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In Memoriam

Orville L. Bandy
1916-1973

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PALYNOLOGY OF THE ALMOND FORMATION (UPPER CRETACEOUS), ROCK SPRINGS UPLIFT, WYOMING

J. Fred Stone*

ABSTRACT

The palynomorph content of the Almond Formation (Upper Campanian) was investigated using 80 samples from six measured sections on the east flank of the Rock Springs Uplift, Wyoming. A composite standard reference section of the total Almond and four additional sections of the marine interval of the upper Almond were used. One hundred thirteen species of palynomorphs were identified. Five new species are described. The affinities or possible relationships of the form species with living plants are noted.

Paleoenvironmental and paleoecological investigations were made using the distribution and stratigraphic range of the species; the absolute abundance of species, groups of species, and dispersed plant tissues; the ratio of marine species to nonmarine species; the diversity of the palynomorphs and the cluster analysis grouping of species. The marine upper Almond Formation is easily distinguished by the presence of 25 species, mainly dinoflagellates and acritarchs, which are restricted to it in the sections studied. The dinoflagellate species, *Trithyrodinium druggii* Stone, n. sp., is abundant and restricted to the marine upper Almond and may be used to characterize it. The dinoflagellate species, *Deflandrea cooksoni* Alberti, has a restricted range within the upper Almond and is used to subdivide the marine interval.

The criteria which are most useful in subdividing the upper Almond are the ratio of marine to nonmarine species and the absolute abundance of marine species and nonmarine species. Three subunits, A, B, and C, are defined using the ratio and absolute abundance as observed from plots of this information for each section.

An R-mode cluster analysis was performed using the Jaccard Coefficient of similarity and resulted in some distinct groupings of species at high similarity levels. The marine species were clustered as one large group, and a subgroup at a higher similarity level contained the more relatively abundant marine species which, it is suggested, represent the most marine association of species. One high level cluster group contains species restricted to the lower Almond and has possible significance as a nonmarine species association.

ACKNOWLEDGMENTS

The author is indebted to A. T. Cross of the Departments of Geology and Botany-Plant Pathology of Michigan State University under whose direction this study was accomplished.

R. L. Tabbert and others of the Atlantic Richfield Company supported the study and contributed helpful suggestions. J. N. Minick and his associates measured and described the geologic sections and collected most of the samples. J. E. Bennett advised as to the chemical processing of the samples and J. W. Dial assisted in the processing.

The facilities of the Field Research Laboratory of the Mobil Research and Development Corporation were utilized by the author. Of particular value was the use of the computer center. The program for the distribution-range charts was written by T. Nash. The programs for relative abundance, absolute abundance, and diversity

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*Mobil Oil Corporation, Exploration Services Center, P.O. Box 900, Dallas, Texas 75221.

were written by R. J. Pauken. The cluster analysis program was written by Ed Hagmeier of the Department of Biology of the University of Victoria, British Columbia, Canada, and implemented for Mobil's computer by R. J. Pauken and D. Duncan.

This study was supported in part by National Science Foundation Grant GA429, "Palynological Analysis and the Determination of Environments of Deposition in the Rocky Mountain Cretaceous," A. T. Cross, principal investigator.

Mobil Research and Development Corporation, Dallas, Texas, provided the funds for the cost of illustrations for the published paper.

The author's wife, Judith C. Stone, assisted in compiling the manuscript and in typing the manuscript.

INTRODUCTION

PURPOSE AND SCOPE

Tht objective of this study was to investigate the palynomorph content of the Upper Cretaceous Almond Formation from measured sections in the area of outcrop on the east flank of the Rock Springs Uplift, Wyoming. The palynomorphs are documented, identified, and classified into form taxa. Five new form species are described. The affinities or possible relationships of the form species with living plants are noted.

Paleoenvironmental and paleoecological inferences are made on the basis of the distribution and stratigraphic range of the species; the absolute abundance of species, groups of species and dispersed plant tissues; the ratio of marine species to nonmarine species; the diversity of the palynomorphs and the cluster analysis grouping of species.

PREVIOUS INVESTIGATIONS

Palynological investigations of Upper Cretaceous rocks in the Western Interior of the United States and Canada have mainly dealt with the Upper Cretaceous-Tertiary boundary and include mainly formations of Maestrichtian and Paleocene age. The major contributions of this type include those of Rouse (1957, 1962), Anderson (1960), Stanley (1965), Srivastava (1966), Drugg (1967), Norton and Hall (1969), Oltz (1969), and Snead (1969). The proceedings volume of the Geological Society of America symposium on Late Cretaceous and Early Tertiary palynomorphs (Kosanke and Cross, ed., 1971) contains pertinent papers by Leffingwell, R. H. Tschudy, B. D. Tschudy and Leopold, Rouse, Hopkins, and Piel, and Zaitzeff and Cross.

Few published palynological studies concerning this geographic area deal with rocks of Campanian age. One important exception is the work of Newman (1964, 1965) which gave the stratigraphic occurrence of selected palynomorphs of Campanian, Maestrichtian, and Paleocene ages in rocks from northwestern Colorado. Most of the palynomorphs which were encountered in the Almond Formation have been illustrated without identification or explanation by Leopold and B. D. Tschudy (1965, unpublished, U.S.G.S. Open-File Report) as a result of their study of upper Campanian-lower Maestrichtian rocks near Redbird, Niobrara County, Wyoming. Two papers of interest in terms of paleoenvironmental interpretations involving slightly older rocks are those of Sarmiento (1957) and Burgess (1970). The Upper Cretaceous palynological literature through 1966 has been adequately reviewed by Srivastava (1967).

STRATIGRAPHY

GENERAL STATEMENT

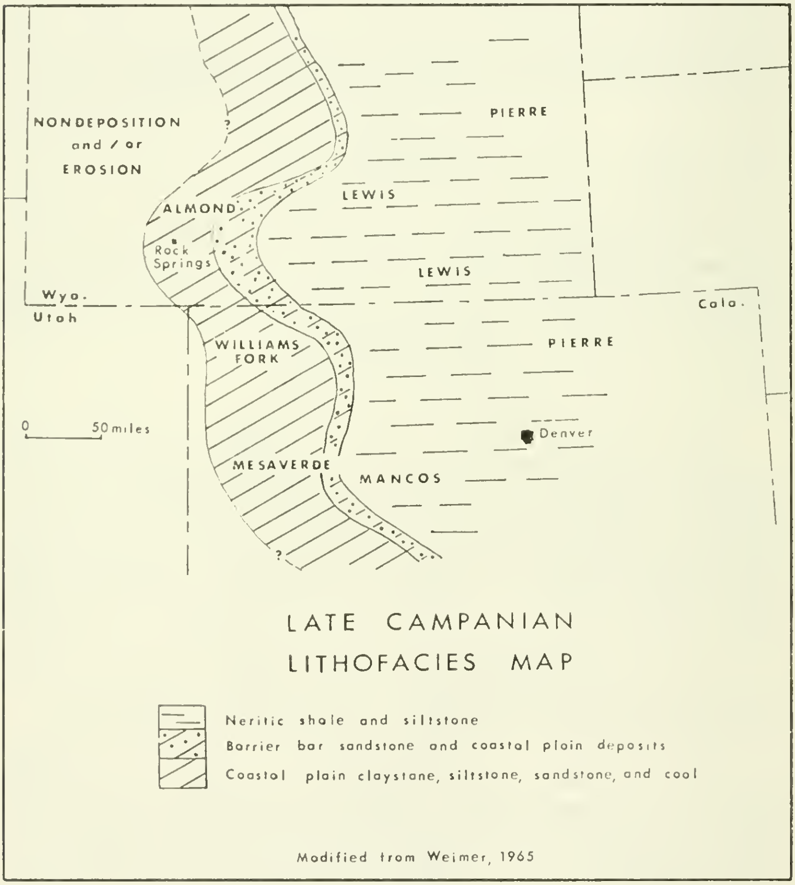
The Rock Springs Uplift, a large, anticlinal, structural feature, is located in Sweetwater County in southwestern Wyoming. The structural axis of the uplift trends north-south and lies east of the town of Rock Springs. The uplift has been breached by erosion, exposing Upper Cretaceous rocks of Santonian, Campanian, and Maestrichtian age. The formational names applied to these rock units are, from oldest to youngest, Baxter Formation, Blair Formation, Rock Springs Formation, Ericson Sandstone, Almond Formation, Lewis Shale, Fox Hills Sandstone, and Lance Formation.

The Mesaverde rock unit name is widely used in the Western Interior of the United States, both with formational and group status. In the Rock Springs area, the Mesaverde is given group status and consists of four formations, Blair, Rock Springs, Ericson, and Almond. The Mesaverde Group is correlated, in part, with the Pierre Shale, also of the Western Interior, and, in part, with the

Taylor and Navarro Groups of the Gulf Coastal Plain (Cobban and Reeside, 1952). The Almond Formation, in a stratigraphic framework, is the uppermost formation of the Mesaverde Group, Gulf Series, (Upper) Cretaceous System of the Mesozoic rocks.

ALMOND FORMATION

The Almond Formation consists of a body of sediments of both nonmarine and marine origin. These were deposited along the western margin of the Late Cretaceous epicontinental sea (Text-fig. 1).



Text-figure 1

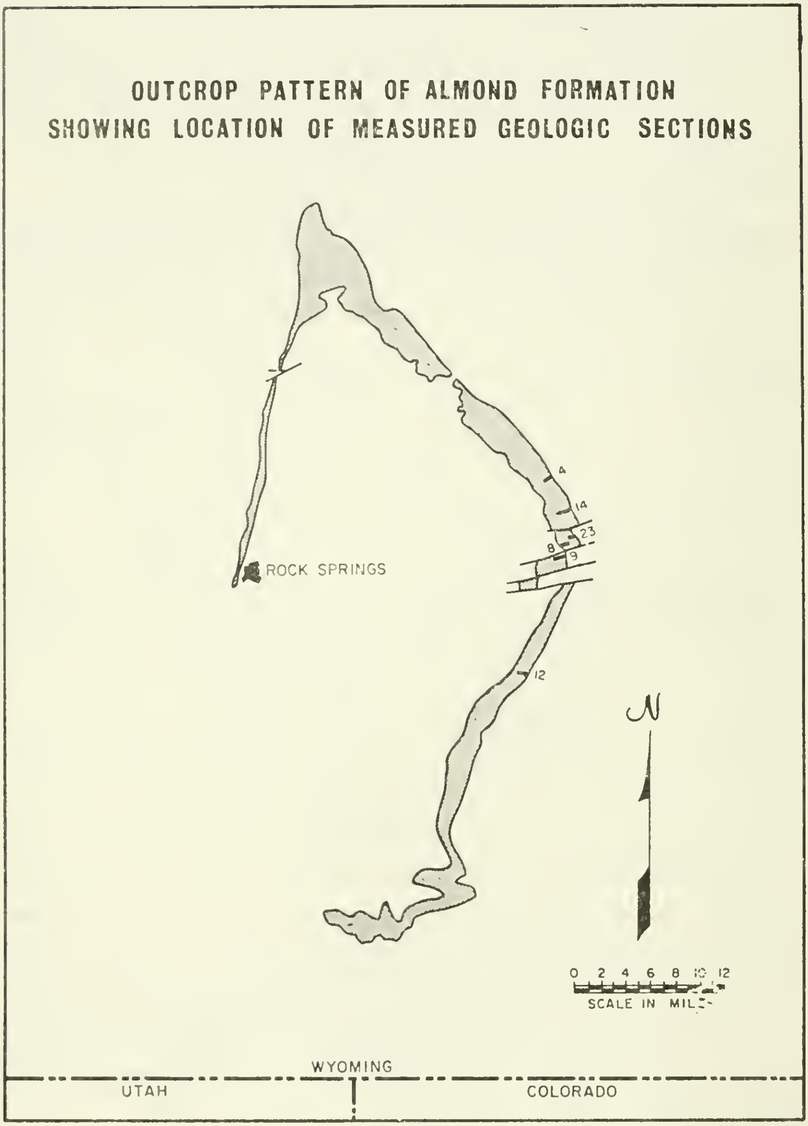
This seaway was elongate north-south and extended from the present Gulf of Mexico to northern Canada. It was bordered on the east by the lowlands of the stable interior of the continent and on the west by the Laramide Highland (Clark and Stearn, 1960). The tectonically positive Laramide Highland is considered to have been the source of the Almond Formation sediments.

Measured surface sections of the Almond Formation on the east flank of the Rock Springs Uplift have been published by Lewis (1965). The thickness ranged from 555′ to 671′ for six sections. The composite section used as a standard in this study has a total thickness of 660′. Lithologically the Almond may be divided into a lower "nonmarine" portion (377′ at the standard section) and an upper "marine" portion (283′). Each of these two units may be further subdivided into two parts; the lower nonmarine portion into a Lower Siltstone Unit and Lower Sandstone Unit, and the upper marine portion into an Upper Shale Unit and Upper Sandstone Unit.

At its base the Almond Formation contrasts sharply with the underlying Ericson, a coarse white to buff-colored sandstone. The Lower Siltstone Unit is a lithologically variable unit of siltstones interbedded with shales, sandstones, and coals which is 331′ thick in the standard section. As a unit these sediments are fluviatile in origin. The Lower Sandstone Unit (46′) consists of light gray to buff-colored, thick-bedded or massively crossbedded, fine-grained sandstone probably of barrier-bar origin. The Upper Shale Unit, the "marine tongue" of the Almond Formation is a gray marine shale and siltstone sequence about 200′ thick with occasional thin layers and lenses of sandstone. The Upper Sandstone Unit is a barrier-bar sequence comparable to the Lower Sandstone Unit. It is not particularly well developed at the standard section (about 83′ thick). The marine shales of the Upper Almond interfinger with the overlying Lewis Shale. The depositional environments and geologic history of the Almond Formation have been studied in considerable detail on the outcrop by Jacka (1965) and in the subsurface by Weimer (1961, 1966) and McCubbin and Brady (1969).

MEASURED SECTIONS AND SAMPLE LOCALITIES

The location of the six measured sections utilized in this study may be seen in Text-figure 2. The sections used are numbered, from



Text-figure 2

north to south, 4, 14, 23, 9, 12 (Upper Almond) and 8 (Lower Almond). The composite section, 8-14, which is used as the standard section for this study was selected because it has the closest sample interval. These six particular stratigraphic sections were chosen from several available sections because of their location on the easternmost portion of the outcrop area where the Upper Shale Unit is best developed. The marine shale thins and pinches out both to the north and the south. Reliable lithologic correlations are present between these sections. The outcrop is continuous and may be "walked out."

The sections were measured, described, and sampled by J. N. Minick and other geologists of the Atlantic Richfield Co. in 1966 and represent unpublished information. In 1967 the author inspected all of the sections in the field with the field geologists and in some cases supplemented the sampling. The measured sections with the field geologists' descriptions have been reproduced by Stone (1971). The lithologic columns with the relative position of the samples may be seen in Text-figures 10, 11-15. The locations of the measured sections in Sweetwater County by township and range notation are as follows: M. S. 8 (Sec. 12, T19N, R101W), M. S. 4 (Sec. 25, 26, T20N, R101W), M. S. 14 (Sec. 36, T20N, R101W; Sec. 31, T20N, R100W), M. S. 23 (Sec. 7, T19N, R101W), M. S. 9 (Sec. 12, T19N, R101W) and M. S. 12 (Sec. 16, T17N, R101W).

TECHNIQUES

SAMPLE COLLECTING

To avoid modern pollen and spore contamination and to avoid to some extent the destructive effects of surface weathering on fossil palynomorphs, all samples were collected from channels dug two to three feet into the outcrop. The samples were composited from approximately one-foot intervals which were exposed in the channel. The samples were placed in cloth bags with plastic liners to prevent contamination. Only the finer clastic rocks, *e.g.,* shales and siltstones, were collected.

SAMPLE PROCESSING

The following procedures were used in the laboratory processing of the samples:

1. Weigh crushed sample, 10 g.
2. Demineralization
   A. Hydrochloric acid, concentrated, 24 hours
   B. Hydrofluoric acid, concentrated, 24 hours
3. Heavy liquid separation, 2.0 specific gravity, zinc bromide, 20 minutes at 2000 r.p.m.
4. Oxidation, Schulze solution, 3 minutes, saturated solution of potassium chlorate in concentrated nitric acid.
5. Oxidation, potassium hydroxide, 5% solution, one minute.
6. Heavy liquid separation, 1.7 specific gravity, 15 minutes at 2000 r.p.m.
7. Stain, safranine 0

SLIDE MAKING

Processing of a known weight of sample permits one to arrive at an estimation of the absolute abundance of palynomorphs in the sample. The technique used was essentially that of Davis (1966) and represents some refinement of the technique of Stone (1967). When a precise aliquot of a known volume of residue from a known weight of sample is counted, the number of "grains per gram" of sediment may be calculated. Critical to the technique is the use of a pipette controlled by a hypodermic syringe. Using a small volume (generally .01 ml) of residue permits the counting of all palynomorphs on the slide. In addition to the known aliquot slide, ordinary slides with a high concentration of palynomorphs were also made.

ASSEMBLAGE ATTRIBUTES

DISTRIBUTION AND RANGE OF SPECIES

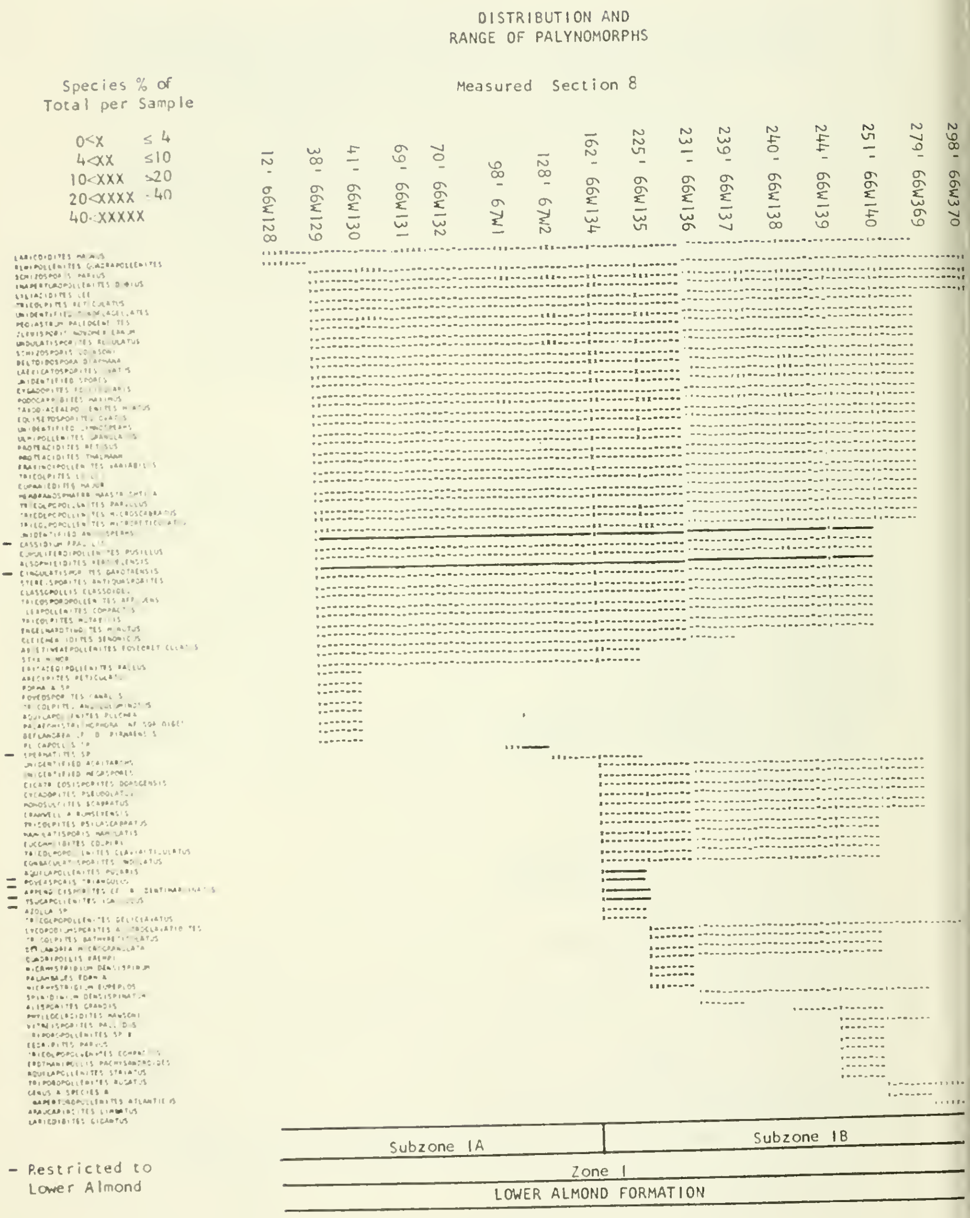
The observed distribution and inferred range of each species at each of the six measured sections and the standard section are presented in Text-figures 3-9. The presence of a given species in a sample is noted by one or more X's (reflecting relative abundance in the sample) and the resulting range is noted by connecting with dashes. The ranges of palynomorphs or groups thought to be characteristic for lower and upper Almond are indicated by solid bars on Text-figures 3 through 9. The arrangement of species is on a "first occurrence-longest range" basis and is not consistent from section to section. A consistent "taxonomic arrangement" of species giving distribution was used in the analysis but is not reproduced here. The numbers given with the species names are code numbers used solely for the computer construction of the distribution-range charts.

A number of observations may be made concerning the distribution of species. The most outstanding distribution characteristic is the restriction of many dinoflagellate and acritarch species to the upper Almond. The following 25 species are restricted to the upper Almond:

Trithyrodinium druggii
Deflandrea magnifica
D. cf. *D. verrucosa*
D. pannucea
D. cooksoni
Palaeocystodinium benjaminii
Spiniferites ramosa var. *membranacea*
Dinogymnium sp. 1
D. nelsonense
Cordosphaeridium fibrospinosum
Hystrichosphaeridium tubiferum
Diphyes colligerum
Palaeostomocystis laevigata
Micrhystridium inconspicuum
M. piliferum
M. fragile
Pterospermopsis australiensis
Sporopollis cf. *S. laqueaeformis*
Trudopollis meekeri
Todisporites cf. *T. minor*
Polypodiisporites favus
Styx major
Liliacidites complexus
Botryococcus sp.
Aquilapollenites reticulatus

The following seven species are restricted to the lower Almond:

Cassidium fragilis
Cingulatisporites dakotaensis



Text-figure 3

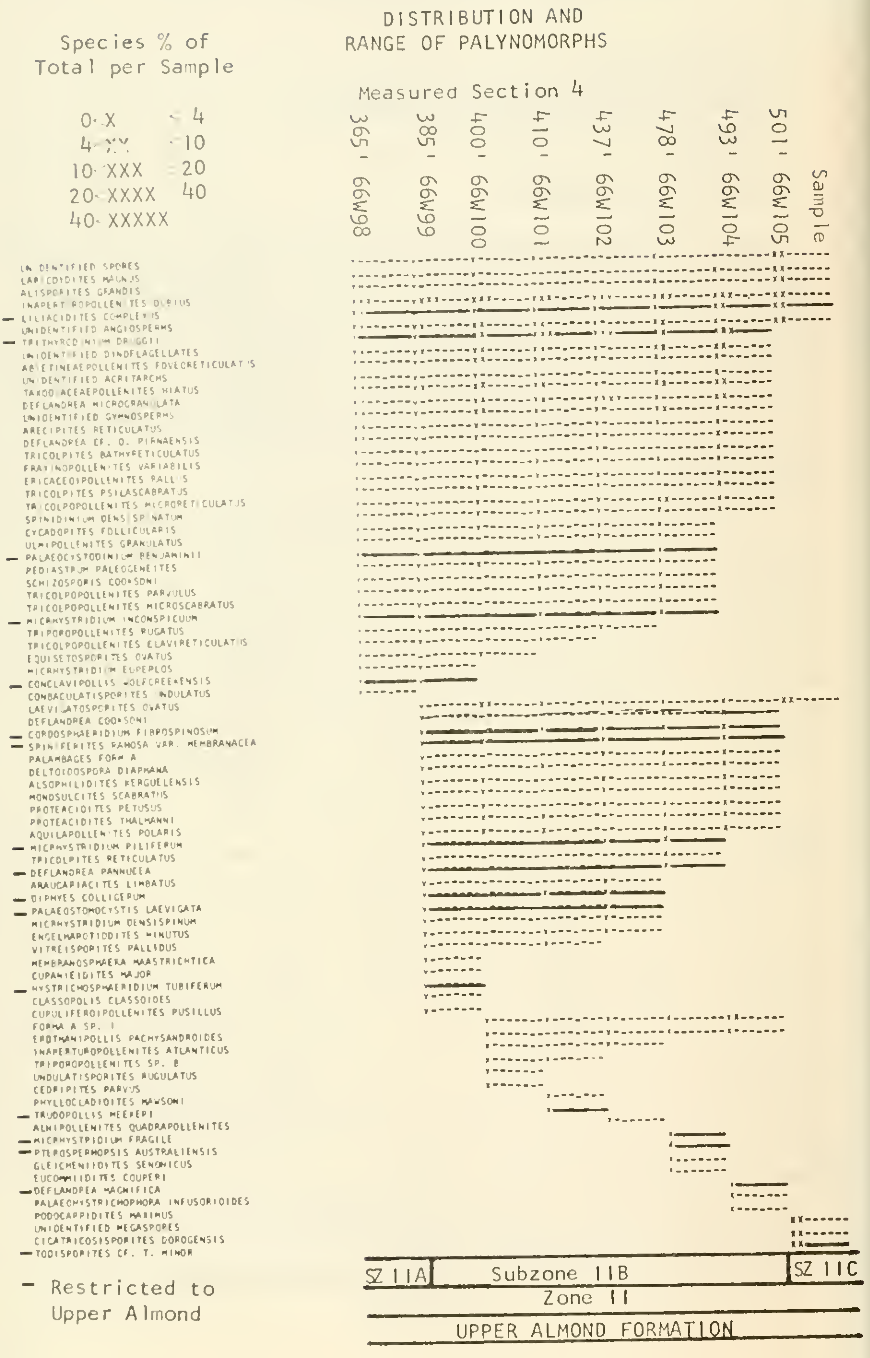
Spermatites sp.
Appendicisporites cf. *A. dentimarginatus*
Tsugaepollenites igniculus
Azolla sp.
Foveasporis triangulus

There was little variation in the geographic distribution of species among the upper Almond sections. Three species, *Dinogymnium nelsonense*, *Botryococcus* sp., and *Aquilapollenites reticulatus*, are restricted to Section 14. *Aquilapollenites pulcher* is restricted to Section 23. *Cicatricosisporites dorogensis* is restricted to Section 4 and *Hamulatisporis hamulatis* is restricted to Section 9. All are rare species and little significance is attached to their geographic distribution.

A biostratigraphic zonation of the Almond Formation may be accomplished using the vertical distribution of species. The criteria used for zonation are restricted ranges, first occurrences, and last occurrences. An obvious Zone I (lower Almond) and Zone II (upper Almond) may be constructed since most dinoflagellate and acritarch species are restricted to the upper Almond. Zone I is characterized by the restricted species, *Cassidium fragilis* and *Cingulatisporites dakotaensis*. Zone II is characterized by *Trithyrodinium druggii*. Five subzones seem evident at the standard section but they can be traced to the other upper Almond sections only to a limited extent. Subzone IA contains no restricted palynomorphs. Subzone IB is characterized by the first occurrence of several species and by the restricted *Tsugaepollenites igniculus*. Subzone IIA is characterized by *Diphyes colligerum* and *Palaeostomocystis laevigata*. Subzone IIB is characterized by *Deflandrea cooksoni*. This species is restricted in all the upper Almond sections to a particular portion of the upper Almond. Subzone IIB is terminated and Subzone IIC started by the last occurrence of several species. Correlation by subzones between sections is limited at best and the zonation would not be expected to persist if a greater stratigraphic interval or greater geographic area were studied.

RELATIVE ABUNDANCE OF SPECIES AND GROUPS OF SPECIES

The relative abundance of each species and of various groups

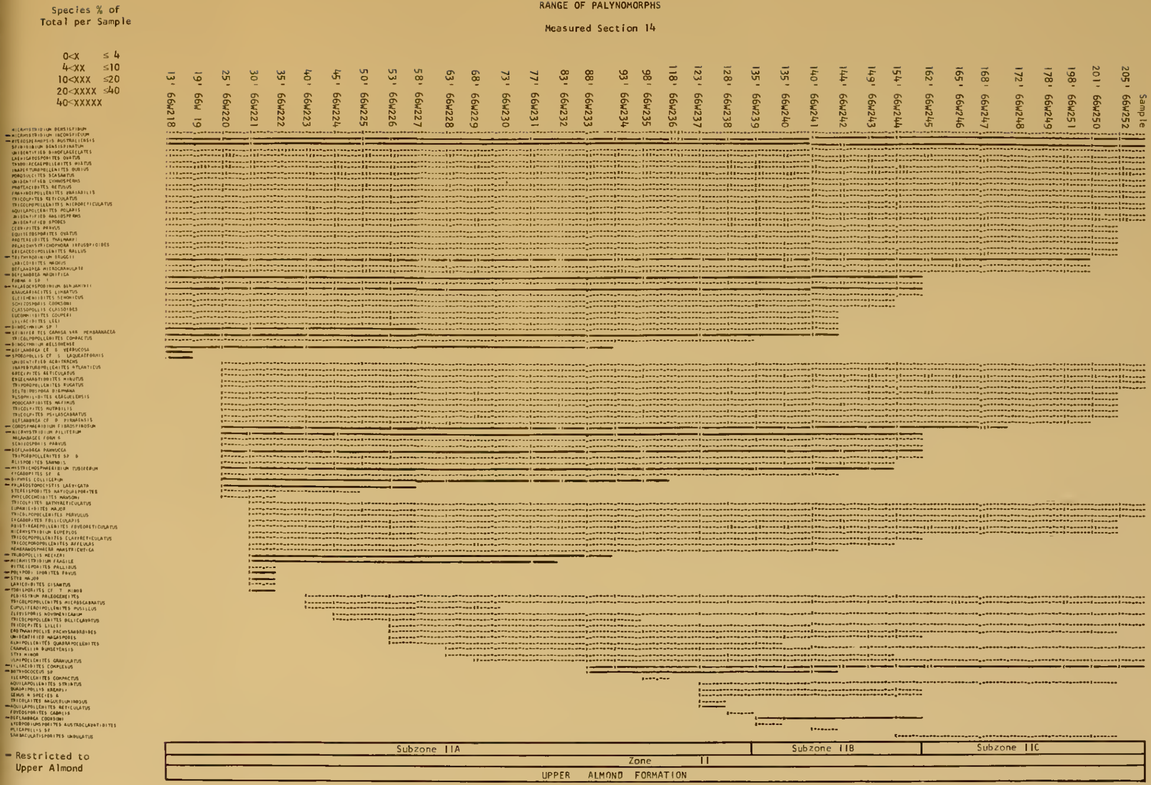


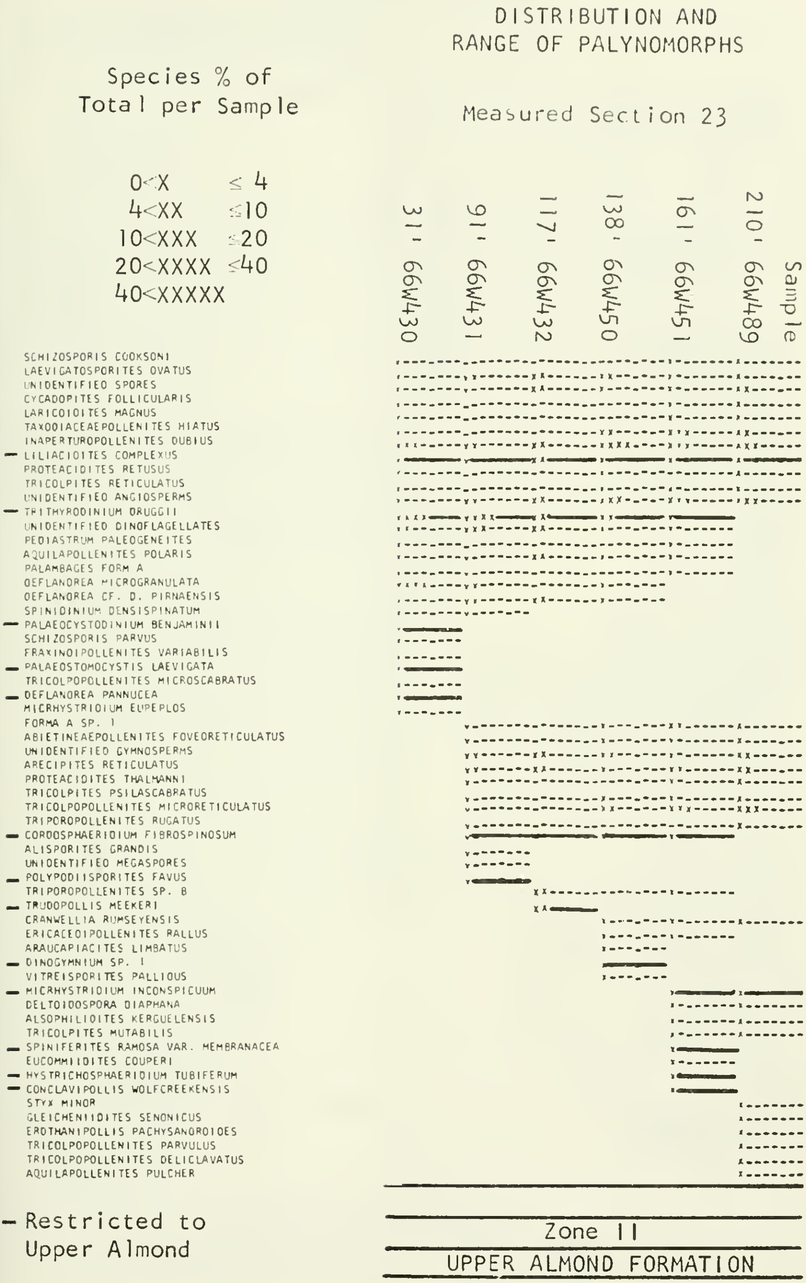
Text-figure 4

FIGURE 5

DISTRIBUTION AND
RANGE OF PALYNOMORPHS

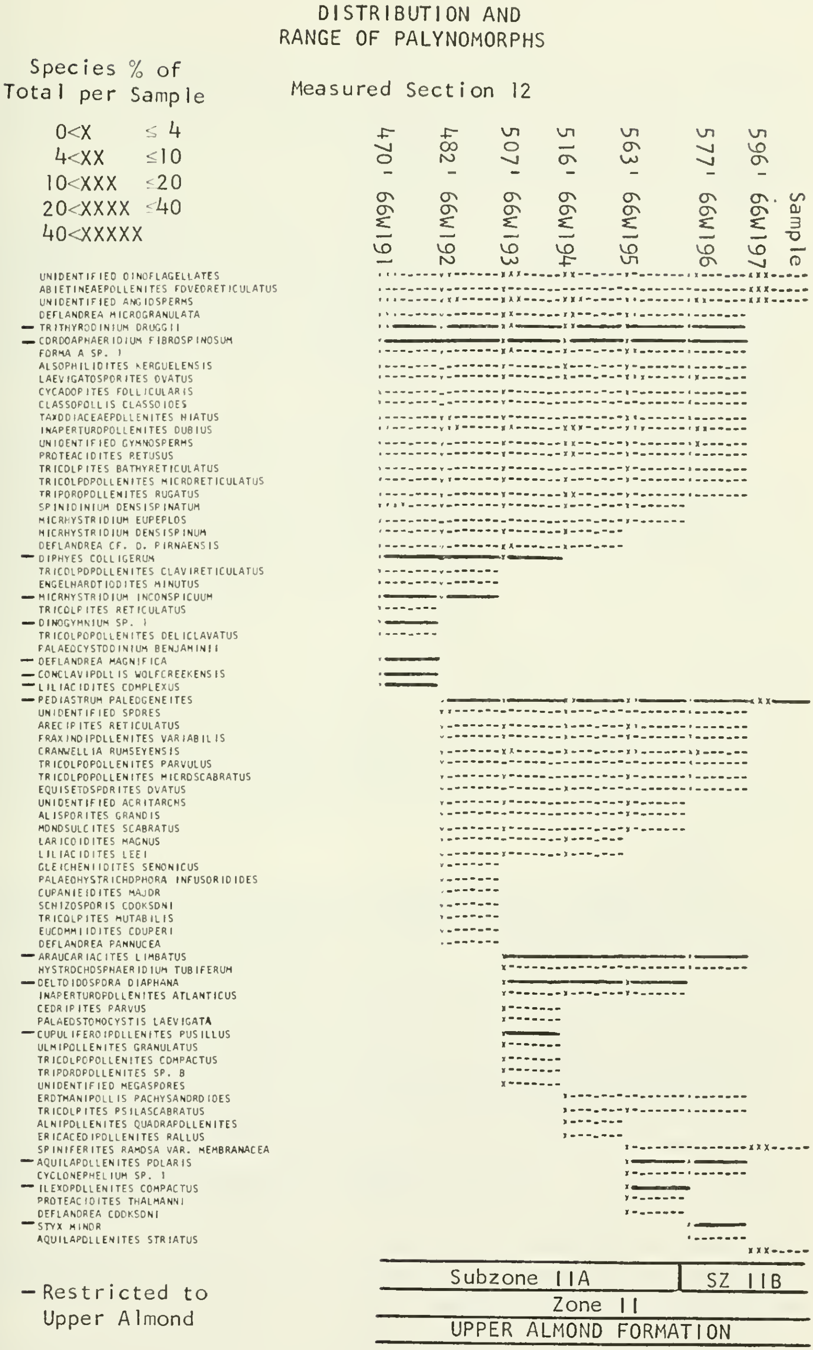
Measured Section 14





Text-figure 6

Text-figure 7



Text-figure 8

of species was investigated and has been summarized by Stone (1971). The basic count data are presented in Table XI (see fold in between pp. 48, 49). The ratios of marine to nonmarine entities are plotted on Text-figures 10 and 17.

ABSOLUTE ABUNDANCE OF GROUPS OF SPECIES AND TISSUE

Counts were made for 45 samples using the known aliquot slides. The dispersed plant tissue in general consisted of cuticles, tracheids, and other cells with bordered pits and secondary thickenings. The palynomorphs were counted as to major group and an additional count was made of the tissue with recognizable cell structure.

Consecutive and non-overlapping traverses were used so that all palynomorphs on the slide were counted. As noted in the slide preparation discussion, counting all the palynomorphs from an aliquot (.01ml) of a known volume of residue (15ml) from a weighed sample (10g) permits calculation of the number of palynomorphs per gram of sediment. Computer calculations were made of the "grains per gram" of the seven major groups, of the tissue, of the total marine palynomorphs, of the total nonmarine palynomorphs (excluding tissue) and of the total palynomorphs (also excluding tissue). The variations in absolute abundance are tabulated (Tables I-V) and are summarized in Text-figures 11-15. The absolute abundances of marine and non-marine palynomorphs are plotted in Text-figure 17.

In light of modern sediment studies of the distribution of palynomorphs (Muller, 1959; McKee, Chronic and Leopold, 1959; Rossignol, 1961; Stanley, 1966; Cross, Thompson and Zaitzeff, 1966; Traverse and Ginsburg, 1966) the "grains per gram" statistic may prove to be one of the more useful in determining sedimentary environments through the use of palynomorphs. Confident comparison of samples is limited by some unknown factors such as the size, composition (and hence the density), and rate of accumulation of the sedimentary particles making up the rock. In the present study all the samples are terrigenous clastics in the clay and silt size fractions with varying sand content. The mineralogic composition has not been investigated and the rate of accumulation is unknown. Evaluation of the absolute abundance data is deferred to the Discussion and Conclusion section.

FIGURE 9

DISTRIBUTION AND
RANGE OF PALYNOMORPHS

Measured Sections 8 and 14
Standard Reference Section
Almond Formation

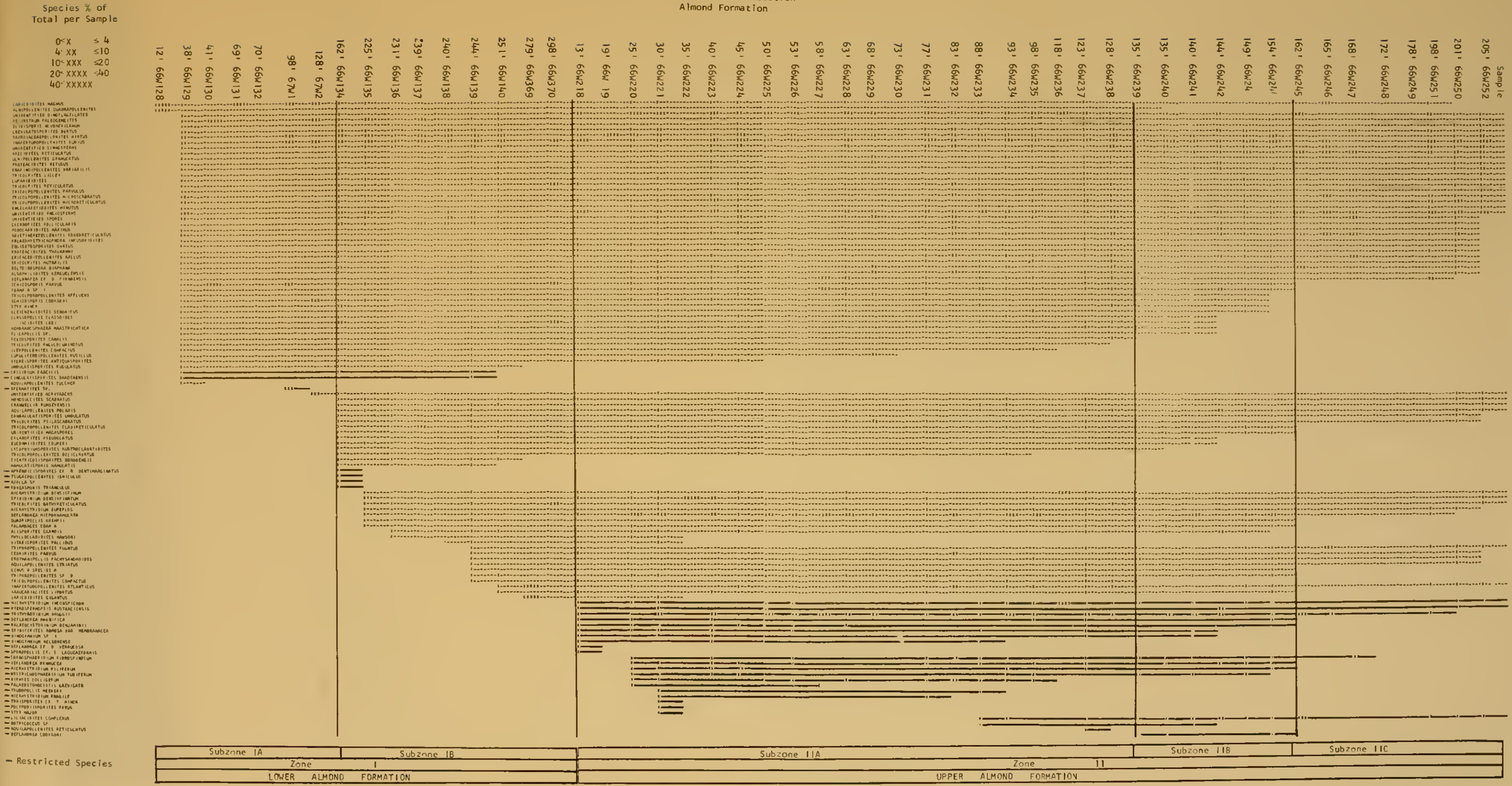
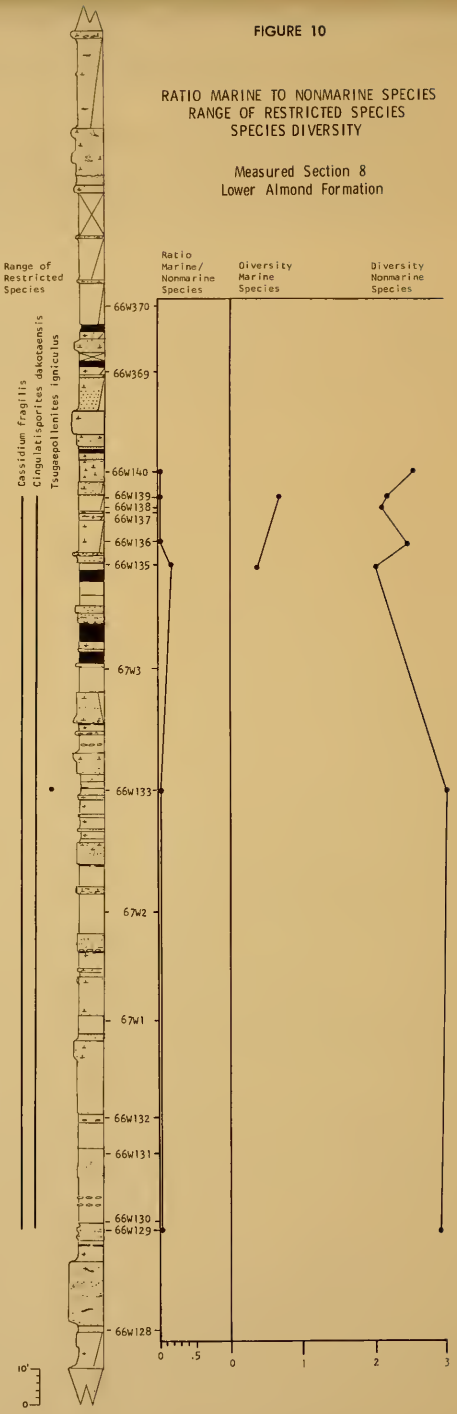
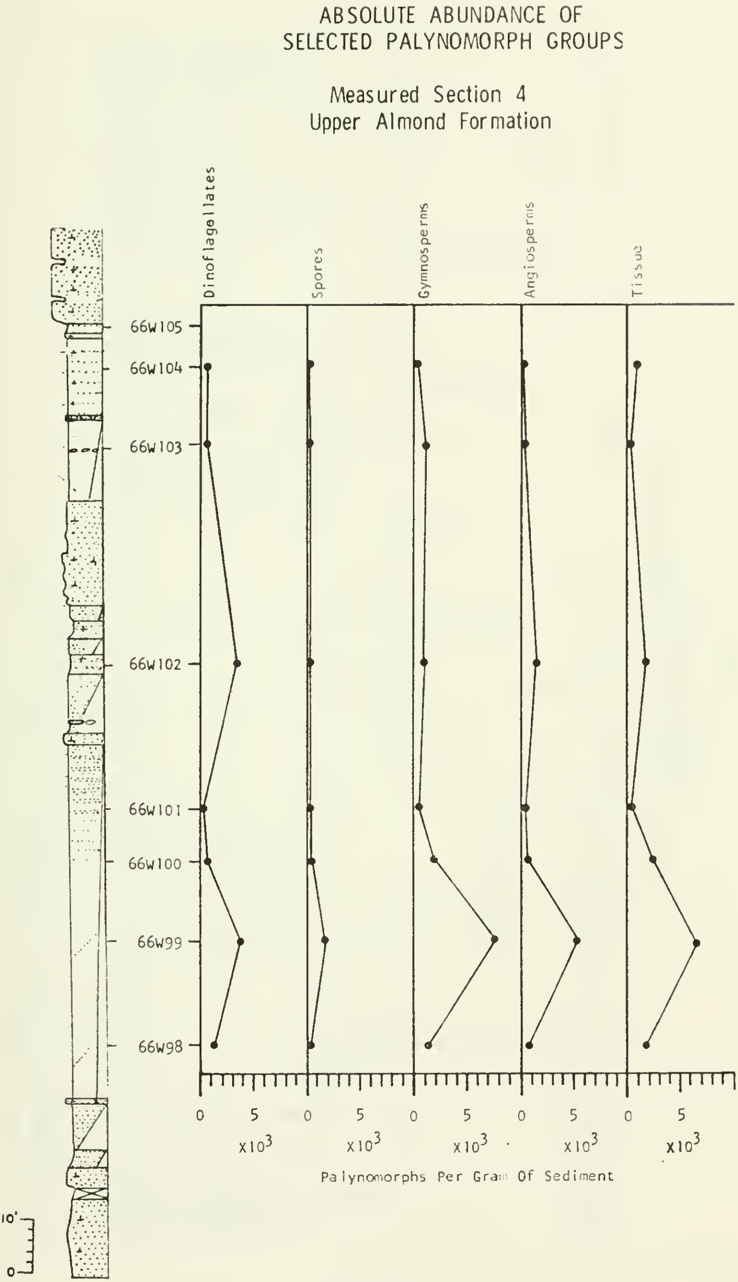


FIGURE 10

RATIO MARINE TO NONMARINE SPECIES
RANGE OF RESTRICTED SPECIES
SPECIES DIVERSITY

Measured Section 8
Lower Almond Formation





Text-figure 11

TABLE I

MEASURED SECTION 4
ABSOLUTE ABUNDANCE OF PALYNOMORPH GROUPS

Sample	Aliquot*	Acritarchs		Dinoflagellates		Algae		Megaspores		Spores		Gymnosperms		Angiosperms		Tissue	
		Count	g/g**	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g
66W105	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W104	.01	0	0	19	950	0	0	0	0	4	200	8	400	9	450	20	1000
66W103	.01	1	50	17	850	2	100	0	0	4	200	22	1100	13	650	15	150
66W102	.05	1	10	333	3330	1	10	0	0	19	190	84	840	149	1490	182	1820
66W101	.03	1	17	10	167	0	0	0	0	2	33	11	183	13	217	31	517
66W100	.01	0	0	17	850	2	100	0	0	5	250	40	2000	14	700	43	2150
66W 99	.03	42	700	238	3967	18	300	0	0	116	1937	470	7833	312	5200	390	6501
66W 98	.02	4	100	47	1175	11	275	0	0	8	200	50	1250	37	925	75	1875

* Aliquots from 5ml of residue, from 10g of rock.
** "Grains per gram", palynomorphs per gram of sediment.

FIGURE 12

ABSOLUTE ABUNDANCE OF
SELECTED PALYNOMORPH GROUPS
Measured Section 14
Upper Almond Formation

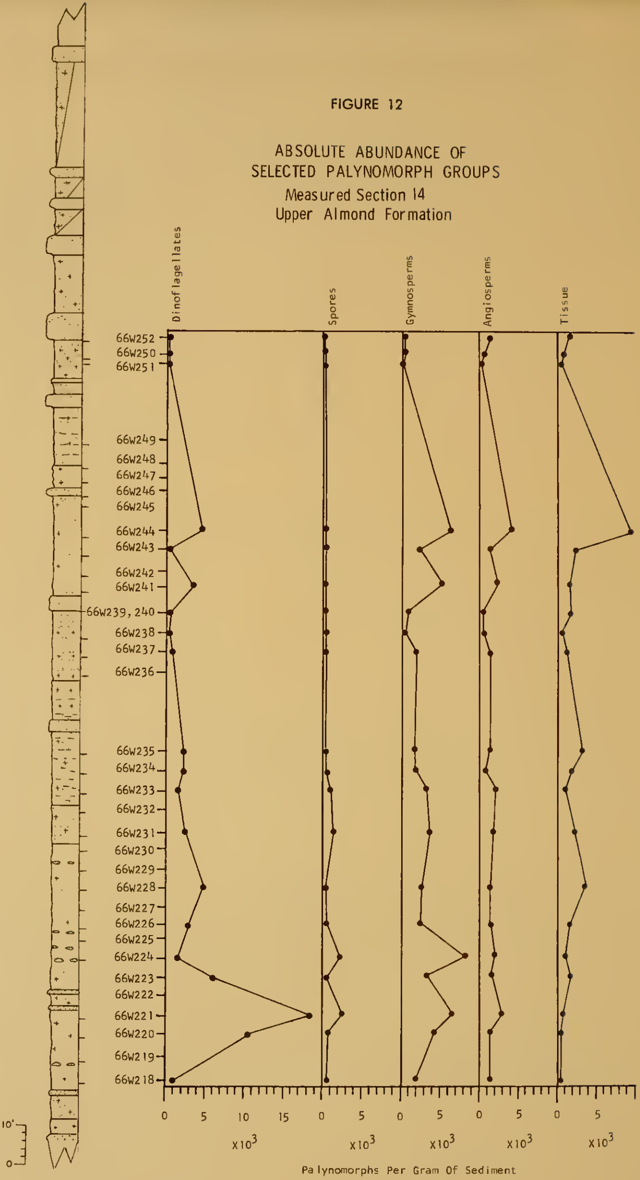


TABLE II

MEASURED SECTION 14

ABSOLUTE ABUNDANCE OF PALYNOMORPH GROUPS

Sample	Aliquot*	Acritarchs		Dinoflagellates		Algae		Megaspores		Spores		Gymnosperms		Angiosperms		Tissue	
		Count	g/g**	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g
66W252	.03	1	17	4	69	3	50	0	0	1	17	32	533	74	1233	87	1450
66W250	.03	2	33	0	0	0	0	0	0	7	117	34	567	47	783	55	917
66W251	.03	0	0	4	67	0	0	0	0	0	0	2	33	3	50	11	183
66W249	.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W248	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W247	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W246	.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W245	.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W244	.01	10	500	98	4900	10	500	0	0	13	650	135	6750	83	4150	193	9650
66W243	.01	1	50	7	350	0	0	2	100	17	850	44	2200	28	1400	50	2500
66W242	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W241	.01	0	0	74	3700	0	0	0	0	5	250	108	5400	51	2550	63	1800
66W240	.01	0	0	6	300	0	0	0	0	2	100	5	250	3	150	39	1950
66W239	.01	0	0	8	400	0	0	0	0	6	300	23	1150	11	550	36	1800
66W238	.01	0	0	2	100	0	0	0	0	7	350	10	500	12	600	10	500
66W237	.02	8	200	43	1075	2	50	0	0	8	200	82	2050	55	1375	47	1175
66W236	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W235	.01	0	0	51	2550	0	0	0	0	8	400	39	1950	25	1250	63	3150
66W234	.01	0	0	44	2200	0	0	0	0	10	500	41	2050	16	800	38	1900
66W233	.01	3	150	36	1600	0	0	1	50	21	1050	63	3150	43	2150	21	1050
66W232	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W231	.01	1	50	56	2800	2	100	0	0	32	1600	75	3950	38	1900	44	2200
66W230	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W229	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W228	.01	2	100	101	5000	0	0	1	50	9	450	56	2800	33	1650	71	3550
66W227	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W226	.01	6	300	59	2950	1	50	0	0	8	400	51	2550	29	1450	36	1800
66W225	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W224	.01	7	350	38	1900	0	0	0	0	45	2250	162	8100	41	2050	21	1050
66W223	.01	2	100	124	6200	0	0	0	0	8	400	65	3250	31	1550	36	1800
66W222	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W221	.01	23	1150	371	18550	0	0	0	0	59	2950	134	6700	61	3050	17	850
66W220	.01	13	650	216	10800	2	100	0	0	18	900	85	4250	24	1200	2	100
66W219	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W218	.01	4	200	20	1000	0	0	0	0	6	300	37	1850	24	1200	13	650

* Aliquots from 5ml of residue, from 10g of rock.

** "Grains per gram", palynomorphs per gram of sediment.

TABLE III

MEASURED SECTION 23
ABSOLUTE ABUNDANCE OF PALYNOMORPH GROUPS

Sample	Aliquot*	Acritarchs		Dinoflagellates		Algae		Megaspores		Spores		Gymnosperms		Angiosperms		Tissue	
		Count	g/g**	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g
66W489	.01	0	0	0	0	0	0	0	0	17	850	49	2450	54	2700	72	3600
66W451	.01	6	300	47	2350	11	550	0	0	15	750	107	5350	104	5200	92	4600
66W450	.01	0	0	4	200	0	0	0	0	0	0	4	200	2	100	7	350
66W432	.01	0	0	3	150	0	0	0	0	0	0	0	0	0	0	3	150
66W431	.01	0	0	12	600	1	50	0	0	1	50	0	0	1	50	8	400
66W430	.01	2	100	37	1850	4	200	0	0	0	0	7	350	2	100	23	1150

* Aliquots from 5ml of residue, from 10g of rock.

** "Grains per gram", palynomorphs per gram of sediment.

TABLE IV

MEASURED SECTION 9
ABSOLUTE ABUNDANCE OF PALYNOMORPH GROUPS

Sample	Aliquot*	Acritarchs		Dinoflagellates		Algae		Megaspores		Spores		Gymnosperms		Angiosperms		Tissue	
		Count	g/g**	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g
66W470	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W469	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W468	.01	0	0	7	350	0	0	0	0	7	350	7	350	14	700	20	1000
66W467	.01	0	0	20	1000	0	0	0	0	22	1100	20	1000	11	550	17	850
66W144	.01	0	0	15	750	0	0	0	0	1	50	14	700	8	400	40	2000
66W379	.01	0	0	5	250	0	0	0	0	0	0	0	0	1	50	40	2000
66W378	.01	0	0	44	2200	0	0	0	6	13	650	27	1350	16	800	37	1850
66W143	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Aliquots from 5ml of residue, from 10g of rock.

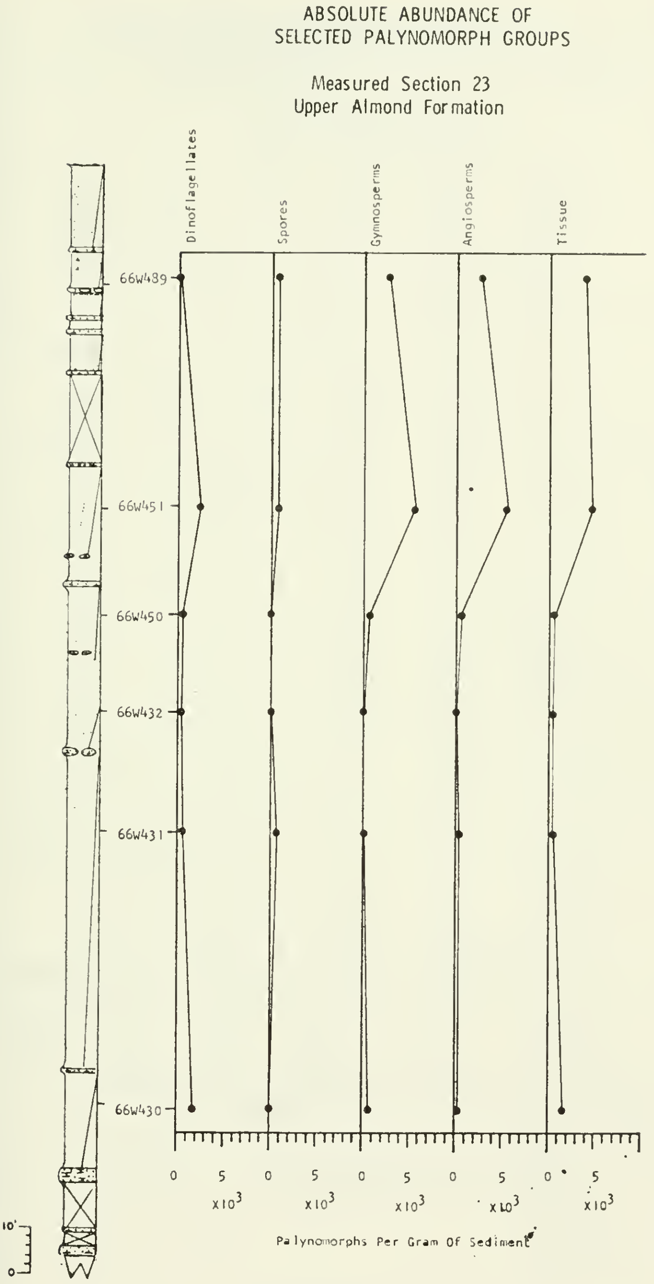
** "Grains per gram", palynomorphs per gram of sediment.

TABLE V

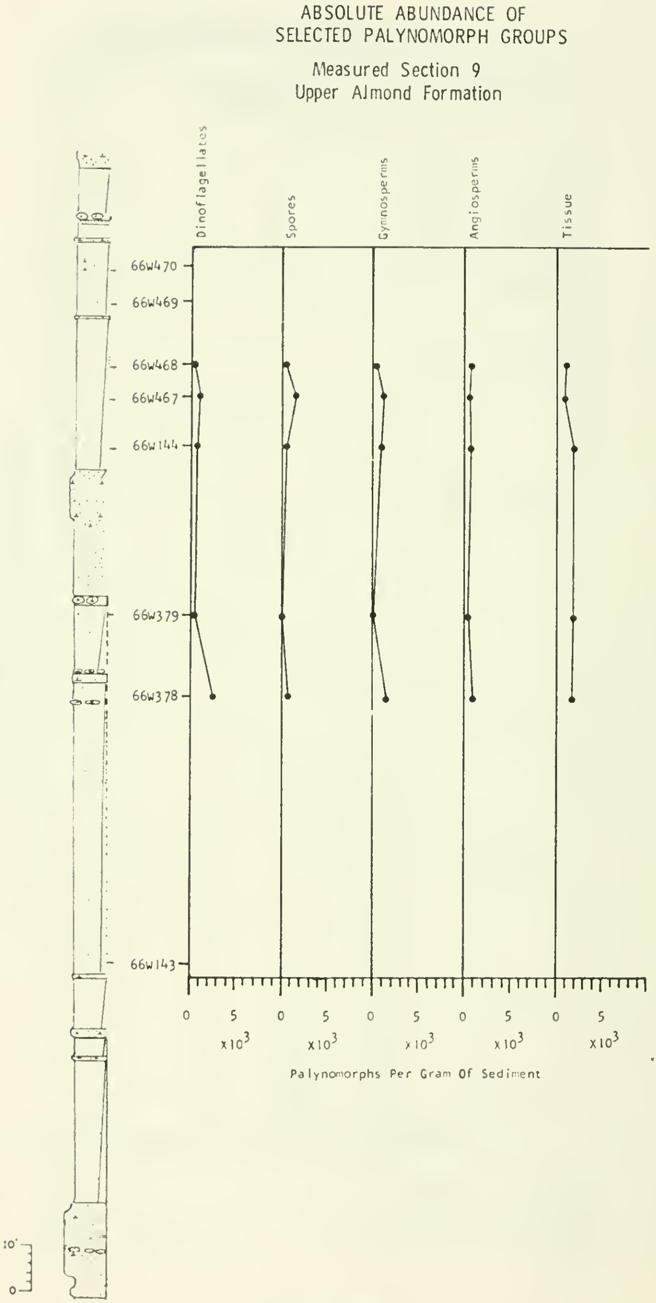
MEASURED SECTION 12
ABSOLUTE ABUNDANCE OF PALYNOMORPH GROUPS

Sample	Aliquot*	Acritarchs		Dinoflagellates		Algae		Megaspores		Spores		Gymnosperms		Angiosperms		Tissue	
		Count	g/g**	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g	Count	g/g
66W197	.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66W196	.01	0	0	0	0	1	50	0	0	2	100	7	350	15	750	104	5200
66W195	.01	1	50	31	1550	0	0	0	0	29	1450	82	4100	67	3350	349	17450
66W194	.01	0	0	9	450	2	100	0	0	0	0	8	400	14	700	38	1900
66W193	.01	1	50	80	4000	2	100	0	0	12	600	17	850	38	1900	54	2700
66W192	.01	7	350	9	450	22	1100	0	0	20	1000	55	2750	57	2850	87	4350
66W191	.01	3	150	61	3050	1	50	0	0	4	200	13	650	14	700	33	1650

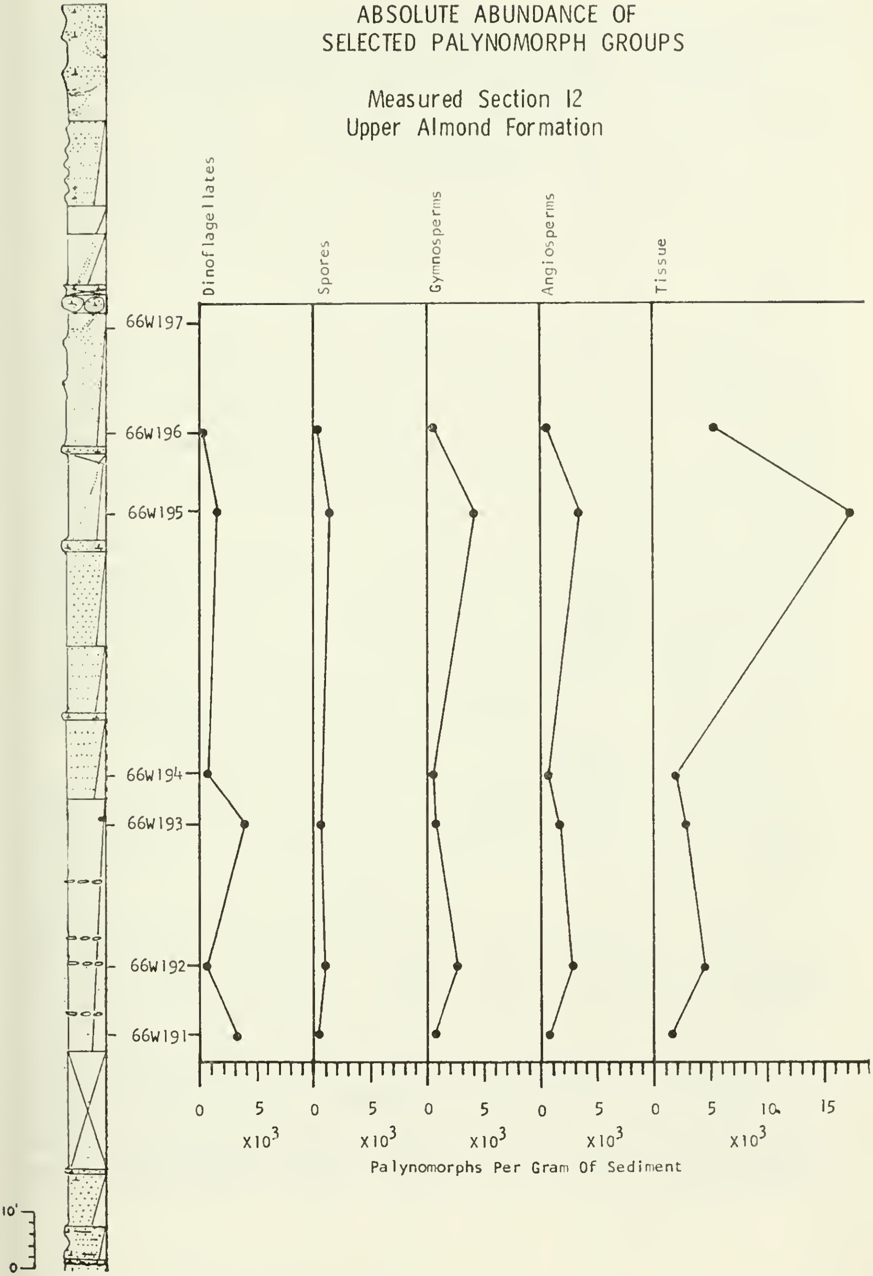
* Aliquots from 5ml of residue, from 10g of rock.
** "Grains per gram", palynomorphs per gram of sediment.



Text-figure 13



Text-figure 14



Text-figure 15

DIVERSITY

Ecologists have applied a measure of diversity which is derived from information theory and takes into consideration the number of species and the distribution of individuals among the species. Pielou (1969) discussed ecological diversity and its measurement. Beerbower and Jordan (1969) investigated diversity of paleontological assemblages. The expression of diversity, $\bar{H}$, used in this study is:

$$\bar{H} = -k \sum_{i=1}^{m} \rho_i \log \rho_i, \text{ where } \rho_i = \frac{n_i}{N}.$$

The number of individuals in species "i" is n_i. The total number of individuals in the sample is N. The number of species in the sample is m, and k is a constant which may be set equal to 1. The number of species and the total individuals determine the range of diversity available to a community. The derivation of this statistic given by Patten (1962) is particularly lucid. Authors vary as to the base of the logarithms used in the calculation. For comparison purposes with other studies the diversity statistic has been computer calculated using base e, base 10 and base 2 logarithms (Tables VI-VIII). The diversity statistics analyzed here use the base e logarithms and are plotted in Text-figures 10 and 17. The diversity statistics have been calculated for the total palynomorphs, the marine palynomorphs, and the nonmarine palynomorphs.

An additional statistic, the equitability (E) of the sample, reflects the distribution of individuals among the species (Buzas and Gibson, 1969). Equitability is the ratio $\frac{e^{\bar{H}}}{m}$. The value of $\bar{H}$ calculated with base e logarithms is used. The equitability varies from o to l with l being the condition in which all species have an equal number of specimens. The equitability has been calculated for all samples for which the diversity was calculated (Tables VI-VIII).

Diversity is a parameter of a community which is independent of its generic and specific composition. It is apparently dependent on the physical, chemical, and biological (interspecific competition) environment (Odum, Cantlon, and Kornicker, 1960). Various diversity indices have been given considerable biostratigraphic importance and used as a correlation tool within individual coal seams (Gibson and Clarke, 1968). Comments concerning the diversity data are deferred to the Discussion and Conclusion section.

CLUSTER ANALYSIS

Cluster analysis in the Q-mode permits comparison of samples as to their species content (or as to the counts of the contained species) and permits the grouping of like samples at various levels of similarity ("community"-approach). In the case of presence or absence data each sample is compared with all other samples and a coefficient of similarity is generated which expresses the comparison. Cheetham and Hazel (1969) have listed in a standardized notation the various similarity coefficients which have been used for presence-absence data. Using the matrix of similarity coefficients the samples are clustered into a hierarchy of pairs and groups of samples which are related at various levels of similarity as determined by consecutive cycles of clustering. Several clustering techniques are discussed by Sokal and Sneath (1963). The final product of cluster analysis is a dendrogram which displays the groups of samples and the similarity levels at which they are grouped. A Q-mode cluster analysis was performed (Stone, 1971), but the results did not suggest a meaningful interpretation.

Cluster analysis in the R-mode is a population approach and is used to group species on a basis of their comparable occurrence. Cluster analysis has been widely used by ecologists and is being used in the study of fossil organisms, *e.g.*, Fox (1968) and Hazel (1970). Cluster analysis in the R-mode has been applied to palynological data by Oltz (1969, 1971).

In the present study the techniques of cluster analysis were applied to the "presence or absence" data for 113 species from 76 samples from six measured sections.

For the Q-mode cluster analysis of presence-absence data the Jaccard Coefficient of Community was used (Jaccard, 1908). The Jaccard Coefficient is a simple coefficient of similarity which has been widely used. It places emphasis on those samples which contain many individuals and many species (Mello and Buzas, 1968).

The coefficient ignores negative matches, *i.e.*, no contribution is made to the coefficient if a species is absent from both samples being compared. In the notation of Cheetham and Hazel (1969), this coefficient is as follows:

$$\text{Jaccard Coefficient} = \frac{C}{(C+E_1) + (C+E_2) - C} = \frac{C}{N_1 + N_2 - C}$$

C, species present in both samples
E_1, species present only in first sample
E_2, species present only in second sample
N_1, total species present in first sample
N_2, total species present in second sample

For any two samples being compared, a value of 1 is contributed to C if a given species is present in both samples, a value of 1 is contributed to E_1 if a given species is present only in the first sample and a value of 1 is contributed to E_2 if a given species is present only in the second sample. After the contribution of all species occurring in both samples is compiled, the coefficient is calculated. Each sample is compared with all other samples under consideration and the coefficients are compiled in a data matrix.

The clustering was done by the weighted pair group method with simple arithmetic averages (Sokal and Sneath, 1963). In the initial clustering step the matrix of similarity coefficients is examined and all samples are paired which have values higher than that value at which a third sample becomes eligible to join the initial cluster. A new matrix is then generated in which the relationship between a bonded pair of cycle 1 and an unbonded sample is the arithmetic mean (simple average) of the two similarity coefficients between the unbonded sample and each member of the bonded pair. A second cycle of clustering is then undertaken on the second matrix. Weighting occurs in this cycle and subsequent cycles since the value of all members of an existing cluster is averaged with the value of a potential sample or cluster of samples. The clustering and recalculation is repeated until all samples have been clustered or the rela-

TABLE VI. Diversity and Equitability of all Species

Measured Sections	SAMPLE	NO. SP.	DIV.-e	DIV.-10	DIV.-2	EQ.(e)
4	66W 98	28	2.76	1.20	.004	.002
	66W 99	32	2.68	1.16	.004	.002
	66W100	25	2.63	1.14	.004	.003
	66W101	30	2.86	1.24	.004	.002
	66W102	29	2.60	1.13	.004	.003
	66W103	34	2.87	1.25	.004	.002
	66W104	31	2.96	1.29	.004	.002
8	66W129	31	2.95	1.28	.004	.002
	66W133	33	3.08	1.34	.005	.001
	66W135	22	2.19	.95	.003	.005
	66W136	21	2.54	1.11	.004	.004
	66W138	18	2.10	.91	.003	.007
	66W139	26	2.29	.99	.003	.004
	66W140	27	2.58	1.12	.004	.003
14	66W218	28	2.47	1.07	.004	.003
	66W220	27	2.31	1.00	.003	.004
	66W221	27	2.63	1.14	.004	.003
	66W223	27	2.68	1.17	.004	.003
	66W224	25	2.47	1.07	.004	.003
	66W225	28	2.47	1.07	.004	.003
	66W226	25	2.52	1.10	.004	.003
	66W228	18	2.07	.90	.003	.007
	66W231	25	2.36	1.02	.003	.004
	66W233	29	2.59	1.13	.004	.003
	66W234	24	2.17	.94	.003	.005
	66W235	26	2.39	1.04	.004	.004
	66W237	43	3.11	1.35	.005	.001
	66W238	22	2.53	1.10	.004	.004
	66W239	29	2.77	1.20	.004	.002
	66W240	17	2.05	.89	.003	.008
	66W241	32	2.80	1.21	.004	.002
	66W243	28	2.63	1.14	.004	.003
	66W244	32	2.74	1.19	.004	.002
	66W251	18	2.52	1.09	.004	.004
	66W250	27	2.70	1.17	.004	.002
	66W252	26	2.55	1.11	.004	.003
23	66W430	23	2.19	.95	.003	.005
	66W431	18	2.24	.97	.003	.006
	66W450	21	2.56	1.11	.004	.004
	66W451	25	2.44	1.06	.004	.003
	66W489	26	2.29	.99	.003	.004
9	66W378	37	3.09	1.34	.005	.001
	66W144	28	2.56	1.11	.004	.003
	66W467	28	2.84	1.23	.004	.002
	66W468	34	2.93	1.27	.004	.002
12	66W191	26	2.32	1.01	.003	.004
	66W192	29	2.78	1.21	.004	.002
	66W193	35	3.03	1.32	.004	.001
	66W194	23	2.59	1.12	.004	.003
	66W195	27	2.78	1.21	.004	.002
	66W196	28	2.85	1.24	.004	.002

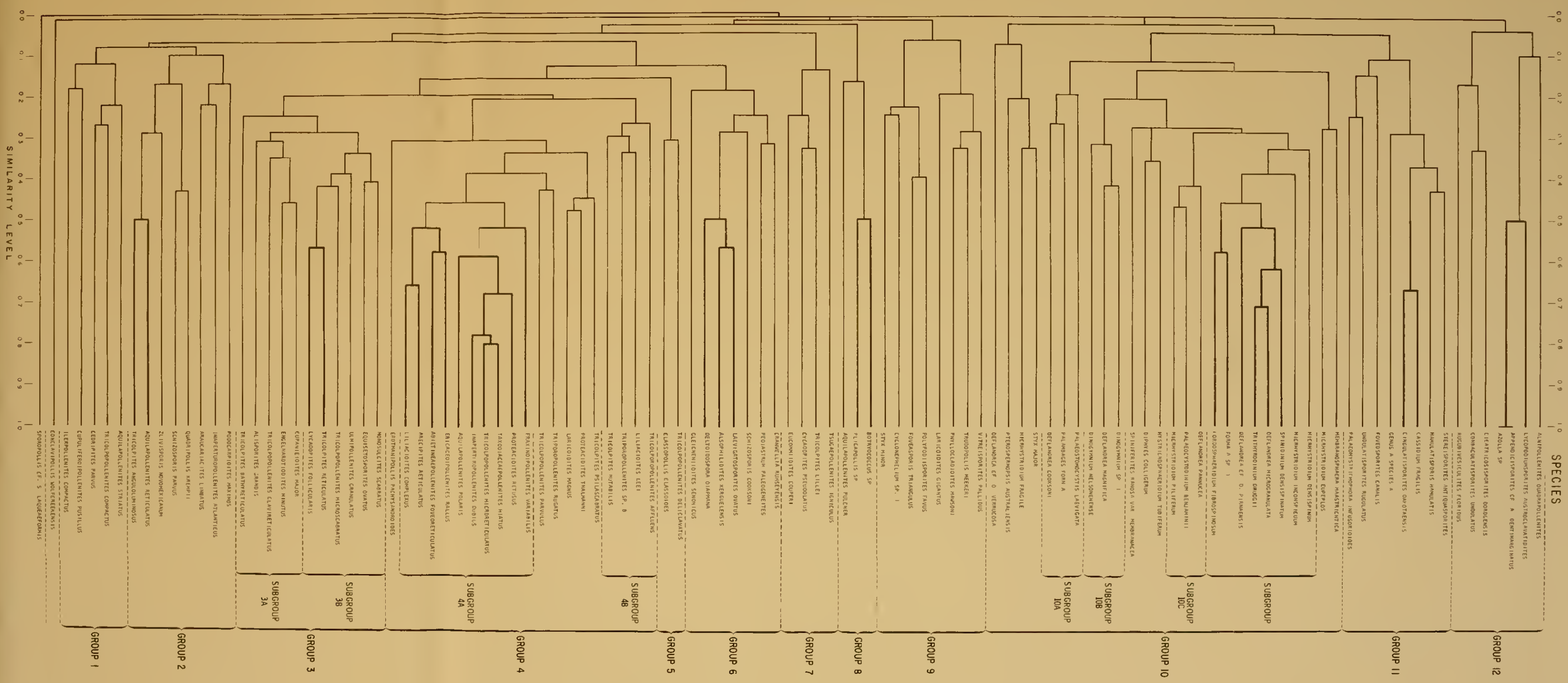
TABLE VII. Diversity and Equitability of Marine Species

Measured Sections	SAMPLE	NO. SP.	DIV.-e	DIV.-10	DIV.-2	EQ.(e)
4	66W 98	7	1.61	.70	.002	.029
	66W 99	11	2.07	.90	.003	.011
	66W100	5	1.47	.64	.002	.046
	66W101	7	1.53	.66	.002	.031
	66W102	10	1.36	.59	.002	.026
	66W103	11	1.84	.80	.003	.014
	66W104	10	1.86	.81	.003	.016
8	66W129	1	0.00	0.00	0.000	1.000
	66W133	1	0.00	0.00	0.000	1.000
	66W135	3	.37	.16	.001	.230
	66W136	1	0.00	0.00	0.000	1.000
	66W138	0	0.00	0.00	0.000	0.000
	66W139	3	.68	.30	.001	.168
	66W140	1	0.00	0.00	0.000	1.000
14	66W218	12	2.22	.96	.003	.009
	66W220	11	1.41	.61	.002	.022
	66W221	10	1.68	.73	.002	.019
	66W223	11	2.06	.90	.003	.012
	66W224	6	1.49	.65	.002	.038
	66W225	9	1.29	.56	.002	.031
	66W226	9	1.75	.76	.003	.019
	66W228	5	1.23	.53	.002	.058
	66W231	8	1.77	.77	.003	.021
	66W233	7	1.65	.72	.002	.027
	66W234	8	1.09	.47	.002	.042
	66W235	10	1.44	.63	.002	.024
	66W237	11	1.69	.73	.002	.017
	66W238	4	1.15	.50	.002	.079
	66W239	6	1.44	.63	.002	.039
	66W240	4	.88	.38	.001	.103
	66W241	7	1.54	.67	.002	.031
	66W243	4	1.15	.50	.002	.079
	66W244	10	1.71	.74	.003	.018
	66W251	4	1.15	.50	.002	.079
	66W250	2	.45	.20	.001	.319
	66W252	4	1.32	.57	.002	.067
23	66W430	8	1.27	.55	.002	.035
	66W431	6	1.27	.55	.002	.047
	66W450	6	1.45	.63	.002	.039
	66W451	5	1.12	.49	.002	.065
	66W489	2	.69	.30	.001	.250
9	66W378	12	1.97	.85	.003	.012
	66W144	7	1.19	.52	.002	.044
	66W467	7	1.54	.67	.002	.031
	66W468	12	2.20	.96	.003	.009
12	66W191	11	1.51	.66	.002	.020
	66W192	7	1.73	.75	.003	.025
	66W193	11	1.97	.86	.003	.013
	66W194	6	1.23	.54	.002	.049
	66W195	8	1.62	.71	.002	.025
	66W196	7	1.71	.74	.003	.026

FIGURE 16

R-MODE CLUSTER ANALYSIS, ALL SAMPLES, ALL SPECIES

Jaccord Coefficient Weighted Pair Group Clustering



tionships are zero. This explanation of clustering follows that of Mello and Buzas (1968).

