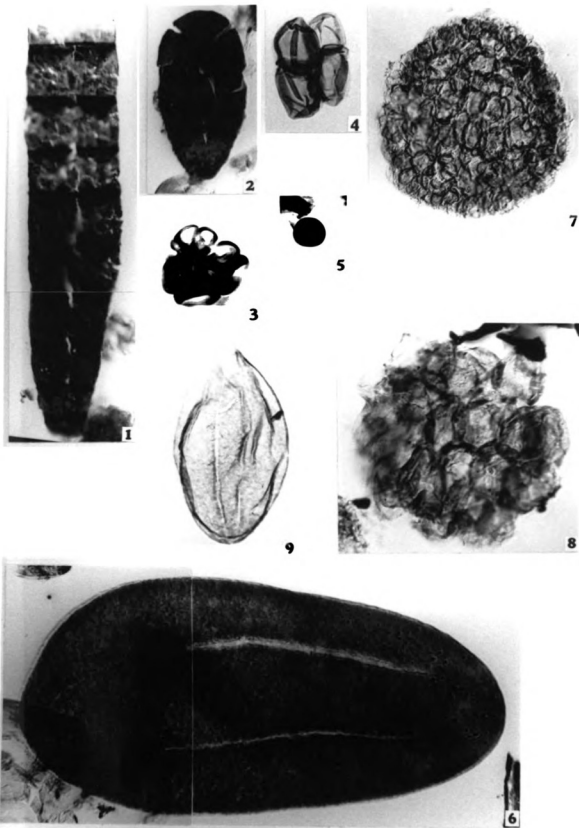


PLATE 20

PLATE 21**MISCELLANEOUS TERRESTRIAL MATERIAL (CONTINUED)***Schizosporis reticulatus*

- 1 PB 14787-2-2 (CO-ME-HCR-22), 146X1163; X500, 150 μ m.

Spermatites ellipticus

- 2 PB 14770-1-1 (CO-ME-HCR-5), 238X1243; X100, 735 μ m.

Spermatites sp. A

- 3 PB 14774-1-1 (CO-ME-HCR-9), 138X1113; X100, 690 μ m.

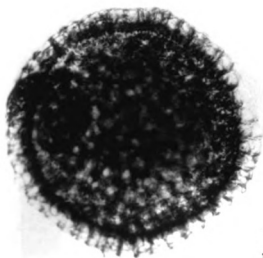
Spermatites sp. B

- 4 PB 9007-1-2 (UT-CA-CVCC-21), 277X1228; X100, 1079 μ m.

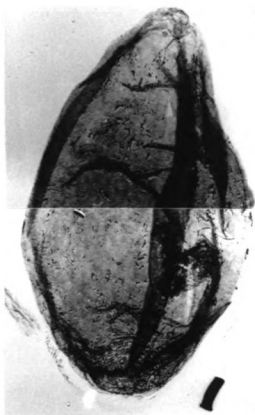
Trichopeltinites sp. A

- 5 PB 14565-1-5 (UT-EM-DW-3), 253X1074; X1000, 76 μ m.

- 6 PB 14565-1-5 (UT-EM-DW-3), 246X1134; X500, 180 μ m.



1



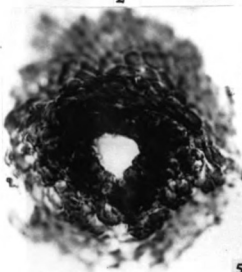
4



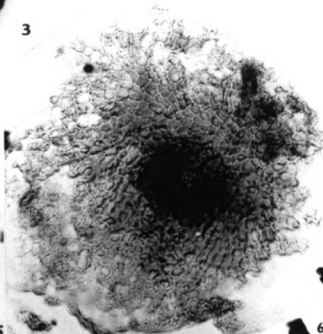
2



3



5



6

PLATE 21

PLATE 22**MISCELLANEOUS TERRESTRIAL MATERIAL (CONTINUED)***Trichopeltinites* sp. A

