A Preliminary Report on the Pollen and Spores of the Pre-Selma Upper Cretaceous Strata of Western Alabama

By ESTELLA B. LEOPOLD *and* HELEN M. PAKISER

STUDIES OF PRE-SELMA CRETACEOUS CORE SAMPLES FROM THE OUTCROP AREA IN WESTERN ALABAMA

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E. A PRELIMINARY REPORT ON THE POLLEN AND SPORES OF THE PRE-SELMA UPPER CRETACEOUS STRATA OF WESTERN ALABAMA

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ABSTRACT

In a preliminary study of the pre-Selma Upper Cretaceous strata the authors report a diverse assemblage of fossil pollen and spores representing a primarily dicotyledonous flora. Two of the vascular plant families represented are now restricted to subtropical areas and one of them is now limited to the southern hemisphere.

Remains of planktonic algae and abundant microforaminifers in the Eutaw and McShan formations suggest that these sediments accumulated in marine waters, probably somewhat below the turbulent wave zone.

The depositional environment of the Coker formation, as inferred from pollen in several lignite seams, was probably shallow water and lagoonal. Pollen and spores that are most abundant in this lignite and in the associated siltstone may be assumed to have been derived locally, and probably represent shore or lagoon-margin vegetation. The modern families to which these pollen are related—for example, the holly, myrtle, tea, and cyrilla families—have representatives that occupy swampy-bay or lagoon-margin habitats in subtropical areas. The land plant assemblage of the Coker formation is only slightly different from that of the overlying lower part of the Gordo formation. The middle part of the Gordo was not sampled and the upper part of the formation was unpolleniferous, so nothing can be inferred from pollen about the depositional environment of the uppermost part of the Tuscaloosa group.

Where affinities with modern vascular plant families can be recognized, pollen and spore identifications to a certain extent corroborate taxa of plant megafossils identified by earlier workers from these strata; but this corroboration is mainly on the family, not the generic level.

Comparison with Cretaceous pollen and spore floras of central and northern Europe supports a Late Cretaceous age for the Alabama pollen flora; a close similarity with Cenomanian and Turonian pollen floras of Germany indicates an early Late Cretaceous age.

INTRODUCTION

The present study is a listing of pollen, spores, and certain other microfossils found in well-core sediments of the Tuscaloosa group and the Eutaw and McShan formations (Monroe, 1955; also see chapter A by Monroe in this bulletin). This report should be considered a

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preliminary contribution, for it is clear from the megafossil remains (Berry, 1919) and from the present evidence that the flora of these strata is an enormously rich and diversified one. The fact that there exist at least 105 species among the 2,000 specimens examined for the present report clearly demonstrates this floristic diversity.

The presently available taxonomic literature concerning microspores and pollen of upper Mesozoic strata is almost entirely based on European material. In the identification of the Alabama material, we compared our specimens with the type figure and descriptions for the species or genera determined. All references utilized in the identifications are included in the bibliography. Though we have encountered many new species and one genus that do not seem to have been named to date, we shall undertake formal description of these at a later date, and for the present report shall refer to the new forms as "confer" (cf. or compare) with their most nearly related species.

SOURCE OF MATERIAL AND METHODS USED

Twenty-nine samples of sediments from the Tuscaloosa group and the McShan and Eutaw formations were taken from three cores (table 14), and were studied for contained pollen, spores, and other microfossils. The locations of these three core holes are shown on the index map of plate 1; the lithologic composition of the core sediments was diagrammed by Bergenback on plate 1 and the positions of the samples analyzed for pollen and spores are shown to the extreme right of the lithologic section of each core. The segments of core utilized in the pollen and spore study are listed according to depth and lithotype in table 14.

The polleniferous material of the Tuscaloosa group includes three groups of samples, one from each of the two cores of the Eoline member of the Coker formation, and one from the Gordo formation. The unnamed upper member of the Coker formation was sampled (Webb hole, 212.2–214.9 feet depth and Boykin hole, 204.2–206.3 feet depth—depth intervals from Monroe, 1955) near its base but these sediments contained no plant fossils; the general mottled pink and yellow color of the unit suggests an oxidation state that makes it an unlikely source for fossil pollen and spores. The only sample obtained from the Gordo formation containing plant fossils is from a gray clay unit in the lower part of the formation, near the top of the Boykin hole. Samples from the main part of the Gordo formation were not available because the bulk of the unit was not cored, but two samples (lower part of Crawford hole, 399.1–420.8 feet depth) of sandy clay from near the top of the formation were prepared and found to be unfossiliferous.

TABLE 14.—*Source and type of samples studied for contained pollen, spores, and other microfossils*

USGS paleobotany loc.	Formation	Sample	Lithotype	Depth intervals sampled (feet)[1]
Core from Crawford hole, sec. 15, T. 18 N., R. 8 E., Perry County				
D1110	Eutaw	1	Siltstone	111.2–118.4
	do	2	Claystone	129.1–131.3
	do	3	do	136.0–139.6
D1456	McShan	4	do	186.5–192.5
	do	5	do	296.5–302.3
	do	6	do	314.5–316.6
	Gordo	7	do[2]	399.1–402.1
	do	8	do[2]	410.1–420.8
Core from Boykin hole, sec. 5, T. 24 N., R. 4 E., Tuscaloosa County				
D1457	Gordo	1	Sandy siltstone	10.5–20.6
D1111	Coker, upper member	2	Lignite[2]	204.2–206.3
	do	3	do	247.7–249.2
	Coker, Eoline member	4	Claystone	near 270.5
		5	do	270.5–271.4
		6	do	314.2–324.4
		7	do	324.4–335.0
		8	Lignite	346.4–348.5
		9	do	352.0–353.8
		10	Silty claystone	378.1–385.1
		11	Sandstone[2]	476.0–477.6
Core from Webb hole, sec. 16, T. 21 N., R. 8 E., Perry County				
D1109	Coker, upper member	1	Claystone[2]	212.2–214.9
	Coker, Eoline member	2	Claystone	226.8–229.8
		3	do	229.8–232.6
		4	do	238.8–248.0
		5	Sandy claystone	248.0–261.0
		6	Claystone	298.0–299.6
		7	Siltstone	360.0–364.0
		8	Claystone	374.3–375.8
		9	do	427.0–430.0
		10	do	457.3–460.0

[1] Depth intervals from Monroe, 1955.
[2] Sediment sampled contained no fossil pollen or spores.

From the Crawford core six polleniferous samples were obtained—three from the middle and upper parts of the McShan formation, and three from the middle part of the Eutaw formation (table 14).

The Boykin hole samples of the Tuscaloosa group and the Crawford hole samples of the McShan and Eutaw formations can be considered a coarsely sampled composite pollen section of the pre-Selma strata, the largest sampling gaps being the probably unfossiliferous upper member of the Coker and the chiefly unsampled Gordo formation. The Webb hole pollen samples, which are spaced from less than 1 to 50 feet apart within the Eoline member of the Coker formation, serve as a laterally equivalent pollen sequence for comparison with the Eoline member in the Boykin hole.

The methods by which the sediments were treated in order to isolate the pollen and spore fraction include the hydrofluoric acid technique described by Faegri and Iversen (1950, p. 62), and the heavy liquid flotation method described by Funkhouser and Evitt (1959). The fossil material was stained with Safranin "O" and mounted in glycerine jelly; after the slides were cured with low heat (50°C) for a few days, the coverslips were sealed with lacquer.

The pollen and spore species are noted in table 15 according to relative abundance in the organic residues, as follows:

	Percent
Rare (R)	<1
Frequent (F)	1–10
Common (C)	10–33
Abundant (A)	33–50
Dominant (D)	>50

COMPOSITION OF THE MICROFOSSIL ASSEMBLAGE AND AFFINITIES WITH MODERN PLANTS

The pre-Selma Upper Cretaceous pollen and spore flora as listed in table 15 embraces a total of 105 identified species and 92 genera. Fifteen forms represent hystrichomorphs and unicellular algae, 30 species are sporae dispersae representing members of pteridophyte groups, 18 species are Gymnospermae, and 40 species are Angiospermae.

FAMILY HYSTRICHOSPHAERIDEAE

The unicellular forms placed in the Hystrichosphaerideae bear organ generic names and are of uncertain affinities. Some evidence indicates that certain hystrichomorphs are members of the Dinoflagellata (Cookson, 1956; Braarud, 1945). Hystrichomorphs may be abundant in modern marine sediments (McKee, Chronic, and Leopold, 1959), though they are occasionally found as fossils in continental deposits.

Most of the species of Hystrichosphaerideae in the present material are known from Upper Cretaceous strata of Europe. *Micrhystridium inconspicuum* Deflandre (1937) was described from Cenomanian sediments from the Paris Basin, but its total stratigraphic range is not known. *Pterospermopsis ginginensis* Deflandre and Cookson, which is now known only from marine Upper Cretaceous Senonian strata of Western Australia, is found in McShan and Eutaw sediments here (plate 9, fig. 6). The forms *Micrhystridium piliferum* Deflandre, *Hystrichosphaeridium multifurcatum* Deflandre, and *Hystrichosphaera cornigera* Wetzel are all common in the Silex deposits of the Paris Basin (Deflandre, 1937). *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson (pl. 9, fig. 13) is a Cretaceous form known primarily from Australia. The other Hystrichosphaerideae species

TABLE 15.—*Microfossils identified in core samples of pre-Selma Upper Cretaceous sediments in western Alabama*

[Relative abundance in samples indicated by R, rare; F, frequent; C, common; A, abundant; and D, dominant]

Species identified	Name of core	Webb core									Boykin core									Crawford core					
	USGS paleobotany locality	D1109									D1111								D1457	D1456			D1110		
	Formation	Coker, Eoline member									Coker, Eoline member								Gordo	McShan			Eutaw		
	Sample No.	10	9	8	7	6	5	4	3	2	10	9	8	7	6	5	4	3	1	6	5	4	3	2	1
Forminifera																					D	F	D	A	D
Hystrichosphaerideae:																									
Hystrichosphaera cornigera Wetzel																					R				
Membranilarnax pterospermoides Wetzel																						R			
Schizosporis reticulatus Cookson & Dettman																					R				
Pterospermopsis ginginensis Deflandre & Cookson																						R	R		
Hystrichosphaeridium multifurcatum Deflandre				R			R	R												R	C	R	F	R	F
H. pulcherrimum Deflandre & Cookson						R														R					R
H. truncigerum Deflandre																								R	
Hystrichosphaeridium Deflandre																R				R		R	F	C	F
Micrhystridium sp. Deflandre																						R			
M. bacilliferum Deflandre																									R
M. parvispinum Deflandre																				R	R	R			
M. inconspicuum Deflandre															R							R			
M. pavimentum Deflandre																						R			
M. piliferum Deflandre							R																	R	
Sporites echinosporus R. Potonié																				R					
Tetraporina Naumova																						R			
Dinoflagellata:																									
Undetermined														R						R				R	
Deflandrea bakeri f. *pellucida* Deflandre & Cookson																									R
Gonyaulax transparens Sarjeant																								R	
Paleohystrichosphora Deflandre																							R		
cf. *Wetzeliella glabra* Cookson												R									F	R	R	F	
Chroococcales:																									
cf. *Aphanothece*																					R				
Sporae Dispersae:																									
Baculatisporites primarius (Wolff) Thomson and Pflug																					R				
Cicatricosisporites brevilaesuratus Couper																			R						
C. dorogensis R. Potonié and Gelletich		F	R		C	F			F			C	R	F	F	F	C	F	C		C	C		R	R
C. dunrobensis Couper												R				R									

TABLE 15.—*Microfossils identified in core samples of pre-Selma Upper Cretaceous sediments in western Alabama—Cont.*

[Relative abundance in samples indicated by R, rare; F, frequent; C, common; A, abundant; and D, dominant]

