TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 11, Number 4 November 19, 1975

MIDDLE EOCENE CALCAREOUS NANNOFOSSILS AT LITTLE STAVE CREEK, ALABAMA

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CONTENTS

ILLUSTRATIONS

(continued next page)

I. ABSTRACT

The middle Eocene Claiborne Group at Little Stave Creek, Alabama, contains a rich and varied assemblage of coccolithophores, with a significant development of provincial forms such as pentaliths, rhabdoliths, and holococcoliths. The pentaliths of the family Braarudosphaeraceae are especially well-developed in the study area. These provincial forms are known from hemipelagic marine deposits in numerous areas, but are notably lacking or sparse in oceanic pelagic sediments. The pentaliths are rare in contemporary nannofloras, but several other Recent coccolithophores have a provincial distribution that is attributed to a benthonic phase in the life cycle of the organism. Eocene pentaliths and the other provincial species may have had similar limitations; nevertheless, they must have possessed a phase which was capable of traversing the open ocean because the same species occur in hemipelagic sediments on all continents. The apparent provincialism of these forms does not diminish their usefulness because the occurrence of a particular species is synchronous throughout the geographic range of that form. These species are useful, therefore, both as stratigraphic indicators in Paleogene sediments and as environmental indicators of the hemipelagic realm.

II. INTRODUCTION

Calcareous nannofossils, including the coccoliths, discoasters, and associated forms, generally are not considered to be provincial. On the contrary, paleontologists generally have been impressed by the similarity of equivalent-age nannofossil assemblages from widely separated areas (*e.g.*, Bramlette and Riedel, 1954; Hay, *et al.*, 1967). The widespread occurrence of individual species, coupled with their great abundance in fine-grained marine sediments, has made nannofossils ideal tools for long-range correlation and high-resolution biostratigraphy. Differences were noted, however, in some nannofossil assemblages of equivalent ages. Sullivan (1964, 1965) observed that pentaliths—nannofossils constructed of five radially arranged calcite crystallites—occur in great abundance in shallow-water marine strata of the Lower Tertiary in California, but may be scarce or lacking in deep-water marine sediments.

Only with the advent of the Deep Sea Drilling Project did samples from early Tertiary oceanic beds in sections far removed from the influence of continents and shelf seas become available in quantity for study. Investigations of this material revealed the almost complete lack of pentalith genera and several other genera including *Daktylethra, Discolithina, Zygrhablithus, Rhabdosphaera, Blackites,* etc., which are so well developed in the many Tertiary marine deposits exposed on the continents.

The present study was undertaken to gain a better understanding of Lower Tertiary coccolithophores, especially the pentaliths. In the process, an attempt was made to evaluate existing knowledge about these forms and to arrive at a reasonable explanation for their peculiar distribution. The middle Eocene Claiborne Group consists of 235 feet of sediments and, according to Berggren's (1971) time scale, ranges in age from about 43 to about 49 million years B.P. This section was chosen for intensive study because of its unusually well-developed calcareous nannofossil assemblage.

Some of the data and illustrations in this paper occur in a previous publication by Bybell and Gartner, 1972. This information has been included in order to present a more comprehensive study of the coccolithophores from the Claiborne Group at Little Stave Creek.

III. METHODS AND TECHNIQUES

A Zeiss light microscope was used extensively, with supplementary information derived from scanning electron photo micrographs. Specimens were examined from various angles with a light microscope using slides mounted with 30,000cs silicone oil. This made it possible to rotate specimens and determine the gross morphology of some of the more complex or unusual species, such as *Micrantholithus altus* Bybell and Gartner and *Pentaster lisbonensis* Bybell and Gartner. Once the gross morphology was determined, these species could then be accurately related to their scanning electron micrograph equivalents. Sample numbers refer to Bandy's (1949) localities at Little Stave Creek, and the samples may be considered to have come from the same statigraphic levels, insofar as it is possible to relocate previously sampled levels in this section.