An R-mode cluster analysis was performed utilizing the presence-absence data. In this instance a species to species comparison is made as to presence or absence in each of the samples. A Jaccard Coefficient is calculated for each species compared with all other species and a matrix of coefficients is generated which is clustered by the weighted pair group method. The resulting dendrogram shows the clustering of related species (Text-figure 16).

Evaluation of the cluster analyses is deferred to the Discussion and Conclusions section.

DISCUSSION AND CONCLUSIONS

AGE OF THE ALMOND FORMATION

Upper Cretaceous relative age dating is based primarily on a standard of ammonoid fossils. In the Western Interior the Campanian Stage encompasses 21 megafossil zones with the end of the Campanian coinciding with the top of the *Baculites eliasi* Zone. In south-central Wyoming the Almond Formation corresponds (in ascending order) to the upper part of *Baculites reesidei* Zone, the *B. jenseni* Zone, and the *B. eliasi* Zone. In the Rock Springs Uplift the Almond Formation also includes the lower part of the overlying *B. baculus* Zone (Gill, Merewether, and Cobban, 1970). The Campanian-Maestrichtian boundary is placed at the *B. eliasi-B. baculus* zonal boundary. Since the upper Shale Unit of the upper Almond interfingers imperceptibly into overlying Lewis Shale the Campanian-Maestrichtian boundary is not a sharp contact except in the area where the Upper Sand Unit of the upper Almond is present. The indigenous palynomorph assemblage of the Almond Formation is, by virtue of the associated ammonoids, Upper Campanian in age (possibly Maestrichtian in the uppermost Almond).

On cursory inspection the Almond Formation palynomorph assemblage is not vastly different from North American Maestrichtian assemblages. At least 25 Almond pollen and spore species have been reported from Maestrichtian-Paleocene rocks of Montana by Norton and Hall (1969), and at least 10 Almond dinoflagellate and acritarch species have been reported from Maestrichtian and Paleocene

TABLE VIII. Diversity and Equitability of Nonmarine Species

Measured Sections	SAMPLE	NO. SP.	DIV.-e	DIV.-10	DIV.-2	EQ.(e)
4	66W 98	21	2.38	1.03	.003	.004
	66W 99	21	2.17	.94	.003	.005
	66W100	20	2.25	.98	.003	.005
	66W101	23	2.59	1.13	.004	.003
	66W102	19	2.46	1.07	.004	.004
	66W103	23	2.50	1.09	.004	.004
	66W104	21	2.59	1.12	.004	.004
8	66W129	30	2.91	1.27	.004	.002
	66W133	32	3.03	1.32	.004	.002
	66W135	19	2.02	.88	.003	.007
	66W136	20	2.48	1.08	.004	.004
	66W138	18	2.10	.91	.003	.007
	66W139	23	2.18	.95	.003	.005
	66W140	26	2.53	1.10	.004	.003
14	66W218	16	1.76	.77	.003	.011
	66W220	16	1.88	.82	.003	.010
	66W221	17	2.28	.99	.003	.006
	66W223	16	1.95	.85	.003	.009
	66W224	19	2.10	.91	.003	.006
	66W225	19	2.19	.95	.003	.006
	66W226	16	1.91	.83	.003	.009
	66W228	13	1.50	.65	.002	.017
	66W231	17	1.91	.83	.003	.009
	66W233	22	2.20	.96	.003	.005
	66W234	16	1.95	.85	.003	.009
	66W235	16	1.93	.84	.003	.009
	66W237	32	2.84	1.23	.004	.002
	66W238	18	2.33	1.01	.003	.005
	66W239	23	2.55	1.11	.004	.003
	66W240	13	1.68	.73	.002	.014
	66W241	25	2.46	1.07	.004	.003
	66W243	24	2.51	1.09	.004	.003
	66W244	22	2.38	1.03	.003	.004
	66W251	14	2.26	.98	.003	.007
	66W250	25	2.63	1.14	.004	.003
	66W252	22	2.40	1.04	.004	.004
23	66W430	15	1.92	.83	.003	.010
	66W431	12	1.92	.83	.003	.012
	66W450	15	2.20	.95	.003	.007
	66W451	20	2.23	.97	.003	.005
	66W489	24	2.23	.97	.003	.004
9	66W378	25	2.77	1.20	.004	.003
	66W144	21	2.31	1.00	.003	.005
	66W467	21	2.55	1.11	.004	.004
	66W468	22	2.52	1.09	.004	.004
12	66W191	15	2.08	.90	.003	.008
	66W192	22	2.55	1.11	.004	.004
	66W193	24	2.67	1.16	.004	.003
	66W194	17	2.30	1.00	.003	.006
	66W195	19	2.45	1.06	.004	.005
	66W196	21	2.49	1.08	.004	.004

rocks of South Dakota by Stanley (1965). Many species are reported for the first time from rocks as old as Campanian. The relevant species are not tabulated here but may be ascertained from the occurrences in the descriptive section.

Seven species are reported for the first time from rocks as young as Campanian:

Deflandrea cf. *D. verrucosa*
Micrhystridium densispinum
M. inconspicuum
M. eupeplos
Schizosporis cooksoni
Inaperturopollenites atlanticus
Rugubivesiculites floridus

Little biostratigraphic significance is attached to their occurrence because of their rarity, morphological ambiguity, and the possibility of reworking.

The palynological age assessment of the Almond Formation must depend on the total assemblage and the percentages (or absolute abundance) of its constituents. The assemblage may be recognized as Upper Cretaceous by the presence of *Aquilapollenites* spp., *Proteacidites* spp., *Styx* spp., and *Liliacidites (Schizosporis) complexus*. Considering the total assemblage and the presence of the genera and species just mentioned, the absence of *Wodehouseia* spp. is suggestive of, but does not prove, an age older than Maestrichtian. With the exception of two index fossils there are no Campanian age-distinctive species. *Trudopollis meekeri* and *Conclavipollis wolfcreekensis* have been reported only from restricted intervals within Campanian age rocks (Newman, 1965). Two new species, *Trithyrodinium druggii* and *Cycadopites pseudolatus* may have possible Campanian age significance.

DEPOSITIONAL ENVIRONMENTS

The Almond Formation consists of sediments formed in three major depositional environments, the nonmarine coastal-plain and lagoonal environment, the shoreline (barrier-bar) environment, and the near shore (neritic) marine environment. These environments may be recognized by the distinctive sediment types which they produced (Weimer, 1966). The coastal-plain (fluviatile) sediments are claystones, siltstones, nonmarine shales, coals, and sandstones. The near-shore sediments are barrier bar sandstones, and the neritic sediments are shales. The variations in environment and in corresponding sediment type are the result of minor transgressions and regressions of the Late Cretaceous sea and their cyclic nature has been described in detail by Jacka (1965).

With the exception of coals, which were not studied, and sandstones, the depositional environments of the Almond Formation sediments have been determined by their palynomorph content. Palynomorphs are ordinarily not recovered from sandstone and this lithology was not sampled. The nonmarine environment of the lower Siltstone Unit is evidenced by the near absence of dinoflagellates and acritarchs. When present these palynomorphs comprise about 1-3% of the sample with the single exception of sample 66W135 which contains 15.8%. This sample represents a dark gray shale bed only two feet in thickness. The marine environment of the upper Shale Unit is evident from the 17 species of dinoflagellates and acritarchs which are restricted to it. These palynomorphs comprise from 20-50% of the total palynomorphs in samples from this unit.

Within the upper Shale Unit, variations, both vertical and horizontal, are noted in the absolute abundance of dinoflagellates and their counterparts in distribution, the acritarchs. To what extent these variations reflect changes in depositional environment is unknown. Living dinoflagellates are known from freshwater and marine environments, but in the rock record they appear to be limited to rocks of estuarine and marine origin. As a generalization, dinoflagellates increase in number away from shores and to some extent the plots of the absolute abundance of marine species (Text-fig. 17) reflect distance from shore. (It is to be remembered that all of the samples represent shallow marine deposition in an epicontinental sea and never an open marine environment.) This generalization is complicated by the fact that dinoflagellates, as do other plankton, have maxima and minima in their distribution that reflect variations in their physico-chemical environment. Such fluc-

FIGURE 17

CORRELATIONS
UPPER ALMOND FORMATION

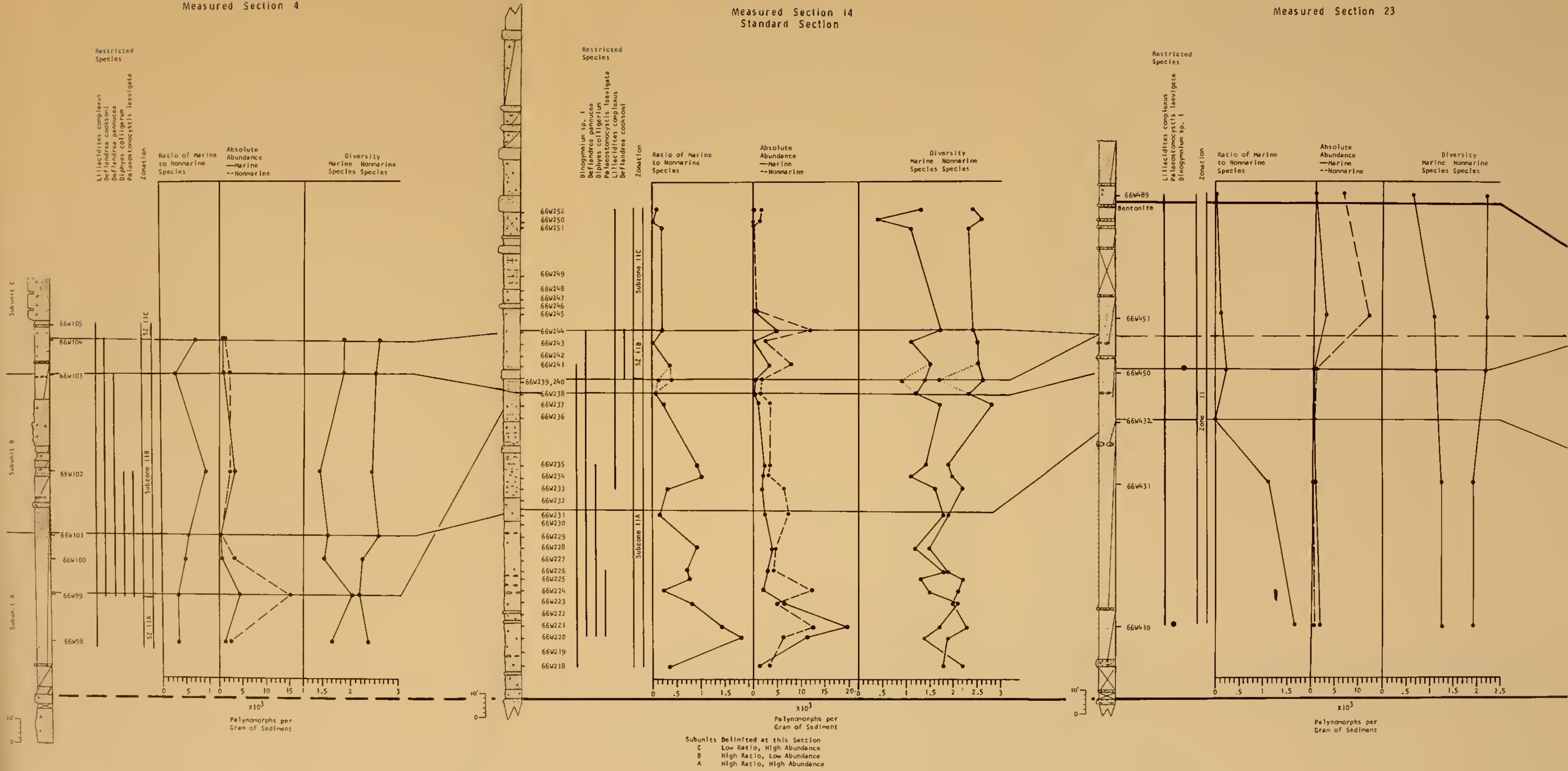
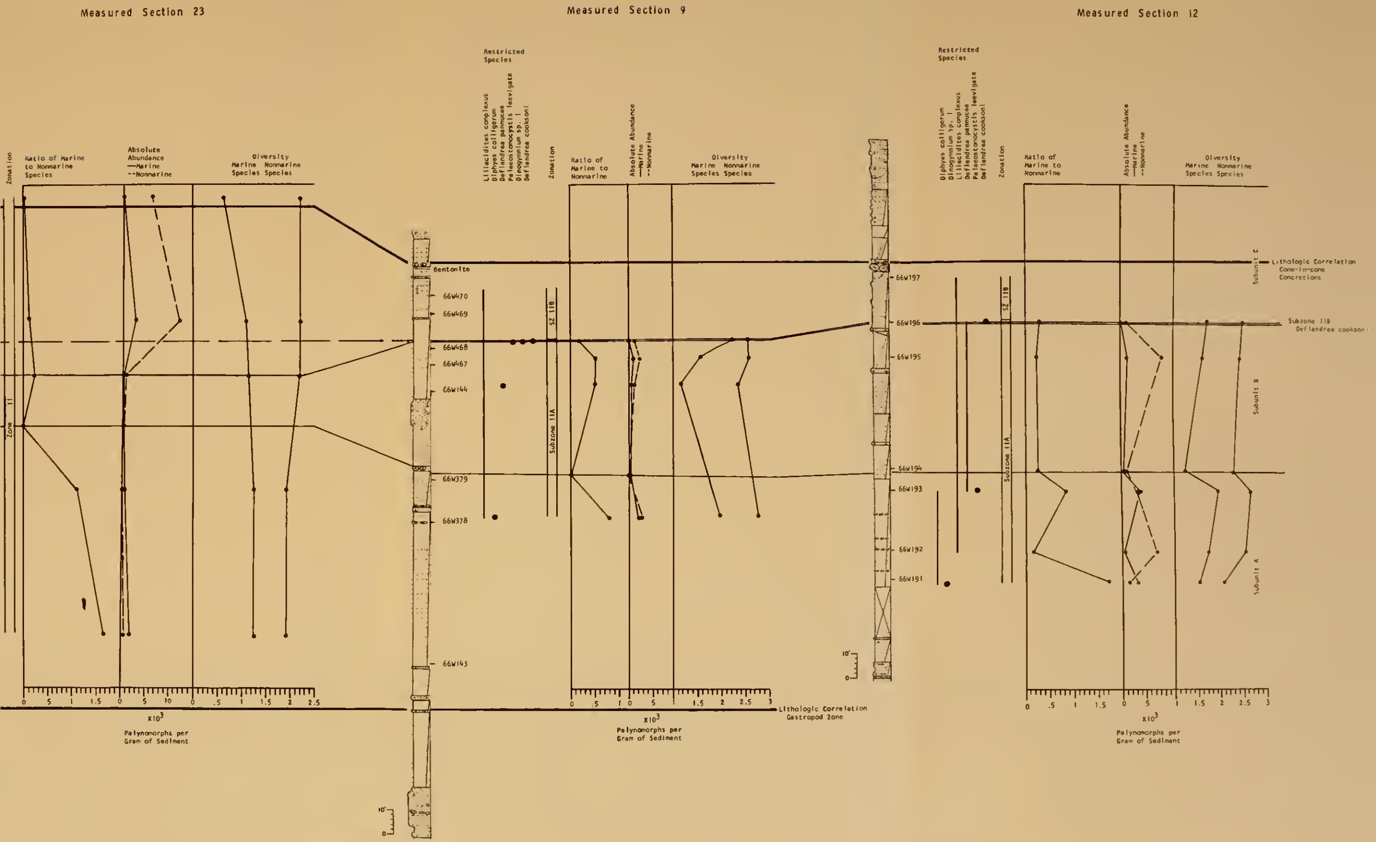


FIGURE 17

CORRELATIONS
UPPER ALMOND FORMATION



tuations have been noted near river mouths and areas of current influence such as upwelling. The absolute abundances of dinoflagellates in the Almond Formation are comparable to those observed in the modern Gulf of California with values of several hundreds to a few thousands per gram of sediment and occasional maxima up to 16-17,000 per gram of sediment (Cross, Thompson, and Zaitzeff, 1966). One such maximum is noted in Section 14, Samples 66W220 and 66W221, which represents an interval of at least five feet with a highest value of 18,000 per gram.

As a generalization the land derived pollen and spores show a decrease in abundance away from shore in a marine environment. They also show maxima and minima in their distribution which are controlled at least in part by the proximity of the parent plants and the sorting action and distribution by water currents.

The assemblage attribute which in the author's opinion best measures the proximity to shore line is the ratio of marine to nonmarine species. This ratio when combined with the absolute abundance information may be used to subdivide the upper Shale Unit of Section 14 into three subunits. Subunit A from Sample 66W218 to Sample 66W229 is an interval of a high ratio marine-nonmarine species and high abundance. Subunit B from Sample 66W230 to Sample 66W236 is an interval of high ratio and relatively low abundance. Subunit C from Sample 66W237 to Sample 66W252 is an interval of a relatively low ratio and a relatively low abundance. These subunits are present to some extent in the other measured sections of the upper Shale Unit.

It may be observed in each section of the upper Shale Unit that the sterile samples show some relationship to the sand content of the interval sampled. In general there is a drop in abundance and sterile samples appear as the upper Sandstone Unit is approached and the sand content of the shale increases.

The diversity of the nonmarine species is consistently higher than that of the marine species. Samples with high diversity indices for the most part are not samples with the highest absolute abundance. Any relationship between diversity and depositional environment has not been demonstrated.

Within the upper Shale Unit no relationship has been demonstrated between the presence-absence or relative abundance of any individual species and the depositional environment other than what has already been discussed for the formation as a whole.

PALYNOLOGICAL CORRELATIONS

The upper Shale Unit is defined on a lithologic basis and correlation between the five upper Almond sections may be accomplished by marker beds including a gastropod zone (shells are abundant enough locally for the rock to be considered a coquina) at the base of Sections 14, 23, and 9, a bentonite layer between Sections 23 and 9 and a cone-in-cone layer between Sections 23, 9, and 12.

As a unit the upper Shale Unit may be correlated palynologically within the Almond Formation by the dinoflagellates, acritarchs, and other species which are restricted to it. The upper Shale Unit may be subdivided at the standard section (14) by several criteria (see Text-figure 17), the most useful of which are considered to be the ratio of marine to nonmarine species, the absolute abundance of marine species and nonmarine species, species restricted in range, and the diversity of the marine and nonmarine species. Attempts have been made to correlate among the five sections using these criteria. The subunits A, B, and C, based on the ratio and absolute abundance of marine and nonmarine species (defined above), may be correlated with some success between sections. A zone of *Deflandrea cooksoni* may be correlated with little success since it varies a great deal in thickness and is absent in Section 23. Some corresponding peaks on the diversity curves may correlate but they are not evident in all sections.

PLANT ASSOCIATIONS

The R-mode cluster analysis results in groups of species which are related by their common occurrence (co-occurrence) in samples. Because these species are related by common occurrence it may be hypothesized that the groups represent assemblages of species from plant communities which have persisted through time. It must be remembered that the program is designed so that all species will eventually cluster. Whether or not a given cluster on the dendrogram has ecological significance is a value judgement on the part of the interpreter and must be based on some knowledge of the species comprising the cluster. The similarity scale of the dendrogram varies from 0 (complete dissimilarity) to 1 (complete similarity).

The species stems of the R-mode dendrogram (Text-fig. 16) which cluster at .5 or greater have been drawn as solid lines for emphasis. These pairs and clusters of species have the greatest similarity of occurrence and are thought to represent portions of plant communities. Eight clusters at approximately the .3-.4 level have been designated as subgroups and 12 clusters at approximately the .2-.3 similarity level have been designated as groups.

Some comments and interpretations may be made concerning the following clusters, but no special significance is attached to the other clusters:

Group 10. Virtually all of the dinoflagellates and acritarchs occur in this cluster. Group 10 represents the marine phytoplankton community.

Subgroup 10A. This subgroup is of interest because *Palambages* Form A, a supposed green alga, has a distribution parallel to that of the dinoflagellates.

Subgroup 10B. The two species of *Dinogymnium* have parallel distributions.

Subgroup 10D. This highly similar subgroup contains the most abundant (relatively abundant) dinoflagellate species. They are closely related in their distribution, and it is suggested that they represent the most marine association of species.

Group 11. This cluster contains two species, *Cassidium fragilis* and *Cingulatisporites dakotaensis,* with parallel distributions, which are restricted to the lower Almond. This cluster may characterize the nonmarine to estuarine lower Almond.

Group 12. Group 12 is an artificial group of extremely rare species with only one or two specimen occurrences.

Group 4. This group is a large and closely related cluster of angiosperms and gymnosperms whose significance is unknown.

PALYNOMORPH DESCRIPTIONS

TAXONOMIC LISTING

Form genera and form species have been used almost exclusively in the identification of the palynomorphs encountered in this study.

To the author's knowledge form taxa have not been published for *Botryococcus* sp., *Pediastrum paleogeneites* and *Azolla* sp. of this study. The affinities of the form species with living plants and in some cases with extinct plant megafossils have been noted in the specific descriptions. These suggested affinities are for the most part the modern genus and family indicated by the original author of the species. To provide the complete taxonomic placement of the palynomorphs Table IX has been compiled. The acritarchs have not yet been classified so only their unofficial group and subgroup status can be given. Their placement following the dinoflagellates reflects the fact that their distribution parallels that of the dinoflagellates and they are presumed to be marine phytoplankton.

TABLE IX
TAXONOMIC PLACEMENT OF FORM GENERA AND SPECIES

- Kingdom Plantae
  - Subkingdom Thallophyta
    - Division Chlorophyta
      - Class Chlorophyceae
        - Order Chlorococcales
          - Family Botryococcaceae
            - *Genus Botryococcus (B. braunii)*
              - *Botryococcus sp.*
          - Family Hydrodictyaceae
            - Genus *Pediastrum*
              - *Pediastrum paleogeneites*
          - Family Uncertain
            - *Palambages* Form A
    - Division Pyrrophyta
      - Class Dinophyceae
        - Order Gymnodiniales
          - Family Gymnodiniaceae
            - *Dinogymnium nelsonense*
            - *Dinogymnium* sp. 1
        - Order Peridiniales
          - Family Deflandreaceae
            - *Deflandrea microgranulata*
            - *Deflandrea* cf. *D. pirnaensis*
            - *Deflandrea cooksoni*
            - *Deflandrea magnifica*
            - *Deflandrea pannucea*
            - *Deflandrea* cf. *D. verrucosa*
            - *Spinidinium densispinatum*
            - *Trithyrodinium druggii*
            - *Palaeocystodinium benjaminii*
        - Order Uncertain
          - Family Spiniferitaceae
            - *Hystrichosphaeridium tubiferum*

- *Cordosphaeridium fibrospinosum*
- Forma A sp. 1
- *Diphyes colligerum*
- *Spiniferites ramosa* var. *membranacea*
- Family Areoligeraceae
  - *Cyclonephelium* sp. 1
  - *Cassidium fragilis*
- Family Uncertain
  - *Membranosphaera maastrichtica*
  - *Palaeohystrichophora infusorioides*
- Division Uncertain
  - Group Acritarcha
    - Subgroup Acanthomorphitae
      - *Micrhystridium densispinum*
      - *Micrystridium inconspicuum*
      - *Micrhystridium piliferum*
      - *Micrhystridium fragile*
      - *Micrhystridium eupeplos*
    - Subgroup Pteromorphitae
      - *Pterospermopsis australiensis*
    - Subgroup Uncertain
      - *Palaeostomocystis laevigata*
      - Genus A species A
- Subkingdom Embryophyta
  - Division Bryophyta
    - Class Musci
      - Order Sphagnales
        - Family Sphagnaceae
          - *Stereisporites antiquasporites*
  - Division Tracheophyta
    - Subdivision Lycopsida
      - Class Lycopodineae
        - Order Lycopodiales
          - Family Lycopodiaceae
            - *Foveosporites canalis*
            - *Hamulatisporis hamulatis*
            - *Lycopodiumsporites austroclavatidites*
            - *Foveasporis triangulus*
            - *Zlivisporis novomexicanum*
        - Order Selaginellales
          - Family Selaginellaceae
            - *Cingulatisporites dakotaensis*
    - Subdivision Uncertain
      - *Undulatisporites rugulatus*
      - *Styx minor* (megaspore?)
      - *Styx major* (megaspore?)
      - *Schizosporis cooksoni* (spore?)
      - *Schizosporis parvus* (spore?)
    - Subdivision Pteropsida
      - Class Filicineae
        - Subclass Leptosporangiatae
          - Order Eufilicales
            - Family Osmundaceae
              - *Conbaculatisporites* sp.
              - *Todisporites* cf. *T. minor*

- Family Schizaeaceae
  - *Cicatricosisporites dorogensis*
  - *Appendicisporites* cf. *A. dentimarginatus*
- Family Gleicheniaceae
  - *Deltoidospora diaphana*
  - *Glenicheniidites senonicus*
- Family Dicksoniaceae
    - *Alsophilidites kerguelensis*
- Family Polypodiaceae
    - *Laevigatosporites*
    - *Polypodiisporites favus*
- Order Hydropteridales
  - Family Salviniaceae
    - Genus *Azolla*
      - *Azolla* sp.
- Class Gymnospermae
  - Order Pteridospermae (extinct)
    - Family Caytoniaceae
      - Genus *Caytonanthus*
        - *Vitreisporites pallidus*
  - Order Cycadales
    - Family Cycadaceae
        - *Cycadopites pseudolatus*
        - *Cycadopites follicularis*
  - Order Coniferales
    - Family Podocarpaceae
        - *Phyllocladidites mawsoni*
        - *Podocarpidites maximus*
        - *Rugubivesiculites floridus*
    - Family Cheirolepidaceae (extinct)
        - *Classopollis classoides*
    - Family Araucariaceae
        - *Inaperturopollenites atlanticus*
        - *Araucariacites limbatus*
    - Family Pinaceae
        - *Laricoidites magnus*
        - *Laricoidites gigantus*
        - *Tsugaepollenites igniculus*
        - *Cedripites parvus*
        - *Abietineaepollenites foveoreticulatus*
        - *Alisporites grandis*
    - Family Taxodiaceae
        - *Taxodiaceaepollenites hiatus*
    - Families Taxodiaceae and Cupressaceae
        - *Inaperturopollenites dubius*
  - Order Gnetales
    - Family Ephedraceae
        - *Equisetosporites ovatus*
  - Orders Bennettitales, Cycadales and Ginkoales
        - *Monosulcites scabratus*
  - Order Uncertain
        - *Eucommiidites couperi*
        - *Quadripollis krempii*
        - *Spermatites* sp. (ovule)
- Class Angiospermae
  - Subclass Monoctyledoneae

  - Order Uncertain
      - *Arecipites reticulatus*
      - *Liliacidites complexus*
      - *Liliacidites leei*
- Subclass Dicotyledoneae
  - Order Salicales
    - Family Salicaceae
      - *Tricolpopollenites clavireticulatus*
  - Order Fagales
    - Family Fagaceae
      - *Cupuliferoipollenites pusillus*
    - Family Betulaceae
      - *Alnipollenites quadrapollenites*
  - Order Urticales
    - Family Ulmaceae
      - *Ulmipollenites granulatus*
- Order Proteales
  - Family Proteaceae
      - *Proteacidites retusus*
      - *Proteacidites thalmanni*
- Orders Santalales and Lamiales
  - Families Olacaceae and Labiatae
      - *Tricolpites bathyreticulatus*
  - Family Olaceceae
      - *Fraxinoipollenites variabilis*
  - Family Loranthaceae
      - *Cranwellia rumseyensis*
- Order Ranales
  - Family Trochodendraceae
      - *Tricolpopollenites compactus*
  - Family Ranunculaceae
      - *Tricolpites lillei*
- Order Sapindales
  - Family Aquifoliaceae
      - *Ilexpollenites compactus*
  - Family Buxaceae
      - *Erdtmanipollis pachysandroides*
  - Family Sapindaceae
      - *Cupanieidites major*
- Order Rhamnales
  - Family Vitaceae
      - *Tricolporopollenites affluens*
- Order Myrtiflorae
  - Family Haloragaceae
      - *Tricolpites reticulatus*
- Order Ericales
  - Family Ericaceae
    - Genus *Kalmia?*
      - *Ericaceoipollenites rallus*
- Order Uncertain
      - *Tricolpopollenites parvulus*
      - *Tricolpites mutabilis*
      - *Tricolpopollenites microscabratus*
      - *Tricolpites psilascabratus*
      - *Tricolpopollenites microreticulatus*

Tricolpopollenites deliclavatus
Tricolpites anguloluminosus
Aquilapollenites polaris
Aquilapollenites pulcher
Aquilapollenites striatus
Aquilapollenites reticulatus
Engelhardtioidites minutus
Triporopollenites rugatus
Triporopollenites sp. B.
Trudopollis meekeri
Plicapollis sp.
Sporopollis cf. *S. laqueaeformis*
Conclavipollis wolfcreekensis

DESCRIPTIVE LISTING

An arbitrary arrangement of the form species has been chosen for the descriptive section. The arrangement consists of six groups: the Algae (exclusive of the dinoflagellates), the Dinoflagellates, the Acritarchs, the Spores, the Gymnosperms and the Angiosperms. This arrangement into groups reflects the gross affinities of each species, and within each group it reflects increasing morphologic complexity. The following list (Table X) gives the order of each species as it appears in the descriptions and the plates.

TABLE X
ARRANGEMENT OF SPECIES IN THE DESCRIPTION AND PLATES

Algae excluding dinoflagellates
  1. *Pediastrum paleogeneites*
  2. *Botryococcus* sp. A
  3. *Palambages* Form A

Dinoflagellates
  4. *Dinogymnium nelsonense*
  5. *D.* sp. 1
  6. *Deflandrea microgranulata*
  7. *D.* cf. *D. pirnaensis*
  8. *D. cooksoni*
  9. *D. magnifica*
  10. *D. pannucea*
  11. *D.* cf. *D. verrucosa*
  12. *Spinidinium densispinatum*
  13. *Trithyrodinium druggii*
  14. *Palaeocystodinium benjaminii*
  15. *Hystrichosphaeridium tubiferum*
  16. *Cordosphaeridium fibrospinosum*
  17. Form A sp. 1
  18. *Diphyes colligerum*
  19. *Spiniferites ramosa* var. *membranacea*
  20. *Cyclonephelium* sp. 1
  21. *Cassidium fragilis*
  22. *Membranosphaera maastrichtica*
  23. *Palaeohystrichophora infusorioides*

24. *Micrhystridium densispinum*
25. *M. inconspicuum*
26. *M. piliferum*
27. *M. fragile*
28. *M. eupeplos*
29. Genus A sp. A
30. *Palaeostomocystis laevigata*
31. *Pterospermopsis australiensis*

Spores

32. *Schizosporis cooksoni*
33. *S. parvus*
34. *Laevigatosporites ovatus*
35. *Polypodiisporites favus*
36. *Todisporites* cf. *T. minor*
37. *Deltoidospora diaphana*
38. *Alsophilidites kerguelensis*
39. *Gleicheniidites senonicus*
40. *Stereisporites antiquasporites*
41. *Cingulatisporites dakotaensis*
42. *Foveosporites canalis*
43. *Conbaculalisporites undulatus*
44. *Undulatisporites rugulatus*
45. *Hamulatisporis hamulatis*
46. *Cicatricosisporites dorogensis*
47. *Appendicisporites* cf. *A. dentimarginatus*
48. *Foveasporis triangulus*
49. *Zlivisporis novomexicanum*
50. *Lycopodiumsporites austroclavatidites*
51. *Styx minor*
52. *S. major*
53. *Azolla* sp.

Gymnosperms

54. *Inaperturopollenites dubius*
55. *I. atlanticus*
56. *Laricoidites magnus*
57. *L. gigantus*
58. *Araucariacites limbatus*
59. *Taxodiaceaepollenites hiatus*
60. *Cycadopites follicularis*
61. *C. pseudolatus*
62. *Monosulcites scabratus*
63. *Eucommiidites couperi*
64. *Equisetosporites ovatus*
65. *Vitreisporites pallidus*
66. *Phyllocladidites mawsonii*
67. *Podocarpidites maximus*
68. *Cedripites parvus*
69. *Abietineaepollenites foveoreticulatus*
70. *Alisporites grandis*
71. *Rugubivesiculites floridus*
72. *Tsugaepollenites igniculus*
73. *Quadripollis krempii*
74. *Classopollis classoides*
75. *Spermatites* sp.

Angiosperms

76. *Arecipites reticulatus*
77. *Liliacidites leei*

78. *L. complexus*
79. *Tricolpopollenites parvulus*
80. *T. microscabratus*
81. *T. microreticulatus*
82. *T. clavireticulatus*
83. *T. deliclavatus*
84. *T. compactus*
85. *Tricolpites mutabilis*
86. *T. psilascabratus*
87. *T. lillei*
88. *T. reticulatus*
89. *T bathyreticulatus*
90. *T. anguloluminosus*
91. *Fraxinoipollenites variabilis*
92. *Cranwellia rumseyensis*
93. *Ilexpollenites compactus*
94. *Ericaceoipollenites rallus*
95. *Aquilapollenites polaris*
96. *A. pulcher*
97. *A. striatus*
98. *A. reticulatus*
99. *Cupuliferoipollenites pusillus*
100. *Tricolporopollenites affluens*
101. *Cupanieidites major*
102. *Engelhardtioidites minutus*
103. *Triporopollenites* sp. B
104. *T. rugatus*
105. *Conclavipollis wolfcreekensis*
106. *Sporopollis* cf. *S. laqueaeformis*
107. *Plicapollis* sp.
108. *Trudopollis meekeri*
109. *Proteacidites retusus*
110. *P. thalmanni*
111. *Ulmipollenites granulatus*
112. *Alnipollenites quadrapollenites*
113. *Erdtmanipollis pachysandroides*

DESCRIPTIONS

The palynomorph descriptions consist of the generic citation, the type species of the genus, the species citation and synonomy, a discussion, the suggested affinities, and the occurrence and Almond Formation distribution. The discussion includes the size range, a notation of important morphology, comparisons with closely related species, and the justification of any new combinations. The known stratigraphic range of each species is given as it has been interpreted from the literature. The occurrences given are in general limited to the Upper Cretaceous-lower Tertiary of North America and are not meant to be all inclusive. The descriptions of new species include a diagnosis, formal description, and a holotype designation.

Table XI

COUNT DATA

200 count data only
unidentifiable specimens
excluded specimens observed
but not included in the
200 counts are excluded

Species

- SPINIFERITES RAMOSUS ... MEMBRANACEUS
- CASSIDIUM FRAGIL...
- MEMBRANOSPHAERA MA...
- PALAEOCYSTODINIUM
- DEFLANDREA ... VERRU...
- BOTRYOCOCCUS SP.
- PEDIASTRUM PALEOGENEUM
- PALAMBAGES FORM
- STYX MINOR
- STYX MAJOR
- AZOLLA SP.
- STEREISPORITES ANTIQUASPOR.
- HAMULATISPORIS HAM...
- LYCOPODIUMSPORITES
- ALIVISPORIS NOVOME...
- CINGULATISPORITES DAKO...
- SCHIZAEOSPORITES
- ABIETINEAEPOLLENITES
- ARAUCARIACITES
- EQUISETOSPORITES
- MONOSULCITES ...ABR
- QUADRIPOLL...
- SPERMATITES
- RUGUBIVESICULITES
- ARECIPITES RE...
- CUPULIFEROIPOLLENITES
- ULMIPOLLENITES GRANULATUS
- PROTEACIDITES RE...
- PROTEACIDITES THALMANNI
- TRICOLPITES BATHYRETI...
- FRAXINOIPOLLENITES VARIAB...
- CRANWELLIA RUMSEY...
- TRICOLPOPOLLENITES ...COMPA...
- CUPANIEIDITES MAJOR
- TRICOLPOROPOLLENITES ...
- TRICOLPITES RETICULATUS
- ERICACEOIPOLLENITES ...
- ILEXPOLLENITES ...

Section	Samples	Counts (in printed order, left to right)
SECTION 4	66W98	4 1 6 2 8 1 9 15 41 3 1 1 4 3 2 3 6
	66W99	3 6 2 7 4 1 1 9 1 1 1 1 1 2 1 1 3 1 3 50 1 1 8 3 1 1 4 1 2 1 1
	66W100	18 7 1 13 9 3 5 3 12 6 36 1 1 4 1 2 1 1 1
	66W101	3 12 28 1 6 3 5 31 9 4 2 8
	66W102	3 48 1 4 32 1 3 2 2 1 3 28 1 1 9 2 1 2 2 9 3 6
	66W103	1 2 1 13 5 2 2 1 9 17 36 2 3 1 3 3 1 1 1 1
	66W104	16 2 3 3 25 13 2 2 25 2 7 1 3 2 1 4 1 2
	66W105	1 1
SECTION [illegible]	66W128	
	66W129	1 1 1 1 1 3 1 1 17 20 2 2 3 3 2 5 4 6 2 1 3 4 1 1 8 11
	66W130	1 1
	66W131	
	67W1	1 1 1
	67W2	1
	66W133	6 3 4 2 1 1 5 1 2 3
	66W135	29 11 4 26 39 1 1 2 1 1 5
	66W136	3 6 1 9 26 6 2 2 6 4 3
	66W137	1
	66W138	4 19 13 33 38 1 2 1 1 1
	66W139	1 7 6 3 1 1 1 14 5 1 1 56 73 1 1 1 1 1 5 1 1 1 1 5
	66W140	3 1 3 4 4 1 29 42 2 2 1 3 1 6 1 5 4 6 2 9
	66W369	
	66W370	1 1 1
SECTION 14	66W218	1 9 2 1 3 8 3 2 3 19 47 1 1 1 1 1 3 2 9
	66W219	1
	66W220	2 1 4 1 1 46 4 1 1 3 9 1 2 1 1 24 17 1 1 1 1 1 1
	66W221	1 6 3 1 1 37 15 1 9 11 1 1 1 1 1 3 2 1 15 15 1 1 1 1 1 2 1
	66W222	1
	66W223	1 1 3 14 3 1 1 16 10 1 3 9 2 5 1 2 7 30 1 3 1 3 1 1 3 25
	66W224	2 11 7 3 2 1 1 1 1 3 1 25 45 1 1 3 2 1 1 3 5 3
	66W225	1 1 32 3 2 23 1 1 1 4 2 10 32 4 1 1 3 3 2 3
	66W226	3 3 10 3 1 2 19 1 1 4 1 1 1 8 30 1 5 2 1 1 1 1 2
	66W227	1 1 1 1
	66W228	1 31 16 3 13 1 1 1 4 2 7 43 1 1 1 1 1 7
	66W229	1 1 1 1 1 1 1 1
	66W231	2 1 8 1 1 2 7 1 1 4 1 1 1 4 13 56 2 1 1 1 2 2 1 4 1 11
	66W232	1 1 1 1 1 1 1 1 1
	66W233	1 1 1 3 6 1 11 5 2 1 4 1 2 24 40 1 1 1 6 1 1 1 1 2 6 1
	66W234	2 1 53 1 23 1 1 4 1 1 10 34 1 3 1 4 3 3
	66W235	4 1 38 2 1 2 15 1 4 1 15 31 2 6 2 1
	66W236	1 1 1
	66W237	2 2 1 1 5 1 1 1 19 2 1 1 2 1 6 4 8 4 6 36 1 1 4 1 3 1 2 1 1 1 6 6
	66W238	4 1 1 1 1 9 6 14 18 1 1 1 1 2 4
	66W239	1 1 2 8 1 1 3 2 7 12 14 33 1 1 1 5 1 3 1 6 2 19
	66W240	6 20 2 2 1 4 7 1 3 37 4 1 2 1
	66W241	2 2 1 25 1 1 10 1 5 8 2 1 1 1 2 1 19 38 1 1 10 7 1 1 3 2 12 1 1 1 1 1 1 1 4 1
	66W242	1 1 1 1 1 1 1 1 1 1 1 1
	66W243	1 1 1 1 1 4 1 6 3 4 9 3 4 7 15 45 27 5 1 1 1 1 2 1 1 4 6
	66W244	4 1 1 19 1 4 1 6 1 2 3 1 4 2 3 26 52 1 1 1 1 14 2 4 4 1 11 1 3 4 16
	66W245	1 1 1
	66W246	1 1 1 1
	66W247	1 1 1 1
	66W251	2 8 2 23 7 2 2 1 9 3 17
	66W250	5 1 1 1 11 7 41 2 1 17 1 4 6 3 6 7 4 1 1 9 7 28
	66W252	3 2 2 2 15 47 1 18 1 3 6 3 14 5 1 2 4 9
SECTION 23	66W430	1 47 3 7 2 44 2 3 2 2 34 2 4 3 1 1
	66W431	11 22 6 49 1 3 1 3 23 15 6 1 2 3
	66W432	1 1 1 1
	66W450	1 2 4 8 1 1 2 5 23 2 3 2 3 2 2 1 5
	66W451	1 1 2 2 11 1 1 1 6 3 30 43 1 13 4 3 1 1 1 2 25
	66W489	1 1 1 3 3 2 15 42 13 2 1 2 1 1 2 3 37
SECTION 3	66W143	1 1 1
	66W378	1 2 6 11 11 26 1 3 14 1 1 3 3 4 3 4 4 4 23 1 1 1 3 2 3 7 1 1 1 4 3
	66W379	1 1 1 1 1
	66W144	1 4 11 1 3 34 4 3 2 3 6 4 37 1 3 15 3 1 5 1 2
	66W467	11 2 21 4 15 1 2 1 2 4 5 22 10 10 1 5 3 2 4
	66W468	1 1 7 4 4 1 3 5 1 1 12 3 17 12 23 11 7 4 4 2 2 6
	66W469	1
	66W470	1 1 1 1 1 1
SECTION 12	66W191	2 1 2 29 1 1 45 15 1 4 1 2 1 5 20 1 3 1 5 5
	66W192	2 2 1 1 5 1 11 6 1 3 17 32 1 1 1 7 1 1 7 4 2 4 1 8 1 4 17
	66W193	3 1 12 10 1 5 20 1 4 11 1 4 9 1 2 1 17 1 1 5 1 1 1 1 5 10 1 7
	66W194	2 15 1 1 10 1 1 5 2 3 38 1 6 16 11 4 5 6 6
	66W195	1 10 1 3 1 2 12 2 1 4 24 2 14 28 4 15 7 1 1 12 1 4 2 4 8
	66W196	8 1 3 9 2 7 2 3 2 4 4 26 2 9 6 2 14 1 4 2 2 8
	66W197	1 1 1

Genus **PEDIASTRUM** Meyer, 1829

Type species: Unknown.

Pediastrum paleogeneites Wilson and Hoffmeister, 1953 Pl. 1, fig. 1

1953. *Pediastrum paleogeneites* Wilson and Hoffmeister, p. 756, pl. 1, figs. 7, 8.

Discussion. — The size range of the coenobia was 43 (65) 86μ based on six specimens. To the author's knowledge a form genus has not been proposed for fossil specimens related to this living genus.

Suggested affinities. — Hydrodictyaceae, *Pediastrum.*

Occurrence. — Upper Campanian-Eocene (?). "Lower Formation", Tertiary (probably Eocene), Sumatra (Wilson and Hoffmeister, 1953); lower Dos Palos Shale, upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the lower and upper Almond Formation.

Genus **BOTRYOCOCCUS** Kutzing, 1849

Type species: *Botryococcus braunii* Kutzing, 1849.

Botryococcus sp. A Pl. 1, figs. 2a, 2b

Discussion. — The sizes of the two colonies observed were 34μ and 79μ. The presence of *Botryococcus* in sediments has been discussed by Cookson (1953), Traverse (1955), and Tschudy (1961). To the author's knowledge a form genus has not been proposed for fossil specimens related to this living genus.

Suggested affinities. — Botryococcaceae, *Botryococcus braunii* Kutzing.

Occurrence. — Cretaceous-Tertiary. Upper Cretaceous and lower Tertiary, Montana (Norton and Hall, 1969). This species is rare in the upper Almond Formation.

Genus **PALAMBAGES** O. Wetzel, 1961

Types species: *Palambages morulosa* O. Wetzel, 1961.

Palambages form A Manum and Cookson, 1964 Pl. 1, fig. 3

1964. *Palambages* form A Manum and Cookson, p. 24, pl. VII, figs. 3-6.
1967. *Palambages* sp. Drugg, p. 12, pl. 1, fig. 2.

Discussion. — Manum and Cookson (1964) indicated that *P.* form A is comparable to *P. morulosa* but did not place it in that species because the ornamentation of the wall of *P. morulosa* was not known. *P.* form A was described as "smooth to very finely granular." Specimens from the Almond Formation are psilate. The size of the individuals is about 20μ. The size range of the colonies (ca. 30 individuals) was 79 (82) 86μ for the three colonies which were measured.

Suggested affinities. — Algae?, Chlorococcales?

Occurrence. — Upper Cretaceous. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the lower and upper Almond Formation.

Genus **DINOGYMNIUM** Evitt, Clarke, and Verdier, 1967

Type species: *Dinogymnium acuminatum* Evitt, Clarke, and Verdier, 1967.

Dinogymnium nelsonense (Cookson) Evitt, Clarke, and Verdier, 1967
Pl. 2, fig. 4

1956. *Gymnodinium nelsonense* Cookson, p. 183, pl. 1, figs. 8-11.
1967. *Dinogymnium nelsonense* (Cookson), Evitt, Clarke, and Verdier, p. 5.

Discussion. — The observed size range was 50 (63) 72μ for three specimens.

Suggested affinities. — Gymnodiniaceae.

Occurrence. — Upper Campanian-Paleocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); upper Moreno Formation, Maestrichtian, California (Drugg, 1967); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs only in Section 14 of the upper Almond Formation.

Dinogymnium sp. 1 Pl. 2, figs. 5, 6

1967. *Gymnodinium* sp. 1 Zaitzeff, p. 83, pl. 21, figs. 1-4, unpublished.

Discussion. — The observed size range was 32 (34) 37μ for eight specimens.

Suggested affinities. — Gymnodiniaceae.

Occurrence. — Upper Campanian-Maestrichtian. Corsicana and Escondido Formations, Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **DEFLANDREA** Eisenack, 1938

Type species: *Deflandrea phosphoritica* Eisenack, 1938.

Deflandrea microgranulata Stanley, 1965 Pl. 2, fig. 7

1965. *Deflandrea microgranulata* Stanley, p. 219, pl. 19, figs. 4-6.

Discussion. — The slightly smaller size of this species distinguished it from *D. ventriosa* Alberti, 1959 which has a size range of 65-78μ. *D. obscura* Drugg, 1967, with a size range of 45-60μ, closely resembles *D. microgranulata* but is separated by its "non-granular cyst". *D. microgranulata* has a microgranulate (±.3μ) endophram. The observed size range was 32 (43) 54μ for 13 specimens.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Campanian-Paleocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967); Upper Cretaceous? or Paleocene?, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Deflandrea cf. **D. pirnaensis** Alberti, 1959 Pl. 2, figs. 8-11

1959. *Deflandrea pirnaensis* Alberti, p. 100, pl. 8, figs. 1-5.
1960. *Scriniodinium cooksonae* Anderson, p. 30, pl. IX, figs. 1-3.

Discussion. — The outline of the periphragm is polygonal to almost rhombic. The periphragm exhibits scattered granules (±1μ in diameter). The second antapical horn is reduced to fairly well developed in some specimens. The cingulum is well developed and wide. The longitudinal furrow is obscure. The endophragm is circular and smaller than the periphragm. The archeopyle is obscure in some specimens (Pl. 2, fig. 10), but in most specimens it involves a single intercalary plate (Pl. 2, fig. 9) which may be attached or detached and found in the interior or missing. Archeopyle formation may also involve the flaplike detachment of the adjacent precingular plate (Pl. 2, fig. 8). A comparable opening is present in the endophragm. The observed size range was 58 (67) 82μ for 16 specimens.

The Almond Formation specimens are comparable to *D. pirnaensis* as defined by Alberti (1959). An archeopyle was not observed in Alberti's specimens. The size range was 80 to 106μ.

Sarjeant and Anderson (1969) have attributed poorly preserved specimens ranging from 75-80μ to *D. piraensis*. They indicate an attached single-plate intercalary archeopyle for their specimens.

This species is only tentatively assigned to *D. piraensis* due to the uncertainty regarding the archeopyle and the slightly smaller size.

Suggested affinities. — Deflandreaceae.

Occurrence. — Turonian - Maestrichtian. Turonian - Coniacian, Germany (Alberti, 1959); Lewis Shale, Maestrichtian, New Mexico (Anderson, 1960 and Sarjeant and Anderson, 1969); ?(Deflandre and Deflandre, 1965). This species occurs in the lower and upper Almond Formation.

Deflandrea cooksoni Alberti, 1959 Pl. 3, figs. 12, 13

1959. *Deflandrea cooksoni* Alberti, p. 97, pl. 9, figs. 1-6.

Discussion. — Considerable variation in shape exists in this species as a result of the development of the "shoulder" of the epitheca. The endophragm is usually wider (transverse dimension) than it is long resulting in a three-part shape of the outline. *D. cooksoni* is distinct from *D. tripartita* Cookson and Eisenack, 1960, which it closely resembles, and *D. cincta* Cookson and Eisenack, 1958, in that it does not exhibit an obvious girdle. Specimens designated *D.* cf. *D. cooksoni* by Manum and Cookson (1964) are distinctly different in shape and should be excluded from the species. Specimens designated *D.* cf. *D. cooksoni* by Clarke and Verdier (1967) have a distinct girdle and should also be excluded. The observed size range for this species was 72 (89) 118μ for 12 specimens.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Senonian-Danian. Upper Senonian, Germany (Alberti, 1959); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the upper Almond Formation.

Deflandrea magnifica Stanley, 1965 Pl. 3, fig. 14

1965. *Deflandrea magnifica* Stanley, p. 218, pl. 20, figs. 1-6.

Discussion. — The observed size range was 86 (106) 123μ for nine specimens.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Campanian-Paleocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Deflandrea pannucea Stanley, 1965 Pl. 4, fig. 15

1965. *Deflandrea pannucea* Stanley, p. 220, pl. 22, figs. 1-4, 8-10.

Discussion. — The size range of the periphragm, including horns, was 104 (129) 144μ while the endophragm was 61 (70) 84μ for six specimens.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Campanian-Paleocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Deflandrea cf. D. verrucosa Manum, 1963 Pl. 4, fig. 16

1963. *Deflandrea verrucosa* Manum, p. 60, pl. 111, figs. 1-4.

Discussion. — The size, verrucate ornamentation, and hexagonal intercalary archeopyle are comparable to those of *D. verrucosa,* 112 (124) 135μ. A point of difference is the more fully expanded endophram seen in the Almond Formation specimens. A definite assignment has not been made because only three incomplete specimens have been found, and none exhibits the "shoulders" of the expanded periphragm above the endophragm or the apical horn. The sizes observed were 86μ, 94μ and 124μ in length. The average length was 101μ.

Suggested affinities. — Deflandreaceae.

Occurrence. — Cenomanian?-Campanian. Lower Upper Cretaceous to mid-Upper Cretaceous, Graham and Ellef Ringnes Islands, Arctic Canada (Manum, 1963 and Manum and Cookson, 1964). This species occurs only in Sample 66W218 of Section 14 of the upper Almond Formation.

Genus **SPINIDINIUM** Cookson and Eisenack, 1962

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

Spinidinium densispinatum Stanley, 1965 Pl. 4, fig. 17

1965. *Spinidinium densispinatum* Stanley, p. 226, pl. 21, figs. 1-5.
1965. *Spinidinium microceratum* Stanley, p. 227, pl. 22, figs. 5-6.

Discussion. — Variations in shape, density of the spine coat, and length of the apical horn were used to distinguish *S. densispinatum* and *S. microceratum* by Stanley (1965). It is here suggested that the differences are so slight that two species are not warranted, and that *S. microceratum* be placed in synonymy with *S. densispinatum.* The Almond Formation specimens are encompassed by the following description: the test is covered with sharp curved spines, 1.5-2μ in length; the apical horn is 5-10μ long; two antapical horns are present, one about 8μ long and a shorter one, 1-4μ long; the girdle is about 6μ wide with spine covered flanges at each side; a longitudinal furrow is not obvious, but one is suggested by folding, the archeopyle is intercalary and polygonal in outline; the overall length is 48 (59) 67μ for eight specimens; excluding the horns, the length is 37 (44) 50μ, and the width is 42 (45) 64μ.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Campanian-Maestrichtian. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); upper Moreno Formation, Danian, California (Drugg, 1967), Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs throughout the Almond Formation.

Genus **TRITHYRODINIUM** Drugg emend. Davey, 1969

Type species: *Trithyrodinium evittii* Drugg, 1967.

Trithyrodinium druggii Stone, n. sp. Pl. 5, figs. 18-19A

Diagnosis. — The distinctive endoblast is scabrate-granulate and exhibits apical and antapical tufts of granules. The archeopyle as observed on the endophragm is formed by the removal of three intercalary plates (1a, 2a, 3a inferred) which may become disassociated.

Description. — The periphram is thin (less than 1μ) and smooth. An apical horn about 28μ in length is present. Two shorter antapical horns are present. A cingulum and sulcus are not known to be present. The periblast contains a rounded endoblast. The endophram is scabrate with tufts of larger granules (ca. 1μ) on the apical and antapical ends. As observed on the endoblast, an intercalary archeopyle is formed by the removal of three plates which may become disassociated. Additional tabulation has not been observed. The range of the length of the periphragm is 95 (108) 130μ for three specimens. The width of the periphragm is about 62μ. The size range of the length of the endophragm is 58 (69) 81μ for 17 specimens.

Holotype. — Plate 5, figure 18. Slide No. 3109A1, Coor. 43.2-118.6, Collection No. 66W231, Section 14, Almond Formation, Late Campanian, Sec. 36, T20N, R101W and Sec. 31, T20N, R101W, Sweetwater County, Wyoming.

Discussion. — Three specimens with a periphragm and endophragm were observed. The exact nature of the antapical horns is not known. The free endoblasts are abundant. *T. evittii* Drugg is a comparable species, but it differs in having a finely punctate endophragm and in exhibiting a cingulum on the periblast. Specimens of *T. evittii* have been observed to have separated opercular plates (Drugg 1971, personal communication). The species is named for Warren S. Drugg.

Suggested affinities. — Deflandreaceae.

Occurrence. — Upper Campanian. This species is abundant in the upper Almond Formation and absent from the lower Almond Formation.

Genus **PALAEOCYSTODINIUM** Alberti, 1961

Type species: *Palaeocystodinium golzowense* Alberti, 1961.

Palaeocystodinium benjaminii Drugg, 1967
Pl. 5, fig. 20; Pl. 6, fig. 21

1967. *Palaeocystodinium benjaminii* Drugg, p. 31, pl. 3, fig. 1.
1967. *Svalbardella* cf. *S. lidiae* (Gorka), Zaitzeff, p. 102, pl. 30, figs. 9-9a, pl. 31, fig. 1, unpublished.

Discussion. — Six specimens were observed from the Almond Formation. They exhibit an inner body, apical horn, and an antapical horn which has a rudimentary second antapical horn bifurcating from it. The archeopyle is occasionally obscured by longitudinal folding. Hairs were not observed on the apical horn. The overall length was 183-236μ (average 213μ) for six specimens. The inner body is about 133μ in length. The width is about 54μ.

Suggested affinities. — Deflandreaceae?

Occurrence. — Upper Campanian-Danian. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **HYSTRICHOSPHAERIDIUM**, Deflandre emend. Eisenack, 1958

Type species: *Hystrichosphaeridium tubiferum* (Ehrenberg), Deflandre, 1937.

Hystrichosphaeridium tubiferum (Ehrenberg), Deflandre, 1937
Pl. 6, figs. 22-24

1838. *Xanthidium tubiferum* Ehrenberg, pl. 1, fig. 16.
1933. *Hystrichosphaera tubifera* (Ehrenberg), Wetzel, p. 40, pl. 4, fig. 16.
1937. *Hystrichosphaeridium tubiferum* (Ehrenberg), Deflandre, p. 68.

Discussion. — The observed size of the central body was 34 (43) 49μ for nine specimens. The processes were 16-20μ in length.

Suggested affinities. — Hystrichosphaeridiaceae.

Occurrence. — Cenomanian-middle Miocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the upper Almond Formation.

Genus **CORDOSPHAERIDIUM** Eisenack, 1963

Type species: Cordosphaeridium inodes (Klumpp), Eisenack, 1963.

Cordosphaeridium fibrospinosum Davey, et al., 1966 Pl. 7, figs. 25

1965. *Hystrichosphaeridium inodes* Klumpp. Stanley, p. 231, pl. 25, figs. 1-6.
1966. *Cordosphaeridium fibrospinosum* Davey, *et al.*, p. 86, pl. 5, fig. 5.

Discussion. — The maximum diameter of the central body varies from 66-94μ, with an average of 81μ. The width of the processes varies from 11-30μ and the length from 14-29μ as observed on six specimens.

Suggested affinities. — Hystrichosphaeridiaceae.

Occurrence. — Upper Campanian-Eocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota, (as *H. inodes*). (Stanley, 1965); London Clay, Eocene, England (Davey, *et al.*, 1966); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **FORMA A** Zaitzeff, 1967

"Type species": Forma A sp. 1 Zaitzeff, 1967, unpublished.

Forma A sp. 1 Zaitzeff, 1967 Pl. 7, figs. 26-27

1967. Forma A sp. 1 Zaitzeff, p. 54, pl. 9, fig. 12; pl. 10, figs. 1-10, unpublished.

Discussion. — The observed size range was 52 (62) 72μ for seven specimens.

Suggested affinities. — Hystrichosphaeridiaceae.

Occurrence. — Upper Campanian - Maestrichtian. Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the lower and upper Almond Formation.

Genus **DIPHYES** Cookson emend. Davey, *et al.*, 1966

Type species: *Diphyes colligerum* (Deflandre and Cookson), Cookson emend. Davey, *et al.*, 1966.

Diphyes colligerum (Deflandre and Cookson), Cookson emend. Davey, *et al.*, 1966 Pl. 8, fig. 28-29

1953. *Hystrichosphaeridium* sp. C Cookson, p. 115, pl. 2, figs. 29, 30.
1955. *Hystrichosphaeridium colligerum* Deflandre and Cookson, p. 278, pl. 7, fig. 3.
1963. *Baltisphaeridium colligerum* (Deflandre and Cookson), Downie and Sarjeant, pl. 91.
1965. *Diphyes colligerum* (Deflandre and Cookson), Cookson, p. 86, pl. 9, figs. 1-12.
1966. *Diphyes colligerum* (Deflandre and Cookson), Cookson emend. Davey, *et al.*, p. 96, pl. 4, figs. 2, 3.

Discussion. — This species is distinguished by a single large antapical process. The size range of the test was 28 (32) 36μ for six specimens.

Suggested affinities. — Hystrichosphaeridiaceae.

Occurrence. — Senonian?-Eocene. Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **SPINIFERITES** Mantell *ex* Loeblich and Loeblich emend. Sarjeant, 1970

Type species: *Spiniferites ramosus* (Ehrenberg), Mantell, 1850.

Spiniferites ramosa var. **membranacea** (Rossignol), Sarjeant, 1970 Pl. 8, fig. 30

1964. *Hystrichosphaera furcata* var. *membranacea* Rossignol, p. 86, pl. 1, figs. 4, 9, 10; pl. 3, figs. 7, 12.
1966. *Hystrichosphaera ramosa* var. *membranacea* (Rossignol), Davey, *et al.*, p. 37, pl. 4, fig. 8, 12.
1967. *Hystrichosphaera* aff. *H. furcata* (Ehrenberg), Wetzel. Drugg, p. 23, pl. 4, figs. 3, 4.
1967. *Hystrichosphaera* sp. 1 Zaitzeff, p. 64, pl. 15, figs. 7-9, unpublished.
1970. *Spiniferites membranaceus* (Rossignol), Sarjeant, p. 76.

Discussion. — The observed size range of the central body was 33 (39) 58μ while the processes were about 12μ long as measured on eight specimens. The genus *Spiniferites* Mantell, 1850 will apparently be accepted as having priority (Wall and Dale, 1970; Sarjeant, 1970).

Suggested affinities. — Spiniferitaceae.

Occurrence. — Upper Campanian-Pleistocene. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Corsicana Formation, Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **CYCLONEPHELIUM** Deflandre and Cookson emend.
Davey, *et al.*, 1966

Type species: *Cyclonephelium compactum* Deflandre and Cookson, 1955.

Cyclonephelium sp. 1 Zaitzeff, 1967 Pl. 8, fig. 31

1967. *Cyclonephelium* sp. 1 Zaitzeff, p. 68, pl. 16, figs. 1-3, unpublished.

Discussion. — The tabulation of this species was not determined. It exhibits a chorate cyst of the *Cylonephelium-Areoligera* type with an apical archeopyle and anastomosing processes 12-40μ in length. The operculum was detached in all specimens examined. The size range of the maximum dimension, exclusive of the processes, was 58 (61) 65μ for five specimens.

Suggested affinities. — Areoligeraceae.

Occurrence. — Upper Campanian - Maestrichtian. Navarro Group, Mastrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Genus **CASSIDIUM** Drugg, 1967

Type species: *Cassidium fragilis* (Harris), Drugg, 1967.

Cassidium fragilis (Harris), Drugg, 1967 Pl. 8, figs. 32-33

1965. *Ovoidites fragilis* Harris, p. 97, pl. 27, figs. 4-5.
1967. *Cassidium fragilis* (Harris), Drugg, p. 22, pl. 3, figs. 15-16.

Discussion. — The observed size range was 52 (56) 66μ on five specimens.

Suggested affinities. — Areoligeraceae.

Occurrence. — Upper Campanian - Paleocene. Pebble Point Formation and Dilwyn Clay, Paleocene, Australia (Harris, 1965); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the lower Almond Formation.

Genus **MEMBRANOSPHAERA** Samoilovitch *ex*
Norris and Sarjeant emend. Drugg, 1967

Type species: *Membranosphaera maastrichtica* Samoilovitch, 1961.

Membranosphaera maastrichtica Samoilovitch, 1961 Pl. 9, figs. 34-35

1961. *Membranosphaera maastrichtica* Samoilovitch *in* Samoilovitch and Mtchedlishvili, p. 252, pl. 83, figs. 1, 2.

Discussion. — The observed size range was 30 (34) 39μ for five specimens. Zaitzeff's (1967) *Hexagonifera* sp. 1 may be referable to this species.

Suggested affinities. — Unknown.

Occurrence. — Upper Cretaceous. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the lower and upper Almond Formation.

Genus **PALAEOHYSTRICHOPHORA** Deflandre emend. Deflandre and Cookson, 1955

Type species: *Palaeohystrichophora infusorioides* Deflandre, 1934.

Palaeohystrichophora infusorioides Deflandre, 1934 Pl. 9, fig. 36

1934. *Palaeohystrichophora infusorioides* Deflandre, p. 967, fig. 8.

Discussion. — The figured specimen appears to exhibit a girdle and sulcus. They are not apparent on other specimens. The observed size range exclusive of the hairlike processes was 33 (49) 59μ for five specimens.

Suggested affinities. — Unknown.

Occurrence. — Cenomanian - Maestrichtian. Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the lower and upper Almond Formation.

Genus **MICRHYSTRIDIUM** Deflandre emend. Downie and Sarjeant, 1963

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

Micrhystridium densispinum Valensi, 1953 Pl. 9, fig. 37

1953. *Micrhystridium densispinum* Valensi, p. 52, pl. XIV, fig. 4.

Discussion. — This species is distinguished by a dense coat of short spines, 1-2.5μ in length. "It differs from *M. castaninum* by its denser, shorter, and sharper spines which never appear flexible" (Valensi, 1953, p. 53). This size range of three Almond Formation specimens was 11-12μ exclusive of the spines.

Suggested affinities. — Unknown.

Occurrence. — Middle Jurassic-Campanian. Middle Jurassic, France (Valensi, 1953). Drugg (1967) reported the similar species, *M. castaninum*, from the Maestrichtian-Danian of California. *M. densispinum* occurs in the lower and upper Almond Formation.

Micrhystridium inconspicuum (Deflandre), Deflandre, 1937 Pl. 9, fig. 38

1935. *Hystrichosphaera inconspicua* Deflandre, p. 233, pl. IX, figs. 11, 12.
1937. *Micrhystridium inconspicuum* Deflandre, p. 80, pl. XII, figs. 11-13.

Discussion. — The observed size range was 10 (13) 17μ for the test of seven specimens. The spines are about 2.5μ in length.

Suggested affinities. — Unknown.

Occurrence. — Middle Jurassic-Campanian. The species has been reported from the Middle Jurassic (Deflandre, 1947) and Cenomanian (Deflandre, 1937). The species occurs in the upper Almond Formation.

Micrhystridium piliferum Deflandre, 1937 Pl. 9, fig. 39

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

Discussion. — The observed size range was 19 (21) 24μ for six specimens.

Suggested affinities. — Unknown.

Occurrence. — Cretaceous-Paleocene. Silex 8, Cretaceous, Paris, France (Deflandre, 1937); Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965). This species occurs in the upper Almond Formation.

Micrhystridium fragile Deflandre, 1947 Pl. 9, fig. 40

1947. *Micrhystridium fragile* Deflandre, p. 8, figs. 13-18.

Discussion. — The observed size range of the test was 16 (18) 20μ for three specimens. The spines are about 16μ in length.

Suggested affinities. — Unknown.

Occurrence. — Middle Jurassic - Oligocene. Upper Moreno Formation, Danian, California (Drugg, 1967); Navarro Group, Maestrichtian, Texas (Zaitzeff, 1967). This species occurs in the upper Almond Formation.

Micrhystridium eupeplos Valensi, 1953 Pl. 9, fig. 41

1953. *Micrhystridium eupeplos* Valensi, p. 48, pl. XIV, figs. 14, 15, 19.
1954. *Cymatiosphaera eupeplos* (Valensi), Deflandre, p. 253.

Discussion. — This species exhibits an irregular reticulum. The muri are thin and membranous. The junctions of muri are dark and extend as "processes" beyond the margin of the test. The size range of the test is 12 (16) 18μ for six specimens.

Suggested affinities. — Unknown.

Occurrence. — Middle Jurassic-Campanian. This species was described from the Middle Jurassic of France. Late Cretaceous occurrences are not known. It occurs in the lower and upper Almond Formation.

Genus A

"Type species": Genus A, species A.

Genus A, species A Pl. 9, figs. 42, 43

Diagnosis. — Spherical body with a coarse reticulum.

Description. — Specimens consist of a compressed spherical body with a coarse reticulum. The central body is dark, psilate?, and without openings. The reticulum extends about 3μ above the body as measured at the periphery. The reticulum is composed of muri ±2.5μ wide and lumina ±3μ in diameter. The reticulum is supported by rods about 2.5μ in diameter. The rods connect at their tips forming the reticulum. The muri are 2μ high above the rods and minute (1μ) spines project as crests on the muri. The size range of the maximum dimension of five specimens is 26 (30) 34μ. The holotype is 32μ overall and has a 28μ central body.

Holotype. — Pl. 9, fig. 42. Slide 3131 AIV, Coor. 44.8-113.7, Collection No. 66W468, Section 9, upper Almond Formation, Late Campanian, Sec. 12, T19N, R101W, Sweetwater County, Wyoming.

Discussion. — This species is grossly comparable to *Reticulatasporites jardinus* Brenner, 1968, but this species has a coarser more closely appressed reticulum and a slightly smaller size.

Suggested affinities. — Unknown.

Occurrence. — Coniacian - Campanian, Mancos Formation, Coniacian-Santonian, Colorado (Thompson, 1969). This species occurs in the lower Almond Formation.

Genus PALAEOSTOMOCYSTIS Deflandre, 1937

Type species: *Palaeostomocystis reticulata* Deflandre, 1937.

Palaeostomocystis laevigata Drugg, 1967 Pl. 9, fig. 44

1967. *Palaeostomocystis laevigata* Drugg, p. 35, pl. 6, figs. 14, 15.

Discussion. — The observed size range was 38 (46) 52μ for six specimens.

Suggested affinities. — Unknown.

Occurrence. — Upper Campanian - Danian. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs in the upper Almond Formation.

Genus PTEROSPERMOPSIS Wetzel, 1952

Type species: *Pterospermopsis danica* Wetzel, 1952.

Pterospermopsis australiensis Deflandre and Cookson, 1955 Pl. 9, fig. 45

1955. *Pterospermopsis australiensis* Deflandre and Cookson, p. 286, pl. 3, fig. 4.

Discussion. — Warren (1967) discussed the status of various species of *Pterospermopsis*. The size range was 24 (45) 88μ overall and 14 (26) 58μ for the body of the five specimens observed.

Suggested affinities. — *Pterosperma,* an extant phytoplankter of uncertain taxonomic placement. Pteromorphitae, the acritarch subgroup of Downie, Evitt, and Sarjeant (1963).

Occurrence. — Jurassic-Tertiary. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965). This species occurs in the upper Almond Formation.

Genus **SCHIZOSPORIS** Cookson and Dettmann, 1959

Type species: *Schizosporis reticulatus* Cookson and Dettmann, 1959.

Schizosporis cooksoni Pocock, 1962 Pl. 9, fig. 46

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

Discussion. — A two-layered exine was not apparent. Specimens up to 56μ in maximum dimension are included here. Pocock gave a size range of 32-42μ. The size range of this species should be increased to 64μ making it continuous with *S. parvus* Cookson and Dettmann, 1959. The observed size range was 38 (49) 56μ for four specimens.

Suggested affinities. — Unknown. Cookson and Dettmann (1959) referred to the species of *Schizosporis* as alete spores. Subsequent authors, *e.g.*, Stanley (1965) considered them to be inaperturate pollen.

Occurrence. — Upper Jurassic-Campanian. Upper Vanguard Formation, Mannville Group, Upper Jurassic-Lower Cretaceous, western Canada (Pocock, 1962). This species occurs in the lower and upper Almond Formation.

Schizosporis parvus Cookson and Dettmann, 1959 Pl. 10, fig. 47

1959. *Schizosporis parvus* Cookson and Dettmann, p. 216, pl. 1, figs. 15-19.
1965. *Schizosporis laevigatus* Stanley, p. 268, pl. 23, figs. 6-7, pl. 37, figs. 4-5.

Discussion. — The observed size range was 83 (90) 98μ for three specimens. A two-layered exine was not observed on these specimens, presumably due to weathering.

Suggested affinities. — Unknown.

Occurrence. — Cretaceous - Paleocene. Albian - Cenomanian?, eastern Australia (Cookson and Dettmann, 1959); Mannville Group, upper Neocomian, western Canada (Pocock, 1962); Mannville

Group, Barremian?-Cenomanian?, Alberta (Singh, 1964); Cannonball Member, Fort Union Formation, Paleocene, South Dakota (*S. laevigatus*) (Stanley, 1965); Red Branch Member, Woodbine Formation, Cenomanian, Oklahoma (Hedlund, 1966); "Walnut Clay", Fredericksburg Group, Albian, Oklahoma, (Hedlund and Norris, 1968); Dakota Sandstone, Cenomanian, Arizona (Agasie, 1969); Hell Creek Formation, uppermost Cretaceous and Tullock Formation, Paleocene, Montana (Norton and Hall, 1969); Hell Creek Formation, Maestrichtian and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **LAEVIGATOSPORITES** (Ibrahim) Schopf, Wilson and Bentall, 1944

Type species: *Laevigatosporites vulgaris* (Ibrahim), Ibrahim, 1933.

Laevigatosporites ovatus Wilson and Webster, 1946 Pl. 10, fig. 48

1946. *Laevigatosporites ovatus* Wilson and Webster, p. 273, fig. 5.

Discussion. — The observed size range was 30 (41) 59μ for nine specimens.

Suggested affinities. — Polypodiaceae.

Occurrence. — Upper Jurassic-Paleocene. Fort Union Series, Paleocene, Carbon County, Montana (Wilson and Webster, 1946); Comox Formation, Vancouver Island and Oldman Formation, Upper Cretaceous, Alberta, (Rouse, 1957); upper Vanguard Formation, Upper Jurassic, Mannville Group and Lower Cretaceous, western Canada (Pocock, 1962); Mannville Group, Lower Cretaceous, Alberta (Singh, 1964); Hell Creek Formation, Upper Cretaceous and Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Red Branch Member, Woodbine Formation, Cenomanian, Oklahoma (Hedlund, 1966); Edmonton Formation, Maestrichtian, Alberta (Srivastava, 1966); upper Moreno Formation, Maestrichtian-Danian, California (Drugg 1967); Hell Creek Formation, uppermost Cretaceous and Tullock and Lebo formations, Paleocene, Montana (Norton and Hall, 1969); Bearpaw, Fox Hills, and Hell Creek formations, Maestrichtian and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Genus **POLYPODIISPORITES** Potonié, 1934

Type species: *Polypodiisporites favus* (Potonié), Potonié, 1934.

Polypodiisporites favus (Potonié), Potonié, 1934 Pl. 10, figs. 49-50

1931. *Polypodii(?)-sporonites favus* Potonié, p. 556, fig. 3.
1934. *Polypodiisporites favus* (Potonié), Potonié, p. 38, pl. 1, figs. 19-20.
1938. *Polypodiumsporites favus* (Potonié), Thiergart, p. 295, pl. 22, fig. 14.
1953. *Verrucatosporites favus* (Potonié), Thomson and Pflug, p. 60, pl. 3, figs. 52-55, pl. 4, figs. 1-4.
1957. *Polypodiaceaesporites favus* (Potonié), Thiergart, 1938, Rouse, p. 364, pl. 3, figs. 70-72.
1971. *Reticuloidosporites pseudomurii* Elsik, 1968. Leffingwell, p. 24, pl. 5, figs. 1a, 1b.

Discussion. — The synonomy follows that of Srivastava (1966). The observed size range of the species was 44 (54) 65μ for five specimens.

Suggested affinities. — Polypodiaceae and Dennstaedtiaceae.

Occurrence. — Upper Cretaceous-Tertiary. The precise stratigraphic range has not been determined. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963); Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966); Lance Formation, Maestrichtian, and Fort Union Formation, Paleocene, Wyoming, (Leffingwell, 1971). This species occurs in the upper Almond Formation.

Genus **TODISPORITES** Couper, 1958

Type species: *Todisporites major* Couper, 1958.

Todisporites cf. **T. minor** Couper, 1958 Pl. 10, fig. 51

1958. *Todisporites minor* Couper, p. 135, pl. 16, figs. 9-10.

Discussion. — Two specimens were measured, each 25μ in diameter. The size range as given by Couper (1958) is 32 (45) 50μ. Although smaller, the Almond Formation specimens agree in other characters.

Suggested affinities. — Osmundaceae, *Todites*.

Occurrence. — Middle Jurassic-Upper Cretaceous. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963). This species is rare in the upper Almond Formation.

Genus **DELTOIDOSPORA** Miner emend. Potonié, 1956

Type species: *Deltoidospora hallii* Miner, 1935.

Deltoidospora diaphana Wilson and Webster, 1946 Pl. 10, fig. 52

1946. *Deltoidospora diaphana* Wilson and Webster, p. 273, fig. 3.
1965. *Cardoiangulina diaphana* (Wilson and Webster), Stanley, p. 248, pl. 30, figs. 17-21.

Discussion. — The observed size range was 28 (37) 48μ based on eight specimens.

Suggested affinities. — Gleicheniaceae.

Occurrence. — Upper Campanian-Paleocene. Fort Union Series, Paleocene, Montana (Wilson and Webster, 1946); Hell Creek Formation, uppermost Cretaceous and Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Hell Creek Formation, uppermost Cretaceous, Montana (Norton and Hall, 1969). This species occurs throughout the Almond Formation.

Genus **ALSOPHILIDITES** Cookson *ex* Potonié, 1956

Type species: *Alsophilidites kerguelensis* Cookson, 1947.

Alsophilidites kerguelensis Cookson, 1947 Pl. 10, figs. 53

1947. *Alsophilidites kerguelensis* Cookson, p. 136, pl. XVI, fig. 69.

Discussion. — The size range was 20 (26) 37μ for five specimens. The trilete rays extend to the equator and distinguish this species from *Deltoidospora diaphana* which has shorter rays. There is no equatorial thickening observed between the apices as in species of *Gleicheniidites.*

Suggested affinities. — Dicksoniaceae?

Occurrence. — Upper Campanian-Tertiary. Tertiary, Kerguelen (Cookson, 1947); Hell Creek Formation, Maestrichtian, and Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Lebo Formation, Paleocene, Montana (Norton and Hall, 1969); Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Genus **GLEICHENIIDITES** Ross *ex* Delcourt and Sprumont, 1955

Type species: *Gleicheniidites senonicus* Ross, 1949.

Gleicheniidites senonicus Ross, 1949 Pl. 10, fig. 54

1949. *Gleicheniidites senonicus* Ross, p. 31, pl. 1, fig. 3.
1957. *Gleichenia concavisporites* Rouse, p. 363, pl. 2, figs. 36, 48; pl. 3, fig. 49.
1961. *Gleichenia senonica* (Ross), Grigorjeva *in* Samoilovitch, *et al.*, p. 46, pl. 13, figs. 1a-b, 2a-b, 3a-b.

Discussion. — The observed size range was 19 (22) 26μ for five specimens.

Suggested affinities. — Gleicheniaceae, *Gleichenia.*

Occurrence. — Jurassic-Paleocene. This species is widely distributed in Jurassic and Cretaceous rocks. Upper Cretaceous and

Paleocene occurrences include the following: Upper Cretaceous, Scania, Sweden (Ross, 1949); Matawan and Monmouth Groups, Senonian, Delaware and New Jersey (Gray and Groot, 1966); Red Branch Member, Woodbine Formation, Cenomanian, Oklahoma (Hedlund, 1966); Dakota Sandstone, Cenomanian, Arizona (Agasie, 1969); Bearpaw Shale, Fox Hills Sandstone and Hell Creek Formation, uppermost Cretaceous and Tullock and Lebo formations, Paleocene, Montana (Norton and Hall, 1969). This species occurs throughout the Almond Formation.

Genus **STEREISPORITES** Pflug, 1953

Type species: *Stereisporites stereoides* (Potonié and Venitz), Pflug, 1953.

Stereisporites antiquasporites (Wilson and Webster), Dettmann, 1963
Pl. 10, fig. 55

1946. *Sphagnum antiquasporites* Wilson and Webster, p. 273, fig. 2.
1953. *Sphagnites australis* (Cookson) forma *parva* Cookson, p. 464, pl. 2, figs. 25-26.
1956. *Sphagnumsporites antiquasporites* (Wilson and Webster), Potonié, p. 17.
1959. *Sphagnum punctaesporites* Rouse, p. 308, pl. 1, figs. 25-26.
1963. *Stereisporites antiquasporites* (Wilson and Webster), Dettmann, p. 25, pl. 1, figs. 20-21.

Discussion. — As described by Dettmann (1963), this species has a 1-2μ equatorial thickening and a low, circular, distal polar thickening, 6-8μ in diameter. The observed size range was 23 (26) 30μ based on six specimens.

Suggested affinities. — Bryophyta.

Occurrence. — This species is widely distributed in the Jurassic, Cretaceous, and Tertiary of the Northern Hemisphere and Southern Hemisphere. Hell Creek Formation, Upper Cretaceous, and Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Edmonton Formation, Maestrichtian, Alberta (Srivastava, 1966); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Fox Hills Sandstone and Hell Creek Formation, uppermost Cretaceous, and Tullock Formation, Paleocene, Montana (Norton and Hall, 1969); Bearpaw, Fox Hills and Hell Creek formations, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Genus **CINGULATISPORITES** Pflug emend. Potonié, 1956

Type species: *Cingulatisporites levispeciosus* Pflug, 1953.

Cingulatisporites dakotaensis Stanley, 1965 Pl. 10, fig. 56

1965. *Cingulatisporites dakotaensis* Stanley, p. 243, pl. 30, figs. 1-8.

Discussion. — The observed size range was 26 (28) 30μ for six specimens.

Suggested affinities. — Selaginellaceae, *Selaginella.*

Occurrence. — Upper Campanian-Paleocene. Hell Creek Formation, Maestrichtian and Ludlow Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Hell Creek Formation, uppermost Cretaceous and Tullock Formation, Paleocene, Montana (Norton and Hall, 1967, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs in the lower Almond Formation.

Genus **FOVEOSPORITES** Balme, 1957

Type species: *Foveosporites canalis* Balme, 1957.

Foveosporites canalis Balme, 1957 Pl. 11, fig. 57

1957. *Foveosporites canalis* Balme, p. 17, pl. 1, figs. 15-17.

Discussion. — The observed size range was 32-45μ based on two specimens.

Suggested affinities. — Lycopodiaceae. Balme (1957) referred this species to the *Lycopodium verticillatum* group.

Occurrence. — Cretaceous. Donnybrook Sandstone, Lower Cretaceous?, Perth Basin, Western Australia (Balme, 1957); Hell Creek Formation, uppermost Cretaceous, South Dakota (Stanley, 1965). This species is rare in the lower and upper Almond Formation.

Genus **CONBACULATISPORITES** Klaus, 1960

Type species: *Conbaculatisporites mesozoicus* Klaus, 1960.

Conbaculatisporites undulatus (Leffingwell), Stone, n. comb.
Pl. 11, figs. 58-59

1971. *Foraminisporis undulatus* Leffingwell, p. 25, pl. 4, figs. 5a, 5b.