1 PB 14376-2-5 (UT-EM-DW-2), 244X1229; X500, 440 μ m.

Terrestrial Unknown Form A

2 PB 14645-1-7 (UT-EM-M-40), 238X1215; X1000, 23 μ m.

Terrestrial Unknown Form B

3 PB 14466-1-1 (UT-EM-M-40), 178X1242; X1000, 45 μ m.

Terrestrial Unknown Form C

4 PB 14788-3-2 (CO-ME-HCR-23) 104X1249; X1000, 42 μ m.

Terrestrial Unknown Form D

5 PB 14645-3-13 (UT-EM-M-40), 246X1275; X750, 81 μ m.

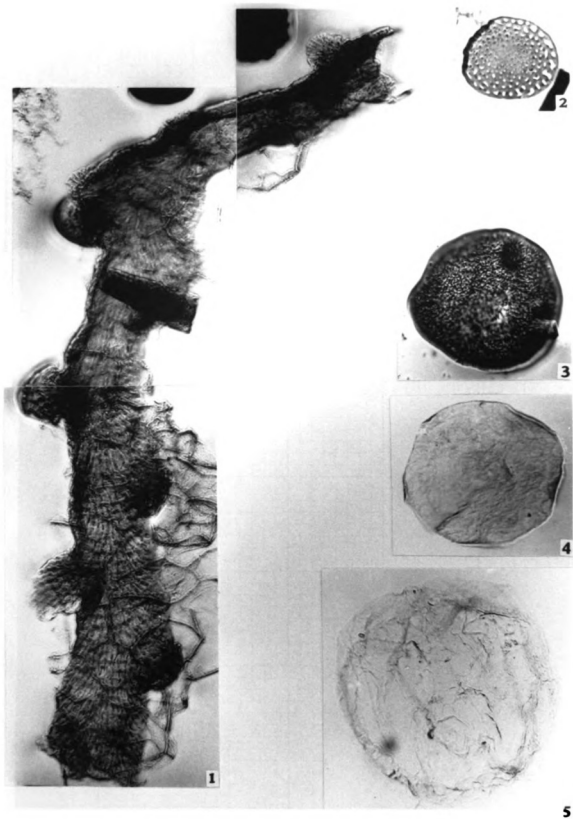


PLATE 22

PLATE 23**DINOFLAGELLATE CYSTS -- PROXIMATE CAVATE***Alterbidinium* sp. A

- 1 PB 14403-2-4 (UT-EM-IC-22), 131X1232; X1000, 50 μ m.

Ascostomocystis giganteus

- 2 PB 15122-1-4 (UT-UI-SD-64), 294X1122; X750, 165 μ m.

Balmula ?pentaradiata

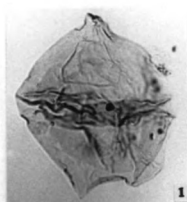
- 3 PB 15102-1-10 (UT-UI-SD-44), 224X1115; X750, 155 μ m.

Catastomocystis sp. A

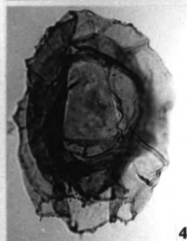
- 4 PB 15107-2-3 (UT-UI-SD-49), 149X1220; X1000, 63 μ m.

Chatangiella ?granulifera

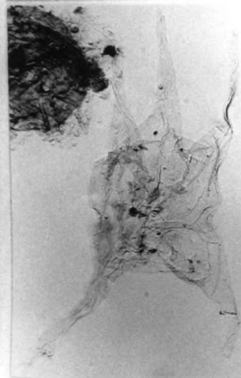
- 5 PB 14704-1-2 (UT-EM-M-60), 151X1171; X750, 92 μ m.



1



4



3



2



5

PLATE 24**DINOFLAGELLATE CYSTS – PROXIMATE CAVATE (CONTINUED)***Chatangiella* sp. A

- 1 PB 14356-3-2 (UT-UI-SD-25), 218X0897; X750, 83 μ m.

Chlamydophorella nyei

- 2 PB 15094-1-3 (UT-UI-SD-36), 269X1145; X1000, 48 μ m.
Dorosventral view showing apical archeopyle.
3 PB 15102-2-4 (UT-UI-SD-44), 267X1274; X1000, 48 μ m.
Apical or antapical view.

Cribroperidinium edwardsii

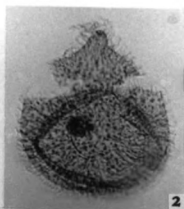
- 4 PB 14754-2-11 (UT-UI-SD-69), 269X1239; X750, 139 μ m.
5 PB 15098-1-3 (UT-UI-SD-40), 135X1206; X1000, 55 μ m.
Enlargement of detached operculum

Cribroperidinium ?exilicristatum

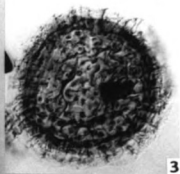
- 6 PB 15121-1-5 (UT-UI-SD-63), 156X1217; X750, 90 μ m.

Endoscrinium campanula

- 7 PB15107-2-4 (UT-UI-SD-49), 298X1231; X750, 115 μ m.



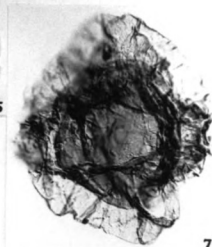
2



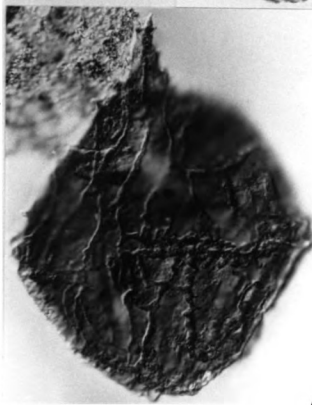
3



5



7



4



6

PLATE 25

DINOFLAGELLATE CYSTS -- PROXIMATE CAVATE (CONTINUED)

Hexagonifera sp. A

- 1 PB 15121-1-3 (UT-UI-SD-63), 163X1196; X1000, 51 μ m.
- 2 PB 15121-1-8 (UT-UI-SD-63), 175X1261; X500, 150 μ m total.

Hexagonifera sp. B

- 3 PB 15122-1-4 (UT-UI-SD-64), 275X1260; X1000, 45 μ m.