Species identified	Name of core	Webb core									Boykin core									Crawford core					
	USGS paleobotany locality	D1109									D1111								D1457	D1456			D1110		
	Formation	Coker, Eoline member									Coker, Eoline member								Gordo	McShan			Eutaw		
	Sample No.	10	9	8	7	6	5	4	3	2	10	9	8	7	6	5	4	3	1	6	5	4	3	2	1
Sporae Dispersae—Continued																									
Cingulatisporites dubius Couper																			R			R			
C. problematicus Couper																			R						
cf. *C. scrabatus* Couper												R										R			
Concavisporites cf. *C. punctatus* Delcourt and Sprumont			F					F	R		F	C		F	F	R	C	C					R	F	R
C. rugulatus Pflug		R																							
Corrugatisporites arcuatus Weyland & Greifeld																						R			
Cyatheacidites annulata Cookson															R										
Cyathidites mesozoicus (Thiergart) R. Potonié		R										R													
Deltoidospora hallii Miner		R								C	F							C				R			R
Densoisporites perinatus Couper												R							R				R		
Gleichenia circinidites Cookson		R																							
Gleicheniidites senonicus Ross										R	F	R													
Hymenozonotriletes reticulatus Bolkhovitina																						R			
Leiotriletes cf. *L. subtilis* Bolkhovitina			R					R										R							
Lycopodium cerniidites Ross																	F								
Monolites major Cookson		F	R	R	C	C		C	F	F	C	F	F		F	F	F	C	C		C	R	C	R	A
Osmundacidites wellmanii Couper																					R				
Plicatella trichacantha Malawkina		R	R		R						R	R							R			R			
Polypodiaceaesporites haardti (R. Potonié and Venitz) Thomson & Pflug		R	R		R					F		R							R		R		R		R
Poroplanites porosinuosus Pflug										F		F													
Rugulatisporites quintus Thomson and Pflug				R	C																				
Schizaeoisporites eocaenicus (Selling) R. Potonié											R				R										R
Schizoplanites reductus Pflug									R																
Sporites arcifer Thiergart		R																						R	
Taurocusporites reduncus (Bolkhovitina) Stover																			R						
Torisporis intrastructurius Krutzsch																			R						
Trilites verrucatus Couper		R																	R						R
Trilites undetermined		R	F		F	F	R		F			F				R	F			F	F	F	C		R
Triplanosporites sinuosus Thomson & Pflug					R			R		C		F	F			C	F	C						R	
Verrucatosporites alienus (R. Potonié) Thomson & Pflug											R					R									

Gymnospermae:																								
Abietineaepollenites microreticulatus Groot & Penny																		R						R
Araucariacites australis Cookson	F	F									F			F				F		F	C	R		R
Caytonipollenites pallidus (Reissinger) Couper																								R
Classopollis classoides Pflug			R		R	R -														R				R
C. torosus (Reissinger) Couper	R												R											
Cycadopites cf. *C. follicularis* Wilson and Webster											R									R				F
Dacrycarpites australiensis Cookson & Pike																				R	R			
"*Dacrydiumites florinii*" Cookson & Pike	R	R																						
Ephedra Tournefort ex L.				F									R		F	R	F		R				R	
Eucommiidites troedssonii Erdtman				R																				
Gynkaletes cf. *G. retroflexus* (Luber) Luber	R	R																						
Inaperturopollenites dubius (R. Potonié & Venitz) Thomson & Pflug.	R	F	R	C		C		F	F	C	F		R	R	R		C	F	R	C	C			A
Labiisporites granulatus Leschik				R			R																R	
Laricoidites magnus (Potonié) R. Potonié & Venitz		C	R	F		C	C	F		C	R	F	D	C	D	A	A	C	C		C	F	C	F
Monosulcites minimus Cookson	F			R																	R	R	F	R
Parvisaccites enigmatus Couper																		R			R			
Perinopollenites cf. *P. elatoides* Couper		C		F		F	F	F			F			R	C	A	R		R					
Pinuspollenites labdacus (R. Potonié) Raatz				R																				
Pityosporites microalatus R. Potonié	F	F	R	R		R	R			C			F	R	R			C	R	R		F	F	
Podocarpidites cf. *P. major* Couper	R																				R	R		
cf. *P. biformis* Rouse	R	R		R						F			F							F	R			F
cf. *Podocarpus* (L'Heritier)Persoon	R									R	R					R		D	C			R		
Sequoiapollenites polyformosus Thiergart				F							R						R -			F				
Taxodiaepollenites hiatus (R. Potonié) Thiergart		C		F		C		F		C			R		F	F	C	F	F	A	D	C	F	A
Tsugaepollenites mesozoicus Couper						R				R						R	R							
Monocotyledonae:																								
Liliacidites intermedius Couper																							R	
Sabalpollenites areolatus (R. Potonié) R. Potonié	F	R				R		F		R											R			
Dicotyledonae:																								
Triporate pollen:																								
Basopollis atumescens (Pflug & Thomson) Pflug																		R						
B. orthobasalis (Pflug) Pflug							R																	
Complexipollis praetumescens Krutzsch																		R			R			
Conclaripollis anulopyramis Pflug																				R				
Extratriporopollenites audax Pflug				R	R									R				R						
Latipollis normis Krutzsch				R																				
L. subtilis Krutzsch				R										R							F	R		
L. latis Krutzsch				R														R			R	R		
cf. *Minorpollis minimus* Krutzsch																					R			
Monstruosipollis monstruosis Krutzsch			R	R	R									R										
Nudopollis ornatus (Pflug) Pflug																		R						
cf. *Oculopollis* Pflug																								R
cf. *Paliurus rhamnoides* Bolkhovitina				R																			R	
Sporopollis laqueaeformis Weyland & Greifeld							R															R		R
S. pseudosporites Pflug	R		R	R										R								F	R	
Sporopollis Thomson & Pflug							R														R			
Triatriopollenites arboratus Pflug			R	R															R					

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	Formation	Coker, Eoline member									Coker, Eoline member								Gordo	McShan			Eutaw		
	Sample No.	10	9	8	7	6	5	4	3	2	10	9	8	7	6	5	4	3	1	6	5	4	3	2	1
Dicotyledonae—Continued																									
Triporate pollen—Continued																									
T. rurensis Pflug & Thomson		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	R	R	F	R
T. coryphaeus subsp. *microcoryphaeus* R. Potonié		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R
cf. *T. concavus* Thomson & Pflug		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----
Triorites cf. *T. edwardsii* Cookson		R	----	C	C	R	F	F	F	R	R	----	----	F	F	R	----	F	----	----	----	R	R	R	R
"*Triporopollenites*" Pflug & Thomson		----	----	----	R	----	R	----	R	----	----	----	----	F	R	----	----	----	----	----	----	----	R	R	R
Trivestibulopollenites betuloides Thomson & Pflug		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	F	R	R	F
Turonipollis turonis Krutzsch		----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----
Tricolpate pollen:																									
Cupanieidites major Cookson		----	R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Fraxinoipollenites pudicus (R. Potonié) R. Potonié		----	----	----	R	----	----	----	F	----	----	----	----	F	----	----	F	----	----	----	----	----	----	----	----
Myrtaceidites parvus forma *anesus* Cookson		----	----	----	----	----	----	----	R	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Platanoidites gertrudae (R. Potonié) R. Potonié, Thomson & Thiergart.		R	R	----	F	----	R	R	----	----	R	R	----	----	R	F	R	C	----	----	----	R	R	----	F
Platanoidites R. Potonié, Thomson & Thiergart		----	----	----	----	----	----	----	F	----	----	R	----	----	----	----	----	C	----	----	----	----	----	----	----
Pollenites grossularius R. Potonié		R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
P. megagertrudae R. Potonié		----	----	----	R	R	----	C	----	----	F	R	----	R	----	F	----	C	----	----	----	----	----	----	----
P. ornatus R. Potonié		----	----	----	----	----	----	----	F	R	----	----	----	----	----	F	----	----	----	----	----	----	----	----	----
P. quisqualis R. Potonié		R	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Quercoidites henrici (R. Potonié) R. Potonié, Thomson & Thiergart.		R	F	R	R	----	----	----	R	----	C	A	F	F	A	F	F	----	F	----	F	F	----	R	R
Q. microhenrici (R. Potonié) R. Potonié, Thomson & Thiergart		----	----	----	----	----	----	----	R	R	----	----	----	----	----	----	----	----	----	R	----	R	----	----	----
Salix discoloripites Wodehouse		----	R	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Tenerina tenera Krutzsch		----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	R
Tricolpites Cookson ex Couper		R	F	C	F	R	C	A	D	C	A	D	F	F	F	C	F	F	F	A	F	F	F	F	F
"*Tricolpopollenites retiformis*" Pflug & Thomson		R	R	R	----	----	R	R	R	----	----	F	----	F	----	R	----	R	R	R	R	R	R	R	R
Tricolporate pollen:																									
Araliaceoipollenites edmundi R. Potonié		----	----	----	----	----	----	----	F	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----
Cyrillaceaepollenites megaexactus (R. Potonié) R. Potonié		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	----	F
C. megaexactus subsp. "*brühlensis*" Thomson		----	----	----	----	----	----	----	----	----	F	----	R	R	R	C	F	----	----	R	----	R	----	----	----
Dicotetradites cf. *D. clavatus* Couper		----	----	----	----	----	----	----	----	----	R	F	C	F	F	----	----	----	----	----	----	----	----	----	----
Ilexpollenites margaritatus forma *minor* Pflug & Thomson		----	----	----	----	----	----	----	----	----	C	----	----	----	----	----	----	----	----	----	F	----	----	----	----

I. margaritatus forma *medius* Pflug & Thomson	----	----	----	----	----	----	----	----	----	----	R	----	F	R	F	F	----	----	----	----	----	----	----	----
Pollenites cingulum subsp. *oviformis* R. Potonié	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	----	----	----	----
P. genuinus R. Potonié	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	----	----	----	----	----	----	----	----
P. kruschi R. Potonié	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----
P. kruschi subsp. *analepticus* R. Potonié	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
P. kruschi "asp. *pseudolaesus*" (R. Potonié) Thomson & Pflug	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	F	----	----	----	R	----	R	----
Porocolpopollenites Thomson & Pflug	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	F	F	F	R	F
P. orbiformis Thomson & Pflug	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----
"*Tricolporopollenites microreticulatus*" Pflug & Thomson	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	R	R
"*T. distinctus*" Groot & Penny	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Symplocoipollenites vestibulum (R. Potonié) R. Potonié	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F	----	----	R
Tricolporate pollen, undetermined	----	----	----	----	----	----	----	----	----	----	A	----	----	----	----	----	R	----	----	----	R	R	----	R

identified here are known to be wide ranging in the Mesozoic and Paleozoic of Europe.

CLASS DINOFLAGELLATA

Two algal forms in the Eutaw formation are clearly members of the planktonic group Dinoflagellata: *Gonyaulax* Diesing is a living genus which is entirely an open water plankter, and most of its presently known living species have marine habitats. *Paleohystrichosphora infusorioides* Deflandre (pl. 9, fig. 14) is a form species typical of marine Upper Cretaceous sediments of Europe. Species of *Deflandrea* Eisenack similar to the present material (pl. 9, figs. 15, 16) are known from marine Upper Cretaceous through Eocene sediments in Australia.

ORDER CHROOCOCCALES

A colonial alga composed of 15 cells embedded in a filmy, if not gelatinous, envelope, and having smooth ovoid cells 7 by 4 microns in size, appears to be a member of the Chroococcales. The form resembles the modern genus *Aphanocapsa.*

ORDER LYCOPODIACEAE

A member of the Lycopodiaceae, *Lycopodium cerniidites* Ross resembling the modern subtropical species *Lycopodium cernuum* L. occurs in the Coker and McShan formations. Leaves and strobili of *Lycopodium* and leaves of *Lycopodites* were found in the Tuscaloosa flora by Berry (1919), who stated elsewhere (Berry, 1910) that *Lycopodium* megafossils are rare in the American Cretaceous.

CLASS FILICINEAE

Of the 30 species of pteridophyte spores identified from the pre-Selma samples, only 7 can be assigned to modern families with certainty, and only 1 represents a living genus.

The terrestrial fern family Schizaeaceae, which has four living component genera, is well represented in the Tuscaloosa group (pl. 3, figs. 1–13; pl. 6, figs. 1–5). The organ genus *Plicatella* Malawkina has affinities with a part of the modern genus *Anemia* Swartz, especially with the living species *A. adiantifolia* (L.) Swartz. *Cicatricosisporites* R. Potonié and Gelletich has affinities both with *Anemia* and *Mohria* Swartz, and *Schizaeoisporites* Potonié closely resembles its living counterpart *Schizaea* Smith, especially *S. digitata* (L.) Swartz. All living species of Schizaeaceae are restricted to subtropical and tropical regions, except two species of *Schizaea* which have boreal distributions. Fossil spores are the only evidence of this family in these pre-Selma strata.