Description. — The spores are triapsidately triangular in shape with strongly convex sides and well-rounded apices. The trilete rays of the faint trilete mark extend 1/2 to 2/3 of the spore radius. Lips are not present and the commissure is closed. A sparse coat of essentially baculate projections is present on both the proximal and distal surfaces. The projections may vary to clavate and a few have blunt bifurcations at the tip. The baculae are ca. 2μ wide and up to 2.5μ in length. The exine is slightly thickened at the equator (1.5μ). A size range of 34 (39) 44μ was observed on five specimens.

Discussion. — This species is not considered to be cingulate. It has been transferred to *Conbaculatisporites* because of its baculate ornament and its triangular shape. It differs from *C. mesozoicus* Klaus, 1960, in having a sparse coat of baculae and from *Baculatisporites comaumensis* (Cookson), Potonié, 1956, in having a triangular shape as well as in the spacing of the baculae. The cingulate nature of *Foraminisporis foraminis* Krutzsch, 1959, and *F. wonthaggiensis* Dettman, 1963, which this species closely resembles, is also questionable.

Suggested affinities. — Osmundaceae.

Occurrence. — Upper Campanian-Maestrichtian. Lance Formation, Maestrichtian, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Genus **UNDULATISPORITES** Pflug, 1953

Type species: *Undulatisporites microcutic* Pflug *in* Thomson and Pflug, 1953.

Undulatisporites rugulatus Stone, n. sp. Pl. 11, fig. 60

1966. *Undulatisporites* cf. *U. undulapolus* Brenner, 1963, Srivastava, p. 515, pl. III, fig. 8.

Diagnosis. — A spore with undulating trilete rays and rugulate ornamentation.

Discussion. — The rugulate ornamentation is sufficient basis for a new species. The description remains as given by Srivastava (1966). The size range of Almond Formation specimens is 22 (29) 38μ for three specimens.

Holotype. — Pl. 11, fig. 60. Slide 1655-3, Coor. 44.3-119.3, Collection No. 66W140, Section 8, lower Almond Formation, Late Campanian, Sec. 12, T19N, R101W, Sweetwater County, Wyoming.

Suggested affinities. — "Pteridophyta".

Occurrence. — Upper Campanian-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada, (Srivastava, 1966). This species occurs in the lower and upper Almond Formation.

Genus **HAMULATISPORIS** Krutzsch, 1959

Type species: *Hamulatisporis hamulatis* Krutzsch, 1959.

Hamulatisporis hamulatis Krutzsch, 1959 Pl. 11, fig. 61

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

Discussion. — The observed size range was 27 (29) 31μ for three specimens.

Suggested affinities. — Lycopodiaceae, *Lycopodium?*

Occurrence. — Upper Campanian-Eocene. Eocene, Germany (Krutzsch, 1959); Hell Creek Formation, Maestrichtian, South Dakota (Stanley, 1965); Fox Hills Formation, Maestrichtian, Montana (Norton and Hall, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Bearpaw, Fox Hills, and Hell Creek Formations, uppermost Cretaceous, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **CICATRICOSISPORITES** Potonié and Gelletich, 1933

Type species: *Cicatricosisporites dorogensis* Potonié and Gelletich, 1933.

Cicatricosisporites dorogensis Potonié and Gelletich, 1933 Pl. 11, fig. 62

1933. *Cicatricosisporites dorogensis* Potonié and Gelletich, p. 522, pl. 1, figs. 1-5.
1951. *Mohrioisporites dorogensis* Potonié, p. 135, pl. 20, fig. 14.
1953. *Mohrioisporites australiensis* Cookson, p. 470, pl. 2, figs. 31-34.
1956. *Cicatricosisporites australiensis* (Cookson), Potonié, p. 48.
1961. *Mohria dorogensis* (Potonié), Markova *in* Samoilovitch, *et al.,* p. 86, pl. 22, fig. 4.

Discussion. — Two specimens were observed, 38μ and 39μ in equatorial diameter.

Suggested affinities. — Schizaeaceae, *Anemia.*

Occurrence. — Jurassic-Tertiary. Oldman Formation, Upper Cretaceous, Alberta, Canada (Rouse, 1957); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1969); Bear Paw and Hell Creek Formations, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs only in Sample 66W140 of Section 8 of the lower Almond and Sample 66W105 of Section 4 of the upper Almond.

Genus **APPENDICISPORITES** Weyland and Krieger, 1953

Type species: *Appendicisporites tricuspidatus* Weyland and Krieger, 1953.

Appendicisporites cf. **A. dentimarginatus** Brenner, 1963 Pl. 11, fig. 63

1963. *Appendicisporites dentimarginatus* Brenner, p. 45, pl. 6, figs. 2-3.

Discussion. — The specimen illustrated here (60μ) and those recorded by Clarke (1963) (63-80μ) are considerably larger than Brenner's specimens, 22 (30) 34μ.

Suggested affinities. — Schizaeaceae, *Anemia.*

Occurrence. — Lower Cretaceous (Barremian)—lower Tertiary.

Potomac Group, Barremian-Albian, Maryland (Brenner, 1963); Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963); Midway and Wilcox groups, lower Tertiary, Gulf Coast, U.S.A. (Fairchild and Elsik, 1969). This species occurs in sample 66W133 of the lower Almond Formation.

Genus **FOVEASPORIS** Krutzsch, 1959

Type species: *Foveasporis fovearis* Krutzsch, 1959.

Foveasporis triangulus Stanley, 1965 Pl. 11, fig. 64

1965. *Foveasporis triangulus* Stanley, p. 239, pl. 27, figs. 18-22.

Discussion. — A single specimen, 56μ in diameter, was found.

Suggested affinities. — Lycopodiaceae, *Selaginella.*

Occurrence. — Upper Campanian-Paleocene. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965). This species was found only in Sample 66W133 of Section 8 of the lower Almond Formation.

Genus **ZLIVISPORIS** Pacltova, 1961

Type species: *Zlivisporis blanensis* Pacltova, 1961.

Zlivisporis novomexicanum (Anderson), Leffingwell, 1971 Pl. 11, fig. 65

1960. *Lycopodium novomexicanus* Anderson, p. 14, pl. 1, fig. 2, pl. 8, fig. 1.
1967. *Lycopodiumsporites novomexicanum* (Anderson), Drugg, p. 40, pl. 6, fig. 27.
1971. *Zlivisporis novomexicanum* (Anderson), Leffingwell, p. 25, figs. 3a, 3b, 4.

Discussion. — The distinctness of Z. *blanensis* from Z. *novomexicanum* as maintained by Norton and Hall (1969) deserves further investigation. This species resembles individuals of the Lower Cretaceous *Rouseisporites* Pocock, 1962, with missing equatorial flanges. It is also comparable to the Cenomanian *Retitriletes pluricellulus* of Pierce (1961). *Inaperturopollenites* sp. A of Orlansky (1967) is apparently identical. The observed size range of Almond Formation specimens was 32 (47) 59μ for four specimens.

Suggested affinities. — Lycopodiaceae?

Occurrence. — Upper Campanian-Paleocene. Kirtland Shale, uppermost Cretaceous and Nacimiento Formation, Paleocene, New Mexico (Anderson, 1960); upper Moreno Formation, Maestrichtian, California (Drugg, 1967); Lance Formation, Maestrichtian and Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Genus **LYCOPODIUMSPORITES** Thiergart *ex* Delcourt and Sprumont, 1955

Type species: *Lycopodiumsporites agathoecus* (Potonié), Thiergart, 1938.

Lycopodiumsporites austroclavatidites (Cookson), Potonié, 1956
Pl. 11, fig. 66

1953. *Lycopodium austroclavatidites* Cookson, p. 469, pl. 2, fig. 35.
1956. *Lycopodiumsporites austroclavatidites* (Cookson), Potonié, p. 46.
1958. *Lycopodiumsporites clavatoides* Couper, p. 132, pl. 15, figs. 12, 13.
1959. *Lycopodiumsporites reticulumsporites* Rouse, p. 309, pl. 1, fig. 3.

Discussion. — The selected synonomy above follows Dettmann (1963). The observed size range was 31-39μ for two specimens.

Suggested affinities. — Lycopodiaceae. This species has been related to the Recent *Lycopodium clavatum* group of Knox (1950).

Occurrence. — Jurassic-Paleocene. This species is widely distributed in Jurassic and Cretaceous rocks. Upper Cretaceous occurrences include the following: Magothy Formation, Turonian-Senonian, Atlantic Coastal Plain, eastern United States (*L. clavatoides*) (Groot, Penny, and Groot, 1961); Bearpaw Shale, Fox Hills, and Hell Creek Formations, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species is rare in the lower and upper Almond Formation.

Genus **STYX** Norton, 1967

Type species: *Styx minor* Norton *in* Norton and Hall, 1967.

Styx minor Norton, 1967 Pl. 12, figs. 67-69

1967. *Styx minor* Norton *in* Norton and Hall, p. 104, pl. 1, fig. C.

Discussion. — The observed size range of the maximum dimension was 108-122μ (two specimens) while that of the endospore excluding spines was 50 (58) 66μ on a total of 10 specimens. A foveolate inner layer of the perispore was not observed. As noted by Oltz (1969) *S. minor* has an extension of the perispore into an arcolamella. The other morphological characters agree favorably especially the size and the radiating ridges within the lumina of the reticulum of the perispore. One specimen with a partially detached perispore clearly reveals a well-defined trilete mark (Pl. 12, fig. 69). In comparing Norton's description with his plate, it is apparent that the photographs of figures B and C have been reversed. Figure C exhibits the "radiating ridges". Refer to Norton and Hall (1969).

Suggested affinities. — Filicinae?, megaspore?

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, uppermost Cretaceous, eastern Montana (Norton and Hall, 1967); Hell Creek Formation, uppermost Cretaceous, Montana (Norton and Hall, 1969); Bearpaw, Fox Hills and Hell Creek Formations, Maestrichtian, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Styx major Norton, 1967 Pl. 13, fig. 70

1967. *Styx major* Norton and Hall, p. 105, pl. 1, fig. B.

Discussion. — As noted by Oltz (1969) *S. major* has an extension of the perispore into an arcolamella. The size was 300μ overall and 115μ for the spore body of the single specimen observed.

Suggested affinities. — Filicinae?, megaspore.

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1967, 1969; Oltz, 1969). This species occurs only in Sample 66W221, Section 14, of the upper Almond Formation.

Genus **AZOLLA** Lamarck, 1783

Type species: Unknown.

Azolla sp. Pl. 13, fig. 71

Discussion. — Glocidia, 75μ in length, were found with seven alternating hooks about 4μ in length and 3μ wide at the base. The hooks taper rapidly to a sharp point and are recurved. Cross walls are present in the glocidia with one hook per division. Three divisions are present at the base without hooks. The glocidia are similiar to those illustrated by Stough (1968) for *Azolla polyancrya* from the Upper Cretaceous of Argentina and Chile and by Srivastava (1968) for *A. sagittifera* from the Maestrichtian Edmondton Formation of Alberta, Canada. To the author's knowledge a form genus has not been proposed for fossil specimens related to this living genus.

Suggested affinities. — Salviniaceae, *Azolla.*

Occurrence. — Upper Campanian. This species was found only in Sample 66W133 of Section 8 of the lower Almond Formation.

Genus **INAPERTUROPOLLENITES** Thomson and Pflug, 1953

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

Inaperturopollenites dubius (Potonié and Venitz), Thomson and Pflug, 1953 Pl. 14, fig. 72

1934. *Pollenites magnus dubius* Potonié and Venitz, p. 17, pl. 2, fig. 21.
1953. *Inaperturopollenites dubius* (Potonié and Venitz), Thomson and Pflug, p. 65, pl. 4, fig. 89; pl. 5, figs. 1-13.
1962. *Inaperturopollenites juniperoides* Rouse, p. 201, pl. 2, fig 6.

Discussion. — The observed size range was 28 (36) 46μ for seven specimens. Brenner (1963, p. 88) and Norris (1967, pl. 16, fig. 14) included deeply split specimens in this species. Such specimens could be contained in the morphological circumscription of *Taxodiaceaepollenites hiatus;* however, in the Almond Formation the individuals of *T. hiatus* have slightly thicker, more distinctly scabrate exines.

Suggested affinities. — Cupressaceae, Taxodiaceae.

Occurrence. — *Inaperturopollenites dubius* is widely distributed in Jurassic, Cretaceous, and Tertiary rocks. Upper Cretaceous occurrences include: Raritan, Tuscaloosa, and Magothy Formations, Cenomanian-Senonian, eastern United States (Groot, Penny, and Groot, 1961); Burrard Formation, Eocene (in part), British Columbia, Canada (Rouse, 1962); Edmonton Formation, Maestrichtian, Scollard, Alberta, Canada (Srivastava, 1966); Hell Creek Formation, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Inaperturopollenites atlanticus Groot, Penny, and Groot, 1961 Pl. 14, fig. 73

1961. *Inaperturopollenites atlanticus* Groot, Penny, and Groot, p. 130, pl. 24, fig. 18.

Discussion. — The size range was 46 (54) 59μ for three specimens.

Suggested affinities. — Araucariaceae.

Occurrence. — Cenomanian-Campanian. Tuscaloosa Formation, Cenomanian-Senonian (?), eastern United States (Groot, Penny, and Groot, 1961). This species occurs in the lower and upper Almond Formation.

Genus **LARICOIDITES** Potonié, Thomson, and Thiergart *ex* Potonié, 1958

Type species: *Laricoidites magnus* (Potonié), Potonié, 1958.

Laricoidites magnus (Potonié), Potonié, Thomson, and Thiergart, 1950
Pl. 14, fig. 74

1931. *Sporonites* (?) *magnus* Potonié, p. 556, fig. 6.
1934. *Pollenites magnus* (Potonié), Potonié, p. 48, pl. 6, fig. 5.
1937. *Larix-pollenites magnus* (Potonié), Raatz, p. 15.
1950. *Laricoidites magnus* (Potonié), Potonié, Thomson, and Thiergart, p. 48, pl. c, figs. 9, 10.
1953. *Inaperturopollenites magnus* (Potonié), Thomson, and Pflug, p. 64, pl. 4, figs. 83-88.
1962. *Larix plicatipollenites* Rouse, p. 200, pl. 1, figs. 14-15.

Discussion. — The arbitrary size designation of 50-100μ (Thomson and Pflug, 1953) of *L. magnus* is intermediate between that of *Inaperturopollenites dubis* (Potonié and Venitz), Thomson and Pflug, 1953, and *L. gigantus* Brenner, 1963. The observed size range was 50 (69) 95μ for 10 specimens.

Suggested affinities. — Pinaceae, *Larix.* Affinities for this species have been suggested with the Pinaceae, *Larix,* and the Araucariaceae (Hedlund, 1966). On the basis of available modern reference material, the *Larix* designation seems the most plausible. Pollen of *Larix americana, L. decidua,* and *L. loricina* are thinner, highly folded, and often ruptured, closely resembling *Laricoidites magnus.* The pollen of *Araucaria cunninghamii* is scabrate, thicker, and less commonly folded.

Occurrence. — Cenomanian - Paleocene. Tertiary, Germany (Potonié, 1931, 1934), Thomson and Pflug, 1953); Burrard Formation, Eocene (in part), British Columbia, Canada (Rouse, 1962); Cannonball Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Red Branch Member, Woodbine Formation, Cenomanian, Oklahoma (Hedlund, 1966); Fort Union Group, Paleocene, Montana (Norton and Hall, 1969); Hell Creek Formation, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Laricoidites gigantus Brenner, 1963 Pl. 14, fig. 75

1963. *Laricoidites gigantus* Brenner, p. 88, pl. 36, figs. 1, 2.
1964. *Inaperturopollenites giganteus* Goczan, p. 239, pl. V, fig. 1.

Discussion. — The observed size range was 101-127μ for the two specimens observed.

Suggested affinities. — Pinaceae, *Larix.*

Occurrence. — Lower Cretaceous (Barremian)-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966). This species is rare in the lower and upper Almond Formation.

Genus **ARAUCARIACITES** Cookson *ex* Couper, 1953

Type species: *Araucariacites australis* Cookson, 1947.

Araucariacites limbatus (Balme), Habib, 1969 Pl. 15, fig. 76

1957. *Inaperturopollenites limbatus* Balme, p. 31, pl. 7, figs. 83-84.
1969. *Araucariacites limbatus* (Balme), Habib, p. 91, pl. 4, fig. 6.

Discussion. — The observed size range was 66 (78) 95μ for five specimens.

Suggested affinities. — Araucariaceae.

Occurrence. — Jurassic(?)-Maestrichtian. Lewis Shale, uppermost Cretaceous, New Mexico (Anderson, 1960). This species occurs in the lower and upper Almond Formation.

Genus **TAXODIACEAEPOLLENITES** Kremp, 1949

Type species: *Taxodiaceaepollenites hiatus* (Potonié), Kremp, 1949.

Taxodiaceaepollenites hiatus (Potonié), Kremp, 1949 Pl. 15, fig. 77

1931. *Pollenites hiatus* Potonié, p. 5, fig. 27.
1933. *Taxodium hiatipites* Wodehouse, p. 493, fig. 19.
1949. *Taxodiaceaepollenites hiatus* (Potonié), Kremp, p. 59, pl. 5, figs. 31, 37, 38.
1950. *Taxodoidites hiatus* (Potonié), Potonié, Thomson, and Thiergart, p. 49, pl. A, fig. 23.
1951. *Taxodioipollenites hiatus* (Potonié), Potonié, p. 143, fig. 17.
1953. *Inaperturopollenites hiatus* (Potonié), Thomson and Pflug, p. 65, pl. 5, figs. 14-20.
1965. *Thuja? hiatus* (Potonié), Stanley, p. 273, pl. 38, figs. 1-3.

Discussion. — The grains from the Almond Formation are scabrate. The ornamentation consists of isodiametric granules which are less than 0.5μ in size. The observed size range was 25 (30) 37μ and was based on seven specimens.

Suggested affinities. — Taxodiaceae, *Taxodium.*

Occurrence. — Cretaceous-Tertiary. Pollen of this species is widely dispersed in Cretaceous and Tertiary rocks. The occurrences given here are selected to illustrate the stratigraphic range. Oligocene-Miocene, Germany, (Kremp, 1949); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Hell Creek and

Fort Union Formations, Upper Cretaceous-Paleocene, South Dakota (Stanley, 1965); Tuscaloosa, Raritan and Magothy Formations, Cenomanian-Senonian, Alabama, Georgia, North Carolina, Delaware, Maryland, and New Jersey, (Groot, Penny, and Groot, 1961); Fredericksburg Group, Albian, Oklahoma (Hedlund and Norris, 1968); Bearpaw Shale, Fox Hills Sandstone and Hell Creek Formation, uppermost Cretaceous, and Tullock and Lebo formations, Paleocene, Montana (Norton and Hall, 1969); Bearpaw, Fox Hills, and Hell Creek formations, Maestrichtian, and Tullock and Lebo formations, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Genus **CYCADOPITES** Wodehouse *ex* Wilson and Webster, 1946

Type species: *Cycadopites follicularis* Wilson and Webster, 1946.

Cycadopites follicularis Wilson and Webster, 1946 Pl. 15, fig. 78

1946. *Cycadopites follicularis* Wilson and Webster, p. 274, fig. 7.

Discussion. — The observed size range was 33 (38) 48μ for five specimens.

Suggested affinities. — Cycadaceae?

Occurrence. — Upper Campanian-Paleocene. Fort Union Group, Paleocene, Montana (Wilson and Webster, 1946); Edmonton Formation, Maestrichtian, Alberta, Canada. (Srivastava, 1966); Lance Formation, Maestrichtian and Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs throughout the Almond Formation.

Cycadopites pseudolatus Stone, n. sp. Pl. 15, fig. 79

Diagnosis. — The subcircular outline, psilate exine, and broad sulcus distinguish this species.

Description. — The shape is subcircular to slightly elliptical. The sulcus extends the entire length of the grain. It is about 2.5μ wide at the center and expands at the ends to about 5μ wide. The exine is psilate and about 1μ thick. The size range is 17 (23) 30μ in the long dimension for eight specimens.

Holotype. — Plate 15, figure 79. Slide No. 1649-3, Coor. 30.4-125.1, Collection No. 66W133, Section 8, Almond Formation, Late Campanian, Sec. 12, T19N, R101W, Sweetwater County, Wyoming.

Discussion. — Slightly weathered specimens appear roughened and pitted. It is not known if this is the scabrate ornamentation of other authors, *e.g.* Stanley (1965, p. 271). *Monosulcites latus* Norton *in* Norton and Hall, 1969, is comparable but larger (30-37μ) and scabrate.

Suggested affinities. — Cycadaceae?

Occurrence. — Upper Campanian. This species occurs in the lower and upper Almond Formation.

Genus **MONOSULCITES** Cookson *ex* Couper, 1953

Type species: *Monosulcites minimus* Cookson, 1947.

Monosulcites scabratus (Stanley), Stone, n. comb. Pl. 15, figs. 80-81

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

Discussion. — The aperture of this species is considered to be monosulcate with occasional flaring at the ends and not inaperturate with splitting as indicated by Stanley (1965). The transfer to *Monosulcites* is made on this basis. The observed size was 20 (30) 40μ for four specimens.

Suggested affinities. — Gymnospermae.

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, Maestrichtian, South Dakota (Stanley, 1965). This species occurs in the lower and upper Almond Formation.

Genus **EUCOMMIIDITES** Erdtman emend. Couper, 1958

Type species: *Eucommiidites troedssonii* Erdtman, 1948.

Eucommiidites couperi Anderson, 1960 Pl. 15, fig. 82

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

Discussion. — Anderson (1960) considered this species to be tricolpate. In light of Hughes' (1961) discussion, the morphology of the apertures seems best interpreted as a sulcus and a ring furrow (zonisulcate); however, from the orientation of specimens illustrated by Anderson and those observed from the Almond Formation it is not readily apparent that the two apertures are on opposite faces. The observed size range was 24 (26) 31μ for six specimens.

Suggested affinities. — Gymnospermae.

Occurrence. — Upper Campanian-Maestrichtian. Lewis Shale, uppermost Cretaceous, New Mexico (Anderson 1960). This species occurs in the lower and upper Almond Formation.

Genus **EQUISETOSPORITES** Daugherty emend. Singh, 1964

Type species: *Equisetosporites chinleana* Daugherty, 1941.

Equisetosporites ovatus (Pierce), Singh, 1964 Pl. 15, fig. 83

1961. *Striainaperturites ovatus* Pierce, p. 45, pl. III, fig. 80.
1964. *Equisetosporites ovatus* (Pierce), Singh, p. 133, pl. 17, fig. 16.
1969. *Ephedripites ovatus* (Pierce), Norton *in* Norton and Hall, p. 34, pl. 3, fig. 19.

Discussion. — The observed size range was 28 (37) 45μ for the polar dimension of 11 specimens.

Suggested affinities. — Ephedraceae, *Ephedra.*

Occurrence. — Aptian-Maestrichtian. Cenomanian, Minnesota, (Pierce, 1961); Ellerslie Member, McMurray Formation, Aptian, Alberta, Canada (Singh, 1964); Bearpaw Shale, Maestrichtian, Montana (Norton and Hall, 1969). This species occurs in the lower and upper Almond Formation.

Genus **VITREISPORITES** Leschik, 1955

Type species: *Vitreisporites signatus* Leschik, 1955.

Vitreisporites pallidus (Reissinger), Nilsson, 1958 Pl. 15, fig. 84

1940. *Pityosporites pallidus* Reissinger, p. 14.
1950. *Pityopollenites pallidus* (Reissinger), Reissinger, p. 109, pl. 15, figs. 1-5.
1958. *Caytonipollenites pallidus* (Reissinger), Couper, p. 150, pl. 26, figs. 7, 8.
1958. *Vitreisporites pallidus* (Reissinger), Nilsson, p. 77, pl. 7, figs. 12-14.

Discussion. — The observed size range was 24 (35) 45μ for nine specimens.

Suggested affinities. — Caytoniaceae, *Caytonanthus.*

Occurrence. — Jurassic-Cretaceous. This species is widely reported from Jurassic and Cretaceous rocks. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963). It occurs in the lower and upper Almond Formation.

Genus **PHYLLOCLADIDITES** Cookson *ex* Couper, 1953

Type species: *Phyllocladidites mawsonii* Cookson *ex* Couper, 1953.

Phyllocladidites mawsonii Cookson *ex* Couper, 1953 Pl. 15, fig. 85

1947. *Phyllocladidites mawsonii* Cookson, p. 133, pl. XIV, figs. 22-28.
1953. *Phyllocladidites mawsonii* Cookson *ex* Couper, p. 38, pl. 9, fig. 135.

Discussion. — The observed size range was 45-50μ for two specimens.

Suggested affinities. — Podocarpaceae, *Dacrydium.*

Occurrence. — Lower Cretaceous-Lower Oligocene. Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1969); Bear Paw and Hell Creek formations, Maestrichtian, Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **PODOCARPIDITES** Cookson ex Couper, 1953

Type species: *Podocarpidites ellipticus* Cookson *ex* Couper, 1953.

Podocarpidites maximus (Stanley), Norton, 1969 Pl. 15, fig. 86

1965. *Podocarpus maximus* Stanley, p. 281, pl. 41, figs. 1-8.
1969. *Podocarpidites maximus* (Stanley), Norton *in* Norton and Hall, p. 31, pl. 4, fig. 12.

Discussion. — The observed size range was 50 (55) 58μ for the overall dimension of four specimens.

Suggested affinities. — Podocarpaceae, *Podocarpus*.

Occurrence. — Upper Campanian-Paleocene. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Tullock and Lebo formations, Paleocene, Montana (Norton and Hall, 1967, 1969); Hell Creek Formation, Maestrichtian, and Tullock and Lebo formations, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **CEDRIPITES** Wodehouse, 1933

Type species: *Cedripites cocenicus* Wodehouse, 1933.

Cedripites parvus Norton, 1969 Pl. 15, fig. 87

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

Discussion. — The overall size range was 60 (65) 69μ for five specimens.

Suggested affinities. — Pinaceae, *Cedrus?*

Occurrence. — Upper Campanian-Paleocene. Tullock Formation, Paleocene, Montana (Norton and Hall, 1969); Fox Hills and Hell Creek formations, Maestrichtian, and Tullock and Lebo formations, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **ABIETINEAEPOLLENITES** Potonié, 1951

Type species: *Abietineaepollenites microalatus* (Potonié), Potonié, 1951.

Abietineaepollenites foveoreticulatus Norton, 1969 Pl. 15, fig. 88

1969. *Abietineaepollenites foveoreticulatus* Norton *in* Norton and Hall, p. 28, pl. 4, fig. 4.

Discussion. — The overall size range was 58 (62) 68μ for four specimens.

Suggested affinities. — Pinaceae.

Occurrence. — Upper Campanian-Paleocene. Fort Union Group, Paleocene, Montana (Norton and Hall, 1969). This species occurs throughout the Almond Formation.

Genus **ALISPORITES** Daugherty, 1941

Type species: *Alisporites opii* Daugherty, 1941.

Alisporites grandis (Cookson), Dettmann, 1963 Pl. 16, fig. 89

1953. *Dissaccites grandis* Cookson, p. 471, pl. 2, fig. 41.
1957. *Pityosporites grandis* (Cookson), Balme, p. 36, pl. 10, figs. 110, 111.
1959. *Alisporites rotundus* Rouse, p. 316, pl. 1, figs. 15, 16.
1963. *Alisporites grandis* (Cookson), Dettmann, p. 102, pl. XXV, figs. 1-4.

Discussion. — The overall size range was 79 (93) 113μ for five specimens.

Suggested affinities. — Pinaceae.

Occurrence. — Upper Jurassic-Cretaceous. This species has been reported from the Upper Jurassic-Lower Cretaceous by Balme (1957) and from the Lower Cretaceous by Cookson (1953), Rouse (1959), Pocock (1962), Dettmann (1963), and Singh (1964). Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966). This species occurs in the lower and upper Almond Formation.

Genus **RUGUBIVESICULITES** Pierce, 1961

Type species: *Rugubivesiculites convolutus* Pierce, 1961.

Rugubivesiculites floridus Pierce, 1961 Pl. 16, fig. 90

1961. *Rugubivesiculites floridus* Pierce, p. 40, pl. II, fig. 63.

Discussion. — The overall size of the single specimen observed was 50μ.

Suggested affinities. — Podocarpaceae.

Occurrence. — Cenomanian-Campanian. To the author's knowledge this species has not been previously reported above the Cenomanian (Pierce, 1961). The genus is known to range throughout the Upper Cretaceous. This species occurs only in Sample 66W144 of Section 9 of the upper Almond Formation.

Genus **TSUGAEPOLLENITES** Potonié and Venitz emend. Potonié, 1958

Type species: *Tsugaepollenites igniculus* (Potonié), Potonié and Venitz, 1934.

Tsugaepollenites igniculus (Potonié), Potonié and Venitz, 1934
Pl. 16, fig. 91

1931. *Sporonites igniculus* Potonié, p. 556, fig. 2.
1934. *Tsugaepollenites igniculus* (Potonié), Potonié and Venitz, p. 17, pl. 1, fig. 8.
1953. *Zonalapollenites igniculus* (Potonié), Thomson and Pflug, p. 66, pl. 4, figs. 75-79.

Discussion. — The observed size range was 44 (49) 53μ for six specimens. A tetrad mark was present on some specimens.

Suggested affinities. — Pinaceae, *Tsuga.*

Occurrence. — Upper Campanian-Pliocene. Miocene-Pliocene, Middle Europe (Thomson and Pflug, 1953); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs only in Sample 66W133, Section 8, of the lower Almond Formation.

Genus **QUADRIPOLLIS** Drugg, 1967

Type species: *Quadripollis krempii* Drugg, 1967.

Quadripollis krempii Drugg, 1967 Pl. 16, fig. 92

1967. *Quadripollis krempii* Drugg, p. 62, pl. 8, figs. 55-56.

Discussion. — The last sentence in Drugg's (1967) generic diagnosis should read, "No visible apertures but the *distal* surfaces are thin and frequently ruptured" and the fifth sentence in the specific diagnosis should read, "The equatorial area tends to curve outward in a *distal* direction." A formal emendation is not necessary to correct this inadvertant error. Drugg compared this species with *Inaperturopollenites limbatus* Balme, 1957. The size range was 41 (46) 56μ for the three tetrads observed.

Suggested affinities. — Gymnospermae?

Occurrence. — Upper Campanian-Maestrichtian. Upper Moreno Formation, Maestrichtian, California (Drugg, 1967). This species occurs in the lower and upper Almond Formation.

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

Type species: *Classopollis classoides* Pflug emend. Pocock and Jansonius, 1961.

Classopollis classoides Pflug emend. Pocock and Jansonius, 1961
Pl. 16, fig. 93

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

Discussion. — The observed size range was 22 (25) 31μ for five specimens.

Suggested affinities. — Gymnospermae. *Classopollis* pollen occurs in the Mesozoic conifer family Cheirolepidaceae (Barnard, 1968).

Occurrence. — Jurassic-Cretaceous. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963). This species occurs in the lower and upper Almond Formation.

Genus **SPERMATITES** Miner, 1935

Type species: None designated.

Spermatites sp. Pl. 17, fig. 94

Discussion. — A single partial specimen was found measuring 279μ in length. No pollen was found in the pollen chamber of this ovule. It has not been identified as to species.

Suggested affinities. — Gymnospermae.

Occurrence. — Cretaceous occurrences are reported by Miner (1935), Hughes (1961), Hedlund (1966), and Brenner (1967). This species occurs only in Sample 67W1 of Section 8 of the lower Almond Formation.

Genus **ARECIPITES** Wodehouse emend. Anderson, 1960

Type species: *Arecipites punctatus* Wodehouse, 1933.

Arecipites reticulatus (van der Hammen), Anderson, 1960 Pl. 17, fig. 95

1954. *Monocolpites reticulatus* van der Hammen, p. 89.
1954. *Pollenites reticulatus* van der Hammen, p. 96.
1960. *Arecipites reticulatus* (van der Hammen), Anderson, p. 18, pl. 1, fig. 19; pl. 7, fig. 6; pl. 8, fig. 3; pl. 10, fig. 7.
1965. *Pseudotricolpites reticulatus* Stanley, p. 317, figs. 26-37.
1966. *Liliacidites variegatus* Couper, Srivastava, p. 525, pl. IV, figs. 15-16.
1969. *Liliacidites* sp. Norton and Hall, p. 36, pl. 5, fig. 3.

Discussion. — The observed size range was 27 (29) 32μ for the polar diameter of four specimens.

Suggested affinities. — Monocotyledoneae?

Occurrence. — Upper Campanian-Paleocene. Kirtland and Lewis shales, uppermost Cretaceous, and Nacimiento Formation, Paleocene, New Mexico (Anderson, 1960); Hell Creek Formation, Maestrichtian, and Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966); Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1969). This species occurs throughout the Almond Formation.

Genus **LILIACIDITES** Couper, 1953

Type species: *Liliacidites kaitangataensis* Couper, 1953.

Liliacidites leei Anderson, 1960 Pl. 17, fig. 96

1960. *Liliacidites leei* Anderson, p. 18, pl. 1, figs. 9-11; pl. 5, fig. 10; pl. 7, fig. 7; pl. 8, figs. 4-5.

Discussion. — The observed size range was 25 (35) 54μ for 13 specimens.

Suggested affinities. — Angiospermae.

Occurrence. — Upper Campanian-lower Paleocene. Kirtland Shale, Ojo Alamo Sandstone and Nacimiento Formation, uppermost Cretaceous-Paleocene, San Juan Basin, New Mexico (Anderson, 1960). This species occurs in the lower and upper Almond Formation.

Liliacidites complexus (Stanley), Leffingwell, 1971 Pl. 17, figs. 97-98

1965. *Schizosporis complexus* Stanley, p. 267, pl. 36, figs. 7-17.
1971. *Liliacidites complexus* (Stanley), Leffingwell, p. 41, pl. 7, figs. 3a-3b.

Discussion. — This species is thought to have a monosulcate aperture. The size range was 22 (37) 48μ for seven specimens.

Suggested affinities. — Angiospermae. The complex exine serves to relate this species to the angiosperms.

Occurrence. — Upper Campanian - Maestrichtian, Paleocene?, Hell Creek Formation, Maestrichtian, South Dakota (Stanley, 1965). Fox Hills and Hell Creek formations, Maestrichtian, Montana (Norton and Hall, 1967 and 1969), Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Bear Paw, Fox Hills, and Hell Creek formations, uppermost Cretaceous, and lower Tullock Formation, Paleocene, Montana (Oltz, 1969), Lance Formation, Maestrichtian, Wyoming (Leffingwell, 1971). This species occurs in the upper Almond Formation.

Genus **TRICOLPOPOLLENITES** Pflug and Thomson, 1953

Type species: *Tricolpopollenites parmularius* (Potonié), Thomson and Pflug, 1953.

Tricolpopollenites parvulus Groot and Penny, 1960 Pl. 18, figs. 99, 100

1960. *Tricolpopollenites parvulus* Groot and Penny, p. 232, pl. 2, figs. 8-9.
1969. *Tricolpopollenites tersus* Oltz, p. 132, pl. 42, fig. 147.

Discussion. — The observed size range was 11 (12) 15μ in the polar diameter for three specimens and 9-12μ for the equatorial diameter of two specimens. This species is comparable to *Tricolpopollenites* sp. 1 Norton and Hall, 1969, but the latter is described as having a margo on the colpi.

Suggested affinities. — Dicotyledonae.

Occurrence. — Cenomanian-Danian. Upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs throughout the Almond Formation.

Tricolpopollenites microscabratus Norton, 1969 Pl. 18, fig. 101

1969. *Tricolpopollenites microscabratus,* Norton *in* Norton and Hall, p. 47, pl. 7, fig. 8.

Discussion. — The observed size range was 16 (19) 22μ in the polar diameter for six specimens.

Suggested affinities. — Dicotyledoneae.

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, uppermost Cretaceous, Montana (Norton and Hall, 1969). This species occurs in the lower and upper Almond Formation.

Tricolpopollenites microreticulatus Norton, 1969 Pl. 18, figs. 102-103

1969. *Tricolpopollenites microreticulatus* Norton *in* Norton and Hall, p. 47, pl. 7, fig. 8.
1969. *Tricolpopollenites tersus* Oltz, p. 152, pl. 42, fig. 147.

Discussion. — The observed size range was 12 (14) 16μ for the polar axis as observed on six specimens and 10 (13) 17μ for the equatorial axis as observed on nine specimens. The small size and microreticulate exine (lumina ca. 0.5μ) distinguish this species. It closely resembles *T. micromunus* Groot and Penny, 1960, except in having a finer reticulum.

Suggested affinities. — Dicotyledoneae.

Occurrence. — Upper Campanian-Paleocene. Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1969); Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Tricolpopollenites clavireticulatus Norton, 1969 Pl. 18, figs. 104-105

1969. *Tricolpopollenites clavireticulatus* Norton *in* Norton and Hall, p. 49, pl. 7, fig. 14.
1969. *Salixipollenites* sp. B Snead, p. 35, pl. 6, figs. 8-9.
1969. *Tricolpites* sp. C Oltz, p. 159, pl 42, fig. 138.

Discussion. — This species is distinguished by a variable reticulum in which the lumina become larger at the equator between the colpi. The size range was 14 (18) 21μ for the polar diameter of five specimens and 12 (13) 14μ in the equatorial diameter for four specimens.

Suggested affinities. — Salicaceae.

Occurrence. — Upper Campanian-Maestrichtian. Bearpaw, Fox Hills, and Hell Creek formations, uppermost Cretaceous, Montana (Norton and Hall, 1969); Hell Creek Formation, Maestrichtian, Montana, (*Tricolpites* sp. C) (Oltz, 1969); Edmonton Formation, Maestrichtian (Snead, 1969). This species occurs in the lower and upper Almond Formation.

Tricolpopollenites deliclavatus Oltz, 1969 Pl. 18, fig. 106

1969. *Tricolpopollenites deliclavatus* Oltz, p. 151, pl. 42, fig. 140.

Discussion. — The size range of this species was 16-17μ for three specimens. The upper Albian-Cenomanian species *T. micromunus* Groot and Penny, 1960 is comparable but slightly smaller (ca. 14μ).

Suggested affinities. — Dicotyledoneae.

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, Maestrichtian, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Tricolpopollenites compactus Norton, 1969 Pl. 18, fig. 107

1969. *Tricolpopollenites compactus* Norton *in* Norton and Hall, p. 47, pl. 7, fig. 9.

Discussion. — The observed size range of the polar axis was 20 (24) 27μ for six specimens.

Suggested affinities. — Trochodendraceae?

Occurrence. — Upper Campanian-Paleocene. Lebo Formation, Paleocene, Montana (Norton and Hall, 1969). This species occurs in the lower and upper Almond Formation.

Genus **TRICOLPITES** Cookson *ex* Couper, 1953

Type species: *Tricolpites reticulatus* Cookson, 1947.

Tricolpites mutabilis Leffingwell, 1971 Pl. 18, fig. 108

1964. *"Tricolpopollenites"* sp. Leopold and Pakiser, pl. 5, figs. 1-2 (figs. 3-5 excluded).
1965. *Tricolpites* sp. Jardiné and Magloire, p. 214, pl. X, figs. 9-10, 13-14 (figs. 8, 11, 12 excluded).
1971. *Tricolpites mutabilis* Leffingwell, p. 44, pl. 8, figs. 1-3.

Description. — The pollen are rounded triangular, with convex sides, and oblate. The three colpi extend for 3/4 of the radius as seen in polar view and divide the grain into distinct lobes. The exine is about 1μ in thickness, psilate to microgranulate (scabrate or *infraponctuée*). The granules are less than .5μ in size. The size range is 12 (15) 20μ as observed on nine specimens.

Discussion. — Stanley (1965, p. 320) listed the synonomy of the genus. Descriptions or sizes are not provided for the specimens listed as "*Tricolpopollenites*" by Leopold and Pakiser (1964), but they appear to be conspecific from the photographs. *Tricolpites mutabilis* is conspecific with *T.* sp. of Jardiné and Magloire (1965). The psilate-scabrate exine of *T. mutabilis* distinguishes it from the reticulate species of the genus. *T. pachyexinus* Couper, 1953 is a psilate species, but it has a thicker exine and a large size (26-40μ).

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Cenomanian-Paleocene. Tuscaloosa Group, Cenomanian-Turonian, Alabama (Leopold and Pakiser, 1964); Turonian?-Lower Senonian, Sénégal and Côte-d'Ivoire (Jardiné and Magloire, 1965), (the Senonian as used by Jardiné and Magloire excludes the Maestrichtian); Lance Formation, Maestrichtian, and Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs throughout the Almond Formation.

Tricolpites psilascabratus Norton, 1969 Pl. 18, figs. 109-110

1969. *Tricolpites psilascabratus* Norton *in* Norton and Hall, p. 45, pl. 7, fig. 3.

Discussion. — The observed size range was 19 (23) 27μ for the equatorial diameter of four specimens and 23-24μ for the polar diameter of two specimens.

Suggested affinities. — Dicotyledoneae.

Occurrence. — Upper Campanian-Paleocene. Hell Creek Formation, Maestrichtian, and Fort Union Formation, Paleocene, Montana (Norton and Hall, 1969); Fox Hills and Hell Creek formations, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Tricolpites lillei Couper, 1953 Pl. 18, fig. 111

1953. *Tricolpites lillei* Couper, p. 62, pl. 8, figs. 116-117.

Discussion. — The observed size range was 26-27μ for the equatorial diameter of two specimens.

Suggested affinities. — Ranunculaceae.

Occurrence. — Cretaceous-Paleocene. Cretaceous, New Zealand (Couper, 1953); Lebo Formation, Paleocene, Montana (Norton and Hall, 1969). This species is rare in the lower and upper Almond Formation.

Tricolpites reticulatus Cookson, 1947 Pl. 18, fig. 112

1947. *Tricolpites reticulatus* Cookson, p. 134, pl. XV, fig. 45.
1954. *Gunnerites reticulatus* Cookson *in* Cookson and Pike, p. 201, pl. 1, figs. 18-19.
1965. *Tricolpites interangulus* Newman, p. 10, pl. 1, fig. 3.
1971. *Gunnera microreticulata* (Belsky, Boltenhagen, and Potonié), Leffingwell, p. 37, pl. 6, figs. 7-8.

Discussion. — Specimens from the Almond Formation are gradational in shape from circular to subcircular with slight convexity between the colpi. The latter condition does not seem to warrant the separate species, *T. interangulus.* The observed size range was 20 (26) 30μ for 12 specimens.

Suggested affinities. — Haloragaceae, *Gunnera.*

Occurrence. — Campanian - Tertiary. Tertiary, Kerguelen (Cookson, 1947); Tertiary, New Guinea, and Australia (Cookson and Pike, 1954); upper Mancos, Mesaverde, Iles and Williams Fork formations, Campanian, and Lewis Formation, Maestrichtian, Colorado (Newman, 1965); Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966); Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1967, 1969; Oltz, 1969); Lance Formation, Maestrichtian, Wyoming, (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Tricolpites bathyreticulatus Stanley, 1965 Pl. 18, fig. 113

1965. *Tricolpites bathyreticulatus* Stanley, p. 320, pl. 47, figs. 18-23.
1969. *Salixipollenites* sp. Snead, p. 34, pl. 1, fig. 8.

Discussion. — The observed size range was 21 (23) 26μ for six specimens.

Suggested affinities. — Dicotyledoneae.

Occurrence. — Upper Campanian-Paleocene. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Tullock and Lebo formations, Paleocene, Montana (Norton and Hall, 1967, 1969); Teurian, Paleocene, New Zealand, (McIntyre, 1968); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Tullock Formation, Paleocene, Montana (Oltz, 1969); Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Tricolpites cf. **T. anguloluminosus** Anderson, 1960 Pl. 18, figs. 114-115

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

Discussion. — The specimens from the Almond Formation have slightly coarser muri (1μ) in comparison to Anderson's specimens (0.5μ), but they compare favorably in the height of the muri (1.5μ) and the width (ca. 2μ) of the angular lumina. The size range of the polar axis of two specimens was $39\text{-}43\mu$ and the equatorial axis of a third specimen was 37μ.

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Upper Campanian-lower Paleocene. Ojo Alamo Sandstone and Naciemiento Formation, lower Paleocene, San Juan Basin, New Mexico (Anderson, 1960); Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Genus **FRAXINOIPOLLENITES** Potonié, 1960

Type species: *Fraxinoipollenites pudicus* (Potonié), Potonié, 1960.

Fraxinoipollenites variabilis Stanley, 1965 Pl. 18, figs. 116-117

1965. *Fraxinoipollenites variabilis* Stanley, p. 306, pl. 45, figs. 29-35.

Discussion. — The observed size range was 18 (20) 27μ for the polar diameter of 12 specimens and 18 (19) 21μ for the equatorial diameter of five specimens.

Suggested affinities. — Oleaceae, *Fraxinus*?

Occurrence. — Upper Campanian-Paleocene. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs throughout the Almond Formation.

Genus **CRANWELLIA** Srivastava, 1966

Type species: *Cranwellia striata* (Couper), Srivastava, 1966.

Cranwellia rumseyensis Srivastava, 1966 Pl. 18, figs. 118-119

1966. *Cranwellia rumseyensis* Srivastava, p. 538, pl. 11, figs. 3, 7.

Discussion. — "*C. rumseyensis* differs from *C. striata* in having inconspicuous or no pore chambers, slightly straight to convex sides, bluntly rounded equatorial arms, less pronounced striations in the polar area" (Srivastava, 1966). The observed size range was 22 (27) 38μ for the equatorial diameter of seven specimens.

Suggested affinities. — Loranthaceae, *Elytranthe.*

Occurrence. — Upper Campanian-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966 and Snead, 1969). This species occurs in the lower and upper Almond Formation.

Genus **ILEXPOLLENITES** Thiergart, 1937

Type species: *Ilexpollenites iliacus* (Potonié), Thiergart, 1937.

Ilexpollenites compactus, Stone, n. sp. Pl. 18, figs. 120-121

1963. *Pistillipollenites?* sp. Clarke, p. 100, pl. 11, figs. 18-19, unpublished.

Diagnosis. — This species is distinguished by its closely spaced gemmate ornamentation, 2μ in height, and its small size.

Description. — The pollen grains are subcircular when seen in polar view and elliptical in equatorial view. Three equatorially positioned indentations which are elongate parallel to the polar axis are interpreted as colpi. These are best seen in Plate 18, figure 120. The gemmate ornamentation is closely spaced. The gemmae are slightly bulbose at the apex, and they are approximately 1.5μ wide and approximately 2μ high. The size range was 21 (24) 28μ for nine specimens. The polar diameter is approximately the same as the equatorial diameter.

Holotype. — Plate 18, figure 120. Slide No. 1649-3, Coor. 27.7-122.8, Collection No. 66W133, Section 8, Almond Formation, late Campanian, Sec. 12, T19N, R101W, Sweetwater County, Wyoming.

Discussion. — *Ilexpollenites compactus* is conspecific with *Pistillipollenites*? sp. of Clarke (1963). It has a closely spaced gemmate ornamentation and is distinct from *P. mcgregorii* Rouse (1962) which has a widely spaced gemmate ornamentation. Drugg (1967, p. 50) identified a comparable species as *Ilexpollenites* sp., but it is somewhat larger (48μ). *I. megagemmatus* McIntyre, 1968 is similar, but it has large gemmae (3-4μ in height and width).

Suggested affinities. — Aquifoliaceae, *Ilex.* This species also agrees with *Rusbyanthus cinchonifolius* of the Gentianaceae as illustrated and described by Erdtman (1952, p. 185).

Occurrence. — Upper Campanian-Maestrichtian. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963). The species occurs in the lower and upper Almond Formation.

Genus **ERICACEOIPOLLENITES** Potonié, 1960

Type species: *Ericaceoipollenites roboreus* (Potonié), Potonié, 1960.

Ericaceoipollenites rallus Stanley, 1965 Pl. 18, fig. 122

1965. *Ericaceoipollenites rallus* Stanley, p. 296, pl. 44, figs. 15-18.

Discussion. — All specimens appear to be weathered. Stanley (1965) described the species as scabrate with partially pitted exines. Specimens from the Almond are best described as reticulate but they agree in other characters. The observed size range was 23 (29) 37μ for 13 specimens.

Suggested affinities. — Ericaceae, *Kalmia*?

Occurrence. — Upper Campanian-Paleocene. Fort Union Formation, Paleocene, South Dakota (Stanley, 1965). This species occurs throughout the Almond Formation.

Genus **AQUILAPOLLENITES** Rouse emend. Funkhouser, 1961

Type species: *Aquilapollenites quadrilobus* Rouse, 1957.

Aquilapollenites polaris Funkhouser, 1961 Pl. 19, figs. 123-124

1961. *Aquilapollenites polaris* Funkhouser, p. 198, pl. 1, figs. 1-2.

Discussion. — The observed size range of the polar axis was 23 (38) 52μ for 17 specimens.

Suggested affinities. — Angiospermae.

Occurrence. — Upper Campanian-Maestrichtian. Lance Formation, Maestrichtian, Wyoming (Funkhouser, 1961); Hell Creek Formation, Maestrichtian, Montana, (Norton, 1965; Norton and Hall, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966 and Snead, 1969). This species occurs throughout the Almond Formation.

Aquilapollenites pulcher Funkhouser, 1961 Pl. 19, fig. 125

1961. *Aquilapollenites pulcher* Funkhouser, p. 198, pl. 1, fig. 7.

Discussion. — The observed size range of the polar axis was 26 (30) 35μ for three specimens.

Suggested affinities. — Angiospermae.

Occurrence. — Upper Campanian-Maestrichtian. Lance Formation, Maestrichtian, Wyoming (Funkhouser, 1961). This species occurs in the lower and upper Almond Formation.

Aquilapollenites striatus Funkhouser, 1961 Pl. 19, fig. 126

1961. *Aquilapollenites striatus* Funkhouser, p. 196, pl. 2, fig. 4.

Discussion. — The size range of the polar axis was 27-43μ on two specimens.

Suggested affinities. — Angiospermae.

Occurrence. — Upper Campanian-Maestrichtian. Lance Formation, Maestrichtian, Wyoming (Funkhouser, 1961). This species occurs in the lower and upper Almond Formation.

Aquilapollenites reticulatus Stanley, 1965 Pl. 19, fig. 127

1965. *Aquilapollenites reticulatus* Stanley, p. 348, pl. 8, figs. 1-12.

Discussion. — The reticulate exine of the body and the striate exine of the protrusions serve to distinguish this species. The size was 56μ for the polar axis of the single specimen observed.

Suggested affinities. — Angiospermae.

Occurrence. — Upper Campanian-Maestrichtian. Hell Creek Formation, Maestrichtian, South Dakota (Stanley, 1961, 1965); Hell Creek Formation, Maestrichtian, Montana (Norton, 1965; Norton and Hall, 1969; Oltz, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969). This species occurs only in Sample 66W237, Section 14, of the upper Almond Formation.

Genus **CUPULIFEROIPOLLENITES** Potonié, 1951

Type species: *Cupuliferoipollenites pusillus* (Potonié), Potonié, 1951.

Cupuliferoipollenites pusillus (Potonié), Potonié, 1951 Pl. 19, figs. 128-129

1934. *Pollenites quisqualis* forma *pusillus* Potonié, p. 71, pl. 3, fig. 21.
1951. *Cupuliferoipollenites pusillus* (Potonié), Potonié, p. 150, pl. 20, fig. 69.

Discussion. — The observed size range was 13 (16) 20μ for the polar dimension of six specimens.

Suggested affinities. — Fagaceae, *Castanea.*

Occurrence. — Upper Campanian-Miocene. Brightseat Formation, Paleocene, Maryland (Groot and Groot, 1962); upper Moreno Formation, Danian, California (Drugg, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969). This species occurs in the lower and upper Almond Formation.

Genus **TRICOLPOROPOLLENITES** Thomson and Pflug, 1953

Type species: *Tricolporopollenites dolium* (Potonié), Thomson and Pflug, 1953.

Tricolporopollenites affluens (Stanley), Stone, n. comb. Pl. 19, fig. 130

1962. *Tricolporopollenites* sp. Rouse, p. 216, pl. 5, fig. 1.
1965. *Vitis? affluens* Stanley, p. 311, pl. 46, figs. 18-21.

1969. *Vitis* sp. cf. *V.? affluens* Snead, p. 29, pl. 7, figs. 8-9.
1969. *Tricolpites abatus* Oltz, p. 147, pl. 41, fig. 123.

Discussion. — The description of this species remains as designated by Stanley. The porate nature is not obvious on all individuals. The colpi are open only at the equator and are not gaping as seen in the polar view. The subtriangular shape is definitive. An equatorial orientation has not been observed. The size range of the Almond Formation specimens was 14 (17) 24μ for seven specimens.

Suggested affinities. — Vitaceae, *Vitis*.

Occurrence. — Upper Campanian-Eocene. Terminal Dock Locality, Burrard Formation, Eocene, British Columbia, Canada (Rouse, 1962); Ludlow Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Tullock Formation, Fort Union Group, Paleocene, Montana (Oltz, 1969). This species occurs in the lower and upper Almond Formation.

Genus **CUPANIEIDITES** Cookson and Pike, 1954

Type species: *Cupanieidites orthoteichus* Cookson and Pike, 1954.

Cupanieidites major Cookson and Pike, 1954 Pl. 20, figs. 131-132

1954. *Cupanieidites major* Cookson and Pike, p. 213, pl. 2, figs. 83-85.
1965. *Cupanieidites speciosus* Stanley, p. 309, pl. 46, figs. 12-17.
1966. *Cupanieidites* sp. Srivastava, p. 533, pl. VII, fig. 20.
1971. *Cupanieidites inaequalis* Leffingwell, p. 49, pl. 9, figs. 5, 9, 10.

Discussion. — *C. speciosus* Stanley, 1965, (18-25μ) is apparently identical to *C. major*, 29-35μ (Cookson and Pike, 1954) and 25-35μ (Norton and Hall, 1969) except for its slightly smaller size. The observed size range of nine specimens from the Almond Formation was 17 (21) 24μ. This species exhibits a tricolporate aperture with the colpi uniting at the poles. The morphological term "syncolporate" is preferred to describe this condition. It is analogous to the term "syncolpate".

Suggested affinities. — Sapindaceae, Cupanieae.

Occurrence. — Upper Campanian-Eocene. Eocene, Victoria, Australia, (*C. major*) (Cookson and Pike, 1954); Hell Creek Formation, Maestrichtian, South Dakota (Stanley, 1965); Edmonton Formation, Maestrichtian, Alberta, Canada, (*C.* sp.) (Srivastava, 1966); upper Moreno Formation, Maestrichtian-Danian California, (*C. major*) (Drugg, 1967); Hell Creek Formation, Maestrichtian, and Tullock Formation, Paleocene, Montana, (*C. major*) (Norton and Hall, 1969); Hell Creek Formation, Maestrichtian, Montana (Oltz, 1969); Lance Formation, Maestrichtian, and Tullock Member, Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Genus **ENGELHARDTIOIDITES** Potonié, Thomson, and Thiergart, 1950

Type species: *Engelhardtioidites microcoryphaeus* (Potonié), Potonié, Thomson, and Thiergart, 1950.

Engelhardtioidites minutus Newman, 1965 Pl. 20, fig. 133

1965. *Engelhardtioidites minutus* Newman, p. 13, pl. 1, fig. 8.

Discussion. — The size range was 10 (13) 14μ for 11 specimens.

Suggested affinities. — Angiospermae.

Occurrence. — Campanian-Maestrichtian. Upper Mesaverde, lower Wasatch, Williams Fork, Lewis, and Lance formations, Campanian, Maestrichtian, Colorado (Newman, 1965). This species occurs in the lower and upper Almond Formation.

Genus **TRIPOROPOLLENITES** Pflug *ex* Thomson and Pflug, 1953

Type species: *Triporopollenites coryloides* Pflug *in* Thomson and Pflug, 1953.

Triporopollenites sp. B Clark, 1963 Pl. 20, fig. 134

1963. *Triporopollenites* sp. B Clarke, p. 94, pl. 11, figs. 5, 6, unpublished.

Discussion. — The observed size range was 25 (28) 32μ for eight specimens.

Suggested affinities. — Betulaceae.

Occurrence. — Upper Campanian-Maestrichtian. Vermejo Formation, Maestrichtian, Colorado (Clarke, 1963). This species occurs in the lower and upper Almond Formation.

Triporopollenites rugatus Newman, 1965 Pl. 20, fig. 135

1964. *Caryapollenites* sp. Newman, pl. 1, fig. 16.
1965. *Triporopollenites rugatus* Newman, p. 12, pl. 1, fig 7.

Discussion. — The observed size range was 19 (26) 32μ for 10 specimens. *Caryapollenites scabratus* Groot and Groot of Snead (1969) may be conspecific.

Suggested affinities. — Juglandaceae, *Engelhardtia* (Norton and Hall, 1969).

Occurrence. — Upper Campanian-Paleocene. Wasatch and Fort

Union formations, Paleocene, Colorado (Newman, 1965); Hell Creek Formation, Maestrichtian, Montana (Norton and Hall, 1967, 1969). This species occurs in the lower and upper Almond Formation.

Genus **CONCLAVIPOLLIS** Pflug, 1953

Type species: *Conclavipollis anulopyramis* Pflug, 1953.

Conclavipollis wolfcreekensis Newman, 1965 Pl. 20, fig. 136

1965. *Conclavipollis wolfcreekensis* Newman, p. 13, pl. 1, fig. 10.

Discussion. — The observed size range was 18 (21) 26μ for five specimens.

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Campanian. Upper Mancos, lower Mesaverde, Iles and lower Williams Fork formations, Campanian, Colorado (Newman, 1965). This species occurs in the upper Almond Formation.

Genus **SPOROPOLLIS** Pflug, 1953

Type species: *Sporopollis documentum* Pflug, 1953.

Sporopollis cf. **S. laqueaeformis** Weyland and Greifeld, 1953
Pl. 20, fig. 137

1953. *Sporopollis laqueaeformis* Weyland and Greifeld, p. 45, pl. 13, figs. 111-112.

Discussion. — The size of the single specimen observed was 20μ. It seems to be identical with *S. laqueaeformis* as used by Newman (1965); however, Weyland and Greifeld's specimens have more strongly protruding pores.

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Upper Cretaceous. Mancos, Mesaverde, Iles, and Williams Fork formations, Campanian, Colorado (Newman, 1965). This species occurred only in Sample 66W218 of Section 14 of the upper Almond Formation.

Genus **PLICAPOLLIS** Pflug, 1953

Type species: *Plicapollis serta* Pflug, 1953.

Plicapollis sp. Pl. 20, fig. 138

Discussion. — Two specimens were observed, 24μ and 26μ in size. They were not identified as to species but appear to belong in the genus *Plicapollis* and somewhat resemble *P. conserta* Pflug, 1953.

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Upper Campanian. This species occurred only in Sample 66W129 of Section 8 and Sample 66W241 of Section 4 of the lower and upper Almond respectively.

Genus **TRUDOPOLLIS** Pflug, 1953

Type species: *Trudopollis pertrudens* (Pflug), Pflug, 1953.

Trudopollis meekeri Newman, 1965 Pl. 20, figs. 139a, 139b

1965. *Trudopollis meekeri* Newman, p. 14, pl. 1, fig. 12.

Discussion. — The observed size range was 25 (28) 32μ for three specimens. Comparable Santonian species have been figured by Gray and Groot (1966) and Doyle (1969).

Suggested affinities. — Angiospermae, Dicotyledoneae.

Occurrence. — Campanian. Mancos Shale, Mesaverde, Iles and Williams Fork formations, Campanian, Colorado (Newman, 1965). This species occurs in the upper Almond Formation.

Genus **PROTEACIDITES** Cookson ex Couper, 1953

Type species: *Proteacidites adenanthoides* Cookson, 1950.

Proteacidites retusus Anderson, 1960 Pl. 20, figs. 140-142

1960. *Proteacidites retusus* Anderson, p. 21, pl. 2, figs. 5-7.

Discussion. — This species is distinguished from *P. thalmanni* on the basis of its pores which appear circular in polar view; whereas, those of *P. thalmanni* are notchlike in polar view. The two species probably represent end members of a continuum of pore shapes. Individuals which conform in size, ornament, and pore shape but which have thinner annuli are included in this species (Pl. 20, fig. 141). Even though Anderson's description specifies a thick endannulus there does not seem to be sufficient difference to warrant a new species. The observed size range was 18 (27) 34μ for 18 specimens.

Suggested affinities. — Proteaceae.

Occurrence. — Upper Campanian-Danian. Kirtland Shale, uppermost Cretaceous, San Juan Basin, New Mexico (Anderson, 1960); Hell Creek Formation, uppermost Cretaceous, South Dakota (Stanley, 1965); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). This species occurs throughout the Almond Formation.

Proteacidites thalmanni Anderson, 1960 Pl. 20, figs. 143-144

1960. *Proteacidites thalmanni* Anderson, p. 21, pl. 2, figs. 1-4; pl. 10, figs. 9-13.
1962. *Proteacidites terrazus* Rouse, p. 205, pl. 2, figs. 20-22.
1966. *Proteacidites thalmanni* var. *major* Srivastava, p. 536, pl. VII, fig. 7.

Discussion. — This species is distinguished on the basis of its pores which are a shallow notchlike "V" shape in polar view and are not circular as in *P. retusus*. The observed size range was 19 (26) 35μ for 10 specimens. Published sizes vary from 17-54μ.

Suggested affinities. — Proteaceae.

Occurrence. — Upper Campanian-Danian. Kirtland Shale and Lewis Shale, uppermost Cretaceous, San Juan Basin, New Mexico (Anderson, 1960); Burrard Formation (Brothers Creek Locality), Upper Cretaceous, Vancouver, British Columbia, (*P. terrazus*), (Rouse, 1962); Mt. Laurel-Navesink formations, Woodbury Clay and Merchantville Formation, Senonian, Delaware and New Jersey (Gray and Groot, 1966); upper Edmonton Formation, Maestrichtian, Scollard, Alberta, (*P. thalmanni* var. *major*), (Srivastava, 1966); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967). Campanian and Turonian occurrences have been indicated for the genus *Proteacidites* by Tschudy (1965) and Orlansky (1968); Fox Hills and Hell Creek formations, Maestrichtian, and Tullock Formation, Paleocene, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

Genus **ULMIPOLLENITES** Wolff, 1934

Type species: *Ulmipollenites undulosus* Wolff, 1934.

Ulmipollenites granulatus Stone, n. sp. Pl. 20, figs. 145-146

Diagnosis. — The granulate exine and the near absence of arci distinguish this species.

Description. — The grains are rounded-triangular to subcircular in shape. The three or four pores are equatorial, circular in outline and about 2.5μ in diameter. The annuli are slightly developed and about 2μ in width. Arci are not distinct. The exine is about 1.5μ in thickness and ornamented with more or less circular granules 1.5-2μ in diameter. The observed size range was 18 (22) 25μ for seven specimens.

Holotype. — Plate 20, figure 145. Slide No. 3055AVII, Coor. 40.5-113.5, Collection No. 66W250, Section 14, Almond Formation, Late Campanian, Sec. 36, T20N, R101W and Sec. 31, T20N, R100W, Sweetwater County, Wyoming.

Discussion. — This species may be conspecific with *Ulmipollenites undulosus* Wolff, 1934, as used by Norton and Hall (1969). *U. granulatus* was not included in that species because *U. granulatus* lacks distinct arci and its ornamentation is not considered to be rugulate. Triporate individuals were observed most often.

Suggested affinities. — Ulmaceae?, *Zelkova*?

Occurrence. — Upper Campanian-Paleocene. Lance Formation, Maestrichtian, and Fort Union Formation, Paleocene, Wyoming (Leffingwell, 1971). This species occurs in the lower and upper Almond Formation.

Genus **ALNIPOLLENITES** Potonié 1931

Type species: *Alnipollenites verus* (Potonié), Potonié, 1934.

Alnipollenites quadrapollenites (Rouse), Srivastava, 1966 Pl. 20, fig. 147

1962. *Alnus quadrapollenites* Rouse, p. 202, pl. 2, figs. 9, 36.
1966. *Alnipollenites quadrapollenites* (Rouse), Srivastava, p. 530, pl. VII, fig. 3.

Discussion. — The size range was 21 (25) 30μ for the three specimens measured. A specimen of *Alnus trina* Stanley, 1965 (Pl. 43, fig. 6) is comparable but smaller (range 13-19μ).

Suggested affinities. — Betulaceae, *Alnus.*

Occurrence. — Upper Campanian-Eocene. Burrard Formation, Eocene (in part?), British Columbia, Canada (Rouse, 1962); Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1966). This species occurs in the lower and upper Almond Formation.

Genus **ERDTMANIPOLLIS** Krutzsch, 1962

Type species: *Erdtmanipollis pachysandroides* Krutzsch, 1962.

Erdtmanipollis pachysandroides Krutzsch, 1962 Pl. 20, figs. 148-150

1962. *Erdtmanipollis pachysandroides* Krutzsch, p. 281, pl. 8, figs. 1-8.
1965. *Pachysandra cretacea* Stanley, p. 294, pl. 44, figs. 1-9.
1969. *Erdtmanipollis cretaceous* (Stanley), Norton *in* Norton and Hall, p. 43, pl. 5, figs. 21.
1969. *Erdtmanipollis cretacea* (Stanley), Oltz, p. 140, pl. 41, fig. 100.

Discussion. — The size variation or *P. cretacea,* 20-40μ, (Stanley, 1965) is not considered sufficient basis for its separation from *E. pachysandroides,* 25-35μ, (Krutzsch, 1962). This contention was advanced by Snead (1969). Specimens with the ektexine removed were common. The observed size range was 29 (34) 40μ for eight specimens.

Suggested affinities. — Buxaceae, *Pachysandra* or *Sarcococca.*

Occurrence. — Upper Campanian-Oligocene. Oligocene, Germany (Krutzsch, 1962); Hell Creek Formation, Maestrichtian, and Ludlow Member, Fort Union Formation, Paleocene, South Dakota (Stanley, 1965); upper Moreno Formation, Maestrichtian-Danian, California (Drugg, 1967); Bearpaw, Fox Hills, and Hell Creek formations, uppermost Cretaceous, and Tullock Formation, Paleocene, Montana (Norton and Hall, 1969); Edmonton Formation, Maestrichtian, Alberta, Canada (Snead, 1969); Bearpaw, Fox Hills and Hell Creek formations, uppermost Cretaceous, Montana (Oltz, 1969). This species occurs throughout the Almond Formation.

ADDENDA

Genus **STELCKA** Srivastava, 1969

Type species: *Stelckia vera* Srivastava, 1969.

Stelcka cf. **S. vera** Srivastava, 1969 Pl. 19, fig. 130A

1969. *Stelcka vera* Srivastava, p. 58, pl. II, fig. 23.

Discussion. — A single poorly preserved specimen (22μ) was observed which compares favorably with this species.

Suggested affinities. — Berberidaceae. Comparable apertures may be found in *Berberis quindikensis.*

Occurrence. — Upper Campanian-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1969). This species occurs only in Sample 66W140 of Section 8 of the lower Almond Formation.

Stelcka unica Srivastava, 1969 Pl. 19, fig. 130B

1969. *Stelcka unica* Srivastava, p. 58, pl. II, fig. 24.

Discussion. — The size of the single individual found was 23μ.

Suggested affinities. — Berberidaceae.

Occurrence. — Upper Campanian-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1969). This species occurs only in Sample 66W140 of Section 8 of the lower Almond Formation.

Stelcka xenoforma Srivastava, 1969 Pl. 19, fig. 130C

1969. *Stelcka xenoforma* Srivastava, p. 60, pl. II, fig. 25.

Discussion. — The size of the individual found was 32μ.

Suggested affinities. — Berberidaceae.

Occurrence. — Upper Campanian-Maestrichtian. Edmonton Formation, Maestrichtian, Alberta, Canada (Srivastava, 1969). This species occurs only in Sample 66W140 of Section 8 of the lower Almond Formation.

REFERENCES

Agasie, J. M.

1969. *Late Cretaceous palynomorphs from northeastern Arizona.* Micropaleontology, vol. 15, No. 1, pp. 13-30.

Alberti, Gerhard

1959. *Zur Kenntnis Gattung Deflandrea Eisenack (Dinoflag.) in der Kreide und im Altertiar Nordund Mitteldeutschlands.* Mitt. Geol. Staatsinst. Hamburg, vol. 28, pp. 93-105.

1961. *Zur Kenntnis Mesozoischer und Alttertiarer Dinoflagellaten und Hystrichosphaerideen von Nord-und Mitteldeutschland souie einigen anderen Europaischen Gebieten.* Palaeontographica, vol. 116, pp. 1-58.

Anderson, R. Y.

1960. *Cretaceous-Tertiary palynology, eastern side of the San Juan Basin, New Mexico.* Bureau Mines Mineral Resources, New Mexico Inst. of Mining and Tech., Mem. 6, 58 pp.

Balme, B. E.

1957. *Spores and pollen grains from the Mesozoic of western Australia.* Phys. Chem. Sur. Nat. Coal Res., Commonwealth of Australia, Ref. T. C., 25, 48 p.

Bernard, P. D. W.

1968. *A new species of Masculostrobus Seward producing Classopollis pollen from the Jurassic of Iran.* Jr. Linn. Soc. (Bot.), vol. 61, No. 384, pp. 167-176.

Beerbower, J. R., and Jordan, Dianne

1969. *Application of information theory to paleontologic problems: taxonomic diversity.* Jr. Paleont., vol. 43, No. 5, pp. 1184-1198.

Brenner, G. J.

1963. *The spores and pollen of the Potomac Group of Maryland.* Dept. Geol., Mines Water Res., Bull. No. 27, 215 p.

1967. *The gymnospermous affinity of Eucommiidites Erdtman, 1948.* Rev. Palaeobot. Palyn., vol. 5, pp. 123-127.

1968. *Middle Cretaceous spores and pollen from northeastern Peru.* Pollen et Spores, vol. X, No. 2, pp. 341-383.

Burgess, J. D.

1970. *Palynological correlation and interpretation of Frontier environment in Central Wyoming.* Wyoming Geol. Assoc. Guidebook, pp. 133-145.

Buzas, M. A., and Gibson, T. G.

1969. *Species diversity: Benthonic Foraminifera in western North Atlantic.* Sci., vol. 163, pp. 72-75.

Cheetham, A. H., and Hazel, J. E.

1969. *Binary (presence-absence) similarity coefficients.* Jr. Paleont., vol. 43, No. 5, pp. 1130-1136.

Clark, T. H., and Stearn, C. W.

1960. *The geological evolution of North America.* Ronald Press Co., 434 pp.

Clarke, 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 Nederlands Akademie van Wetenschappen, afd. Natuurkunde, vol. XXIV, No. 3, pp. 1-94.

Clarke, R. T.

1963. *Palynology of Vermejo Formation coals (Upper Cretaceous) in the Canon City Coal Field, Fremont County, Colorado.* Univ. Oklahoma, unpub. Ph.D. thesis, 136 p.

Cobban, W. A., and Reeside, Jr., J. B.

1952. *Correlation of Cretaceous formations of the Western Interior of the United States.* Geol. Soc. Amer., Bull., vol. 63, pp. 1011-1044.

Cookson, I. C.

1947. *Plant microfossils from the lignites of Kerguelen Archipelago.* B. A. N. Z. Antarctic Res. Exp. 1929-31, Rep. Ser. A. 2., pp. 127-142.

1950. *Fossil pollen grains of proteaceous type from Tertiary deposits in Australia.* Australian Jr. Sci., Res. B., vol. 3, No. 2, pp. 166-177.

1953. *Records of the occurrence of Botryococcus brownii, Pediastrum and the Hystrichosphaerideae in Cainozoic deposits of Australia.* Nat. Mus. Victoria, Mem., vol. 18, pp. 107-123.

1956. *Additional microplankton from Australian Late Mesozoic and Tertiary sediments.* Australian Jr. Marine Freshwater Research, vol. 7, pp. 183-191.

1965. *Cretaceous and Tertiary microplankton from southeastern Australia.* Roy. Soc. Victoria., Proc., vol. 78, pp. 85-93.

Cookson, I. C., and Dettman, M. E.

1959. *On Schizosporis, a new form genus from Australian Cretaceous deposits.* Micropaleontology, vol. 5, No. 2, pp. 213-216.

Cookson, I. C., and Eisenack, A.

1958. *Microplankton from Australia and New Guinea Upper Mesozoic deposits.* Royal Soc. Victoria, Proc., vol. 70, pp. 18-79.

1960. *Microplankton from Australian Cretaceous sediments.* Micropaleontology, vol. 6, No. 1, pp. 1-18.

1962. *Additional microplankton from Australian Cretaceous sediments.* Micropaleontology, vol. 8, No. 4, pp. 485-507.

Cookson, I. C., and Pike, K. M.

1954. *Some dicotyledonous pollen types from Cainozoic deposits in the Australian region.* Australian Jr. Bot., vol. 2, pp. 197-219.

Couper, R. A.

1953. *Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand.* New Zealand Geol. Sur., Paleont., Bull. No. 22, 77 p.

1958. *British Mesozoic microspores and pollen grains, a systematic and stratigraphic study.* Palaeontographic B, vol. 103 (B), pp. 75-179.

Cross, A. T., Thompson, G. G., and Zaitzeff, J. B.

1966. *Source and distribution of palynomorphs in bottom sediments, southern part of Gulf of California.* Marine Geol., vol. 4, pp. 467-524.

Daugherty, L. H.

1941. *The Upper Triassic floras of Arizona.* Carnegie Inst., Pub. No. 526, 108 p.

Davey, R. J.

1969. *Some dinoflagellate cysts from the Upper Cretaceous of northern Natal, South Africa.* Palaeontologia Africana., vol. 12, pp. 1-23.

Davey, R. J., Downie, Charles, Sarjeant, W. A. S., and Williams, G. L.

1966. *Studies on Mesozoic and Cainozoic dinoflagellate cysts.* Bull. Brit. Mus. (Nat. Hist.) Geol., No. 3, pp. 1-248.

Davis, M. B.

1966. *Determination of absolute pollen frequency.* Ecology, vol. 47, pp. 310-311.

Deflandre, G.

1934. *Sur les microfossils d'origine planctonique, conserves a l'etae de matiere organizue dans les silex de la craie.* Acad. Sci., Paris C. R., vol. 199, pp. 966-968.

1935. *Microorganisms d'origine planctonique conserves dans les silex de la craie.* Bull. Biol., vol. 69, pp. 213-244.

1937. *Microfossiles des silex Cretaces, deuxieme partie, flagelles incertae sedis, hystrichosphaerides, sarcodines, organismes divers.* Ann. Paleont., vol. 26, pp. 49-103.

1947. *Sur quelques microorganismes planctoniques des silex Jurassiques.* Monaco, No. 921, pp. 1-10.

1954. *Systématique des hystrichosphaeridés: sur l'acception du genre Cymatiosphaera O. Wetzel.* Soc. Géol. France, C. R. Summ., No. 12, pp. 257-258.

Deflandre, G., and Cookson, I. C.

1955. *Fossil microplankton from Australian late Mesozoic and Tertiary deposits.* Australian Jr. Marine Freshwater Res., vol. 6, pp. 242-313.

Deflandre, G., and Deflandre, M.

1965. *Dinoflagelles, 4. Deflandreaceae 1, Fichier.* Micropaleontologique General, Ser. 14, Arch. Originales Centre Doc., Centre Nat. Res. Sci., 407 (1-4).

Delcourt, A., and Sprumont, G.

1955. *Les spores et grains de pollen du Wealdien du Hainaut.* Soc. Belg. Geol., Paleont., Hydrolog., Mem. Nouv., ser. in 4, No. 5, 73 p.

Dettmann, M. E.

1963. *Upper Mesozoic microfloras from southeastern Australia.* Proc. Roy. Soc. Victoria, vol. 77, No. 1, pp. 1-148.

Downie, C., Evitt, W. R., and Sarjeant, W. A. S.

1963. *Dinoflagellates, hystrichospheres and the classification of the acritarchs.* Stanford Univ. Pub., Geol. Sci., vol. 7, No. 3, pp. 1-16.

Downie, C., and Sarjeant, W. A. S.

1963. *On the interpretation and status of some hystrichosphere genera.* Palaeontology, vol. 6, No. 1, pp. 83-96.

Doyle, J. A.

1969. *Cretaceous angiosperm pollen of the Atlantic Coastal Plain and its evolutionary significance.* Arnold Arboretum, Jr., vol. 50, No. 1, pp. 1-35.

Drugg, W. S.

1967. *Palynology of the Upper Moreno Formation (Late Cretaceous/Paleocene) Escarpado Canyon, California.* Palaeontographica B, vol. 120, Nos. 1-4, pp. 1-71.

Ehrenberg, C. G.

1838. *Uber das massenverhaltnis der jetzt lebenden kieselinfusorien und uber ein neues Infusorien-Conglomerat als polierschiefer ven Jastraba in Ungarn.* Akad. Wiss. Berlin, vol. 1, pp. 109-135.

Eisenack, A.

1938. *Die phosphoritknollen der Bersteinformation als Ubertierferer Tertiaren planktons.* Scher. Physicokon. Ges. Konigsberg (Pr.), vol. 70, pp. 181-188.

1958. *Mikroplankton aus dem Nortdeutschen apt nebst einigen bermerkunger uber fossile dinoflagellaten.* Neues Jahrb. Geol. Palaeont., vol. 106, pp. 383-422.

1963. *Sind die hystrichosphaeren zysten von dinoflagellaten?* Neues Jahrb. Geol. Palaeont., Monatsch., No. 5, pp. 225-231.

Elsik, W. C.

1968. *Palynology of a Paleocene Rockdale Lignite, Milam County, Texas. I. Morphology and taxonomy.* Pollen et Spores, vol. X, No. 2, pp. 265-314.

Erdtman, G.

1948. *Did dicotyledonous plants exist in Early Jurassic times?* Geol. Foren. Forhandl., vol. 70, No. 2, pp. 265-271.

1952. *Pollen morphology and plant taxonomy.* Almquist and Wiksells, Uppsala, 539 p.

Evitt, W. R., Clark, R. F. A., and Verdier, J. P.

1967. *Dinoflagellate studies III, Dinogymnium acuminatum n. gen., n. sp. (Maastrichtian) and other fossils formerly referable to Gymnodinium Stein.* Stanford Univ. Pub., Geol. Sci., vol. X, No. 4, pp. 1-27.

Fairchild, W. W., and Elsik, W. C.

1969. *Characteristic palynomorphs of the Lower Tertiary in the Gulf Coast.* Palaeontographica B, vol. 128, pp. 81-89.

Fox, W. T.

1968. *Quantitative paleoecologic analysis of fossil communities in the Richmond Group.* Jr. Geol., vol. 76, No. 6, pp. 613-640.

Funkhouser, J. W.

1961. *Pollen of the genus Aquilapollenites.* Micropaleontology, vol. 7, No. 2, pp. 193-198.

Gibson, L. B., and Clarke, R. T.

1968. *Floral succession and palynological correlation.* Jr. Paleont., vol. 42, No. 8, pp. 576-581.

Gill, J. R., Merewether, E. A., and Cobban, W. A.

1970. *Stratigraphy and nomenclature of some Upper Cretaceous and Lower Tertiary rocks in South-Central Wyoming.* U.S. Geol. Sur., Prof. Paper 667, 53 pp.

Goczan, F.

1964. *Stratigraphic palynology of the Hungarian Upper Cretaceous.* Acta Geologica, vol. 8, No. 1-4, pp. 229-264.

Gray, T. C., and Groot, J. J.

1966. *Pollen and spores from the marine Upper Cretaceous formations of Delaware and New Jersey.* Palaeontographica B, vol. 117, pp. 114-134.

Groot, J. J., and Groot, C. R.

1962. *Some plant microfossils from the Brightseat Formation (Paleocene) of Maryland.* Palaeontographica B, vol. 111, No. 4-6, pp. 161-171.

Groot, J. J. and Penny, J. S.

1960. *Plant microfossils and age of nonmarine Cretaceous sediments of Maryland and Delaware.* Micropaleontology, vol. 6, No. 2, pp. 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 B, vol. 108, pp. 121-140.

Habib, Daniel

1969. *Middle Cretaceous palynomorphs in a deep-sea core from the Seismic Reflector A outcrop area.* Micropaleontology, vol. 15, No 1, pp. 85-101.

Harris, W. K.

1965. *Tertiary microfloras from Brisbane, Queensland.* Geol. Sur. Queensland, Rept. 10, pp. 1-7.

Hazel, J. E.
1970. *Binary coefficients and clustering in biostratigraphy.* Geol. Soc. Amer., Bull., vol. 81, pp. 3237-3252.

Hedlund, R. W.
1966. *Palynology of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County.* Oklahoma Geol. Sur. Bull. 112, 69 p.

Hedlund, R. W., and Norris, G.
1968. *Spores and pollen grains from Fredericksburgian (Albian) strata, Marshall County, Oklahoma.* Pollen et Spores, vol. X, No. 1, pp. 129-159.

Hughes, N. F.
1961. *Further interpretation of Eucommiidites Erdtman, 1948.* Palaeontology, vol. 4, pp. 292-299.

Ibrahim, A.
1933. *Sporenformen des Agirhorizonts des Ruhr-Reviers, dissertation an der technischen Hoschschule zu Berlin.* Privately pub. by Konrad Triltch, Wurzburg, 48 p.