IV. MODERN COCCOLITHOPHORES

Coccolithophores are unicellular, biflagellate, golden-brown algae, which produce calcareous platelets during some phase of their life cycle. These plates may be holococcoliths, which are constructed of uniform calcite crystals, or the more common heterococcoliths, which are constructed of variously shaped calcareous particles. Coccoliths normally form within the cell of the alga, migrate to the surface, and then are extruded to form an external covering. Recently Parke (1971, 1973) has isolated a form that produces calcareous elements in a mucilaginous covering around the outside of the cell. Some of these forms closely resemble species of the genus *Tetralithus,* while others are somewhat similar to nannoconids. The production of these calcareous plates appears to be light-dependent, but the exact function of the coccoliths is unclear. An organic layer of unknown composition coats each coccolith which retards calcite dissolution of the coccolith. Coccolithophores are herein placed in the kingdom Protista. They are mainly photosynthesizers, but under certain conditions may ingest food particles or absorb nutrients from their surroundings. Most coccolithophores occur in the marine environment, but a few species inhabit brackish or fresh waters. Some modern marine coccolithophores show geographic preferences in their occurrence, inhabiting definite latitudinal belts, and their distribution appears to be closely related to the temperatures of oceanic surface waters. Others prefer a hemipelagic environment *(i. e.,* sharing neritic and pelagic qualities), but most are cosmopolitan. It is in the low and middle latitudes of the open ocean, however, that coccolighophores reach their acme.

Some living species have been studied and seem to have complex life cycles, but the data available result almost exclusively from studying laboratory cultures under conditions which are far different from those in nature. These studies are very useful, however, because they may reveal previously unrecognized relationships between dissimilar stages in the life cycle of a single organism. Some modern coccolithophores have at least two stages in their life cycle and possibly more.

Cricosphaera carterae (Braarud and Fagerland) appears to have several similar phases, which bear coccoliths or organic scales on the surface of the cell. This species also has a benthonic, filamentous stage without scales or coccoliths (Ryans, 1962; Leadbeater, 1970). It has been speculated that most nearshore benthonic members of the Chrysophyta may have a motile stage in their life cycle, although not necessarily one bearing coccoliths (Parke, 1961). A second type of life cycle occurs in *Coccolithus pelagicus* (Wallich), an open ocean form. In this species, a holococcolith-bearing form alternates with a heterococcolith-bearing form (Parke and Adams, 1960; Manton and Leedale, 1969). Schwarz in 1932 described a third type of life cycle in which nonmotile cells are covered with coccoliths and can reproduce sexually. Other equally complex life cycles probably exist. Some may have one phase endophytic in the wall of another alga or symbiotic in an animal (Parke, 1961). Although the phase changes and the conditions which bring them about can be observed in the laboratory, there is some danger in extending these generalizations to organisms living in the open ocean, because the natural conditions under which these organisms live are impossible to duplicate artificially.

V. ECOLOGY OF FOSSIL COCCOLITHOPHORES

The majority of fossil coccolithophores have worldwide occurrence in marine beds. A few genera have restricted geographical ranges. These genera are found almost exclusively in marine sections which were deposited in the hemipelagic realm of shelf seas and large embayments. Martini (1965, 1970) found the family Braarudosphaeraceae, the genera *Discolithina* and *Scyphosphaera,* and some species of the genus *Rhabdosphaera* characteristic of nearshore deposits. Bukry, *et al.* (1971), considered as characteristically nearshore the genera *Braarudosphaera, Clathrolithus, Daktylethra, Lanternithus, Micrantholithus, Pemma, Peritrachelina, Rhabdosphaera, Transversopontis* and *Zygrhablithus.* The family Braarudosphaeraceae, including the genera *Braarudosphaera, Micrantholithus, Pemma* and *Pentaster,* is especially restricted in its distribution. Eocene representatives of this family occur in hemipelagic deposits in California, Louisiana, Mississippi, Alabama, Mexico, England, France, Germany, Austria, Hungary, USSR, India and the Blake Plateau. They are conspicuously absent from deep-water, open ocean deposits of the same age. A notable exception is the widespread occurrence of one *Braarudosphaera* species in the Oligocene sediments of the South Atlantic recovered during Leg 3 of the Deep Sea Drilling Project (Maxwell, *et al.*, 1970).