Spores assignable to the modern austral and tropical fern genus *Gleichenia* Smith are present in the Eoline member of the Coker formation. Our specimens are of the *G. circinata* type and compare in all respects with Cookson's late Mesozoic species *G. circinidites* Cookson. Spores of probable affinities with the Gleicheniaceae are represented by the species *Gleicheniidites senonicus* Ross. Megafossils of *Gleichenia* were found by Berry (1919) within the Tuscaloosa group at Shirleys Mill, Ala. That leaf locality is considered by Monroe (written communication, 1960) to be part of the Coker formation.

CLASS GYMNOSPERMAE

Of 22 genera of gymnosperm pollen, 18 of which are identified on the species level, 1 is a living genus, and about half of the species can be assigned to modern families. By far the most interesting aspect of the gymnospermous forms reported here are those which assuredly represent the now exotic family Podocarpaceae. Except for a single report of *Podocarpus* (L'Heritier) Persoon in northeastern Mexico (Sharp, 1949), evidence indicates that living members of this family are restricted to the Southern Hemisphere. The fossil forms are as follows:

Fossil form	Affinity
Dacrycarpites australiensis Cookson & Pike (pl. 7, figs. 1–2)	*Podocarpus* (L'Heritier) Persoon, section *Dacrycarpus*
"*Dacrydiumites* (Phyllocladites) *florinii*" Cookson & Pike	*Dacrydium* Soland (group b of Cookson, 1953)
Parvisaccites radiatus Couper (pl. 7, fig. 3)	*Dacrydium cupressinum* Soland ex Forster f.
cf. *Podocarpus* (an unnamed pollen genus) (pl. 7, fig. 7)	*Podocarpus* and *Phyllocladus* Rich
Podocarpidites cf. *P. biformis* Rouse (pl. 7, figs. 12–13)	*Podocarpus*
Podocarpidites cf. *P. major* Couper (pl.4, figs. 11–13 and, pl. 7, figs. 4–6).	*Podocarpus*

Reports of fossil remains of undoubted Podocarpaceae in the United States are rare in the paleobotanical literature. A podocarpaceous plant from the Tuscaloosa group, known to have been widespread in Cretaceous vegetation of west-central and eastern United States (Dakota, Magothy, and Raritan formations), is *Protophyllocladus subintegrifolius* (Lesquereaux) Berry, but its actual relation to the modern genus *Phyllocladus* is still in doubt, according to Berry (1919, p. 58). Two species of American Eocene woods, *Podocarpoxylon washingtonense* Torrey and *P. texense* Torrey, may be assigned to the Podocarpaceae according to an evaluation by Kräusel (1948). A study of Lower Cretaceous or Upper Jurassic pollen from British

Columbia by Rouse (1959) provided the first published evidence that pollen assignable to the Podocarpaceae is represented in North American Mesozoic strata.

Pollen of the *Podocarpidites biformis* type is, according to our observations, common in Lower Cretaceous sediments of Wyoming and very rare in younger strata of that area.

Another interesting pollen is *Caytonipollenites pallidus* (Reissinger) Couper in the Eutaw formation (pl. 6, figs. 33 and 34), a species which Couper (1958) has shown represents pteridosperm pollen and assigned provisionally to the family Caytoniaceae. Pollen forms of this sort are known in Triassic and Jurassic rocks of Utah (R. A. Scott, oral communication, 1960), and are common in Upper Jurassic and less common in Lower Cretaceous sediments (Lower Greensand or Aptian) of England (Couper, 1958). Megafossil remains of the pteridosperms, or seed ferns, are known to range from Mississippian through Jurassic (Arnold, 1947); published records of the unique order Caytoniales demonstrate only Jurassic and Lower Cretaceous occurrences. As far as we know, the *Caytonipollenites* in the Eutaw formation represents the first Upper Cretaceous record of Pteridospermae.

The broad-leaved conifer family Araucariaceae, now distributed mainly in temperate climates and now limited to the southern hemisphere, is represented by pollen in all four formations of this study by the pollen genus *Araucariacites* Cookson (pl. 6, fig. 29), which closely resembles modern pollen of *Araucaria* Jussieu and *Agathis* Salisbury species. The family is represented in the Eutaw and McShan floras by leaves assigned to the species *Araucaria bladensis* Berry and *A. jeffreyi* Berry (Berry, 1919).

Couper (1958, p. 130) has suggested that the pollen genus *Classopollis* (Pflug) Couper, of which two species were found in the pre-Selma sediments, might have its affinities with the family Araucariaceae on the basis of the similarity of the genus to the pollen of *Pagiophyllum* Heer, a provisional fossil member of the family. Pollen of *C. classoides* Pflug is figured on plate 6 (figs. 30–32).

Classopollis and *Araucariacites* are common in our Upper Cretaceous collections from Colorado and Wyoming and occur occasionally in lower Paleocene sediments of Wyoming.

Three species of the pollen assemblage as identified here are clearly members of the Taxodiaceae, resembling pollen of *Taxodium* Rich and *Sequoia* Endlicher; these are *Taxodiaepollenites hiatus* (Potonié) Thiergart, *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug (pl. 6, figs. 25–28), and *Sequoiapollenites polyformosus* Thiergart (pl. 4, fig. 1). Individual pollen grains of Taxodiaceae are rarely sufficient to identify even genera in modern material; but tallies of 100 grains from acetolysed pollen taken from male cones of all living genera of

Taxodiaceae indicate that *Taxodium* pollen differs from that of the other members of the family in at least two features. *Taxodium* pollen is characterized by a relatively thin cell wall which contributes to characteristically high frequency (20 to 75 percent) of split pollen, while among pollen of other Taxodiaceae, splitting is generally less than 5 percent. *Taxodium* pollen is also characterized by the small number (less than 15 percent) of grains bearing papillae; but at least among the nearest relatives of *Taxodium,* papillae occur on from 66 to 99 percent of the pollen grains. (Lacking papillae, *Cunninghamia* R. Brown and *Athrotaxis* D. Don pollen differ from that of *Taxodium* by having especially thick walls; Cupressaceae pollen are not considered here because they differ from the fossils in question in having larger gemmae scattered on the exteriors of the pollen walls.)

In the present material, we have discovered that the split pollen grains of the *Taxodium* type, assigned to *Taxodiaepollenites hiatus* (pl. 6, figs. 27 and 28), are somewhat more numerous in each sample than unbroken spherical pollen of the same type, assigned to *Inaperturopollenites dubius* (pl. 6, figs. 25 and 26). As can be seen in table 15, *T. hiatus* and *I. dubius* occur together in almost every sediment sample examined, and are especially abundant in sediments of the Coker formation.

Though leaves and twigs from the Tuscaloosa group have been assigned to three species of the genus *Sequoia* Endlicher by Berry (1919), papillate pollen that might represent *Sequoia* (pl. 4, fig. 1) were found to be exceedingly rare in the present material.

Pollen representing two forms of the modern genus *Ephedra* Tournefort ex L. are the only fossils of the Gnetaceae yet uncovered in the Tuscaloosa group, but the genus is known to range from Triassic to Recent (Scott, 1960). One form that is like the pollen of the living species *E. torreyana* is figured on plate 6 (figs. 23 and 24).

Pollen assigned to the species *Pityosporites microalatus* R. Potonié and *Pinuspollenites labdacus* (R. Potonié) Raatz represent Pinaceae cf. *Pinus* (Tournefort) L. (pl. 4, figs. 4–10). Megafossil remains of *Pinus* have been described from middle and lower beds of the Tuscaloosa group and are known from other Upper Cretaceous deposits in the United States. *Tsugaepollenites mesozoicus* Couper may be considered a member of the pine family, having affinities with *Tsuga* Carrière.

The members of the gymnosperm list in table 15 not mentioned in this discussion are gymnospermous pollen of uncertain position.

CLASS ANGIOSPERMAE

The angiosperm flora as represented by pollen, like the megafossil forms of the pre-Selma strata, is primarily dicotyledonous. Only two pollen types, *Sabalpollenites areolatus* (R. Potonié) R. Potonié and *Liliacidites intermedius* Couper (pl. 7, figs. 16–18) can be considered monocots, but these are not assignable to living families because their morphology is suggestive of several: Palmae, Bromeliaceae, Calycanthaceae, or Liliaceae.

The Dicotyledonae of the flora represented by pollen include 55 forms or 40 identified species, a relatively unimpressive number when compared with 123 dicot species that have been described from leaves from the Tuscaloosa group (Berry, 1919). But where pollen can be assigned to still existing dicot families, an interesting corroboration of taxa exists between pollen and megafossil evidence. Pollen species assigned to dicotyledonous families are listed below in table 3 along with their distribution in the pre-Selma Cretaceous formations:

TABLE 16.—*Dicotyledonous families represented by pollen in pre-Selma strata*

Family	Pollen species	Formation	Family identified by leaves in Tuscaloosa group (Berry, 1919)
Salicaceae	*Salix discoloripites*	Coker	X
Fagaceae	*Quercoidites henrici*	Coker, McShan, Eutaw	
	Q. microhenrici	Coker, McShan	
Aquifoliaceae	*Ilexpollenites margaritatus*	Coker, McShan	X
Myrtaceae	*Myrtaceidites parvus*	Coker	X
Cyrillaceae	*Cryillaceaepollenites megaexactus*	Coker, McShan, Eutaw	
Theaceae	*Pollenites ornatus*	Coker	X
Araliaceae	*Araliaceoipollenites edmundi*	Coker, McShan	X
Symplocaceae	*Symplocoipollenites vestibulum*	McShan	

The family Salicaceae is represented in the flora by leaves assigned to *Salix* (Tournefort) L. and *Populus* L. by Berry (1919), and by *Salix* pollen as listed above in table 16. The few specimens we have assigned to *Salix* are entirely like modern *Salix* pollen of the *S. discolor* Muhl. type.

Some of the specimens referred to *Quercoidites henrici* (R. Potonié) R. Potonié, Thomson & Thiergart (pl. 5, figs. 10–11) seem to be quite like the pollen of modern *Quercus* (Tournefort) L. but the others seem tricolporoid, perhaps like *Fagus* (Tournefort) L. We consider these tricoplate forms, which occur in three pre-Selma formations, sufficiently diagnostic to assign them to the family Fagaceae. No members of the family were found in the Tuscaloosa group by Berry (1919).

Large and small pollen of the family Aquifoliaceae, common in the Coker formation, are assigned to forms of the organ species *Ilexpollenites margaritus* (R. Potonié) Thiergart. As in certain European Tertiary material of this species, our specimens resemble the pollen of the genus *Ilex* (Tournefort) L. and *Nemopanthus* Raf., but the size of the clavae and, for the most part, the size of the pollen cell are much smaller than in pollen of living *Ilex* or *Nemopanthus* species. The pollen morphology of the family is so unique among living dicots that there can be little mistake about the affinity cited. Hollylike leaves assigned to *Ilex*, which are similar to leaves of modern *Ilex* species in margins and veination, are mentioned by Berry (1919) as being frequent in sediments of the Tuscaloosa group.

The dicotyledonous pollen listed in table 15 as *Platanoidites* sp. is a unique form resembling pollen of the plane tree, *Plantanus occidentalis*, in having a pronounced membrane across the colpae, and very obvious gemmae of uniform size on the colpae membranes: these unusual features are known to us in the pollen of the Platanaceae and Hammamelidaceae. Though several species of leaves from the Tuscaloosa were assigned to the Platanaceae (Berry, 1919), their morphology was more conclusive than that of the pollen we have identified as *Platanoidites* (pl. 5, figs. 14–15).

Pollen of the Cyrillaceae is represented in the flora of the Gordo and McShan formations by the species *Cyrillaceaepollenites megaexactus* (R. Potonié) R. Potonié. Though Potonié (1960, p. 102) has synonymized the *C. megaexactus* forma *"brühlensis"* Thomson with the species *C. megaexactus* we refer to the form here because its type provides more convincing evidence for assignment in this family than the type for *C. megaexactus*. As in the Rheinish lignite specimens on which this species was founded (Potonié, 1931), the range in morphology within *C. megaexactus* includes the pollen characters of both *Cliftonia* Banks et Gaertner and *Cyrilla* Gardner. Also the fossil material exhibits a somewhat greater range of variation in wall structure or texture than modern reference material of the family we have seen. Remains of Cyrillaceae are reported in the Brandon lignite (Oligocene) of Vermont (Traverse, 1955), but we know of no other fossils of the group yet recorded in the American literature. European fossils of the family are mainly of middle and late Tertiary age.