Leberidocysta sp. A.

- 4 PB 15102-1-9 (UT-UI-SD-44), 228X1168; X1000, 56 μ m.

Luxadinium propatulum

- 5 PB 15106-2-4 (UT-UI-SD-48), 233X1195; X1000, 89 μ m.
- 6 PB 15122-1-4 (UT-UI-SD-64), 152X1135; X1000, 42 μ m.
Enlargement of detached operculum.

Odontochitina operculata

- 7 PB 14315-2-7 (UT-UI-SD-3), 106X1189; X500, 222 μ m.

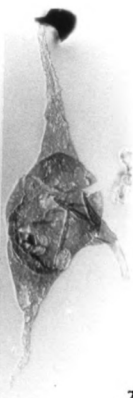
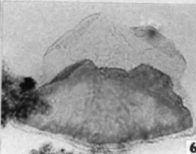
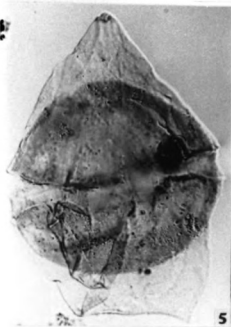
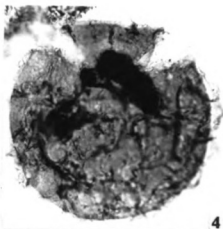
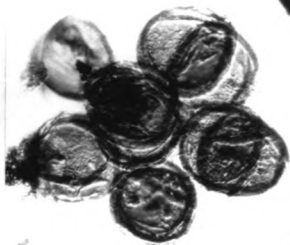
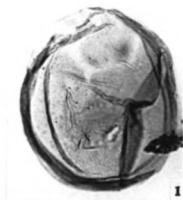


PLATE 26**DINOFLAGELLATE CYSTS -- PROXIMATE CAVATE (CONTINUED)***Odontochitina singhii*