Jaccard, P.
1908. *Nouvelles recherches sur la distribution florale.* Bull. Soc. Vaud. Sci. Nat., vol. 44, pp. 223-270.

Jacka, A. D.
1965. *Depositional dynamics of the Almond Formation, Rock Springs Uplift, Wyoming.* Wyoming Geol. Assoc. Guidebook, pp. 81-100.

Jardiné, S., and Magloire, L.
1965. *Palynologie et stratigraphie du Cretace des Bassins du Sénégal et de Côte D'Ivoire.* Mémoires du Bureau de Recherches Geologique et Minieres, No. 32, pp. 187-245.

Klaus, W.
1960. *Sporen der karnischen stufe der ostalpinen Trias.* Geol. Jahrb. B.A., vol. 5, pp. 107-184.

Knox, E. M.
1950. *The spores of Lycopodium, Phylloglossum, Selaginella and Isoetes.* Bot. Soc. Edinburgh, Trans., vol. 35, pt. 3, pp. 207-357.

Kosanke, R. M., and Cross, A. T. (Editors)
1971. *Symposium on palynology of the Late Cretaceous and Early Tertiary.* Geol. Soc. Amer., Spec. Paper 127, 396 pp.

Kremp, G.
1949. *Pollenanalytische Untersuchung des Miozanen Braunkohlenlagers von Konin an der Warthe.* Palaeontographica B., vol. 90, pp. 53-93.

Krutzsch, W.
1959a. *Mikropalaontologiche (sporenpalaontologische) Untersuchungen in der Braunkohle des Geiseltales.* Geologie, vol. 8, pp. 21-22.
1959b. *Einige neue formgattungen und-arte von sporen and pollen aus der Mitteleuropaischen Oberkreide und dem Tertiar.* Palaeontographica B, vol. 105, pp. 125-157.
1962. *Stratigraphisch bzw. botanisch wichtige neue sporen und pollenformen aus dem deutscher Tertiär.* Geologie, vol. 11, No. 3, pp. 265-307.

Leffingwell, H. A.
1971. *Palynology of the Lance (Late Cretaceous) and Fort Union (Paleocene) formations of the Type Lance Area, Wyoming.* Geol. Soc. Amer., Special Paper 127, (R. M. Kosanke and A. T. Cross, Eds.) pp. 1-65.

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. Geol. Sur., Bull. 1160, pp. 71-95.

Leopold, E. B., and Tschudy, B. D.
1965. *Plant and miscellaneous microfossils of the Pierre Shale.* U.S. Geol. Sur., Open-File Report, 7 p.

Leschik, G.
1955. *Die Keuperflora von Neuewelt bei Basel. II. Die Iso-und Mikrosporen.* Schweiz, Palaeont., Abh. Mém. Suisses Paléont., vol. 72, No. 1, 70 pp.

Lewis, J. L.
1965. *Measured surface sections of the Almond Formation on the east flank of the Rock Springs Uplift, Sweetwater County, Wyoming.* Wyoming Geol. Assoc. Guidebook, pp. 101-111.

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".* London: Henry G. Bohn, 207 p.

Manum, S.
1963. *Some new species of Deflandrea and their probable affinity with Peridinium.* Norske Polarinstitut, Arlok 1962, Oslo, 1963, pp. 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).* Skr. Norske Vidensk Akad. I. Mat.-Nat. Kl., n. Ser. 17, 36 p.

McCubbin, D. G., and Brady, M. J.
1969. *Depositional environment of the Almond reservoirs, Patrick Draw Field Wyoming.* Mountain Geologist, vol. 6, No. 1, pp. 3-26.

McIntyre, D. J.
1968. *Further new pollen species from New Zealand Tertiary and uppermost Cretaceous deposits.* New Zealand Jr. Bot., vol. 6, No. 2, pp. 177-204.

McKee, E. D., Chronic, John, and Leopold, E. B.
1959. *Sedimentary belts in lagoon of Kapingamarangi Atoll.* Amer. Assoc. Petr. Geol., Bull., vol. 43, pp. 501-562.

Mello, J. F., and Buzas, M. A.
1968. *An application of cluster analysis as a method of determining biofacies.* Jr. Paleont., vol. 42, No. 3, pp. 747-758.

Miner, E. L.
1935. *Paleobotanical examinations of Cretaceous and Tertiary coals.* Amer. Midl. Nat., vol. 16, No. 4, pp. 585-625.

Muller, Jan
1959. *Palynology of recent Orinoco delta and shelf sediments.* Micropaleontology, vol. 5, pp. 1-32.

Newman, K. R.
1964. *Palynologic correlations of Late Cretaceous and Paleocene formations, northwestern Colorado.* Soc. Ec. Pal. Min., Spec. Pub. 11, (*Palynology in Oil Exploration,* R. M. Kosanke and A. T. Cross, Ed.), pp. 169-179.
1965. *Upper Cretaceous-Paleocene guide palynomorphs from northwestern Colorado.* Univ. Colorado Studies, Series in Earth Sciences, No. 2, 21 pp.

Nilson, T.
1958. *Uber das vorkommen lines Mesozoischen sapropelgesteins in schonen.* Lunds Univ. Arsskrift, N.F., Avd. 2, Bd. 54, No. 10.

Norris, G.
1967. *Spores and pollen from the Lower Colorado Group (Albian?-Cenomanian) of central Alberta.* Palaeontographica B, vol. 120, pp. 72-115.

Norton, N. J., and Hall, J. W.
1967. *Guide sporomorphae in the Upper Cretaceous-Lower Tertiary of eastern Montana (U.S.A.).* Rev. Palaeobot. Palynol., vol. 2, pp. 99-110.
1969. *Palynology of the Upper Cretaceous and Lower Tertiary in the type locality of the Hell Creek Formation, Montana, U.S.A.* Palaeontographica B, vol. 125, Nos. 1-3, pp. 1-64.

Odum, H. T., Cantlon, J. E., and Kornicker, L. S.
1960. *An organizational hierachy postulate for the interpretation of species-individual distributions, species entropy, ecosystem evolution and the meaning of a species-variety index.* Ecology, vol. 41, pp. 395-399.

Oltz, D. F.
1969. *Numerical analyses of palynological data from Cretaceous and Early Tertiary sediments in East Central Montana.* Palaeontographica B, vol. 128, Nos. 3-6, pp. 90-166.
1971. *Cluster analyses of Late Cretaceous-Early Tertiary pollen and spore data.* Micropaleontology, vol. 17, No. 2, pp. 221-232.

Orlansky, O.
1967. *Palynology of the Upper Cretaceous Straight Cliffs Sandstone Garfield County, Utah.* Univ. Utah, Unpub., Ph.D. thesis, 186 p.
1968. *Palynology of the Upper Cretaceous Straight Cliffs Sandstone, southcentral Utah.* Geol. Soc. Amer., S. C. Sect. 2d. Ann. Meet., Program p. 31, (Abstract).

Pacltova, B.
1961. *Nektere rostlenné mickrofosilii ze sladkovodnich ulozenin Svrchni kridy (Senon) jihoceskych panvich.* Sb. ustred.-Ust. Geol., Odd. Paleont., vol. 26, pp. 47-102.

Patten, B. C.
1962. *Species diversity in net phytoplankton of Raritan Bay.* Jr. Marine Res., vol. 20, No. 1, pp. 57-75.

Pflug, H. D.
1953. *Zur Entstehung und Entwicklung des Angiospermiden pollen in der Erdgeschichte.* Palaeontographica B, vol. 95, pp. 60-171.

Pielou, E. C.
1969. *An introduction to mathematical ecology.* John Wiley & Sons, New York, pp. 221-235.

Pierce, R. L.
1961. *Lower Upper Cretaceous plant microfossils from Minnesota.* Minnesota Geol. Sur., Bull., vol. 42, 86 p.

Pocock, S. J.
1962. *Microfloral analysis and age determination of strata at the Jurassic-Cretaceous boundary in the Western Canada Plains.* Palaeontographica B, vol. 111, pp. 1-95.

Pocock, S. J., and Jansonius, J.
1961. *The pollen genus Classopollis* Pflug, 1953. Micropaleontogy., vol. 7, pp. 439-449.

Potonié, R.
1931. *Pollen formen aus Teriären Braunkohlen, 111.* Jb. Preuss. Geol. L. A., vol. 52, pp. 1-7.
1934. *Zur Mikrobotanik des eozanen Humodils des Geiseltals.* Arb. Inst. Palaobot. Petrograph. Brennsteine, vol. 4, pp. 25-125.
1951. *Revision stratigraphisch wichtiger sporomorphen des Mitteleuropaischen Tertiärs.* Palaeontographica B, vol. 91, pp. 131-151.

1956. *Synopsis der gattungen der sporae dispersae. Teil I.* Beih. Geol. Jb., vol. 23, 103 p.

1958. *Synopsis der gattungen der sporae dispersae. Teil II.* Beih. Geol. Jahrb., vol. 31, 114 p.

1960. *Synopsis der gattungen der sporae dispersae. Teil III.* Beih. Geol. Jahrb., vol. 39, 189 p.

Potonié, R., and Gelletich, J.

1933. *Uber pteridophyten-sporen einer Eozanen Braunkohle aus Dorog in Ungarn.* S.B. Ges. Nat. Freunde (1932), vol. 33, pp. 517-528.

Potonié, R., Thomson, P. W., and Thiergart, F.

1950. *Zur nomenklatur and klassifikation der neogenen sporomorphae.* Geol. Jahrb. 65.

Potonié, R., and Venitz, A.

1934. *Zur mikrobotanik des Miozänen Humodils der niederrheinischen Bucht.* Arb. Inst. Palaob. Petrogr. Brennstein, vol. 5, pp. 1-54.

Raatz, G.

1937. *Mikrobotanisch-stratigraphische Untersuchung der Braunkohle des Muskauer Bogens.* Preuss. Geol. Landes, Abh., neue Folge, No. 183, 48 p.

Reissinger, Adolf

1940. *"Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit".* Palaeontographica B, vol. 84, pp. 1-20.

1950. *Die "pollen-analyse" ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit.* Palaeontographica B, vol. XC, pp. 99-126.

Ross, N. E.

1949. *On a Cretaceous pollen and spore bearing clay of Scania.* Geol. Instn. Univ. Uppsala, Bull. vol. 34, pp. 25-43.

Rossignol, M.

1961. *Analyse pollinique de sédiments marins Quaternaires in Israël I; Sédiments Récents.* Pollen et Spores, vol. III, pp. 303-324.

1964. *Hystrichospheres du Quaternaire en Mediterranee Oriental dans les Sédiments Pleistocene et les Boues marines actuelles.* Rev. Micropaleontologie, vol. 7, No. 2, pp. 83-99.

Rouse, G. E.

1957. *The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from western Canada.* Canada Jr. Botany, vol. 35, No. 3, pp. 349-375.

1959. *Plant microfossils from Kootenay coal measures strata of British Columbia.* Micropaleontology, vol. 5, pp. 303-324.

1962. *Plant microfossils from the Burrard Formation of western British Columbia.* Micropaleontology, vol. 8, No. 2, pp. 187-218.

Rouse, G. E., Hopkins, Jr., W. S., and Piel, K. M.

1966. *Palynology of some Late Cretaceous and Early Tertiary deposits in British Columbia and adjacent Alberta.* Geol. Soc. Amer., Special Paper 127, (R. M. Kosanke and A. T. Cross, Eds.) pp. 213-246.

Samoilovitch, S. R., and Mchedlishvili, N. D.

1961. *Pollen and spores of Western Siberian Jurassic to Paleocene.* Tr. Vses. Neft. Nauchn. Issled. Geologarazved. Inst., vol. 177, pp. 1-658.

Sarjeant, W. A. S.

1970. *The genus Spiniferites Mantell, 1850 (Dinophyceae).* Grana, vol. 10, pp. 74-78.

Sarjeant, W. A. S., and Anderson, R. Y.

1969. *A re-examination of some dinoflagellate cysts from the uppermost Lewis Shale (Late Cretaceous) New Mexico (U.S.A.)* Rev. Palaeobotan. Palynol., vol. 9, pp. 226-237.

Sarmiento, Roberto

1957. *Microfossil zonation of Mancos Group.* Bull. Amer. Assoc. Petr. Geol., vol. 41, No. 8, pp. 1683-1693.

Schopf, J. M., Wilson, L. R., and Bentall, Ray

1944. *An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. Ill.* Geol. Sur., Report of Investigations, No. 91, pp. 1-72.

Singh, C.

1964. *Microflora of the Lower Cretaceous Mannville Group, East Central Alberta.* Geol. Div. Res. Council Alberta, Bull., vol. 15, pp. 1-238.

Snead, R. G.

1969. *Microfloral diagnosis of the Cretaceous-Tertiary boundary Central Alberta.* Res. Council Alberta, Bull. 25, 148 p.

Sokal, R. R., and Sneath, P. H. A.

1963. *Principles of numerical taxonomy.* W. H. Freeman and Co., 359 pp.

Srivastava, S. K.

1966. *Upper Cretaceous microflora (Maestrichtian) from Scollard, Alberta, Canada.* Pollen et Spores, vol. VIII, No. 3, pp. 497-552.

1967. *Upper Cretaceous palynology—A Review.* Botanical Review, vol. 33, No. 3, pp. 260-288.

1968. *Azolla from the Upper Cretaceous Edmonton Formation, Alberta, Canada.* Canadian Jr. Earth Sci., vol. 5, pp. 915-919.

1969. *Some angiosperm pollen from the Edmonton Formation (Maestrichtian) Alberta, Canada.* J. Sen Memorial Volume (H. Santapau, *et al.*, editors), Bot. Soc. Bengal, pp. 47-68.

Stanley, E. A.

1965. *Upper Cretaceous and Paleocene plant microfossils and Paleocene dinoflagellates and hystrichosphaerids from northwestern South Dakota.* Bull. Amer. Paleont., vol. 49, No. 222, pp. 170-384.

1966. *Abundance of pollen and spores in marine sediments off the Eastern coast of the United States.* Southeastern Geol., vol. 7, No. 1, pp. 25-33.

Stone, J. F.

1967. *Quantitative palynology of a Cretaceous Eagle Ford exposure.* Compass, vol. 45, No. 1, pp. 17-25.

1971. *Palynology of the Almond Formation (Upper Cretaceous), Rock Springs Uplift, Wyoming.* Michigan State Univ., Unpub. Ph.D. thesis, 190 pp.

Stough, J. B.

1968. *Palynomorphs from South America.* Univ. of Kansas Paleont. Contributions, Paper 32, pp. 1-7.

Thiergart, F.

1938. *Die pollenflora der Niederlausitzer Braukohle.* Jahrb. Preuss. Geol. L. A. (Berlin) vol. 58, pp. 282-351.

Thompson, G. G.

1969. *Paleoecology of palynomorphs in the Mancos Shale southwestern Colorado.* Michigan State Univ., Unpub. Ph.D. thesis, 169 pp.

Thomson, P. W., and Pflug, H.

1953. *Pollen and sporen des Mitteleuropäischen Tertiärs.* Palaeontographica B., vol. 94, pp. 1-138.

Traverse, Alfred

1955. *Pollen analysis of the Brandon lignite of Vermont.* U.S. Dept. Int., Bur. Mines Rept. Inv. No. 5151, 107 pp.

Traverse, Alfred, and Ginsburg, R. N.

1966. *Palynology of the surface sediment of Great Bahama Bank, as related to water movement and sedimentation.* Marine Geol., vol. 4, No. 2, pp. 417-459.

Tschudy, B. D., and Leopold, E. B.
1971. *Aquilapollenites (Rouse) Funkhouser — Selected Rocky Mountain taxa and their stratigraphic ranges.* Geol. Soc. Amer., Special Paper 127, (R. M. Kosanke and A. T. Cross, Eds.) pp. 113-167.

Tschudy, R. H.
1961. *Palynomorphs as indicators of facies environment in Upper Cretaceous and Lower Tertiary strata, Colorado and Wyoming.* Wyoming Geol. Assoc. Guidebook, pp. 53-59.
1965. *An Upper Cretaceous deposit in the Appalachian Mountains.* U.S. Geol. Sur., Prof. Paper 525-B, pp. 64-68.
1971. *Palynology of the Cretaceous-Tertiary boundary in the Northern Rocky Mountain and Mississippii Embayment regions.* Geol. Soc. Amer., Special Paper 127, (R. M. Kosanke and A. T. Cross, Eds.) pp. 65-111.

Valensi, L.
1953. *Microfossils des silex du Jurassique Moyen, remarques petrographiques.* Soc. Geol. France, Mem. No. 68, 100 pp.

van der Hammen, T.
1954. *El desarrollo de la flora Colombiana en los periodos geologicos. I. Maestrichtiano hasta Terciario mas inferior.* Bol. Geol. Colombio, vol. 2, No. 1, pp. 49-106.

Wall, D., and Dale, B.
1970. *Living hystrichosphaerid dinoflagellate spores from Bermuda and Puerto Rico.* Micropaleontology, vol. 16, No. 1, pp. 47-58.

Warren, J. S.
1967. *Dinoflagellates and acritarchs from the Upper Jurassic and Lower Cretaceous rocks on the west side of the Sacramento Valley, California.* Stanford Univ., Unpub. Ph.D. thesis, 409 pp.

Weimer, R. J.
1961. *Uppermost Cretaceous rocks in central and southern Wyoming and northwest Colorado.* Wyoming Geol. Assoc. Guidebook, pp. 17-28.
1965. *Stratigraphy and petroleum occurrences, Almond and Lewis Formations (Upper Cretaceous), Wamsutter Arch, Wyoming.* Wyoming Geol. Assoc., Guidebook, pp. 65-80.
1966. *Time-stratigraphic analysis and petroleum accumulations Patrick Draw Field, Sweetwater County, Wyoming.* Bull. Amer. Assoc. Petr. Geol., vol. 50, No. 10, pp. 2150-2175.

Wetzel, O.
1933. *Die in Organischer substanz Erhaltenen mikrofossilien des Baltischen Kreide-Freuersteins.* Palaeontographica B, vol. 77, pp. 141-188.
1961. *New microfossils from Baltic Cretaceous flintstones.* Micropaleontology, vol. 7, No. 3, pp. 337-350.

Wetzel, W.
1952. *Beitrage zur Kennthis des dan-Zeitlichen mikroplanktons.* Geol. Jahrb. vol. 6, pp. 391-419.

Weyland, H., and Greifeld, G.
1953. *Uber strukturbietende Blatter und pflanzliche microfossilien aus den Untersenonen Tonen der Gegen von Quedlinburg.* Palaeontographica B, vol. 95, pp. 30-52.

Weyland, H., and Krieger, W.
1953. *Die sporen und pollen der Aachener Kreide and ihre Bedeutung fur die charakterisierung des Mittleren Senons.* Palaeontographica B, vol. 95, pp. 6-29.

Wilson, L. R., and Hoffmeister, W.
1953. *Four new species of fossil Pediastrum.* Amer. Jr. Sci., vol. 251, pp. 753-760.

Wilson, L. R., and Webster, R. M.
1946. *Plant microfossils from a Fort Union coal of Montana.* Amer. Jr. Bot., vol. 33, pp. 271-278.

Wodehouse, R. P.
1933. *Tertiary pollen. II. The oil shales of the Eocene Green River Formation.* Bull. Torrey Bot. Club, vol. 60, pp. 479-525.

Wolff, H.
1934. *Mikrofossilien des Pliozänen Humodils der Grube Freigericht bei Dettingen a.m. und Vergleich mit alteren Schichten des Tertiäres sowie posttertiären Ablagerungen.* Arb. Inst. Paleobot. U. Petrogr. Brennst. Preuss. Geol. Landes., Berlin, vol. 5, pp. 55-86.

Zaitzeff, J. B.
1967. *Taxonomic and stratigraphic significance of dinoflagellates and acritarchs of the Navarro Group (Maestrichtian) from east central and southwest Texas.* Michigan State Univ., unpub. Ph.D. thesis, 172 pp.

Zaitzeff, J. B., and Cross, A. T.
1971. *The use of dinoflagellates and acritarchs for zonation and correlation of the Navarro Group (Maestrichtian) of Texas.* Geol. Soc. Amer., Special Paper 127 (R. M. Kosanke and A. T. Cross, Eds.), pp. 341-377.

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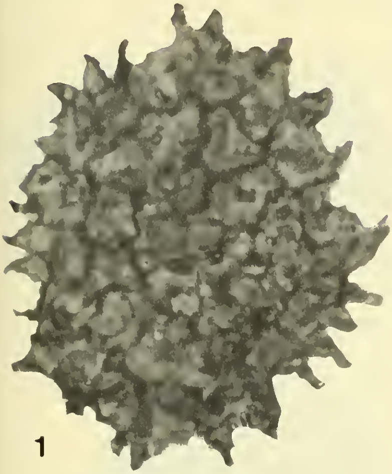

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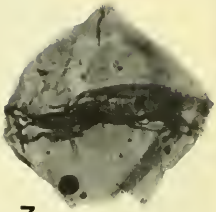
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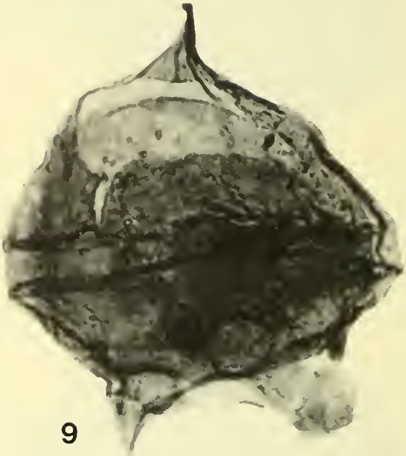
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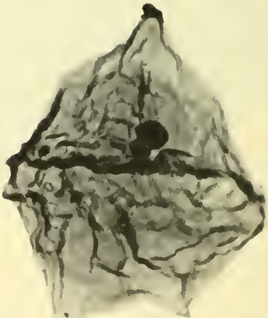
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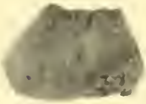
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14. **Deflandrea magnifica** Stanley, 1965 52

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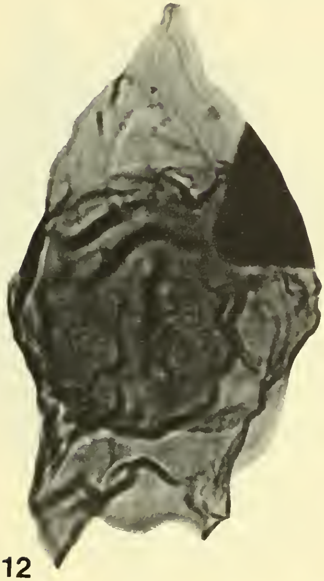

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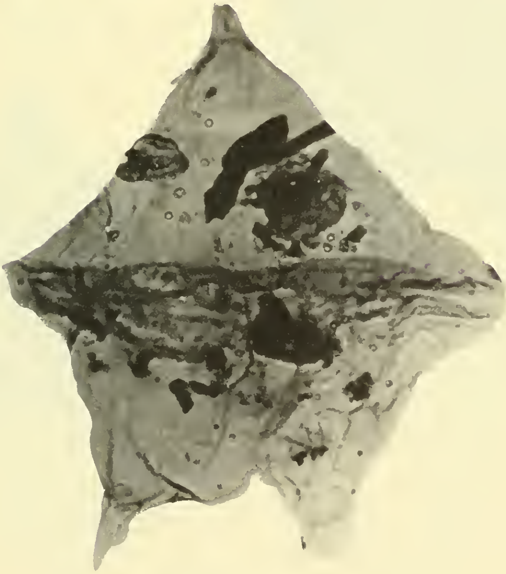

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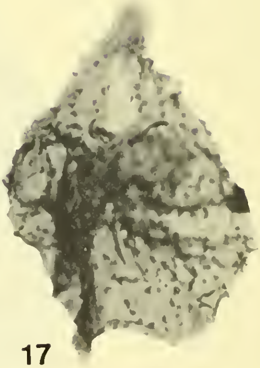
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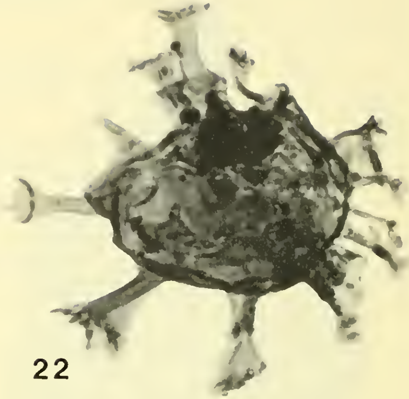

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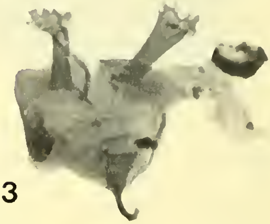

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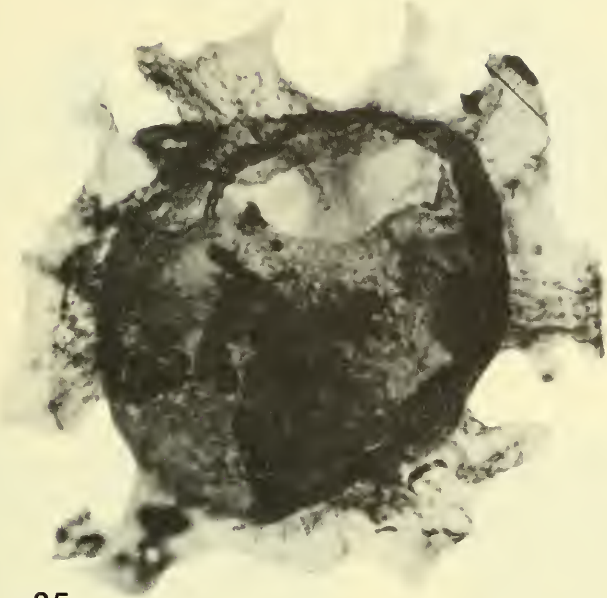

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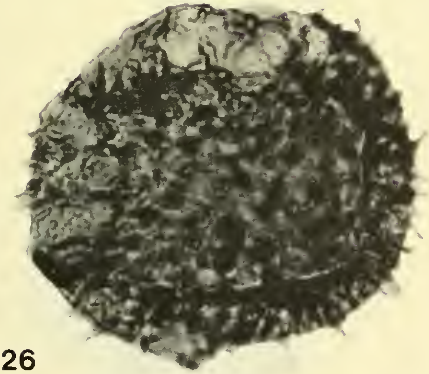

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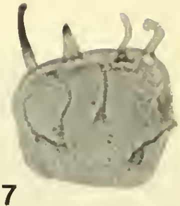

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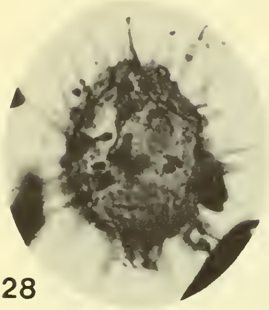

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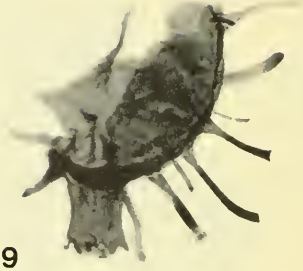

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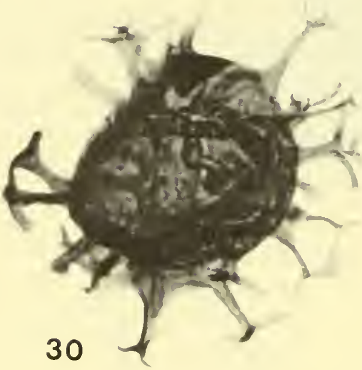

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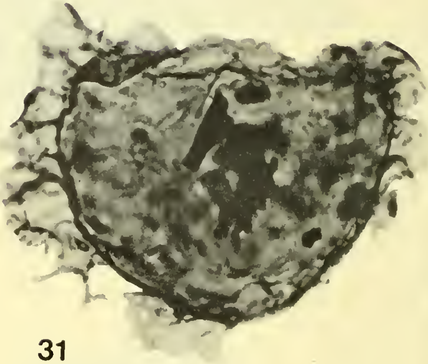

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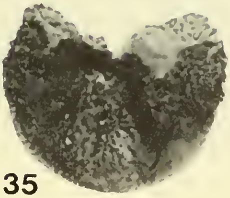
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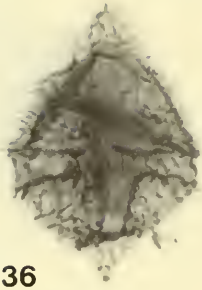
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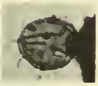
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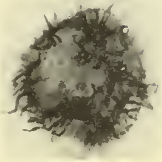
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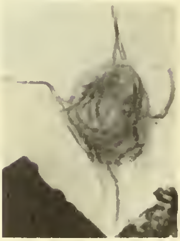
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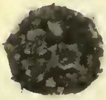
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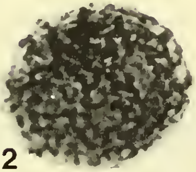
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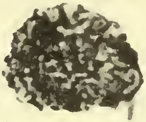
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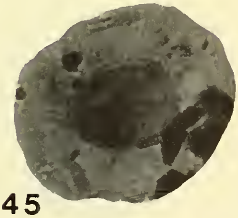
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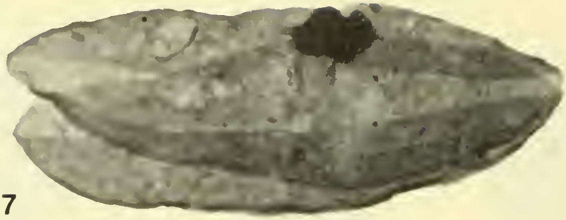

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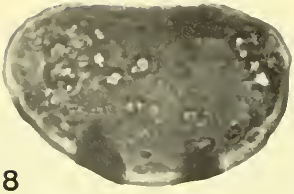

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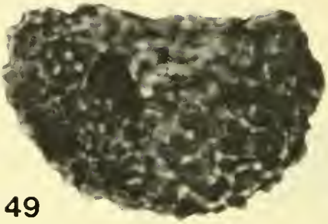

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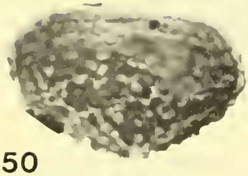

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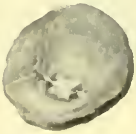

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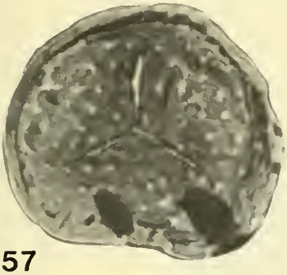
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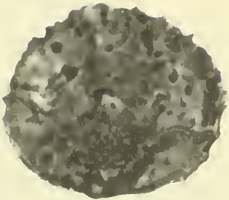
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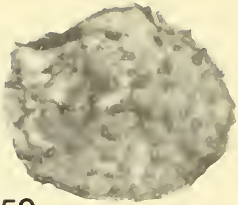
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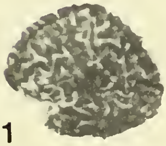
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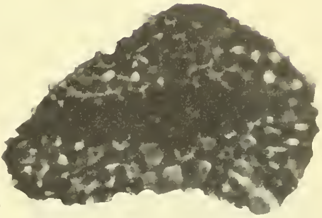
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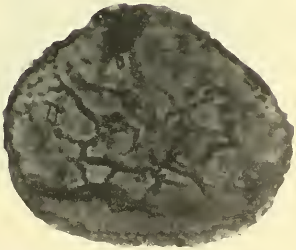
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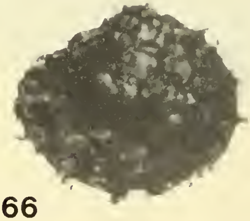
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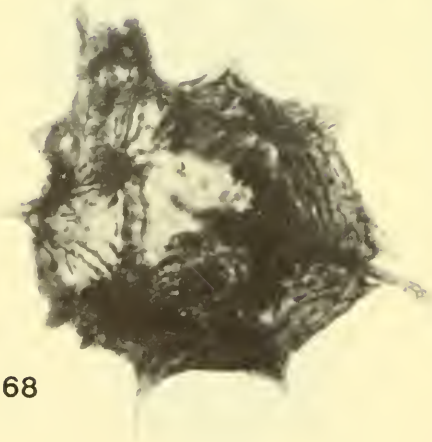

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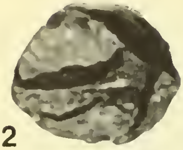

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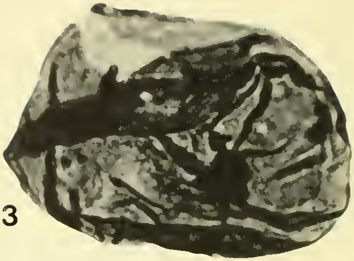

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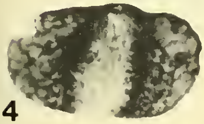

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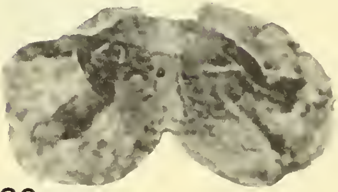

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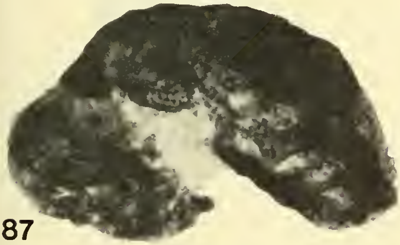

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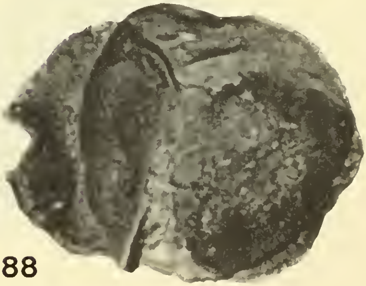

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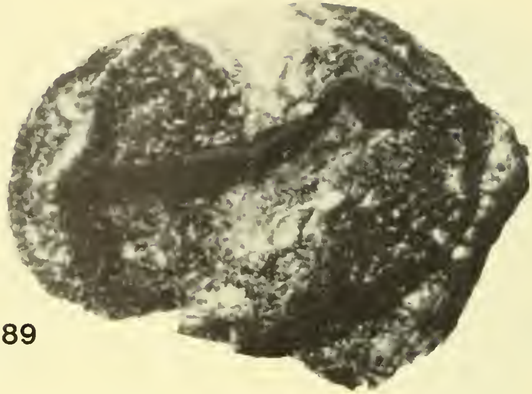

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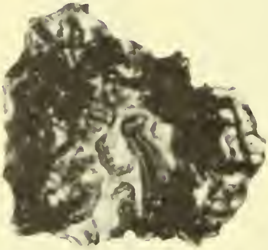

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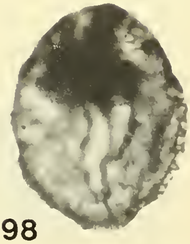

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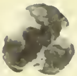
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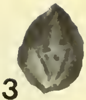
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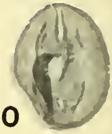
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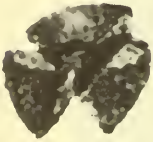
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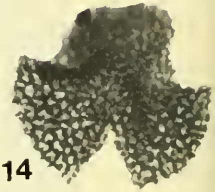
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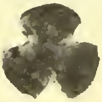
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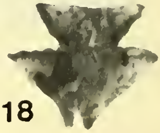
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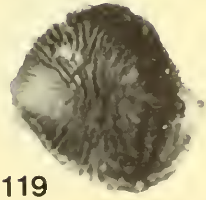
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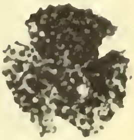
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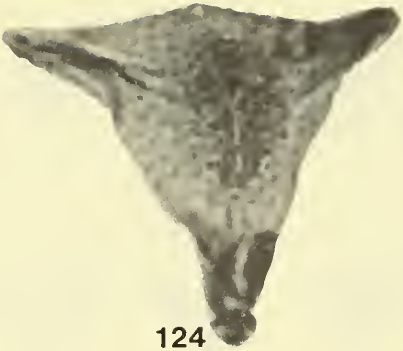
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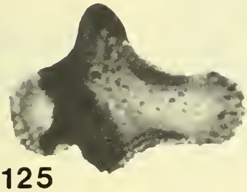
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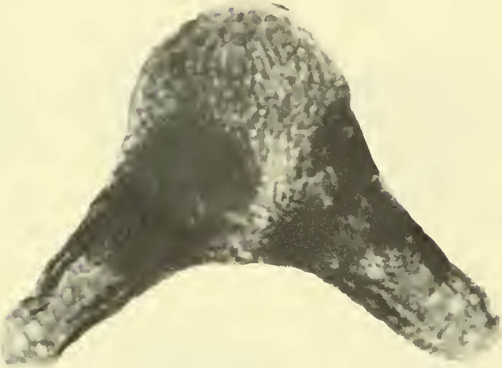
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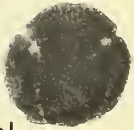
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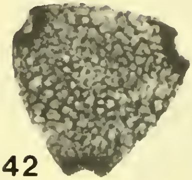
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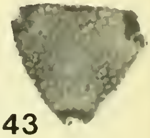
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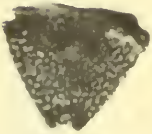
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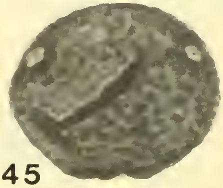
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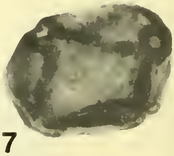
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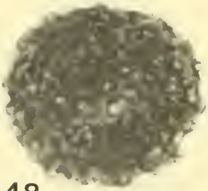
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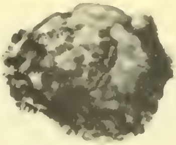
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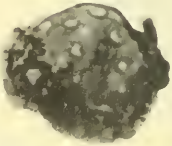
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1973

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ABSTRACT

The Pennsylvanian Missourian Hogshooter Formation of northeastern Oklahoma locally contains abundant tabulate corals, crinoids, and rare blastoids in calcarenites and calcareous shales. These organisms are most abundant in reef associated beds at a single locality. None were collected from the phylloid algal mound complex which comprises most of the Hogshooter outcrop belt in Oklahoma.

Species of four tabulate coral genera are described from reef flank beds. They are *Sutherlandia* cf. *S. irregularis* Cocke and Bowsher, 1968, *Striatopora kolmani,* n. sp., *Michelinia adibilus,* n. sp., and *Cladochonus conus,* n. sp. From the same locality the echinoderms *Aglaocrinus compactus* Moore and Plummer, 1940, *Lecythiocrinus graybilli,* n. sp., *Delocrinus* cf. *D. verus* Moore and Plummer, 1940, *Erisocrinus* sp., *Graffhamicrinus* sp., *Paragassizocrinus mcguirei* Strimple, 1939, and *Agmoblastus dotti* (Moore and Strimple, 1942) were recovered. Additional species of crinoids known from two other localities are *Erisocrinus* cf. *E. typus, Sciadiocrinus* sp., *Sciadiocrinus abolitus,* n. sp., *Ulocrinus buttsi* Miller and Gurley, 1890, *Laudonocrinus* sp. *Laudonocrinus subsinuatus* Moore and Plummer, 1940, and *Parerisocrinus obovatus* (Moore and Plummer, 1940).

INTRODUCTION

Tabulate corals and echinoderms are only locally abundant in thin shales and calcarenites of the Hogshooter Formation, Missourian of Oklahoma. The formation is characterized by considerable lithic variability southward from the Kansas-Oklahoma boundary to southern Tulsa County, Oklahoma. It consists of four members in ascending order, Canville Limestone, Stark Shale, Lost City Limestone and Winterset Limestone. The Hogshooter Formation has been correlated with the Dennis Formation of Kansas (Oakes, 1940; Oakes, 1952; Cronoble and Mankin, 1965). Near the Kansas-Oklahoma boundary, the Hogshooter is composed of crinoid-rich calcarenites and calcilutites. Southward, near Bartlesville, Oklahoma, the formation consists of a phylloid algal mound complex (Heckel and Cocke, 1969) which extends several miles along the outcrop belt. No corals, crinoids, or blastoids were collected from the mound complex; however, extensive collecting was not attempted. In the vicinity of Ramona, Oklahoma, which lies a few miles south of the southernmost extent of the algal complex, a local reef is present in the Winterset Member. Beds associated with this reef furnished all of the tabulate corals and many of the echinoderms described or discussed here. Strimple recognized the reefoid characteristics of this structure and brought them to the attention of William Cronoble who subsequently worked out the detailed stratigraphy (*see* Cronoble and Mankin, 1965). This reef differs in several important details from features in Kansas referred to as *algal banks* (Harbaugh, 1959) and from those described by Heckel and Cocke (1969) as *phylloid algal mound complexes.* Features in Kansas previously referred to as *reefs* by Davis (1959) and Wilson (1957) are more properly termed *algal banks* or *phylloid algal mound complexes.*

The reef core as lineated by Cronoble and Mankin (1965) consists of calcilutite with abundant invertebrates and the green alga *Epimastopora.* We believe, but cannot prove, that this body represents a lobe of the main reef body which prior to its destruction by recent erosion lay a few hundred yards north of the present exposure. Surrounding and overlying the reef lobe are steeply dipping, thin, interbedded calcarenites and calcareous shales. Within these units are abundant tabulates *Striatopora* Hall, 1851, *Michelinia* de Koninck, 1841, *Cladochonus* McCoy, 1847, and rare *?Sutherlandia* Cocke and Bowsher, 1968. Two rugose coral genera *?Amplexi-Zaphrentis* and *Lophophyllidium* are present in small numbers but are not described in this report. Many *Striatopora* and *Michelinia* are badly broken and abraded indicating possible effects of wave and current action. Tabulate corals are seemingly restricted to reef related rocks with the exception of rare michelinids in calcareous shales and limestone lentils overlying the massive Lost City Limestone of Tulsa County, Oklahoma. Neither Lost City corals nor echinoderms have been analyzed carefully. Blastoids are restricted to reef flank beds in Locality 1.

Complete crinoid crowns have not been found in this formation but several dorsal cups have been recovered from the three localities. At Locality 1, large specimens of *Erisocrinus, Aglaocrinus, Lecythiocrinus,* and *Delocrinus* have been found in close association with the core of the reef. The first specimen of the blastoid *Agmoblastus dotti* (Moore and Strimple, 1942) was discovered on a slab of limestone about 30 feet to the west of the reef core and subsequently several complete specimens were recovered from a six inch shale in flank beds several hundred feet to the west, in association with *Paragassizocrinus mcguirei* (Strimple, 1939). Large crinoid cups have been observed several hundred feet to the north along a tributary of Double Creek but they are badly eroded and firmly embedded in dense limestone. At Locality 2, several dorsal cups were recovered on bedding planes and from a thin shale unit. *Aglaocrinus, Erisocrinus, Delocrinus, Graffhamicrinus, Laudonocrinus, Parerisocrinus, Sciadiocrinus,* and *Paragassizocrinus* were all represented. *Ulocrinus buttsi* was reported by Cronoble (1960, p. 96) from Locality 3, and *Aglaocrinus, Erisocrinus, Laudonocrinus, Lecythiocrinus,* and *Sciadiocrinus* have subsequently been recovered from the exposure.

No crinoids have been found retaining arms or blastoids retaining brachioles. Crinoid cups and one specimen of the blastoid *Agmoblastus dotti* have been found in close association with the reef lobe, but most material has been recovered from flank beds or well removed from the reef area to the northwest on U.S. Hwy. 75 (Loc. 2) or in California Creek in Nowata County (Loc. 3).

LOCALITIES

Corals and echinoderms described in this report were collected from the following localities:

1. SW NE sec. 28, T. 24 N., R. 13 E., Washington County, Oklahoma, south bank of Double Creek, a few hundred yards north of Ramona High School. Winterset Member, Hogshooter Formation (see Cronoble and Mankin, 1965), measured sections 10, 20, 33-38.
2. SW sec. 16, T. 24 N., R. 13 E., Washington County, Oklahoma, drainage ditch east of U.S. Highway 75, on west facing slope, Winterset Member, Hogshooter Formation.
3. SE SE sec. 18, T. 28 N., R. 15 E., Nowata County, Oklahoma, outcrop on both sides of north-south country road crossing California Creek, Winterset Member, Hogshooter Formation.

SYSTEMATIC PALEONTOLOGY

Phylum COELENTERATA Frey and Leuchart, 1847

Class ANTHOZOA Ehrenberg, 1834

Order TABULATA Milne-Edwards and Haime, 1850

Family **FAVOSITIDAE** Dana, 1846

Subfamily **PSEUDOFAVOSITINAE** Sokolov, 1955

Genus **SUTHERLANDIA** Cocke and Bowsher, 1968

Type species: *Sutherlandia irregularis* Cocke and Bowsher, 1968.

Generic diagnosis. — The genus *Sutherlandia* is characterized by spherical to hemispherical or rarely irregular coralla. Hemispherical forms commonly encrust tabular objects; in most instances, spherical colonies circumscribe cylindrical organic material. Internally, squamulae, mural pores, and distal processes are common. Faint longitudinal ridges mimic septa in some corallites (from Cocke and Bowsher, 1968, p. 2).

Discussion. — Forms similar to *Sutherlandia* but which lack squamulae or tabulae were retained in *Pseudofavosites* Gerth, 1921 by Cocke and Bowsher (1968). *Sutherlandia* has been reported prepreviously from two Midcontinent Pennsylvanian Desmoinesian units, the Wewoka, and Oologah Formations and from the Seminole Coffeyville, Dewey, and Stanton Formations of Pennsylvanian Missourian age (Cocke and Bowsher, 1968). Subsequently, Strimple collected externally similar forms from the Missourian Iola and Nellie Bly Formations of Oklahoma as well as those from the Hogshooter Formation described here. The junior author observed externally similar forms from Permian Guadalupian rocks, Glass Mountains, Texas.

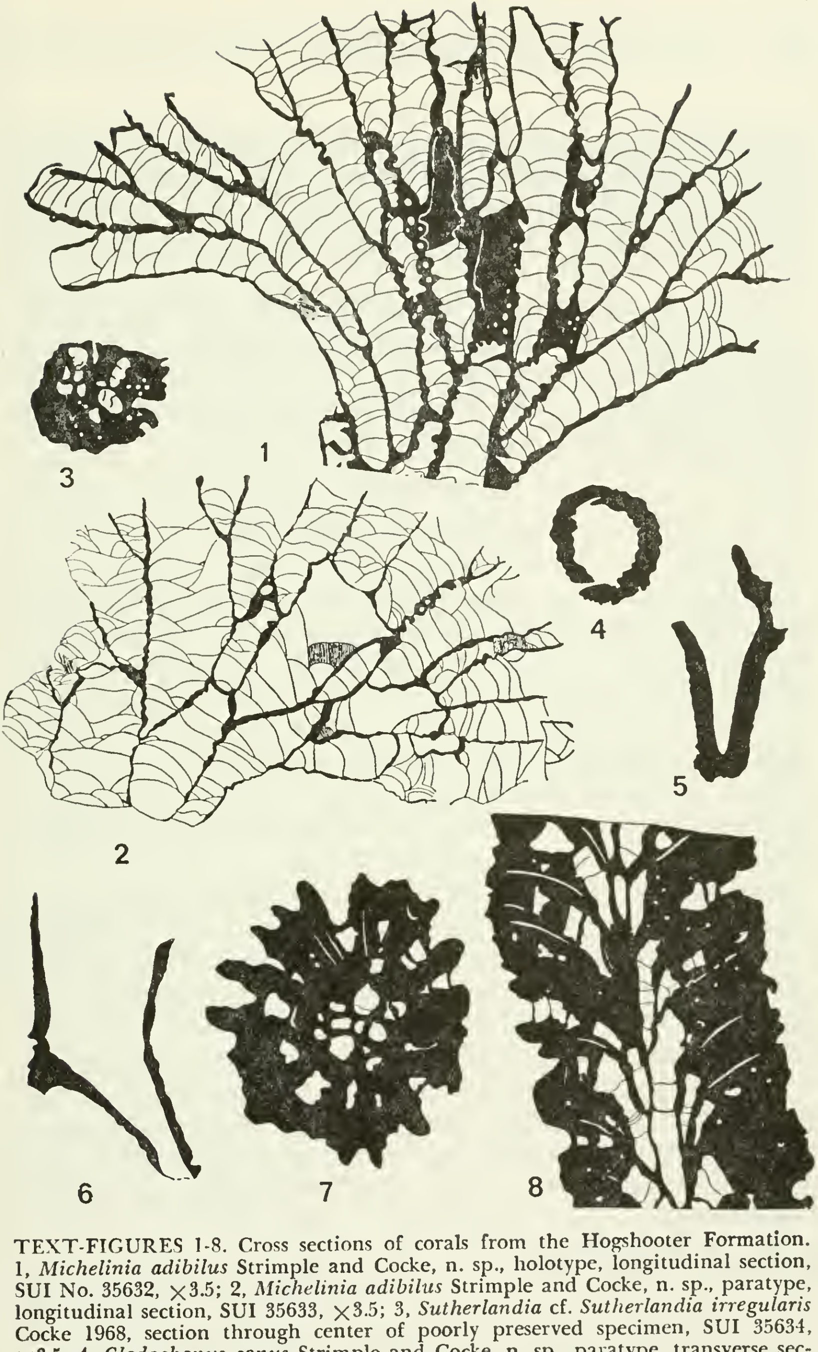
Outside of the American Midcontinent, *Sutherlandia* has been described from Lower and Upper Carboniferous rocks of China (Lin, 1963) and Lower Permian Artinskian beds of the Urals, USSR (Yakovlev, 1939; Sokolov, 1955). Tchudinova (1965) described two species of the genus from Upper Permian Djulfian beds, *Pseudofavosites certus* and *P. finitimus.*

Sutherlandia cf. S. irregularis Cocke and Bowsher, 1968 **Text-fig. 3**

Description. — Two of the three specimens are approximately spherical and have diameters of 0.48 and 0.52 mm; a single ellipsoidal specimen is larger, with minimum and maximum diameters of 2.3 and 2.7 mm respectively. Calices are smoothly polygonal. Mural pores are rare except in the upper part of corallites. Longitudinal ridges were not observed in the calices.

Internally corallite walls are straight and range in thickness from 0.08 mm to 0.16 mm. Mural pores intersected in longitudinal sections have diameters near 0.05 mm. Squamulae are rare in the specimens studied; perhaps because of poor preservation, their distribution pattern cannot be determined. Most squamulae are irregularly convex distally or recurved and reach lengths equal to two-thirds of corallite diameter.

Remarks. — Hogshooter specimens are rare and poorly preserved making taxonomic assignment difficult. They are similar



TEXT-FIGURES 1-8. Cross sections of corals from the Hogshooter Formation. 1, *Michelinia adibilus* Strimple and Cocke, n. sp., holotype, longitudinal section, SUI No. 35632, ×3.5; 2, *Michelinia adibilus* Strimple and Cocke, n. sp., paratype, longitudinal section, SUI 35633, ×3.5; 3, *Sutherlandia* cf. *Sutherlandia irregularis* Cocke 1968, section through center of poorly preserved specimen, SUI 35634, ×3.5; 4, *Cladochonus conus* Strimple and Cocke, n. sp., paratype, transverse section, SUI No. 35629, ×4.4; 5, *C. conus* Strimple and Cocke, n. sp., paratype, longitudinal section, SUI No. 35630, ×4.4; 6, *C. conus* Strimple and Cocke, n. sp., paratype, longitudinal section, SUI No. 35631, ×3.5; 7, *Striatopora kolmani* Strimple and Cocke, n. sp., paratype, transverse section, SUI No. 35626, ×3.3; 8, *Striatopora kolmani* Strimple and Cocke, n. sp., paratype, longitudinal section, SUI 35627, ×3.3.

to *S. irregularis* Cocke and Bowsher, 1968 in possessing large mural pores and irregular squamulae. *Sutherlandia seminolensis* Cocke and Bowsher, 1968 differs in having spinose squamulae; *S. alani* Cocke and Bowsher, 1968 has longer and more uniformly regular squamulae.

Occurrence. — Three poorly preserved specimens were studied, two of which are probably juveniles. One specimen was collected at Locality 1; two others were collected at Locality 2. The specimens are reposited in the Geology Department Repository, University of Iowa. Figured specimen is SUI 35634.

Subfamily **PACHYPORINAE** Gerth, 1921

Genus **STRIATOPORA** Hall, 1851

Type species: *Striatopora flexuosa* Hall, 1851.

Generic diagnosis. — Species of *Striatopora* consist of regularly to irregularly branched coralla which are approximately cylindrical. Trumpet-shaped corallites are approximately normal to the corallum periphery but intersect the corallum axes at higher angles. Axially, walls are moderately thick but thicken peripherally and in some instances appear to fuse into solid stereoplasmic deposits. Mural pores are widely spaced. Tabulae vary considerably in packing and thickness; most are complete. If present, septa are low, rounded, longitudinal ridges spaced widely in the calyx.

Remarks. — Wells (1944), Moore and Jeffords (1945), and Rowett (*in* Rowett and Cocke, 1966) discussed fully relationships between the related genera *Thamnopora, Pachypora, Striatopora,* and *Trachypora*. Concepts of the genus studied here vary considerably among workers. Hill and Stumm (1956, F 464) noted that species of *Striatopora* have 12 septa; however, Moore and Jeffords included two aseptate species as well as one septa-bearing species in the genus. In addition the type specimen of *Striatopora flexuosa* Hall has not been sectioned; hence its internal characters are unknown, and assignment of any species to the genus is somewhat tenuous.

Striatopora kolmani Strimple and Cocke, n. sp.

Pl. 21, figs. 13-15; Text-figs. 7,8

Description. — Colonies are ramose with branches arising at irregular intervals along the corallite length. All coralla are fragmented; the longest available fragment measured 64 mm. Coralla diameters range from 4 mm to 13 mm; however, most specimens have diameters near 8 mm. Corallites are not noticeably dimorphic; diameters of corallites range from 0.8 mm to 1.6 mm. Corallites with diameters over 1.5 mm possess smooth subcircular walls; those walls of lesser diameters are more angulate. Calices are inversely conical with depths approximating diameter length.

Corallites originate at angles of 20 to 40 degrees to coralla axis but may be subhorizontal near the periphery of the corallum. Corallite walls which are 0.25 mm to 0.38 mm thick in early stages thicken rapidly near the edge of the colony and generally fuse into solid deposits of stereoplasm. Mural pores are widely and erratically distributed; diameters range from 0.10 mm to 0.20 mm averaging 0.15 mm. Most tabulae are complete; of those, 13 percent are barlike; 25 percent are convex distally and approximately 50 percent are proximally convex. The remaining 12 percent are incomplete tabulae; the majority of which are barlike to gently convex upward. Spacing of tabulae is erratic; in a few corallites only one tabula per 5 mm is present. The closest spacing is three tabulae in 2.0 mm.

Remarks. — *Striatopora kolmani,* n. sp. can be separated from the lower Pennsylvanian species, *S. oklahomensis* (Snider, 1915), *S. immota* Moore and Jeffords, 1945, and *S. religiosa* Moore and Jeffords, 1945 by fewer tabulae and greater stereoplasmic deposits in the Hogshooter forms. Three Pennsylvanian species described by Wells (1944), *S. moorei, S. plummeri,* and *S. trachyporoides,* resemble *S. kolmani* in abundance of peripheral stereoplasm. However, *Striatopora moorei* and *S. trachyporoides* have more tabulae and mural pores; *S. plummeri* has no tabulae. Wells figured types of *Trachypora austini* Worthen (1890) and placed them in *Striatopora.* However, West (1964) described other specimens which he believed to be conspecific with *T. austini* and placed them in *Acaciapora austini.* Specimens illustrated by West possess squamulae but no tabulae and are properly assigned to *Acaciapora* Moore and Jeffords. Recent examination of *Trachypora austini* syntypes by the junior author revealed the presence of tabulae and thick stereoplasmic deposits which indicate that the species cannot be assigned to *Acaciapora.*

Occurrence. — Several hundred fragments of *Striatopora kolmani,* n. sp. were collected from the reef flank beds at Locality 1.

The holotype is SUI 35624, numbered paratypes are SUI 35625, SUI 35626, SUI 35627. Specimens are reposited in the Geology Department Repository, University of Iowa.

Subfamily **MICHELINIINAE** Waagen and Wentzel, 1886

Genus **MICHELINIA** de Koninck, 1841

Type species: *Calamopora tenuisepta* Phillips, 1836, Lower Carboniferous, England.

Generic diagnosis. — Tabulate colonies comprised of tightly packed corallites of relatively large size are included in the genus. Coralla typically have wrinkled holotheca at the base. Intercorallite walls are relatively thin throughout length. Mural pores are common. Corallites contain numerous complete and incomplete tabulae. There are no true septa (after Moore and Jeffords, 1945, p. 167).

Remarks. — The status of the genus *Michelinia* is not discussed here; interested workers are referred to excellent discussions by Moore and Jeffords (1945, p. 167) and Rowett (*in* Rowett and Cocke, 1966, p. 15).

Michelinia adibilus Strimple and Cocke, n. sp. Text-figs. 1,2

Description. — Coralla of this species are large; some fragments measured 145 mm in diameter with heights approaching 50 mm. The largest known complete colony is considerably smaller, measuring 76 mm at the greatest diameter. Small colonies are subconical to subspherical; the more common larger coralla are ellipsoidal to irregular. The holotheca is transversely wrinkled and covers only a small portion of the corallum. Corallites attain diameters of 6.0 mm. Calices are smooth and deep.

Walls range in thickness from 0.16 mm to 0.40 mm; the average is 0.30 mm. Typically, they have sharply polygonal outlines particularly in larger specimens. Corallite diameters are variable ranging from 2.5 mm to 6.0 mm in the distal parts of the coralla. Mural pores rarely attain 0.30 mm and are relatively rare. Four to eight tabulae are present in corallites cut near the calicular bases.

In the calicular region, corallite diameters range from 0.4 mm to 3.6 mm. Walls are slightly sinuous except near juncture of corallites where as many as four sharp flexures occur in 2.2 mm. Wall thickness is commonly near 0.2 mm throughout most of the length; in a few corallites the wall approximately doubles in thickness in the calyx. Mural pores, most of which are concentrated near the juncture of corallites, have a diameter range of 0.18 mm to 0.40 mm. Two basic types of tabulae are identified: 1) complete tabulae which join to both sides of a given corallite, and 2) incomplete tabulae which may either originate at a corallite wall and terminate on a lower tabula or may rest entirely on an underlying tabula. Slightly more than one-half of the tabulae are complete. Tabulae are moderately packed; they are separated by an average distance of 0.8 mm. Maximum spacing of the tabulae is 1.6 mm.

Remarks. — *Michelinia referta* Moore and Jeffords (1945) resembles *M. adibilus* in size but has as many as 30 tabulae per 10 mm as compared to eight tabulae per 10 mm in the latter. *Michelinia exilimura* Mather (1915) is similar to *M. adibilus,* n. sp. in spacing of tabulae, size of corallum, and rarity of mural pores; however, *Michelinia adibilus* has a considerably higher percentage of complete tabulae which are convex distally. In addition, *M. exilimura* has more incomplete distally convex tabulae.

Study of partially preserved Hogshooter coralla suggests that those with larger corallite diameters were differentially destroyed by compaction.

Occurrence. — Ten coralla and many fragments from reef flank beds of Locality 1 were examined in thin sections; the holotype is SUI 35632; numbered paratype is SUI 35633. All material is reposited at the Geology Department Repository, University of Iowa.

Family **AULOPORIDAE** Milne-Edwards and Haime, 1851

Subfamily **AULOPORINAE** Milne-Edwards and Haime, 1851

Genus **CLADOCHONUS** McCoy, 1847

Type series: *Cladochonus tenuicollis* McCoy, 1847.

Generic diagnosis. — Proximal corallites in a reptant ring from which free branches arise; individual corallites, trumpet or pipe shaped, in contact only at points of origin, each giving rise to another by lateral increase through wall of the expanded calice; each with a thick peripheral stereozone of laminar or reticulate sclerenchyme. Septal spines and tabulae lacking in the narrow lumen, but septa ridges may appear in the calice (Hill and Stumm, 1956, F472).

Discussion. — For an excellent discussion of the genus, see Moore and Jeffords (1945, p. 185).

Cladochonus conus Strimple and Cocke, n. sp.
Pl. 21, fig. 16; Text-figs. 4-6

Description. — Coralla characteristic of this species consist of trumpet to funnel-shaped individuals which have calicular diameters from 5.0 mm to 7.2 mm but which average approximately 6.0 mm. Fragmental nature of the material studied does not permit precise determination of corallite length. Budding apparently occurs sporadically on all sides of previous corallites. In well-preserved specimens the exterior is marked by closely spaced growth lines. Calices are deep and inversely conical. Most are smooth; however, in a few specimens, up to 24 longitudinal ridges simulate septa. Below the top of the calice wall thickness ranges from 0.4 mm to 1.2 mm. Constriction of the corallite results in small openings in connecting tubes. No tabulae or other internal structures have been observed.

Remarks. — Morphologically *Cladochonus conus,* n. sp. is somewhat intermediate between the Lower Pennsylvanian forms, *C. fragilis* Mather, 1915 and *C. texasensis* Moore and Jeffords, 1945. The former has more closely spaced septal ridges as well as smaller connecting tubes and calicular diameters; the latter has considerably greater septal spacing, connecting tube diameter of *C. texasensis* is approximately two to three times greater than those of *C. conus.* Further, the Texas species possesses consistently greater calicular diameters. *Cladochonus bennetti* Beede, 1898, from Pennsylvanian Desmoinesian rocks, differs in possessing smaller corallite diameters and a more strongly wrinkled epitheca.

Occurrence. — Several hundred specimens were available from shales of the reef flank at Locality 1. No complete coralla were found; most specimens consisted of isolated corallites. The holotype is SUI 35628; numbered paratypes are SUI 35629, SUI 35630 and SUI 35631. All specimens are at the Geology Department Repository, University of Iowa.

Phylum ECHINODERMATA

Class CRINOIDEA J. S. Miller

Subclass INADUNATA Wachsmuth and Springer

Order CLADOIDEA Moore and Laudon

Suborder DENDROCRINIOIDEA Bather

Family **CROMYOCRINIDAE** Jaekel, 1918

Genus **AGLAOCRINUS** Strimple, 1961

Type species: *Ethelocrinus magnus* Strimple, 1939.

Generic diagnosis. — Dorsal cups of *Aglaocrinus* are distinguished from other cromyocrinids in having sutures deeply impressed in V-shaped depressions and a relatively broad basal invagination and infrabasal circlet. Typically surfaces of the dorsal cup are irregular or undulating; however, *A. compactus* has smooth surfaces.

Discussion. — *Aglaocrinus* is recognized from the Atokan of Texas, the Desmoinesian of Oklahoma, and the Missourian of Nebraska and Kansas. It is questionably reported from the Lower Permian of Nevada by Lane and Webster (1966). The closely related *Parethelocrinus* lacks impressed sutures and has a proportionately smaller infrabasal circlet.

Aglaocrinus compactus (Moore and Plummer, 1939) Plate 21, figs. 17-19

Description. — The dorsal cup has a circular outline, is moderately high and truncate globe-shaped. In side view the cup has erect, vertical sides. The base is broad with midportion impressed. The broad, subhorizontal, impressed area is occupied by the infrabasals and the proximal portions of the basals. The portion of infrabasals occupied by proximal columnals is sharply impressed and columnals are marked by short crenulations. Sutures between plates are in V-shaped notches. There is a small shelf formed at the summit of radial just below the outer ligament furrow.

Measurements of hypotype in millimeters:

Width of cup (maximum)	31.8
Width of cup posterior-anterior	30.5
Height of cup	13.9
Diameter of infrabasal circlet	10.3
Diameter of columnar scar	5.0
Length of basal	16.6*
Width basal	16.6*
Length of radial (to transverse ridge)	11.0*
Width of radial	17.0*

*measurement taken along surface curvature

Remarks. — The dorsal cup of *Aglaocrinus compactus* has V-shaped notches marking sutures, lacks the pronounced protrusion in the region of the radianal found in typical forms of *Parethelocrinus,* and has a proportionately broader infrabasal circlet. The most comparable species is *A. plattsburgensis* (Strimple), 1938.

Occurrence. — Hypotypes, SUI 34215 collected at Locality 2, hypotype, 34216 at Locality 3, reposited in Geology Department Repository, University of Iowa.

Genus **ULOCRINUS** Miller and Gurley, 1890

Type species: *Ulocrinus buttsi* Miller and Gurley, 1890.

Generic diagnosis. — Globular to pyramidal calyx; infrabasals form convex pentagonal disc; basals each as large as or larger than infrabasal disc; radials moderately large; two anal plates. Arms 10, long, well-rounded exteriors, secundibrachs cuneate in proximal portions, equibiserial above.

Discussion. — The large, thin plates of *Ulocrinus* appear distinctive and are common in many shale exposures of Pennsylvanian age.

Ulocrinus buttsi Miller and Gurley, 1890

Description. — A specimen in excellent preservation was described and illustrated by Cronoble (1960).

Occurrence. — Locality 3, reposited in Paleontological Collections, The University of Oklahoma, Norman, Oklahoma.

Family **PIRASOCRINIDAE** Moore and Laudon, 1943

Genus **SCIADIOCRINUS** Moore and Plummer, 1938

Type species: *Zeacrinus* (*Hydreionocrinus*) *acanthophorus* Meek and Worthen, 1874.

Generic diagnosis. — Crown short, somewhat expanded. Dorsal cup low, with basal concavity, infrabasals not visible from side and basals generally not visible from side except at posterior; three anal plates, anal X and right tube plate entering cup only slightly. Arms uniserial, branching two or more times in each ray. Anal sac with prominent marginal spines at distal extremity.

Sciadiocrinus abolitus Strimple and Cocke, new species Pl. 21, figs. 1-3

Description. — Dorsal cup low, with lateral sides of cup composed entirely of subvertical distal portions of radials which then curve sharply to form the basal plane and enter into the shallow broad basal concavity; B radial makes contact with B infrabasal and all other sutures between basals are short. Basals are small slightly tumid, of unequal dimensions and confined to the basal concavity except for CD basal which is elongated for contact with posterior anal plate (anal X) and the distal tip is visible in side view of the cup; infrabasals extend slightly beyond the columnar scar and appear to be slightly upflared due to the ridge formed about the columnar attachment area, but are actually subhorizontal. In the posterior interradius the radianal has been eliminated, anal X is large, extends well above the cup summit and is faceted for a large tube plate above, a small tube plate on the left toward the interior, and a small right tube plate to the right which is jointly supported by the left shoulder of an extension of the C radial; all articular facets slope outward but especially those of the C and D rays which are extended to assist in support of the anal pyramid, the outer ligament grooves are thin and are at the perimeter of the cup, transverse ridge is thin, two large shallow muscular scars occupy each facet and a broad intermuscular groove divides them, intermuscular notch is broad and not too deep, adsutural notches are apparent in summit or basal views of the cup but particularly in summit view. Columnar attachment area is round, depressed which is accentuated by a built-up rim surrounding the perimeter, short crenulations mark the outer part of the cicatrix, lumen round. Arms and anal tube unknown.

Measurements of holotype in millimeters:

Width of dorsal cup	24.2
Height of dorsal cup to transverse ridge	4.1
To maximum height of articular facets	8.6
Diameter of columnar scar	4.1
Width of infrabasal circlet	6.8
Length of AE basal	4.7
Width of AE basal	5.9
Length (along surface curvature) of A radial	10.6
Width (along surface curvature) of A radial	13.7
Length of anal plate	7.0
Width of anal plate	5.8

Remarks.—*Sciadiocrinus abolitus* is shallower than other species and has a highly advanced posterior interradius (one anal plate). A form described as *Pirasocrinus invaginatus* Strimple (1951b, p. 203) was referred to *Sciadiocrinus* as *Sciadiocrinus invaginatus* (Knapp, 1969, p. 371) based on the tumidity of the basal plates and subhorizontal attitude of the infrabasals. *Pirasocrinus* and *Sciadiocrinus* have many features in common, but Knapp (*ibid.*, p. 378) pointed out that typically *Pirasocrinus* has downflared infrabasals and basals and a deep basal invagination. In *Sciadiocrinus invaginatus* the radianal is a long, slender element, the sutures between basals are short and the posterior (CD) basal is elongated. It is closely related to *S. abolitus* although slightly younger. Comparison with the closely comparable Atokan species *Sciadiocrinus llanoenis* Strimple and Watkins, 1969, which has a dorsal cup almost as shallow, shows that species has larger basals, longer sutures between basals, and three normal anal plates in the posterior interradius. *Parabursacrinus* Wanner (1924, p. 221), from the Permian of Timor, is possibly a derivative of this lineage.

The name *abolitus* (L. terminate) indicates the advanced nature of the species.

Occurrence. — Locality 2, holotype (SUI 34224) reposited in Geology Department Repository, University of Iowa.

Genus **LAUDONOCRINUS** Moore and Plummer, 1940

Type species: *Hydreionocrinus subsinuatus* Miller and Gurley, 1894.

Generic diagnosis. — Dorsal cup moderately low bowl-shaped, characterized essentially by smooth contour of surface. Base flat or, at most, marked by small almost imperceptible concavity.

Laudonocrinus subsinuatus (Miller and Gurley, 1894) Pl. 21, figs. 7,8

Description. — Dorsal cup moderately low, bowl-shaped, smooth contour to the surface. The base is essentially flat with the infrabasals forming a subhorizontal to almost imperceptibly upflared attitude. Basals are small, mainly confined to the basal area. Radials form most of cup height. Articular facets are wide, long, and directed outwardly. Three anal plates are in normal (Primitive) arrangement. Anal sac and arms unknown.

Occurrence. — Locality 2, Hypotype (SUI 34223) is reposited in Geology Department Repository, University of Iowa.

Family **DIPHUICRINIDAE** Strimple and Knapp, 1966

Genus **GRAFFHAMICRINUS** Strimple, 1961

Type species: *Graffhamicrinus acutus* Strimple, 1962.

Generic diagnosis. — Dorsal cup low, bowl-shaped with basal concavity, surface covered by pustules, nodes, tubercles, ridges, or strong granules, or a combination of any of these features. Single anal plate in cup or excluded; arms 10, branch on primibrach *1*, equibiserial; column small, round.

Discussion. — A modification of the concept of *Graffhamicrinus* was proposed by Knapp (1969, p. 363) disregarding surface ornamentation as a generic character. A clarification of the lineage is given by Strimple and Moore (1971b, p. 3).

Graffhamicrinus sp.

Discussion. — A fragment of a dorsal cup showing pustulose ornamentation and a single, elongated anal X is ascribed to *Graffhamicrinus* as an undeterminate species. The distal portion of the anal plate is flexed sharply inwardly, is long and narrow, and flared at its inner extremity as though it might be faceted for two tube plates.

Occurrence. — Locality 2, SUI 34219 reposited in Geology Department Repository, University of Iowa.

Family **CATACRINIDAE** Knapp, 1969

Genus **DELOCRINUS** Miller and Gurley, 1890

Type species: *Poteriocrinus hemisphericus* Shumard, 1858.

Generic diagnosis. — Dorsal cup low, bowl-shaped with basal concavity and slight constriction at summit, smooth surface. Arms 10, branching on primibrach *1,* equibiserial.

Discussion. — The generic concept of *Delocrinus* was sharply curtailed by Knapp (1969, p. 367) but was returned to original status by Moore and Strimple (1970) through proposal of a neotype of the type species.

Delocrinus sp. cf. **D. verus** Moore and Plummer, 1940

Discussion. — A partial cup is assigned to *Delocrinus verus* with some reservation because of the preservation. The holotype of *D. verus* is from the Palo Pinto Formation, Canyon Group of Texas and two paratypes are reported from the Dennis Formation (Winterset Limestone Member) east of Bartlesville, Washington County, Oklahoma, which is more properly referred to as the Hogshooter Formation. We have been unable to locate the crinoid bearing exposure east of Bartlesville.

Occurrence. — Hypotype (SUI 34221) is from Locality 2, reposited in Geology Department Repository, University of Iowa.

Family **ERISOCRINIDAE** S. A. Miller

Genus **ERISOCRINUS** Meek and Worthen, 1865

Type species: *Erisocrinus typus* Meek and Worthen, 1865.

Generic diagnosis. — Dorsal cup medium, truncate cone-shaped with planate or gently convex base, infrabasals not visible in side view of cup. When viewed from above or below the cup has a pentagonal outline. Arms 10, primibrach *1* axillary, equibiserial. Column round, moderately large.

Discussion. — *Erisocrinus* and *Delocrinus* have been considered to be closely related for the past 100 years until Strimple and Moore (1971a, p. 9) reported completely different morphologic features of the anal tube which is a small, short, recurved tube in *Erisocrinus* but is long, slender, and terminates with a long slender spine in *Delocrinus* (as in *Phanocrinus*). Differences in the dorsal cups of the two genera were then recognized to be of generic significance.

Erisocrinus sp. cf. **E. typus** Meek and Worthen, 1865

Description. — The specimens at hand are apparently closely related to typical examples of *E. typus* but differ slightly in that the columnar scar is proportionately large in the presently considered specimens. The exact age of the syntypes of *E. typus* is not known, but we believe it to be somewhat younger than lower Missourian.

Occurrence. — Locality 1, specimen SUI 34220 is reposited in Geology Department Repository, University of Iowa.

Genus **PARERISOCRINUS** Knapp, 1969

Type species. — *Paradelocrinus obovatus* Moore and Plummer, 1940.

Generic diagnosis. — Basal concavity shallow; infrabasals moderately downflared; basals large; distal ends of radials curved slightly inward so that transverse ridge is well removed from periphery of cup, proximal tips almost reach basal plane; rudimentary anal plate notches inner edge of articular surfaces of posterior radials.

Parerisocrinus obovatus (Moore and Plummer, 1940) Pl. 21, figs. 4-6

Description. — Same as for monotypic genus.

Discussion. — The holotype is from the northwest side of Kyle Mt., Palo Pinto County, Texas; Graford Formation, Canyon Group, Missourian. The hypotype increases the geographic range to Oklahoma.

Occurrence. — Locality 2, hypotype (SUI 34221) reposited in Geology Department Repository, University of Iowa.

Family **AMPELOCRINIDAE** Kirk, 1942

Subfamily **PARAGASSIZOCRININAE** Strimple and Watkins, 1969

Genus **PARAGASSIZOCRINUS** Moore and Plummer, 1940

Type species: *Agassizocrinus tarri* Strimple, 1938.

Generic diagnosis. — The genus is characterized by having a cone-shaped dorsal cup, fused infrabasals, a single anal plate and arms branching on primibrach *2* in all rays.

Discussion. — *Paragassizocrinus* is known from rocks of Pennsylvanian age in the eastern United States (Kentucky) the midcontinent region (Kansas, Oklahoma, Texas) and from west of the Rocky Mountains (Utah, Nevada).

Paragassizocrinus mcguirei (Strimple, 1939)

Description. — The original species concept of *Paragassizocrinus mcquirei* was based on a single infrabasal cone. The holotype (by monotypy) was narrow and elongated with a sharp flare near the summit. Subsequently discovered topotypes do not have such a flare. The species was accepted by Strimple (1960, p. 13) and hypotypes from the Checkerboard Limestone were assigned to the species at that time, including a complete dorsal cup.

Occurrence. — Locality 1 and 2, hypotypes (SUI 35635, 35636) reposited in Geology Department Repository, University of Iowa.

Suborder CYATHOCRINOIDEA Bather

Family **CODIACRINIDAE** Bather

Genus **LECYTHIOCRINUS** White, 1880

Type species: *Lecythiocrinus olliculaeformis* White, 1880.

Generic diagnosis. — Dorsal cup full, globose; three infrabasal plates; five elongate basal plates; five medium radial plates with narrow arm articulating facets; anal vent in side of cup at distal end of posterior basal extending into adjacent posterior radials.

Lecythiocrinus graybilli Strimple and Cocke, n. sp. Pl. 21, figs. 9-12

Description. — Dorsal cup is broad at base and narrows at midsection to form a narrow upper portion, being in the general shape of a vase. Three large infrabasals form most of the basal plane and have a small columnar attachment scar with a raised rim in mid-section. Five basals participate to a small degree in the basal area but flex gently upward for a short distance and then curve strongly to form the greater portion of the cup height. Radial plates are confined to the slender "neck" of the vaselike structure and the distal ends flex sharply inward at the summit of the cup to form a covering over most of the body cavity. The arm articulating facet of each radial is narrow, shaped like a horseshoe, and situated in mid-portion of the radial at the summit of the cup, directed slightly outward. Ambulacral grooves pass to the center of the structure and are marked on each side by raised, ridgelike structures, giving the appearance of five radiating troughs. The anal opening is large and is placed in the summit of the CD basal, as well as in the lower left corner of C radial and the lower right corner of D radial. There is a slightly raised section of the CD in its center below the opening.

Measurements of holotype in mm.	
Height of cup	24.2
Average width of cup	15.0
Average width of cup at summit	7.5
Diameter of infrabasal circlet	12.5
Diameter of stem scar	1.0
Length of basal	11.2
Width of basal	9.2
Length of radial	7.0
Width of radial	7.3

Remarks.—The small size of the columnar attachment scar as compared to the size of the cup suggests that a column, if present, was certainly not a rigid stalk. The shape of the base of the cup is much like that of the associated *Agmoblastus dotti* (Moore and Strimple) which form apparently discarded its stem. The obvious inference is that these forms were bottom dwellers, sitting on the ocean floor. Another associated form, which in ontogeny dessicated most of its small column and surrounded any remaining portion with stereom to form a fused, pointed-cone, is *Paragassizocrinus mcguirei* (Strimple), 1938.

Close relationship is with *Lecythiocrinus optimus* Strimple, 1951a, of the Oologah Limestone, Marmathon Group, Desmoinesian. There is not so pronounced a "neck" formed in *L. optimus,* giving it more squat appearance than found in *L. graybilli. L. urnaeformis* Strimple, 1939, from the Stanton Formation, Missourian has a similar shape but has a proportionately longer, more slender cup.

Occurrence.—Holotype SUI 34217 is from the west edge of the bioherm at Locality 1, collected by Ralph and Marilyn Graybill, paratype SUI 34218 is from Locality 3. Specimens reposited in the Geology Department Repository, University of Iowa.

Class BLASTOIDEA Say

Order FISSICULATA Jaekel

Family **CODASTERIDAE** Etheridge and Carpenter

Genus **AGMOBLASTUS** Fay, 1961

Type species: *Paracodaster dotti* Moore and Strimple, 1942.

Generic diagnosis. — A fissiculate blastoid with eight moderately well-exposed hydrospire fields, with four-eight hydrospire slits in each field, one large U-shaped epideltoid with an elongate anal opening between it and the radial plates, possibly with a small atrophied hyperdeltoid (missing), with four high, wide, arrow-shaped deltoid plates, ambulacra well away from oral opening, three large basal plates, and subcylindrical shape in side view (*fide* Fay, 1961).

Agmoblastus dotti (Moore and Strimple), 1942

Discussion. — The species *Agmoblastus dotti* remains the only reported blastoid of Pennsylvanian age above the Morrowan in the United States of America. Rich blastoid faunas are known from the Permian, particularly in Russia and Timor. The first specimen of *A. dotti* was found by Strimple in 1940, and close to a dozen specimens have been recovered through the years at the same locality.

Occurrence. — West flank of small bioherm exposed Locality 1. Original types are reposited in the U.S. National Museum and a topotype in the Paleontological Collections, University of Oklahoma, Norman, Oklahoma.

REFERENCES

All references to crinoids prior to 1943 may be found in Bassler, R. S., and Moodey, M. W., 1943, *Bibliographic and Faunal Index of Paleozoic Pelmatozan Echinoderms.* Geol. Soc. Amer., Special Paper 45, 734 pp.

Beede, J. W.
1898. *New corals from the Kansas Carboniferous.* Univ. Kansas Quart., vol. 7, pp. 17-18.

Cocke, J. M. and Bowsher, A. L.
1968. *New tabulate genus Sutherlandia (Coelenterata, Anthozoa) from Pennsylvanian of Oklahoma and Kansas.* Univ. Kansas Paleontological Contr. 33, 8 pp.

Cronoble, W. R.
1960. *An occurrence of Ulocrinus buttsi Miller and Gurley in Oklahoma.* Oklahoma Geol. Sur., Oklahoma Geol. Notes, vol. 20, No. 4, pp. 96-99, 1 pl.

————, and Mankin, C. J.
1965. *Petrology of the Hogshooter Formation.* Oklahoma Geol. Sur. Bull. 107, 148 pp.

Dana, J. D.
1846. *Genera of fossil corals of the family Cyathophyllidae.* Amer. Jour. Sci. (and Arts), vol. 2, i. pp. 178-189, 5 text-figs.

Davis, J. C.
1959. *Reef structure in the Plattsburg and Vilas Formations (Missourian) in southeast Kansas.* Compass, vol. 36, No. 4, pp. 319-335.

Fay, R. O.
1961. *Agmoblastus, a new Pennsylvanian blastoid.* Oklahoma Geol. Sur., Oklahoma Geol. Notes, vol. 21, No. 10, pp. 278-280, 1 pl.

Gerth, H.
1921. *Die Anthozoen der Dyas von Timor.* Lief ix, No. 16 of Wanner, J., *Palaontologie von Timor.* Stuttgart, pp. 67-147, pls. cxlv-cl.