Pollenites ornatus R. Potonié, found in the Coker formation, was first described from Eocene lignites of Germany by Potonié (1934), who suggested that the species is similar to pollen of *Jasaminum* (Tourefort) L. of the Oleaceae. Specimens assignable to *P. ornatus* from the Tuscaloosa group, and some specimens in U.S. Geological Survey collections from the Laramie formation of Late Cretaceous age in Colorado, are closely similar to the pollen morphology of *Gordonia* Ellis or *Schima* Reinwardt ex Blume of the Theaceae; in our material this similarity suggests an affinity with that family. No megafossil remains from the Tuscaloosa group have thus far been assigned to the Theaceae.

Two species sporadically distributed in the Coker and Gordo formations are *Myrtaceidites parvus* forma *anesus* Cookson of the Myrtaceae, and *Cupanieidites major* Cookson of affinities with either Myrtaceae or Sapindaceae. These forms occur in Upper Cretaceous and lower Paleocene strata in Colorado and Wyoming. Megafossil forms having affinities with *Eucalyptus* L'Heritier and *Eugenia* Michaux ex L. of the Myrtaceae are cited by Berry (1919) in the Tuscaloosa flora, but he recorded no sapindaceous megafossils.

PALYNOMORPH ZONES OF THE PRE-SELMA STRATA

Although many components of the pre-Selma pollen and spore flora have a somewhat random distribution within the four formations, a number of species seem to be restricted to certain parts of this section, or show definite changes in abundance within the section. Rather clear differences also exist between the laterally equivalent parts of the Eoline member of the Coker formation in the Boykin and Webb cores. These differences, which apparently represent facies changes, suggest that definition of pollen zones here should be undertaken with some caution. Berry (1919), in his study of the plant remains, noted only minor differences between the flora of the Tuscaloosa group and that of the McShan and Eutaw formations, and comparatively small floristic changes from bottom to top within the Tuscaloosa group (Berry, 1919, p. 22).

With respect to the palynomorphs identified here, including the algae and hystrichomorphs, significant changes exist at only one level within the pre-Selma section, and these occur at or near the top of the Tuscaloosa group. These changes involve a partial replacement of land plants by aquatic forms as well as a significant change in species of land plants.

FACIES CHANGES

The replacement of land plants by aquatic forms appears rather abruptly near the base of the McShan formation. Clay above the basal sandy gravel of the McShan formation in the Crawford core contains a mixed gymnospermous and dicotyledonous land plant assemblage and very occasional hystrichomorphs (algae?), but the clay only 12 feet higher in the core contains predominantly microforaminifer remains; hystrix forms are both varied and more abundant, and land plant forms are numerically unimportant. Near the top of the McShan formation and in the middle part of the Eutaw formation, remains of microforaminifers are frequent to dominant—hystrix and dinoflagellate algae occurring regularly. That this change is related to increased depth of water is suggested by the overall lithologic evidence and by modern environments in which microforaminifers accumulate.

A study of the sedimentary environment of some marine microorganism remains within Kapingamarangi lagoon by McKee, Chronic, and Leopold (1959) indicates that microforaminifers occur in small numbers in several sediment types on the lagoon floor, but their numbers per gram of bottom sediment are especially great in the environment where clay-sized particles are the chief constituent of the sediment. At Kapingamarangi, this environment is where water depths are from 225 to 240 feet, the deepest and quietest part of the lagoon floor. Though little is yet known about their taxonomy, these microforaminifera (<150 microns) from Kapingamarangi are taxonomically distinct from both the "larger" (>1 mm) and "smaller" (150 microns to 1 mm) Foraminifera (in the usage of Wilson and Hoffmeister, 1952, p. 26).

The Kapingamarangi study (McKee, Chronic, and Leopold, 1959) also demonstrated that planktonic dinoflagellate algae and their hystrixlike resting cysts accumulate primarily in the deeper parts of the lagoon along with the clay-sized sediments; that these microorganisms are deposited allochthonously in water below wave base at Kapingamarangi lagoon is of interest here.

The apparent absence of microforaminifers and scarcity of dinoflagellate algae in the Tuscaloosa group and their presence in large numbers in the McShan and Eutaw formations may be attributed to environmental factors. Several lines of evidence suggest that sediments of the Tuscaloosa group were deposited in shallow water and were oxidized intermittently during deposition. The presence in the Eoline member of the Coker formation of lignite beds and crossbedded glauconitic sands with oysters and brackish-water larger Foraminifera (Applin, chap. D of this bulletin) point to a shallow water lagoonal or shoreline environment of deposition for that member. The variegated color and the general absence of glauconite in sediments of the upper member of the Coker formation suggest a very shallow water environment in which possibly the sediments were intermittently exposed to the air during deposition, as perhaps in a tidal flat environment.

In contrast, the comparatively great amounts of glauconitic sand and absence of lignite beds or oxidized zones in the McShan and Eutaw formations suggest a depositional environment of somewhat deeper water than that of the Tuscaloosa group. The great numbers of microforaminifers, along with the other remains of marine life such as sharks' teeth (Monroe, 1955) and oysters and other mollusks (Sohl, chap. C of this bulletin) in the McShan and Eutaw formations, strongly support this interpretation.

FLORISTIC ZONES

Of the 105 species in the total palynomorph flora, 34 are in the Tuscaloosa group, but not in the McShan and Eutaw formations. Conversely, 22 species in the McShan and Eutaw formations seem to be lacking in the Tuscaloosa flora (table 17). Disregarding the assortment of algae and microforaminifer remains, 13 species of the

TABLE 17.—*List of palynormorphs of restricted distribution within the pre-Selma section*

Forms in Tuscaloosa group, not found in McShan and Eutaw formations	Forms in McShan and Eutaw formations, not found in Tuscaloosa group
Hystrichosphaerideae:	Hystrichosphaerideae, microforaminifers, and dinoflagellate algae:
Micrhystridium inconspicuum	*Hystrichosphaera cornigera*
	Membranilaranx pterospermoides
	Schizosporis reticulatus
	Pterospermopsis ginginensis
	Micrhystridium bacilliferum
	M. parvispinum
	M. pavimentum
	Microforaminifers
	Paleohystrichosphora infusorioides
Sporae Dispersae:	Sporae Dispersae:
Taurocusporites reduncus	*Baculatisporites primarius*
Cicatricosisporites brevilaesuratus	*Corrugatisporites arcuatus*
C. dunrobensis	*Hymenozonotriletes reticulatus*
Cingulatisporites problematicus	*Osmundacidites wellmanii*
Concavisporites rugulatus	
Cyatheacidites annulata	
Cyathidites mesozoicus	
Gleichenia circinidites	
Gleicheniidites senonicus	
Leiotriletes cf. *L. subtilis*	
Lycopodium cerniidites	
Poroplanites porosinuosus	
Rugulatisporites quintus	
Schizoplanites reductus	
Torisporis intrastructurius	
Gymnospermae:	Gymnospermae:
Classopollis torosus	*Caytonipollenites pallidus*
"Dacrydiumites florinii"	*Dacrycarpites australiensis*
Eucommiidites troedsonii	
Pinuspollenites labdacus	
Tsugaepollenites mesozoicus	
Monocotyledonae:	Monocotyledonae:
None	*Liliacidites intermedius*
Dicotyledonae:	Dicotyledonae:
Triporate pollen:	Triporate pollen:
Basopollis atumescens	*Triatriopollenites rurensis*
B. orthobasalis	*T. coryphaeus*
Extratriporopollenites audax	*Trivestibulopollenites betuloides*
Latipollis normis	
Monstruosipollis monstruosis	
Turonipollis turonis	
Tricolpate pollen:	Tricolpate pollen:
Cupanieidites major	None
Fraxinoipollenites pudicus	
Myrtaceidites parvus	
Pollenites megagertrudae	
P. ornatus	
Salix discoloripites	
Tricolporate pollen:	Tricolporate pollen:
Araliaceoipollenites edmundi	*Pollenites cingulum*
Pollenites genuinus	*Porocolpopollenites*
	"Tricolporopollenites microreticulatus"
	Symplocoipollenites vestibulum

McShan-Eutaw flora do not occur in the Tuscaloosa group. Our data indicate that of the 90 nonaquatic species, the combined differences between the floras of the Tuscaloosa group and of the McShan and Eutaw formations amount to about 55 percent of the land-plant flora. Because of the limited scope of the sampling for the present report, we feel that some of the floristic differences now apparent between these two segments of pre-Selma strata may disappear with exhaustive sampling and larger tallies. In part, this might be expected because about two-thirds of the forms in table 17 are known to have a wide distribution within the Cretaceous.

Part of the differences in floras of the Tuscaloosa group and of the McShan and Eutaw formations may be explained by evolutionary changes. The dicotyledonous flora of the Eoline member of the Coker formation contains a group of very distinctive triporate *Normapolles* Pflug types which are very similar to some of the earliest dicot pollen types from the European Cretaceous section, and these distinctive forms are so different from pollen of modern groups that no affinities with modern families can be cited. These forms include several species that Krutzsch (1959) has described and figured from Turonian sediments of Germany, which are well dated by the presence of *Inoceramus labiatus* (Schlotheim) and *Scaphites geinitzi* (d'Orbigny) fossils.

The distinctive *Normapolles* forms are listed below with their known stratigraphic ranges according to Krutzsch (1957, 1959):

Complexipollis praeatumescens Krutzsch	Lower and middle Turonian
Latipollis subtilis Krutzsch	Lowest Turonian
L. normis Krutzsch	Middle Turonian
L. latis Krutzsch	Middle Turonian
Monstruosipollis monstruosis Krutzsch	Turonian and Santonian
Tenerina tenera Krutzsch	Turonian and Coniacian
Turonipollis turonis Krutzsch	Lower Turonian

Five of these species seem to be restricted to the Turonian in Germany and the other two range from Turonian through Coniacian and Santonian strata respectively. All these forms are present in the Eoline member of the Coker formation, and half of them also occur in the McShan-Eutaw collections. No other records on these species except those by Krutzsch (1957, 1959) are available to us at the time of this writing.

These dicot pollen types are less numerous in the McShan-Eutaw flora, and accompanying them are a group of simple triporates that are not seen in the Tuscaloosa group: *Trivestibulopollenites betuloides* Thomson and Pflug, *Triatriopollenites coryphaeus* (R. Potonié) Thomson and Pflug, *T. rurensis* Pflug and Thomson, which closely resemble pollen of modern Betulaceae genera, and cf. *T. concavus* Thomson and Pflug which is similar to some living Myrtaceae forms.

Appearing in every pollen sample of the McShan-Eutaw strata are many diverse species (mainly unnamed) of the genus *Porocolpopollenites* Thomson & Pflug, which are indeed absent in Tuscaloosa group sediments. (According to Potonié (1960), the genus *Porocolpopollenites* is synonomous with *Symplocoipollenites* Potonié 1951, but we do not agree. Both are valid genera.)

The Tuscaloosa group also has a very much richer fern flora than the overlying strata and contains several forms not found in the McShan and Eutaw—for example, *Leiotriletes*, *Cingulatisporites*, *Hymenozonotriletes*, and others listed in table 4.

Further zonation of these pre-Selma strata may well be possible by additional sampling and statistical tallies of forms. We expect that in a later report on the flora of these strata we shall be able to present histograms demonstrating more precisely relative abundance of forms.

STRATIGRAPHIC INTERPRETATION AND AGE OF THE FLORAS

The forms that probably are of greatest use in correlating the flora from the pre-Selma strata with other floras are the dicotyledons. Available records of Cretaceous floras clearly indicate that the percent of dicot forms in the total assemblage, and the stage of evolution these dicots represent, are far more valuable criteria for generalized dating within Cretaceous rocks than the use of individual lower plant forms or groups. With this in mind, a comparison of the dicotyledons of this flora with those of other dated floras from the region is pertinent.

In a recent summary of the pollen floras in the Potomac group of Cretaceous age in the eastern United States, Groot and Penny (1960) stated that dicot pollen represent less than 28 percent of pollen and spore tallies within those strata. In table 18, the range of percentages for the Raritan formation and older Cretaceous strata are listed, along with a tally from USGS collections from the type section of the Magothy formation; ages of the formations are listed according to Dorf (1952) and the Stephenson committee (Stephenson and others, 1942).