1 PB 15102-1-8 (UT-UI-SD-44), 238X1286; X500, 325 μ m.

Ovoidinium verrucosum

2 PB 15122-1-4 (UT-UI-SD-64), 142X1194; X1000, 62 μ m.

Palaeohystrichophora infusorioides

3 PB 14789-2-3 (CO-ME-HCR-24), 221X1177; X1000, 64 μ m.

Subtilisphaera inaffecta

4 PB 15108-1-3 (UT-UI-SD-50), 163X1242; X1000, 47 μ m.

Subtilisphaera sp. A

5 PB 15102-1-9 (UT-UI-SD-44), 158X1198; X1000, 54 μ m.

Subtilisphaera sp. B

6 PB 15102-2-4 (UT-UI-SD-44), 138X1277; X1000, 52 μ m.

Subtilisphaera sp. C

7 PB 15108-1-3 (UT-UI-SD-50), 151X1162; X750, 91 μ m.

Subtilisphaera sp. D

8 PB 15102-1-8 (UT-UI-SD-44), 145X1197; X750, 94 μ m.

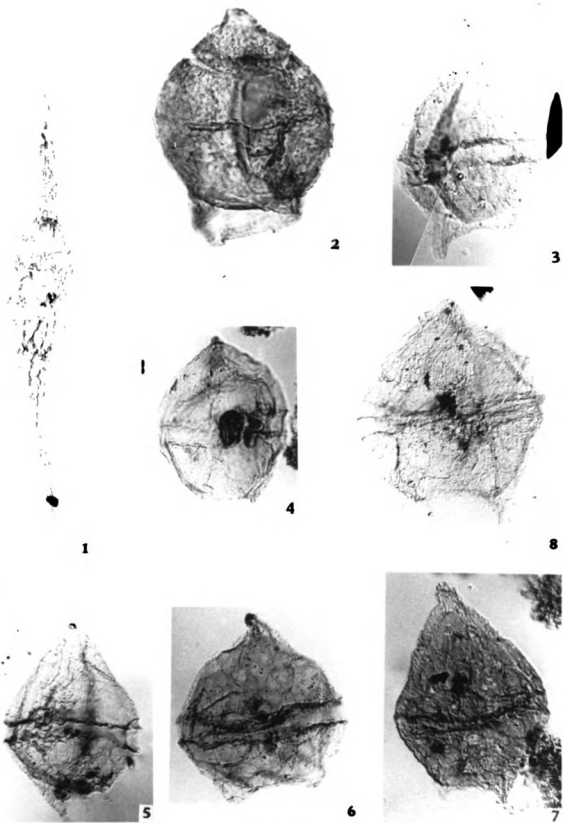


PLATE 26

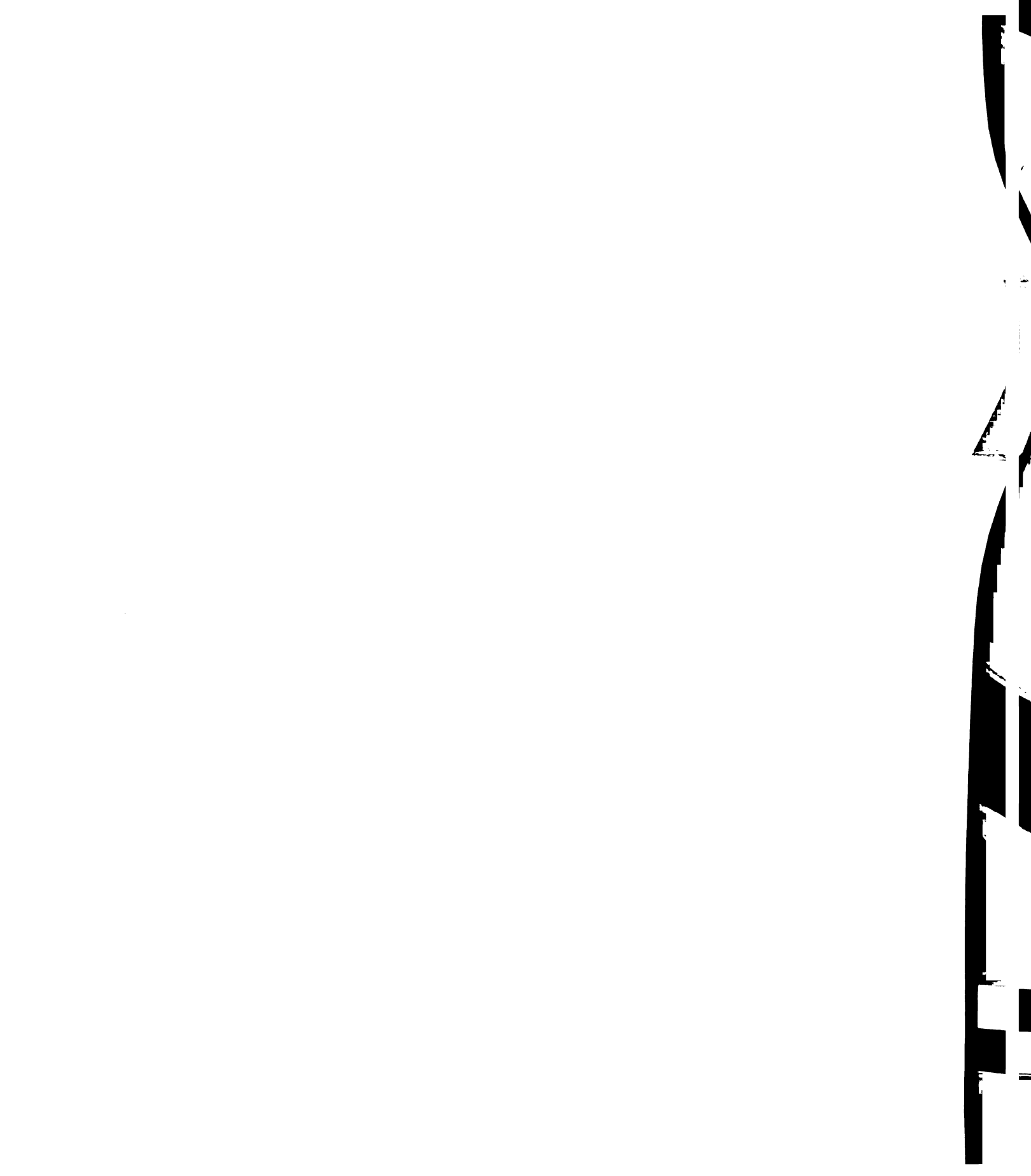


PLATE 27**DINOFLAGELLATE CYSTS -- PROXIMATE CAVATE (CONTINUED)***Thalassiphora microcysta*

- 1 PB 15106-2-4 (UT-UI-SD-48), 277X1246; X750, 75 μ m total 29 μ m body.

Dinoflagellate Form B

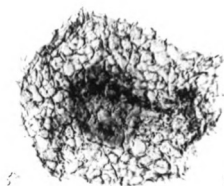
- 2 PB 15099-1-3 (UT-UI-SD-41), 127X1165; X1000, 54 μ m.
3 PB 15108-1-3 (UT-UI-SD-50), 214X1119; X1000, 46 μ m.

DINOFLAGELLATE CYSTS -- PROXIMATE ACAVATE*Apteodinium maculatum*

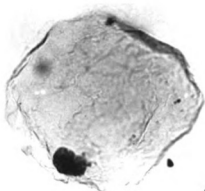
- 4 PB 14754-1-4 (UT-UI-SD-69), 212X1262; X1000, 51 μ m.
5 PB 14754-2-10 (UT-UI-SD-69), 301X1176; X750, 105 μ m.
Enlargement of detached operculum.

Batioladinium jaegeri

- 6 PB 15102-1-8 (UT-UI-SD-44), 135X1266; X750, 142 μ m.
7 PB 15107-2-3 (UT-UI-SD-49), 210X1215; X750, 185 μ m.