Several explanations have been proposed to account for this provincial distribution. According to Bramlette and Martini (1964) and Martini (1965), turbidity and salinity in the nearshore environment may have had significant control over the distribution of phytoplankton living in that area. Martini (1970) stated that paleocurrents may also have been an important factor. Physical-chemical factors may be significant, since the slow sedimentation rate and deep water in the oceanic environment may be unfavorable for the preservation of some species (Gartner and Bukry, 1969; Gartner, 1971). Thus, turbidity, salinity, paleocurrents, or preferential preservation may account for apparent provincialism among certain fossil coccolithophores.

Documented occurrences of living specimens of *Braarudosphaera bigelowi* (Gran and Braaud) include the nearshore area of the Bay of Fundy (Gran and Braarud, 1935) and the open ocean waters of the Sargasso Sea (Gaarder, 1954). Takayama (1972) examined the distribution of this species in nearshore, surface sediments of Sendai Bay off Japan. *B. bigelowi* was recorded only from samples collected in less than 87 meters of water. More comprehensive studies of the Recent occurrences of *B. bigelowi,* the only surviving species of the family Braarudosphaeraceae, and correlation between surface and sediment distribution may shed light on this problem. If living specimens of *B. bigelowi* are cosmopolitan, but are found only in hemipelagic sediments, then their distribution must be controlled by preservation. Clearly, additional observations are needed to verify this distribution. An alternative and more likely possibility is that *B. bigelowi* lives predominantly in the hemipelagic environment and that the distribution of the remains of this organism is indicative of the environment inhabited by it. As noted above, several modern marine phytoplankters prefer hemipelagic conditions. Their restriction to shallow water may be accounted for by an actively photosynthesizing benthonic stage in the life cycle (Parke, 1961; Gaarder, 1971). If a similar benthonic stage, as yet not discovered, exists in the life cycle of *B. bigelowi,* concentration of the species in the hemipelagic realm would be readily explained.

Alternatively, species able to live only in shallow water are unlikely to have worldwide distribution. Smayda (1958) pointed out that large distances can be traversed by phytoplankton only if active cell division is maintained. In deep water the benthonic stage would never develop and the organism would have to remain viable in the pelagic stage for an extended period of time under the assumed unfavorable conditions of the open ocean. In the Eocene, especially in the middle Eocene, the family Braarudo-