By comparison, the average of 39 and 38 percent of dicots in the Tuscaloosa and McShan-Eutaw floras, respectively, is higher than percent of dicots for the Potomac group as observed by Groot and Penny (1960) and significantly lower than their percentage in the available USGS material from the Magothy formation.

In a recent evaluation of evidence concerning the evolutionary rise of the angiosperms, Scott, Barghoorn, and Leopold (1960) concluded that many of the pre-Cretaceous fossil "angiosperms" are of questionable affinities, that the preponderant clear evidence of early angiosperms indicates that they first appear in the fossil record in

TABLE 18.—*Comparative percentages of dicot pollen and spore tallies of the Potomac group of Maryland and Delaware (Groot and Penny, 1960) and pre-Selma Cretaceous strata of Alabama*

Age	European Stages	Age of the pre-Matawan strata of the Atlantic Coastal Plain		Dicot pollen as percent of pollen and spore tallies (Groot and Penny, 1960; USGS data)	Age of pre-Selma Cretaceous strata of the Gulf Coastal Plain (Stephenson and others, 1942)	Dicot pollen as percent of pollen and spore tallies (this report)
		Stephenson and others, 1942	Dorf, 1952			
Late Cretaceous	Santonian					
	Coniacian	Magothy formation	Magothy formation	40 to 60 percent	Eutaw (=Mc Shan and Eutaw formations)	29 to 51 percent, 38 percent average
	Turonian					
	Cenomanian	Raritan formation	Raritan formation	28 percent, average	Tuscaloosa formation (=Coker and Gordo formations)	19 to 75 percent, 39 percent average
Early Cretaceous	Albian	Patapsco formation	Patapsco formation	2 to 26 percent		
	Aptian		Arundel formation			
	Neocomian	Arundel and Patuxent formations	Patuxent formation	0 to 21 percent		

late Early Cretaceous (Albian) time, and that their remains are infrequent until early Late Cretaceous (Cenomanian stage). In a sample of the Patuxent formation (table 18), Groot and Penny (1960) recorded as much as 21 percent angiosperm pollen, but, because they recognized that some of their data were at variance with those from other Neocomian material, they concluded that the angiosperm-rich material very probably is younger than Neocomian (Groot and Penny, 1960, p. 228). Pollen and spore tallies are not available from European Cenomanian through Coniacian and Senonian strata but floral lists indicate that the first striking increase in dicot species occurs in the Turonian (Krutzsch, 1957).

Comparison of the actual species of the Tuscaloosa and Eutaw-McShan floras with our collections from the Magothy formation (USGS Paleobotany loc. D1322) indicates a marked similarity of the floras; many of the dicot as well as gymnosperm species are in common. In addition, an array of highly distinctive dicot pollen types (for example *Oculopollis* Pflug, *Trudopollis* Pflug, and others) that are known from the Senonian of Europe (Weyland and Greifeld, 1953) occur in the Magothy in profusion, but are essentially rare or lacking in the pre-Selma material. (We report one tentatively identified *Oculopollis* specimen in our youngest sample.)

About half of the 20 forms that Groot and Penny (1960) described from the Potomac group also are represented in the pre-Selma floras. Most of the dicots described by Groot and Penny are of simple, primitive morphology, being mainly of tricolpate and tricolporoid structure.

The most rewarding comparison of the pre-Selma floras is with the material of Krutzsch (1957, 1959) from five Turonian localities in Germany. From a third to a fourth of the dicots in the present material, which have not been previously described from American material, occur in Krutzsch's assemblages of Turonian age. These forms are structurally complex, with gross morphology so different from that of known living dicots that their relations to extant plant families are not at all understood. They include the form genera *Complexipollis, Latipollis, Turonipollis, Sporopollis, Monstruosipollis, Tenerina,* and others.

One dicot species in the flora at hand, cf. *Paliurus rhamnoides* Bolkhovitina, is named from Cenomanian and Turonian strata of central Russia (Bolkhovitina, 1953). Several fern spores named from Lower Cretaceous strata of Russia (for example, *Hymenozonotriletes, Leiotriletes,* and *"Chomotriletes"* (now *Taurocusporites*) *reduncus* of Bolkhovitina, 1953) are present also, but these are known to be wide-ranging Cretaceous forms.

Pollen data from the Raritan and Magothy formations reported by Margaret W. Steeves [1] indicate that a gradual increase in species and numbers of dicot pollen occurs within the Raritan formation. Because of their unique morphologies, many of these dicot forms cannot be assigned to modern families. We have not compared our material directly with Dr. Steeves' flora, but her observation that the upper parts of the Raritan formation are rich in dicotyledonous forms suggests that a careful comparison of the Raritan flora with the present material might be profitable indeed.

The Tuscaloosa and McShan-Eutaw floras, lacking the structurally advanced forms of *Oculopollis* and *Trudopollis,* are pre-Senonian in age, and probably they are older than the Magothy formation in its type area in Maryland. That these floras are younger than the parts of the Potomac group as reported by Groot and Penny (1960) is shown by the relatively higher compositional percentages of dicots, and by the more advanced morphology of the dicot forms represented in the pre-Selma floras. The unpublished data of Steeves concerning the Raritan pollen flora is permissive evidence for the correlation of the upper part of the Raritan formation with the Coker formation, as suggested by Stephenson and others (1942). The similarity of the dicot forms of the pre-Selma Late Cretaceous floras with those of uppermost Cenomanian, Turonian, and Coniacian deposits of Germany (Krutzsch, 1957), supports an early Late Cretaceous age for the floras in the Tuscaloosa group and the McShan and Eutaw formations.

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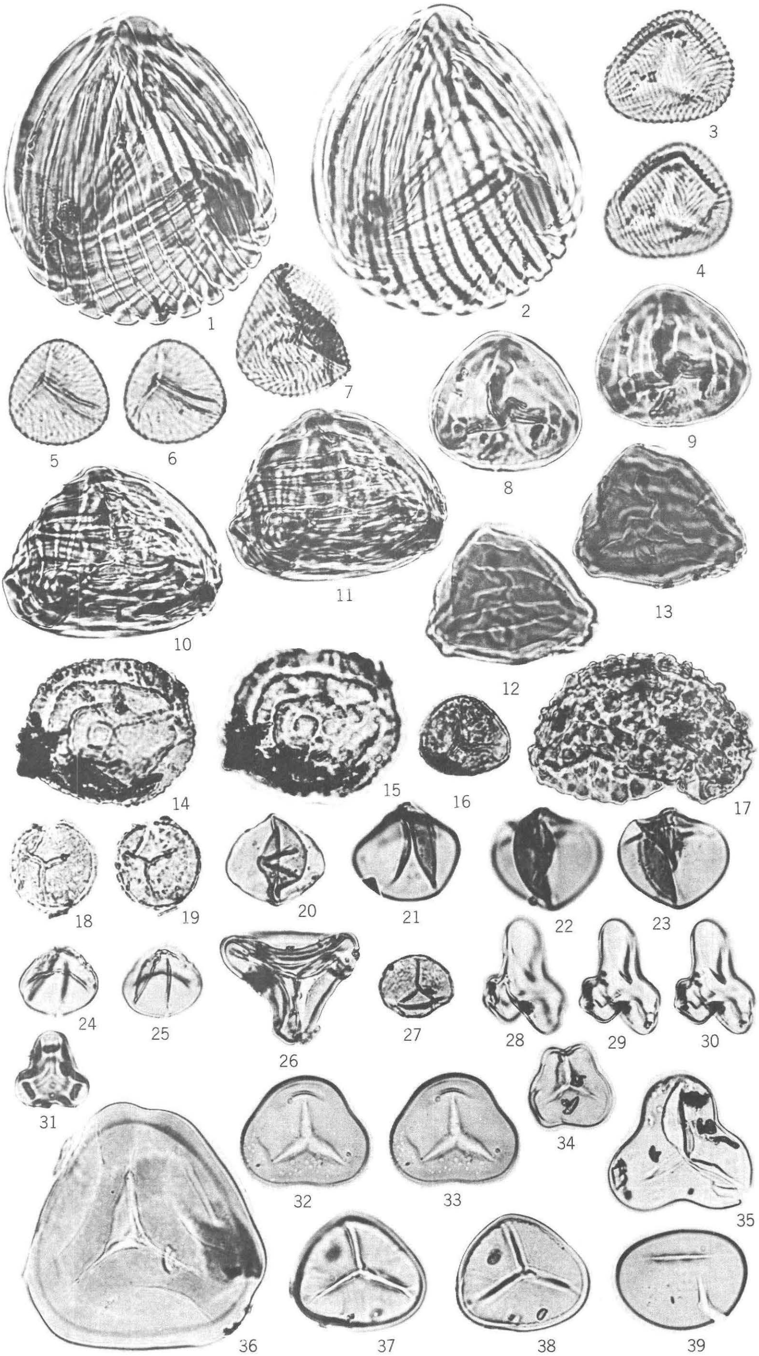
PLATE 3

[All figures magnified 500 ×]

FIGURES 1, 2. *Cicatricosisporites brevilaesuratus* Couper 1953. Slide D1457–1(2) at 100 × 7.4.
3–7. *Cicatricosisporites dorogensis* R. Potoni° & Gelletich, 1933.
    3, 4. Slide D1111–9(5) at 128.8 × 6.9.
    5, 6. Slide D1111–9(5) at 104.1 × 8.3.
    7. Slide D1111–9(5) at 116.5 × 8.
8, 9. *Cicatricosisporites* sp.? Slide D1457–1(3) at 128.8 × 10.5.
10–13. *Cingulatisporites problematicus* Couper 1958.
    10, 11. Slide D1457–1(5) at 113.9 × 11.
    12, 13. Slide D1457–1(2) at 105 × 9.9.
14, 15. *Taurocusporites reduncus* (Bolkhovitina) Stover 1962. Slide D1457–1(3) at 129.3 × 20.8.
16, 18–19, 27. 16. Slide D1109–10(5) at 127.8 × 23.1.
    18, 19. Slide D1109–10(4) at 105.8 × 5.1.
    27. Slide D1109–10(5) at 122 × 23.
Trilites sp.
17. *Trilites veriucatus* Couper 1953. Slide D1457–1(3) at 109.9 × 17.1
20–25. *Triplanosporites sinuosis* Pflug & Thomson 1953.
    20. Slide D1109–7(2) at 115.2 × 19.2.
    21. Slide D1111–9(5) at 123.5 × 14.5.
    22, 23. Slide D1111–9(5) at 121.7 × 12.8.
    24, 25. Slide D1109–4(2) at 123 × 9.8.
26. *Concavisporites rugulatus* Pflug 1953. Slide D1109–10(4) at 132 × 4.3.
28–30. *Leiotriletes* cf. *L. subtilis* Bolkhovitina 1953. Slide D1109–4(2) at 122.7 × 12.
31. *Sporites arcifer* Thiergart 1948. Slide D1109–10(1) at 119.3 × 11.9
32–34. *Cyathidites mesozoicus* (Thiergart) R. Potoni° 1956.
    32, 33. Slide D1111–9(5) at 133.5 × 13.5.
    34. Slide D1109–10(5) at 109.9 × 23.
35. *Concavisporites* cf. *C. punctatus* Delcourt & Sprumont 1955. Slide D1109–4(5) at 121.4 × 16.
36. *Torisporis intrastructurius* Krutzsch 1959. Slide D1457–1(2) at 114.9 × 18.1.
37, 38. *Deltoidospora* cf. *D. hallii* Miner 1935. Slide D1109–10(4) at 136.1 × 12.3.
39. *Monolites major* Cookson 1947. Slide D1111–9(5) at 112.4 × 4.9.



FERN AND LOWER PLANT SPORES OF THE TUSCALOOSA GROUP

PLATE 4

[All figures magnified 500 ×]

Figures 1. *Sequoiapollenites polyformosus* Thiergart 1938. Slide D1111–9 (5) at 133.5 × 8.2.

2. *Inaperturopollenites* Pflug 1953. Slide D 1109–4(4) at 130.2 × 9.1.
3. *Cingulatisporites* cf. *C. scabratus* Couper 1958. Slide D1111–9 (5) at 120.7 × 4.7.

4–7. *Pityosporites microalatus* (R. Potonié) Thomson & Pflug 1953.
    4. Slide D1109–10(4) at 122.5 × 12.2.
    5, 6, 7. Slide D1109–10(4) at 132.1 × 16.5.