Hall, J.
1851. *New genera of fossil corals from the report by James Hall on the paleontology of New York.* Amer. Jour. Sci., ser. 2, vol. 11, pp. 398-401.

Harbaugh, J. W.
1959. *Marine bank development in Plattsburg Limestone (Pennsylvanian), Neodesha-Fredonia area, Kansas.* Kansas Geol. Sur. Bull. 134, pt. 8, pp. 289-331.

Heckel, Philip H., and Cocke, J. M.
1969. *Phylloid algal mound complexes in outcropping Upper Pennsylvanian rocks of Mid-Continent.* Amer. Assoc. Petro. Geol. Bull., vol. 53, No. 5, pp. 1058-1074.

Hill, Dorothy, and Stumm, E. C.
1956. *Tabulata,* in *Coelenterata,* pt. F of Moore, R. C., ed., *Treatise on invertebrate paleontology.* Geol. Soc. America and Univ. Kansas Press, pp. F444-476.

Knapp, W. D.
1969. *Declinida, a new order of late Paleozoic inadunate crinoids.* Jour. Paleont., vol. 45, pp. 340-391, pls. 61, 62, 50 text-figs.

Koninck, L. G. de
1841-1844. *Description des animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique.* Pp. i-iv, 1-650, pls. A-H; 1-55, Liege.

Lin, B-yu
1963. *Nekotorie Kamennougolnuie i Permskie Tabulata Yuzhnoi Chasti Kitaya.* Acta Palaeont. Sinica, vol. 11, No. 4, pp. 579-607 (Some Carboniferous and Permian Tabulata from the southern part of China).

Mather, K. F.
1915. *The fauna of the Morrow Group of Arkansas and Oklahoma.* Denison Univ. Bull. Jour. Sci. Labs, vol. 18, pp. 59-284.

McCoy, F.
1847. *On the fossil botany and zoology of the rocks associated with the coal of Australia.* Ann. Mag. Nat. Hist., ser. 1, vol. 20, pp. 145-147, 226-236, 298-312, pls. 9-17.

Meek, F. B., and Worthen. A. H.
1865. *Note in relation to a genus of crinoids (Erisocrinus) from the Coal Measures of Illinois and Nebraska.* Amer. Jour. Sci., vol. 39, No. 2, p. 350.

Miller, S. A., and Gurley, W. F. E.
1890. *Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri, and Iowa.* Cincinnati Soc. Nat. Hist., Jour., vol. 13, pp. 3-25, pls. 1-4.

——— and ———
1894. *New genera and species of Echinodermata.* Illinois State Mus. Nat. Hist., Bull. 5, 53 pp., 5 pls.

Milne-Edwards, H. M., and Haime, J.
1850-1854. *A monograph of British fossil corals.* 1850, Intro. and pt. 1, lxxxv + 71 pp., 11 pls., 1851a, pt. 2, pp. 73-145, pls. xii-xxx: 1852, pt. 3, pp. 147-210, pls. xxxi, xlvi: 1853, pt. 4, pp. 211-244, pls. xlvii-lvi: 1854, pt. 5, pp. 245-299, pls. lvii-lxxii, Palaeontogr. Soc.

Moore, R. C., and Jeffords, R. M.

1945. *Description of Lower Pennsylvanian corals from Texas and adjacent states.* Univ. Texas Publ. 4401, pp. 63-208.

Moore, R. C., and Plummer, F. B.

1939. *Upper Carboniferous crinoids from the Morrow subseries of Arkansas, Oklahoma and Texas.* Denison Univ. Bull., Jour. Sci. Labs., vol. 32, pp. 209-313, pls. 12-16.

——— and ———

1940. *Crinoids from the Upper Carboniferous and Permian strata in Texas.* Univ. Texas Publ. 3945, 468 pp., 21 pls., 78 text-figs.

Moore, R. C., and Strimple, H. L.

1942. *Blastoids from Middle Pennsylvanian rocks of Oklahoma.* Denison Univ. Bull., Jour. Sci. Labs., vol. 37, pp. 85-91, 1 fig.

——— and ———

1970. *Proposed fixation of neotype of Poteriocrinus hemisphericus, 1858, type-species of Delocrinus, Miller and Gurley, 1890 (Crinoidea, Echinodermata), Z N. (S.) 1905.* Bull. Zool. Nomenclature, vol. 27, pp. 202-204, pl. 4.

Oakes, M. C.

1940. *Geology and mineral resources of Washington County, Oklahoma.* Oklahoma Geol. Sur. Bull. 62, 208 pp.

———,

1952. *Geology and mineral resources of Tulsa County, Oklahoma.* Oklahoma Geol. Sur. Bull. 69, 234 pp.

Phillips, J.

1836. *Illustrations of the geology of Yorkshire. Part II, The Mountain Limestone District.* pp. xx, 253, 25 pls. London.

Rowett, C. L.

1966. *Tabulate corals of the Wapanucka Formation,* in Rowett, C. L., and Cocke, J. M., *Studies of Pennsylvanian corals in Oklahoma.* Oklahoma Geol. Sur. Circ. 72, pp. 1-33.

Snider, L. C.

1915. *Paleontology of the Chester Group in Oklahoma.* Oklahoma Geol. Sur. Bull. 24, pp. 67-122, pls. 3-7.

Sokolov, B. S.

1955. *Tabulyaty Paleozoya Europeyskoy Chasty SSSR.* Vses. Neft. Nauchno-Issled. Geol. Razved. Inst. (VNIGRI), nov. ser., vol. 85, 527 pp., 82 figs., 90 pls. (Paleozoic tabulates of the European part of USSR).

Strimple, H. L.

1938. *A group of crinoids from the Pennsylvanian of northeastern Oklahoma.* Bartlesville, Oklahoma, 12 pp., 2 pls.

———,

1939. *A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma.* Bull. Amer. Paleont., vol. 25, No. 87, 26 pp., 3 pls.

———,

1951a. *New Desmoinesian crinoids.* Washington Acad. Sci., Jour., vol. 41, pp. 191-194, 20 figs.

———,

1951b. *Pennsylvania crinoids from Lake Bridgeport, Texas.* Jour. Paleont., vol. 25, pp. 200-207, pls. 36-39.

———,

1960. *The genus Paragassizocrinus in Oklahoma.* Oklahoma Geol. Sur.. Cir. 55, 30 pp., 3 pls.

———,

1961. *Late Desmoinesian crinoid faunule from Oklahoma.* Oklahoma Geol. Sur., Bull. 93, 189 pp., 19 pls., 23 text-figs.

————, and Moore, R. C.

1971a. *Crinoids of the LaSalle Limestone (Pennsylvanian) of Illinois.* Univ. Kansas, Paleo. Contr. Art. 55, 48 pp., 23 pls.

———— and ————.

1971b. *The family Diphuicrinidae.* Univ. Kansas, Paleo. Contr., Paper 56, pp. 1-9, figs. 1-3.

————, and Watkins, W. T.

1969. *Carboniferous crinoids of Texas with stratigraphic implications.* Palaeontographica Americana, vol. 6, No. 40, pp. 141-266, pls. 30-56, 2 text-figs.

Tchudinova, I. I.

1965. *The Coelenterata,* in *Evolution and change of marine organisms at the boundary between Paleozoic and Mesozoic.* By V. E. Ruzhencev and T. G. Sarycheva, editors. Akad. Nauk SSSR, Paleont. Inst., Trudy, vol. 108, pp. 150-156, pls. 7-11.

Waagen, W., and Wentzel, J.

1886. *Salt Range fossils.* vol. 1, *Productus Limestone fossils, pt. 6, Coelenterata*: India Geol. Sur. Mem., Paleontologia Indica, ser. 13, pp. 835-924, pls. 97-116, text figs. 26-32.

Wanner, J.

1924. *Die permischen Krinoiden von Timor.* Teil 2, Jaarb. Mijnw. Ned-Indie, Verh. 1921, Gedeelte 3, 348 pp., 22 pls., 61 text-figs.

Wells, J. W.

1944. *New tabulate corals from the Pennsylvanian of Texas.* Jour. Paleont. vol. 18, No. 3, pp. 259-262, pls. 40-41.

West, R. R.

1964. *A Middle Pennsylvanian tabulate coral.* Jour. Paleont., vol. 38, No. 1, pp. 151-153.

White, C. A.

1880. *Descriptions of new species of Carboniferous invertebrate fossils.* U.S. Nat. Mus., Proc., vol. 21, pp. 252-260, 1 pl.

Wilson, F. W.

1957. *Barrier reefs of the Stanton Formation (Missourian) in southeast Kansas.* Kansas Acad. Sci. Trans., vol. 60, No. 4, pp. 429-436.

Worthen, A. H.

1890. *Description of fossil invertebrates.* Illinois Geol. Sur., vol. 8, pt. 2, pp. 71-83, 102-154, pls. 9-11, 18-28.

Yakovlev, N. N.

1939. *Noveaux genres de coraux Tabulata du Permien inferieur de l' Oural et du bassin der Donetz.* C. R. Acad. Sci., Moscow, n. s., vol. 24, No. 6, pp. 629-632.

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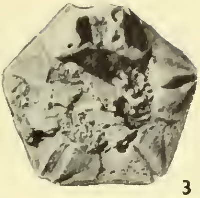
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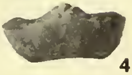
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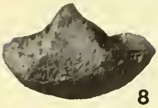
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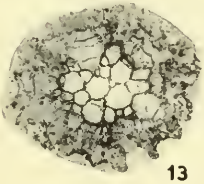
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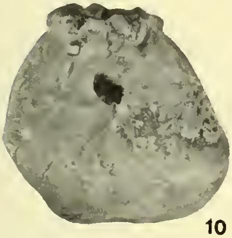
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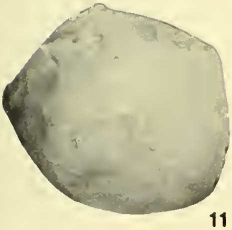
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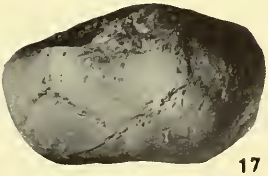
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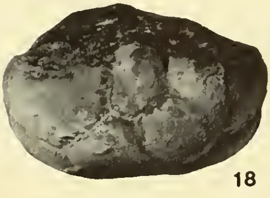
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1973

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STRATIGRAPHY AND GENERA OF CALCAREOUS FORAMINIFERA OF THE FRAILEYS FACIES (MISSISSIPPIAN) OF CENTRAL KENTUCKY

R. G. Browne*
and E. R. Pohl†

ABSTRACT

An unusual and prolific free-form foraminiferal assemblage of the Fraileys Shale facies of the Big Clifty Formation (Chesterian) in central Kentucky is discussed at the generic level. The lithostratigraphy of the deposits shows that they are part of a regressive sequence related to the Beech Creek Limestone as a clay prodelta accumulation below sheet sands in a prograding delta extending into the Illinois Basin from the east and north. Faunal comparisons indicate that the Fraileys facies occupies a position near the end of the Visean Stage and is essentially equivalent to beds of the Lower Serpukhov or Upper Okskaya Suites of the Russian Platform.

Twenty-one genera in the families Parathuramminidae, Earlandiidae, Archaediscidae, Lasiodiscidae, Pseudoammodiscidae, Tetrataxidae, Endothyridae, and Ozawainellidae are treated, comparing original descriptions and illustrations with indigenous forms. The genera *Archaesphaera, Eotuberitina,* and *Neotuberitina* are shown to be synonyms of *Diplosphaerina.* The first American occurrence of *Rauserina* is reported. The phylogenetics of the family Archaediscidae are discussed and trends are associated with relative chronologic stages in its short history. *Tubispirodiscus,* a new planospiral archaediscin genus, is established, and its value as a biostratigraphic marker is indicated. *Planospirodiscus* is assigned to the asteroarchaediscins. The first mid-Continent record of *Monotaxinoides* is given. The genus *Cornuspira,* as used in America, is assigned to *Pseudoammodiscus.* The genus term *Endothyra* is discussed at length and is restricted in its application in the present paper. *Calcivertella, Calcitornella, Pseudoglomospira, Trepeilopsis,* and *Rectocornuspira* are assigned to the family Pseudoammodiscidae.

INTRODUCTION

A preliminary note was published in 1968 (Pohl, Browne, and Chaplin) announcing the discovery of an unusual, prolific, and excellently preserved free microfauna in deposits of the Fraileys facies of the Big Clifty Formation in central Kentucky, and plans for its study. The systematics section of this paper concerns itself exclusively with the genera of the calcareous Foraminifera. Forms other than calcareous make up the remainder of the original determination of a faunule containing representatives of 16 families and 37 genera. The section on stratigraphy provides a sedimentational framework for the deposits preserving this remarkable microfaunal assemblage.

At the time this study was begun the magnitude and intrinsic problems of the project were not fully comprehended by the authors. Because the fauna is free form and mostly ultrasmall, a method

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was required to help eliminate the tedious and mostly inadequate process of thin section making employed by previous workers. A technique to provide ultimate control of orientation in specimens often no larger than 100 microns had to be devised (Pohl and Browne, 1973, in press). Validity of taxon diagnosis depends often on precisely correct specimen orientation — sections that parallel axial or equatorial planes and which pass through specimen center (proloculus of coiled forms). Rauser-Chernousova (1948 a,b) in a discussion of the family Archaediscidae lamented the unavailability of specimens except those randomly cut in embedding limestone. This fauna has provided a unique opportunity to practice controlled orientation of material.

The largest share of thin section studies of calcareous Foraminifera has been done by Russian workers. Few of these publications are readily available in this country. The procuring and translation of original Russian papers have been excessively time-consuming. Although our original intent was to systematize taxonomically allied forms, it became evident that laboratory technique should be reported first. Likewise, a paper devoted to descriptions of genera, including descriptive text and illustrations direct from original authors, should take precedence over detailed taxonomic organization.

Some of the pertinent genera are characterized in the Treatise on Invertebrate Paleontology (Loeblich and Tappan, 1964). However, because of the magnitude of that work and its all-encompassing nature, generic details are sometimes limited. We are not in accord with the Treatise on its concept and synonymic treatment of some genera. In addition, much information has become available since 1964. It is our desire to share this knowledge with American workers.

We have been able to visualize and hopefully establish some evolutionary trends among Mississippian Foraminifera which might otherwise have been impossible had we not had an inexhaustible supply of three-dimensional specimens for study.

PREVIOUS WORKERS

A great number of papers treating calcareous Mississippian Foraminifera have been published by American workers since 1968.

B. L. Mamet, micropaleontologist of the Department of Geology at the University of Montreal, Montreal, Canada, has been the most prolific worker. The publications of Dr. Mamet, as well as those of most other American workers, however, have been devoted primarily to biostratigraphical studies, the listing of species, faunal assemblages with percentages of various genera, their ranges, and worldwide distribution. In this category are those of Sando, Mamet, and Dutro (1969) and Mamet and Skipp (1971). Outstanding studies that deal with detailed faunas and specific identifications are those of Skipp, Holcomb, and Gutschick (1966) of the subfamily Tournayellinae and Mamet (1970) on a microfauna from the Windsor Group (Carboniferous), from Nova Scotia and New Brunswick.

Acknowledgments

We are especially indebted to Dr. Raphael Conil of the Department of Geology, the University of Louvain, Louvain, Belgium. He reviewed our material and a preliminary draft of this manuscript. His counsel, advice, and suggestions were invaluable.

Both authors greatly appreciate the time and help given by Dr. Mamet in providing suggestions and his interpretation of various genera. We also appreciate his permission to publish a part of his unpublished work in respect to the genus *Endothyra.*

We gratefully acknowledge the assistance of the following individuals besides Dr. Conil and Dr. Mamet who helped us by providing needed difficult-to-obtain publications and illustrations — the late Prof. Thomas Perry, Department of Paleontology, Indiana University, Dr. Alan Horowitz of the same institution, and Dr. James W. Baxter of the Illinois State Geological Survey.

All persons involved have been unstinting in their generosity, both of time and material, without which the preparation of this study would have been more difficult and the scope less broad.

STRATIGRAPHY

E. R. Pohl

Review

Field and laboratory material for this study resulted from investigations begun in 1964 on the biostratigraphy of Illinois Basin

Upper Mississippian carbonates. Systematic close-interval sampling of numerous vertically extensive exposures, particularly in central Kentucky, has provided an integrated library of thin sections under one roof that offers ready comparison of deposits from the limestone lenticles of the Fort Payne Formation upward through the Kinkaid Limestone. These include controlled stratigraphic samplings of all type or principal reference sections for carbonate deposits in the type region of the Mississippian System.

During the field work all argillaceous or poorly consolidated strata in the field sections were also systematically sampled for disaggregation, preparation, and examination for microfossils. Nine horizons yielded essentially unabraded examples of the foraminiferal microfauna in natural form.

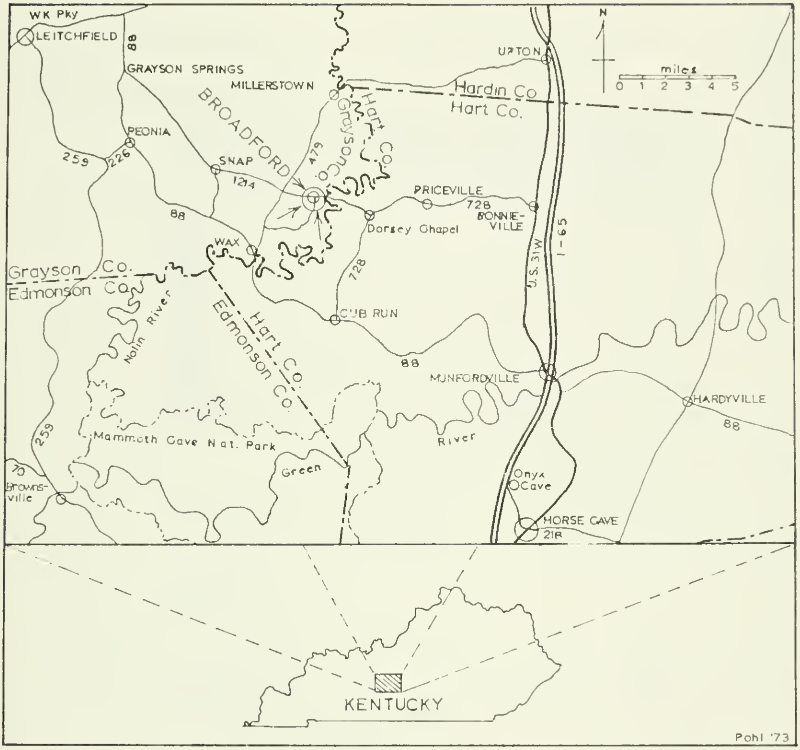
The microfauna of the Fraileys Shale facies at Broadford is unique, because it is the only one of several dozen localities sampled at this horizon to produce the magnificently preserved and varied assemblage of Foraminifera reported in this paper.

Prior to the initiation of this study serious attention to the calcareous Foraminifera of the Mississippian type region was limited to a handful of paleontological references. Some of these were incidental to other interests or were not interested in total assemblages or taxon range and distribution; others included serious misidentification of stratigraphic occurrence. There was little or no awareness of the monumental contribution of Russian foraminiferologists to the fields of systematics and biostratigraphy.

LOCATION

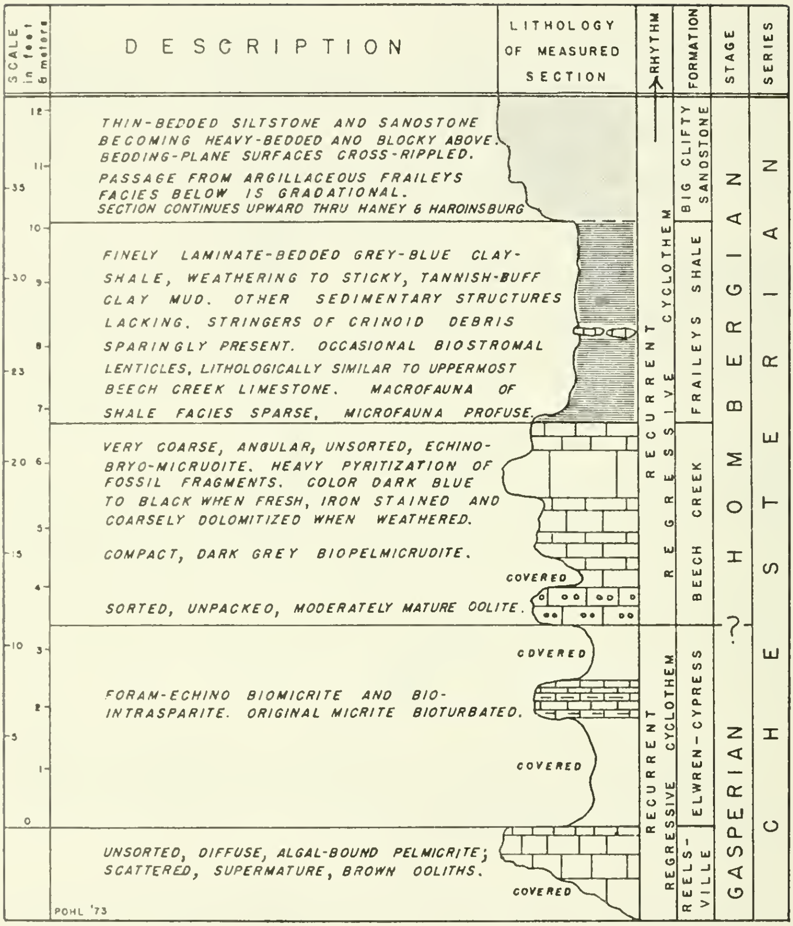
The entire assemblage of Foraminifera reported in the Systematics section of this paper comes from a single locality in central Kentucky. Geographical location is shown in Text-figure 1, along with its accessibility by highway, and details of local stratigraphy are represented in Text-figure 2.

The concerned beds are 11 feet (3 m) of grey-blue clay shale exposed for 200 feet in the road ditch and bank of the west side of the Broadford Church Road, 200 feet south of its junction with Ky. 1214 at Broadford, Grayson County, in the northwest quarter of Section 11, K42, NJ 16-8, Evansville Sheet of the Carter Coordinate System, Millerstown Quadrangle, GQ-417, Kentucky.



Text-figure 1. — Map showing geographic location of collecting site for the Fraileys facies. The exposure is an artificial road bank and ditch that has become obscure through overgrowth and surface slump. Precise directions for finding this site are contained in the text.

The lowest two feet of the Fraileys Shale at this site is covered, and its depth to the top of the underlying Beech Creek Limestone was determined through the use of post-hole equipment. Samples of the limestone at the contact were secured for thin sectioning to establish the sequence. The entire exposure is presently badly deteriorated through the overgrowth of vegetation and could easily be overlooked. The shale, as described in the measured section, is finely bedded, grey-blue in color and weathers to a dirty tannish-buff mud. When first exposed, during road construction in 1963, occasional streaks of crinoid debris and a single layer of crinoidal limestone lenticles up to two inches in thickness were in evidence.



Text-figure 2. — Composite measured section, consisting of the type locality of the Fraileys facies for the microfauna described in this report and a nearby exposure of the Beech Creek Limestone and related beds below. The Fraileys exposure is near the junction of Ky. Highway 1214 and the Broadford Church road at Broadford, Grayson County, and the supplementary exposure is along Ky. 1214 one mile east near Howe's Store, Hart County. The former exposure lies in an area of complex warping and faulting and does not clearly show the rock succession bounding the Fraileys Shale. The classification of the beds by stage differs from the standard in the inclusion of the Beech Creek Limestone in the Hombergian because the microfaunas of the Beech Creek and Fraileys are essentially similar and unlike that of the underlying Gasperian.

Small sideritic single crystals and masses, pseudomorphic after pyrite and marcasite, were abundant. These features no longer remain.

The exposure is on the edge of a northwardly dipping sharp flexure in a complex structural pattern of the Rough River Fault Zone. Although Upper Gasperian limestone beds are exposed nearby, the immediate vicinity can not be used to determine columnar section. Because of this, a continuous, undisturbed exposure one mile east of the Broadford site was used to supplement and establish the relations of the Fraileys facies to overlying and underlying strata. The second exposure is along the south side and bank of Ky. 1214 in a steep rise one-half mile east of the bridge crossing of Nolin River. Here, a pronounced topographic bench marks the base of the Fraileys shale where the tough, heavily pyritized upper beds of the Beech Creek Limestone resist erosion. Another bench occurs at the base of the Elwren horizon because of the resistent character of the upper beds of the Reelsville Limestone. About 12 feet of shale occupies the Fraileys interval; but here it contains no calcareous inclusions and no fauna has been recovered.

At both sites there is a depositional gradation from the fine clay of the Fraileys facies upward into the fine siltstones of the lower part of the Big Clifty facies. Gradation continues to the coarse, heavy-bedded sandstones of the main body of the Big Clifty Sandstone above. Elsewhere throughout the exposure of these deposits the sequence above the Beech Creek Limestone is not so clearly defined.

ENVIRONMENT

The depositional environment that accounted for the accumulation and preservation of the finely argillaceous Fraileys facies at Broadford can best be exemplified by comparison with a recent delta occurrence. Gould (1970, p. 11) summarized the shoal-water deltaic facies of the Lafourche delta in the Gulf of Mexico. Here, prograding deposits have extended over shallow inner-shelf areas and the frequent plugging of distributary channels has required the delta front to expand laterally to accommodate an increasing number of bifurcating distributaries as the delta moved forward on the shelf. Sands were transported to form the continuous delta front, while silts and clays were carried further into the Gulf in a prodelta zone. Water depth rarely exceeded 30 feet, although local subsidence consequent upon additional burden accounts for some sand bodies of greater thickness. The accumulation of sheet sands was followed by marsh conditions in a deltaic plain. A sequence of prodelta silty clay, delta-front sheet sands, and marsh deposits, is typical of such an environment. The entire complex, now abandoned, has continued to subside, allowing marine waters to transgress its seaward parts. The latest marsh deposits are presently being either eroded or buried by transgressing marine deposits.

All facets of sequential events portrayed for the Lafourche delta are found in the Fraileys-Big Clifty deposits at exposures within a mile or two of Broadford.

Following comparatively rapid filling by predominantly clastic deposits during early Mississippian time the eastern part of the Illinois Basin underwent a long period of stability. During the accumulation of thick St. Louisan, Genevievian, and Gasperian evaporites and marine limestone subsidence was controlled by internal conditions corresponding to the slow development of chemogenic and biogenic deposits. An overall steady state of equilibrium was maintained in the Basin, but there was a periodic response of overreaction to the loading which resulted in the production of a series of regressive cyclothems (Pohl, 1970, p. 7). Only occasionally was the carbonate sequence interrupted by submarine scour and advance of finger-like sand-body projections from the east, notably those of the Bethel Sandstone and Sample Sandstone (Simon and Hopkins, 1966, p. 12). The introduction of terrigenous clastics from outside the Basin is responsible for triggering the irregularly spaced subsidences which continued, at a decreasing rate, following the overloading episode. Continued subsidence permitted both burial and removal of parts of the marsh deposits prior to the deposition of later clear-water marine limestones. As the clastics extended farther and farther into the Basin from various directions, the periods of offlap grew and those of marine onlap were less pronounced until the final overwhelming of the Basin by massive deltaic material, and accompanying scour, at and near the Mississippian-Pennsylvanian boundary, curtailed marine invasion.

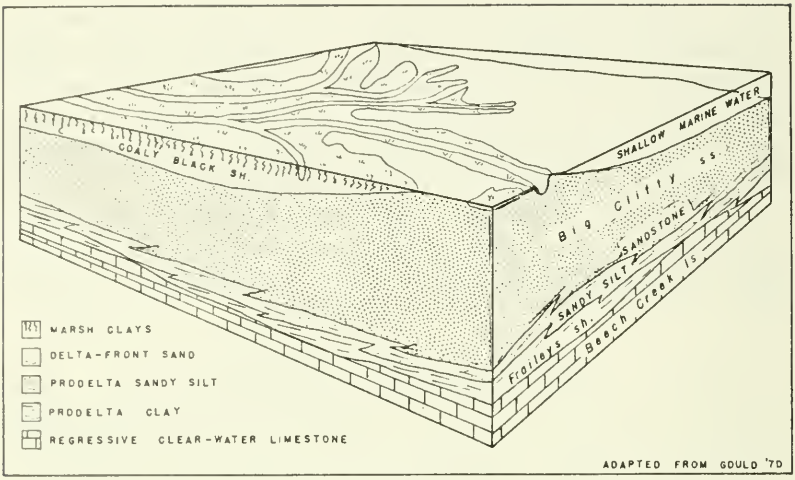
The clay-shale comprising the Fraileys facies in the Broadford area accumulated as an early facet in this complex environment of a filling and subsiding gulf. Farther west and south this lithology occupied later stages in the life of the expanding deltaic complex. Throughout the deposition of a thick sedimentary series connection with the open seas was maintained and marine waters transgressed the sinking deltaic clastics in an ever-changing pattern.

Text-figure 3 graphically represents generalized depositional conditions at a time corresponding to the end of the Fraileys-Big Clifty regression and just prior to the encroachment into the Broadford area of the Haney marine environment.

DISTRIBUTION AND STRATIGRAPHY

Text-figure 2 depicts a composite measured field section of the deposits involved in the present report. The Beech Creek member of the cyclic couplet is widely distributed. Malott (1952, p. 14) reported the northernmost occurrence in an outlier in northern Owen County, Indiana. This is just south of the latitude of Indianapolis, some 20 miles north of its type section. It is a most persistent unit, considering its average thickness of less than 15 feet (5 m), having been reported as far east as Pulaski County (McFarlan and Walker, 1956) and Rowan County (Pohl and Philley, 1971) in eastern Kentucky, far outside the Illinois Basin. It is apparently uniformly present throughout central Kentucky. It is the commonly identified Barlow Lime of the Basin subsurface and outcrops on the western border of the Basin in southern Illinois. In the latter area, however, the lowest beds of what McFarlan and Swann (*in* 1955, p. 20) assigned to the Fraileys Shale is identical, in lithology and microfauna, to the uppermost beds of the Beech Creek Limestone at the Broadford, Kentucky locality. Thus, the thickness of the Beech Creek Limestone in Illinois is probably about 15 feet (5 m) instead of the one foot six inches (0.5 m) reported.

In the vicinity of Broadford, the Beech Creek Limestone outcrops at numerous points and was studied in relation to this paper at more than 30 localities. Notable exposures are to be found along U.S. Highway 62 near Summit in Hardin County; along the county road between Kessinger and Priceville, in the upper part of the Hart Stone Co. quarry near Horse Cave in Hart County; and along Ky. 70 near Turnhole and beside the Cedar Sink road in Mammoth Cave



Text-figure 3. — Generalized depositional conditions in an environment during the development of a shallow-water delta and the resulting sequence of sediments. The time shown corresponds to the close of the Fraileys-Big Clifty regression and just prior to the advance of clear-water marine conditions of the Haney sea in the Broadford area.

National Park. The southeasternmost known exposure in the Basin is in new cuts of the Green River Parkway, four miles west of Bowling Green in Warren County, Kentucky.

The Fraileys-Big Clifty member of the couplet constitutes the most prominent geomorphic expression of the rock column in central Kentucky, standing as a scarp wherever the member is predominently sandstone. However, the shale facies is seldom to be seen. On natural slopes the shale disassociates freely, dissolution of the underlying limestone removes support further and the resistent sandstone beds slump over the scarp edges, effectively masking the existence of a shale horizon. Also, the shale is known to be absent at about one-half of the exposures of this interval which have been examined. Such an absence is most likely due to scour removal following deposition and prior to the settling of sheet sands in contact with the Beech Creek Limestone. Wherever the limestones of the Beech Creek are followed upward by the Fraileys Shale facies the contact between these lithologies is sharp but conformable. In the absence of the shale, it is customary that the upper surface of the limestone is grossly hummocky and exhibits irregular discontinuity of strata.

The Fraileys Shale is not reported from Indiana; however, exceptionally, there appears a "transitional contact" or "arenaceous" limestone at the top of the Beech Creek limestone (Perry and Smith, 1958, pp. 72-73). Throughout central Kentucky the Beech Creek Limestone is commonly followed by 2 to 15 feet (1 to 5 m) of the Fraileys facies, most often composed of clay-shale which becomes increasingly coarse and micaceous upward and occasionally includes one or more layers or lenticles or beds of limestone. These relations are excellently exhibited in the Green River Parkway cuts mentioned above in the listing of notable exposures of the Beech Creek Limestone. Across the Basin in southern Illinois siliceous, clayey, and calcareous beds alternate. A fresh outcrop of this interval occurs in cuts of Illinois Highway 146, near its intersection with Interstate Highway 1-57, four miles east of Anna.

BIOSTRATIGRAPHY

Text-figure 4 lists the known calcareous Foraminifera of the Fraileys sediments at the generic and species-group level. It does not show siliceous forms, of which a number are known, nor does it indicate the presence of organic remains whose exact affinities presently are questionable or unknown. The listing here of *Climacammina mississippiana* Conkin requires explanation, because it does not occur at Broadford and has not been identified in Fraileys deposits except at Conkin's type locality for the species. It is known from massive yellowish oo-biosparites of uncertain stratigraphic affinities near Natural Bridge State Park and, in company with an assemblage of *Zellerina, Endothyra* aff. *kentuckyensis, Hemiarchaediscus,* and *Neoarchaediscus* at Armstrong Hill, Rowan County, in eastern Kentucky (Pohl and Philley, 1971). Here it occurs in profusion, as it does also in the type area deposits of the Beech Creek Limestone. It may prove to be a stenobiont, although this appears unlikely in view of the wide facial acceptance known among the paleotextularids. It is mentioned here because of its dominance of the Beech Creek microfauna at its type locality and its absence at Broadford despite the similarity in the remainder of the assemblages.

SYMBOLS---P-profuse, VA-very abundant, A-abundant, VC-very common, C-common, R-rare, VR-very rare, X-present.	K-23 Fraileys facies, Broadford, Grayson Co., Ky.	K-24 Beech Creek ls. Howe's Store, Hart Co., Ky.	N-9 Beech Creek ls. Beech Creek Type Loc. (Ind.)	L-3 Beech Creek ls. Fraileys Type Loc. (Ill.)
Calcisphaera laevis (W)	VC	X-A	C	C
?Asterosphaera sp.	X			
Diplosphaerina (Diplosphaerina) sp.	C	X-A		
D. (Eotuberitina) sp.	C	X-A	C	C
Rauserina sp.	X		VR	
Earlandia gr. vulgaris	P	X-A	C	C
E. gr. elegans	C	X	C	R
Pseudoammodiscus sp.	VR	X	R	R
Rectocornuspira sp.	VR			
Calcitornella sp.	C	X-C	C	
Calcivertella sp.	R		C	
Trepeilopsis sp	R			
Pseudoglomospira sp.	R	X-C	C	R
Endothyra gr. similis	R	X	A	A
E. (minute, few chambers)	VA	X	A	
E. aff. kentuckyensis (D. Zeller)		X		R
Zellerina sp. (2-whorl)	R	X		C
Z. sp. (3-4 whorl)	R	X	R	C
Z. sp. (ovoid)	C			
Tetrataxis sp.	C	X	R	R
Archaediscus sp. (w/2 layers)	C	X	R	C
A. sp. (w/1 layer)	C	X		
Hemiarchaediscus aff. cornuspiroides (B&V)	A	X		C
Tubispirodiscus simplissimus B&P	C			
T. sp. #2	C	X	VR	R
Neoarchaediscus gr. gregorii	P	X	P	C
N. gr. incertus	C	X		C
N. sp.	C			
Planospirodiscus sp.	X	X	R	R
Monotaxinoides sp.	VR			VR
Eostaffella sp.	R	X-C		R
Climacammina mississippiana Conkin*			P	

*It is noteworthy that Climacammina mississippiana is reported only from the type locality of the Beech Creek Limestone. Its inclusion in the above listing emphasizes its absence from the Fraileys facies at Broadford.

Text-figure 4. — Faunal listing of the calcareous foraminifer assemblage of the Fraileys facies at Broadford, Kentucky, compared with similar assemblages of the associated Beech Creek Limestone nearby and at two distant sites, in Indiana and Illinois. The locality symbols refer to the catalogue of the Pohl Collection of petrographic thin sections of the Mississippian carbonate succession of the Illinois Basin.

Four previously separate genera are included here under the encompassing term *Diplosphaerina* because it is now known that they are all unicameral, possibly colonial but more probably accidentally combined. This, along with *Calcisphaera* and *Asterosphaera,* because of shell simplicity and known long range are of little stratigraphic value. Likewise, *Earlandia* and *Pseudoglomospira* lend themselves poorly to such purposes. Although simple in construction, on the other hand *Pseudoammodiscus, Rectocornuspira, Calcitornella, Calcivertella,* and *Trepeilopsis* are generally unknown below the middle Gasperian. Of the endothyrids present, only *Endothyra* aff. *kentuckyensis* (D. Zeller) is known to have a restricted range. *Zellerina* ranges from the mid-St. Louisan through the Chesterian; however, its dominant role, with a peak in the Reelsville Limestone, from mid-Gasperian through mid-Chesterian gives it broad value. *Eostaffella* is an uncommon component in the Illinois Basin faunas and, therefore, is of no consequence. This also applies to *Monotaxinoides* which is listed here probably at the base of its range, yet which, because of its scarcity and difficulty of recognition, has been little used.

Values for stratigraphic purposes, on the other hand, are extremely high in the case of the abundant archaediscids. Only *Archaediscus* sp. (with two layers) retains the ancestral characteristic of the double-layered wall structure of an inner dark, homogeneous and an outer clear, radial crystalline test. All other forms, both archaediscin and asteroarchaediscin, exhibit a terminal stage of a phylogenetic trend toward the elimination of the inner dark, separate layer. The peculiar assemblage of one-layered *Archaediscus* sp., *Hemiarchaediscus* aff. *cornuspiroides* (Brazhnikova and Vdovenko), *Tubispirodiscus simplissimus* Browne and Pohl, n. gen., n. sp., several undescribed species of *Tubispirodiscus, Neoarchaediscus* gr. *incertus,* and *Planospirodiscus* sp. is one of advanced archaediscids of the single-layer type and is unique to this stratigraphic position. Some beds of the Beech Creek Limestone, particularly in its upper part, and the Fraileys facies microfauna are overwhelmed by these forms.

A microfauna composed of the genera *Archaediscus, Hemiarchaediscus, Neoarchaediscus,* and *Planospirodiscus,* all of the single-layer type, with many elements closely related to the Fraileys forms occurs in the highest Visean of Belgium (V3c, Bioul). Samples of these strata have been provided for study by Prof. R. Conil of the University of Louvain. Among the examples is a form tentatively identified as *Tubispirodiscus* Browne and Pohl, n. gen. As is the case with the Beech Creek-Fraileys occurrence these small, advanced archaediscids appear in overwhelming numbers, nearly to the exclusion of other taxa.

Vdovenko (1968) reported an unusual assemblage of Foraminifera from the Dnieper-Donetz depression. Striking similarities to the Beech Creek-Fraileys microfauna are found in the occurrence of *Archaediscus* (*Hemiarchaediscus*) *cornuspiroides* Brazhnikova and Vdovenko, *Archaediscus compressa* Vdovenko, *Asteroarchaediscus* (*Neoarchaediscus*) *parvus* Reitlinger, and *Neoarchaediscus* gr. *timanicus*. Moreover, Vdovenko reported the presence of associated *Rectocornuspira*, a *Plectogyra* (*Endothyra*) with features apparently identical to those of the American Fraileys, and an *Endostaffella* which would appear to be identical to a Fraileys *Zellerina*. These forms are found in a "clayish limestone", and Vdovenko (1968, p. 6) said that "This assemblage characterizes the final regression phase of the Visean sedimentary cycle".

The general complexion of the macrofauna for the Fraileys Shale facies at Broadford was reported by Pohl, Browne and Chaplin (1968). The fauna is uncommon but varied and is mostly associated in thin biostromes irregularly spaced throughout the 11 feet of shales present at this locality. Elements include the solitary coral *Triplophyllites spinulosus* (Edwards and Haime); the brachiopods *Cleiothyridina* aff. *C. sublamellosa* (Hall), *Reticulariina spinosa* (Norwood and Pratten), *Orthotetes kaskasiensis* McChesney, *Derbyia* sp., *Rhynchopora*(?) *perryensis* Weller, *Spiriferina transversa* McChesney, *Eumetria costata* (Hall), *E. vera* (Hall), and *Diaphragmus cestriensis* (Worthen); the Bryozoa *Batostomella spinulosa*, *B.* sp., and *Archimedes* several sp.; and the pelecypod *Aviculopecten* sp. None of these taxa is stratigraphically narrowly restricted, but the assemblage typically represents the upper middle Chesterian.

The crinoid assemblage of the Broadford Fraileys was examined by H. L. Strimple and has been reported by Burdick and

Strimple *in* Furnish, *et. al.* (1971, p. 17). Among the forms recognized are *Zeacrinites* sp., *Intermediacrinus hinmanni* Burdick and Strimple, *Agassizocrinus* several sp., *Phacelocrinus* sp., *Aphelocrinus* sp., and *Acrocrinus constrictus* Burdick and Strimple. This group of crinoids was compared with a crinoid assemblage recovered from the Beech Creek Limestone of southwest Illinois, the Lower Fayetteville Formation of Oklahoma, and the Visean of Great Britain. It is concluded that the crinoids of the Beech Creek-Fraileys association are of little value for correlation of strata over extended distances.

Prepared samples of the Fraileys Shale at Broadford were sent to Dr. V. A. Chizgova of the All-Union Oil-and-Gas Scientific-research Institute (VNII), Moscow, USSR, for examination of the ostracode assemblage. Following are excerpts of her report, as contained in a letter dated July 6, 1972:

> The ostracod association of this sample is rich and represented by perfectly preserved forms. There are found:
>
> 1. *Shivaella* aff. *nichlensis* (Ulrich)
> 2. *Psuedoparaparchites kansensis* Kellet
> 3. *Polytilites trilobus* (Croneis and Gale)
> 4. *Amphissites* aff. *batalinae* Posner
> 5. *Amphissites* cf. *mosquensis* Posner
> 6. *Kirkbya regularia* Croneis and Gale (Specimen is similar to *K. lessnikovae* Posner)
> 7. *Kirkbya marginata* Croneis and Funkhouser (specimen is similar to *K. volginoensis* Posner)
> 8. *Knightina* sp.
> 9. *Joungiella naviculata* Posner
> 10. *Kirkbyella* (*Berdanella*) aff. *quadrata* (Croneis and Gutke)
> 11. *Scrobicula* sp.
> 12. *Glyptopleurina* aff. *bulbosa* Croneis and Gale
> 13. *Healdia menisca* Cooper (specimen is similar to *H. kudrjavtzevi* Posner)
> 14. *Healdia* aff. *cornuta* Posner
> 15. *Healdianella* aff. *darwinuloides* Posner
> 16. *Acutiangulata* sp.
> 17. *Bairdia* sp.

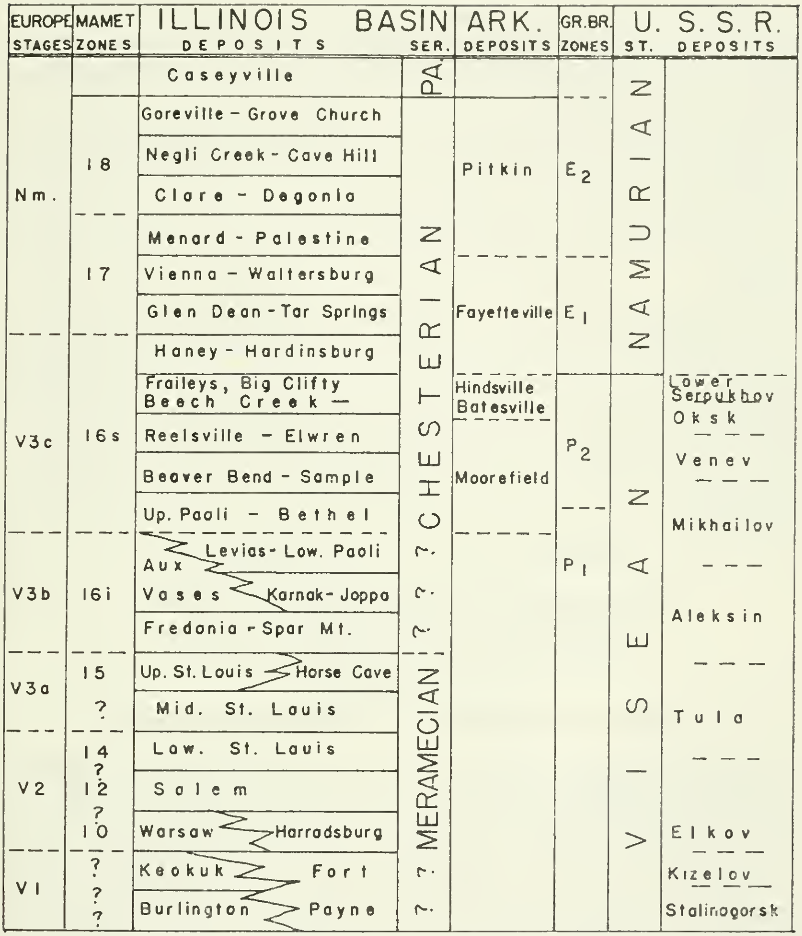
Chizhova's report continues by indicating that ostracod associations of similar composition are distributed in the upper part of the Oksk and the lower part of the Serpukhov deposits of the Russian Platform (which is exactly the stratigraphic position ascribed to Vdovenko's peculiar foraminiferal assemblage given in detail above). However, it is difficult to be more exact on the question of correlation because the species composition of the Fraileys is somewhat different from any known in the Lower Carboniferous of the USSR. The most satisfactory correlation according to generic composition would be with the lower part of the Serpukhov deposits. On the basis of comparison of Chizhova's and Vdovenko's explications it would seem that a precise intercontinental correlation can be pointed to.

The abundance of botanical fossils in the silts and sandstones of the Big-Clifty facies is well known. These occur both as carbonized remains and as internal and external impressions. Less well known is the presence of occasional pyritized and silicified *Dadoxylon* logs, large fragments of which have been recovered near Munfordville in Hart County, Kentucky. In such specimens the cellular structure is most excellently preserved.

CORRELATION

In the absence of ammonoids or colonial corals from among the biota of the Fraileys deposits at Broadford, no exact comparison of these beds is possible with deposits occupying a similar interval outside the Illinois Basin. There is, however, a mounting body of information being built on the basis of foraminifer content for a universal scale for the lower Carboniferous deposits. Russian micropaleontologists have been foremost in their efforts to systematize an understanding of a foraminifer sequence for Eurasia. European efforts in this direction have intensified in Belgium and Great Britain. In North America the systematic use of Mississippian Foraminifera for stratigraphic understanding is less than 25 years old and has suffered from some seriously inexact chronostratigraphic concepts.

In view of all known considerations, comparisons are made for the Fraileys facies as shown in Text-figure 5. Direct comparisons are presently not possible with the standard stages of western and eastern Europe because they have been established on faunal elements which are either not present in the Kentucky Mississippian record in sufficient quantities for use, or on which no definitive work exists. It has, therefore, become necessary to rely on a correlation of the Fraileys deposits in Kentucky and Illinois with those of Arkansas (Furnish, 1971, p. 5) where an established ammonoid sequence has been determined. Thus correlations, of what can be



Text-figure 5. — Chart of inferred correlation of the Fraileys facies deposits with units in Arkansas, Great Britain, and the USSR (North-Western Border of the Mediterranean Geosyncline and Russian Platform) compared with regional and interregional zonal schemes. Formational units in the Illinois Basin above the St. Louis Limestone have been arranged into recurrent couplets, recognizing their predominantly regressive cyclical common characteristics.

considered in close tolerance, are possible with European counterparts. The use of foraminifer content, as indicated in this report, may well become worthwhile additional information toward this end.

An effort has been made in Text-figure 5 to adjust the foraminiferal zonation scheme of Mamet and Skipp (1971, pp. 1135-1139) to known generic occurrence and range within the Illinois Basin. This has been difficult in view of the lack of reliable published information for the Basin; but more particularly because of severe stratigraphic misinterpretation, that, prior to their examinations, had been applied to thin section collections at some of the institutions on which Mamet and Skipp relied in large part for their faunal listings.

Faunal evidence has been uncovered that brings up, once more, the possibility of the inclusion into the Chesterian Series of deposits as low as the Fredonia Limestone. It is now clear that fully developed representatives of the genus *Neoarchaediscus* are persistently present in beds near the base of the Ste. Genevieve Limestone throughout the Illinois Basin, including those at the type locality in Missouri.

SYSTEMATIC PALEONTOLOGY

Family **PARATHURAMMINIDAE** Bykova, 1955

Genus ?**ASTEROSPHAERA** Reitlinger, 1957

Plate 22, figures 1-3

Type species: *Asterosphaera pulchra* Reitlinger, 1957.

Archaesphaera Bykova and Polenova, 1955, pp. 16, 17, pl. 1, figs. 2-12; pl. 2, fig. 1; pl. 4, fig. 3.
Asterosphaera Reitlinger, 1957, p. 775; Bogush and Yuferev, 1962, p. 214, pl. 9, figs. 28-30.
?*Asterosphaera* Brazhnikova and Vdovenko, 1971, pl. 1, figs. 1, 6, 7.

Original description. — Spheres with radiated wall structures consisting basically of closely spaced massive 'rays'; the ends of the rays are sharp and the spaces between them are filled with a vitreous mass which makes the outer surface of the sphere smooth.

Remarks. — In this report, we are adopting Reitlinger's (1957) classification of calcispheres which she formulated for the radioshaerid calcispheres. A single broken and abraded specimen is questionably assigned to her described genus *Asterosphaera*. The diameter of the sphere is just slightly smaller than the diameter

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1 Classification in this study follows Raphael Conil's "Key to the sub-orders: Allogromiina, Textulariina, Fusulinina, Miliolina and Rotaliina of the Order Foraminiferida (Protista) of the Paleozoic." (Unpublished.)

of the type species described by Reitlinger. The specimen has a thin microgranular inner wall from which pointed vitreous spines project. Filling the intervals between the spines is a vitreous material of a similar composition to the spines. No axial canals are detectable.

Occurrence. — Radiosphaerid calcispheres have been reported from Europe and Russia. On the North American Continent they have been reported from the Cordillera and central parts of the country. These records are from Alberta, Canada, and from Arizona, North Dakota, and Nevada in the United States.

Range. — The stratigraphic range of radiosphaerid calcispheres in Europe and Russia is from the Frasnian (Upper Devonian) to Middle Carboniferous. In contrast, all positive reports of radiosphaerid calcispheres in North America are from strata of Frasnian age with the one possible exception of a form described by Baxter (1960, pl. 144, fig. 9) from the Salem Limestone at a horizon now considered to be basal St. Louisan. The generic name *Asterosphaera* has been applied only to forms of Frasnian age prior to present probable occurrence.

Genus **CALCISPHAERA** Williamson, 1880

Plate 22, figures 4-7

Type species: *Calcisphaera laevis* Williamson, 1880.

Calcisphaera Williamson, 1880, p. 521, pl. 20, fig. 70; Cayeux, 1929, pp. 594-597; Derville, 1941, p. 365, pl. 7, fig. 1; Baxter, 1960 (part), p. 1153-1157, pl. 144, (part); Mamet, 1970, p. 10, pl. 4, figs. 1, 2, pl. 12, fig 2

Granulosphaera Derville, 1931, pp. 133, 134, fig. 21(1), p. 28, figs. 73, 75, pl. 16, fig. 58

Not *Pachysphaera* Conil and Lys, 1964, pp. 42-44; pl. 6, figs. 59-68; 1968, p. 501

Original description. — Fig. 70 represents the inner portion of a hemisphere of *C. laevis,* viewed as an opaque object. I select this for our first consideration, because it exhibits these organisms in their simplest form. Its maximum diameter is about .006 (150 μ) whilst the thickness of the sphere wall is about .00058 (15 μ). I can detect no trace of structure in the sphere wall, neither has it any peripheral appendages. It is simply a smooth sphere — with a thick sphere wall and an equally smooth internal spherical cavity — the latter portion being occupied by a crystalline calcic carbonate, which has obviously reached the cavity as a solution that filtrates through the permeable sphere-wall.

See Plate 22, figure 4.

Remarks. — When Williamson (1880) wrote the above description he was reporting on a group of spherical organisms recovered from the Lower Carboniferous of Wales. They were found together with fossil plants, and these sperical forms were first considered to be radiolarians. Williamson was the first to seriously study them. He believed them to be extinct forms of protozoans or allied to reproductive capsules of some marine vegetation. Being uncertain of their exact nature, but still desirous of having a provisional form for their classification he adopted generic and specific names. In so doing, he stated this procedure as "not involving any premature hypothesis regarding their specific nature."

Cayeux (1929) separated Williamson's genus *Calcisphaera* into two general types; one of which he called "Calcispheres typiques" (typical calcispheres) and the other "radiolaires calcifies." The latter evidently referred to those forms with thin wall from which spines project.

Reitlinger (1957) divided the various types of calcispheres into eight different forms. Of these, she retained two in the genus *Calcisphaera,* assigned two others to the genera *Archaesphaera* Suleimanov and *Polyderma* Derville, and erected four new genera for those forms with rays or spines. These genera include *Radiosphaera,* *Sphaerella,* *Asterosphaera,* and *Radiina.* The form we illustrate Plate 22, figures 4-6, is identical to Williamson's type species *Calcisphaera laevis.*

Many other workers have reported on calcispheres since Williamson. Their manuscripts have covered a variety of forms. At the present writing, there is still diversity of opinions as to the true affinities of calcispheres. It is our opinion that several different groups of organisms are involved.

Occurrence. — *Calcisphaera* belonging to the genus as restricted and separate from the radiosphaerid calcispheres, namely those types which Cayeux called "Calcisphere typiques" have been reported from Great Britain, Belgium, France, Poland, Czechoslovakia, Egypt, Ireland, Japan, and the Soviet Union. From North America it is reported from Arctic Alaska, Alberta, British Columbia, northern Yukon, the western Cordilleran, and the Mid-Continent of the United States.

Range. — Late Tournaisian through Early Namurian.

DIPLOSPHAERINA Derville, 1952 emend. Browne and Pohl

Plate 22, figures 8-12; Plate 23, figures 1-3, 8

Type species: *Diplosphaera inequalis* Derville, 1931.

Diplosphaera Derville, 1931, p. 141, pl. 18, figs. 77, 80; 1950, p. 471, pl. 24, figs. 1-4.
Tuberitina Mikhailov, 1939, p. 61, pl. 1, figs. 11-12; Suleimanov, 1948, pp. 62. 244, fig. 1; Reitlinger, 1950, p. 88; Rich, 1970 (part), p. 1061, pl. 144, figs. 1-30.
Archaesphaera Suleimanov, 1945, p. 126; Miklukho-Maklay, 1963, p. 142, fig. 9; Conil and Lys, 1964, p. 35, pl. 4, figs. 36-40.
Diplosphaerina Dervillle, 1952, pp. 236, 237; Conil and Lys, 1964, p. 46, pl. 46, pl. 6, figs. 76-87.
Eotuberitina Miklukho-Maklay, 1958, p. 134, table 1; 1963, p. 150, fig. 9; Bogush and Yuferev, 1962, p. 94, pl. 1, fig. 32; Conil and Lys, 1964, p. 34, pl. 4, figs. 27-32; Brenckle, 1970, p. 54, pl. 1, figs. 31-35.
Neotuberitina Miklukho-Maklay, 1958, p. 134, table 1; 1963, p. 150, fig. 9; Bogush and Yuferev, 1962, p. 95, pl. 1, fig. 33.

Original description of Diplosphaera Derville, 1931. — A calcareous ball formed by two spheres, one large and one small, the latter being more or less enclosed in the larger. The cortical layer of the two spheres is of fine grained granular calcite.

Derville (1952, p. 236), being informed that the generic name *Diplosphaera* was preoccupied by Haeckel, 1860, for a protozoan, changed the name *Diplosphaera* to *Diplosphaerina.*

Emendation. — We would emend the genus to include the above synonymy and to read as follows: — Test free or attached and occurring singly or in combination, one-cell and two-cell forms being the most common; attached tests assume a wide variety of forms, the shape being determined by the configuration of the substrate; wall is calcareous, thin, dark, and finely granular, finely porous or with pores not in evidence except in well-preserved and carefully prepared thin section; aperture not present.

Remarks. — Miklukho-Maklay (1958) erected the family Tuberitinidae in the belief that the genus *Tuberitina,* as defined by Galloway and Harlton (1928), included several distinct forms. Two new genera were established at the same time — *Eotuberitina* and *Neotuberitina.* The genus *Capidulina* Maslov, 1935 was assigned to this new family. Miklukho-Maklay (1963) separated the family Tuberitinidae into two subfamilies — Tuberitininae and Neotuberitininae. The former consisted of those forms with attached tests and an undetermined mouth, the latter being free of attachment and possessing a mouth in the form of a cut. The walls of members of both subfamilies were described alike in being calcareous, finely granular, and nonporous or finely porous.

We have included in the genus *Diplosphaerina* four genera proposed by earlier authors. All previous work on this group of organisms was done with thin sections of impacted limestones which provided two dimensional observation only. The Fraileys fauna, described from liberated, uncrushed specimens occurring in vast numbers, of which the taxon *Diplosphaerina* is relatively abundant, has provided the opportunity for three-dimensional study of the varying forms which make up the genus. We have had the advantage of unrestricted orientation of our specimens and direct comparison of individual specimens in the round and in thin section.

The logic employed in this study for determining that we are concerned solely with the genus *Diplosphaerina* and not several genera is as follows:

1. The present study is restricted to one stratigraphic, and lithologically uniform, horizon where the various forms coexisted.
2. Numerous examples of great variety, shape and size were observed, both in free form and in thin section. It was possible to determine that all stages in transition exist between the various generic taxa listed in the synonymy above. There are both attached and unattached single-cell forms, and two-cell (occasionally multicell) forms which are transitional between those with minimal attachment of one or both cells, to attachment by both (or all) cells to extraneous material. Sometimes a flange is present surrounding the cell base, but more frequently the tests lay flat or wrapped themselves partially or completely around the indescriminate objects of attachment (spines, vegetation). It is clear that the choice of a substrate was not narrowly limited as to configuration or quality, and that the attachment was for purposes of sedentation and not parasitism. When encompassing an impermanent substrate object, partially or completely, a tunnel remains in the cell or cells, which, in thin section, presents the appearance of an "aperture", "mouth", or "reproductive cyst", attributes which have been ascribed to such features.

We are aware that the genus term *Archaesphaera* Suleimanov, 1945 was published earlier than the replacement term *Diplosphaerina* Derville, 1952 [for *Diplosphaera*, Derville, 1931 (rejected)]. However, it is considered that the latter term is exempted under the International Zoological Nomenclature Code from competition in priority, due to that fact that it was available and that there were no synomymic competitors at the time of its introduction by the author of the type species.

Occurrence. — *Diplosphaerina* is a widely dispersed genus. It has been reported from the Russian Platform, the Ukraine, the central Pyrenees, Poland, Czechoslovakia, Belgium, France, Great Britain, Ireland, and Egypt. On the North American continent it is recorded from the Canadian Cordillera of British Columbia and Alberta, from the Maritime Provinces and Newfoundland, and in the United States from the northern Cordillera and the mid-continent.

Range. — Famennian (Idaho only) to Middle Carboniferous (Westphalian).

Genus **RAUSERINA** Antropov, 1950

Plate 23, figures 4-7

Type species: *Rauserina notata* Antropov, 1950.

Rauserina Antropov, 1950, p. 27, pl. 3, figs. 2-5; Brazhnikova and Vdovenko, 1971, pl. 1, figs. 31-35.

Original description. — Test unattached, consisting of two spherical chambers. Wall calcareous, finely granular. Aperture small, in the septum separating the chambers. This new genus is closest to *Sorosphaera* Brady, from which it differs basically in the wall-structure; the wall in *Sorosphaera* is areanceous and coarsely granular, whereas in *Rauserina* it is calcareous and fine-grained. Family Saccamminidae. Upper Devonian. Monotypic. (From Ellis and Messina, Catalogue of Foraminifera).

Remarks. — In the description of the type species (*R. notata*) Antropov stated that it consists of two spherical chambers, stressing their small dimension (up to 80 μ per chamber with a test whose greatest dimension is 140 μ). Antropov's determination of an aperture, or intercameral opening, "in the septum separating the chambers" is insecure and may be incorrect, since only one of the four specimens illustrated shows such an opening. It is obvious from the illustrations that some diagenetic invasion of the tests by coarse crystals has taken place. An opening in the septum of the one specimen may have had such a cause.

Our material representing this genus, instead of consisting of only two chambers, sometimes possesses as many as eight chambers, arranged in a seemingly botryoidal manner which, in section, however, reveals an unorganized alignment in a single plane as if in a colony (see Pl. 23, figs. 4, 5). Under high magnification in polarized light, however, the wall is shown to be continuous between chambers. We have seen no indication of intercameral openings and our specimens were probably attached. The fine-grained character of the wall is striking and is additionally characterized, both in the Fraileys free forms and in the embedding limestones of the Beech Creek and the Reelsville where it also occurs uncommonly, by having a distinctive yellowish tinge in section.

The Fraileys representatives of this genus are most closely related to *Rauserina notata* Antropov forma *polycellata* (see Brazhnikova and Vdovenko, 1971, pl. 1, figs. 31, 32).

Occurrence. — Until the time of the present report the genus has been unknown except from the Russian Platform.

Range. — From the Frasnian through the Visean Stages.

Superfamily **ENDOTHYRACEA** Brady 1884

Family **EARLANDIIDAE** Cummings, 1955

Genus **EARLANDIA** Plummer, 1930

Plate 24, figures 1-8

Type species: *Earlandia perparva* Plummer, 1930.

Nodosinella Brady, 1876 (part).

Earlandia Plummer, 1930, pp. 12-14, pl. 1, figs. 2a-c; Cummings, 1955, pp. 227-229, pl. 1, figs. 1-15, text-fig. 3; Conkin, 1961, pp. 272-274, pl. 21, figs. 14-16; pl. 26, figs. 10-11; Conil and Lys, 1964, pp. 52-54, pl. 7, figs. 95-101; Hallett, 1970, p. 876, pl. 3, fig. 10; Brenckle, 1970, pp. 48-53, pl. 1, figs. 22-30.

Hyperammina Rauser-Chernousova, and Reitlinger, *in* Rauser-Chernousova, and Fursenko, 1937, pp. 253-257, figs. 190-191; Birina, 1948, pp. 155-159, pl. 2, figs. 7-8.

Original description. — Test free; very elongate, composed of a globular or subglobular proloculum and an elongate, nonseptate, second chamber; shell wall of minute crystalline calcareous granules bound by a calcareous cement, imperforate, smoothly finished; aperture a broad circular opening at the end of the tube.

Remarks. — *Earlandia* is a common element of the fauna. There are several forms, with a considerable range in size. The specimens break readily so it is not possible to determine the exact length and maximum diameter on the majority of specimens. Proloculi are detached from all of the larger forms, belonging to the group *E. vulgaris* Rauser-Chernousova, but approximately 12 specimens with their proloculi intact were retrieved. These are probably related to the group *E. elegans* (*Earlandia perparva* Plummer). The common "*Earlandia*" of the literature, *E. clavatula* (Howchin), so frequently reported from Chester formations, is present in large numbers but is siliceous and thus does not belong with these calcareous forms but conforms to Howchin's original description and designation as *Hyperammina clavatula* (*Hyperammina casteri* megalospheric form, Conkin).

The size and abundance of examples of this genus make it the most prominent element in the microfauna, but it has little stratigraphic value.

Range. — Tournaisian to Early Namurian.

Family **ARCHAEDISCIDAE** Cushman, 1927⁽²⁾

Historical outline. — In 1953 L. P. Grozdilova, *in* Dain and Grozdilova, published a monographic study of the Archaediscidae of the USSR. She assigned all known archaediscids, with the exception of those described under the genus term *Permodiscus* Dutkevitch, 1948, to one of four groups and six subgroups, as follows:

Genus *Archaediscus* Brady, 1873
    Group *Archaediscus* karreri Brady, 1873
        Subgroup *Arch. karreri* Brady, 1873
            Arch. moelleri Rauser, 1948
            Arch. donetzianus Sosnina, 1953
    Group *Archaediscus krestovnikovi* Rauser, 1948
    Group *Archaediscus baschkiricus* Krestovnikov and Theodorovich, 1936
        Subgroup *Arch. baschkiricus* Krestovnikov and Theodorovich, 1936
            Arch. rugosus Rauser, 1948
            Arch. gregorii Dain, 1953
    Group *Archaediscus spirillinoides* Rauser, 1948

This classification had been preceded by the basic works of D. M. Rauser-Chernousova in 1948 and of T. I. Shlykova in 1951; but Grozdilova was the earliest to attempt to organize what were diverse elements within the genus as it was understood at that time.

Also in 1953 Grozdilova and Lebedeva, *in* Dain and Grozdilova,

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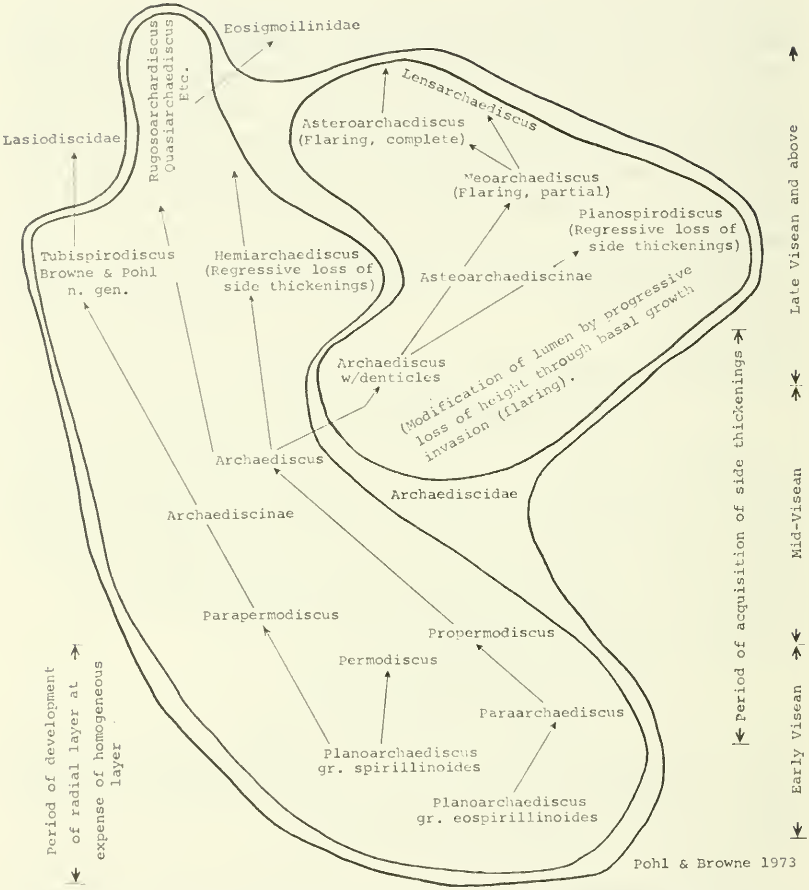
(2) Since the completion of this manuscript we have been made aware of the pending publication of a complete revision of the family Archaediscidae by H. Pirlet and R. Conil. We believe that there are no important inconsistencies between the traditional treatment given here and that presented in the proposed revision. In fact, the results, which were independently arrived at, are essentially similar. We have had an opportunity to review a pre-publication copy of Pirlet and Conil's paper and welcome its revolutionary concept as an alternative. We have also learned of F. Bozorgnia's monogeneric approach to the family Archaedisidae, to be published soon, but do not have sufficient information to form an opinion.



Text-figure 6. — Phylogenetic scheme to show the time-progressive relationships among representatives of the family Archaediscidae. Principle paths of evolution are (1) *Planoarchaediscus* gr. *spirillinoides* → *Parapermodiscus* → *Tubispirodiscus* Browne and Pohl, n. gen. → Lasiodiscidae; (2) *Planoarchaediscus* gr. *eospirillinoides* → *Archaediscus* → *Hemiarchaediscus;* (3) *Archaediscus* → *Archaediscus* with nodosities → *Neoarchaediscus* → *Asteroarchaediscus.*

established the species *Arch. minimus* and compared it to the genus *Permodiscus,* without the latter's side-thickenings, thus emphasizing its planospiral character.

It is notable that Grozdilova assigned the species *Arch. gregorii, acutiformis, postrugosus, borealis,* and *timanicus* to one group (*Arch. gregorii*). The diagnostic features of this subgroup are set forth as follows: "In this subgroup belong those species having a discoidal shell form with sub-parallel lateral sides, a glomerate coiling of the inner whorls and a planospiral, evolute coiling of the external spires." In contrast, the species *Arch. minimus* Grozdilova and Lebedeva, 1953, was referred to the group *Arch. spirillinoides.* This was done because she considered the evolute and planospiral character of *minimus* to be of primary phylogenetic importance; greater even than the restricted lumen common to all these species.

In a series of five short papers between 1953 and 1963 A. D. Miklukho-Maklay discussed the justification for the establishment of 11 archaediscid genera. His studies of the Archaediscidae culminated in a phylogenetic scheme (1963, fig. 11) showing what are today recognized as the main paths of developmental divergence and giving validity to the use of the family for stratigraphic determinations.

A major effort to understand the phylogenetic relationships among the widely differing representatives of the family was included in a monographic section of the work of Conil and Lys (1964, pp. 98-135). One page 104 of that publication is given an outline key for the principal points of generic differences, according to their concept.

Subfamily **ARCHAEDISCINAE** Cushman, 1927

Genus **ARCHAEDISCUS** Brady, 1873 emend. Miklukho-Maklay, 1957

Plate 24, figures 9-13

Type species: *Archaediscus karreri* Brady, 1873.

Archaediscus Brady, 1873, p. 286, pl. 11, figs. 1-6; Chernysheva, 1948[1], p. 152, pl. 2, fig. 1; Rauser-Chernousova, 1948[a], p. 229, pl. 15, figs. 10-18, pl. 16, figs. 1-5; 1948[b], p. 10, pl. 2, figs. 18-20, pl. 3, figs 1-3; Shlykova, 1951, p. 159, pl. 3, figs. 12-18, pls. 4, 5, 6, figs. 1-6; Grozdilova *in* Dain and Grozdilova, 1953, p. 76, pls. 1, 2, 3, figs. 1-10; Grozdilova and Lebedeva, 1954, p. 43, pls. 5, 6, 7, figs. 1-5; Miklukho-Maklay, 1963, p. 159, Table 10, fig. 11; Conil and Lys, 1964, p. 105, pl. 14, figs. 267-272, pl. 15, figs.

275-296, pls. 16-19; Brenckle, 1970, pl. 10, figs. 15, 20, 21; Hallett, 1970, p. 877, pl. 5, figs. 1-8; Petryk, 1971, p. 249, text-fig. 2.

Original description. — General characters — Shell convoluted, rounded, more or less unsymmetrical; formed of a non-septate tube coiled upon itself in a constantly varying direction. Shell wall transversed by very numerous, parallel, minute tubuli. (See Pl. 24, figs. 11, 12.)

Emendation. — *Archaediscus* Miklukho-Maklay, 1957. Egg-shaped shells, usually somewhat irregular consisting of original spheric chamber and the second-tube-shaped, undivided (without partitions). The surface of the shell is smooth. The coiling of the second chamber is glomerate. Representatives of this genus have asymmetric side thickenings. The wall is calciferous and bright, usually roughly porous, usually with a bright exterior layer and a very apparent, dark interior layer.

Remarks. — This genus is well represented in our fauna by several forms of small size; with proloculus and undivided pseudotubular second chamber which is skew coiled and dominantly involute and which may be free in the last whorl. The forms are discoidal to subglobular with rounded margins. Lateral side thickenings are slight to thick. The two-layered wall is distinct, an outer bright layer of radial calcite and an inner thin layer which is dark and microgranular, the latter sometimes absent in our forms. The aperture is a single opening at the terminus of the final whorl.

Many forms have been identified as belonging to this genus. *Archaediscus* is unlike *Propermodiscus* in its coiling habit which, in the latter, is similar to *Hemiarchaediscus*. The last two genera differ in the lateral side thickening of the wall of *Propermodiscus*, and in the modified shoulder of *Hemiarchaediscus*.

Occurrence. — *Archaediscus* is a cosmopolitan genus being reported from both the Northern Hemisphere and Southern Hemisphere. Localities in Eurasia include Great Britain, Western and Central Europe, the Russian Platform, Donbass, the Urals, and northern Siberia. Areas of the Pacific include Indochina and Vietnam. It has been found in North Africa and Australia. In North America *Archaediscus* is recorded in Alaska, the Yukon, British Columbia, the Maritime provinces, the Midcontinent, and Mexico.

Range. — *Archaediscus* makes its appearance in the upper part of the Lower Visean (1964 Congress of the Carboniferous, 1971), reaches its peak in the Late Visean and disappears in the Middle Westphalian. On the authority of Prof. R. Conil (personal communication) its earliest occurrence is at the base of V1b, by definition.

Genus **HEMIARCHAEDISCUS** Miklukho-Maklay, 1957

Plate 25, figures 1-3

Type species: *Hemiarchaediscus planus* Maklukho-Maklay, 1957.

Hemiarchaediscus Hewitt and Conil, 1969, pl. 2, fig. 40; Miklukho-Maklay, 1957, p. 36, figs. 1-2; 1963, p. 161; Hallett, 1970, pl. 5, fig. 13.
Archaediscus Conil and Lys, 1964, p. 105, pl. 16, figs. 314; pl. 15, figs. 273-274.

Original description. — Shells flat, lens shaped with slightly circular edges. Test consists of a proloculus and a second pseudotubular chamber, glomerately coiled at the beginning. The final coils are relatively freely coiled in a flat spiral plane. The wall is bright calcareous, distinctly porous with a clear dark interior layer.

Remarks. — This genus is well represented in our fauna. The forms are small to moderate size. The surface of the tests are smooth and lateral side thickenings are absent.

Conil, unpublished, in a key to the various suborders of Paleozoic Foraminifera equates both *Propermodiscus* Miklukho-Maklay and *Hemiarchaediscus* with *Archaediscus* Brady.

Brenckle (1970) equated *Hemiarchaediscus* with *Archaediscus* but retained *Propermodiscus* as a separate genus. Brenckle contended that *Hemiarchaediscus* and *Archaediscus* have similar coiling habits, compressed lateral shape, and a like wall structure. However, according to definition, *Archaediscus* is skew-coiled throughout, whereas *Hemiarchaediscus,* similar in its initially coiled stage, possesses more than one late whorl coiled freely in nearly one plane, and without side thickenings. The change in type of coiling is abrupt in *Hemiarchaediscus.* The base of the lumen of the final coils is flat and the lumen outline is that of a semicircle.

Occurrence. — *Hemiarchaediscus* has been reported from Great Britain, Europe, and the Soviet Union. In the United States it has been reported from the northern Cordillera. This is a first report of the genus from the Mid-Continent and at a lower horizon than from the western United States.

Range. — *Hemiarchaediscus* ranges from early Visean to the end of the Namurian. However, its recorded occurrence in the United States is from the Namurian, except for this report, which extends its range as low as Upper Visean. A possible reason for the lack of information on the genus in the United States may be that it has gone unrecognized.

Genus **TUBISPIRODISCUS** Browne and Pohl, n. gen.

Plate 25, figures 10-12; Plate 26, figures 1-3

Derivation: tubus — pipe or tube, spira — coil or spire, discus — disk.

Type species: *Tubispirodiscus simplissimus* Browne and Pohl, n. sp.

Diagnosis. — Test free, flattened, concave-discoidal with narrowest dimension through the axis of revolution; composed of a proloculus followed by a freely coiled, undivided chamber which is planospirally enrolled and entirely evolute throughout; periphery well-rounded and surface somewhat uneven with evident sutures; side thickenings absent; wall bright calcareous, composed of a single fibro-radiate layer only; aperture a circular opening at the end of the tube.

Comparison. — We consider this genus to have developed in the phylogenetic corridor, beginning with the Cornuspiridae, which links the primitive archaediscid *Planoarchaediscus* and the family Lasiodiscidae. The planospirality, evoluteness, loss of side thickenings and the character of the single-layered wall in which the radial layer has progressed to totality at the expense of a microgranular layer, are features which serve to bridge this relationship.

Tubispirodiscus has the planospiral coiling habit of both *Parapermodiscus* and *Permodiscus* but differs in all other important respects such as the lumen and side thickenings.

Examination of the exquisitely preservd tests under high magnification (× 1940) and various modes of illumination reveals a complete absence of any microgranular structure or layer at any position in the wall. The total elimination of the double wall structure and the retention of the radial layer alone is an appropriate end product for one twig of this branch of the archaediscids which early evinced a tendency to develop a hyaline wall at the expense of the microcrystalline structure which was so prominent in its earlier phylogenetic history.

Tubispirodiscus simplissimus Browne and Pohl, n. gen., n. sp.
Plate 25, figures 10-12; Plate 26, figure 1

Derivation. — *simplissimus* — most simple
Holotype USNM 186634, axial section

Paratype USNM 186635, axial section
Paratype USNM 186636, equatorial section

Description. — Test free, with well-rounded periphery, consists of a proloculus and a second tubular chamber which is completely evolute and planospiral throughout. The surface is somewhat uneven and marked by weakly impressed sutural lines.

The whorls, numbering from four and one-half to five, increase gradually and uniformly in size, thus imparting a broadly umbilicate appearance to the central and narrowest portion of the test. In axial cut the lumen typically presents a semicircular outline.

In thin section the wall is seen as a single undifferentiated layer, composed of fibro-radiate crystals. No vestige of a microgranular structure is visible.

The aperture is a subcircular opening at the terminus of the tube.

Dimensions. — Diameter — 155 μ to 191 μ; width — 32 μ; diameter of proloculus — 24 μ to 30 μ; wall thickness — about 5 μ; W/D — 0.17 to 0.21.

Occurrence. — *Tubispirodiscus,* consisting of two species, is presently known only from the Fraileys locality here recorded. A possible additional occurrence is a tentative identification from a late Visean sample from Bioul, Belgium.

Range. — Unknown, except for this first report from the Fraileys horizon. It has not been recovered from the underlying Beech Creek Limestone in spite of the fact that its archaediscid population is astounding.

Subfamily **ASTEROARCHAEDISCINAE** Miklukhlo-Maklay, 1957

Miklukhlo-Maklay (1957) divided the family *Archaediscidae* Cushman (1927) into two subfamilies, *Archaediscinae* Cushman (1927) and *Asteroarchaediscinae* Miklukhlo-Maklay (1957). He defined the subfamily Asteroarchaediscinae as follows:

> The shells are of varying form, as a rule with somewhat uneven surface. They have been formed with the pseudo-tubular chamber coiled in a glomerate manner, glomerate and flat spiral or only flat spiral. The height of the clearance of the pseudo-tubular chamber is several times the thickness of the wall between corresponding volutions. The wall is very slightly porous.

Miklukhlo Maklay (1963, p. 162), in describing this subfamily, referred to the "broken star" shape contour of the second chamber formed by the sharp turns of this pseudo-tube-shaped chamber.

We would emend the definition of this subfamily to read as follows:

Forms belonging to this subfamily have tests that are discoidal to subglobular in shape. The surface of the test may be smooth to somewhat rough, with or without side thickenings. The coiling habit may be glomerate, glomerate-planospiral or entirely planospiral. The nature of the tight coiling of the spires and the filling of the floor of the lumen by "flaring", or growth of nodosities and denticulations unites the genera belonging to this subfamily. This habit has imparted a stellate pattern to the various forms when viewed in axial section. Sometimes the stellate appearance is only present in the initial coils while in others it is apparent throughout. It is less evident in the genus *Planospirodiscus* in which the initial coils of the spires may depart slightly from the flat spiral plane but are never glomerately coiled. The height of translucency of the tubular chamber varies, producing forms with open lumen and also those with partially or completely closed lumens. The relationship of the height of the translucency to the wall thickness also varies but is equal to, or less than, the wall thickness, except for some forms (*i.e.*, certain species of *Neoarchaediscus*), in which the final coils may be freer and less tightly wound. The wall pattern is partially or totally crenulated and chevron-shaped.

Genus **NEOARCHAEDISCUS** Miklukho-Maklay, 1956

Plate 25, figures 7-9

Types species: *Archaediscus incertus* Grozdilova and Lebedeva, 1954.

Archaediscus Grozdilova and Lebedeva, 1954, p. 60, pl. 7, figs. 14, 15; 1960, p. 98, pl. 11, fig. 11.

Neoarchaediscus Miklukho-Maklay, 1956, p. 11; 1963, p. 162, table 10; Conil and Lys, 1964, p. 130, pl. 20, figs. 389-392; Brenckle, 1970, p. 184, pl. 10, figs. 27-33, pl. 11, figs. 1-10; Hallett, 1970, pl. 5, figs. 11, 12; Mamet, 1970, p. 41, pl. 7, figs. 7, 8, 12, 14, 17.

Planospirodiscus Mamet, 1970, p. 42, pl. 7, figs. 10, 14; Brenckle, 1970, p. 189, pl. 11, figs. 16-25.

Original description. — The shells are flat-discus shaped with more or less parallel sides. The surface of the shell is smooth or somewhat uneven. The beginning chamber is spheric. The second chamber, not divided, coiled at the beginning (frequently with star-shaped structure), is followed by two to three coils turned more or less in one plane and more freely. The wall is calciferous, bright, quite thick, glass-like, finely porous, with an interior, thin dark layer.