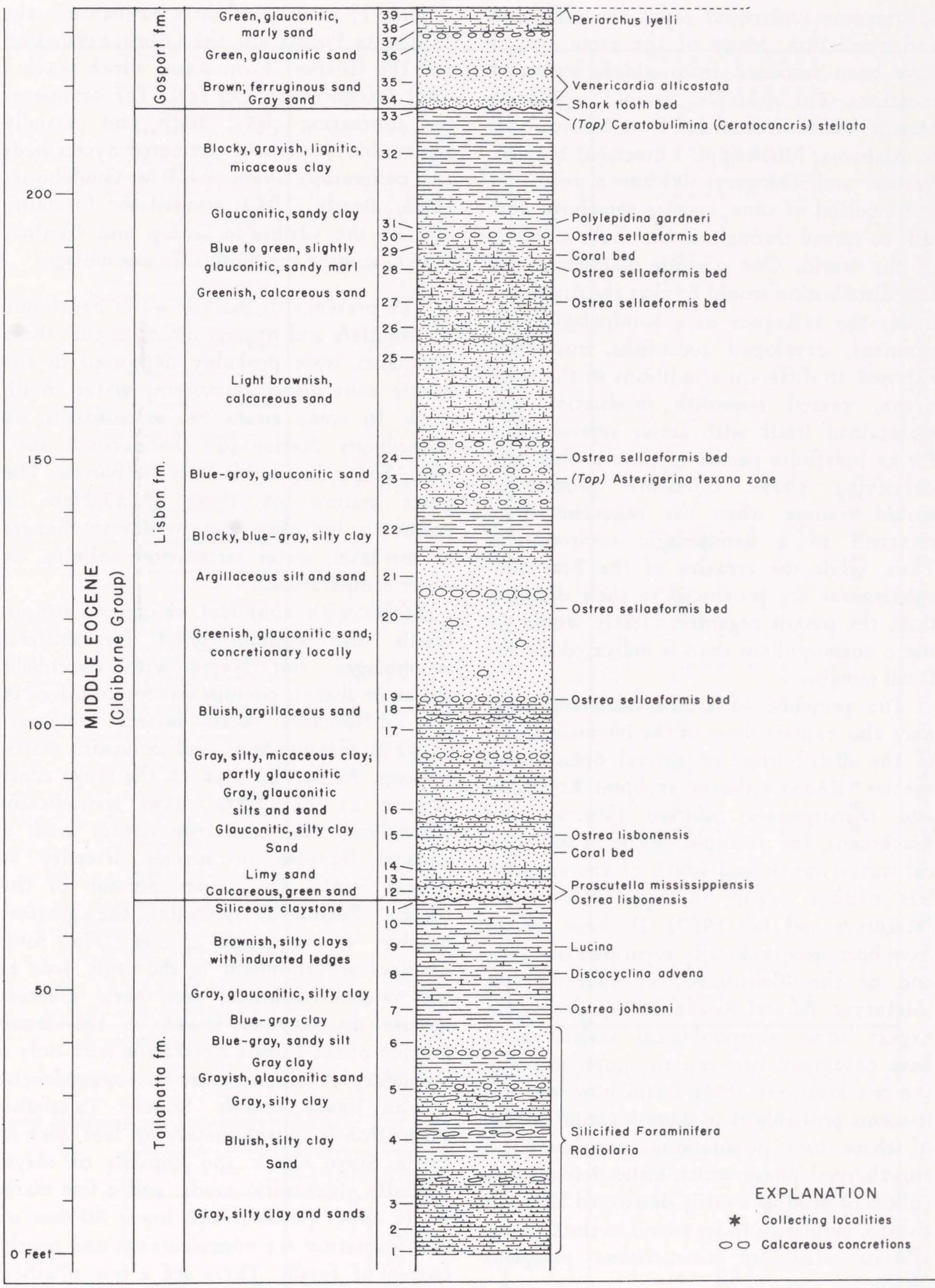

Figure 1. Generalized columnar section at Little Stave Creek, Alabama, indicating sample locations. After Bandy, 1949.

sphaeraceae underwent rapid diversification and speciation. Many of the same species have been recorded from widely separated locations. For example, *Pemma papillatum* Martini has been recorded from Eocene beds in Alabama, Mississippi, Louisiana, Mexico, France and Hungary. Within a relatively short period of time, species somehow were able to spread throughout the shallow waters of the world. One possible mechanism for this distribution would be that the organism, under the influence of a hemipelagic environment, developed coccoliths, but when exposed to different conditions in the open ocean, ceased coccolith production and maintained itself with active reproduction for an indefinite period of time in this noncalcifying phase. Coccolith production would resume when the organism again returned to a hemipelagic environment. Thus, while the remains of the Braarudosphaeraceae are provincial in their distribution, the parent organism clearly would be more cosmopolitan than is indicated by the fossil remains.