8–10. *Pinuspollenites labdacus* (R. Potonié) Raatz 1937. Slide D1109–7(4) at 109.2 × 10.1.

11–13. *Podocarpidites* cf. *P. major* Couper 1953. Slide D1109–10(4) at 120.8 × 4.

14–16. *Podocarpidites* cf. *P. biformis* Rouse. Slide D1109–10(4) at 105.8 × 5.1.

17–18. *Cycadopites* cf. *C. follicularis* Wilson & Webster 1946. Slide D1111–9(5) at 124.4 × 6.7.

19. *Gynkaletes* cf. *G. retrfloexus* (Luber) Luber 1956. Slide D1109–10(4) at 130.5 ×19.3.

20–22. ?*Gynkaletes* Luber 1955. Slide D1109–10(5) at 129.7 1× 3.

23, 24. *Perinopollenites* cf. *P. elatoides* Couper 1958. Slide D109–4(2) at 122.2 × 18.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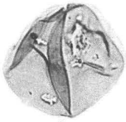
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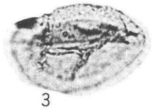
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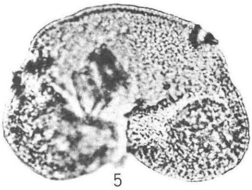
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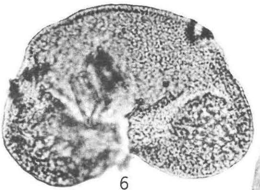
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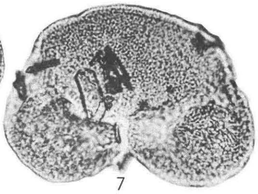
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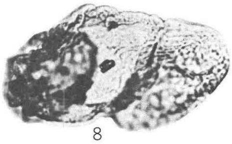
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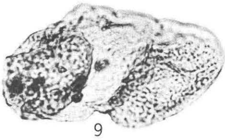
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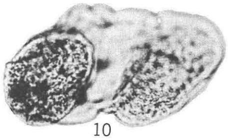
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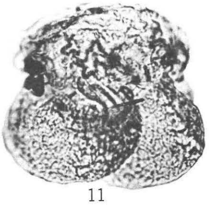
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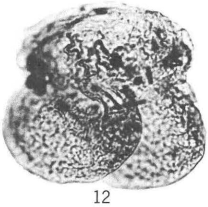
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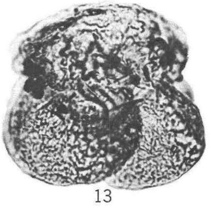
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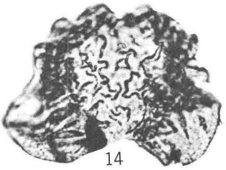
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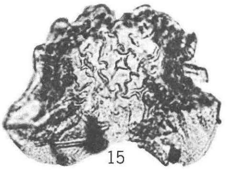
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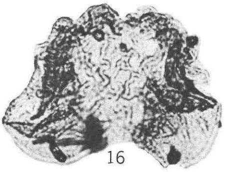
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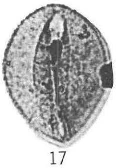
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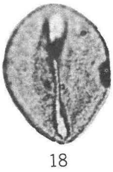
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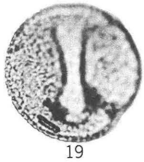
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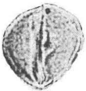
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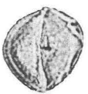
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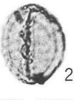
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24

GYMNOSPERM POLLEN OF THE TUSCALOOSA GROUP

PLATE 5

[All figures magnified 500 ×]

FIGURES 1–5. "*Tricolpopollenites*" Thomson & Pflug 1953 (unnamed species).
  1, 2. Slide 1109–4(3) at 114.8 × 20.
  3. Slide D1111–9(5) at 111.4 × 9.2.
  4, 5. Slide D1109–10(5) at 125.8 × 2.9.

6, 7. *Pollenites quisqualis* R. Potonié 1934.
  6. Slide D1109–10(5) at 108.9 × 23.
  7. Slide D1111–9(5) at 126.2 × 9.3.

8, 9, 18, 19. *Pollenites megagertrudae* R. Potonié 1931.
  8, 9. Slide D1109–7(3) at 117.9 × 4.8.
  18, 19. Slide D1109–4(3) at 125.9 × 20.

10, 11. *Quercoidites henrici* (R. Potonié 1931) R. Potonié, Thomson & Thiergart 1950. Slide D1109–7(4) at 116.8 × 10.2.

12, 13. *Pollenites grossularius* R. Potonié 1934. Slide D1109–10(5) at 104.2 × 11.7.

14, 15. *Platanoidites* Potonié, Thomson & Thiergart, 1950. Slide D1111–9(5) at 130.5 × 4.9.

16. "*Tricolpopollenites* cf. *T. retiformis*" Thomson & Pflug 1953. Slide D1111–9(5) at 127 × 14.5.

17. "*Tricolpopollenites retiformis*" Thomson & Pflug 1953. Slide D1111–9(5) at 108.8 × 9.1.

20, 21. *Salix discoloripites* Wodehouse 1933. Slide D1111–9(5) at 111.5 × 9.4.

22. cf. *Paliurus rhamnoides* Bolkhovitina 1953. Slide D1109–7 (4) at 129 × 12.4.

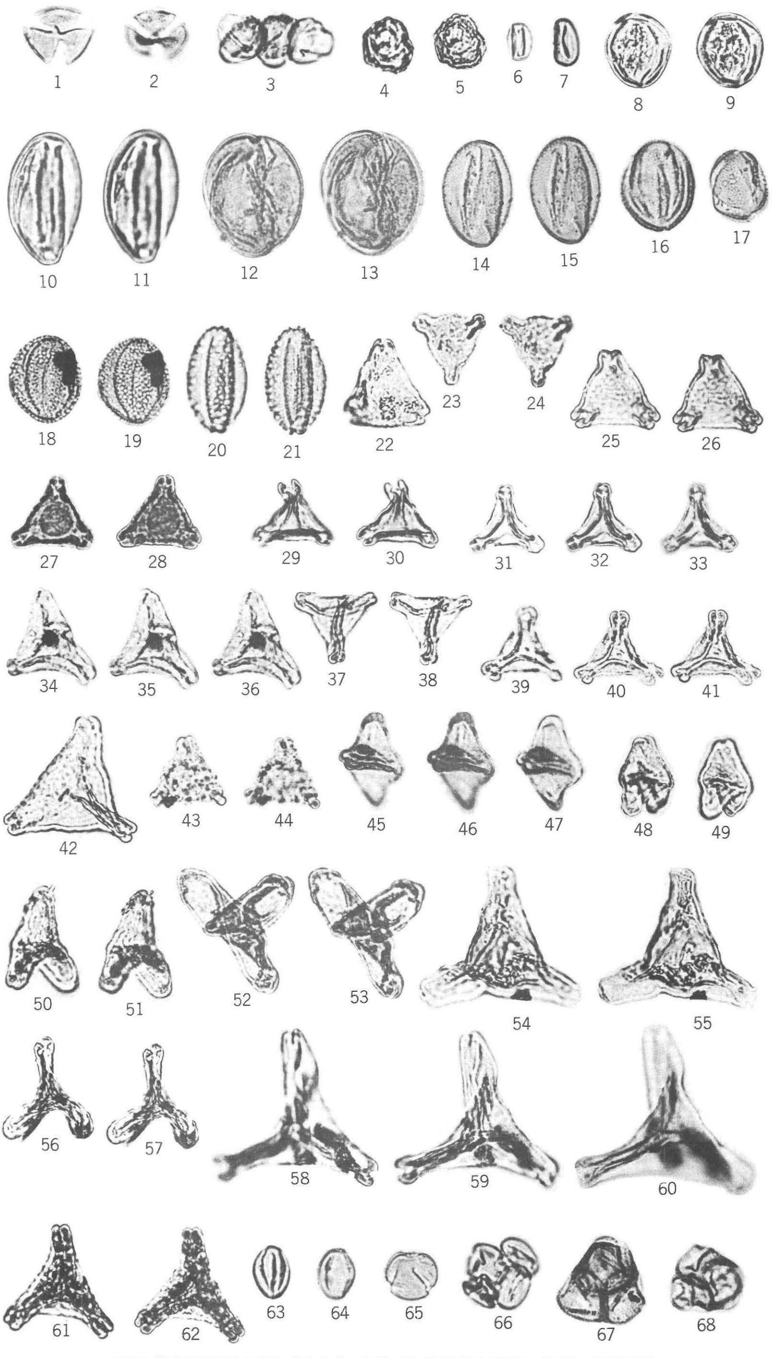
23, 24. *Triorites* cf. *T. edwardsii* Cookson & Pike 1954. Slide D1109–7(4) at 124 × 6.2.

25, 26. *T. edwardsii* Cookson & Pike 1954. Slide D1109–4(3) at 122.4 × 20.

27, 28. *Basopollis orthobasalis* (Pflug) Pflug 1953. Slide D1109–4(2) at 102.2 × 11.8.

29–33. *Sporopollis* Pflug 1953.
  29, 30. Slide D1109–4(3) at 103.3 × 17.8.
  31, 32, 33. Slide D1109–4(3) at 138.9 × 18.

34–38. *Sporopollis pseudosporites* Pflug 1953.
  34, 35, 36. Slide D1109–7(4) at 131.5 × 7.5.
  37, 38. Slide D1109–10(5) at 109.9 × 20.



DICOTYLEDONOUS POLLEN OF THE TUSCALOOSA GROUP

PLATE 5—Continued

[All figures magnified 500 ×]

FIGURES 39, 40, 41. *Sporopollis* cf. *S. pseudosporites* Pflug 1953. Slide D1109–7(3) at 111.2 × 17.1.

42. *Complexipollis praeatumescens* Krutzsch 1959. Slide D1457–1(4) at 117.2 × 16.9.

43, 44. *Triorites* cf. *T. edwardsii* Cookson & Pike 1954. Slide D1109–7(2) at 110 × 13.4.

45–47. *Latipollis latis* Krutzsch 1959. Slide D1109–7(4) at 114.4 × 3.8.

48, 49. *Latipollis normis* Krutzsch 1959. Slide D1109–7(3) at 115.1 × 8.

50–53. *Latipollis* cf. *L. latis* Krutzsch 1959.
  50, 51. Slide D1457–1(5) at 113 × 13.
  52, 53. Slide D1457–1(2) at 106.4 × 5.

54–60. ?*Latipollis* Krutzsch 1959. Polar view.
  54, 55. Slide D1109–7(4) at 128.8 × 22.
  56, 57. Slide D1457–1(3) at 115.2 × 19.
  58–60. Slide D1109–7(4) at 136 × 18.3.

61, 62. *Nudopollis ornatus* (Pflug) Pflug 1953. Slide D1457–1(2) at 110.5 × 5.3.

63, 64. "*Tricolporopollenites distinctus*" Groot & Penny 1960.
  63. Slide D1111–9(5) at 105.1 × 13.
  64. Slide D1111–9(5) at 123.9 × 4.9.

65. "*Tricolpopollenites parvulus*" Groot & Penny 1960. Slide D1111–9(5) at 119.4 × 4.7.

66. Tricolpate pollen undetermined. Slide D1111–9(5) at 103 × 8.5.

67, 68. *Dicotetradites* cf. *D. clavatus* Couper 1953.
  67. Slide D1111–9(5) at 104.9 × 9.6.
  68. Slide D1111–9(5) at 103.9 × 9.6.

PLATE 6

[All figures magnified 500 ×]

FIGURES 1, 2. *Plicatella trichacantha* Malawkina 1949. Slide D1456–4(3) at 138.2 × 20.

3, 4. *Cicatricosisporites* sp. R. Potonié & Gelletich 1933. Slide D1456–4(3) at 102.4 × 12.

5. cf. *Schizaeoisporites* sp. R. Potonié 1951. Slide D1110–1(3) at 129.5 × 7.8.

6, 7. *Sporites arcifer* Thiergart 1948. Slide D1110–2(5) at 126.4 × 22.9.

8. *Cingulatisporites* cf. *C. scabratus* Couper 1958. Slide D1456–4(3) at 122.1 × 8.4.

9, 10. cf. *Rugulatisporites* Thomson & Pflug 1953. Slide D1110–2(5) at 127.1 × 22.8.