Remarks. — *Neoarchaediscus* is a common element in the fauna of the Fraileys Shale facies. It is so closely allied to *Planospirodiscus* that these genera are frequently confused with each other. *Neoarchaediscus* differs from *Planospirodiscus* in having its inner whorls typically involute with closed lumen of stellate appearance. *Planospirodiscus,* on the contrary, is totally evoluate with low lumen.

The height of the lumen of some forms of this genus is not in accord with Miklukho-Maklay's definition of the subfamily Asteroarchaediscinae, because the translucency of the last whorls is sometimes greater than the wall thickness. Likewise, the wall construction fails to correspond to Grozdilova and Lebedeva's description, consisting, in some of our forms, of a single radiate layer.

Asteroarchaediscus, belonging to the same subfamily, is always completely involute with the lumen nearly closed. The wall is totally crenulate.

Occurrence. — *Neoarchaediscus* has wide distribution. It has been reported from the Soviet Arctic and all basins of the USSR. It is present in Western Europe. In North America it is recorded from the Maritime Provinces, British Columbia and Alberta, the Cordillera, Alaska, and the Mid-Continent area.

Range. — *Neoarchaediscus*' earliest appearance is in Late Visean time (V_3bB-γ), and it continues into the Westphalian. It is rare in early V3b, becoming common at the end of the stage, according to R. Conil (personal communication, 1972).

Genus **PLANOSPIRODISCUS** Sosipatrova, 1962

Plate 25, figures 4-6

Type species: *Planospirodiscus taimyricus* Sosipatrova, 1962.

Archaediscus Grozdilova and Lebedeva *in* Dain and Grozdilova, 1953, p. 111, table 4, fig. 15.
Archaediscus? Grozdilova and Lebedeva, 1954, p. 62; pl. 7, fig. 16.
Planospirodiscus Sosipatrova, 1962, p. 63; pl. 5, figs. 15-24, 1966, p. 21, pl. 3; Mamet, 1970, p. 42, pl. 7, figs. 11, 13, 18, 22.
Not *Planospirodiscus* Mamet, 1970, p. 42, pl. 7, figs. 9-12, 14-17; Brenckle, 1970, p. 189, pl. 11, figs. 16-25.

Original description. — Test small, discoidal, with depressed, parallel, or only slightly convex lateral sides, with rounded peripheral edges. Proloculus spherical. The coiling of the second fistulous chamber is evolute, planospiral or with weak deflection in the first two whorls, the coiling tube being narrow in the first whorls and more open in the last formed. The clear space (translucency) of the second tubular chamber is low, the height of the clear space in the last whorl being either of like thickness of the wall or smaller. The wall is smooth, consisting of an exterior conspicuous (stout) vitreous (hyaline) radiant, and an inner wall of a dark granular layer which is not always quite noticeable.

We isolate the genus *Planospirodiscus* contrasting to the genus *Permodiscus* in the absence of preponderant (heavy) lateral thickenings and in the depressed evolute coiling spirals, while from the genus *Planoarchaediscus* it differs in the symmetry of the whorl coiling, well-developed radiant layer of the walls and the inferior height of the spiral opening.

Planospirodiscus is, as previously mentioned, closely allied to *Neoarchaediscus,* the difference being given under that genus.

While *Planospirodiscus* is common in the layers immediately underlying the Frailey's horizon, typical *Planospirodiscus* either did not flourish in the muddy habitat of the Frailey's, or which seems less probable, in picking and selecting of forms for sectioning we neglected to choose *Planospirodiscus.*

Planospirodiscus, normally has forms with low translucency at the beginning and then changing noticeably, to somewhat more open lumen in the final whorls to forms with low translucency throughout. The number of whorls varies considerably.

We illustrate a form we are assigning to the genus *Planospirodiscus* (see Pl. 25, fig. 4) which is somewhat intermediate between *Planospirodiscus* and *Neoarchaediscus.* However, it has the definitely open lumen of *Planospirodiscus* even though the last whorls are not completely evolute.

Occurrence. — *Planospirodiscus* has been reported from the Siberian Arctic, western Europe (Rhineland, and Hesse), and England. It is also present in Nova Scotia and the Mid-Continent of the United States.

Range. — *Planospirodiscus* ranges from the Latest Visean to the Early Namurian.

Remarks. — As noted above, we have placed the genus *Planospirodiscus* in the subfamily Astroarchaediscinae. Sosipatrova (1962) referred to the "starry character" of the starting coils in describing some forms of *Planospirodiscus* present in the fauna from the Taimyr Peninsula. Her generic diagnosis described the relationship of the height of the translucency to the wall thickness. These are the basic characters for the erection of the subfamily Astroarchaediscinae.

Sosipatrova separated *Planospirodiscus* from *Permodiscus* by the absence of lateral thickenings and the depressed evolute coiling of the spirals.

Family **LASIODISCIDAE**, Reitlinger, 1956

Genus **MONOTAXINOIDES** Brazhnikova and Yartseva, 1956

Plate 26, figures 4-9

Type species: *Monotaxinoides transitorius* Brazhnikova and Yartseva, 1956.

Monotaxinoides Brazhnikova and Yartseva, 1956, p. 62-68, pl. 1, fig. 1.
?*Turrispira* Reitlinger, 1950, p. 19-20, pl. 2, figs. 7-9.
?*Eolasiodiscus* Reitlinger, 1956, p. 75.
?*Turrispiroides* Reitlinger, 1959; Brenckle, 1970, pp. 55, 56, pl. 1, figs. 36-40.

Original description.—Test planospiral, concave on one side, flattened or gently convex on the other side, occasionally with a slightly displaced final whorl. Spiral rather tightly, uniformly coiled. Spiral suture usually more or less distinct or nearly flush. Tubular chamber strongly compressed parallel to the axis of coiling. Number of whorls seven to eight or nine, sometimes more. Initial chamber small, spherical in shape, 0.015-0.019 mm. in diameter. Wall double-layered, consisting of a dark, very finely granular layer and a light, hyaline-radiate layer. Outer hyaline-radiate layer of the wall weakly developed, present mainly on one (concave) side, where it fuses with the distinct hyaline, sometimes fibrous, material constantly filling the concave portion of the test aperture, formed by the open end of the tubular chamber. Diameter of the test 0.28-0.35 mm.; greatest thickness 0.05-0.06 mm.; thickness of the wall of the final whorl 0.010-0.012 mm.

Remarks.—Reitlinger (1950) erected the genus *Turrispira*. Mainly the characteristics which she attributed to this genus are applicable to *Monotaxinoides*. These include the size, number of whorls, manner of coiling, and the conical shape of the test. The description of the wall differs in failing to include a description of the weakly developed outer hyaline-radiant layer. Reitlinger (1949) changed the name of the genus to *Turrispiroides* because the generic name *Turrispira* was occupied by Conrad (1866). The genus *Eolasiodiscus* was erected by Reitlinger (1956). This genus was described as having supplementary fissure-like openings along the spiral suture which are shown in her illustration of the equatorial section of the holotype. From our experience, in sectioning of forms in our fauna, we have found the supplementary openings only become apparent when the specimens are oriented so that the hyaline radiant layer is exposed. Accordingly, we suggest that the genera *Turrispiroides, Eolasiodiscus,* and *Monotaxinoides* are synonymous.

Monotaxinoides is not a common element of the Fraileys fauna with some five to six specimens having been retrieved. The specimens conform to Brazhnikova and Yartseva's description of the genus *Monotaxinoides* in size, manner of coiling, shape and wall layering. However, a properly oriented and cut specimen shows the fissure-like openings or chambers along the spiral suture (see Pl. 26, fig. 4). This feature was not mentioned by Brazhnikova and Yartseva in their above translated diagnosis nor is it detectable in their illustrations (see Pl. 26, figs. 8, 9).

Occurrence.—*Monotaxinoides* is reported from the Soviet Union, Great Britain, France, Algeria, and North Africa. In the United States it has been recorded in Arkansas and as *Turrispiroides* from Nevada. So far as is known, this is a first report from the Mid-Continent region.

Range.—*Monotaxinoides* is listed as ranging from the uppermost part of the Visean, where its presence is rare, through the Namurian.

Family **PSEUDOAMMODISCIDAE** Conil, 1970

In the present paper we assign certain genera to this family which had been referred to other families by earlier workers. Conil (Conil and Pirlet, 1970, pp. 52-53), in a preliminary notice establishing the family Pseudoammodiscidae presented the following summary:

> Until now we have attributed to the family Ammodiscidae the Dinantian genera usually designated under the names *Ammodiscus, Brunsia* (in the sense of *Glomospirella*) and *Glomospira.* Their microgranular wall, like that of the Endothyracea, however, distinguishes them from the Ammodiscidae with an agglutinated wall. We propose to reunite these genera in one new family of Endothyracea: the Pseudoammodiscidae. This family probably originated from the Archaediscidae whose early species have a highly developed microgranular wall and a radiant layer limited to the initial whorls. This feature is inverted progressively throughout the evolution of the Archaediscidae, whose Namurian species generally possess a microgranular layer that is but little apparent.
>
> The essential characteristics of the Pseudoammodiscidae are:
>
> — Proloculum + an enrolled non-septate tube.
> — Wall calcareous, simple, microgranular.
> — Aperture terminal and simple.
>
> This family appears for the first time in western Europe at the base of the Visean with the more primitive Fusulinacea. It constitutes therefore, a good regional guide, having arrived at a well-defined moment from the Ural basin. The first representatives are, in effect, much better known from the Devonian and the upper Tournaisian, in the U.S.S.R. (Bykova, Lipina).
>
> We propose to assign under the name *Pseudoammodiscus* those ammodiscoid species with a microgranular wall and to choose as the type species *Ammodiscus priscus* Rauser-Chernousova 1948.

Comparison:

(Cf. A. Loeblich, and H. Tappan 1964)	TEXTULARIINA	FUSULININA	MILIOLINA
Planispiral	*Ammodiscus* Reuss	*Pseudoammodiscus* n. gen.	*Cyclogyra* Wood
Tangled	*Glomospira* Rzehak	*Pseudoglomospira* Bykova	
Tangled later planispiral	*Glomospirella* Plummer	*Brunsia* Mikhailov	*Hemigordius* Schubert

Preliminary note, by R. Conil and M. Lys *in* Conil and Pirlet, 1970.

Remarks. — The Russian workers never separated the agglutinated genera of Foraminifera from their calcareous "isomorphous" forms but adopted the practice, established in the Russian Treatise, of including both types within one family. This principal has been followed by European workers in general.

American workers, on the contrary, tended to separate calcareous genera from the agglutinated genera and placed them in separate families.

We question that most Carboniferous forms which have been assigned to the genus *Cornuspira* Schultze, 1854, belong to that genus or to the genus *Cyclogyra* Wood, 1842. We are transferring those Carboniferous forms previously assigned to the genus *Cornuspira* by the American workers to the genus *Pseudoammodiscus*.

Cushman (1917) designated the type species of *Cornuspira* as *Orbis foliaceus* Philippi, 1844. In 1927 Cushman changed the type species to *Cornuspira planorbis* Schultze, stating that the previous designation was in error, as *C. foliaceus* was not one of the names used by Schultze. However, Loeblich and Tappan (Treatise, 1964) stated that, "Schultze, 1854, p. 41 (footnote) definitely included *Orbis foliaceus* in the genus, the original designation of Cushman must stand. The two species are not conspecific".

Loeblich and Tappan (Treatise, 1964, p. 438) placed *Cornuspira* Schultze, 1854 in synonymy with *Cyclogyra* Wood, 1842. The original illustration of *Cornuspira planorbis* Schultze (see Pl. 27, fig. 6) shows no proloculus. The genus *Cyclogyra* Wood is indeterminate, but in one of the original illustrations the aperture shows what appears to be a tooth (see Pl. 27, fig. 7). Moreover, both genera *Cyclogyra* Wood and *Cornuspira* Schultze are Recent forms which would give an improbably long range to the genus *Cornuspira.*

Cushman (text, 1948) placed many of the genera, including *Cornuspira,* in the family Ophthalmidiidae which Conil would assign to the family Pseudoammodiscidae. Cushman did not recognize their relationship to the endothyrids which, at the time, had not been placed in the superfamily Endothyracea. On the other hand, he was aware that the genera he placed in the family Ophthalmidiidae should not be classified with the *Miliolina.* None developed an arenaceous exterior or a definite tooth in the aperture, nor do they possess an early stage in which the chambers constantly change their plane of coiling.

Occurrence. — *Pseudoammodiscus* has been reported either as *Cornuspira* or *Ammodiscus* from both Eastern Europe and Western Europe, the Soviet Union, and the Siberian Arctic. On the North American continent it is recorded from Alaska, Alberta, British Columbia, the Maritime Provinces, and the Mid-Continent region.

Range. — *Pseudoammodiscus* first appears in the Devonian of eastern Europe and at the base of the Visean in western Europe. It ranges into the Early Namurian, its acme coinciding with the Visean-Namurian boundary.

Genus **PSEUDOAMMODISCUS** Conil, 1970

Plate 27, figures 1-5

Type species: *Ammodiscus priscus* (Rauser-Chernousova), 1948, p. 227, pl. 15, figs. 2-3.

Pseudoammodiscus Conil and Lys *in* Conil and Pirlet, 1970, p. 52, 53.
Cornuspira Cushman and Waters, 1928[a], p. 44, pl. 5, fig. 5; 1930, p. 61, pl. 5, figs. 4, 5.
Ammodiscus Rauser-Chernousova, 1948[a], p. 240, pl. 17, figs. 7, 8; Braznikova et al., 1956, p. 23-24, pl. 1, figs. 13-15, 17; Conil and Lys, 1964, p. 22, 57-60, pl. 7, figs. 106-112.

Original description. — The test is a planospiral, consisting of a proloculus with a diameter of 50 μ and a pseudotubular chamber of three whorls. The whorls increase gradually in both width and height. The height of the last whorl varies from 30 to 45 μ (averaging 45 to 45 μ). The width of the tube in the final whorls is somewhat larger than its height, being about 60 μ at a height of 45 μ. The thickness of the wall in the last whorl is 5 to 8 μ. The average diameter of the test is 0.17-0.25 mm.

Remarks. — *Pseudoammodiscus* is a genus not present in large numbers in the Frailey's fauna although reported to be common in the Russian sub-Moscow Basin. We have recovered at least two forms.

Genus **CALCITORNELLA** Cushman and Waters, 1928

Plate 27, figures 8-11

Type species: *Calcitornella elongata* Cushman and Waters, 1928.

Calcitornella Cushman and Waters, 1928[a], pp. 45-47, pl. 6, figs. 5, 8; Plummer, 1945, p. 247.
Tolypammina Harlton, 1928, p. 305.
?*Apterinella* Cushman and Waters, 1928[b], p. 64.

Original description. — Test attached, consisting of a proloculum and tubular second chamber with the early portion coiled about the proloculum, then uncoiling and wandering over the surface to which it is attached; wall calcareous, imperforate; aperture semicircular, formed by the open end of the tubular chamber.

Remarks. — This is a form which probably evolved from *Pseudoammodiscus* which became attached and, in so doing, developed a peculiar habit. In this respect it is related to the genus *Calcivertella,* described below. Both apparently adapted well to a suitable ecological habitat, because there is a sudden appearance of diversification. The variation is such that speciation will prove difficult. The shape of test depends, to a large degree, on the surface of attachment. The aperture is not always semicircular but may be entirely circular — this feature being due to manner of attachment.

Occurrence. — *Calcitornella* has been reported from the northern Cordillera of the United States and the Mid-Continent.

Loeblich and Tappan (1964) reported it from Europe.

Range. — Known range from Late Visean to Westphalian. Loeblich and Tappan (1964) gave a range from Namurian to Bashkirian.

Genus **CALCIVERTELLA** Cushman and Waters, 1928a

Plate 27, figures 12-14

Type species: *Calcivertella adherens* Cushman and Waters, 1928a.

Calcivertella Cushman and Waters, 1928[a], p. 48, pl. 6, figs. 8a. 8b.
?*Ammovertella* Mamet, 1970, pl. 19, fig. 2; Conil, R. (unpublished key to the suborders of Paleozoic Foraminifera).

Original description. — Test attached with the earlier stages irregularly coiled, later in a definite zigzag series, the tubular second chamber bending back and forth but with the sides of the resulting test very slightly tapering, the last portion losing the coiled portion and becoming somewhat straight; wall calcareous, imperforate; aperture rounded, formed by the open end of the tubular chamber.

Remarks. — *Calcivertella,* as noted above, flourished at this horizon. Because it has an isomorphous arenaceous counterpart in the genus *Ammovertella,* the two genera are confused in the literature. The Russian treatise gives a diagnosis of the genus *Ammovertella,* placed in the family Tolypamminidae. Conil (unpublished key to the suborders of the Paleozoic Foraminifera) placed the genus *Ammovertella* in the newly erected family, *Pseudoammodiscidae* under the superfamily Endothyracea.

Occurrence. — *Calcivertella* and ?*Ammovertella* have been reported on the North American Continent from British Columbia and Alberta, and in the United States from the northern Cordillera and the Mid-Continent. Their occurrence in Eurasia and elsewhere is not known. It seems that they may be present in Europe, at least, because Conil has placed calcareous forms under the generic name *Ammovertella.*

Range. — The known range is from Late Visean to Westphalian.

Genus **PSEUDOGLOMOSPIRA** Bykova and Polenova, 1955

Plate 28, figures 8-10

Type species: *Pseudoglomospira devonica* Bykova, 1955.

Pseudoglomospira Bykova and Polenova, 1955, p. 30.
Glomospira Mikhailov, 1939; Rauser-Chernousova, 1948^a; Cooper, 1947, p. 87, pl. 20, fig. 18; Malakova, 1956^a, p. 37, pl. 1, figs. 2, 3; 1956^b, p. 88, pls. 1-3; Conil and Lys, 1964, p. 60, pl. 7, figs. 106-112; Brenckle, 1970, p. 222, pl. 12, figs. 26-28.

Original description. — Test free, consisting of an initial chamber followed by a second, streptospirally enrolled chamber. The aperture is simple, at the extremity of the tubular chamber. The wall of the test is calcareous, homogeneous, dark, and finely granular.

Remarks. — *Pseudoglomospira* is common in the Frailey's fauna. This genus has been confused in the literature with its isomorphous counterpart *Glomospira.* In morphology and manner of enrollment they are similar but *Glomospira,* belonging to the family Ammodiscidae, has an agglutinated test.

Occurrence. — *Pseudoglomospira* has been reported from Great Britain, France, North Africa, and Russia. On the North American Continent it is recorded from the Maritime Provinces, all along the western Cordilleran, and in the Mid-Continent region.

Range. — Mid-Visean to Early Namurian. Due to the confusion in the literature between the genera *Glomospira* and *Pseudoglomospira* it is not possible to determine the precise horizon at which *Pseudoglomospira* first occurs. *Glomospira* is first seen in the Tournaisian.

?**RECTOCORNUSPIRA** Warthin, 1930

Plate 28, figures 5-7

Type species: *Rectocornuspira lituiformis* Warthin, 1930.

Rectocornuspira Warthin, 1930, pp. 15, 16, pl. 1, figs. 5-7.
Cornuspira Harlton, 1927, p. 25, pl. 5, fig. 9.
Lituotuba Harlton, 1927, p. 17, pl. 1, fig. 3; p. 273, pl. 42, figs.2-3.

Original description. — Test free, or attached only in the gerontic stage, consisting of a proloculum and a tubular second chamber, involute and coiled planispirally or nearly so in the young stage, evolute and straight or irregular in the adult; wall porcellaneous, imperforate; aperture the open end of the tube. Length, up to 1 mm."

Remarks. — Warthin (1930), in erecting the genus noted that "(it) evolved from *Cornuspira* by becoming evolute without greatly specializing the tube." It is our belief that Warthin, in tracing the phylogeny of *Rectocornuspira,* was referring to forms, at that time considered to belong to the genus *Cornuspira,* which we are transferring to the genus *Pseudoammodiscus* of the family Pseudoammodiscidae. We have retrieved only one specimen of *?Rectocornuspira;* however, it possesses the diagnostic features of the Pseudoammodiscidae — proloculus plus an enrolled nonseptate tube, a calcareous microgranular wall, and a simple terminal aperture. Our specimen resembles the genus *Pseudoammodiscus* except for the final rectoid part of the tube.

Occurrence. — The Mid-Continent region of the United States.

Range. — Middle Visean through the Namurian.

TREPEILOPSIS Cushman and Waters, 1928, emend. Browne and Pohl

Plate 28, figures 1-4

Type species: *Turritellella grandis* Cushman and Waters.

Trepeilopsis Cushman and Waters, 1928[a], p. 38, pl. 4, figs. 12, 13; Plummer, 1945, p. 247; Cooper, 1947, pp. 81, 87; Hewitt and Conil, 1969, p. 179, pl. 1, figs. 7-9; Conil, (unpublished key to suborders of Paleozoic Foraminifera).
Turritellella Cushman and Waters, 1927, p. 149, pl. 26, fig. 9.

Original description. — Test elongate, spiral, consisting of a proloculum and an elongate tubular second chamber in an elongate close spiral, line between the coils distinct and depressed, wall arenaceous. Length of holotype 1 mm; maximum breadth 0.40 mm.

Remarks. — *Trepeilopsis* is a scarce element in the fauna with few specimens retrieved. The Frailey's horizon is probably close to the beginning of its range. This genus seems to be confused in the literature with the genus *Turritellella* Rhumber which is an arenaceous form. Plummer (1945, p. 247) stated that Cushman and Waters' holotype is porcellaneous with a *Calcitornella*-like initial stage and not arenaceous. She included the genus in the family Ophthalmediidae. She stated, "A future paper will treat of this problem more extensively with many illustrations." Unfortunately, her death occurred before the proposed paper was completed.

Because *Trepeilopsis* is a valid name and the authors changed the generic name from *Turritellella* to *Trepeilopsis,* there seems no need to erect a new generic name but rather to emend the genus to read as follows:

Test attached, commonly to brachiopod spines or algae, consisting of a proloculus and a tubular second chamber with the early portion of test enrolled about the proloculus in a "*Calcitornella*-like" initial stage, then winding in a high trochospiral coil in a fashion similar to that of the genus *Turritellella;* wall is calcareous, homogenous, composed of microgranular calcite grains.

The siliceous arenaceous forms which have been described in the literature under the generic names of *Trepeilopsis* do not belong to this genus. Conkin and Conkin (1964, p. 39) noted that fact. Loeblich and Tappan (Treatise, 1964) made no mention of Plummer's study of the holotype and retained the genus *Trepeilopsis* in the family Ammodiscidae.

Occurrence. — *Trepeilopsis* has been reported from Eastern Europe. On the North American Continent it is known from Arctic Alaska, the Yukon, the northern Cordillera of the United States, and the Mid-Continent.

Range. — Known range is from Late Visean to Upper Namurian.

Family **TETRATAXIDAE** Galloway, 1933

Genus **TETRATAXIS** Ehrenberg, 1854, emend. von Möller, 1879

Plate 29, figures 1-7

Type species: *Tetrataxis conica* Ehrenberg, 1854 emend. Möller, 1879.

Tetrataxis Ehrenberg, 1854, p. 24, pl. 37, figs. 12, 13.
(*Valvulina*) Brady, 1876, p. 83, pl. 4, figs. 1-5; Cushman and Waters, 1928[a], p. 65, pl. 8, figs. 9a, 9b; Cherynsheva, 1940, p. 132, pl. 2, fig 9; Rauser-Chernousova, 1948[b], pp. 12, pl. 3, figs. 10-11; Reitlinger, 1950, p. 71, pl. 15, figs. 1-11; Grozdilova and Lebedeva, 1954, p. 65, pls. 7, 8; Malakhova, 1956[a], p. 44, pls. 5, figs. 4-7; Potievskaya, 1962, p. 63, pl. 4, figs. 1-4; Pronina, 1963, p. 148, pl. 7, figs. 4-9; Conil and Lys, 1964, p. 85, pl. 11, figs. 215-217; Brenckle, 1970, pp. 157-171, pl. 9, figs 10, 11, 15; pl. 10, figs. 1-13; Hallett, 1970, p. 881, pl. 4, figs. 9-11; Michelsen, 1971, p. 34, pl. 1, figs. 5-19.

Original description — (From von Möller.) Shell conical, more or less regular, with flat, somewhat concave or the opposite, convex underside. Aperture four-lobed, exceptionally with three or five lobes. Apex more or less pointed, sometimes slightly rounded or displaced to one side: the apical angle varies between 70° and 85°. Chambers are very flat, trapezoidal, more or less clearly regimented spirally and not split into cells (that is, groups). Each whorl is occupied by four or, less often, three such chambers, which, on the underside of the shell, are separated by more or less conspicuous arched radial furrows; but on the upper side of the shell the borders between the individual chambers are not so clearly seen.

Möller goes on to mention the presence of "radial pore-canals" but does not describe the two-layer structure of the wall so evident in his text-figure 30 (Möller, 1879, p. 72).

Occurrence. — *Tetrataxis* occurs throughout the Northern Hemisphere. It has been reported from Great Britain, Belgium, France, all basins of the Soviet Union, North Africa, and the Siberian Arctic. On the North American Continent *Tetrataxis* is recorded from the Maritime Provinces, British Columbia, and the Cordillera from Alaska to New Mexico. It is also present in the Mid-Continent region.

Range. — *Tetrataxis* ranges from the Late Tournaisian through the Triassic, being a common element in Visean faunas.

Family **ENDOTHYRIDAE** Brady, 1884

Genus **ENDOTHYRA** Phillips, 1846, emend. Brady (restricted) 1876, sensu Mamet, ms.

Genus **ENDOTHYRA** Phillips, 1846

Plate 29, figures 8, 9; Plate 30, figures 1a, 1b, 2

Type species: *Endothyra bowmani* Phillips, 1846.

Endothyra Phillips, 1846, emend. Brady (restricted), 1876; Cushman and Waters, 1927, p. 110; Harlton, 1927, pp. 18-20 (part); Galloway and Harlton, 1928, p. 12; Plummer, 1930, pp. 15, 16 (part); St. Jean, 1957, pl. 1, figs. 4, 6, 8, 9, 11, pl. 2, figs. 1, 2; Mamet, 1970, pp. 34, 35; Brenckle, 1970, p. 102, pl. 4, figs. 9-35.
Not *Endothyra* Phillips *in* Brown, 1843, p. 17; Phillips, 1846, pp. 277-279; Brady, 1876, pl. 5, fig. 3; Zeller, 1950, pp. 1-23, pls. 1-5; 1957, pp. 679-704,

pls. 75-80; St. Jean, 1957, p. 23, pl. 1, figs. 5, 7, 10, 12; Loeblich and Tappan, 1964 (text description), pp. 343-346.

Plectogyra Zeller, 1950, pp. 1-12 (part), pl. 2, figs. 4-7, 12, 14, 16, 17; pl. 4, fig. 8; pl. 5, figs. 4, 7-9, 12, 13, 18, 22; Zeller, 1953, pp. 195-198, pl. 27, figs. 12-20; pl. 28, figs. 1-18; Conil and Lys, 1964, pp. 155-226 (part); Hallett, 1970, p. 896 (part).

Plectogyrina Reitlinger *in* Rauser-Chernousova and Fursenko, 1959, p. 196.

Original description. — *Endothyra* Phillips *in* Brown, 1843. Invalid China, 1965, 724/1a, p. 37.

> Shell involute, discoidal, internally concamerated, the chambers communicating by a large perforation; the septa arranged in stellated order; their emarginations on the inner part of their disk; destitute of any shelly siphuncle. Form of the septal edge unknown. Size, one fiftieth of an inch.

Endothyra Phillips, 1843 is probably a fusulinid (See Pl. 30, fig. 4.)

Original description — *Endothyra* Phillips, 1846. Validated China, 1965, 724/2, p. 37.

> Amongst these fossils I distinguish a beautiful concamerated shell, most probably a foraminifer, with a large opening in each septum, on the interior edge. Formerly, I saw in possession of Mr. John E. Bowman a specimen of this kind, visible to the naked eye, and named it *Endothyra Bowmanni*. The volutions are swollen externally between the septa.

Endothyra Phillips, 1846 is almost certainly an endothyranopsin (see Pl. 30, fig. 3) or a globoendothyrin.

Revision. — *Endothyra* Brady (restricted) 1876.

Phillips' types had been lost previously. Brady collected topotypes, described and figured specimens from Lanarkshire and established Phillips' *Endothyra Bowmanni* 1846 (corrected to *E. bowmani*).

Unfortunately, Brady subjected *Rotalia* (currently *Globoendothyra*) *Baileyi* Hall, 1856 into synonymy with *E. bowmani* (1876, p. 93, pl. V, fig. 3: "Detailed examination has convinced me that, notwithstanding the somewhat stouter proportions presented by the American specimens they do not differ in any important character from *Endothyra Bowmani*." On this basis Brady, in describing the test of the genus *Endothyra* (1876, p. 91), now known to include representatives of the current genera *Loeblichia*, *Globoendothyra*, *Eostaffella*, *Endothyranopsis*, and *Pseudoendothyra* (Mamet, ms.), attributed characteristics not present in the Lanarkshire form of the type species *E. bowmani*: "The texture of the shell in *Endothyra* is to a greater or less degree arenaceous — calcareous sand embedded in a calcareous cement — the grains are minute and rounded and set in a homogeneous material. Sometimes the fine calcareous cement is in large excess — ". Brady illustrated, under the designation *Endothyra Bowmani,* Phillips, a specimen of *Globoendothyra baileyi* (Hall) (see pl. V, fig. 3). The remaining illustrations of Brady (pl. V, figs. 1, 2a-b, 4) are of the Lanarkshire form of *E. bowmani.* The British forms range in size from 548 μ to 692 μ; the Indiana specimen measures 1303 μ.

Revision. — *Endothyra* Loeblich and Tappan 1964.

Loeblich and Tappan (1964, p. C346, 262/1a-b) designated and illustrated a neotype for *E. bowmani* (BMNH-P41665 *ex* P35440 from Brady's collection) as part of their intended revision of the genus (Bull. zool. Nomencl., vol. 20, part 4, July, 1963, p. 289). The maximum dimension of the neotype is 566 μ. The action of Loeblich and Tappan was validated (China, 1965, 724/3): " — the binomen *Endothyra bowmani,* as interpreted by the neotype designated by Loeblich and Tappan, 1964, (type-species of *Endothyra* Phillips, (1846)) is hereby placed on the Official List — ". At the same time Loeblich and Tappan published an indeterminate drawing of an equatorial section of *E. bowmani* from Brady's collection (BMNH-P41674 *ex* P35440) with a diameter of 639 μ. The accompanying description (p. C343) states: " — wall calcareous, with 2 layers, thin dark outer layer (tectum) and thicker, fibrous alveolar, inner layer (diaphanotheca); partial recrystallization may result in granular appearance — ".

There is no way to be certain about the wall characteristics of the intact neotype, and Loeblich and Tappan's drawing of the accompanying thin section reveals nothing. It is assumed here that these specimens are entirely identical to Brady's Lanarkshire forms illustrated in 1876, on the basis of a 1973 communication to Pohl from B. L. Mamet: "I have seen the type in the British Museum and it is only a tectum and tectoria *without* diaphanotheca!"

The validity of the designation of a neotype by Loeblich and Tappan is not questioned; but their descriptive text relative to wall structure for *E. bowmani* is rejected, since what they describe is, without doubt, that of an endothyranopsin or a globoendothyrin.

Remarks. — The genus term *Endothyra* is used in this paper for those Late Paleozoic endothyrids with a skew type of coiling and irregularly present and sometimes prominent secondary deposits. The wall structure is a simply secreted, thin, homogeneous, microcrystalline theca without pores or alveoloi and most often with a denser outer layer or tectum.

The confusion that has existed over the status of the genus term *Endothyra* stems principally from a desire on the part of paleozoologists to conserve a name that has become widespread in the literature, and secondly from a failure to understand the relative phylogenetic importance of wall structure versus gross morphology. Diagenetic alteration of test and the general limitation imposed by random-cut examination of these fossils pose additional difficulties. A phylogenetic link is recognized at present among the endothyrins: *Endothyra, Spinoendothyra, Latiendothyra, Tuberendothyra, Laxoendothyra, Inflatoendothyra, Mediendothyra,* and the advanced form *Zellerina.* They are distinguished by wall characteristics from the endothyranopsins and globoendothyrins *Endothyranopsis, Globoendothyra, Banffella, Eoendothyranopsis, Eogloboendothyra,* and *Skippella* Mamet (ms.) The former have homogeneous walls, the latter possess porous, alveolar walls. A period of uneasiness and uncertainty has existed among paleontologists most closely involved with Mississippian and Pennsylvanian Endothyridae since the ruling of the I.C.Z.N. in 1965 (China, pp. 37-39). An untenable situation was created, in which the type species of the genus and the family was covered by a revised description relating it to the families Endothyranopsidae and Globoendothyridae. It is hoped that the solution offered in this paper will clarify this taxonomic difficulty.[3]

The endothyrids, together with the archaediscids are abundant, comprising a large part of the Fraileys fauna. Some half-dozen species are present, of small to medium size, with chambers numbering from five to nine-and-a-half in the final whorl. Most specimens do not preserve the two-layered wall.

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[3] Another taxonomic problem which must be met soon is the question of the continued use of the generic term *Globoendothyra.* Mamet was the first to point out (Sando, *et al.,* 1969, footnote p. E13) that *Globoendothyra* Reitlinger, 1954 in all probability is a junior synonym of *Plectogyra* Zeller, 1950. Pohl arrived at the same conclusion independently, following comparison of the Zeller type and study material with separate collections.

Occurrence.—*Endothyra* in the present sense has been reported from western and eastern Europe, all territories of the USSR, north Africa and the Siberian and Russian Arctic. On the North American continent it occurs in British Columbia, Alberta, the Maritime Provinces, the southern Cordillera, and the Mid-Continent.

Range.—The genus *Endothyra* ranges from the Late Tournasian to the Early Namurian, as previously reported. In its present restricted sense its principle occurrence is in the Middle and Late Visean. The group *E. prisca* has the longest range, extending from the Late Tournasian to the Early Namurian. It is especially prominent at the Visean-Namurian boundary.

Genus **ZELLERINA** Mamet, 1970

Plate 30, figures 11, 12; Plate 31, figures 1-4

Type species: *Endothyra discoidea* Girty, 1915.

Zellerina Mamet *in* Mamet and Skipp, 1970, p. 336.
Endothyra Girty, 1915, p. 27, pl. 10, figs. 10, 11, 13-16; Wray, 1952, text figs. 1-5-17.
Millerella Zeller, E. J., 1950, pl. 5, figs. 16, 17; Zeller, D. E. N., 1953, pp. 192-194, pl. 26, figs. 7-10, 12-26, pl. 27, figs. 1-11.
Paramillerella Zeller, 1957, pl. 75, figs. 1, 3-8, 10-13; Skipp, 1961, pp. C242, 243, fig. 236-3 1. J.

Original description.—Shell lenticular, very small, usually less than one-third millimeter in diameter. Thickness usually less than one-half the diameter. Nearly complanate, consists of two to three volutions composed of rather large chambers of which six or seven occur in the last volution. Walls of the final volution about 0.02 millimeters thick. Different sections, apparently perpendicular to the plane of revolution, measure 0.31 by 0.13 millimeters; 0.3 by 0.14 millimeters; 0.24 by 0.1 millimeters; 0.21 by 0.084 millimeters; 0.27 by 0.11 millimeters. A large section in the plane of revolution has a diameter of 0.38 millimeters.

Original description.—*Zellerina* new genus, *Endothyra discoidea* emend., Mamet. Shell lenticular, planispiral, involute, non-keeled, with smooth periphery and faint umbilici. Proloculum followed by 3-4 rather regulary coiled whorls. Ten to twelve chambers in the last whorl, usually 25-35 in the adult shell. Septa nearly straight, anteriorly directed. Secondary deposits feebly developed in the form of the minute pseudochomata. Wall calcareous, trilayered.

Remarks.—*Zellerina* is a common element in the Fraileys fauna. It is represented by small forms with three whorls and from 8 to 11 chambers in the final whorl. Mamet stated (1970) that the genus is transitional between an advanced *Endothyra* of the group *E. prisca* (Rauser-Chernousova and Reitlinger) and *Eostaffella*.

The character of the wall and the subquadratic chambers link it to this group. It lacks the umbilical plug of *Mediocris.*

Occurrence. — Indochina is the only place this genus has been reported in Eurasia. On the North American Continent it is common; sometimes occuring in swarms.

Range. — Mid-Visean to Early Namurian.

Superfamily **FUSULINACEA** von Möller 1878

Family **OZAWAINELLIDAE** Thompson and Foster, 1937

Genus ? **EOSTAFFELLA** Rauser-Chernousova, 1948

Plate 31, figures 5-7

Type species: *Staffella (Eostaffella) parastruvei* Chernousova, 1948.

Eostaffella Rauser-Chernousova, 1948^b, p. 15, pl. 3, figs. 16-18; Brazhnikova, *et al.,* 1956, p. 66; Conil and Lys, 1964, p. 233, pl. 40, figs 820-839.
Endothyra Cherynsheva, 1948, p. 246.
Paramillerella Thompson, 1951, p. 115.

Original description. — The shell is lenticular to ovoid, depressed at the sides. The first coils are endothyroid, sometimes expressed in the oscillating attitude of the coiling axis when viewed at 90 degrees. Dimensions from small to average. The wall is thin, not differentiated or consisting of three layers: tectum, exterior and interior tectoria. The septa are completely straight. Supplementary deposits are present in the form of the thickened septal ends on both sides of the aperture, but usually they do not form constant chomata.

Remarks. — A single specimen was retrieved from the fauna which externally and in saggital section appears to resemble the genus *Eostaffella.* The specimen, unfortunately, is broken on one side. Having but one specimen, no determining axial section was obtainable. However, the specimen is not a juvenile form. It is a symmetrically coiled spire and must have had at least 13 chambers in the final coil. The periphery is somewhat sharp and the sides of the test compressed and slightly umbilicate. The wall is not differentiated. Pseudochomata are present in *Eostaffella* and usually a keel is evident.

Occurrence. — *Eostaffella* has been reported from Europe, North Africa, the USSR, and the Siberian Arctic. On the North American Continent it is present in Alaska, British Columbia, the Yukon Territories, the Maritime Provinces and in the Mid-Continent region of the United States.

Range. — Early Visean through the Namurian.

REFERENCES

Aizenverg, D. E., Brazhnikova, N. E., and Potievakaya, P. D.

1968. *Biostratigraphic subdivision of the Carboniferous deposits of the southern slope of the Voronezhsk Massif.* Akad. Nauk Ukrainian SSR, Inst. Geol. Nauk, "Naukova Dumka", Kiev, pp. 1-151, 60 pls.

Antropov, I. A.

1950. *New species of Foraminifera from the Upper Devonian of certain areas of the eastern Russian platform.* Akad. Nauk SSSR, Geol. Inst. Kazan, Izvestiya Kazanskogo Filiala, vol. 1, pp. 21-33, 3 pls.

Baxter, J. W.

1960. *Calcisphaera from the Salem (Mississippian) Limestone in southwestern Illinois.* Jour. Paleont., vol. 34, No. 6, pp. 1153-1157, pl. 144.

Birina, L. M.

1948. *New species of calcareous algae and Foraminifera from the Devonian and Carboniferous strata on the edge of the Sub-Moscow Basin.* Soviet Geol., Sbornik 28, Minist. Geol. Soyuzo SSR, pp. 154-159, 2 pls.

Bouckaert, J., Conil, R., Delmer, A., Groessens, E., Mortelmans, G., Pirlet, H., Streel, M., and Thorez, J.

1971. *Aperçu Geologique des Formations du Carbonifere Belge 7.* Internationaler Kongress für Stratigraphie und Geologie des Karbons-Krefeld, Serv. Geol. Belg., Prof. Paper 1971, No. 2, Chapt. 2, pp. 1-34.

Bogush, O. I., and Yuferev, O. V.

1962. *Foraminifera and stratigraphy of the Carboniferous succession of Karatau and Talasskiy Alatau.* Akad. Nauk SSSR., Sibirskoe Otdel., Inst. geol. i Geophys., pp. 1-234, 9 pls.

Brady, H. B.

1873. *On Archaediscus karreri, a new type of Carboniferous Foraminifera.* Ann. and Mag. Nat. Hist., ser. 4, vol. 12, pp. 286-290, 11 pls.

1876. *A monograph of the Carboniferous and Permian Foraminifera (the genus Fusulina excepted).* Palaeontograph. Soc., London, pp. 1-166, 12 pls.

Brazhnikova, N. E.

1956. *Foraminifera. The fauna and flora of the Carboniferous deposits of the Gallic depression.* Akad. Nauk Ukrainian SSR, Inst. Geol., Trudy, ser. strat. paleont., No. 10, pp. 16-103.

1962. *Quasiendothyra and related forms from the Lower Carboniferous of the Donetz basin and neighboring regions of the Ukraine.* Akad. Nauk USSR, Inst. Geol., Trudy, ser. strat. paleont., No. 44, pp. 3-48, 14 pls.

Brazhnikova, N. E., and Vdovenko, M. K.

1971. (*In* Aizenverg, D. E.), *Atlas of the Tournaisian fauna of the Donetz Basin.* Akad. Nauk Ukrainian SSR, Inst. Geol. Nauk, "Naukova Dumka", Kiev, pp. 1-327, pls. 1-45.

Brazhnikova, N. E., and Yartseva, M. V.

1956. *On the evolution of the genus Monotaxis.* Akad. Nauk SSSR, Voprosy Mikropaleontologii, vol. 1, pp. 62-68, 1 pl., 1 fig.

Brenckle, Paul

1970. (Unpublished doctoral thesis), University of Colorado, pp. 1-237, 12 pls.

Brown, T.

1843. *The elements of fossil conchology; according to the arrangement of Lamarck: with the newly established genera of other authors.* Houlston and Stoneman (London), pp. 1-133, 12 pls.

Burdick, D. W., and Strimple, H. L.

In Furnish, W. M., Saunders, W. B., Burdick, D. W., and Strimple, H. L.

1971. *Faunal studies of the type Chesteran, Upper Mississippian of southwestern Illinois.* Univ. Kansas Paleontol. Contrib., Paper 51, pp. 15-47, pls. 3-7.

Bykova, E. V., and Polenova, E. N.

1955. *Foraminifera, Radiolaria, and Ostracoda of the Devonian of the Volga-Ural district.* VNIGRI, Trudy, new ser., No. 87, pp. 5-190, 25 pls.

Cayeux, M. L.

1929. *Les Calcisphères typiques sont des algues siphonées.* Acad. Sci. Paris, C. R., vol. 188, pp. 594-597.

China, W. E.

1965. Opinion 724. *Endothyra bowmani Phillips (1846) (Foraminifera): validated under the plenary powers.* Bull. Zool. Nomenclature, vol. 22, pt. 1, pp. 37-39.

Chernysheva, N. E.

1940. *On the stratigraphy of the Lower Carboniferous of the Makarovskoy district of the southern Urals on the basis of the foraminiferal fauna.* Moskov. Obschch. Ispyt. Prirody, Otdel. Geol., Bull., vol. 18, Nos. 5-6, pp 113-135, 2 pls.

1948a. *About Archaediscus and similar forms from the Lower Carboniferous of the USSR.* Akad. Nauk SSSR, Inst. Geol. Nauk, Trudy, no. 62 (Geol. ser. No. 19), pp. 150-158, 2 pls.

1948b. *Some new species of Foraminifera from the Visean Stage in the Makarovsk region (southern Urals).* Akad. Nauk SSSR, Inst. Geol. Nauk, Trudy, vol. 62 (Geol. ser. No. 19) pp. 246-250, 18 pls.

Conil, R.

—— Key to suborders: Allogromiina, Textulariina, Fusulinina, Miliolina and Rotaliina of the Order Foraminiferida (Protista of the Paleozoic) (unpublished).

Conil, R., and Lys, M.

1964. *Materiaux pour l'étude micropaleontologique du Dinantien de la Belgique et de la France (Avesnois).* Mem. Inst. Geol. Univ. Louvain, t. 23, pp. 1-296, 42 pls.

1968. *Utilisation stratigraphique des Foraminiferes du Dinantien.* Annales de la Société Geologique de Belgique, vol. 91, pp. 491-558, 11 pls.

Conil, R., and Pirlet, H.

1970. *Le calcaire carbonifère du synclinorium de Dinant et le sommet du Fammennien. Colloque sur la stratigraphie du Carbonifère.* (Notice infrapaginale de Conil and Lys). Congres et Colloques de l'Université de Liège, vol. 55, pp. 52, 53.

Conkin, J. E.

1961. *Mississippian smaller Foraminifera of Kentucky, southern Indiana, northern Tennessee and southcentral Ohio.* Bull. Amer. Paleont., vol. 43, No. 196, pp. 131-368, 9 pls., 43 text-figs., 1 map, 23 tables.

Conkin, J. E. and Conkin, B. M.

1964. *Mississippian Foraminifera of the United States, Part 1 — The Northview Formation of Missouri.* Micropaleontology, vol. 10, No. 1, pp. 19-47, 2 pls.

Cooper, C. L.

1947. *Upper Kinkaid (Mississippian) microfauna from Johnson County, Illinois.* Jour. Paleont., vol. 21, No. 2, pp. 81-92, 5 pls., 1 fig., 3 tables.

Cummings, R. H.

1955. *Nodosinella Brady, 1876 and associated upper Paleozoic genera.* Micropaleontology, vol. 1, No. 3, pp. 221-238, 1 pl., text figs. 1-10.

Cushman, J. A.

1917. *A monograph of the Foraminifera of the North Pacific Ocean.* U.S. Nat. Museum, Bull. 71(f), pt. 6, Miliolidae. pp. 1-108, 39 pls., 52 text figs.

1948. (revised 1959). *Foraminifera, their classification and economic use.* Harvard Univ. Press, 1959, pp. 1-478, 55 key pls., 31 text pls., 9 text figs.

1959. *Foraminifera, their classification and economic use.* Fourth edition Harvard Univ. Press., pp. 1-605, 35 pls., 31 text figs.

Cushman, J. A., and Waters, J. A.

1927. *Arenaceous Paleozoic Foraminifera from Texas.* Cushman Lab. Foram. Research, Contrib., vol. 3, pt. 3, pp. 146-153, 2 pls.

1928a. *Some Foraminifera from the Pennsylvanian and Permian of Texas.* Cushman Lab. Foram. Research, Contrib. vol. 4, pt. 2, pp. 31-55, 4 pls.

1928b. *Additional Cisco Foraminifera from Texas.* Cushman Lab. Foram. Research, Contrib. vol. 4, pt. 3, pp. 62-67, 8 pls.

Dain, L. G., and Grozdilova, L.

1953. *Fossil Foraminifera of the USSR: Tournayellidae and Archaediscidae.* VNIGRI, Trudy, new series, No. 74, pp. 1-115, 11 pls.

Derville, P. H.

1931. *Les marbres du calcaire, carbonifére, en Bas-Boulonnais.* Imprimerie O. Boehm, Strasbourg, pp., 1-322, 24 pls.

1941. *De quelque manieres d'etre calcisphères.* Soc. Geol. France, Bull. ser. 5, vol. 11, pp. 357-365, pl. 7.

1950. *De quelgue Calcisphères de nature végétale.* Soc. Geol. France, Bull. ser. 5, vol. 20, pp. 467-478, pl. 24.

1952. *À propos de Calcispheres (Rectification).* Compte Rendu Sommaire. Soc. Geol. France, pp. 236-237.

Ehrenberg, C. G.

1843. *Beobachtungen über die Verbreitung des jetzt wirkenden kleinsten organischen Lebens in Asien, Australien und Afrika und über die vorherrschende Bildung auch des Oolithkalkes der Juraformation aus kleinen polythalamischen Thieren.* K. Preuss. Akad. Wiss. Berlin, Abhandl. Ber., pp. 101-106.

1854. *Mikrogeologie.* Pp. 1-374, 40 pls., L. Voss (Leipsig).

Ellis, B. F., and Messina, A. R.

1940. *Catalogue of Foraminifera.* New York, Amer. Mus. Nat. Hist., Spec. Pubs. (supplements, 1940-1963).

Galloway, J. J., and Harlton, B. H.

1928. *Some Pennsylvanian Foraminifera of Oklahoma, with special reference to the genus Orobias.* Jour. Paleontol., vol. 2, No. 4, pp. 338-357, 2 pls.

Girty, G. H.

1915. *Fauna of the Batesville Sandstone of northern Arkansas.* U.S. Geol. Sur., Bull. 593, pp. 1-170, 11 pls.

Gould, H. R.

1970. *The Mississippi delta complex. In* Morgan, J. P., Editor. *Deltaic sedimentations modern and ancient.* Soc. Econ. Paleont. Mineral., Spec. Pub. 15, pp. 3-30.

Grozdilova, L. P., and Lebedeva, N. S.

1954. *Foraminifera of the Lower Carboniferous and Bashkirian stage of the Middle Carboniferous of the Kolvo-Visherky Area.* Mikrofauna SSSR, Sbornik 7, VNIGRI, vol. 81, pp. 1-203, 15 pls.

1960. *Foraminifera from the Carboniferous deposits of the western slope of the Urals and Timan.* Vses. Neft. Nauchno-Issledov. Geol. Razved. Inst. (VNIGRI), Trudy, n. s., vol. 150, pp. 1-264, 33 pls.

Hallett, D.

1970. *Foraminifera and algae from Yoredale series (Visean-Namurian) of northern England.* Esso Exploration, Inc., Walton-on-Thames, Surrey, pp. 873-900, 8 pls.

Harlton, B. H.

1927. *Some Pennsylvanian Foraminifera of the Glenn Formation of southern Oklahoma.* Jour. Paleont., vol. 1, pp. 15-27, 5 pls.

1928. *Pennsylvanian Foraminifera of Oklahoma and Texas.* Jour. Paleont., vol. 1, No. 4, pp. 305-310, 2 pls.

Hewitt, P. C. and Conil, R.

1969. *Foraminiferes du Meramecien et du Chesterien des Etats-Unis (Tennessee).* Bull. Soc. belge Geol., Paleont., Hydrol., t. 78, fasc. 3-4, pp. 175-185, 2 pls.

Howchin, W.

1895. *Carboniferous Foraminifera of western Australia with descriptions of new species.* Royal Soc. S. Australia, Trans. and Proc., vol. 19, pp. 194-198, 10 pls.

Krestovnikov, V. P. and Teodorovich, G. I.

1936. *New species of the genus Archaediscus from the Carboniferous of the southern Urals.* Moskov. Obshch. Ispyt. Prirody, vol. 44, Otdel. Geol. Byul., vol. 14 (1), pp. 86-89.

Loeblich, A. R., Jr., Tappan, H.

1964. *Sarcodina, chiefly "Thecamoebians" and Foraminiferida,* Pt C., *in* Moore, R. C., ed., *Treatise on Invertebrate Paleontology, Pt. C, Protista 2.* Geol. Soc. Amer. and Kansas Univ. Press, 2 vols., pp. 1-900.

Malakhova, N. P.

1956a. *Foraminifera of the Zhartimke River Limestone of the southern Urals.* Akad. Nauk SSSR, Trudy, vol. 24, pp. 26-71, 8 pls.

1956b. *Foraminifera from the Carboniferous rocks of the western slope of the northern and central Urals.* Akad. Nauk SSSR, Inst. Geol., Urals Branch, Trudy, vol. 24, pp. 72-155, 15 pls.

Malott, C. A.

1952. *Stratigraphy of the Ste. Genevieve and Chester Formations of southern Indiana.* Edwards Letter Shop, Ann Arbor, Mich., pp. 1-105.

Mamet, B. L.

1970. *Carbonate microfacies of the Windsor group (Carboniferous), Nova Scotia and New Brunswick.* Geol. Sur. Canada, Dept. of Energy, Mines and Resources, paper 70-21, pp. 1-64, 19 pls., 7 figs.

1973. *Synonymy of the genus Endothyra* (excerpt from unpublished manuscript).

Mamet, B. L., and Skipp, B. A.

1970. *Preliminary foraminiferal correlations of early Carboniferous strata in the North American Cordillera.* Les Congres et Colloques de l'Université de Liège, vol. 55, pp. 327-348.

1971. *Lower Carboniferous calcareous Foraminifera: Preliminary zonation and stratigraphic implications for the Mississippian of North America.* Sixth International Congress of Carboniferous geology and stratigraphy, Sheffield 1967, vol. III-1970, pp. 1129-1146.

Michelsen, O.

1971. *Lower Carboniferous foraminiferal faunas of the Boring Orslev, No. 1, Island of Falster, Denmark.* Denmark Geol. Sur., 2nd Rk., No. 98, pp. 1-86, 22 pls.

McFarlan, A. C., Swann, D., Walker, F., and Nosow, E.

1955. *Some old Chester problems — Correlations of lower and middle Chester Formations of western Kentucky.* Kentucky Geol. Sur., ser. 9, Bull. 16, pp. 1-37.

Mikhailov, A. V.

1939. *On characteristics of the genera of Lower Carboniferous Foraminifera in the territory of the USSR.* Leningrad, Geol. Upravl., No. 3, pp. 47-62, 4 pls.

Miklukho-Maklay, A. D.

1956. *New families and genera of invertebrates.* Materialy p. Paleont., Vses. Naucho-Issledov. Geol. Inst. (VSEGEI), Min. Geol. i Okhrana Nedr. SSSR, n.s. vol. 12, pp. 9-15.

1957. *New data on the systematics and phylogeny of the Archaediscidae.* Vestnik Leningrad Univ., No. 24, ser. Geol. and Geogr., No. 4, pp. 34-46, 4 text figs.

1958. *A new foraminiferal family, Tuberitinidae.* Voprosy Mikropaleontologii, vol. 2, Akad. Nauk SSSR, Otdel. Geol. Geog. Nauk, pp. 130-135, 1 text fig., 1 tab.

1963. *Stratigraphy of the Upper Paleozoic and the systematics and phylogeny of Foraminifera. Upper Paleozoic of central Asia.* Izdatel. Leningrad Univ., pp. 1-328.

Möller, V. von.

1879. *Die Foraminiferen des russischen Kohlenkalks.* Acad. Imper. Sci., St. Petersbourg, Mem. ser. 7, vol. 27, No. 5, pp. 131, 7 pls., 30 text figs.

Moore, F. B.

1965. *Geology of the Millerstown Quadrangle, Kentucky.* Map GQ-417: U.S. Geol. Survey.

Perry, T. G., and Smith, N. M.

1958. *The Meramec-Chester and intra-Chester boundaries and associated strata in Indiana.* Indiana Geol. Sur., Bull. 12, pp. 1-110.

Pohl, E. R.

1970. *Upper Mississippian deposits of south-central Kentucky.* Kentucky Acad. Sci., Trans., vol. 31(1-2), pp. 1-15.

Pohl, E. R., and Browne, R. G.

1973. *A thin section method for ultrasmall paleontological specimens.* Jour. Paleont., vol. 47, No. 2, in press.

Pohl, E. R., Browne, R. G., and Chaplin, J. R.

1968. *Foraminifera of the Fraileys Member (Upper Mississippian) of central Kentucky.* Jour. Paleont., vol. 42(2), pp. 581-582.

Pohl, E. R., and Philley, J. C.

1971. *Age and stratigraphy of Upper Mississippian carbonates of northeastern Kentucky.* Geol. Soc., Amer., SE. Sec., Abst. with Prog., vol. 3, No. 5, p. 340.

Potievskaya, P. D.

1962. *Representatives of new families of small Foraminifera of the Lower Permian of the northwest district of the Donbass.* Akad. Nauk SS Ukraine, Trudy, ser. strat. and paleont., vol. 44, pp. 49-93, 8 pls.

Pronina, T. V.

1963. *Foraminifera of the Berezovski Carboniferous suite of the east slope of the southern Urals.* Akad. Nauk SSSR, Trudy, Inst. Geol., Urals Branch, vol. 65, pp. 119-176, 7 pls.

Rauser-Chernousova, D. M.

1948a. *Certain new Lower Carboniferous Foraminifera from the Syzransky district.* Akad. Nauk SSSR, Trudy, Geol. Inst., vol. 62, Geol. Ser. No. 19, pp. 239-243, 17 pls.

1948b. *Foraminifera from the Carboniferous deposits of the central Kazakhstan.* Akad. Nauk SSSR, Trudy, Geol. Inst., vol. 66, Geol. ser. No. 21, pp. 1-27, 3 pls.

1948c. *Stratigraphy of the Visean Stage of the region of the south Moscow Basin.* Akad. Nauk SSSR, Trudy Inst. Geol. Nauk, vol. 62, (Geol. ser. No. 19), pp 3-40.

Rauser-Chernousova, D. M., and Fursenko, A. V.

1937. *A monographic study of the Foraminifera from the oilfields of the USSR.* Leningrad-Moskva, Glavnaya Redak., Gorno-Topliv., pp. 1-315.

1959. Responsible eds., Orlov, Yu. A. Chief ed., *Fundamentals of Paleontology, general part, Protoza.* Izdatel., Akad. Nauk SSSR, pp. 482, 13 pls; translated into English and published for the Nat. Sci. Found., Washington, by the Israel Program for Sci. Translations, Jerusalem 1962.

1959a. *Atlas of microscopical organic remains and problematica of ancient strata of Siberia.* Akad. Nauk SSSR, Trudy, Geol. Inst., vol. 25, pp. 1-59, 22 pls.

1969. *On the systematics of the Paleozoic cornuspirids.* Akad. Nauk SSSR, Trudy, Geol. Inst., Voprosy Mikropal., vol. 11, pp. 3-17, 2 pls.

Reitlinger, E. A.

1950. *Foraminifera of the Middle Carboniferous deposits of the central part of the Russian Platform.* Akad. Nauk SSSR, Trudy, Geol. Inst. vol. 126, Geol. Ser. No. 47, pp 1-126, 22 pls., 15 text figs.

1956. *New family Lasiodiscidae.* Voprosy Mikropaleontologii, No. 1, Akad. Nauk SSSR, pp. 69-78, 2 pls.

1957. *Spheres from Devonian deposits of the Russian Platform.* Akad. Nauk SSSR, Doklady, vol. 115, No. 4, pp. 774-776, 1 pl.

Rich, M.

1970. *The genus Tuberitina (Foraminiferida) in Lower and Middle Pennsylvanian rocks from the eastern Great Basin.* Jour. Paleont. vol. 44, No. 6, pp. 1060-1066, pls. 143, 144, text figs. 1-3.

Sando, W. J., Mamet, B. L., and Dutro, J. T.

1969. *Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States.* U.S. Geol. Sur., Prof. Paper 613-E, pp. E1-E25, 1 pl., 7 text figs.

Shlykova, T. I.

1951. *Foraminifera of the Visean and Namurian (Lower Carboniferous) Stages of the western part of the Moscow Basin.* Trudy VNIGRI, n.s., Bull. 56, pp. 109-178, 5 pls.

Simon, J. A., and Hopkins, M. E.

1966. *Sedimentary structures and morphology of late Paleozoic sand bodies in southern Illinois.* Illinois Geol. Sur. Guidebook Ser. 7, pp. 1-67.

Skipp, B. L.

1961. *Stratigraphic distribution of endothyrid Foraminifera in Carboniferous rocks of the Mackay quadrangle, Idaho, Art. 236.* U.S. Geol. Sur., Prof. Paper 424-C, pp. C239-C244.

Skipp, B., Holcomb, L. D., and Gutschick, R. C.

1966. *Tournayellinae, calcareous Foraminifera, in Mississippian rocks of North America.* Cushman Found. Foram. Res., Spec. Pub. No. 9, pp. 1-38.

Sosipatrova, G. P.

1962. *Foraminifera of the Upper Paleozoic of the Taimyr.* Sbornik Stat. p. paleont. i biostrat., Nauchno-Issledov. Inst. Geol. Arkt., Min. Geol. i Okhrana Nedr SSSR, vol. 30, Leningrad, pp. 35-72, 5 pls.

1966. *Foraminifera of the Tiksinski suite of the northern Kharandash Range.* Uchen. Zapis., paleont. i biostrat., Nauchno-Issledov. Inst. Geol. Arkt. Min. Geol. SSSR, vol. 11, Leningrad, pp. 5-32, 3 pls.

St. Jean, J., Jr.

1957. *A middle Pennsylvanian foraminiferal fauna from Dubois County, Indiana.* Indiana Dept. Conserv., Geol. Sur., Bull. 10, pp. 1-66, 5 pls.

Suleimanov, I. S.

1945. *Some new species of small foraminifers from the Tournaisian of the Ishimbayevo oil-bearing region.* Akad. Nauk SSSR, Doklady (Acad. Sci. USSR, Comptes Rendus), vol. 48, No. 2, pp. 124-127, 5 figs, 2 tables.

1948. *Report on some Foraminifera of the Lower Carboniferous from the region of Sterlitamak.* Akad. Nauk SSSR, Inst. Geol. Nauk, vol. 62, Geol. ser. No. 19, pp. 244-245, 4 figs.

Swann, D. H.

1963. *Classification of Genevievian and Chesterian (Late Mississippian) rocks of Illinois.* Illinois Geol. Sur., RI 216, pp. 1-91.

1964. *Late Mississippian rhythmic sediments of Mississippi Valley.* Amer. Assoc. Petrol. Geol., Bull., vol. 48 (5), pp. 637-658.

Thompson, M. L.

1951. *New genera of fusulinid Foraminifera.* Cushman Found. Foram. Research, Contrib., vol. 2, pt. 4, pp. 115-119, 2 pls.

Vdovenko, M. V.

1968. *On an unusual assemblage of Foraminifera from the upper Visean succession of the Dnieper-Donetz Basin.* Paleontol. Sbornik, No. 5, Isdatel. L'vov Univ., pp. 3-7, 2 pls.

Warthin, A. S., Jr.

1930. *Micropaleontology of the Wetumka, Wewoka and Holdenville Formations.* Oklahoma Geol. Sur., Bull. No. 53, pp. 1-81, 7 pls., 1 chart.

Waters, J. A.

1928. *A group of Foraminifera from the Canyon division of the Pennsylvanian formation of Texas.* Jour. Paleont., vol. 1, No. 4, pp. 271-275, 1 pl.

Williamson, W. C.

1880. *On the organization of the fossil plants of the Coal Measures. Part 10.* Roy. Soc. London, Philos Thans., vol. 17, pp. 493-539, 7 pls.

Wray, J. L.

1952. *Endothyroid Foraminifera from the Greenbrier series of northern West Virginia.* Jour. Paleont. vol. 26, No. 6, pp. 946-952, 20 text figs.

Zeller, D. E. N.

1953. *Endothyroid Foraminifera and ancestral fusulinids from the type Chesterian (Upper Mississippian).* Jour. Paleont., vol. 27, No. 2, pp. 183-199, 3 pls.

Zeller, E. J.

1950. *Stratigraphic significance of Mississippian endothyroid Foraminifera.* Kansas Univ. Paleont. Contrib., Protozoa, Article 4, pp. 1-23, 6 pls.

1957. *Mississippian endothyroid Foraminifera from the Cordilleran Geosyncline.* Jour. Paleont., vol. 31, No. 4, pp. 679-704, 7 pls.

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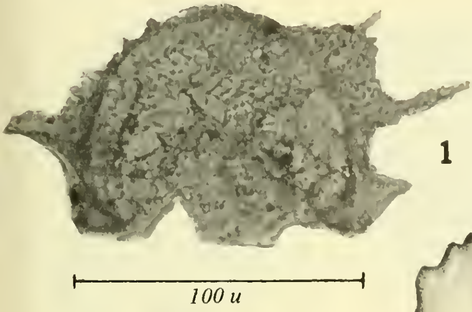

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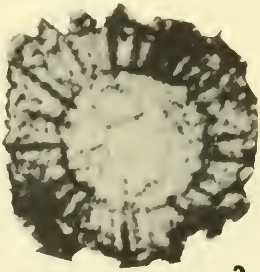

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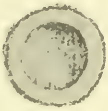

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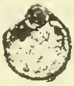

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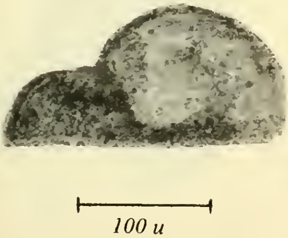

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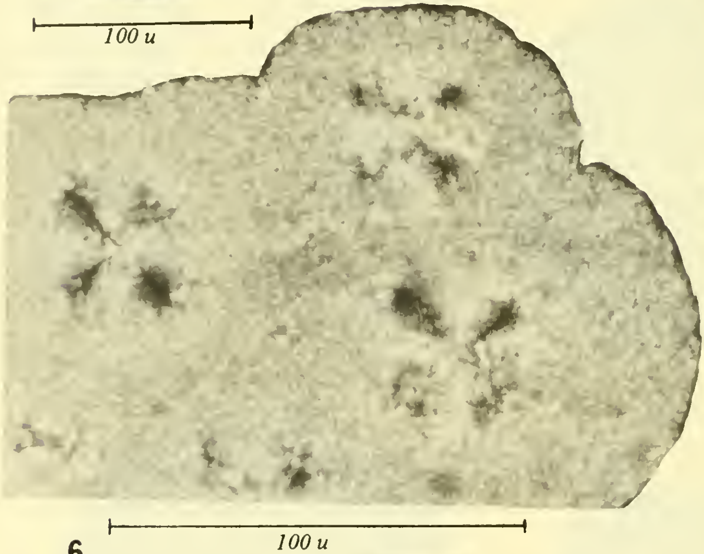

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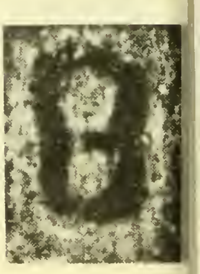

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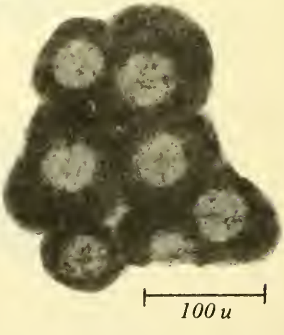

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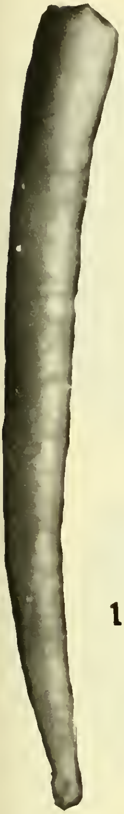
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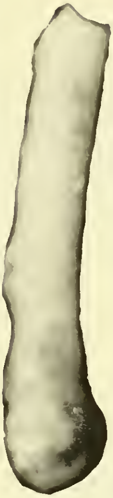
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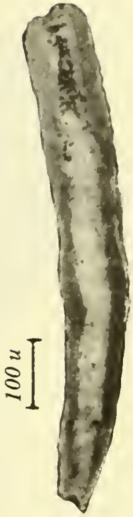

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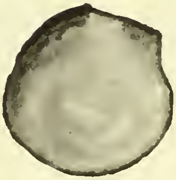
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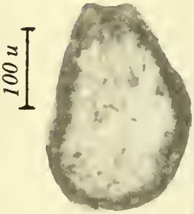

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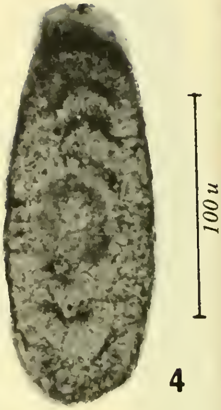

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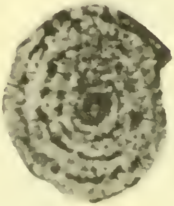

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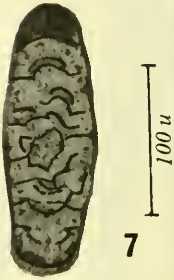

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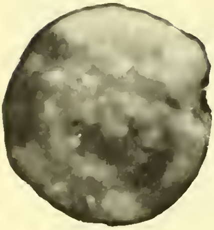

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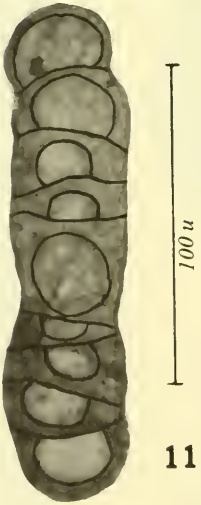

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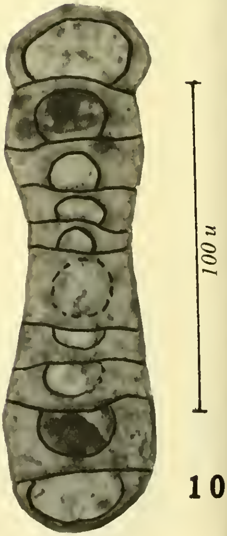

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9. **Monotaxinoides transitorius** Brazhnikova and Yartseva 207
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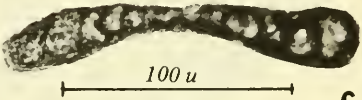

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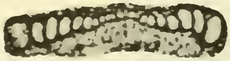

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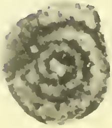

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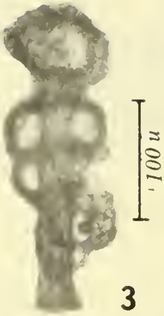

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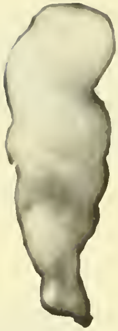

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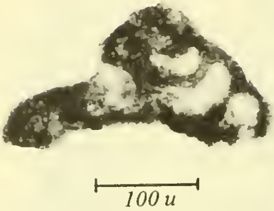

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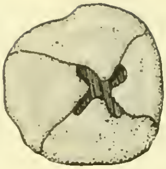

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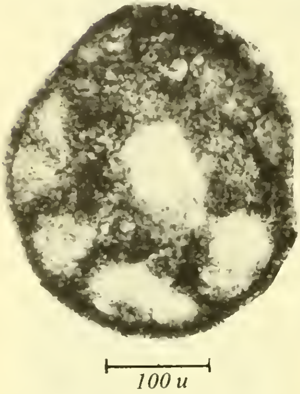

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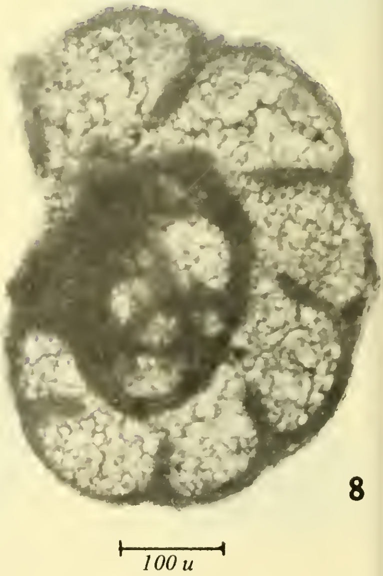

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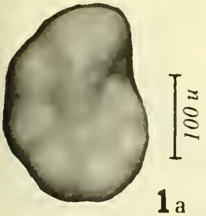

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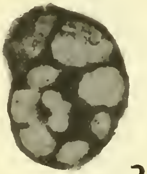

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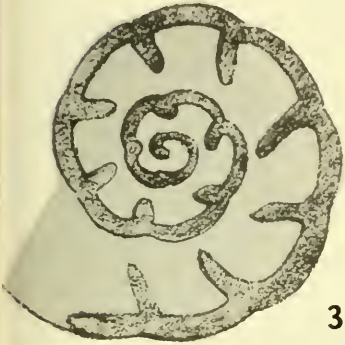

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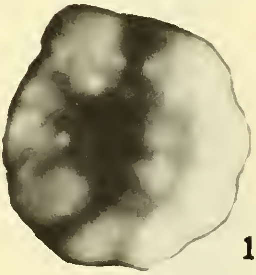

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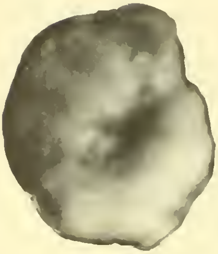
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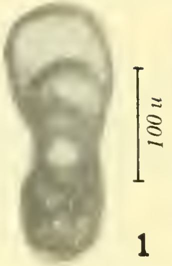

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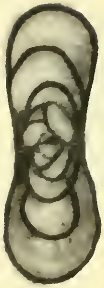
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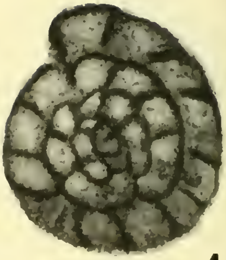
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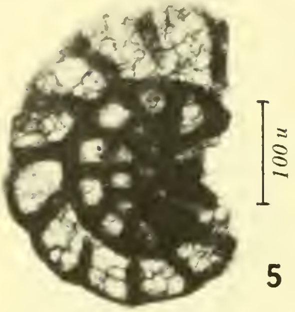

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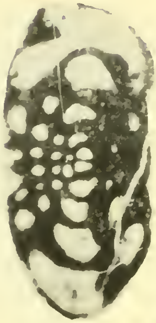
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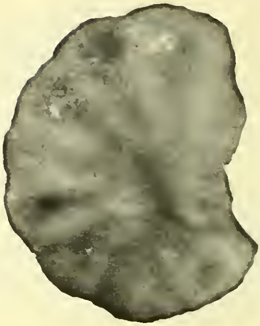
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CRINOID STUDIES

PART I. SOME PENNSYLVANIAN CRINOIDS FROM NEBRASKA

PART II. SOME PERMIAN CRINOIDS FROM NEBRASKA, KANSAS, AND OKLAHOMA

By

ROGER K. PABIAN
AND
HARRELL L. STRIMPLE

1974

Paleontological Research Institution
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CRINOID STUDIES

Roger K. Pabian[1]
and
Harrell L. Strimple[2]

PART I.

SOME PENNSYLVANIAN CRINOIDS FROM NEBRASKA

ABSTRACT

Systematic collecting from Upper Pennsylvanian (Missourian and Virgilian) rocks in southeastern Nebraska has yielded crowns and dorsal cups of 68 crinoids representing 34 species, seven of which, *Erisocrinus healdae, Graffhamicrinus tetraspinosus, Arrectocrinus comminutus, Pyndaxocrinus gerdesi, Apographiocrinus virgilicus, Bathronocrinus wolfriverensis,* and *Galateacrinus gossameri,* are new.

Tentative Range-Zones are given for most of the previously described crinoid species reported herein.

INTRODUCTION

The 68 specimens used in this study of crinoids from Nebraska were obtained over about a ten-year period from various natural and artificial, man-made exposures of several horizons of Upper Pennsylvanian rocks in southeastern Nebraska. The material discussed herein is reposited in the invertebrate paleontological collections of the University of Nebraska State Museum (UNSM), The University of Iowa (SUI), University of Oklahoma (OU), or the United States National Museum (USNM).

The purpose of this study is to describe several new species of crinoids found in Nebraska and to record the geographic (Text-fig. 1, Appendix I) and stratigraphic occurrences in Nebraska of both the new species and previously described species.

Additional material from Nebraska will be considered in subsequent studies.

PREVIOUS WORK

Erisocrinus nebrascensis Meek and Worthen (= *Erisocrinus typus* Meek and Worthen) was probably the first species of crinoid described from Nebraska. Meek and Worthen (1865b, p. 174) reported this specimen from the Coal Measures, Bellevue, Nebraska. H. B. Geinitz (1866) described the species, *Cyathocrinus inflexus,* which is now referred to the genus *Delocrinus* Miller and Gurley. The specimen was collected from the middle Wabaunsee beds, just above the Tarkio Limestone, at Nebraska City. F. B. Meek (1872) described a partial crown of *Delocrinus* from the neighborhood of Omaha, Nebraska, and called it *Scaphiocrinus*? *hemisphaericus*

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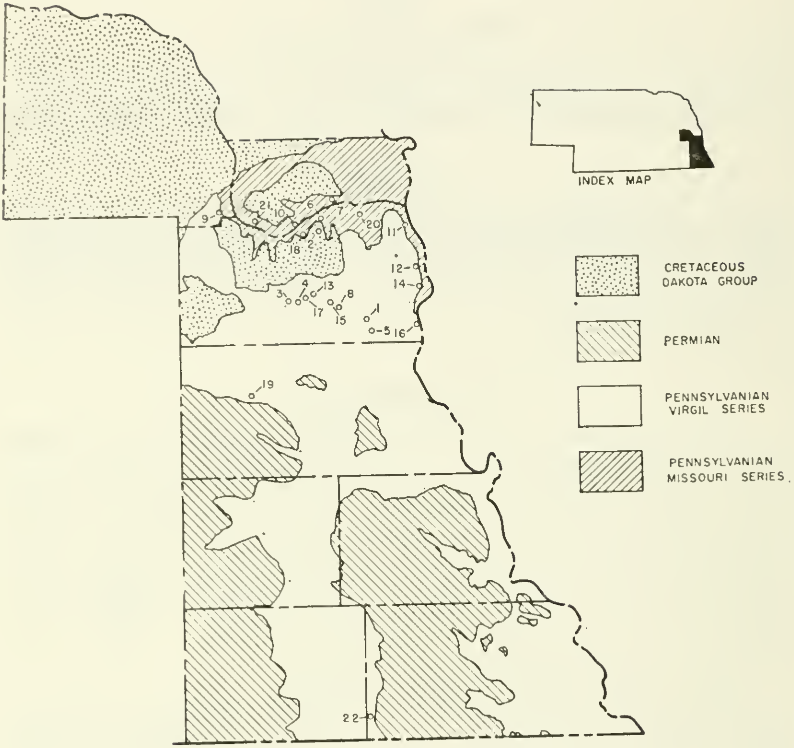
[1] Conservation and Survey Division, University of Nebraska, Lincoln.

[2] Department of Geology, University of Iowa, Iowa City.



Text-figure 1. — Index map showing the distribution of Pennsylvanian crinoids in Nebraska.

(Shumard), and he refigured Geinitz's illustration of *Delocrinus inflexus,* which he referred to the same species. Meek also reported the occurrence of *Erisocrinus typus* and *Eupachycrinus verrucosus* from Nebraska. The horizon from which Meek's specimen was collected is doubtful, but it probably came from the Shawnee Group. Barbour (1903) reported the occurrence from Nebraska of *Barycrinus subtumidus, Ceriocrinus hemisphaericus, Erisocrinus typus, Eupachycrinus* sp., *Hydreionocrinus kansasensis, Zeacrinus acanthophorous, Zeacrinus mucrospinus,* and a species of *Pachylocrinus,* but he gave no stratigraphic details. Woodruff (1906) listed the same species reported by Barbour but figured specimens called *Scaphiocrinus hemisphericus, Erisocrinus typus,* and *Barycrinus subtumidus.* These specimens were in the collections of the Honorable Charles H. Morrill. Moore (1939) erected the genus *Nebraskacrinus* to accommodate a lower Permian form from the Grant Shale in Gage County. Strimple (1949c) described two cromyocrinids, *Ethelocrinus iatani* and *Mooreocrinus meadowensis,* from the "Iatan" and Meadow Limestones, respectively, which are exposed along the lower Platte Valley. In popular articles, Graffham (1954) reported the occurrence of *Delocrinus, Ethelocrinus, Endelocrinus, Plaxocrinus,* and *Oklahomacrinus* from Virgilian rocks in Queen Hill Quarry. White (1964) reported *Aesiocrinus, Delocrinus, Ethelocrinus, Apollocrinus* (= *Stellarocrinus*), *Plaxocrinus, Erisocrinus, Nebraskacrinus, Allagecrinus, Cibolocrinus, Apographiocrinus, Haeretocrinus, Laudonocrinus, Neozeacrinus, Perimestocrinus,* and *Utharocrinus* from the Pennsylvanian of Nebraska.

Strimple and Priest (1969) described the species *Tholiacrinus decapodos* and recorded it from the Snyderville Shale. Stratigraphic sections of Nebraska quarries made by Burchett and Burchett and Prichard[3] indicate that the Snyderville Shale is unfossiliferous. Field data indicate that the specimen described by Strimple and Priest came from the Stull Shale.

Pabian and Strimple (1969) discussed the stratigraphic occurrences of Pennsylvanian crinoids in Nebraska and Pabian and Strimple (1970) indicated that two types of fossil crinoid populations were found in the Pennsylvanian of Nebraska.

---

[3] Open file, University of Nebraska, Conservation and Survey Division.

ACKNOWLEDGMENTS

Text-figure 1 was drafted by Perry L. Poyner. Doris Peabody typed the manuscript. The manuscript was edited by Marjorie Seidel. Constructive criticisms were made by staff members of the Conservation and Survey Division and Department of Geology of the University of Nebraska. United Mineral Products and Hopper Brothers Quarries of Weeping Water, Nebraska, B. C. Burden of Lincoln, and Kenneth Gerdes of Union gave access of property. Specimens collected by persons other than the senior author are so indicated in the text.

SYSTEMATIC PALEONTOLOGY

Phylum ECHINODERMATA

Subphylum PELMATAZOA

Class CRINOIDEA

Subclass INADUNATA Wachsmuth and Springer

Order CLADIDA Moore and Laudon, 1943

Suborder POTERIOCRINITINA Jaekel, 1918

Family **ERISOCRINIDAE** S. A. Miller, 1899

Diagnosis. — See Strimple and Moore, 1971, p. 9.