The presence of a non-calcifying stage may also explain some of the inconsistencies in the distribution of several open ocean species. *Rhabdosphaera stylifera* Lohmann and *Discosphaera tubifera* (Murray and Blackman), for example, occur in subtropical waters north and south of the equator, but neither occurs in equatorial waters (McIntyre and Bé, 1967). If these species have been geographically separated since the end of the Pleistocene, as data indicate (McIntyre, Bé and Roche, 1970), one would expect some morphological variations to have developed between the populations in the two locations. None exists, however, and it seems probable that there is actual mixing of these two populations, possibly by a eurythermal phase which either has no coccoliths or produces easily destroyed holococcoliths, similar to those found in the *Crystallolithus* stage of *Coccolithus pelagicus* (Wallich).

VI. THE CLAIBORNE GROUP AT LITTLE STAVE CREEK

The middle Eocene Claiborne Group exposed at Little Stave Creek, Alabama, (Figure 1) consists of three formations: the Tallahatta Formation, the Lisbon Formation and the Gosport Formation, which reach a total thickness of 235 feet. The sediments are alternating clays, marls and partially glauconitic sands with scattered oyster beds and concretion layers (S.E.P.M. Guidebook, 1962). Bandy (1949) studied the foraminifers of the Claiborne Group and Gardner (1957) studied the molluscan assemblage.

The presence of shallow water benthonic foraminifers and oysters indicates that these sediments were probably deposited in the neritic zone under fluctuating water conditions. In some strata the microfossils are exceedingly diverse (60 nannofossil species), but other levels may be barren. The exact nature of these fluctuations is unknown, but they may be due to changes in sea level, water circulation, salinity, or water temperature.

Strata with abundant calcareous nannofossils also contain good foraminiferal assemblages, but layers with coccoliths sparse or absent, contain few foraminifers. A few differences were noted, however, between foraminiferal and coccolith distributions. As can be seen on the range chart (Figure 2), coccoliths occur sporadically throughout the Claiborne Group with a marked increase in species diversity at several levels. The upper portion of the Lisbon Formation contains the greatest number of coccolith species. The foraminifers are abundant in the same beds as the coccolithophores, but their greatest species diversity is found in the lower portion of the Lisbon Formation with only a secondary development at the upper levels.

The lower middle Eocene Tallahatta Formation is approximately 65 feet thick at Little Stave Creek and consists of clays, partially glauconitic sands, and a few marls in its upper portion. The lower 40 feet of this formation are noncalcareous and nearly barren of fossils. There are a few silicified species of foraminifera present; the molluscan fauna is poor and normally preserved only as impressions or molds. Calcareous nannofossils are completely absent. Radiolarians are the only common fossils in these