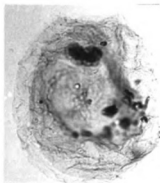
1



2



4



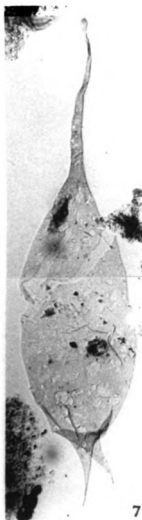
3



5



6



7

PLATE 27

PLATE 28**DINOFLAGELLATE CYSTS -- PROXIMATE ACAVATE (CONTINUED)***Caligodinium aceras*

- 1 PB 15102-1-8 (UT-UI-SD-44), 170X1224; X500, 104 μ m total, 60 μ m body.

Canningia sp. A

- 2 PB 15108-1-3 (UT-UI-SD-50), 170X1125; X750, 87 μ m.

Cyclonephelium uannophorum

- 3 PB 15098-1-3 (UT-UI-SD-40), 239X1140; X1000, 78 μ m.

Cyclonephelium sp. A

- 4 PB 15102-2-4 (UT-UI-SD-44), 154X1249; X750, 92 μ m.

Cyclonephelium sp. B

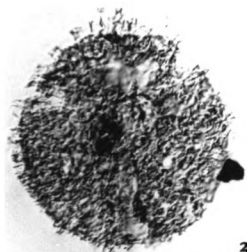
- 5 PB 6430-3-2 (UT-EM-IC-3), 064X1189; X1000, 66 μ m.

Fromea amphora

- 6 PB 15094-1-4 (UT-UI-SD-36), 174X1248; X1000, 85 μ m.



1



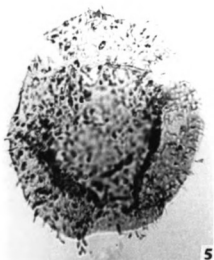
2



3



4



5



6

PLATE 29**DINOFLAGELLATE CYSTS -- PROXIMATE ACACATE (CONTINUED)***Fromea ?fragilis*

- 1 PB 15118-1-8 (UT-UI-SD-60), 205X1166; X750, 89 μ m.

Fromea sp. A

- 2 PB 15102-1-9 (UT-UI-SD-44), 250X1266; X750, 81 μ m by 69 μ m.

Fromea sp. B

- 3 PB 15102-2-4 (UT-UI-SD-44), 278X1145, X1000, 59 μ m.

Fromea sp. C

- 4 PB 15087-1-3 (UT-UI-SD-39), 176X1270; X750, 104 μ m.

Pareodinia sp. A

- 5 PB 14319-2-5 (UT-UI-SD-7), 295X1179; X1000, 52 μ m.

Pseudoceratium polymorphum

- 6 PB 15122-1-4 (UT-UI-SD-64), 304X1173; X750, 56 μ m.

Pterodinium cingulatum

- 7 PB 14752-1-9 (UT-UI-SD-67), 129X1286; X1000, 45 μ m.

Pterodinium sp. A

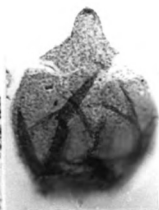
- 8 PB 15099-1-4 (UT-UI-SD-41), 254X1278; X1000, 56 μ m.



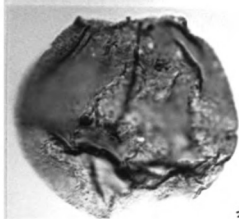
1



2



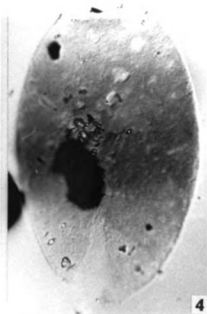
5



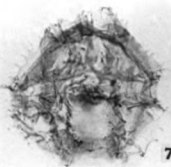
3



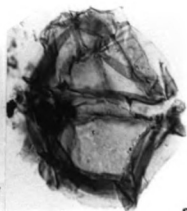
6



4



7



8

PLATE 29

PLATE 30**DINOFLAGELLATE CYSTS – PROXIMATE ACAVATE (CONTINUED)***Trichodinium castaneum*

1 PB 15094-1-3 (UT-UI-SD-36), 237X1102; X1000, 63 μ m.

Wigginsiella canadense

2 PB 15108-1-3 (UT-UI-SD-50), 217X1097; X750, 108 μ m.

Dinoflagellate Form A

3 PB 15102-1-9 (UT-UI-SD-44), 298X1224; X1000, 68 μ m.

4 PB 15102-1-10 (UT-UI-SD-44), 219X1165; X750, 73 μ m.

Dinoflagellate Form E

5a-b PB 15113-1-4 (UT-UI-SD-55), 161X1111; X1000, 62 total.
Two levels of focus.