Genera. — *Erisocrinus* Meek and Worthen (1865);? *Protencrinus* Jaekel (1918); *Libratocrinus* Knapp (1969); *Neoprotencrinus* Knapp (1969); *Sinocrinus* Tien (1924) (= *Stemmatocrinus*); *Pontotocrinus* Knapp (1969); *Exaetocrinus* Strimple and Watkins (1969); *Parerisocrinus* Knapp (1969).

Genus **ERISOCRINUS** Meek and Worthen, 1865

Type species: *Erisocrinus typus* Meek and Worthen, 1865.

Other species included. — *Erisocrinus elevatus* Moore and Plummer, 1940; *Erisocrinus propinquus* Weller, 1909; *Erisocrinus georgeae* Strimple and Watkins, 1969; *Erisocrinus longwelli* Lane and Webster 1966; *Erisocrinus healdae* Pabian and Strimple, new species.

Diagnosis. — The dorsal cup is truncate, cone-shaped with a flat or slightly rounded base and little or no basal concavity. The outline of the cup is clearly pentagonal whether viewed from the base or top. There are five small infrabasals that extend beyond the proximal columnal. Five basals are large and the posterior basal may be slightly longer than the others. There are five large pentagonal radials. There may be a single small anal plate that is wedged between the posterior radials at the inner border in mature specimens but may enter the cup in juveniles. There are ten biserial arms composed of wedge-shaped, interlocking segments. The arms divide evenly from an axillary first primibrachial which is slightly protruded at the distal apex.

Remarks. — Nebraska specimens of *Erisocrinus* are divisible into two groups: those with radial plates having an even curvature and those having radial plates that flare outward. This is the same division indicated by Strimple and Watkins, 1969 (p. 180).

Range. — Desmoinesian through Virgilian Stages, Pennsylvanian and Lower Permian. North America.

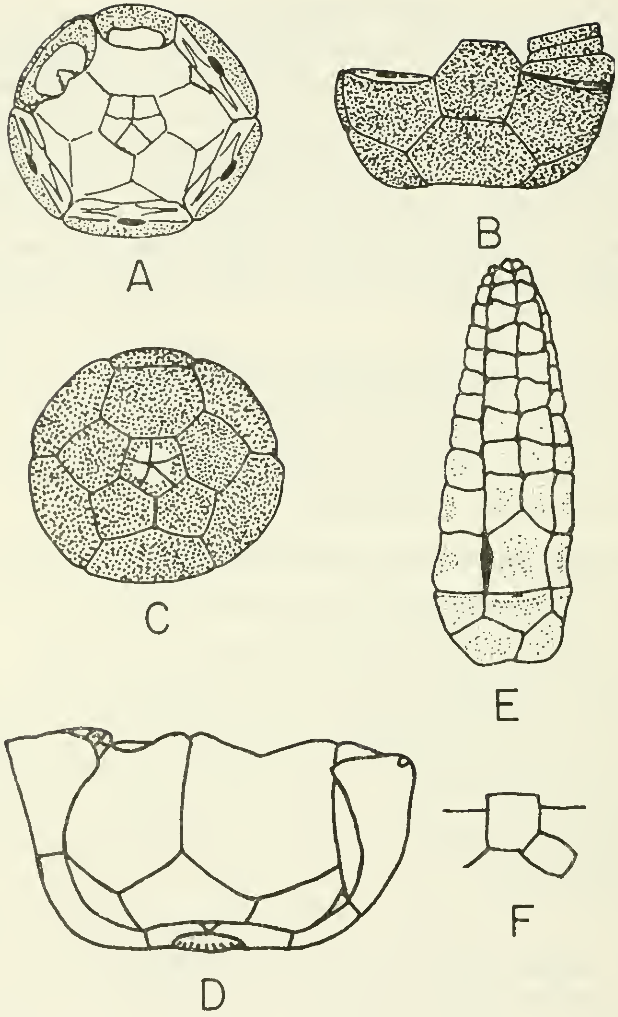
Erisocrinus elevatus Moore and Plummer, 1940 Text-fig. 2d

Erisocrinus elevatus Moore and Plummer, 1940, pp. 156-157, text-figs. 26, pl. 4, fig. 1; Knapp, 1969, p. 359.

Emended description (emended to Moore and Plummer, 1940). — The radial articulating facets are moderately wide and fairly well detailed. The outer marginal ridge is sharp and there is a deep, well-defined outer-ligamental furrow and wide ligamental pit. The transverse ridge has small, sharp denticles. The oblique ridge is faint and the muscle areas slope inward to a large, shallow central pit. The intramuscular notch is wide and the intramuscular furrow appears to be absent.

Remarks. — Two damaged specimens, UNSM-7957 and UNSM-7962, are assigned to *Erisocrinus elevatus.* Because of poor preservation, accurate measurements could not be derived.

Occurrence. — Haskell (Cass) Limestone, Stranger Formation, Douglas Group, Virgil Series, Pennsylvanian (Location 1, Appendix I). Shoemaker Bridge, north of Nehawka, Nebraska. South Bend Limestone, Stanton Formation, Lansing Group, Missouri Series Pennsylvanian. (Loc. 2, App. I) Moore and Plummer (1940) Location 181-T-41, Palo Pinto Limestone, Canyon Group, Missouri Series, Pennsylvanian, Oran, Palo Pinto County, Texas.



Text-figure 2. — A, B, C. Dorsal, posterior, and basal views, respectively, of reconstruction of dorsal cup of *Allosocrinus* sp. cf. *O. bronaughi* Strimple, based on specimen UNSM-10029, × 3. D. Median cross-section of dorsal cup of *Erisocrinus elevatus* Moore and Plummer, based on hypotypes, UNSM 7957 and UNSM 7962, × 5. E, F. Reconstruction of crown and posterior interradius, respectively, of *Syctalocrinus* sp., based on specimen UNSM 10030.

Erisocrinus healdae Pabian and Strimple, new species Pl. 32, figs. 6-8

Description. — This species is described on the basis of a single medium-high, truncate, bowl-shaped dorsal cup with a flat base and slightly outflared sides. There are five kite-shaped infrabasals that extend only a slight distance from the relatively large, concave columnar scar. The outline of the infrabasal circlet is pentagonal. The proximal ends of the five-sided, slightly tumid basals form a part of the flat base. The basals rise sharply upward and their distal ends slope at an angle of about 75 degrees to the horizontal. One basal is slightly longer than the others and is thought to be the posterior basal. There are five pentagonal radials that are about one and one-half times as wide as long.

Articulating facets are narrow, weakly defined, and slope slightly outward. The outer marginal ridge and transverse ridge surround a shallow, narrow outer ligamental furrow. The transverse ridge is faintly denticulate. The ligamental pits are shallow and poorly defined. There is a large, poorly defined oblique ridge. The muscle areas slope inward to a large, faint central pit that connects almost directly with a faint intermuscular notch.

The surface of the cup is slightly granular. Sutures are faint though slightly impressed. The columnar cicatrix is slightly pentagonal, concave and nearly as large as the infrabasal circlet. There are about 30 crenellae and a pentalobate lumen.

Table 1. Measurements (in mm) of *Erisocrinus healdae*

	UNSM 7982
Diameter of dorsal cup (posterior to anterior)	9.1
Diameter of dorsal cup (maximum)	9.5
Height of dorsal cup (anterior)	4.7
Height of dorsal cup (posterior)	4.1
Length of curvature of AB basal	3.3
Width of curvature of AB basal	4.3
Length of curvature of A radial	3.8
Width of curvature of A radial	5.3
Diameter of infrabasal circlet	4.2
Diameter of columnar cicatrix	3.0

Remarks. — This species most closely resembles the Atokan species *Erisocrinus georgeae* Strimple. *Erisocrinus healdae* differs from *E. georgeae* by having narrower, lesser detailed radial articulating facets. It seems likely that *E. healdae* developed from the lineage represented by *E. georgeae*.

Occurrence. — Ervine Creek Limestone, Deer Creek Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 3, Appendix I).

Material studied and repository. — The holotype, UNSM-7982.

Erisocrinus sp. Pl. 32, figs. 1-2

Description. — This juvenile specimen is described on the basis of a small, well-preserved immature crown. The cup is a medium-rounded bowl with a flat base and is circular in outline when viewed from above or below. There are five diamond-shaped infrabasals with well-defined sutures between them. A deep cusp is present at the distal ends of each suture, giving the infrabasal circlet a strongly stellate outline. The distal tips of the infrabasals extend only a short distance from the relatively large columnar cicatrix. Only the proximal ends of the five six-sided basals enter into the flat base. The basals rise sharply from the basal plane to about half the height of the cup. One basal appears to extend somewhat higher than the others and is considered to be the posterior basal. There are five pentagonal radials that rise upward with the same radius of curvature as that of the basals, and which are about one and one-half times as wide as long.

The axillary first primibrachials are about one and one-half times as long as wide and each is slightly pointed at the distal apex. The proximal secundibrachials are trapezoidal and grade upwards to triangular (biserial) segments by the fifth or sixth secundibrachial. There appear to be pinnules.

The crown is smooth, the sutures between plates are variable in sharpness and impression. There is a round columnar cicatrix with about 28 crenellae and a pentalobate lumen.

Table 2. Measurements (in mm) of *Erisocrinus* sp.

	UNSM 7969
Length of crown	22.5
Diameter of dorsal cup (posterior to anterior)	6.0
Diameter of dorsal cup (maximum)	6.1
Height of dorsal cup	3.1
Length of curvature of AB basal	2.4
Width of curvature of AB basal	3.5
Length of curvature of A radial	2.4
Width of curvature of A radial	3.6
Diameter of infrabasal circlet (posterior to anterior)	2.5
Diameter of columnar cicatrix	1.5

Remarks. — Because the arms of mature individuals of this species may differ markedly from the arms of juvenile specimens it is not plausible to specifically assign this specimen without knowledge of the ontogenetic sequence.

Occurrence. — Wolf River Limestone, Topeka Formation, Virgil Series, Pennsylvanian (Location 4, Appendix I).

Figured specimen. — UNSM-7969.

Genus **EXAETOCRINUS** Strimple and Watkins

Type species: *Stuartwellercrinus argentinei* Strimple, 1949b.

Range. — Missourian and Virgilian stages, Pennsylvanian, North America.

Remarks. — *Exaetocrinus* includes "primitive" type erisocrinids with high, conical cups, that are thought to have regressively evolved to a stage comparable to their primitive progenitors, (see Strimple and Watkins, 1969, p. 181), or to represent the basic lineage.

Exaetocrinus sp. cf. **E. lustrum** (Strimple) Pl. 32, figs. 11-12

Description. — The cup is a high truncate bowl with a planate or slightly convex base. There are five nearly square infrabasals that are slightly upflared, and have a cusp between each suture. The cup rests on a base formed by the infrabasal circlet and the proximal ends of the six-sided basals. The medial portions of the basals curve upward sharply and the distal ends slope at an angle of about 75 degrees to the horizontal. One basal is slightly longer than the others and is thought to be the posterior basal. There are five pentagonal radials that are about two-thirds as long as wide and flare outward near the summit of the cup.

The radial articulating facets are sharply detailed. The outer marginal ridge is sharp and there is only a deep, narrow outer ligamental furrow. The ligamental pit is small but sharply defined. The transverse ridge is marked by many small, well-defined denticles. There is a narrow, sharp oblique ridge that marks off a well-defined but not deep oblique furrow. The muscle areas slope inward to a deep central pit which is connected to a semicircular intramuscular notch by a short intramuscular furrow.

The first primibrachials are pentagonal and axillary and are slightly protruded at the distal apex. The first secundibrachials are trapezoidal-shaped elements and all succeeding brachials are biserial. There are facets for the reception of long, apparently segmented, pinnules.

The cup is smooth. The columnar cicatrix is slightly protruded. The proximal stem is round and has a round lumen.

Table 3. Measurements (in mm) of *Exaetocrinus* sp. cf. *E. lustrum*

	UNSM 7974
Diameter of dorsal cup	
(anteroposterior)	18.8
(B-DE interradius)	19.8
Height of dorsal cup	
(anterior)	10.9
(posterior)	10.3
Diameter of infrabasal circlet	
(anteroposterior)	8.3
Length of curvature of AB basal	7.8
Width of curvature of AB basal	7.1
Length of curvature of A radial	6.7
Width of curvature of A radial	12.7
Diameter of columnar cicatrix	3.0

Occurrence. — Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 5, Appendix I).

Figured specimen. — UNSM-7974.

Genus **LIBRATOCRINUS** Knapp, 1969

Type species: *Erisocrinus mediator* Strimple, 1962.

Other species included. — *Erisocrinus terminalis* Strimple, 1962a.

Remarks. — The presence of *Libratocrinus,* which is typically Desmoinesian in age, in Missourian rocks extends its known generic range zone through the lower part of the upper Missourian Series.

Libratocrinus mediator (Strimple) Pl. 37, figs. 1-3

Erisocrinus mediator Strimple, 1962a, pp. 14-16, pl. 8, figs. 4-7.

Remarks. — The surface of the cup is smooth, except for a wart or tumor on the C radial. The anal plate is visible in the side view of the cup, *cf.* Strimple, 1962a (p. 8) who indicated this plate was seen only in the side view of juvenile specimens. The radials of the Nebraska specimen do not demonstrate the tendency to touch the infrabasals.

Table 4. Measurements (in mm) of *Libratocrinus mediator*

	UNSM 7941
Diameter of dorsal cup (posterior to anterior)	14.5
Diameter of dorsal cup (B-DE interray)	14.6
Height of dorsal cup	5.9
Diameter of columnar scar	2.7
Diameter of infrabasal circlet (posterior to anterior)	4.2
Length of curvature of AB basal	5.0
Width of curvature of AB basal	5.9
Length of curvature of A radial	4.8
Width of curvature of A radial	9.2

Occurrence. — Meadow Limestone Member, Plattsburg Formation, Lansing Group, Missouri Series, Pennsylvanian (Location 6, Appendix I). Oologah Formation, Marmaton Group, Desmoines Series, Pennsylvanian, Garnett Quarry, SW 1/4, Sec. 28, T. 20N., R. 14E., and Interstate Highway 44 Locality, NE 1/4, Sec. 5, T. 19N., R. 14E., Tulsa County, Oklahoma.

Material studied. — Hypotype, UNSM-7941, collected by the late G. E. Condra.

Genus **PARERISOCRINUS** Knapp, 1969

Type species: *Paradelocrinus obovatus* Moore and Plummer, 1940.

Other species included. — *Erisocrinus erectus* Moore and Plummer, 1940.

Diagnosis. — See Knapp, 1969, p. 358, figs. 3, 13.

Remarks. — *Parerisocrinus* resembles species of both *Paradelocrinus* and *Erisocrinus.* The former has a deep basal concavity, whereas the latter has either a shallow concavity or none, and *Parerisocrinus* has a medium basal concavity.

Range. — Missourian Stage, Pennsylvanian, Texas, Nebraska.

Parerisocrinus obovatus Moore and Plummer, 1940 Pl. 38, figs. 10-11

Paradelocrinus obovatus Moore and Plummer, 1940, pp. 326-328, pl. 15, fig. 9; pl. 20, fig. 4; text-fig. 66.

Erisocrinus obovatus (Moore and Plummer), Strimple and Watkins, 1969, pp. 180-182.

Table 5. Measurements (in mm) of *Parerisocrinus obovatus*

	UNSM 7929
Diameter of dorsal cup (posterior to anterior)	18.5
Diameter of dorsal cup (maximum)	18.7
Height of dorsal cup	7.4
Length of curvature of AB-basal	8.6
Width of curvature of AB-basal	8.4
Length of curvature of A radial	6.1
Width of curvature of A radial	11.3

Occurrence. — Graford Formation, Canyon Group, Missouri Series, Palo Pinto County, Texas (Moore and Plummer, 1940). Westerville Limestone, Kansas City Group, Missouri Series, Pennsylvanian, from P.W.A. Quarry (Location 7, Appendix I).

Material studied. — Hypotype, UNSM-7929.

Parerisocrinus erectus (Moore and Plummer) Pl. 32, figs. 3-5

Erisocrinus erectus Moore and Plummer, 1940, pp. 157-158, pl. 4, fig. 3; text-fig. 26; Strimple and Watkins, 1969, p. 180.

Parerisocrinus erectus (Moore and Plummer), Knapp, 1969, pp. 358, 385.

Emended description (emended to Moore and Plummer, 1940). — Radial articulating facets are flat. Outer marginal ridge and transverse ridge surround a narrow outer ligamental furrow. There is a deep ligamental pit. Numerous fine denticles line the transverse ridge. The oblique ridge is large but not well defined. The muscle areas slope toward a deep, large central pit which is connected to an intermuscular notch by a short furrow.

Table 6. Measurements (in mm) of *Parerisocrinus erectus*

	UNSM 7964
Height of dorsal cup	
(posterior)	4.5
(anterior)	4.5
Diameter of dorsal cup	
(anteroposterior)	10.8
(B-DE interradius)	10.5
Length of curvature of AB basal	3.8
Width of curvature of AB basal	5.0
Length of curvature of A radial	3.9
Width of curvature of A radial	6.8
Diameter of infrabasal circlet (posterior to anterior)	4.6
Diameter of columnar cicatrix	2.0

Remarks. — *Parerisocrinus erectus* varies from *Parerisocrinus obovatus* by having a more narrow, shallow, but distinct, basal concavity. *Parerisocrinus erectus* does not have a flat, broad base or slightly outflared radials such as found in *Erisocrinus elevatus.*

Material studied. — Hypotypes, UNSM-7963 and UNSM-7964.

Occurrence. — Haskell (= Cass) Limestone, Stranger Formation, Douglas Group, Virgil Series. Pennsylvanian (Location 8, Appendix I). Toronto (Weeping Water) Limestone, Oread Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 9, Appendix I). Palo Pinto Limestone, Strawn Group, DesMoines Series, Pennsylvanian (Moore and Plummer, 1940). Location 248-T-4, Wise County, Texas.

Genus **NEOCATACRINUS** Knapp, 1969

Type species: *Paradelocrinus protensus* Moore and Plummer, 1940.

Diagnosis. — See Knapp, 1969, page 366, text-figure 22.

Neocatacrinus protensus (Moore and Plummer) Pl. 36, figs. 1-3

Paradelocrinus protensus Moore and Plummer, 1940, pp. 324-326, pl. 16, fig. 6, text-fig. 66.

Erisocrinus protensus (Moore and Plummer), Strimple and Watkins, 1969, p. 182.

Neocatacrinus protensus (Moore and Plummer), Knapp, 1969, p. 366, text-fig. 22.

Emended description (emended to Moore and Plummer, 1940). — The radial articulating facets are fairly well defined. The outer marginal ridge is broad but faint; there is a narrow outer ligamental furrow; the transverse ridge is sharp, has fine denticles, and is separated in two parts by a deep, well-defined ligamental pit. The oblique ridge is faint and the muscle areas narrow, sloping gently inward to a broad central pit that is connected to an intermuscular notch by a short, wide intermuscular furrow.

Remarks. — Because of its decidedly pentagonal outline, *Paradelocrinus protensus* was placed in *Erisocrinus*, with reservations, by Strimple and Watkins, 1969, page 182.

Table 7. Measurements (in mm) of *Neocatacrinus protensus*

	UNSM 10027
Height of dorsal cup	
(posterior)	5.8
(anterior)	5.4
Diameter of dorsal cup	
(anteroposterior)	13.3
(B-DE interradius)	14.0
Length of curvature of AB basal	5.1
Width of curvature of AB basal	5.1
Length of curvature of A radial	5.1
Width of curvature of A radial	7.8
Diameter of infrabasal circlet	3.7

Occurrence. — Meadow Limestone Member, Plattsburg Formation, Lansing Group, Missouri Series, Pennsylvanian, exposed in the old Kiewit Quarry (Location 10, Appendix I). Graford Formation, Canyon Group, Missouri Series, Pennsylvanian, Lane Camp, Palo Pinto County, Texas.

Material studied. — A hypotype, UNSM-10027, collected by the late George Evert Condra.

Family **CYMBIOCRINIDAE** Strimple and Watkins, 1969

Diagnosis. — See Strimple and Moore 1971, p. 27.

Genera. — *Cymbiocrinus* Kirk, 1944; *Aesiocrinus* Miller and Gurley, 1890 (syn. *Pentadelocrinus* Strimple, 1939a); *Phialocrinus* Trautschold, 1879 (*non* Eichwald, 1856); *Oklahomacrinus* Moore, 1939; *Allosocrinus* Strimple 1949a; *Lecobasicrinus* Strimple and Watkins, 1969.

Occurrence. — Mississippian — Permian, USA, USSR.

Genus **ALLOSOCRINUS** Strimple, 1949

Type species: *Allosocrinus bronaughi* Strimple, 1949a, pp. 17-20, pl. 4, figs. 1-4.

Allosocrinus sp. cf. **A. bronaughi** Strimple, 1949 Text-figs. 2a-c

Description. — The specimen under study is a badly damaged, partial dorsal cup. The infrabasals are large, nearly rhombic elements that appear to have entered a broad, shallow concavity. It appears that the basal plane of the cup is formed by the proximal portions of the basals. Medially the basals are slightly tumid and slope upward; the distal ends of the basals slope at about 60 degrees to the horizontal. The posterior basal is truncated for the reception of a large, six-sided anal X plate. The radial plates are large, tapered pentagons. The plates are covered with many closely spaced fine granules.

The radial articulating facets are narrow; there is a sharp outer marginal ridge and sloping outer ligamental furrow. The transverse ridge is sharp. There is a ligamental pit. The narrow muscle areas slope inward to a central pit which is connected to a shallow, broad intermuscular notch by a faint furrow.

Remarks. — Because of poor preservation, measurements were not made.

Occurrence. — UNSM-10029 was collected from the Ervine

Creek Limestone Member, Deer Creek Formation, Shawnee Group, Virgil Series, Upper Pennsylvanian, exposed in an abandoned quarry (Location 3, Appendix I).

Family **AMPELOCRINIDAE** Kirk, 1942

Subfamily **AMPELOCRININAE** Kirk, 1942

Genus **HALOGETOCRINUS** Strimple and Moore, 1971

Type species: *Aesiocrinus paucus* Strimple, 1951b, p. 22.

Other species included. — *Aesiocrinus prudentia* Strimple, 1963, p. 192. *Lecobasicrinus subidus* Strimple, 1969, p. 192.

Halogetocrinus paucus (Strimple), 1951 Pl. 32, figs. 14-15

Aesiocrinus paucus, Strimple, 1951b, pp. 22-23, pl. 5, figs. 1-3.
Halogetocrinus paucus Strimple and Moore, 1971, pp. 29-30; fig. 9, 1a-c; pl. 1, fig. 4; pl. 4, fig. 1; pl. 8, fig. 3.

Remarks. — The occurrence of *Halogetocrinus paucus* in Nebraska suggests that the Bonner Springs Shale may be about the same age as the Bond Formation of Illinois. The Nebraska specimen (UNSM-7937) is placed in the species *Halogetocrinus paucus* because of its resemblance to the holotype. This species has been recently redescribed by Strimple and Moore (1971, pp. 29-30, fig. 9; pl. 1, fig. 4; pl. 4, fig. 1; pl. 8, fig. 3).

Material studied. — Figured hypotype, UNSM-7937.

Occurrence. — Upper 2 feet, Bonner Springs Shale, Kansas City Group, Missouri Series, Pennsylvanian. Location 6 (Appendix I). Bond Formation, Missouri Series, Pennsylvanian, Wagner Quarry, Livingston County, Illinois.

Family **CATACRINIDAE** Knapp, 1969

Genus **DELOCRINUS** Miller and Gurley, 1890

Type species: *Poteriocrinus hemisphericus* Shumard, 1858, p. 221.

Delocrinus hemisphericus (Shumard), 1858 Pl. 33, figs. 15-17

Poteriocrinus hemisphericus Schumard, 1858, p. 221.

Remarks. — This species is common in Nebraska, especially in the uppermost Missourian and lowermost Virgilian rocks. Thirteen specimens, measurements of which are given in Table 8, are included in this study. The status of this species is not absolutely certain. Many described species of *Delocrinus* may prove to be synonyms of *D. hemisphericus.*

Table 8. – Measurements of <u>Delocrinus</u> <u>hemisphericus</u> in mm*

	UNSM-7930	-7931	-7932	-7933	-7934	-7935	-7960	-7961	-7965	-7966	-7968	-7980	-7983
Height of Dorsal Cup													
(anterior)	5.1	6.3	7.5	6.9	5.2	5.2	4.0	6.7	6.3	5.5	7.9	8.2	-
(posterior)	5.8	7.5	8.6	7.8	7.8	5.9	4.7	7.8	-	7.0	9.5	8.2	5.2
Width of Dorsal Cup													
(anterosposterior)	15.2	17.2	18.2	18.2	15.0	18.7	11.7	17.7	14.7	15.0	20.2	21.4	-
(B-DE interradius)	15.5	18.0	18.7	18.7	15.3	18.2	12.4	18.5	-	15.6	21.7	22.6	-
Height of Basal Concavity	3.2	3.9	-	3.9	2.9	-	-	3.3	-	3.3	-	4.0	-
Length of AB basal	8.7	-	8.8	8.2	6.7	7.9	4.5	8.0	7.3	8.3	10.1	10.4	-
Width of AB basal	4.9	-	8.0	6.9	5.2	7.8	3.8	5.8	6.4	7.0	9.0	-	-
Length of A radial	6.2	5.7	6.5	6.2	5.2	5.1	4.0	5.7	6.1	5.7	8.0	7.0	-
Width of A radial	10.5	10.5	10.7	11.0	9.4	11.0	7.5	11.1	8.3	9.0	13.2	14.4	12.3
Length of anal plate	3.0	4.1	5.3	5.5	2.9	4.0	2.5	5.1	-	3.3	4.3	3.7	3.0
Width of anal plate	2.5	2.3	4.1	3.1	2.1	3.7	2.1	3.6	-	4.1	1.8	2.2	1.7

* Measured along surface of curvature.

A large sample of cups and crowns from Oklahoma, Kansas, and Nebraska may help resolve this problem. These will be the subject of a subsequent investigation.

Occurrence. — Hypotypes UNSM-7930, UNSM-7931, UNSM-7932, collected from Raytown Limestone. Location 6 (Appendix I), Iola Formation, UNSM-7933, collected from Argentine Limestone, Wyandotte Formation (Location 6, Appendix I), Cass County, Nebraska; UNSM-7934, UNSM-7935, collected from Bonner Springs, Shale, (Location 6, Appendix I), Cass County, Nebraska; UNSM-7960, UNSM-7961, collected from Haskell (Cass) Limestone (Location 1, Appendix I); UNSM-7965, UNSM-7966, collected from Toronto (Weeping Water) Limestone (Location 11, Appendix I). UNSM-7968, from Toronto (Weeping Water) Limestone, collected by G. E. Condra (Location 12, Appendix I), SW 1/4; UNSM-7980, collected by B. W. Johnston from Plattsmouth Limestone, Oread Formation (Location 13, Appendix I); UNSM-7983, collected from Ervine Creek Limestone, Deer Creek Formation (Location 14, Appendix I).

Delocrinus paucinodus Moore and Plummer, 1940 Pl. 37, figs. 6-8

Delocrinus paucinodus Moore and Plummer, 1940, pp. 276-278, pl. 13, fig. 2.

Emended description (emended to Moore and Plummer, 1940). — The radial articulating facets are poorly defined. The outer marginal ridge coalesces with the transverse ridge and surrounds a shallow, poorly defined ligamental pit. There are a few indistinct denticles. The oblique ridge is poorly defined and the muscle areas slope inward to a poorly defined central pit that may be composed of two smaller pits.

Table 9. Measurements (in mm) of *Delocrinus paucinodus*

	UNSM 7971
Diameter of dorsal cup (posterior to anterior)	15.3
Diameter of dorsal cup (maximum)	16.2
Diameter of infrabasal circlet (posterior to anterior)	3.7
Height of cup	4.8
Length of curvature of right anterior basal	5.2
Width of curvature of right anterior basal	5.2
Length of curvature of anterior radial	5.2
Width of curvature of anterior radial	9.3
Length of curvature of anal x	2.7
Width of curvature of anal x	2.8
Diameter of basal concavity (posterior to anterior)	8.3
Height of basal concavity	4.1

Remarks. — This species is characterized by the faint ridges at the sutures between the plates and the irregularly scattered, pimply nodes on otherwise smooth plates.

Material studied. — One dorsal cup, hypotype, UNSM-7971.

Occurrence. — Yellow shale, Palo Pinto Formation, Canyon Group, Missouri Series, Pennsylvanian; Moore and Plummer (1940), locality 248-T-4 on the west side of Martins Lake, Wise County, Texas. Heumader Shale, Oread Formation, exposed at an abandoned Snyderville Quarry (Location 7, Appendix I).

Delocrinus vulgatus Moore and Plummer, 1940 Pl. 35, figs. 10-12

Delocrinus vulgatus Moore and Plummer, 1940, pp. 286-288, pl. 18, figs. 1, 2; Shimer and Shrock, 1944, p. 173, pl. 65, fig. 19.

Emended description (emended to Moore and Plummer, 1940). — The large arm-articulating facets occupy the width of the radials. The outer marginal ridge is narrow and fairly well defined. There is a narrow outer ligamental furrow. Denticles are on either side of the transverse ridge and on the outer ligamental ridge near the margin of the deep ligamental pit. The faint oblique ridges are mildly denticulate. The muscle area slopes gently into a large, shallow central pit that connects to the intermuscular notch by way of faint intermuscular furrow.

The A and D radials of UNSM-8001 have short, slightly-protruded, pentagonal primibrachials attached.

Table 10. Measurements (in mm) of *Delocrinus vulgatus*

	UNSM 7981	UNSM 8001
Height of cup		
(anterior)	7.5	9.5
(posterior)	9.6	12.9
Width of cup		
(anteroposterior)	23.5	26.5
(B-DE interray)	24.7	27.4
Height of basal concavity	—	—
Length of AB basal	11.3	13.4
Width of AB basal	8.4	10.4
Length of A radial	7.9	9.4
Width of A radial	14.3	16.7
Length of anal plate	6.6	9.0
Width of anal plate	5.1	4.3

Remarks. — *Delocrinus vulgatus* closely resembles *D. hemisphericus* but has more sharply defined sutures and only slightly protruded primibrachials, as opposed to long, spinose primibrachials of the later species. *D. verus* has a higher basal concavity than *D. vulgatus*. *D. missouriensis* has a distinct angulation in the basal plates.

Occurrence. — Saddle Creek Limestone, Harpersville Formation, Cisco Group, Virgil Series, Pennsylvanian, Young County Texas. Plattsmouth Limestone Member, Oread Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 13, Appendix I) and (Location 15, Appendix I).

Material studied. — Hypotypes, UNSM-7981 and UNSM-8001.

Delocrinus sp. Pl. 33, figs. 6-8

Description. — This specimen is a partial dorsal cup with the proximal portion of one arm intact. The dorsal cup is low and bowl-shaped and has a broad, shallow basal concavity. The five infrabasals slope downward at about 45 degrees and a short section of stem is attached to the columnal cicatrix. Four pentagonal basals are preserved. Their proximal portions slope downward at the same angle as the infrabasals. The basal plane of the cup is situated on the medial portions of the basals. The basals recurve and their distal portions slope upward at about 75 degrees. The radials slope steeply upwards, their medial portions are nearly vertical, and they curve inward at their summit. The plates of the cup are all smooth. There is a long, six-sided anal plate situated between the C and D radials, truncating the CD basal, and having one facet for the reception of a tube plate.

The radial articulating facets are fairly well defined and cover the entire upper surface of the radials. The outer marginal ridge is fairly sharp and borders a nearly flat-lying outer ligamental furrow. The transverse ridge is fairly sharp and has some faint denticles. There is a deep ligamental pit. The oblique ridge is poorly defined. The lower portions of the lateral slopes are fairly flat, whereas the upper portions are steep and delineate a sharp lateral ridge. The muscle areas slope inward to a broad, poorly defined central pit that connects to an intermuscular notch by a short, fairly well-defined intermuscular furrow. The C ray has a five-sided, somewhat protruded primibrachial. The secundibrachial is trapezoidal and is followed by several biserially arranged tertibrachials.

Table 11. Measurements (in mm) of *Delocrinus* sp.

	UNSM 7979
Height of dorsal cup	
(anterior)	7.0
(posterior)	6.1
Width of dorsal cup	
(anteroposterior)	20.5
Length of AB basal	7.0
Width of AB basal	6.5
Length of A radial	8.1
Width of A radial	12.2
Length of anal plate	5.0
Width of anal plate	3.4

Occurrence. — Ervine Creek Limestone, Deer Creek Formation, Shawnee Group, Virgil Series, Pennsylvanian. Location 14 (Appendix I).

Material studied. — UNSM-7979.

Family **DIPHUICRINIDAE** Strimple and Knapp, 1969

Genus **GRAFFHAMICRINUS** Strimple, 1961

Type species: *Graffhamicrinus acutus* Strimple, 1961, pp. 123-124.

Other species included. — *Delocrinus granulosus,* Moore and Plummer, 1940; *D. wolforum,* Moore and Plummer, 1940; *D. bispinosus,* Moore and Plummer, 1940; *D. bullatus* Moore and Plummer, 1940; *D. nodosarius* Moore and Plummer, 1940; *D. aristatus* Strimple, 1949c; *D. armatura* Strimple, 1949c; *D. subcoronatus* Moore and Plummer, 1940; *D. granulosus* var. *moniliformis* Moore and Plummer, 1940; *D. waughi* Moore and Strimple, 1941; *D. stullensis* Strimple, 1947; *D. magnificus* Strimple, 1947; *D. papulosus* Moore and Plummer, 1940; *D. pictus* Moore and Plummer, 1940; *D. granulosus* var. *zonatus* Moore and Plummer, 1940; *D. graphicus* Moore and Plummer, 1940; *Cyathocrinus somersi* Whitfield, 1882; *Graffhamicrinus tulsaensis* Strimple, 1962; *G. variabilis* Strimple, 1962a.

Diagnosis. — The cup is a low, truncate bowl with a deep basal concavity. There are five down-flared infrabasals, five recurved basals, and five radials, the proximal tips of which are visible and above the basal plane. One anal plate is in the cup. The primibrachials are spinose and the ten arms are biserial above the second secundibrach.

Remarks. — Strimple (1961, p. 123) erected this genus to accommodate erisocrinids with deeply invaginated bowl-shaped dorsal cups and ten biserial arms. The primibrachs were mildly protruded or spinelike but not as long as in *Delocrinus subhemisphericus.* All cups are ornamented in the form of ". . . pustules, nodes, tubercles, ridges, or strong granules, or any combination of any of these features. . ." (Strimple, 1961, pp. 123-124).

Range. — Pennsylvanian (Desmoinesian to Virgilian), Lower Permian (Big Blue). North America.

Graffhamicrinus tetraspinosus Pabian and Strimple, new species
Pl. 34, figs. 8-11; Pl. 35, figs. 8-9

Description. — This species is based on a large weathered crown and large weathered dorsal cup. The dorsal cup has steep sides and a pronounced basal concavity. The five infrabasals are kite-shaped and are separated by sutures that form a relatively deep cusp at the junction between the adjacent infrabasals and basal plates. Five long basals form the sides of the basal concavity, and they curve sharply out of the concavity so that about their middle third makes up the base and their distal third makes up the lower part of the outer wall of the cup. The CD basal is truncated for the reception of the anal plate. There are five large, pentagonal radials that are about twice as wide as long; they curve abruptly inward near the summit of the cup and each has a pair of large nodes in the upper corners. The C and D radials are separated by a large, six-sided anal plate that curves sharply inward and has a deep facet for reception of a tube plate. The holotype has a tube plate in place. The plates have fine nodes which grade into long, fine ridges from summit to base of each plate. Sutures between plates are well defined but not deeply impressed.

The outer-marginal ridge is faint. There is a broad, shallow outer ligamental furrow. The outer ligamental ridge is faint but has well-developed denticles near a deep, centrally located ligamental pit. The transverse ridge occupies nearly the entire width of the radial articulating facet and is bordered by many fine, sharp denticles. The short oblique ridges are denticulate. The lateral ridge is sharp and borders a large muscle area that slopes inward to a nearly square central pit that is connected to the intermuscular notch by a deep short intermuscular furrow.

The five first primibrachs are low, axillary elements with spinose sides. All are about the same size. The first secundibrach is a large, quadrangular plate and the succeeding segments are biserial. The arms are constricted to about the eighth secundibrach segment, after which there is a notable widening. The first primibrach and first secundibrach are covered with small nodes. The small nodes thin out beginning with the second secundibrach hence the central portions of the lower arms are smooth and the outer portions are nodose. By the fifth secundibrach the nodes are found only on the outer edges of the arms and the arms are smooth by the tenth secundibrach. The proximal column has an indeterminate number of crenellae and a round lumen. Sutures between plates are well defined but not deeply impressed.

Table 12. Measurements (in mm)* of *Graffhamicrinus tetraspinosus*

	Holotype UNSM-8068	Paratype UNSM-10022
Overall length of crown	58.5	—
Height of dorsal cup		
(anterior)	12.8	12.8
(posterior)	—	15.4
Width of dorsal cup		
(anteroposterior)	30.2	34.1
(B-DE radial)	31.3	35.1
Length of curvature of AB basal	14.7	18.8
Width of curvature of AB basal	11.8	12.8
Length of curvature of A radial	11.0	11.4
Width of curvature of A radial	18.9	20.1
Length of anal X	7.9	11.0
Width of anal X	5.1	4.2
Diameter of proximal columnal	4.3	3.9

*All measurements linear.

Remarks. — Comparisons of the numerous other species of *Graffhamicrinus* are given by Strimple (1961, pp. 126-127). *Graffhamicrinus tetraspinosus* most closely resembles *G. bispinosus* (Moore and Plummer), differing from it by having four nodes at the sutures between the radials instead of only two.

Occurrence. — Curzon Limestone, Shawnee Group, Virgil Series, Upper Pennsylvanian. (Location 16, Appendix I).

Material studied and repository. — Holotype, UNSM-8068; paratype, UNSM-10022.

Graffhamicrinus sp. cf. **G. magnificus** (Strimple), 1947 Pl. 33, figs. 9-11

Delocrinus magnificus Strimple, 1947, pp. 3-5, pl. 1, figs. 1-4; pl. 2, fig. 1.

Remarks. — Only the distal end of the anal plate is visible in the side view of the cup and the C and D radials are in contact on the outer side. The tendency of *Graffhamicrinus* toward eliminating the anal X plate is shown here. This tendency was demonstrated for *Delocrinus subhemisphericus* Moore and Plummer [= *D. hemisphericus* (Shumard)] by Strimple (1949b, pp. 123-124, pl. 4, figs. 8-15). The specimen at hand is comparable to the "Extreme Type" in which the anal X is retained only as a rudimentary element.

Occurrence. — Beil Limestone, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 17, Appendix I).

Material studied and repository. — Hypotype, UNSM-7975, collected by B. F. Rowell.

Graffhamicrinus subcoronatus (Moore and Plummer) Pl. 37, figs. 9-11

Delocrinus subcoronatus Moore and Plummer, 1940, pp. 280-282, pl. 17, fig. 1.

Table 13. Measurements (in mm) of *Graffhamicrinus subcoronatus*

	UNSM 7956	UNSM 7965
Height of dorsal cup		
(anterior)	7.0	7.1
(posterior)	8.6	8.3
Width of dorsal cup		
(anterior)	18.7	18.2
(posterior)	20.0	19.1
Height of basal concavity	4.0	4.5
Length of AB basal	9.8	9.8
Width of AB basal	8.0	8.9
Length of A radial	7.1	7.0
Width of A radial	11.3	10.7
Length of anal plate	4.2	5.0
Width of anal plate	2.5	2.8

Occurrence. — South Bend Limestone Member, Stanton Formation, Lansing Group, Missouri Series, Pennsylvanian (Location 18, Appendix I). Toronto (Weeping Water) Limestone, Oread Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 11, Appendix I).

Material studied. — Hypotypes, UNSM-7956, UNSM-7965.

Graffhamicrinus graphicus (Moore and Plummer) Pl. 33, figs. 1-3

Delocrinus graphicus Moore and Plummer, 1940, pp. 273-274, pl. 12, figs. 4, 11; Shimer and Shrock, 1944, p. 173, pl. 65, fig. 16.

Table 14. Measurements (in mm) of *Graffhamicrinus graphicus*

	UNSM 8002
Height of dorsal cup	
(anterior)	9.0
(posterior)	10.2

Width of dorsal cup	
(anteroposterior)	24.0
(B-DE interray)	24.8
Height of basal concavity	4.2
Length of AB basal	11.9
Width of AB basal	10.2
Length of A radial	8.7
Width of A radial	15.3
Length of anal plate	7.3
Width of anal plate	3.7

Occurrence. — Plattsmouth Limestone Member, Oread Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 15, Appendix I).

Material studied. — Hypotype, UNSM-8002.

Graffhamicrinus stullensis (Strimple), 1947 Pl. 33, figs. 4-5

Delocrinus stullensis Strimple, 1947, pp. 5-6, pl. 2, figs. 4-6.

Table 15. Measurements (in mm) of *Graffhamicrinus stullensis*

	UNSM 7990	UNSM 4610
Height of dorsal cup		
(anterior)	7.1	
(posterior)	7.1	
(at C radial)	5.9	
(at D radial)	7.3	
(at E radial)	8.4	
Width of dorsal cup		
(anteroposterior)	24.1	27.6
(B-DE interray)	25.8	25.9
Height of basal concavity	2.5	2.3
Length of AB basal	9.4	—
Width of AB basal	9.1	—
Length of A radial	8.0	—
Width of A radial	15.0	—
Length of anal plate	5.2	—
Width of anal plate	3.2	—

Remarks. — Hypotype, UNSM-7990, collected by Charles Messenger, is a disfigured individual; the C radial of the cup is low, whereas the D radial is high, and the E radial the highest.

Occurrence. — Hypotype UNSM-7990, Soldier Creek Limestone, Wabaunsee Group, Virgil Series, Pennsylvanian (Location 19, Appendix I). Hypotype, UNSM-4610, Ervine Creek Limestone, Shawnee Group, Virgil Series, Pennsylvanian (Location 12, Appendix I).

Genus **ARRECTOCRINUS** Knapp, 1969

Type species: *Delocrinus abruptus* Moore and Plummer, 1940, pp. 289-292, pl. 18, figs. 3-4, text-fig. 59.

Other species included. — *Arrectocrinus comminutus* Pabian and Strimple, new species.

Remarks. — The generic range zone of *Arrectocrinus* is lowered to the Curzon Limestone Member, Topeka Formation, Upper Pennsylvanian. *A. comminutus,* new species is the earliest known representative of this genus.

Arrectocrinus comminutus Pabian and Strimple, new species
Pl. 38, figs. 12-15

Description. — This species is based on a single large, medium-truncate cone-shaped dorsal cup with a very fine, granular surface. There is a shallow but well-pronounced basal concavity with a sharp stem impression. The five infrabasals slope downward at about 45 degrees. The proximal portions of the five large pentagonal basals then curve sharply upward and their distal portions slope at about 75 degrees to the horizontal. The proximal tips of the five pentagonal radials slope at about 75 degrees to the horizontal and their medial portions are slightly tumid. The radials curve sharply inward near their summit. The C and D radials are separated by a large, hexagonal anal plate which bears a large facet and truncates the distal extremity of the CD basal.

The detailed radial articulating facets are nearly level. There is a sharp outer marginal ridge that borders a shallow, well-defined outer ligamental furrow which is separated by a deep ligamental pit. There is a prominent denticulate transverse ridge. The oblique ridge is short and denticulate. The adsutural slope is gentle and there is a low lateral ridge. The muscle areas slope inward to a broad, shallow central pit that connects to a deep intermuscular notch by way of a thin intermuscular furrow.

Table 16. Measurements (in mm) of *Arrectocrinus comminutus*

	UNSM 7986
Height of dorsal cup	
(anterior)	12.4
(posterior)	15.0
Width of dorsal cup	
(anteroposterior)	29.8
(B-DE interradius)	30.5
Height of basal concavity	5.4
Length of AB basal	15.5
Width of AB basal	14.6
Length of A radial	10.4
Width of A radial	18.5
Length of anal plate	7.0
Width of anal plate	5.7

Remarks. — *Arrectocrinus comminutus* most closely resembles the lower Permian species *Arrectocrinus abruptus* (Moore and Plummer). *A. comminutus* has fine, granular ornamentation on the outer surface, whereas *A. abruptus* has a smooth surface.

Occurrence. — Curzon Limestone Member, Topeka Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I).

Material studied. — Holotype, UNSM-7986.

Genus **PYNDAXOCRINUS** Knapp, 1969

Type species: *Delocrinus separatus* Strimple, 1949a.

Other species included. — *Pyndaxocrinus gerdesi*, n. sp.

Diagnosis. — (After Knapp, 1969, p. 365, text fig. 3). The base is flat or shallow and the infrabasals are subhorizontal. The arms are unknown.

Remarks. — *Pyndaxocrinus* was erected to include flat based delocrinids in which the anal X plate is entirely visible in the posterior view of the cup.

Range. — Virgil Series, Pennsylvanian, mid-Continent region, North America.

Pyndaxocrinus gerdesi Pabian and Strimple, new species

Pl. 35, figs. 5-7; Pl. 36, fig. 6

Description. — This species is based on a single large truncated bowl-shaped cup with steep sides and flat base. The infrabasal circlet is slightly larger than the proximal column and is composed of five kite-shaped plates, and there is a sharp cusp at the distal ends of the sutures between them. The center of the infrabasal circlet is sharply depressed and is slightly larger than the proximal columnal which is intact. There are five large basals, the proximal third of each forming a large, flat base that is about three-fourths the maximum diameter of the cup. The basals curve sharply upward and extend upward about one-half the height of the cup. The posterior basal is elongate and truncated for reception of anal X. The anal X is a six-sided plate. The sutures between anal X and the C and D radials are gently undulating. The five large radials are pentagonal and about two-thirds as long as wide.

The radial articulating facets have prominent outer marginal ridges and transverse ridges, between which there is a deep ligamental pit amounting to about one-third the length of the radial width. There are many fine denticles along the transverse ridge. Large, flat muscle areas slope toward the center of the facet to a large central pit. There is a short, intermuscular furrow leading to a deep, well-defined intermuscular notch. The proximal columnal has about 33 crenellae and a small, pentalobate lumen. The sutures on the basal plane are sharp but not impressed, and they become faint toward the distal ends of the basals and are almost indistinct between the radials. The surface of the cup is covered by many fine granules.

Table 17. Measurements (in mm) of *Pyndaxocrinus gerdesi*

	UNSM 7987
Height of dorsal cup	
(anterior)	12.1
(posterior)	13.5
Width of dorsal cup	
(anteroposterior)	25.1
(B-DE radial)	26.8
Length of curvature of AB basal	13.5
Width of curvature of AB basal	13.0
Length of curvature of A radial	8.8
Width of curvature of A radial	16.1
Diameter of infrabasal circlet (posterior to anterior)	7.2
Diameter of proximal columnal	3.8
Height of basal concavity	0.0
Length of anal plate	7.6
Width of anal plate	4.7

Remarks.—*Pyndaxocrinus gerdesi* appears to have developed from *P. separatus* (Strimple) by deepening the dorsal cup. *P. gerdesi* has well-developed radial articulating facets, whereas these features are poorly developed in *P. separatus*. *P. gerdesi* has no basal concavity, whereas *P. separatus* has a small concavity.

Occurrence.—Curzon Limestone, Topeka Formation, Shawnee Group, Virgil Series, Upper Pennsylvanian (Location 16, Appendix I).

Material studied.—Holotype, UNSM-7987.

Family **APOGRAPHIOCRINIDAE** Moore and Laudon, 1943

Genus **APOGRAPHIOCRINUS** Moore and Plummer, 1940

Type species: *Apographiocrinus typicalis* Moore and Plummer, 1940, pp. 118-123, plate 3, figs. 4, 5, text-figs. 14-16.

Other species included.—*Apographiocrinus calycinus* Moore and Plummer, 1940; *A. decoratus* Moore and Plummer, 1940; *A. facetus* Moore and Plummer, 1940; *A. wolfcampensis* Moore and Plummer, 1940; *A. rotundus* Strimple, 1948; *A. obtusus* Strimple, 1948; *A. quietus* Strimple, 1948; *A. angulatus,* Strimple, 1948; *A. arcuatus* Strimple, 1949; *Graphiocrinus carbonarius* Meek and Worthen, 1861.

Diagnosis. — The dorsal cup is low, bowl-shaped, and has gently tumid plates separated by impressed sutures. The base is flat or shallowly concave, and infrabasals are down-flared or subhorizontal. There is a single anal plate with two facets.

Apographiocrinus calycinus Moore and Plummer Pl. 38, figs. 6-8

Apographiocrinus calycinus Moore and Plummer, 1940, pp. 128-129, pl. 3, fig. 7, text-fig. 16.

Table 18. Measurements (in mm) of *Apographiocrinus calycinus*

	UNSM 7936
Height of dorsal cup	
(anterior)	2.0
(posterior)	2.9
Width of basal cup	
(anteroposterior)	7.6
(B-DE interray)	7.6
Height of basal concavity	
Length of AB basal	2.3
Width of AB basal	2.3
Length of A radial	2.3
Width of A radial	4.8
Length of anal plate	2.2
Width of anal plate	2.1

Remarks. — The specimen at hand is not so finely ornamented as the holotype of *Apographiocrinus calycinus.* The Nebraska cup is low and the basal concavity shallow, in which respects it resembles the holotype.

Occurrence. — Graford Formation, Canyon Group, Missouri Series, Pennsylvanian, Kyle Mountain, Palo Pinto County, Texas. Hypotype, UNSM-7936, Bonner Springs Shale, Kansas City Group, Missouri Series, Pennsylvanian (Location 20, Appendix I).

Material studied. — Hypotype, UNSM-7936.

Apographiocrinus virgilicus Pabian and Strimple, new species
Pl. 38, figs. 3-5

Description. — This species is described from a basally impressed, medium bowl-shaped dorsal cup. There is a distinctly impressed, pentagonal infrabasal disk. The columnar cicatrix is round. The proximal portions of the five infrabasals are nearly level and the distal portions slope downward at about 45 degrees. Only the most proximal portions of the five tumid, pentagonal basals are included in the basal concavity. The basals recurve upwards in such a fashion that most of their proximal ends make up the basal plane of the cup. The basals rise upward at about 45 degrees about half way up the side of the cup. The five pentagonal radials are tumid and slope upward at about 45 degrees, the slope steepening near the summit of the cup and the distal ends of the radials curving inward. The C and D radials are separated by a large anal plate, the lower end of which truncates the CD basal. The anal plate has two facets for the reception of tube plates. The dorsal outline of the cup is distinctly but not strongly scalloped.

The radial articulating facets are wide, slope inward, and are separated by prominent prongs. There are some granules near the outer marginal ridge. The outer ligamental furrow is wide and there is a deep, well-defined ligamental pit. The transverse ridges are broad. The muscle areas slope inward to a deep central pit that connects to a broad intermuscular notch by way of a faint furrow.

Table 19. Measurements (in mm) of *Apographiocrinus virgilicus*

	UNSM 7978
Height of dorsal cup	
(anterior)	3.4
(posterior)	4.8
Width of dorsal cup	
(anteroposterior)	8.9
(B-DE interradius)	9.3
Length of AB basal	3.1
Width of AB basal	3.1
Length of A radial	3.4
Width of A radial	5.6
Length of anal plate	3.0
Width of anal plate	2.7

Remarks. — *Apographiocrinus virgilicus* most closely resembles *A. wolfcampensis* from the Permian of Texas and *A. typicalis* from the Missourian of mid-continent North America. It differs from the former by having some ornamentation near the summit of the radials and from the latter by having a relatively deeper dorsal cup. It is possible that *A. virgilicus* is an intermediate species between *A. typicalis* and *A. wolfcampensis.*

Occurrence. — Ervine Creek Limestone, Deer Creek Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 3, Appendix I).

Material studied. — The holotype, UNSM-7978.

Family **PARADELOCRINIDAE** Knapp, 1969

Diagnosis. — The dorsal cup has a concave base. There are five down-flared infrabasals. The basals are small and visible in side view of the cup. The anal plate may be in the cup or absent. There are ten arms which are uniserial in the lower portions and biserial above.

Genera. — *Paradelocrinus* Moore and Plummer, 1938; *Endelocrinus* Moore and Plummer, 1940; *Tholiacrinus* Strimple, 1962.

Remarks. — The placing of *Endelocrinus* in this family by Strimple requires that Knapp's original diagnosis be emended to include those forms with an anal plate visible on the side of the cup and with uniserial arms that may grade upward into biserial arms. *Pontotocrinus* Knapp, 1969, is thought to belong to the family Erisocrinidae contrary to Knapp's assignment.

Range. — Morrowan through Virgilian Stages, Pennsylvanian. North America.

Genus **ENDELOCRINUS** Moore and Plummer, 1940

Type species: *Eupachycrinus fayettensis* Worthen, 1873.

Diagnosis. — The cup is bowl-shaped with down-flared infrabasals. The basal plates are tumid to bulbous. The anal plate is followed by a single tube plate. The primibrachials are somewhat protruded and arms are uniserial grading upward to biserial.

Endelocrinus tumidus (Strimple), 1939 Pl. 32, figs. 9-10

Delocrinus tumidus Strimple, 1939, pp. 8-9, pl. 2, figs. 6-7; 1950, pp. 112-113; 1971, p. 14, pl. 2, fig. 2.
Endelocrinus parvus Moore, 1940, pp. 303-306, pl. 14, figs. 1-2; text-fig. 63; Shimer and Shrock, 1944, p. 173, pl. 65, fig. 1.
Tholiacrinus tumidus (Strimple), Knapp, 1969, p. 367.
Tholiacrinus parvus (Moore), Knapp, 1969, p. 367.

Table 20. Measurements (in mm) of *Endelocrinus tumidus*

	UNSM 7959	UNSM 7984	UNSM 7985	UNSM 7989
Height of dorsal cup				
(anterior)	4.4	4.6	3.9	3.5
(posterior)	4.9	5.2	—	4.6
Width of dorsal cup				
(anteroposterior)	10.6	10.0	9.4	10.1
(B-DE interradius)	11.0	11.1	9.4	10.1
Height of basal concavity	2.0	—	—	—
Length of AB basal	4.8	4.6	—	4.3
Width of AB basal	4.6	4.0	3.5	3.8
Length of A radial	4.8	4.1	2.8	3.5
Width of A radial	7.2	7.1	—	6.7
Length of anal plate	2.3	3.6	—	2.0
Width of anal plate	2.0	2.0	—	1.5

Occurrence. — UNSM-7959, Cass (Haskell) Limestone, Stranger Formation, Douglas Group, Virgil Series, Pennsylvanian (Location 21, Appendix I). UNSM-7984 and 7985, Curzon Limestone Member, Topeka Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I). UNSM-7989, Church Member, Howard Limestone Formation, Wabaunsee Group, Pennsylvanian (Location 22, Appendix I). Wann Formation, Ochelata Group, Missouri Series, Pennsylvanian, exposed at "The Mound," west of Bartlesville, Oklahoma. LaSalle Limestone Member, Bond Formation, Mac Leansboro Group, Missouri Series, near Pontiac, Livingston County, Illinois. Mineral Wells Formation, Canyon Group, Missouri Series, Pennsylvanian, Moore and Plummer locations 25-T-5, Brown County, Texas, and 119-T-29, Jack County, Texas. Winterest Limestone, Dennis Formation, Kansas City Group, Coffeyville, Kansas, and Stanton Formation, Lansing Group, Missouri Series, Wayside, Kansas.

Endelocrinus tumidus spinosus Strimple Pl. 37, figs. 4-5

Delocrinus tumidus Strimple, 1939, pp. 10-11, pl. 2, figs. 4-5.
Endelocrinus tumidus spinosus Strimple, 1950, p. 112; 1971, pp. 14-15, pl. 3, fig. 7.

Table 21. Measurements (in mm) of *Endelocrinus tumidus spinosus* Strimple

	UNSM 7935
Height of dorsal cup	
(anterior)	5.5
(posterior)	5.6
Width of dorsal cup	
(anteroposterior)	11.5
(B-DE interradius)	12.9
Height of basal concavity	2.2
Length of AB basal	6.4
Width of AB basal	5.4
Length of A radial	4.8
Width of A radial	7.7
Length of anal plate	3.2
Width of anal plate	3.1

Occurrence. — Bonner Springs Shale, Kansas City Group, Missouri Series, Pennsylvanian (Location 6, Appendix I).

Material studied. — Hypotype UNSM-7935.

Endelocrinus cf. **allegheniensis** (Burke) Pl. 34, figs. 12-14

Delocrinus allegheniensis Burke, 1932, pp. 89-93, pl. 3, figs. 1-5.
Endelocrinus allegheniensis (Burke), Moore and Plummer, 1940, pp. 254, 257, fig. 63c.

Description. — This species is represented by a dorsal cup with a broad, moderate basal concavity and tumid plates. The five infrabasals are small and steeply down-flared; all but their distal extremities are covered by the round columnar cicatrix. Outline of the infrabasal disk is substellate. Proximal ends of the five basals are gently down-flared to produce the broad concavity. The basal plane of the cup is comprised of the medial portions of the five basals. Distal ends of the basals are nearly vertical. The CD basal is truncated for the reception of the anal plate. Proximal tips of the five pentagonal radials extend to the basal plane, with medial portions bulbous, giving the cup an inflated outline. The radials curve sharply inward near their summit. The C and D radials are separated by a long, narrow anal plate. With the exception of the bulbous plates, the cup is unornamented.

The radial articulating facets are broad and occupy the entire width of the radials. The outer marginal ridge and transverse ridge are broad and wide. The outer ligamental furrow is shallow but the ligamental pit is deep. There are only a few fine denticles on the transverse ridge. The oblique ridge is short and faint. The lateral slope rises at about 45 degrees, and there is a broad lateral ridge. The muscle areas slope inward to a broad central pit that is connected to an intramuscular notch by way of a short, narrow intramuscular furrow.

Table 22. Measurements (in mm) of *Endelocrinus* cf. *E. allegheniensis*

	UNSM 10024
Height of dorsal cup	
(anterior)	4.0
(posterior)	4.4
Width of dorsal cup	
(anteroposterior)	12.6
(B-DE interray)	13.4
Height of basal concavity	2.3
Length of AB basal	5.6
Width of AB basal	4.9
Length of A radial	5.2
Width of A radial	8.0
Length of anal plate	2.9
Width of anal plate	1.7

Occurrence. — Ervine Creek Limestone, Deer Creek Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I).

Material studied. — Figured specimen, hypotype UNSM-10024.

Family **PIRASOCRINIDAE** Moore and Laudon, 1943

Diagnosis. — The crown is compact having a low, dicyclic cup with a flat, concave, or slightly convex base. The arm-articulating facets are wide, slope outward and have a distinct transverse ridge, muscle, and ligamental areas. There are three anals in the cup and the sac is prominent and mushroom-shaped. The arms are uniserial, branching isotomously two or more times.

Genus **BATHRONOCRINUS** Strimple, 1962

Bathronocrinus Strimple, 1962, p. 37.
Hypermorphocrinus Arendt, 1968, pp. 529-530, fig. 1.

Type species: *Bathronocrinus turioformis* Strimple, 1962a, p. 38, pl. 1, figs. 15-18.

Other species included. — *Hypermorphocrinus magnospinosus* Arendt, 1968, pp. 529-530, pl. 1. *Hydreionocrinus deweyensis* Strimple, 1939a, pp. 374-375, pl. 2, figs. 13-17. *Bathronocrinus wolfriverensis* Pabian and Strimple, new species.

Bathronocrinus wolfriverensis Pabian and Strimple, new species

Pl. 35, figs. 1-4

Description. — This species is based on a single, flat cone-shaped dorsal cup. The infrabasal circlet is made up of five small plates that slope upward to about 20 degrees starting at the margin of the large columnar cicatrix. The five medium-sized basals flare upward at about the same angle as the infrabasals. The EA, AB, and BC basals are pentagonal whereas the CD and DE basals are hexagonal in order to accommodate the radianal and anal plates. The radianal is in contact with the CD and DE basals below and the D radial, the anal, and right tube plates above. The anal plate is in contact with the CD basal, radianal, and C radial below and the right tube plate above. The five radials slope upward at about the same angle as the basals and are slightly tumid in their medial portions.

The radial articulating facets slope outward at about 45 degrees. The outer marginal ridge is below the outer distal ends of the radials and not visible from the top view of the cup. The outer ligamental furrow is narrow and shallow and there is a ligamental pit. The lateral furrows are indistinct and the muscle areas slope outward. There is a faint, but large, intramuscular notch.

The columnar cicatrix has about 38 crenellae and a round lumen.

Table 23. Measurements (in mm) of *Bathronocrinus wolfriverensis*

	UNSM 7972
Height of dorsal cup	
(anterior)	8.3
(posterior)	10.0
Width of dorsal cup	
(anteroposterior)	19.5
(B-DE interradius)	21.5
Length of AB basal	6.2
Width of AB basal	6.2
Length of A radial	5.5
Width of A radial	11.5
Length of radianal	5.4
Width of radianal	3.1
Length of anal plate	5.3
Width of anal plate	3.6

Remarks.—*Bathronocrinus wolfriverensis* does not have the deep notches between the radials as does *B. turioformis*, and the radial facets of the former slope outward much more steeply. *B. magnospinosus* has a flat or somewhat concave base.

Occurrence.—Wolf River Limestone, Topeka Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 4, Appendix I).

Material studied.—The holotype, UNSM-7972.

Genus **PLAXOCRINUS** Moore and Plummer, 1938

Type species: *Hydreionocrinus crassidiscus* Miller and Gurley.

Other species included.—*Hydreionocrinus kansasensis* Weller; *Zeacrinus discus* Meek and Worthen; *Eupachycrinus sanctoludovici* Worthen; *Plaxocrinus perundatus* Moore; *P. aplatus* Moore and Plummer; *P. lobatus* Moore and Plummer; *P. modestus* Moore; *P. omphaloides* Moore and Plummer; *P. orthodoxus* Moore; *P. parilis* Moore and Plummer; *P. praevalens* Moore; *P. strigosus* Moore and Plummer; *P. virginarius* Moore; *P. gloukosensis* Strimple; *P. laxus* Strimple; *P. oeconomicus* Strimple; *P. dornickensis* Strimple; *P. tumulosus* Strimple; *P. normalis* Strimple; *P. octarius* Strimple; *Hydreionocrinus uddeni* Weller.

Diagnosis.—The dorsal cup is round, has broad, interradial notches and a shallow basal concavity. The infrabasals and proximal part of the basals are slightly down flared. The dorsal cup rests on the medial portions of the basals and the distal portions flare upward and are readily visible in the side view of the cup. Radials are wide and slightly tumid and their proximal tips are included in the basal plane of the cup. The posterior interradius is narrow, the RA is in direct posterior position, and the anal plate is directly above it. The radial articulating facets slope slightly outward.

Plaxocrinus parilis Moore and Plummer Pl. 34, figs. 1-4

Plaxocrinus parilis Moore and Plummer, 1940, pp. 199-202, pl. 9, figs. 5-6, text-fig. 39; Shimer and Shrock, 1944, p. 163, pl. 63, fig. 5.
Vertigocrinus parilis (Moore and Plummer), Knapp, 1969, p. 378.

Table 24. Measurements (in mm) of *Plaxocrinus parilis*

	UNSM 7940	UNSM 10023
Height of dorsal cup		
(anterior)	3.9	3.2
(posterior)	5.5	3.7
Width of dorsal cup		
(anteroposterior)	14.5	8.4
(B-DE interradius)	13.9	9.0
Length of AB basal	4.6	2.7
Width of AB basal	4.0	2.9
Length of A radial	3.1	3.3
Width of A radial	8.7	5.3
Length of radianal	4.8	2.7
Width of radianal	2.2	1.4
Length of anal plate	3.7	1.7
Width of anal plate	2.1	1.1

Occurrence. — Hypotype 7940, Spring Hill Limestone Member, Plattsburg Formation, Lansing Group, Missouri Series, Pennsylvanian (Location 6, Appendix I). Hypotype, UNSM-10023, Winterset Limestone, Dennis Formation, Kansas City Group, Missouri Series, Pennsylvanian (Location 23, Appendix I). Graford Formation, Canyon Group, Missouri Series, Pennsylvanian, Moore and Plummer (1940) location 119-T-29, Jack County, Texas. Argentine Limestone Member, Wyandotte Formation, Kansas City Group, Pennsylvanian, Moore and Plummer (1940) location 6032, Wyandotte County, Kansas.

Plaxocrinus gloukosensis Strimple Pl. 36, figs. 4-5

Plaxocrinus gloukosensis Strimple, 1951, pp. 374-375, pl. 57, figs. 1-6.
Vertigocrinus gloukosensis (Strimple), Knapp, 1969, p. 378.

Table 25. Measurements (in mm) of *Plaxocrinus gloukosensis*

	USNM 7938
Height of dorsal cup	
(posterior)	—
(anterior)	7.1

Width of dorsal cup	
(anteroposterior)	22.5
(B-DE interradius)	24.5
Length of AB basal	6.4
Width of AB basal	6.0
Length of A radial	7.2
Width of A radial	13.4
Length of radianal	6.4
Width of radianal	4.0

Occurrence. — Merriam Limestone Member, Plattsburg Formation, Lansing Group, Missouri Series, Pennsylvanian (Location 6, Appendix I). Cass (Haskell) Limestone, Douglas Group, Virgil Series, Pennsylvanian, Homewood, Kansas.

Material studied. — Hypotype UNSM-7938.

Genus **SCIADIOCRINUS** Moore and Plummer

Type species: *Hydreionocrinus acanthophorus* Meek and Worthen, 1870.

Other species included. — *Sciadiocrinus crassacanthus* Moore and Plummer, 1938, pp. 276-277, text-fig. 24; *S. disculus* Moore and Plummer, 1940; *S. harrisae* Moore and Plummer, 1940; *Plaxocrinus obesus* Moore and Plummer, 1940; *Eupachycrinus platybasis* White, 1876; *Schistocrinus confertus* Moore and Plummer, 1940; *S. planatus* Moore and Plummer, 1940; *S. parvus* Moore and Plummer, 1940; *Sciadiocrinus llanoensis* Strimple and Watkins, 1969; *Pirasocrinus invaginatus* Strimple, 1951c; *Sciadiocrinus humilis* Strimple, 1951.

Diagnosis. — The dorsal cup is flat with a deep, broad basal concavity which includes the proximal tips of the radials. The radials are bulging and the arm-articulating facets slope steeply outward.

Sciadiocrinus humilis Strimple — Pl. 35, figs. 13-15

Sciadiocrinus humilis Strimple, 1951a, p. 373, pl. 53, figs. 11-14; Knapp, 1969, p. 378.

Table 26. Measurements (in mm) of *Sciadiocrinus humilis*

	UNSM 10026
Height of dorsal cup	
(anterior)	6.2
(posterior)	6.9
Width of Dorsal cup	
(anteroposterior)	17.7
(B-DE interradius)	20.0
Height of basal concavity	4.0

Length of AB basal	5.4
Width of AB basal	4.7
Length of A radial	5.6
Width of A radial	11.5
Length of radianal	5.8
Width of radianal	2.4
Length of anal plate	2.7
Width of anal plate	0.9

Occurrence. — Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I).

Material studied. — Hypotype, UNSM-10026.

Genus **ATHLOCRINUS** Moore and Plummer

Type species: *Athlocrinus placidus* Moore and Plummer, 1940, pp. 169-170.

Other species included. — *Athlocrinus nitidus* Moore and Plummer, 1940; *Athlocrinus clypeiformis* Moore and Plummer, 1940; *Athlocrinus clarus* Strimple, 1962a.

Diagnosis. — The dorsal cup is a low, truncate bowl with three anal plates. The base is almost flat except for the indented, round-stem impression. The sides of the cup flare upward gently and are nearly vertical at their summit. The posterior interradius is broad giving the cup a nearly hexagonal outline. The sutures are not impressed and the cup is smooth. The radial facets are slightly less than the maximum width of the radials.

Athlocrinus placidus Moore and Plummer — Pl. 33, figs. 12-14

Athlocrinus placidus Moore and Plummer, 1940, p. 170, pl. 6, fig. 1, text-fig. 30; Shimer and Shrock, 1944, p. 163, pl. 62, fig. 1; pl. 63, fig. 13; Knapp, 1969, p. 373, text-fig. 42.

Table 27. Measurements (in mm) of *Athlocrinus placidus*

	UNSM 7939
Height of dorsal cup	
(anterior)	5.0
(posterior)	7.6
Width of dorsal cup	
(anteroposterior)	14.4
(B-DE interradius)	15.6
Length of AB basal	4.2
Width of AB basal	3.7
Length of A radial	5.2
Width of A radial	9.0
Length of radianal	3.2
Width of radianal	1.8
Length of anal plate	4.0
Width of anal plate	2.0

Occurrence. — Meadow (Merriam) Limestone, Plattsburg Formation, Lansing Group, Missouri Series, Pennsylvanian (Location 6, Appendix I). Plattsburg Limestone, Lansing Group, Missouri Series, Pennsylvanian, Moore and Plummer (1940), Locality 5999, Altoona, Kansas.

Material studied. — Hypotype, UNSM-7939.

Family **PACHYLOCRINIDAE** Kirk, 1942

Diagnosis. — The dorsal cup is a low, truncate bowl with a slightly concave base; the five infrabasals are not visible in the side view of the cup. The radial articulating facets are wide, do not always fill the distal surfaces of the radials, and have transverse ridges and ligamental pits. There are three anal plates in the cup, the anal sac is long, slender, and composed of vertical rows of small plates. The pinnulate arms are uniserial, branching two or more times.

Genus **GALATEACRINUS** Moore, 1940

Type species: *Galateacrinus stevensis* Moore, 1940, pp. 46-48, pl. 1, figs. 9a-d, 10; text-figs. 6a, b; 7a, b; 8 a-d.

Other species included. — *Galateacrinus ewersi* Moore, 1940, pp. 48-49, pl. 1, figs. 12a-d; *Galateacrinus allisoni* Moore, 1940, pp. 49-51, pl. 1, figs. 11a-c; text-figs. 5a, b; *Galateacrinus ornatus* Moore, 1940, pp. 51-52; pl. 1, figs. 13a, b; text-figs. 9a-e. *Galateacrinus coacervatus* Strimple and Moore, 1971, p. 18, pl. 8, fig. 1, pl. 12, figs. 3a, b. *Galateacrinus gossameri* Pabian and Strimple, new species.

Remarks. — There appear to be several species of *Galateacrinus* in Virgilian rocks in eastern Nebraska. Only *Galateacrinus gossameri* Pabian and Strimple, new species, is described here, the other species to be described in subsequent reports.

Galateacrinus gossameri Pabian and Strimple, new species Pl. 34, figs. 5-7

Description. — This species is based on a single dorsal cup with a narrow, fairly shallow basal concavity. The large crenulate stem with a pentalobate lumen is deeply impressed and covers most of the infrabasal circlet, so that only its distal tips remain unconcealed. The distal ends of the five infrabasals are slightly down flared. The proximal half of the extremely bulbous basals are somewhat down flared. The basal plane of the cup is formed by the medial portions of the basals which then sharply recurve so that the distal ends of the basals are nearly vertical. There is a short ridge on each side of each basal. The radials are nearly horizontal, curving upward sharply near their distal ends, and then inwards for about 1/4 the length of the radial. There is a pair of ridges on each radial, each of which connects with the ridges on the adjacent basals, so that a fine weblike structure results between these plates. A deep depression occurs at the junctures between adjacent radials and basals. The radials bear irregularly distributed, granular ornamentation. There is a small, trapezoidal radianal plate, a large, pentagonal anal x, and a minute, nearly square right tube plate.

The radial articulating facets are not well defined. The outer marginal ridge is faint; outer ligamental furrow is shallow, and the transverse ridge is faint. The ligamental pit is fairly well defined. The muscle areas are small and nearly horizontal.

Table 28. Measurements (in mm) of *Galateacrinus gossameri*

	UNSM 7976
Height of dorsal cup	
(anterior)	2.4
(posterior)	2.8
Width of dorsal cup	
(anteroposterior)	8.2
(B-DE interradius)	9.6

Remarks. — The external ligamental area of *Galateacrinus gossameri* appears to be narrower than is typical for the genus. The ligamental area may be confused with the distal ends of the radials which recurve sharply and form a broad adjacent platform (forefacet).

Galateacrinus gossameri is named in allusion to the weblike structures between the radials and adjacent basals.

Occurrence. — Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 12, Appendix I).

Material studied. — Holotype, UNSM-7976.

Family **CROMYOCRINIDAE** Jaekel, 1918

Diagnosis. — The dorsal cup is medium globular, globose, or bowl- to cone-shaped, with greatest width below the summit of the radials. The infrabasals may be down flared or subhorizontal in older forms but are generally up flared. There are two or three plates in the posterior interradius. The arms are long, uniserial in older forms and usually biserial in younger forms. There may be five arms (*Cryomyocrinus* and *Ureocrinus*), or ten arms branching on the first primibrach in most species, with as many as 16 arms in one species (*Parulocrinus pontiacensis*).

Genera. — *Cromyocrinus* Trautschold, 1867; *Dicromyocrinus* Jaekel, 1918; *Mooreocrinus* Wright and Strimple, 1945; *Parulocrinus* Moore and Plummer, 1940; *Parethelocrinus* Strimple, 1966; *Aglaocrinus* Strimple, 1961, *Paracromyocrinus* Strimple, 1966; *Metacromyocrinus* Strimple, 1961; *Synarmocrinus* Lane, 1964; *Ulocrinus* Miller and Gurley, 1890; *Ureocrinus* Wright and Strimple, 1945; *Mantikosocrinus* Strimple, 1951c; *Probletocrinus* Strimple and Moore, 1971; *Ethelocrinus* Kirk, 1937.

Genus **PARETHELOCRINUS** Strimple, 1961

Type species: *Parethelocrinus ellipticus* Strimple, 1961, pp. 81-85, pl. 8, figs. 4-5; pl. 18, figs. 1-2; pl. 19, fig. 5.

Other species included. — *Ethelocrinus variabilis* Strimple, 1949; *Ethelocrinus plattsburgensis* Strimple, 1949; *E. millsapensis* Moore and Plummer 1940; *E. watkinsi* Strimple, 1949; *Parulocrinus beedei* Moore and Plummer, 1940.

Diagnosis. — The dorsal cup is low, broad and shallow. The base is shallowly concave or subhorizontal. There are two anal plates within the cup. The surface is smooth or granular and the sutures are not deeply impressed.

Parethelocrinus plattsburgensis (Strimple) Pl. 36, figs. 7-8

Ethelocrinus plattsburgensis Strimple, 1938 (emended and republished, 1959), p. 126; pl. II, figs. 6, 9, 12.

Parethelocrinus plattsburgensis (Strimple), Strimple, 1961, pp. 80, 82; 1971, pp. 80-81, figs. 1a-e; 1971, p. 172, pl. 49, figs. 1-3.

Table 29. Measurements (in mm) of *Parethelocrinus plattsburgensis*

	UNSM 7977
Height of dorsal cup	
(anterior)	11.2
(posterior)	12.2
Width of dorsal cup	
(anteroposterior)	36.9
(B-DE interradius)	35.2
Length of AB basal	16.2
Width of AB basal	18.5
Length of A radial	9.4
Width of A radial	19.0
Length of radianal	15.1
Width of radianal	11.8
Length of anal plate	11.0
Width of anal plate	9.4

Occurrence. — Hypotype, USNM-7977, Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I). Brownwood Shale, Missouri Series, Plummer Location 153-T-23, McCulloch County, Texas. Wann Formation, Ochelata Group, Missouri Series, "The Mound," Barttlesville, Oklahoma.

Family **SCYTALOCRINIDAE** Moore and Laudon, 1943

Genus **SCYTALOCRINUS** Wachsmuth and Springer, 1879

Type species: *Scaphiocrinus robustus* Hall.

Other species included. — *Scytalocrinus sansabensis* Moore and Plummer, 1938; *Scytalocrinus* sp. Strimple and Watkins, 1969; *Scytalocrinus validus* Wachsmuth and Springer, 1879; *Scytalocrinus aftonensis* Strimple, 1951; *Scytalocrinus larvalis* Strimple, 1939; *Scytalocrinus deminutivus* Strimple, 1939.

Diagnosis. — Cup truncate cone with low infrabasals. Three anal plates in CD interray. Arms branch isotomously on first primibrachial. The rami are short, stout, round, one pinnule to each brachial. Stem round.

Range. — Mississippian (Osagean) through Pennsylvanian (Virgilian).

Scytalocrinus sp. Pl. 33, fig. 18; Text-figs. 2, e, f

Remarks. — Because of the damaged nature of the dorsal cup of the specimen at hand, no attempt has been made to assign a species name. The specimen under study differs from other species of *Scytalocrinus* by having longer, more robust secundibrachials, finely granular ornamentation on the dorsal cup, primibrachials and lower secundibrachials, and a dorsal cup which has an apparently more flattened base than typical specimens.

Occurrence. — UNSM-10030, Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 16, Appendix I).

FAMILY UNKNOWN

Genus and species undetermined Pl. 32, fig. 13

Occurrence. — A single holdfast, UNSM-10025 was collected from the Beil Limestone Member, Lecompton Formation, Shawnee Group, Virgil Series, Pennsylvanian (Location 12, Appendix I).

Appendix I. Register of Pennsylvanian Localities (see Text-figure 1).

Location Number	Description
1.	SE 1/4, Sec. 18, T. 10N., R. 13E., Cass County, Nebraska.
2.	SW 1/4, Sec. 18, T. 12N., R. 12E., Cass County, Nebraska.
3.	NW 1/4, NW 1/4, Sec. 4, T. 10N., R. 11E., Cass County, Nebraska.
4.	SE 1/4, Sec. 2, T. 10N., R. 11E., Cass County, Nebraska.
5.	SW 1/4, NE 1/4, Sec. 29, T. 10N., R. 13E., Cass County, Nebraska.
6.	SE 1/4, SE 1/4, Sec. 7, T. 12N., R. 12E., Cass County, Nebraska.
7.	SW 1/4, SE 1/4, Sec. 28, T. 13N., R. 12E., Sarpy County, Nebraska.
8.	SE 1/4, Sec. 10, T. 10N., R. 12E., Cass County, Nebraska.
9.	SW 1/4, Sec. 1, T. 12N., R. 9E., Saunders County, Nebraska.
10.	SW 1/4, NW 1/4, Sec. 15, T. 12N., R. 11E., Sarpy County, Nebraska.
11.	Location 11, near abandoned Plattsmouth ferry boat moorings, approx. N 1/4, Sec. 20, T. 12N., R. 14E., Cass County, Nebraska.
12.	SW 1/4, Sec. 9, T. 11N., R. 14E., Cass County, Nebraska.
13.	SE 1/4, SE 1/4, Sec. 34, T. 11N., R. 11E., Cass County, Nebraska.
14.	E 1/2, NW 1/4, NE 1/4, SW 1/4, Sec. 22, T. 11N., R. 14E., Cass County, Nebraska.
15.	SE 1/4, NW 1/4, Sec. 3, T. 10N., R. 11E., Cass County, Nebraska.
16.	NW 1/4, NW 1/4, NW 1/4, Sec. 21, T. 10N., R. 14E., Cass County, Nebraska.
17.	SE 1/4, SW 1/4, Sec. 35, T. 11N., R. 11E., Cass County, Nebraska.
18.	SE 1/4, Sec. 13, T. 12N., R. 11E., Sarpy County, Nebraska.
19.	SE 1/4, SW 1/4, Sec. 2, T. 8N., R. 10E., Otoe County, Nebraska.
20.	SW 1/4, NE 1/4, Sec. 6, T. 12N., R. 13E., Cass County, Nebraska.
21.	SW 1/4, Sec. 10, T. 12N., R. 10E., Cass County, Nebraska.
22.	SW 1/4, SW 1/4, Sec. 18, T. 1N., R. 13E., Richardson County, Nebraska.

CRINOID STUDIES

PART II

SOME PERMIAN CRINOIDS FROM NEBRASKA, KANSAS, AND OKLAHOMA

ABSTRACT

Systematic collecting in Big Blue (= Wolfcampian) rocks in southeastern Nebraska, eastern Kansas, and northeastern Oklahoma has yielded crowns or dorsal cups of 44 crinoids representing ten species, two of which, *Halogetocrinus boellstorffae* and *Graffhamicrinus boelstorffi,* are new.

The presence of *Delocrinus vastus* Lane and Webster and *Contocrinus* sp. cf. *scopulus* (Lane and Webster) in Nebraska and Nevada and *Brabeocrinus cuneatus* (Lane and Webster) in Oklahoma and Nevada indicates that the Battleship Wash crinoid fauna from Nevada is approximately the same age as the upper Council Grove Group — Lower Chase Group of the mid-continent region.

It is suggested that crinoid stems may have functioned to balance the crown.

INTRODUCTION

Occurrences of Upper Paleozoic crinoids are of special interest to students of fossil echinoderms for many reasons. Three subclasses of crinoids (Flexibilia, Inadunata, and Camerata) became extinct during the Permian and one subclass (Articulata) appeared in the Triassic. Any light shed on the inadunates' last few million years could yield evidence of the changes that took place leading to the total extinction of so many fossil groups in the late Paleozoic.