FIGURE 2

Species	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Age	Middle Eocene																																						
Calcareous Nannofossil Zones, Gartner, 1971	P 14 Helicopontosphaera compacta–Chiasmolithus grandis														P 12 Pemma papillatum					P 11 Reticulofenestra umbilica–Sphenolithus furcatolithoides																			
Specimens per traverse (500X)	16	180	120	114	172	0	212	440	385	645	381	557	292	361	128	142	37	0	150	99	58	13	0	371	298	323	540	104	110	278	266	87	1845	42	0	0	0	0	0
Species per sample	4	9	6	14	11	0	21	36	31	56	29	40	3	28	1	6	17	0	19	14	16	1	0	21	36	28	23	23	10	19	22	17	25	20	0	0	0	0	0
																																			Barren interval				
Blackites creber										X	X	X													X	X	X	X				X	X						
Blackites spinosus	X			X			X	X	X	X	X	X		X			X		X	X	X			X	X	X	X	X		X	X		X	X					
Blackites tenuis								X		X		X		X											X		X	X			X	X	X	X					
Braarudosphaera bigelowi		X	X	X	X			X	X	X	X	X		X		X	X		X	X	X				X	X	X	X			X								
Braarudosphaera cheloma										X		X																											
Braarudosphaera discula										X									X																				
Braarudosphaera irregularis			X							X		X																											
Braarudosphaera rosa				X	X			X		X																													
Braarudosphaera stylifer				X				X	X	X		X		X			X		X	X					X	X													
Campylosphaera dela								X	X	X																			X	X				X					
Cepekiella lumina				X			X		X	X											X				X	X	X			X									
Chiasmolithus grandis											X													X	X	X				X	X		X	X					
Chiasmolithus solitus										X	X	X	X						X		X			X	X	X	X	X			X	X		X					
Chiasmolithus titus							X			X		X													X		X				X		X	X					
Coccolithus crassipons																									X	X	X												
Coccolithus pelagicus		X	X				X	X	X	X	X	X	X			X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X					
Cruciplacolithus staurion								X																	X	X				X			X	X					
Cyclococcolithina formosa							X	X	X	X	X	X		X			X		X	X	X			X	X	X	X	X	X	X	X	X	X	X					
Cyclococcolithina reticulata				X			X	X	X	X	X	X					X			X																			
Daktylethra punctulata							X	X	X	X	X	X		X							X			X	X					X									
Discoaster barbadiensis	X				X		X	X	X	X	X	X		X		X	X		X	X	X			X	X	X	X	X	X	X	X	X	X	X					
Discoaster elegans										X	X																		X	X	X	X	X						
Discoaster nodifer							X	X	X	X		X							X		X				X						X	X		X					
Discoaster saipanensis					X			X		X		X							X							X	X	X		X		X	X	X					
Discolithina bicaveata										X																					X			X					
Discolithina cribraria										X																		X			X		X						
Discolithina multipora			X	X	X			X		X	X	X		X										X	X		X	X		X			X	X					
Discolithina vesca							X	X	X			X		X										X	X	X						X	X						
Discolithina wechesensis										X		X												X	X	X		X			X		X						
Ericsonia fenestrata							X			X		X															X												
Helicopontosphaera compacta							X			X				X																									
Helicopontosphaera lophota																									X		X			X		X	X	X					
Helicopontosphaera seminulum								X	X	X	X			X										X	X	X	X	X		X	X	X	X	X					
Helicopontosphaera reticulata									X	X																													
Helicopontosphaera wilcoxoni										X		X																											
Lanternithus minutus	X			X	X		X	X	X	X	X	X												X	X	X							X						
Lithostromation operosum					X		X	X		X		X					X							X	X														
Lithostromation perdurum										X		X																											
Lithostromation simplex										X		X													X														
Lophodolithus mochlophorus																										X							X						
Markalius inversus										X				X							X				X			X	X										
Micrantholithus altus								X	X	X	X	X		X			X																						
Micrantholithus angulosus								X	X	X	X	X		X					X																				
Micrantholithus ornatus										X							X																						
Micrantholithus procerus							X		X	X	X			X																									
Micrantholithus vesper				X				X	X	X		X		X											X	X		X			X								
Pemma balium								X	X	X		X		X							X																		
Pemma basquense basquense	X	X	X	X	X			X	X	X	X	X		X		X	X		X	X							X												
Pemma basquense crassum							X	X	X	X	X	X		X					X						X	X													
Pemma papillatum		X		X	X			X	X	X	X	X		X			X		X																				
Pemma rotundum														X					X		X				X	X	X				X								
Pemma serratum								X	X	X	X	X																											
Pemma stradneri		X						X	X	X	X						X																						
Pentaster lisbonensis								X	X	X		X		X						X					X														
Reticulofenestra bisecta		X					X	X		X	X			X					X					X	X	X	X	X					X						
Reticulofenestra umbilica	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X					
Rhabdosphaera vitrea										X	X																												
Sphenolithus moriformis		X		X			X	X	X	X	X	X	X	X			X		X	X	X			X	X	X	X	X	X	X	X	X	X	X					
Sphenolithus radians								X		X		X																											
Transversopontis exilis											X													X	X			X		X		X							
Transversopontis fimbriatus										X														X	X	X		X			X								
Transversopontis obliquipons							X	X	X	X	X	X		X		X	X			X	X			X	X	X	X	X	X	X	X	X	X	X					
Zygolithus dubius								X		X	X	X		X						X				X		X		X		X			X						
Zygrhablithus bijugatus		X		X	X		X	X	X	X	X	X		X			X		X	X	X			X	X	X	X	X	X		X	X	X	X					