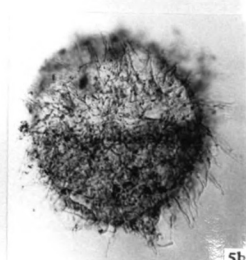
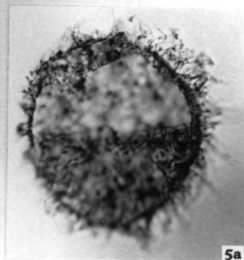
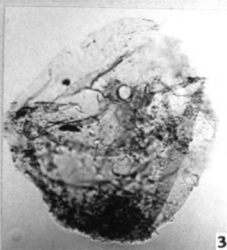
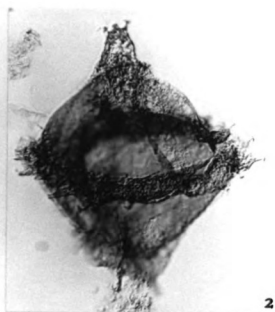
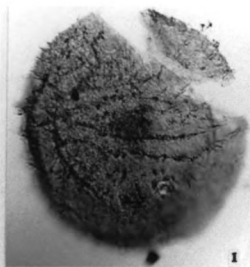


PLATE 31**DINOFLAGELLATE CYSTS -- PROXIMATE ACAVATE (CONTINUED)****Dinoflagellate Form F**

1 PB 15106-2-3 (UT-UI-SD-48), 141X1190; X1000, 63 μ m.

Dinoflagellate Form G

2 PB 14315-2-5 (UT-IU-SD-3), 185X1251; X1000, 69 μ m total.

Dinoflagellate Form H

3 PB 6430-2-3 (UT-EM-IC-3), 220X1233; X1000, 50 μ m.

DINOFLAGELLATE CYSTS -- SPINIFERATE***Hystichodinium oligacanthum***

4 PB 15102-1-9 (UT-UI-SD-44), 157X1195; X750, 100 μ m total 55 μ m body.

Spiniferites ramosus* ssp. *gracilis

5 PB 6442-1-3 (UT-EM-IC-15), 150X1213; X1000, 68 μ m total 36 μ m body.

Spiniferites ramosus* ssp. *ramosus

6 PB 15098-1-4 (UT-UI-SD-40), 144X1233; X1000, 56 μ m total.

DINOFLAGELLATE CYSTS -- CHORATE***Bourkidinium granulatum***

7 PB 15124-1-4 (UT-UI-SD-64), 245X1112; X1000, 75 μ m total 55 μ m body.

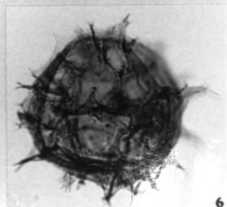
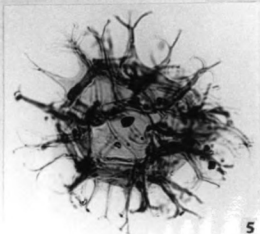
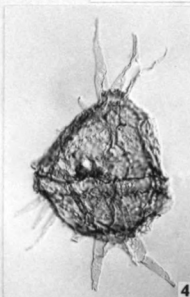
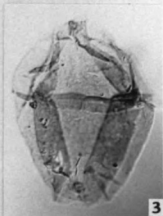
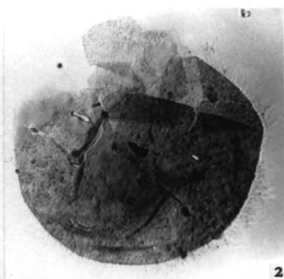
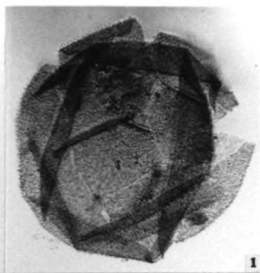


PLATE 32**DINOFLAGELLATE CYSTS -- CHORATE (CONTINUED)***Cleistosphaeridium ?multispinosum*

1 PB 15102-2-4 (UT-UI-SD-44), 158X1252; X1000, 54 μ m tota.

Cleistosphaeridium sp. A

2 PB 14315-2-5 (UT-UI-SD-3), 230X1196, X1000, 55 μ m total 46 μ m body.

Coronifera oceanica

3 PB 14315-2-7 (UT-UI-SD-3), 138X1221; X750, 89 μ m total.

Dapsilidinium marinum

4 PB 15107-2-3 (UT-UI-SD-49), 309X1196; X1000, 44 μ m total 29 μ m body.

Florentinia cooksoniae

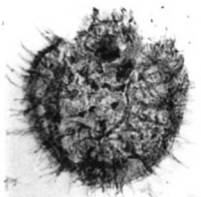
5 PB 15122-1-4 (UT-UI-SD-64), 125X1110; X1000, 67 μ m total 41 μ m body.

Kiokansium polypes

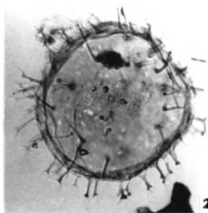
6 PB 15107-2-4 (UT-UI-SD-49), 237X1114; X1000, 38 μ m total 30 μ m body.