The crinoid fauna described herein contains three species common to the fauna from Nevada described by Lane and Webster (1966) and Webster and Lane (1967). The Nevada fauna is much more prolific and diverse than the material treated here. Many of the crinoids in the Nebraska material retain primitive characteristics whereas the Nevada material ". . . belong to families that have been judged among the most advanced of any of the Inadunata" (Lane and Webster, 1966, p. 2). Most of the species described herein are restricted geographically to the Nebraska-Kansas-Oklahoma area (Text-fig. 1), but two species found in Nebraska, *Delocrinus vastus* Lane and Webster and *Contocrinus* sp. cf. *C. scopulus* (Lane and Webster), were originally described from material collected in Nevada, and one species reported herein from Oklahoma, *Brabeocrinus cuneatus* (Lane and Webster), was also described from material collected in Nevada.

In addition to the material treated from Odell, Nebraska, and Burbank, Oklahoma, material from several other locations and stratigraphic horizons in Nebraska, Kansas, and Oklahoma, is described herein.

PREVIOUS WORK

Works on Permian crinoids from the mid-continent region have been few, reflecting the general paucity of material. Weller (1909) described several species from Texas. Moore (1939) described Permian crinoid species from Nebraska, Kansas, and Oklahoma, and Moore and Plummer (1940) described a few Permian crinoid species from Texas. Moore and Strimple (1941) described *Delocrinus waughi* from Kansas. Lane and Webster (1966) described a large number of Permian crinoids from Nevada, and Webster and Lane (1967) described some additional material from the Battleship Wash, Nevada, fauna. Pabian and Strimple (1971) discussed some Permian crinoids and associated fauna from Nebraska.

STRATIGRAPHIC POSITION

In the spring of 1970, Mr. Gordon Baird, a graduate assistant in the Geology Department of the University of Nebraska, reported to the authors a number of crowns and partial crowns of crinoids in the Lower Permian Grant Shale (Big Blue Series) which is exposed just east of Odell, Nebraska. Subsequent examination showed the material to consist of *Nebraskacrinus, Delocrinus, Contocrinus*, and *Microcaracrinus* and dissociated plates of several unidentified crinoid genera.

The crinoids collected from the Odell, Nebraska, locality occur in a mottled, gray-green, slightly fissile, fossiliferous siltstone with abundant worm burrows, quartz and celestite geodes, and some nodular chert. The occurrence is about 12 feet above the base of the Grant Shale Member of the Winfield Limestone Formation, Chase Group, Big Blue Series (= Wolfcampian), Lower Permian, exposed in the NE 1/4, NW 1/4, Sec. 20, T. 1N, R. 6E, Gage County, in a cut on Nebraska State Highway 8, about 2 miles east of the community of Odell (Location 1, Text-fig. 2).

The crinoids from Burbank, Oklahoma, were collected from a blue shale zone in the middle of the Bennett Shale Member of the Red Eagle Formation exposed in the quarry just north of Highway 66 near C., Sec. 25, T. 26N, R. 5E, one-half mile east of Burbank, Osage County, Oklahoma (Location 2, Text-fig. 2).

Lane and Webster (1966, pp. 3-4) indicated that the Battleship Wash, Nevada, crinoids, on the basis of correlations effected by fusulinids, were approximately Middle Wolfcampian in age. *Delocrinus vastus* and *Contocrinus* sp. cf. *C. scopulus* from Nebraska are from beds in the middle part of the Upper Big Blue (= Wolfcampian), whereas *Brabeocrinus cuneatus* from Oklahoma is from beds determined to be in the middle part of the Big Blue.

It is suggested here that *Delocrinus vastus* from Nebraska occurs nearer the top, and *D. vastus* from Nevada, nearer the base, of the *Delocrinus vastus* Range Zone. Since range zones for Permian crinoids have not generally been established with any certainty, this would explain the discrepancy in stratigraphic position. *Brabeocrinus cuneatus* from Oklahoma has been collected from rocks near the middle of the Big Blue (= Wolfcampian) and is from about the same stratigraphic position as the type horizon in Nevada.

PALEOECOLOGICAL IMPLICATIONS

The fossil evidence obtained in the field indicates that in Nebraska, Pennsylvanian and Permian crinoids are almost always associated with large, diverse faunas which include many of the other invertebrate phyla. A study of the crinoids and associated fauna, and a study of sedimentary features of the fossil-bearing strata should add to our specific knowledge of Permian fossil assemblages and our general understanding of the fossil community concept.

The Odell crinoids include calcified to slightly silicified crowns of *Nebraskacrinus tourteloti* Moore, *Microcaracrinus twenhofeli* (Moore) [= *Plummericrinus twenhofeli* (Moore) = *Pachylocrinus twenhofeli* Moore], and *Delocrinus vastus* Lane and Webster. *Nebraskacrinus tourteloti* is by far the most common crinoid species to be found at Odell, about 30 crowns or partial crowns of the species having been recovered. The largest crown of *N. tourteloti* has a length of about 100 mm; the calyces ranged from about 18 to 30 mm in height and from about 14 to 25 mm in diameter.

Though a number of calyces of crinoids of all species represented had sections of stem attached, none of the stems terminated with a holdfast or root system. One holdfast which appears to be a secondary structure is illustrated (Plate 39, figs. 1-3). The substrate at Odell appears to have been a soft, silty mud without a firm anchorage to which a holdfast could have been attached. It is suggested that the stems of some crinoids might have functioned to balance the crown as a sea anchor balances a buoy or as a tail balances a flying kite. Strimple and Moore (1971, p. 35) reported that the stems of *Clathrocrinus* tended to diminish in diameter distally. A similar interpretation of stems of crinoids from Odell is considered here. Many of the crinoid crowns and other fossils collected at Odell show evidence of having undergone weathering.

Other echinoderms at Odell are represented by spines and plates of an echinoid that appears to be a species of *Archeocidaris*.

ASSOCIATED FAUNA

At the Odell locality the crinoids are associated with a large, diverse fauna, summarized below:

BRACHIOPODA
  Reticulatia
  Derbyia
  Linoproductus
  Composita

BIVALVIA
  Aviculopecten
  Pteronites
  Myalina
  Septimyalina

GASTROPODA
  Straparollus
  Euphemites?

ECTOPROCTS
  Fenestella
  Stenopora

ANNELIDA
  Spirorbis (on myalinoid bivalves)
  Unidentified chitinous exoskeleton

ARTHROPODA
  Trilobita
    Ameura
  Ostracoda
    Bairdia

CHORDATA
  Cladodont shark teeth.

Identifications of the above genera are based on Dunbar and Condra (1933), Muir-Wood and Cooper (1960), Newell (1937, 1942, 1968), Mudge and Yochelson (1962), Condra (1903), Shimer and Shrock (1944), Upson (1931), and Romer (1967).

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SYSTEMATIC PALEONTOLOGY

Phylum ECHINODERMATA

Subphylum PELMATAZOA

Class CRINOIDEA

Subclass INADUNATA

Order CLADIDA Moore and Laudon, 1943

Suborder POTERIOCRINITINA Jaekel, 1918

Family **BLOTHROCRINIDAE** Moore and Laudon, 1943

Genus **NEBRASKACRINUS** Moore, 1939

Type species: *Nebraskacrinus tourteloti* Moore, 1939.

Nebraskacrinus tourteloti Moore, 1939
Pl. 39, figs. 9-11; Pl. 40, fig. 8; Text-figs. 1a, b

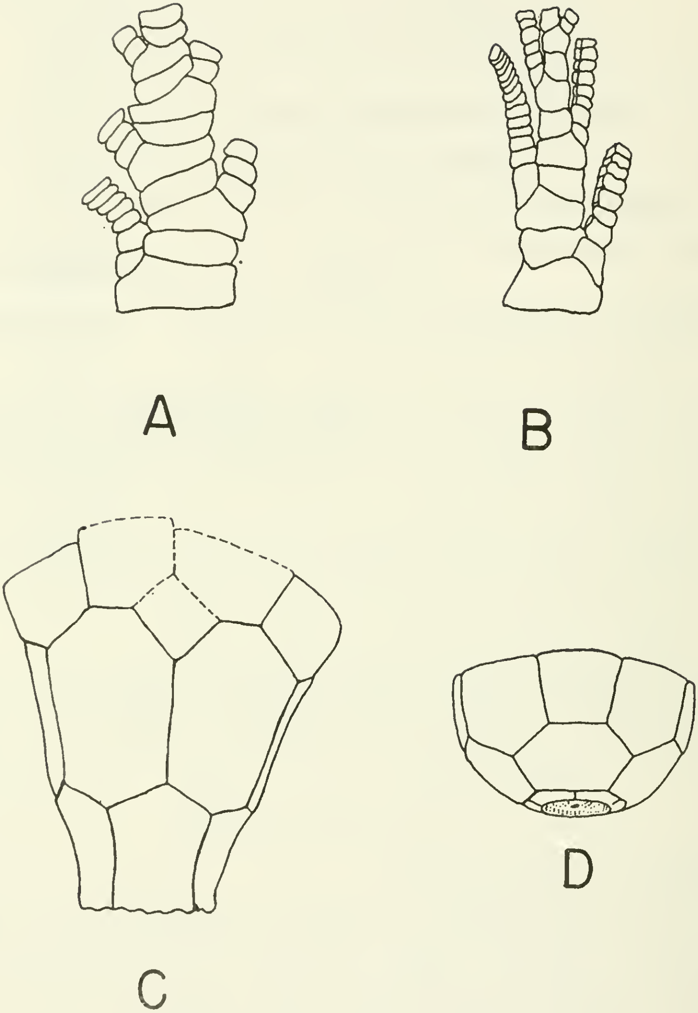
Nebraskacrinus tourteloti Moore, 1939, pp. 199-203, pl. 5, figs. 1a-d, text-fig. 4; Shimer and Shrock, 1944, p. 159, pl. 60, figs. 13a, b.

Description. — The dorsal cup is a high, rounded cone or ellipsoid with five up-flared infrabasals rising at about 45 degrees from the distal outline of a flattened columnar cicatrix. Five curved basals continue to rise upward at about 45 degrees for about one-half their height and then rise much more sharply, sloping at about 75 degrees at their distal extremities. EA, AB, and BC basals have six sides and CD and DE basals have seven sides. The five radials are about one and one-half times as wide as long.

Radial articulating facets flat, about half as wide as long. Outer marginal ridge wide, faintly defined. Outer ligamental furrow wide, shallow. Ligamental pit large, wide, shallow. Transverse ridge faint with few small denticles; oblique ridge absent. Lateral ridge faint and adsutural slope is about 45 degrees to the horizontal. Muscle areas slightly concave, sloping inward to a large, shallow, central pit that is connected to a narrow intermuscular notch by a short, deep intermuscular furrow.

The three anal plates are in primitive arrangement. The large RA and anal X plates have six sides each, and the right tube plate touches the D radial, the RA, and anal X plates. The long anal sac tapers upward and is made up of several columns of plates which are fairly smooth on small specimens and somewhat bulbous and sometimes ornamented on large specimens.

Arms uniserial, pinnulate, branching heterotomously. First primibrachial (IBr) axillary, branching exotomously. Second secundibrachial (IIBr), tertibrachial (IIIBr), quartibrachial (IVBr), etc. are axillary, branching exotomously. The upper articular facets of the axillary IBr, IIBr, IIIBr, etc., are not equal. The



Text-figure 1 — (A, B). *Nebraskacrinus tourteloti* Moore, right handed and left handed branching of arms on first primibrachial of A ray. (A) UNSM 9617, × 2; (B) UNSM 9619, × 2. (C) *Elibatocrinus* sp. cf. *E. elongatus* Webster and Lane, reconstruction showing posterior interradius, × 2. (D) *Halogetocrinus boellstorffae* Pabian and Strimple, new species, reconstruction showing posterior interradius, × 10.

wider facet on the IBr, IIIBr, VBr is on the posterior in the B, C, D, and E rays. The wider articular facet on the axillary IIBr, IVBr and the like is on the anterior in the B, C, D, and E rays. A long, uniserial, pinnulate arm rises from the narrower facet on the axillary IBr, IIBr, IIIBr, and the like in such a manner that the uniserial arm alternates its position back and forth from anterior to posterior from the IBr to IIBr to IIIBr, and the like in the B, C, D, and E rays. In the A ray the wider facet of the axillary IBr may be in either the right or left side, in which case the wider facet of the axillary IIBr will be on the left or right side (see Text-fig. 2).

Remarks. — The distal extremities of several of the arms in the B ray of UNSM 9617 show evidence of regeneration of broken off parts. The fact that the arms branch heterotomously rather than isotomously indicates that either Blothrocrinidae should be amended to include forms with heterotomous arms or that the placing of *Nebraskacrinus* in this family should be more critically reviewed.

Occurrence. — Grant Shale Member, Winfield Limestone Formation, Chase Group, Big Blue Series, Permian. Hypotypes UNSM-9617 - UNSM-9623, hypotypes UNSM-10002 - UNSM-10014 and hypotype SUI-35533 were collected from Location 1 (Appendix II, Text-fig. 1).

Material studied. — Holotype, UNSM-10028; hypotypes, UNSM-9617 - UNSM-9623; UNSM-10002 - UNSM-10014; hypotype, SUI-35533.

Family **STELLAROCRINIDAE** Strimple, 1961

Genus **BRABEOCRINUS** Strimple and Moore, 1971

Type species: *Brabeocrinus christinae* Strimple and Moore, 1971, p. 32.

Other species included. — *Stellarocrinus distinctus* Strimple, 1940, pp. 3-4; *Stellarocrinus cuneatus* Lane and Webster, 1966, pp. 24-26; *Stellarocrinus comptus* Webster and Lane, 1967, p. 13.

Range. — Pennsylvanian-Permian; North America.

Diagnosis. — Stellarocrinids which do not develop well-defined biserial arms, but have more primitive, narrow arms with cuneate brachals are assigned to *Brabeocrinus*.

Remarks. — *Stellarocrinus* Strimple is typically a biserial form that has evolved from a uniserial form like *Heliosocrinus*. There are species, *e.g., Stellarocrinus distinctus* Strimple, which have cuneate brachials and one Permian species, *S. cuneatus* Lane and Webster, which has cuneate to incipiently interlocked brachials. *Heliosocrinus* has two primibrachs and a pentalobate-shaped stem, whereas *Stellarocrinus* has one primibrach in each arm and a round stem. For forms previously assigned to *Stellarocrinus* but which retain cuneate brachials (as the above mentioned species), *Brabeocrinus* Strimple and Moore has been established.

Lane and Webster (1966, pp. 24, 48) apparently considered the nature of the radial articulating facet to be of generic stature, *i.e.,* whether the radial facet occupies the entire width of the radial or does not occupy the full width of the radial. They (*ibid,* p. 48) proposed a genus *Celonocrinus* with a monotypic species *C. expansus* Lane and Webster for which the description is also designated as the generic description. They state that ". . . radial facet occupies full width of radial" but actually this is only demonstrated in the D ray of the holotype and examination of a plastotype shows the entire area to be collapsed. In the other rays there is an appreciable gap so that the facets could not possibly fill the full width of the radials. They also reported the arms to be nonpinnular but corrected this in Webster and Lane, 1967.

Characteristics which serve to differentiate *Celonocrinus* from *Stellarocrinus* are that the anal plate of the former extends well above the cup and the radiating ridges between cup plates are absent. *Stellarocrinus angulatus* (Miller and Gurley) is referred here to *Celonocrinus angulatus* (Miller and Gurley), new combination.

Brychiocrinus Moore and Plummer has also eliminated radiating ridges between cup plates but in addition has widened the radial articulating facets which eliminates the notch between the facets, a feature which would affect connection with minute plates covering the viscera. The arms of the monotypic *B. texanus* remain narrow, as in *Brabeocrinus,* but are fully biserial.

Brabeocrinus cuneatus (Lane and Webster), 1966 Pl. 41, figs. 8-10

Description. — Dorsal cup low, bowl-shaped with broad relatively shallow basal invagination. Five infrabasals almost entirely covered by the proximal columnals. Five basals are large and extend well out of the basal concavity. Five radials are wide and the facets are considerably narrower than the width of the plates. A single anal plate rests on the truncated posterior basal and is followed above by two anal plates of subequal size. The areas at the proximal apices of the radials and the distal apices of the basals are depressed as well as the adsutural areas between radials. This is accentuated by a series of elongated tubercles starting at the center of each basal and passing onto adjacent plates (the ridge passing toward the infrabasals does not extend far into the concavity). The anal plates are marked in a similar manner.

The first primibrach is low and axillary in all rays. A low vertical ridge is present in mid-section. There is an appreciable depression at the juncture with the radial and the width of the primibrach is substantially less than the width of the radial. The upper brachials are wedge-shaped but the arms do not become biserial. Each brachial has a sharp spine on the wider, pinnule-bearing side. The arms are thick and have short pinnules with well-rounded exteriors which are almost at right angles to the arms as preserved. Only proximal columnals preserved which are wide, round, and each has a sharp horizontal rim.

Remarks. — The ornamentation of the dorsal cup of the Oklahoma specimen is more pronounced than found in the holotype of *Brabeocrinus cuneatus,* the latter also being distinctive in not having any ridges passing onto the anal plate and in having more of a tendency toward biserial arm structure. There also is an extra ridge passing from radial to radial in *B. cuneatus,* according to Lane and Webster (1966, text-fig. 7). *B. distinctus* has sharp, crested ridges passing from plate to plate, creating sharply angled surfaces as opposed to the more gentle curvature of the surfaces of the other two species.

Occurrence. — Lower Permian, Battleship Wash, Nevada. Bennet Shale Member, Red Eagle Formation, Location 2 (Appendix II, Text-fig. 1).

Material studied and repositories. — Holotype 23658 and hypotype 6267 are reposited in the invertebrate paleontological collections of the University of California at Los Angeles. Hypotype OU-2735 is reposited in the Paleontological Collection of the University of Oklahoma.

Table 2. Measurements of *Brabeocrinus cuneatus**, Hypotype OU-2735 in mm

Height of cup	
(posterior)	7.1
(anterior)	10.0
Width of cup	
(anteroposterior)	18.2
(B to DE radius)	17.5
Width of infrabasal circlet	4.6
Length of AB basal	4.7
Width of AB basal	5.9
Length of A radial	3.3
Width of A radial	8.8
Length of anal plate	4.6
Width of anal plate	4.6

*All measurements linear

Family **DIPHUICRINIDAE** Strimple and Knapp, 1966

Genus **GRAFFHAMICRINUS** Strimple, 1961

Type species: *Graffhamicrinus acutus* Strimple, 1961.

Remarks. — Though *Graffhamicrinus* is probably the most common genus of crinoid in the Pennsylvanian rocks of Nebraska, it is represented in the Permian of Nebraska by only a single dorsal cup. The scarcity of *Graffhamicrinus* in the Nebraska Permian may be the result of inadequate collecting, however, because this genus has been reported from the Hughes Creek Shale in Kansas (Moore and Strimple, 1941, p. 10) and this paper.

Graffhamicrinus boellstorffi Pabian and Strimple, new species
Pl. 41, figs. 4-7

Description. — Basal concavity broad and shallow. There are five kite-shaped infrabasals which are nearly flat lying proximally. The middle portion of the infrabasals slope steeply downward and the distal ends slope gently downward. There are five gently curved, pentagonal basals which rise about as high on the side of the cup as the basal concavity rises within the cup. The cup sits on a plane defined by the middle portions of the basals and the tips of the five radials. The radials have five sides and are about 1/3 as high as wide, their tips just visible in the side view of the cup. Anal X short, blunt, subhexagonal, slightly higher than wide, curving sharply inward, and situated on the truncated posterior basal and between the C and D radials. There is a facet for the reception of a tube plate. Sutures sharp but not impressed. Radial plates with rows of nodes that approximately parallel the outer ligamental ridge.

Outer ligamental furrow narrow, bounded by distinct, high transverse ridge with a few dull denticles. Ligamental pit large, deep, well defined. Oblique ridge small to absent. Central pit broad, shallow and connected to poorly defined intramuscular notch by a short, narrow intermuscular furrow. Lateral lobes large, poorly defined.

Remarks. — This species is described on the basis of a single, shallow, slightly crushed dorsal cup that is about 1/5 as high as wide. This species bears resemblance to both *Graffhamicrinus stullensis* Strimple and *G. waughi* Moore and Strimple. *G. waughi* has similar, though considerably more numerous, nodes and a much narrower, deeper basal concavity. *G. waughi* and *G. boellstorffi* both occur in the same stratigraphic position. *G. boellstorffi* has a more decided pentagonal outline than *G. stullensis* and also has coarser, less uniformly distributed ornamentation. The facetal areas of *G. stullensis* and *G. boellstorffi* are similar but not nearly as sharply defined on the latter which, however, may be due to preservation. In view of the shallow nature of the basal concavity and the similarity of the facetal areas of the two species, it is thought that *Graffhamicrinus boellstorffi* is more closely related to *G. stullensis* than *G. waughi.* The species is named in honor of Mr. Charles Boellstorff on whose farm the holotype was collected.

Occurrence. — Hughes Creek Shale Member, Foraker Formation, Council Grove Group, Big Blue Series, Lower Permian (Location 3, Appendix II, Text-fig. 1).

Material studied. — Holotype, UNSM-7992.

Table 3. Measurements of holotype of *Graffhamicrinus boellstorffi* in mm*

Height of cup	
(posterior)	5.7
(anterior)	4.3
Width of cup	
(anteroposterior)	19.3
Width of infrabasal circlet	3.9
Length of AB basal	7.5
Width of AB basal	7.5
Length of A radial	5.6
Width of A radial	11.5
Length of anal plate	4.0
Width of anal plate	3.7
Diameter of stem impression	3.0

*Measured along surface of curvature.

Graffhamicrinus sp. cf. **G. waughi** (Moore and Strimple), 1941

Pl. 41, figs. 1-3

Delocrinus waughi Moore and Strimple, 1941, pp. 9-11, pl. 1, 3 figs. 7a, b, c.

Emended description. — Emended to Moore and Strimple, 1941, pp. 9-11. Radial articulating facets wide, well defined, sloping outward. Deep, narrow ligamental pit and narrow ligamental pit furrow separate sharply defined outer ligamental ridge and transverse ridge which has five denticles on both sides. Oblique ridge with fine denticles. Lateral ridge sharp, defining a sharp, deep adsutural slope. Lateral lobes large, sloping outwardly and merging with a bumpy muscle area. Muscle areas slope toward each other and terminate at a shallow, well-defined central pit which is connected to a deep intermuscular notch by a short intermuscular furrow.

Remarks. — The ornamentation of the specimen is not so coarse as that shown in the figured holotype; however, in all other respects the cup is similar. It is not felt that the ornamentation is sufficiently different to warrant proposal of a new species.

Material studied. — Hypotype UNSM-9611.

Occurrence. — Hughes Creek Shale Member, Foraker Formation, Council Grove Group, Big Blue Series, Permian (Location 4, Appendix II, Text-fig. 1).

Table 4. Measurements of Hypotype UNSM 9611 of *Graffhamicrinus waughi*, in mm*

Height of cup		
(posterior)	7.8	
(anterior)	9.2	
Width of cup		
(anteroposterior)	23.9	
(B-DE interradius)	24.8	
Height of infrabasal circlet	5.7	(from basal plane)
Width of infrabasal, circlet	4.8	
Length of AB basal	12.1	
Width of AB basal	9.9	
Length of A radial	7.9	
Width of A radial	15.0	
Length of anal plate	6.7	
Width of anal plate	4.6	
Diameter of stem impression	3.6	

*Measured along surface of curvature.

Family **CATACRINIDAE** Knapp, 1969

Genus **DELOCRINUS** Miller and Gurley, 1890

Type species: *Poteriocrinus hemisphericus* Shumard, 1858.

Delocrinus vastus Lane and Webster, 1966 Pl. 40, fig. 7

Delocrinus vastus Lane and Webster, 1966, pp. 45-46, pl. 12, figs. 1, 2, 5; Webster and Lane, 1967, p. 24.

Remarks. — It appears that in the Big Blue rocks of Nebraska and Kansas there are three closely related species of delocrinids, *Delocrinis densus* Strimple, *D. admirensis* Strimple, and *D. vastus* Lane and Webster. Both *D. densus* and *D. vastus* have broad, bowl-shaped cups with a deep, narrow basal concavity, and the cups of both species appear similar in outline. *D. admirensis* has much wider radial articulating arm facets than *D. vastus*. The specimens from Odell are assigned to *Delocrinus vastus* Lane and Webster because they bear a much closer resemblance to the holotype of *D. vastus* than to *D. densus* or *D. admirensis*. The geographic distribution of this species is Nevada and Nebraska.

Occurrence. — Grant Shale Member, Winfield Limestone, Chase Group, Big Blue Series, Lower Permian (Location 1, Appendix II, Text-fig. 1).

Material studied and repository. — Holotype 39626 and hypotype 45852 are reposited in the invertebrate paleontological collections of the University of California at Los Angeles; hypotypes UNSM-9606, UNSM-9608, UNSM-10015, UNSM-10016, and UNSM-10017 are reposited in the invertebrate paleontological collections of the University of Nebraska.

Table 5. Measurements of *Delocrinus vastus*, in mm*

	UNSM 9606	UNSM 10015	UNSM 10016	UNSM 10017
Height of cup				
(anterior)	9.5**	15.6	14.3	—
(posterior)	11.5**	—	—	—
Width of cup				
(anteroposterior)	18.0**	—	—	—
(B-DE interradius)	22.3	—	—	—
Width of infrabasal circlet	4.5	—	—	—
Length of AB basal	8.7	14.8	14.9	12.6
Width of AB basal	8.7	13.6	14.9	11.7
Length of A radial	5.9	10.5	10.5	—
Width of A radial	12.6	20.7	17.9	—
Length of anal plate	5.0	—	—	—
Width of anal plate	4.0	—	—	—

*Measured along surfaces of curvature.
**Estimated.

Delocrinus densus Strimple, 1962

Delocrinus densus Strimple, 1962b, p. 70, pl. 12, figs. 21-24.

Emended description. — Emended to Strimple, 1962b, p. 70. Radial articulating facets about three times as wide as long; outer marginal ridge borders a narrow outer ligamental furrow. Outer ligamental ridge sharp. Ligamental pit deep and narrow. Transverse ridge narrow, sharp; denticles numerous and faint. Oblique ridge faint and nearly parallel to transverse ridge. Lateral ridge broad; adsutural slope gentle. Lateral lobes small, muscle area slopes steeply to a broad, shallow central pit that is separated from a small intermuscular notch by a short intermuscular furrow.

The cup has a basal concavity of medium depth and width. This feature could not be accurately determined on the holotype.

Remarks. — A specimen from the Bennett Shale in the Red Eagle Formation exposed at a quarry 1/2 mile east of Burbank, Oklahoma, and a specimen from the Neva Limestone exposed in a quarry (presumably the same one) east of Burbank, Oklahoma, are identified as *Delocrinus densus* Strimple because of their similarity to the illustrated holotype.

Delocrinus densus has narrow radial articulating facets which are similar to those of *Delocrinus vastus* Lane and Webster.

The tentative range zone for *D. densus* is from the Five Point Limestone Member, Janesville Shale, to the Neva Limestone Member of the Grenola Formation. The geographic distribution of the species is from Pottawatamie County, Kansas, to Osage County, Oklahoma.

Judging from the nature of the basal concavity and radial articulating facets, *Delocrinus densus* may have been the oldest species in a lineage including *D. denus, D. vastus* Lane and Webster, and *D. conicus* Boos.

Occurrence. — Upper Shale, Neva Limestone, Grenola Formation, Council Grove Group, Permian, presumably in the quarry at Location 2 (Appendix II, Text-fig. 1).

Material studied. — Hypotype UNSM-9610; hypotype, SUI-35537.

Table 6. Measurements of *Delocrinus densus* in mm*

	UNSM-9610	SUI-35537
Height of cup		
(anterior)	9.0	10.9
(posterior)	10.7	13.0
Width of cup		
(anteroposterior)	24.7	25.8
(B-DE interradius)	25.8	26.9
Depth of basal concavity	—	5.7
Width of infrabasal circlet	5.8	5.4
Length of AB basal	11.9	10.3
Width of AB basal	10.9	10.5
Length of A radial	9.6	8.8
Width of A radial	15.4	16.1
Length of anal plate	7.5	7.3
Width of anal plate	3.7	5.5
Diameter of stem impression	—	4.3

Delocrinus admirensis Strimple, 1962 Pl. 39, figs. 4-5; Pl. 40, fig. 6

Delocrinus admirensis Strimple, 1962b, pp. 69-70, text-fig. 29, pl. 12, figs. 9-12.

Emended description. — Emended to Strimple (1962, pp. 69-70). Primibrachials low, wide, non-spinose, axillary. Secundibrachial *1* trapezoidal, followed by wedge-shaped, biserially arranged secundibrachs *2 - 10* which are faceted for the attachment of pinnules.

Remarks. — The identification of a Kansas specimen (SUI 32950) as *Delocrinus admirensis* is based on its similarities to the illustrated holotype. The geographic distribution of this species is extended from Pottawatamie County, Kansas, to Cowley County, Kansas.

The tentative range zone for *D. admirensis* extends from the Falls City Limestone to the lower part of the Morrill Limestone Member of the Beattie Formation.

D. admirensis appears closely related to *D. abruptus* Moore and Plummer and *D. densus* Strimple. *D. abruptus* has a wider, shallower basal concavity than *D. admirensis* and *D. densus* has narrower radial articulating facets than *D. admirensis* or *D. abruptus.*

Occurrence. — Beattie Limestone, Council Grove Group, Permian (Location 5, Appendix II, Text-fig. 1).

Material studied and repository. — Hypotype, SUI-32950, collected by Larry Solomon.

Genus **SUBARRECTOCRINUS** Knapp, 1969

Type species: *Delocrinus perexcavatus* Moore and Plummer.

Subarrectocrinus perexcavatus (Moore and Plummer) Pl. 41, figs. 11-12

Delocrinus? perexcavatus Moore and Plummer, 1940, pp. 284-286, pl. 4, fig. 6, text-fig. 58.
Subarrectocrinus perexcavatus (Moore and Plummer), Knapp, 1969, p. 364; text-fig. 18.

Emended description. — Emended to Moore and Plummer, 1940 (pp. 284-286). Radial articulating facets large, level, well defined. Outer marginal ridge broad, sharp. Outer ligamental furrow deep, broad, separated by deep ligamental pit. Transverse ridge large, well defined, with few, faint denticles, and separated from muscle area by a deep furrow. Lateral lobes large, crescentic. Muscle areas slope inward to a deep central pit that is connected to a large intermuscular notch by a deep intermuscular furrow. Adsutural slopes steep, well defined.

Remarks. — The specimen of *Subarrectocrinus perexcavatus* at hand is part of a dorsal cup, presumably the A, D, and E radials. Unfortunately this specimen adds nothing to our knowledge of the anal plate. The specimen does add to our knowledge of the radial articulating facets which more closely resemble those of species assigned to *Endelocrinus*. Moore and Plummer (1940, p. 285) indicated that the arms of *Delocrinus perexcavatus* were uniserial in the lower segments and more closely resembled *Endelocrinus* than *Delocrinus*. It appears that *Subarrectocrinus* may be in the same lineage as *Endelocrinus*.

Occurrence. — Roca Shale Formation, Council Grove Group, Big Blue Series, Permian (Location 6, Appendix II, Text-fig. 1).

Material studied. — Hypotype, UNSM-9612.

Family **PACHYLOCRINIDAE** Kirk, 1942

Genus **MICROCARACRINUS** Strimple and Watkins, 1969

Type species: *Microcaracrinus delicatus* Strimple and Watkins, 1969, p. 201.

Other species included. — *Pachylocrinus pachypinnularis* Yakovlev and Ivanov, 1956, pp. 140-144; *P. bellirugosus* Moore, 1939, pp. 215-217; *P. twenhofeli* Moore, 1939, pp. 217-219; *P. colubrosus* Moore, 1939, pp. 220-222; *Microcaracrinus conjugulus* Strimple and Moore, 1971, pp. 17-18.

Microcaracrinus twenhofeli (Moore), 1939 Pl. 38, fig. 9; Pl. 39, figs. 6-8

Pachylocrinus twenhofeli Moore, 1939, p. 205.
Plummericrinus twenhofeli (Moore), Moore and Laudon, 1943, p. 58.
Microcaracrinus twenhofeli (Moore), Strimple and Moore, 1971, p. 17.

Emended description. — Emended to Moore (1939, pp. 217-219). The arms are preserved on the C ray of specimen SUI-35533. The arms branch isotomously from a large pentagonal axillary primibrach *1*. Secundibrach *1* is a large trapezoidal plate; secundibrach *2* is a rectangular plate and secundibrachs *3 - 4* are small, staggered, trapezoidal plates. Pentagonal secundibrach *5* is axillary with even distal facets and branches isotomously. Tertibrach *1* is large, trapezoidal. Tertibrachs preserved as the last five smaller, trapezoidal plates are nearly uniform in size. Tertibrachs bear long pinnules though secundibrach *1* of SUI-35533 appears to also be pinnulate.

Remarks. — Five specimens from Odell, Nebraska, are placed in their species because of their similarities to the illustrated holotype. The tentative range zone of this species is from the Fort Riley Limestone, Chase Group, to the Grant Shale, Chase Group.

Table 7. Measurements of *Microcaracrinus twenhofeli* in mm*

	SUI 35533	UNSM 9613	UNSM 9614	UNSM 9615	UNSM 10018	UNSM 10019
Height of cup						
(anterior)	5.7	5.4	6.0	3.5	6.2	—
(posterior)	—	6.4	6.8	4.1	—	3.7
Width of cup						
(anteroposterior)	—	10.8	12.2	—	15.1	—
(B-DE interradius)	—	12.0	12.8	—	13.6	—
Width of infrabasal circlet	3.2	2.9	2.9	2.2	4.5	—
Length of AB basal	4.6	4.9	—	2.7	6.2	3.6
Width of AB basal	4.6	4.9	4.3	3.1	5.5	4.3
Length of A radial	4.1	3.7	3.4	2.9	5.1	—
Width of A radial	6.9	5.3	6.6	4.5	8.7	—
Length of radianal plate	4.1	3.7	3.5	2.0	3.7	2.9
Width of radianal plate	2.9	3.3	3.2	1.4	3.8	2.5
Length of anal plate	—	3.5	3.7	2.1	4.6	2.9
Width of anal plate	—	3.1	2.6	1.9	3.8	2.7
Diameter of stem impression	2.4	—	—	1.9	—	—

*Measured on surface of curvature

Occurrence. — Grant Shale Member, Winfield Formation, Chase Group, Big Blue Series, Permian (Location 1, Appendix II, Text-fig. 1).

Material studied. — Hypotypes, UNSM-9613, UNSM-9614, UNSM-9616, UNSM-10018, UNSM-10019, hypotype SUI-35533.

Family **SCYTALOCRINIDAE** Moore and Laudon, 1943

Genus **ELIBATOCRINUS** Moore, 1940

Type species: *Elibatocrinus leptocalyx* Moore, 1940, p. 35.

Other species included. — *Elibatocrinus notabilis* Moore, 1940, p. 41; *Elibatocrinus concinnulus* Moore, 1940, p. 42; *Elibatocrinus catactus* Moore, 1940, p. 43; *Elibatocrinus hoodi* Strimple, 1961, p. 132; *Elibatocrinus elegans* Strimple and Moore, 1971, pp. 8-9; *Elibatocrinus* sp. Lane and Webster, 1966, p. 30; *Elibatocrinus elongatus* Webster and Lane, 1967, pp. 16-17.

Elibatocrinus sp. cf. **E. elongatus** Webster and Lane, 1967
Pl. 40, figs. 4-5; Text-fig. 1c

Elibatocrinus sp. Lane and Webster, 1966, p. 30, pl. 10, fig. 7.
Elibatocrinus elongatus Webster and Lane, 1967, pp. 16-17, pl. 5, figs. 1-2.

Description. — Dorsal cup, large, high, conical with a small section of stem attached. There are three up-flared infrabasals, the C ray infrabasal being the smaller, the larger ones occupying the AB and DE rays. The proximal portions of the infrabasals are nearly vertical, the upper two-thirds of the plates sloping outward at about 75 degrees to the horizontal.

There are five large basals that are about three-fourths as wide as long. They slope outward at about 75 degrees from the horizontal. The CA, AB, and BC basals each has six sides, and the DE and CD basals each have seven sides. The upper left corner of the DE basal is truncated, probably for reception of an RA plate and the top of the CD basal is truncated, probably for the reception of anal X.

RA and anal X missing but the plates present indicate RA had at least four sides and fitted between the lower left border of the D radial and upper right border of the CD basal and the upper left border of the DE basal.

Anal X would have at least three sides contacting the right border of the C radial and upper border of the CD basal (see Text-fig. 1c).

The five pentagonal radials are about twice as wide as long. Their outward slope cannot be accurately determined but it appears to be about the same as seen in the upper portion of the basals. The cup is covered with irregularly distributed nodes and tubercles.

The radial articulating facets are much longer than wide and occupy almost the entire width of the radial. A long, deep ligamental pit is situated between wide outer-marginal and transverse ridges. There appears to be only a few faint denticles. The oblique ridge is short and confined to the innermost portion of the facet. A deep, wide muscle area slopes inward to a dimple-like central pit which is connected to the interior of the cup by a wide, poorly defined intermuscular furrow.

Remarks. — Only five species of *Elibatocrinus* are represented by crowns, or complete or nearly complete dorsal cups: *Elibatocrinus leptocalyx, E. catactus, E. hoodi, E. elegans,* and *E. elongatus.* The specimen at hand appears to be characterized by the irregular ornamentation and the infrabasals which go from a vertical attitude proximally to an out-flared attitude distally. *E. leptocalyx, E. elegans,* and *E. hoodi* have no surface ornamentation. The infrabasals of *E. elongatus* differ from those of the specimen at hand by flaring outward immediately at the base and the cup. *E. elongatus* has an elliptical outline whereas the cup of the Oklahoma specimen has a more conical outline.

Occurrence. — Bennett Shale Member, Red Eagle Formation, Council Grove Group, Big Blue Series, Permian. Quarry on north side of old U.S. Highway 60, (Location 2, Appendix 2).

Material studied. — SUI-35537, collected by W. M. Furnish.

Table 8. Measurement of *Elibatocrinis* sp. cf. *E. elongatus* in mm*

Height of cup (anterior)	21.5
Height of infrabasal circlet	8.7
Length of AB basal	12.1
Width of AB basal	9.8
Length of A radial	7.3
Width of A radial	10.5
Diameter of stem attachment	8.6

*linear

Family **AMPELOCRINIDAE** Kirk, 1942

Subfamily **AMPELOCRININAE** Kirk, 1942

Genus **HALOGETOCRINUS** Strimple and Moore, 1971

Type species: *Aesiocrinus paucus* Strimple, 1951.

Other species included. — *Aesiocrinus prudentia* Strimple, 1963, p. 72; *Lecobasicrinus subidus* Strimple, 1969, p. 192.

Occurrence. — Pennsylvanian (Atokan-Virgilian) and Permian (Big Blue); USA, (Texas, Oklahoma, Kansas, Illinois, Nebraska).

Halogetocrinus boellstorffae Pabian and Strimple, new species
Pl. 38, figs. 1-2; Text-fig. 2d

Description. — This species is based on a single, small truncate, cone-shaped cup with five more or less flat-lying infrabasals. The cup sits on the sharp ridge formed by the columnal cicatrix (see text-figure 2d).

The AB, BC, DE, and EA basals are pentagonal and the CD basal is hexagonal as it is truncated for the reception of a large, trapezoidal anal X plate, the upper facet of which is flush with the articulating arm facets of the radials.

There are five pentagonal radials that are about as wide as long. The narrow radial articulating facets occupy nearly the entire width of the radials. The outer marginal and transverse ridges are separated by deep, prominent ligamental pits. Denticles were not observed. The muscle areas slope inward to a deep, narrow central pit that appears to directly join the intermuscular notch, the intermuscular furrow being absent. Three rays have nonaxillary, trapezoidal, flattened, primibrachs.

Remarks. — *Halogetocrinus boellstorffae* is named in honor of Mrs. Charles Boellstorff from whose farm the holotype was collected. It is the youngest representative of this genus. The radials of *H. boellstorffae* do not have the tendency to touch the infrabasals as do the radials of *H. paucus. H. boellstorffae* has a higher, less rounded cup than *H. paucus. H. boellstorffae* has a slightly up-flared base and *H. paucus* a shallow basal concavity. *H. boellstorffae* has long, distally narrowing first primibrachs whereas *H. subidus* has low, wide first primibrachs. *H. prudentia* has a much lower, wider cup than *H. boellstorffae.*

H. boellstorffae appears to be most similar to the Atokan species, *H. subidus,* which has a flattened base. Strimple (1962, p. 72) suggested a divergent trend in the evolution of aesiocrinids, some species evolving from forms with a shallow basal concavity to forms with upflared bases. *H. boellstorffae* appears to be in this group.

Occurrence. — Hughes Creek Shale Member, Foraker Formation, Council Grove Group, Big Blue Series, Permian, Location 3, exposed along a creek in the NW 1/4, NE 1/4, Sec. 36, T. 6N., R. 12E., Nemaha County, Nebraska.

Material studied. — Holotype, UNSM-7992.

Table 9. Measurements of *Halogctocrinus boellstorffae* in mm*

Height of cup	
(anterior)	2.1
(posterior)	2.1
Height of infrabasal circlet	0.5
Diameter of infrabasal circlet	1.5
Length of AB basal	1.0
Width of AB basal	1.1
Length of A radial	0.9
Width of A radial	1.5
Length of anal plate	0.7
Width of anal plate	1.4
Diameter of stem attachment	1.0

*linear

Family **PARADELOCRINIDAE** Knapp, 1969

Genus **ENDELOCRINUS** Moore and Plummer, 1940

Type species: *Eupachycrinus fayettensis* Worthen in Meek and Worthen, 1873, p. 565.

Endelocrinus rotundus Strimple, 1962b

Remarks. — This species is represented by a partial calyx collected by Bruce Rowell. It is included here to note the extended range zone and geographic distribution of this species.

Occurrence. — The holotype was collected from the Aspinwall Limestone Member, Onaga Shale Formation, SE 1/4, Sec. 6, T. 29S., R. 9E., Elk County, Kansas. Hypotype, UNSM-9609, was collected from the Grant Shale Member, Winfield Formation (Location 7, Appendix II, Text-fig. 1). NW 1/4, NE 1/4, Sec. 28, T. 7S., R. 6E., Riley County, Kansas.

Family **GRAPHIOCRINIDAE** Bather, 1899

Diagnosis. — Crown cylindrical, moderately slender. Dorsal cup bowl-shaped; five small infrabasals, not visible in side view, may be in basal plane or in mild to deep concavity; basals medium-sized with distal portions visible in side view; radials moderately large, wider than long, articular facets filling distal face of plates; single anal plate in cup or may be absent in late genera. Arms ten, wide and usually rectiuniserial, branching on large primibrach *1* in all rays. Column round.

Genera. — *Graphiocrinus* de Koninck and LeHon, 1854; *Acylocrinus* Kirk, 1947; *Contocrinus* Knapp, 1969; *Euerisocrinus* Strimple, 1939; *Holcocrinus* Kirk, 1945; *Parastachyocrinus* Wanner, 1949; *Stachyocrinus* Wanner, 1916.

Genus **CONTOCRINUS** Knapp, 1969

Diagnosis. — Characters of family with single anal plate.

Contocrinus sp. cf. **C. scopulus** (Lane and Webster), 1966 Pl. 40, figs. 1-3

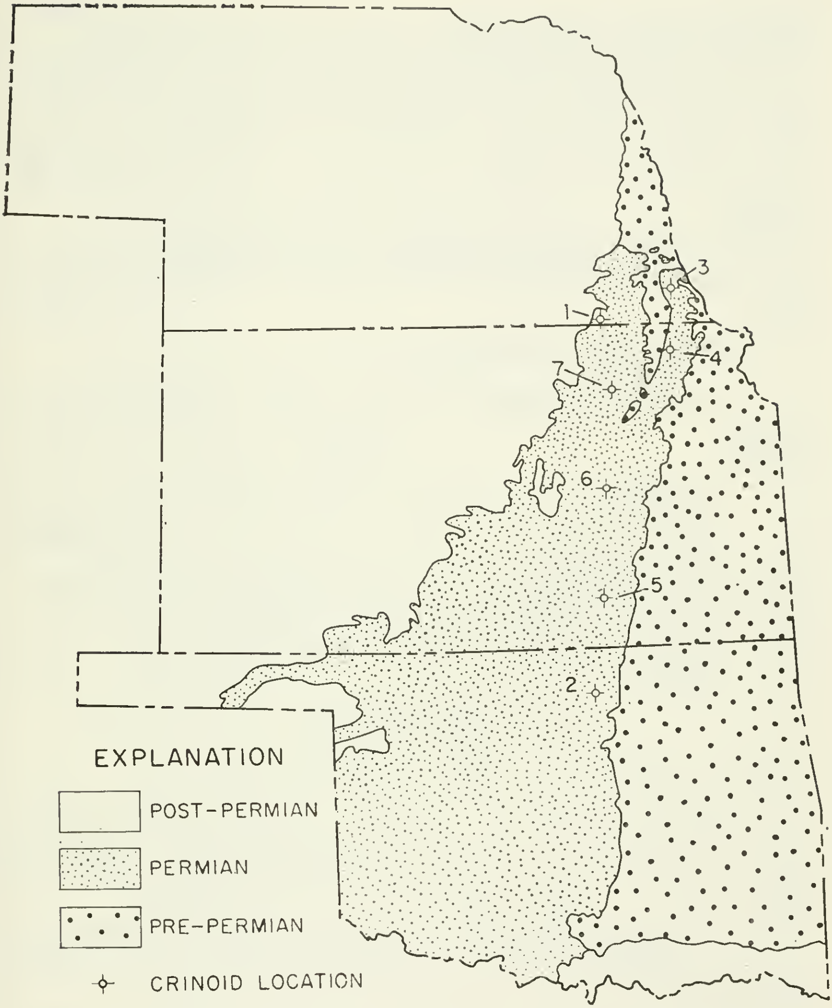
Graphiocrinus scopulus Lane and Webster, 1966, p. 46, pl. 10, figs. 4-8.
Graphiocrinus scopulus Lane and Webster, Webster and Lane, 1967, p. 26, pl. 4, figs. 1-3.

Description. — The presently considered dorsal cup is similar in morphology to the specimens described from Nevada and is intermediate in size between the holotype (No. 39653) and paratype (No. 39654). Of particular interest is the deep, funnel-like basal concavity with the infrabasals confined to the top of the concavity. Reservation in the assignment is made because in the Nebraska specimen the anal plate does not extend appreciably above the cup summit and is somewhat broader than shown by the original specimens. Also, there are fine granules, giving a frosted appearance to the cup which is found in other species of the genus but has not been reported for the material from Nevada. The typically thin anal plate of the Nebraska specimen is atypical of the genus in having facets for two tube plates on its distal surface.

Material studied. — Hypotype, UNSM-9607.

Table 10. Measurements of *Contocrinus* sp. cf. *C. scopulus,* in mm*

	UNSM 9607
Height of cup	
(anterior)	6.0
(posterior)	6.8
Width of cup	
(anteroposterior)	11.9
(B-DE interradius)	12.8
Height of infrabasal circlet	3.2
Width of infrabasal circlet	2.9
Length of AB basal	6.8
Width of AB basal	6.5
Length of A radial	3.2
Width of A radial	7.8
Length of anal plate	4.2
Width of anal plate	3.0
*Diameter of stem attachment	2.1



Text-figure 2. — Distribution of Permian rocks in Nebraska, Kansas, and Oklahoma, and locations from which crinoids described herein have been collected (Appendix II).

Genus and species undetermined **Pl. 39, figs. 1-3**

A portion of stem collected at the Odell locality shows that the crinoid evidently secreted stem material around some foreign object of unknown affinity. The specimen does not appear to be a primary holdfast. This specimen supports the notion that the stem was free from attachment at least during part of the life of the crinoid.

Occurrence. — Grant Shale Member, Winfield Formation, Chase Group, Big Blue Series, Permian. (Location 1, Appendix II, Text-fig. 1).

Figured specimen. — SUI-35535.

Appendix II. Register of Permian Localities (Text-fig. 2).

Location Number	Description
1.	Roadcut in NE 1/4, NW 1/4, Sec. 20, T. 1N., R. 6E., Gage County, Nebraska.
2.	Quarry in C, Sec. 25, T. 26N., R. 5E., Osage County, Oklahoma.
3.	Creek bank, NW 1/4, NE 1/4, Sec. 36, T. 6N., R. 12E., Nemaha County, Nebraska.
4.	Creek bank, SE 1/4, Sec. 30, T. 2S., R. 16E., Brown County, Kansas.
5.	NE 1/4, NW 1/4, Sec. 36, T. 33S., R. 7E., Cowley County, Kansas.
6.	C, Sec. 26, T. 19S., R. 7E., Chase County, Kansas.
7.	Roadcut, NW 1/4, NE 1/4, Sec. 28, T. 7S., R. 6E., Riley County, Kansas.

REFERENCES

Parts I and II

Arendt, U. A.

1968. *Pirasocrinids from Krasnoufimsk.* Paleont. Zhur., pp. 99-101, fig. 1.

Barbour, E. H.

1903. *Report of the State Geologist.* Nebraska, Geol. Sur., vol. 1, 258 pp., illus., maps. Jacob North & Co., Lincoln, Nebraska.

Boos, M. F.

1929. *Stratigraphy and fauna of the Luta Limestone (Permian) of Oklahoma and Kansas.* Jour. Paleont., vol. 3, No. 3, pp. 241-253, pl. 27, 3 figs.

Burke, J. J.

1932. *A new species of Delocrinus.* Annals Carnegie Mus., vol. XXI, pp. 89-93, pl. III.

Dunbar, C. O., and Condra, G. E.

1931. *Brachiopods of the Pennsylvanian System in Nebraska.* Nebraska Geol. Sur., 2d series Bull. 5, 377 pp., 44 pls.

Eichwald, E.

1856. *Beitrag zur geogrophischen Verbreitung der fossilen thiere Russlands.* Alte Periode. Soc. Imp. Nat. Moscou, Bull., vol. 29, Nos. 1, 2, pp. 34-120.

Geinitz, H. B.

1866. *Carboniferous und Dyas in Nebraska.* K. Leopoldina-Carolinische Dent. Akad. Naturl., Vech. 33, Abh. 4, 91 pp., illus.

Graffham, A. A.

1954. *Minerals and fossils of Queen Hill Quarry.* Rocks and Minerals, vol. 29, Nos. 11, 12, pp. 607-609, Nov.-Dec.

Jaekel, Otto

1918. *Phylogenie und System der Pelmatozoen.* Paleont. Zeitschr., Bd. 3, pp. 1-128.

Kirk, E.

1937. *Eupachycrinus and related Carboniferous crinoid genera.* Jour. Paleont., vol. 11, No. 7, pp. 598-600, pl. 34.

1942. *Ampelocrinus, a new crinoid genus from the Upper Mississippian.* Amer. Jour. Sci., vol. 240, pp. 22-28, pls. 1, 2.

1944. *Cymbiocrinus, a new inadunate crinoid genus from the Upper Mississippian.* Amer. Jour. Sci., vol. 242, pp. 233-245, 1 pl.

Knapp, W. D.

1969. *Declinida, a new order of late Paleozoic inadunate crinoids.* Jour. Paleont., vol. 43, No. 2, pp. 340-391, pl. 61-62, 50 text figs.

Lane, N. Gary

1964. *Inadunate crinoids from the Pennsylvanian of Brazil.* Jour. Paleont., vol. 38, No. 2, pp. 362-366, pl. 57.

Lane, N. G., and Webster, G. D.

1966. *New Permian crinoid fauna from southern Nevada.* Univ. California Publ. Geol. Sci., vol. 63, 86 pp., 13 pls., 19 figs.

Meek, F. B.

1865. *Remarks on the Carboniferous and Cretaceous rocks of eastern Kansas and Nebraska, and their relations to those of the adjacent states and other localities farther eastward, in connection with review of a paper recently published on this subject by M. Jules Marcou, in the Bulletin of the Geological Society of America,* Amer. Jour. Sci., ser. 2, vol. 39, pp. 157-174, 1856. (*Erisocrinus* Meek and Worthen, n. gen., *E. typus* Meek and Worthen, n. sp., *E. nebraskensis* Meek and Worthen, n. sp.)

1872. *Report on the paleontology of eastern Nebraska, with some remarks on the Carboniferous rocks of that district. Final Report of the U.S. Gelogical Survey of Nebraska and portions of the adjacent territories.* 42nd Cong., 1st sess., House Ex. Doc. 19, pt. 2, pp. 83-264, pls. 1-11 (crinoids, pp. 146-151, pls. 1, 5, 7).

———, and Worthen, A. H.

1865a. *Descriptions of new crinoidea etc., from the Carboniferous rocks of Illinois and some of the adjoining states.* Acad. Nat. Sci. Philadelphia, Proc., ser. 1, vol. 17, pp. 155-166.

1865b. *Remarks on the Carboniferous and Cretaceous rocks of eastern Kansas and Nebraska.* Amer. Jour. Sci., ser. 2, vol. 30, pp. 157-174.

1865c. *Note in relation to a genus of crinoids* [*Erisocrinus*] *from the Coal Measures of Illinois and Nebraska.* Amer. Jour. Sci., ser. 2, vol. 39, p. 350.

1873. *Descriptions of invertebrates from Carboniferous System.* Geol. Sur. Illinois Geol. Paleont., vol. 5, pp. 321-619.

Miller, S. A., and Gurley, W. F. E.

1890. *Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri, and Iowa.* Cincinnati Soc. Nat. History, Jour., vol. 13, pp. 3-25, pls. 1-4 (April). Republished privately, Danville, Ill., with additional descriptions and plates, pp. 3-59, pls. 1-10 (June, 1890). Republished, Indiana Dept. Geology, Nat. History, Ann. Rept. 16 (1888), pp. 327-373, pls. 1-10 (1890).

Moore, R. C.

1939. *New crinoids from Upper Pennsylvanian and Lower Permian rocks of Oklahoma, Kansas and Nebraska.* Denison Univ. Bull., Jour. Sci. Labs., vol. 34, art. 6, pp. 171-279, 9 pl.

1940. *New genera of Pennsylvanian crinoids from Kansas, Oklahoma, and Texas.* Denison Univ. Bull., Jour. Sci. Labs., vol. 35, pp. 32-54, pl. 1.

————, and Laudon, L. R.

1943. *Evolution and classification of Paleozoic crinoids.* Geol. Soc. America, Spec. Pap. 46, 167 pp., 14 pls.

Moore, R. C., and Plummer, F. B.

1938. *Upper Carboniferous crinoids from the Morrow subseries of Arkansas, Oklahoma* and *Texas.* Denison Univ., Bull., Jour. Sci. Lab., vol. 32, pp. 209-313, pls. 12-16.

1940. *Crinoids from the upper Carboniferous and Permian strata in Texas.* Univ. Texas Publ. 3945, 468 pp., 21 pls.

Moore, R. C., and Strimple, H. L.

1941. *Tegminal structure of the Pennsylvanian-Permian crinoid Delocrinus.* Denison Univ., Bull., Jour. Sci. Labs., vol. 36, pp. 1-12, pl. 1.

Mudge, M. R., and Yochelson, E. L.

1962. *Stratigraphy and Paleontology of the Uppermost Pennsylvanian and Lowermost Permian Rocks in Kansas.* U.S. Geol. Sur., Prof. Pap. 323, 213 pp., 17 pls., 36 figs., 6 tbls.

Muir-Wood, H. M., and Cooper, G. A.

1960. *Morphology, classification, and life habits of the Productoidea (Brachiopoda).* Geol. Soc. America, Mem. 81, 447 pp., 135 pls., 8 figs.

Newell, N. D.

1937. *Late Paleozoic Pelecypods, Pectinacea.* Kansas Geol. Sur., vol. 10, 123 pp., 20 pls., 42 figs.

1942. *Late Paleozoic Pelecypods Mytilacea.* Kansas Geol. Sur., vol. 10, pt. 2, 80 pp., 15 pls., 22 figs.

1968. *Pectinacea in Treatise on Invertebrate Paleontology.* Univ. Kansas Press and Geol. Soc. America, pt. N, pp. 335-382, figs. C57-C101.

Pabian, R. K., and Strimple, H. L.

1969. *The stratigraphic occurrence of Pennsylvanian crinoids in Nebraska.* [Abs.] Proc. Nebraska Acad. Sci., vol. 79, p. 27.

1970. *Paleoecology of Pennsylvanian crinoids from southeastern Nebraska and southwestern Iowa.* [Abs.] Proc. Nebraska Acad. Sci., vol. 80, p. 36.

1971. *Some Permian crinoids and associated fauna from Nebraska.* [Abs.] Abstracts with Programs, North Central Sec., Fifth Ann. Meeting, Geol. Soc. Amer., vol. 3, p. 274.

Romer, A. S.

1967. *Vertebrate paleontology.* Univ. of Chicago Press, Chicago and London, 3d edition, 468 pp., illus.

Shimer, H. W.. and Shrock, R. R.

1944. *Index fossils of North America.* M.I.T. Press, Cambridge, Mass. 837 pp., illus.

Shumard, B. F.

1865b. *Remarks on the Carboniferous and Cretaceous rocks of eastern Kansas and Nebraska.* Amer. Jour. Sci., ser. 2, vol. 30, pp. 157-174.

1873. *Descriptions of invertebrates from Carboniferous System.* Geol. Sur. Illinois, Geol. Paleont., vol. 5, pp. 321-619.

Shumard, B. F., and Swallow, G. C.

1858. *Descriptions of new fossils from the Coal Measures of Missouri and Kansas.* Acad. Sci. St. Louis, Trans., vol. 1, pp. 199-227.

Strimple, H. L.

1938. *A group of crinoids from the Pennsylvanian of northeast Oklahoma.* Bartlesville, Oklahoma, 12 pp., 2 pls.

1939a. *A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma.* Bull. Amer. Paleont., vol. 24, No. 87, pp. 363-386, 3 pls.

1939b. *Eight species of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma.* Bull. Amer. Paleont., vol. 25, No. 89, pp. 35-48, 2 pls.

1940. *Stellarocrinus new name for Whiteocrinus Strimple.* Bull. Amer. Paleont., vol. 25, No. 92a, 5 pp., 1 pl.

1947. *Three new crinoid species from the Virgil Series of southeastern Kansas.* Bull. Amer. Paleont., vol. 31, No. 124, pp. 3-12, pls. 1-2.

1948. *Crinoid studies. Part II. Apographiocrinus from the Altamont Limestone of Oklahoma.* Bull. Amer. Paleont. vol. 32, No. 130, pp. 20-26, pl. 2, figs. 1-16.

1949a. *Crinoid studies.* Bull. Amer. Paleont., vol. 32, No. 133, 42 pp., 7 pl.

1949b. *Evolution of Delocrinus to Paradelocrinus and description of Stuartwellercrinus argentinei, sp. nov.* Geol. Mag., vol. 86, pp. 123-127, pl. 4.

1949c. *Studies of Carboniferous Crinoids. I. A. group of Pennsylvanian crinoids from the Ardmore Basin. II. Delocrinids of the Brownville Formation of Oklahoma. III. Description of two new cromyocrinids from the Pennsylvanian of Nebraska. IV. On new species of Alcimocrinus and Ulrichicrinus from the Fayetteville Formation of Oklahoma.* Palaeont. Amer., vol. 3, No. 23, pp. 323-348, figs. 1, 2, pls. 29-33.

1950. *Emendation of Endelocrinus tumidus* (Strimple). Jour. Paleont., vol. 24, pp. 112-113.

1951a. *New species of crinoids from the Pennsylvanian of Kansas.* Jour. Paleont., vol. 25, No. 3, pp. 372-376, pls. 56-57.

1951b. *Some new species of Carboniferous crinoids.* Bull. Amer. Paleont., vol. 33, No. 137, pp. 183-218, 5 pls.

1951c. *New Carboniferous crinoids.* Jour. Paleont., vol. 25, No. 5, pp. 669-676, pls. 98, 99.

1961. *Late Desmoinesian crinoid faunule from Oklahoma.* Oklahoma Geol. Sur., Bull. 93, 189 pp., 18 pls.

1962a. *Crinoids from the Oologah Formation.* Oklahoma Geol. Sur., Circular 60, 75 pp., 9 pls.

1962b. *Echinodermata. Crinoidea.* (Pp. 66-74, 2 pls., 2 figs.; *in* Mudge, M. R. and Yochelson, E. L., *Stratigraphy and paleontology of the uppermost Pennsylvanian and lowermost Permian rocks in Kansas.* U.S. Geol. Sur., Prof. Pap. 323.

1966. *New species of cromyocrinids from Oklahoma and Arkansas.* Oklahoma Geol. Sur., Oklahoma Geol. Notes, vol. 26, No. 1, pp. 3-12, 2 pls.

1971. *Ethelocrinids from the vicinity of Bartlesville, Oklahoma.* Oklahoma Geol. Notes, vol. 31, pp. 80-81, fig. 1a-g.

Strimple, H. L., and W. D. Knapp

1966. *Lower Pennsylvanian fauna from eastern Kentucky, part 2, crinoids.* Jour. Paleont., vol. 40, No. 2, pp. 309-314, pl. 36, 1 text-fig.

Strimple, H. L., and Moore, R. C.

1971. *Crinoids of the La Salle Limestone (Pennsylvanian) of Illinois.* Univ. Kansas, Paleont. Contr. Art. 55 (Echinodermata II) 48 pp., 23 pls., 19 figs.

Strimple, H. L., and Priest, Amel

1969. *New Erisocrinid from Nebraska.* Univ. of Kansas, Paleont. Contr., Paper 42, pt. 6, pp. 23-25, fig. 9.

Strimple, H. L., and Watkins, W. T.

1969. *Carboniferous crinoids of Texas with stratigraphic implications.* Palaeont. Amer., vol. 6, No. 40, pp. 140-275, pls. 30-56, 2 text-figs.

Tien, C. C.

1924. *Carboniferous crinoids from the Taiyuan Series of North China.* Geol. Sur. China, Bull. 6, 57 pp., 2 pls.

Trautschold, H.

1867. *Einige Crinoideen und andere Tierreste des jüngeren Bergkalkes in Gouvernement Moskau.* Soc. Imp. Nat. Moscou Bull., vol. 40, pt. 2, No. 3, pp. 1-49, pls. 1-4.

1879. *Die Kalkbrüche von Mjatschwkow: eine Monographie des oberen Bergkalks.* Soc. Imp. Nat. Moscou, Nouv. Mem., vol. 14, pp. 101-180, pls. 12-18.

Upson, M. E.

1931. *The ostracods of the Big Blue Series in Nebraska.* Nebraska Geol. Sur., 2d ser., Bull. 8, 54 pp., 1 fig., 4 pl.

Wachsmuth, C., and Springer, F.

1885. *Revision of the Palaeocrinidae, Pt. 3, sec. 1.* Acad. Nat. Sci. Philadelphia, Proc. 1885, pp. 225-364, pls. 4-9 (separate repaged, pp. 1-138, pls. 4-9).

Webster, G. D., and Lane, N. G.

1967. *Additional Permian crinoids from southern Nevada.* Univ. Kansas Paleont. Contr., Paper 27, 32 pp., 8 pls., 4 figs.

Weller, S.

1909. *Description of a Permian crinoid fauna from Texas.* Jour. Geol., vol. 17, pp. 623-635, 1 pl.

White, C. A.

1876. *Invertebrate paleontology of the Plateau Province: U.S. Geol. Geog. Surv. Terr. Report on the geology of the Uinta Mountains,* by J. W. Powell, pp. 74-135.

White, W. D.

1964. *Pennsylvanian fossils of eastern Nebraska and western Iowa.* Earth Science Digest, vol. 17, No. 5, pp. 204-206, illus.

Woodruff, E. G.

1906. *The geology of Cass County, Nebraska.* Nebraska Geol. Sur., vol. 2, pt. 2, pp. 181-292, illus.

Wright, James, and Strimple, H. L.

1945. *Mooreocrinus and Ureocrinus gen. nov., with notes on the family Cromyocrinidae.* Geol. Mag., vol. 82, pp. 221-229, pl. 9.

Yakovlev, N. N., and A. P. Ivanov

1956. *Morskie lilii i blastoides kamennougolykh i permskikh otlozhenig SSSR (Crinoids and blastoids from Carboniferous and Permian deposits of USSR).* Vsesoyuznoga Nauchno-Issledovatelakogo Geologicheskogo Instituto (VSEGEI), Trudy, n. ser., vol. 11, 142 pp., 23 figs., 21 pls.

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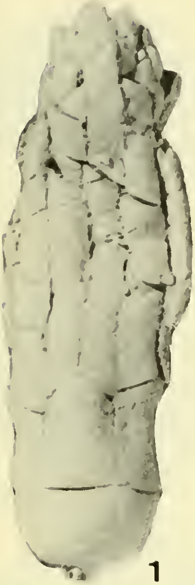
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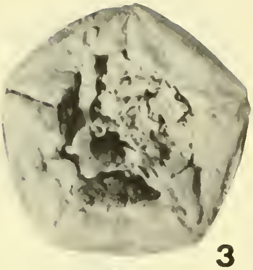
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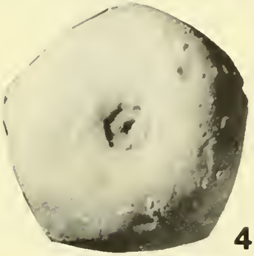
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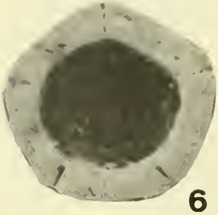
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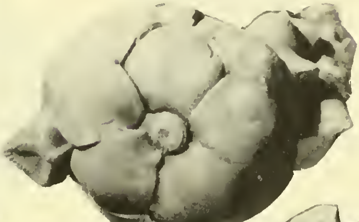
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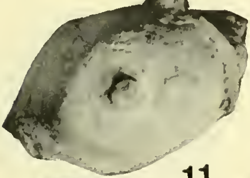
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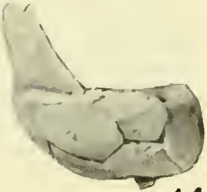
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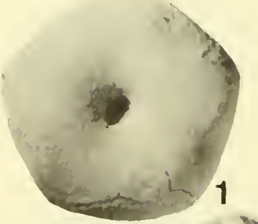
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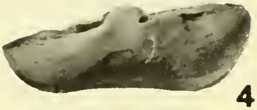
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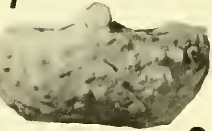
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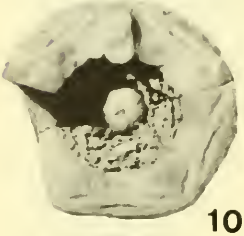
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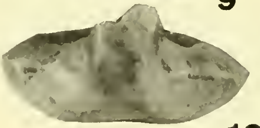
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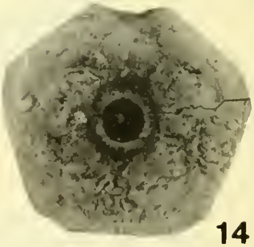
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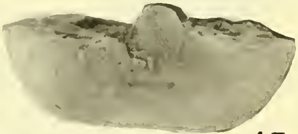
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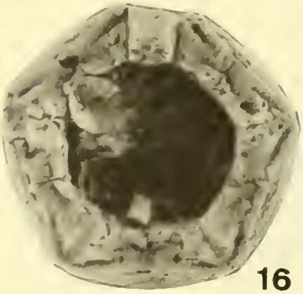
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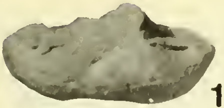
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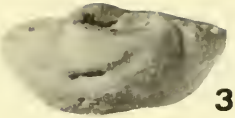
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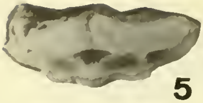
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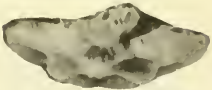
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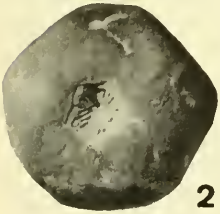
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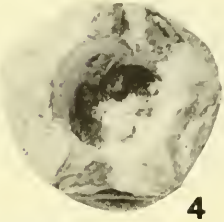
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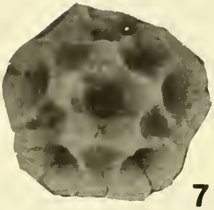
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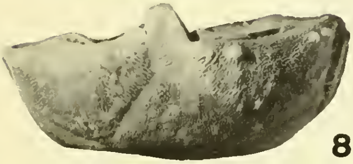
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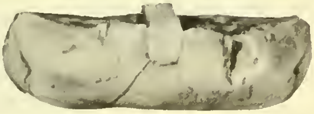
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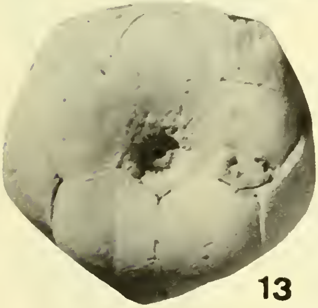
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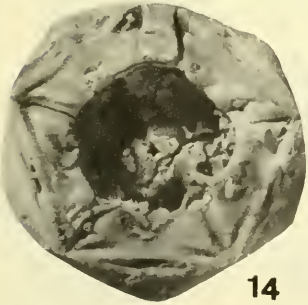
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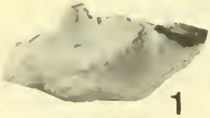
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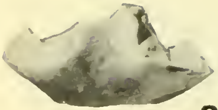
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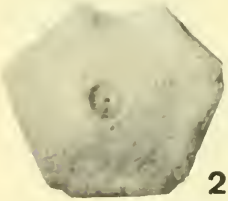
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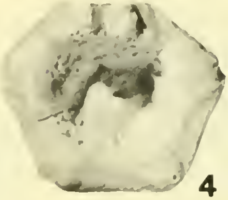
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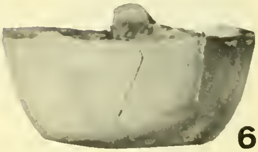
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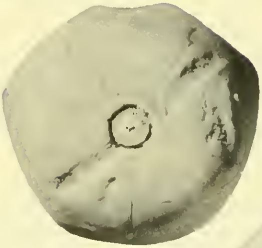
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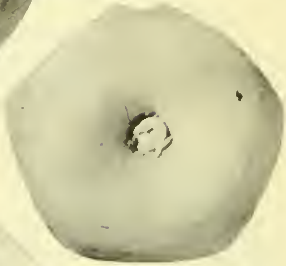
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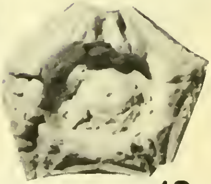
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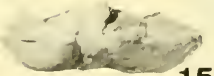
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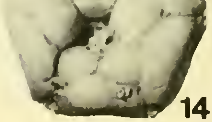
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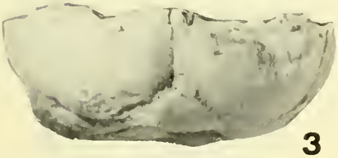

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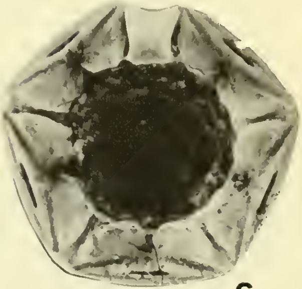

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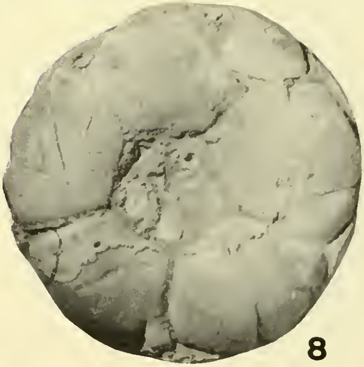

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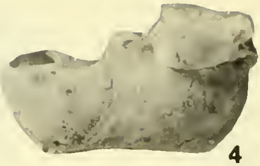

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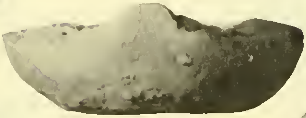

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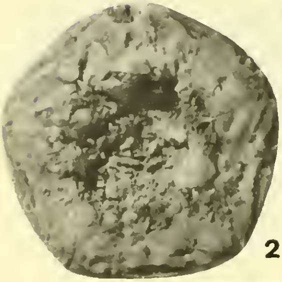

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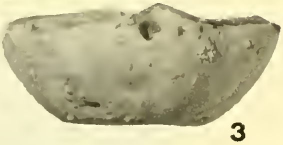

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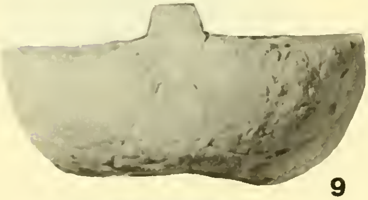

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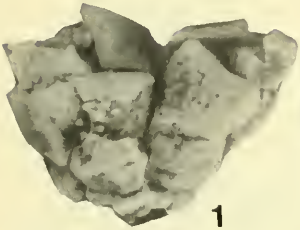
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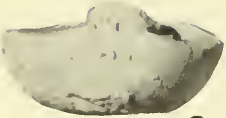
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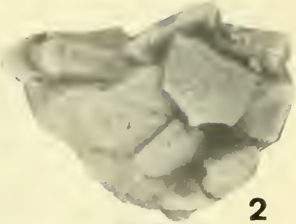
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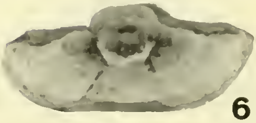
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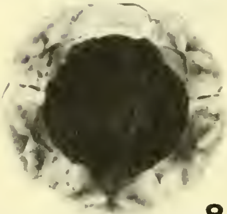
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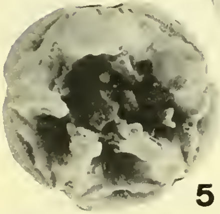
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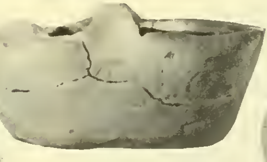
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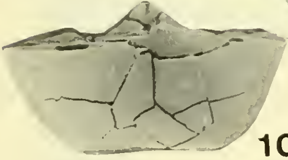
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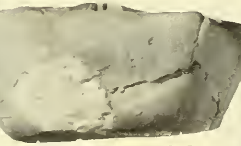
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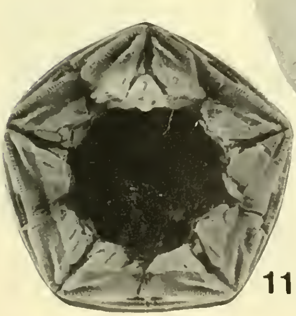
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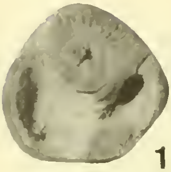
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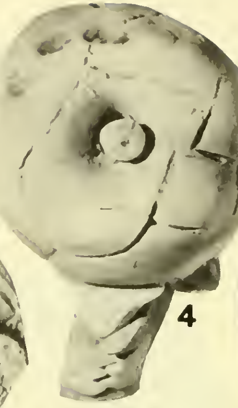
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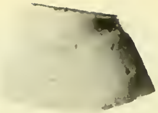
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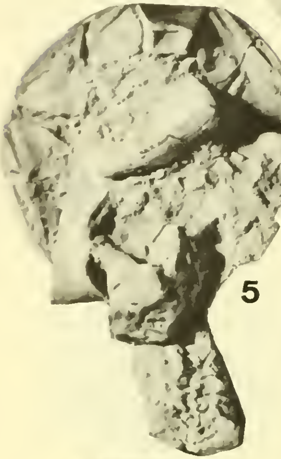
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Permian crinoids

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Permian crinoids

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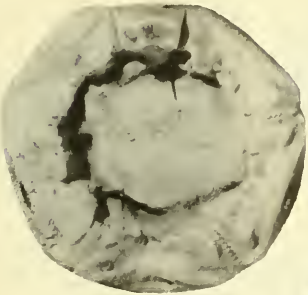
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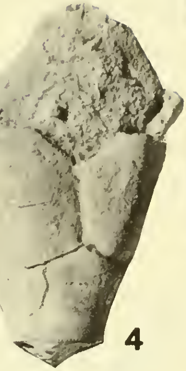
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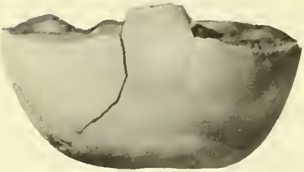
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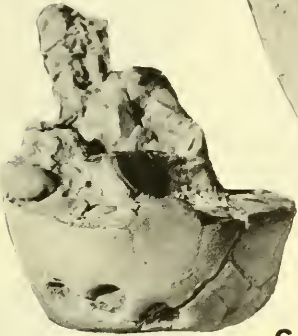
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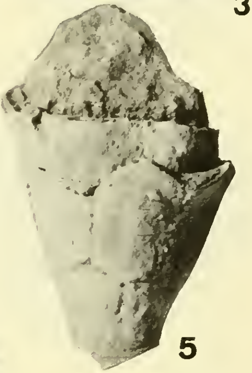
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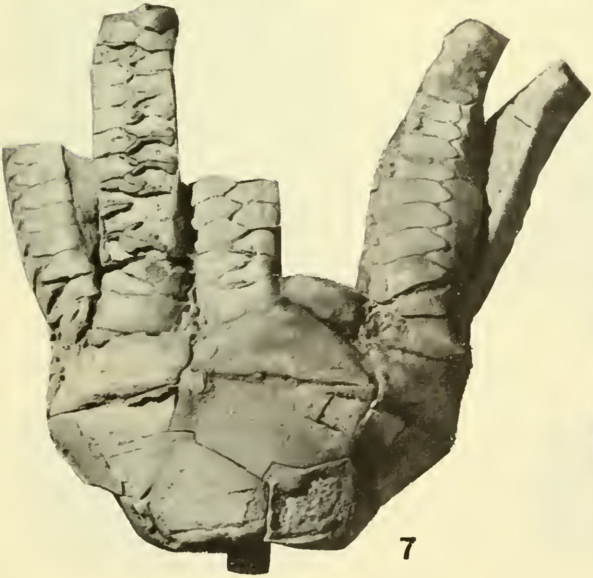
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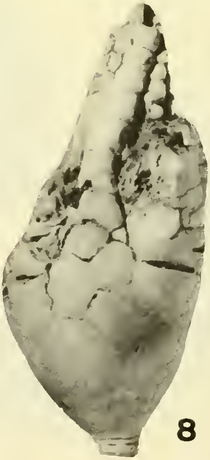
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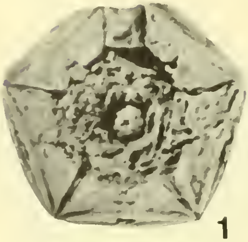
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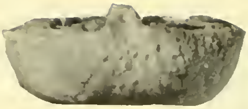
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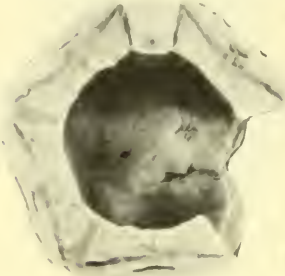
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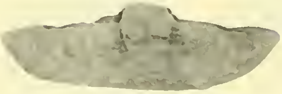
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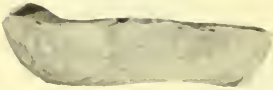
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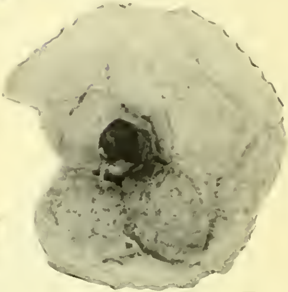
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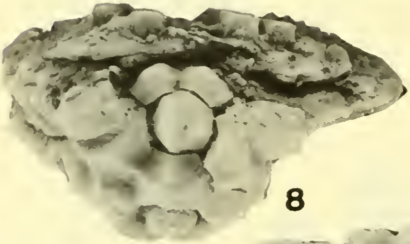
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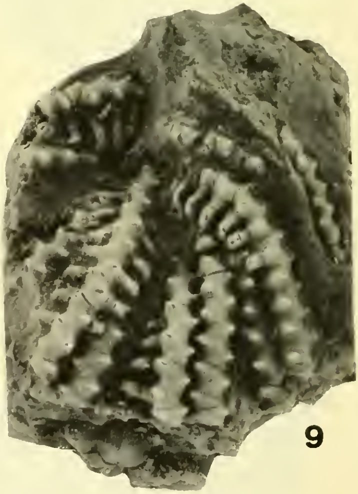
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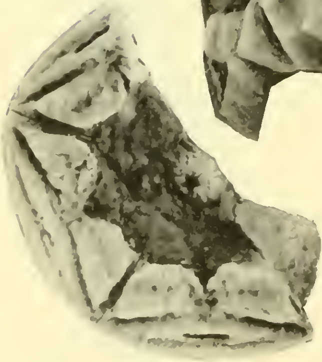
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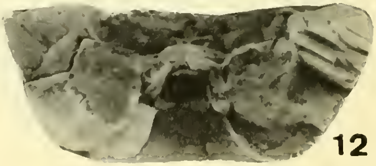
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Permian crinoids

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