11, 12. *Densoisporites perinatus* Couper 1948. Slide D1110–3(3) at 117.2 × 5.1.

13–15. *Deltoidospora hallii* Miner 1935.
13. Slide D1456–4(1) at 129.5 × 8.9.
14, 15. Slide D1110–1(5) at 113.9 × 10.8.

16, 17. *Hymenozonotriletes reticulatus* Bolkhovitina 1953. Slide D1456–4(5) at 101.5 × 19.

18. *Corrugatisporites arcuatus* Weyland & Greifeld 1953. Slide D1456–4(5) at 106.5 × 22.8.

19. *Cingulatisporites dubius* Couper 1958. Slide D1456–4(3) at 119 × 17.9.

20. Araucariaceae? Slide D1456–4(1) at 126.9 × 18.

21, 22. Spores undetermined.
21. Slide D1456–5(1) at 127.2 × 10.3.
22. Slide D1456–4(5) at 114.8 × 23.

23, 24. *Ephedra* sp. Tournefort ex Linnaeus 1737. Slide D1110–2(5) at 122.1 × 14.7.

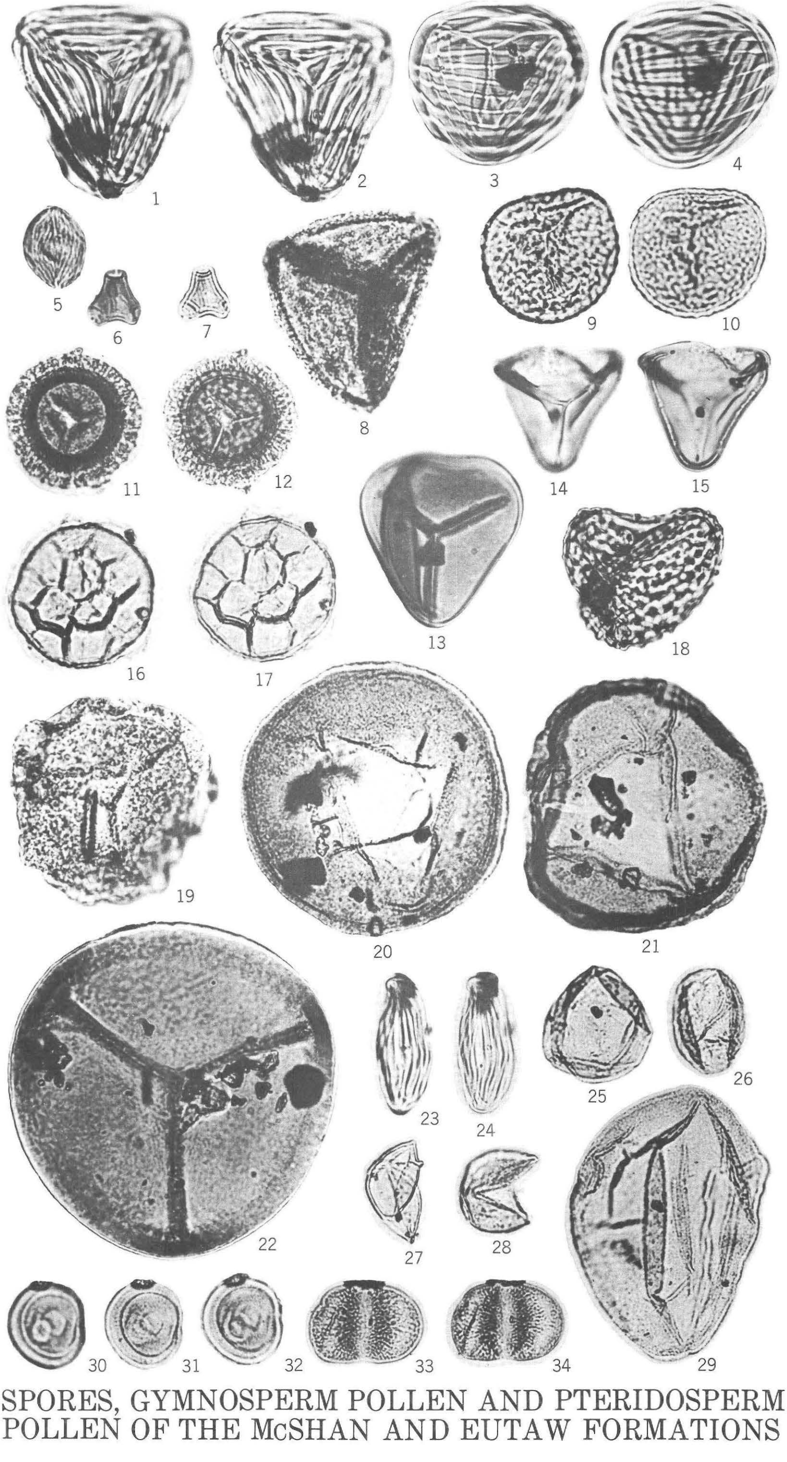
25, 26. *Inaperturopollenites dubius* (R. Potonié & Venitz) Thomson & Pflug 1953.
25. Slide D1456–4(3) at 134.3 × 17.2.
26. Slide D1456–4(3) at 131.2 × 11.

27, 28. *Taxodiaepollenites hiatus* (R. Potonié) Thiergart 1940.
27. Slide D1110–3(5) at 123.9 × 22.1.
28. Slide D1456–4(3) at 130.5 × 8.9.

29. *Araucariacites australis* Cookson 1947. Slide D1456–4(3) at 123 × 19.

30–32. *Classopollis classoides* Pflug 1953. Slide D1456–5(1) at 123.5 × 14.

33–34. *Caytonipollenites pallidus* (Reissinger) Couper 1958. Slide D1110–1(3) at 131.7 × 5.2.



SPORES, GYMNOSPERM POLLEN AND PTERIDOSPERM POLLEN OF THE McSHAN AND EUTAW FORMATIONS

PLATE 7

[All figures magnified at 500 × except figure 7]

FIGURES 1, 2. *Dacrycarpites australiensis* Cookson & Pike 1953. Slide D1456-4(3) at 141.1 × 3.3.

3. *Parvisaccites radiatus* Couper 1958. Slide D1456–4(3) at 119.2 × 13.4.

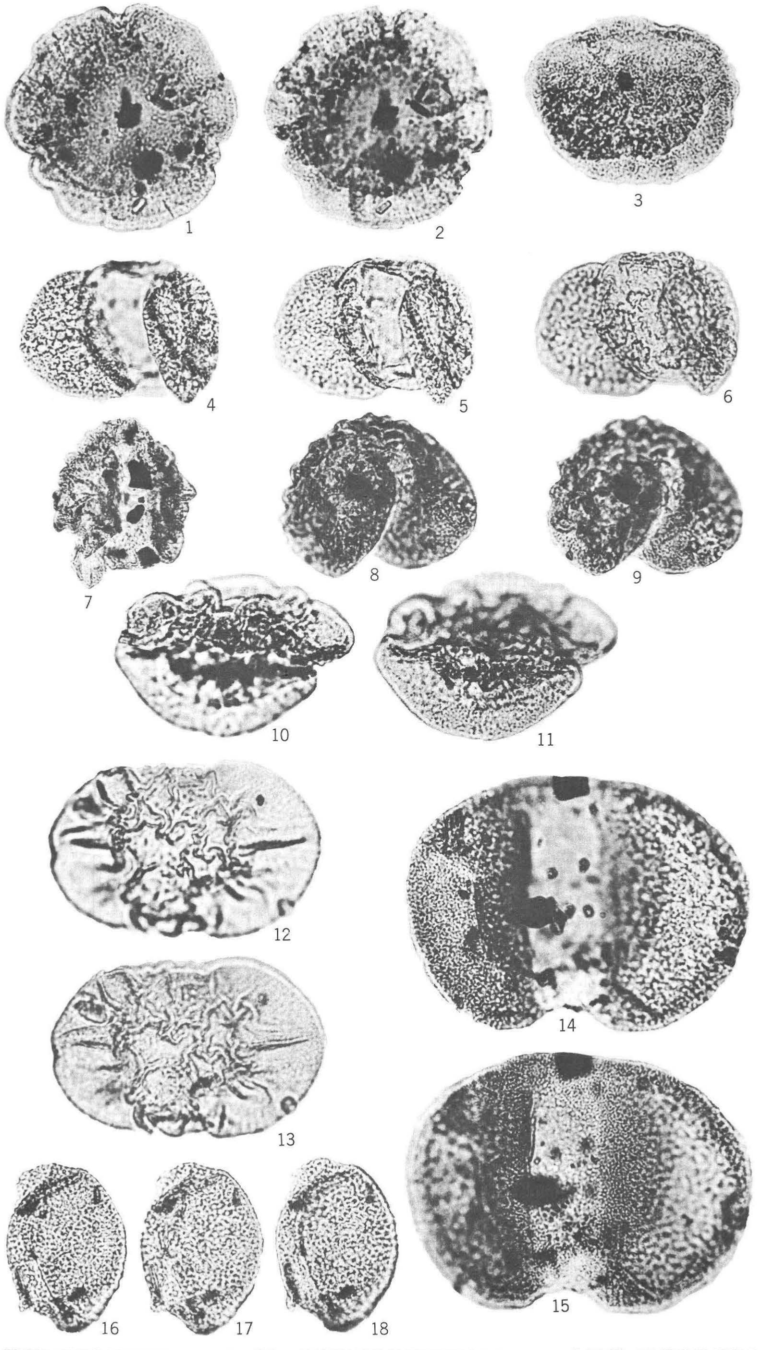
4–6. *Podocarpidites* cf. *P. major* Couper 1953. Slide D1110–3(5) ta 113.6 × 11.8.

7. cf. *Podocarpus* (L'Heritier) Persoon 1807. (× 375). Slide D1456–6(1) at 123.3 × 11.9.

8–13. *Podocarpidites* cf. *P. biformis* Rouse 1957.
  8, 9. Slide D1110–1(3) at 124.2 × 9.9.
  10, 11. Slide D1456–4(3) at 141.2 × 10.2.
  12, 13. Slide D1110–1(6) at 105.3 × 1.8.

14–15. *Abietineaepollenites microreticulatus* Groot & Penny 1960. Slide D1110–1(3) at 134.9 × 9.2.

16–18. *Liliacidites intermedius* Couper 1953. Slide D1110–2(6) at 110.1 × 4.4.

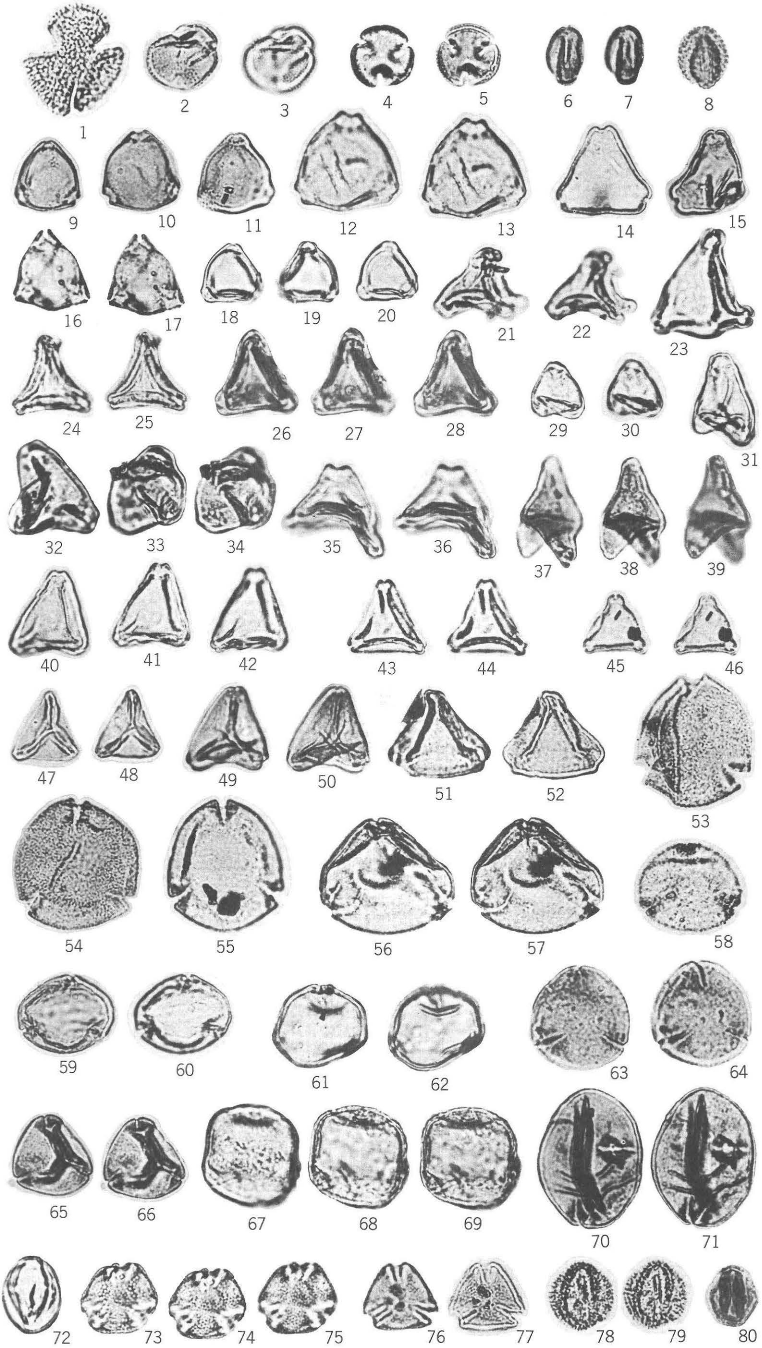


GYMNOSPERM AND MONOCOTYLEDONOUS POLLEN OF THE McSHAN AND EUTAW FORMATIONS

PLATE 8

[All figures magnified 500 ×]