?Litosphaeridium sp. A

7 PB 15102-1-8 (UT-UI-SD-44), 209X1139; X750, 77 μ m total 54 μ m body.



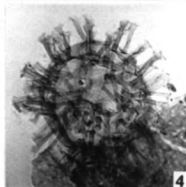
1



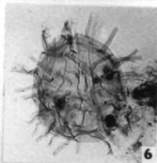
2



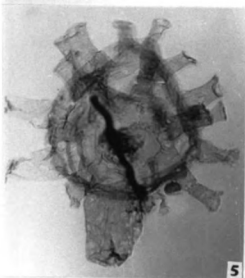
3



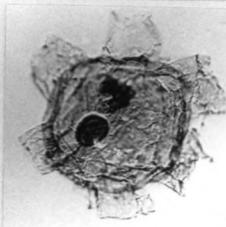
4



6



5



7

PLATE 33**DINOFLAGELLATE CYSTS -- CHORATE (CONTINUED)***Oligosphaeridium complex*

1 PB 14471-2-3 (UT-EM-M-12), 216X1225; X750, 115 μ m total 50 μ m body.

Oligosphaeridium pulcherrimum

2 PB 15102-2-4 (UT-UI-SD-44), 119X1139; X750, 110 μ m total 63 μ m body.

Oligosphaeridium tenuiprocessum

3 PB 15102-1-9 (UT-UI-SD-44), 221X1133; X750, 112 μ m total 68 μ m body.

Oligosphaeridium sp. A

4 PB 15102-1-9 (UT-UI-SD-44), 186X1236; X750, 103 μ m total 62 μ m body.

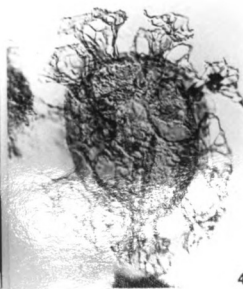
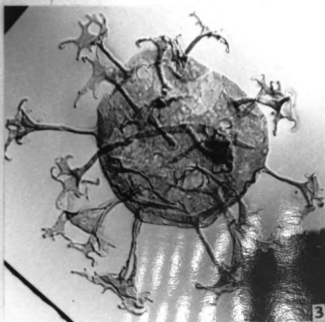
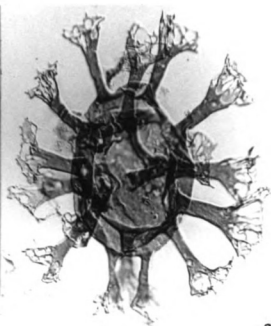
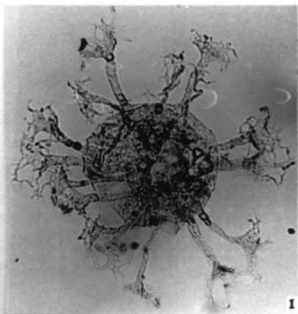


PLATE 34**DINOFLAGELLATE CYSTS -- CHORATE (CONTINUED)***Tanyosphaeridium salpinx*

- 1 PB 15098-1-4 (UT-UI-SD-40), 243X1134; X1000, 55 μ m total 36 μ m body.

Tanyosphaeridium sp. A

- 2 PB 14319-2-5 (UT-UI-SD-7), 293X1186; X1000, 54 μ m total, 41 μ m body.

Dinoflagellate Form C

- 3 PB 15098-1-4 (UT-UI-SD-40), 252X1138; X1000, 60 μ m total 40 μ m body.

Dinoflagellate Form D

- 4 PB 15122-1-4 (UT-UI-SD-64), 145X1227; X1000, 40 μ m total 25 body.

ACRITARCHS -- WITHOUT PROCESSES*Bipatellifera ?clathrata*

- 5 PB 15100-1-2 (UT-UI-SD-42), 160X1177; X1000, 24 μ m.

Pterospermella aureolata

- 6 PB 14754-2-7 (UT-UI-SD-69), 244X1114; X750, 81 μ m.

Pterospermella eurypteris

- 7 PB 15094-1-3 (UT-UI-SD-36), 176X1171; X750, 89 μ m total 41 body.

Acritarch Form A

- 8 PB 15106-2-4 (UT-UI-SD-48), 218X1223; X1000, 26 μ m.

ACRITARCHS -- WITH PROCESSES*Baltisphaeridium multispinosum*

- 9 PB 15122-1-4 (UT-UI-SD-64), 168X1092; X1000, 54 μ m total 39 μ m body.

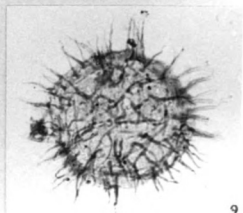
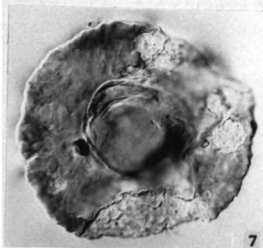
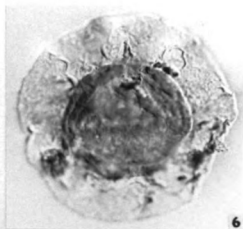
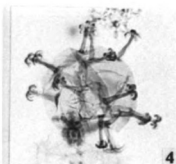
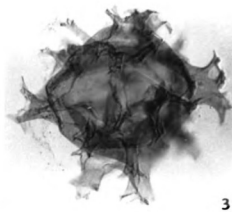
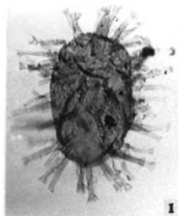


PLATE 35**ACRITARCHS -- WITH PROCESSES (CONTINUED)***Baltisphaeridium whitei*

1 PB 15118-1-8 (UT-UI-SD-60), 200X1165; X1000, 63 μ m total 41 μ m body.

Baltisphaeridium sp. A

2 PB 14594-1-4 (UT-EM-IC-21), 055X1130; X1000, 54 μ m total 38 μ m body.

Baltisphaeridium sp. B

3 PB 14403-2-4 (UT-EM-IC-22), 110X1163; X1000, 41 μ m total 26 μ m body.

Leiofusa jurassica

4 PB 15125-1-9 (UT-UI-SD-67), 307X1202; X750, 74 μ m.

Leiofusa sp. A

5 PB 15098-1-4 (UT-UI-SD-40) 222X1095; X1000, 38 μ m.

Micrhystridium fragile

6 PB 15122-1-4 (UT-UI-SD-64), 215X1147; X1000, 11 μ m.

Micrhystridium stellatum

7 PB 6430-2-3 (UT-EM-IC-3), 219X1189; X1000, 24 μ m total 16 μ m body.

Micrhystridium sp. A

8 PB 15108-1-3 (UT-UI-SD-50), 170X1125; X1000, 12 μ m.

Verhachium irregulare forma *subtetraedron*

9a-b PB 14954-1-4 (UT-EM-IC-21), 147X1258; X1000, 44 μ m total.

Verhachium lairdi

10 PB 14735-1-8 (UT-UI-SD-68), 153X1249; X1000, 67 μ m total.

MISCELLANEOUS MARINE MATERIAL*Microforaminiferal Lining Form A*

11 PB 14469-1-1 (UT-EM-M-9), 175X1114; X1000, 66 μ m.

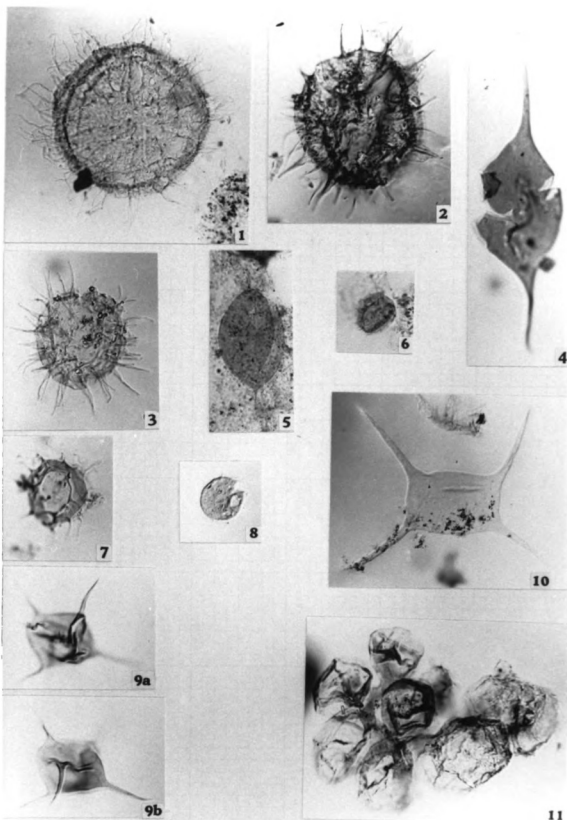


PLATE 35

PLATE 36**FORMS OF UNCERTAIN ORIGIN****Unknown Form A**

1 PB 15102-2-3 (UT-UI-SD-44); 171X1219; X1000, 114 μ m.

2 PB 15102-1-7 (UT-UI-SD-44); 168X1291; X1000, 129 μ m.

Unknown Form B

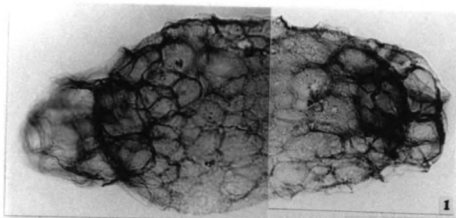
3 PB 15107-2-4 (UT-UI-SD-49), 234X1009; X1000, 47 μ m.

Unknown Form C

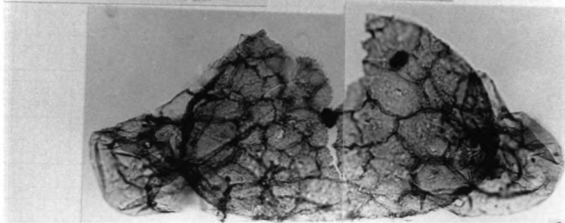
4 PB 15094-1-4 (UT-UI-SD-36), 232X1263; X1000, 53 μ m.

Unknown Form D

5 PB 15102-1-8 (UT-UI-SD-44), 144X1124; X1000; 60 μ m.



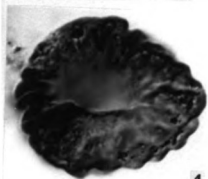
1



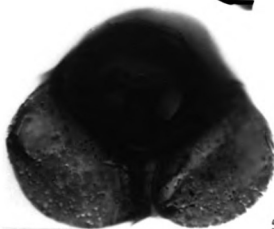
2



3



4



5