FIGURE 1. *"Tricolpopollenites* cf. *T. retiformis"* Thomson & Pflug 1953. Slide D1110–1(6) at 132.1 × 9.8.
2, 3. *Platanoidites gertrudae* (R. Potonié 1931) R. Potonié, Thomson & Thiergart, 1950. Slide D1110–1(6) at 117.7 × 12.
4, 5. *Quercoidites microhenrici* (R. Potonié 1931) R. Potonié, Thomson & Thiergart 1950. Slide D1456–6(2) at 139.2 × 9.
6, 7. *Quercoidites microhenrici* subsp. *intragranulatus* Thomson & Pflug 1953. Slide D1456–4(1) at 123 × 9.8.
8. *"Tricolpopollenites retiformis"* Thomson & Pflug 1953. Slide D1110–1(3) at 130.8 × 4.1.
9–13. *Triatriopollenites rurensis* Pflug & Thomson 1953.
9. Slide D1456–4(7) at 128.3 × 14.1.
10. Slide D1110–1(6) at 128.5 × 20.2.
11. Slide D1456–4(3) at 136.3 × 12.4.
12, 13. Slide D1110–1(4) at 130 × 10.
14, 15. *Triatriopollenites* cf. *T. concavus* Thomson & Pflug 1953.
14. Slide D1110–3(4) at 106.4 × 6.4.
15. Slide D1110–3(4) at 131.6 × 16.1.
16, 17. cf. *Minorpollis minimus* Krutzsch 1959. Slide D1456–4(1) at 123.5 × 10.7.
18–20. *Trivestibulopollenites betuloides* Thomson & Pflug 1953. Slide D1110–3(5) at 131 × 2.8.
21–23. *Sporopollis* Pflug 1953.
21, 22. Slide D1456–4(3) at 131.3 × 8.
23. Slide D1456–4(5) at 137 × 5.
24, 25. cf. *Paliurus rhamnoides* Bolkhovitina 1953. Slide D1110–2(5) at 103.4 × 16.2.
26–28. *Conclavipollis anulopyramis* Pflug 1953. Slide D1456–5(1) at 110.8 × 17.
29, 30. *Latipollis subtils* Krutzsch 1959. Slide D1110–3(3) at 138.7 × 9.1.
31–34. *Latipollis* Krutzsch 1959.
31. Slide D1110–3(4) at 114.5 × 6.4.
32. Slide D1456–4(3) at 136.2 × 11.1.
33, 34. Slide D1456–4(3) at 120 × 10.
35, 36. *Triatriopollenites* Pflug 1953. Slide D1456–6(2) at 128 × 3.6.



DICOTYLEDONOUS POLLEN OF THE McSHAN AND EUTAW FORMATIONS

PLATE 8—Continued

FIGURE 37, 38, 39. *Latipollis latis* Krutzsch 1959. Slide D1456–4(1) at 126 × 9.4.

40–46. *Sporopollis pseudosporites* Pflug 1953.
  - 40, 41, 42. Slide D1110–3(4) at 103×4.1.
  - 43, 44. Slide D1110–3(5) at 107.8 × 9.5.
  - 45, 46. Slide D1110–3(5) at 134.5 × 22.

47, 48. *Sporopollis laqueaeformis* Weyland & Greifeld 1953. Slide D1110–3(4) at 127.4 × 4.0.

49, 50. *Sporopollis* Pflug 1953. Slide D1456–4(1) at 110.8 × 6.2.

51, 52. *Tenerina tenera* Krutzsch 1957. Slide D1110–1(4) at 117.2 × 9.4.

53–58. *Porocolpopollenites* Thomson & Pflug 1953 (some unnamed species).
  - 53. Slide D1456–4(3) at 124.3 × 12.2.
  - 54. Slide D1110–1(6) at 127 × 17.9.
  - 55. Slide D1456–4(8) at 101.4 × 16.8.
  - 56, 57. Slide D1456–4(5) at 98.2 × 20.2.
  - 58. Slide D1456–4(8) at 116.3 × 11.9.

59, 60. *Porocolpopollenites orbiformis* Thomson & Pflug 1953. Slide D1110–2(5) at 111.3 × 13.

61–64, 67–71. *Porocolpopollenites* Thomson & Pflug 1953 (some unnamed species).
  - 61, 62. Slide D1456–5(1) at 126.5 × 16.
  - 63, 64. Slide D1110–1(3) at 117.4 × 19.9.
  - 67, 68, 69. Slide D1110–3(4) at 104 × 15.7.
  - 70, 71. Slide D1456–4(1) at 129.8 × 6.3.

65, 66. *Symplocoipollenites vestibulum* (R. Potonié 1931) R. Potonié 1951. Slide D1456–4(7) at 121.5 × 14.3.

72. "*Tricolporopollenites* cf. *T. eschweilerensis*" Thomson & Pflug 1953. Slide D1110–2(3) at 128.6 × 13.7.

73–77. *Pollenites kruschi* (R. Potonié) "asp. *pseudolaesus*" (R. Potonié) Thomson & Pflug 1953.
  - 73, 74, 75. Slide D1456–4(5) at 133.9 × 18.8.
  - 76, 77. Slide D1110–2(5) at 137.8 × 20.1.

78, 79. "*Tricolporpollenites*"Thomson & Pflug 1953 (unnamed species with bacculae). Slide D1110–1(5) at 111.3 × 3.3.

80. "*Tricolporopollenites*" Thomson & Pflug 1953 (unnamed species). Slide D1110–1(3) at 134.4 × 9.9.

PLATE 9

[All figures magnified 500× except figure 4]

FIGURE 1. Fungal teleutospore of the Basidiomycetae. Slide D1456–4(5) at 128.5 × 7.

2, 3. cf. *Tetraporina* Naumova 1950. Slide D1456–4(3) at 131.1 × 12.2.

4. Microforaminifer (× 250). Slide D1110–1(3) at 131.8 × 6.0.

5. *Schizosporis reticulatus* Cookson & Dettmann 1959. Slide D1456–5 (1) at 122.2 × 19.9.

6. *Pterospermopsis ginginensis* Deflandre & Cookson 1955. Slide D1456–4(3) at 132.5 × 5.2.

7. *Hystrichosphaeridium* cf. *H. multifurcatum* Deflandre 1937. Slide D1110–1(3) at 125.3 × 5.4.

8. *Micrhystridium pavimentum* Deflandre 1945. Slide D1456–4(3) at 129 × 22.9.

9. *Sporites echinosporus* R. Potonié 1934. Slide D1456–6(4) at 129 × 21.

10. *Micrhystridium piliferum* Deflandre 1936. Slide D1110–2(5) at 108 × 7.3.

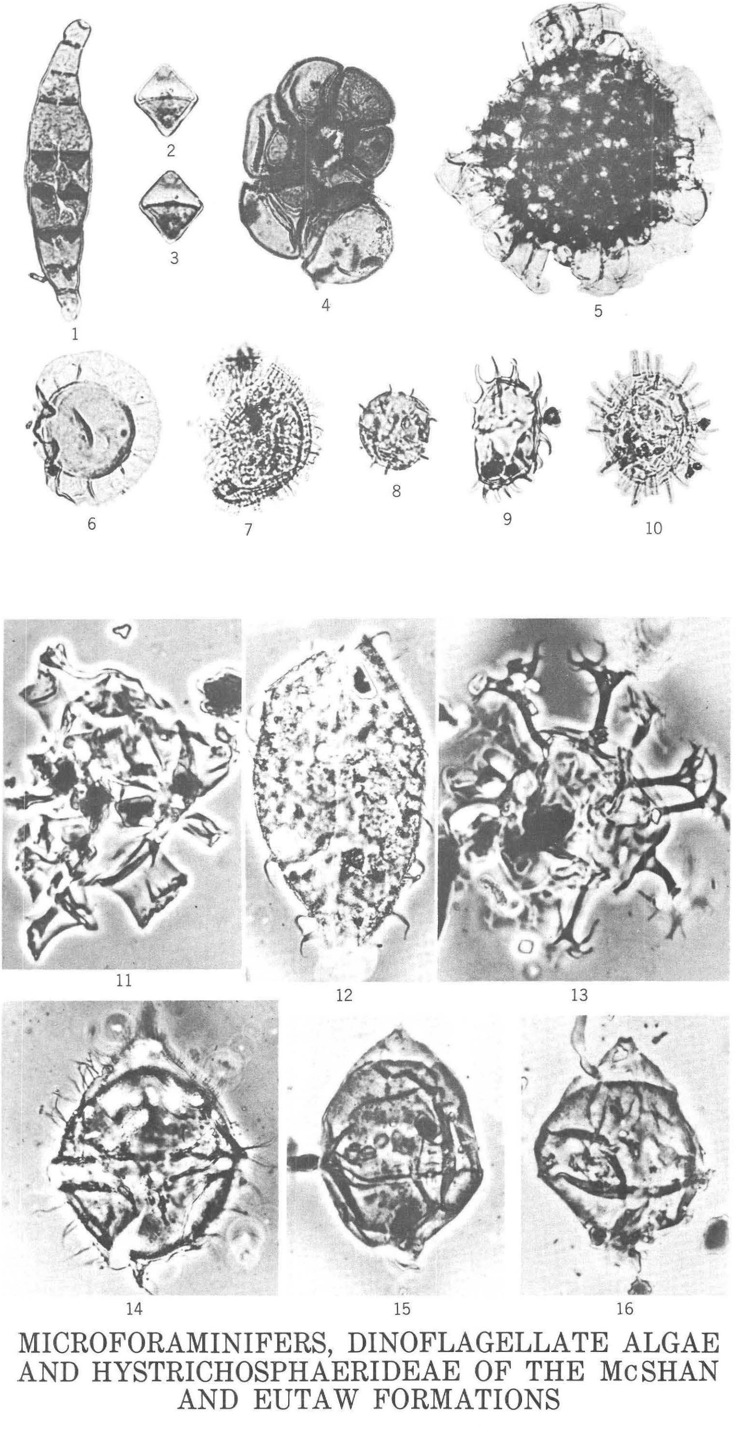
11. *Hystrichosphaeridium truncigerum* Deflandre 1937. Slide D1110–2 (5) at 106.2 × 14.

12. *Hystrichosphaeridium xanthiopyxides* var. *parvispinum* Deflandre 1937. Slide D1110–1(6) at 125.1 × 20.2.

13. *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson 1955. Slide D1110–1(6) at 107 × 11.6.

14. *Paleohystrichosphora infusorioides* Deflandre 1955. Slide D1110–3 (1) at 129.9 × 18.9.

15, 16. *Deflandrea bakeri* forma *pellucida* Deflandre & Cookson 1955.
   15. Slide D1110–1(3) at 132.2 × 16.4.
   16. Slide D1110–1(3) at 134 × 9.



MICROFORAMINIFERS, DINOFLAGELLATE ALGAE AND HYSTRICHOSPHAERIDEAE OF THE McSHAN AND EUTAW FORMATIONS