Figure 2. Distribution of calcareous nannofossils in the middle Eocene Claiborne Group at Little Stave Creek, Alabama.

beds. Above this barren zone is the *Ostrea johnsoni* bed, which contains the most diverse molluscan, foraminiferal and calcareous nannofossil assemblages in the Tallahatta. Above the oyster beds are mainly clays with a somewhat less diverse fossil assemblage. The Tallahatta-Lisbon Formation contact is disconformable and there is an abrupt floral and faunal decrease. Just below the contact, there is evidence of burrowing and broken shell fragments are common, probably indicating shallower water.

The Lisbon Formation consists of approximately 150 feet of exposed, predominantly calcareous and glauconitic sands and silty clays with intermittent oyster beds. *Ostrea lisbonensis* reefs occur sporadically in the lower third of the formation and correspond to increased calcareous nannofossil and foraminiferal assemblages. *Ostrea sellaeformis* reefs are scattered throughout the upper portion of the formation and these beds have an impoverished microfossil flora and fauna. This may indicate that *Ostrea lisbonensis* preferred deeper water, more open water conditions, or a different salinity than *Ostrea sellaeformis*. Foraminifers and mollusks are greatest in species diversity in the lower part of the formation, but calcareous nannofossils are at their acme near the top of the Lisbon Formation.

There are approximately 20 feet of glauconitic and ferruginous sands in the Gosport Formation. The megafossils are more numerous than the microfossils. The Lisbon-Gosport Formation contact is unconformable and above the contact is a shell fragment coquina that may indicate a beach deposit. This zone is barren of calcareous nannofossils and foraminifers and the iron present is oxidized. The upper portion of the Gosport is a glauconitic sand with more abundant foraminifers than calcareous nannofossils. No new coccolith species appear in the Gosport and the possibility of reworking cannot be eliminated, although this is not indicated by the foraminiferal evidence.

VII. COCCOLITHOPHORES OF THE CLAIBORNE GROUP

Eighty-one species of coccolithophores, representing 30 genera, were identified in samples from the Little Stave Creek Claiborne Group. There are ten new generic combinations and one new species.

Pentaliths are the most diagnostic forms in the middle Eocene and all four genera are represented in the Claiborne Group. Some pentalith species have considerable morphologic variation, and intermediate forms may exist between species. Other species, for example, *Pemma papillatum* Martini, are distinctive and can be identified even if only represented by fragments. A few pentalith species occur throughout the Lisbon Formation, for example, *Braarudosphaera bigelowi* (Gran and Braarud) and *Micrantholithus vesper* Deflandre, but the majority are restricted to the upper half of the Lisbon and the Gosport formations of late middle Eocene age. Within this zone there is rapid species expansion, six pentalith species occuring in the lower portion of the Lisbon and 18 in the uppermost Lisbon. A similar species diversity is found in middle Eocene deposits of other continents.

Rhabdoliths of the three genera *Blackites, Rhabdosphaera,* and *Cepekiella* are abundant in the Claiborne. Several species, previously illustrated only with light photomicrographs, have now been viewed also with the scanning electron microscope. This has resulted in several generic changes and some species are placed in synonomy. One new species belonging to the genus *Blackites* is described.

Only a few species of *Discoaster* are present in the Claiborne Group and many specimens of these have heavy calcite overgrowths, making identification difficult. Discoasters are more resistant to solution than other calcareous nannofossils probably due to the vertical orientation of the principal optic axis of the crystallites (Bukry, 1971b; Black, 1972). Similarly, these forms are the most likely to have calcite overgrowths (Adelseck, Geehan, and Roth, 1973). Scanning electron photomicrographs of Claiborne Group coccolithophores show that calcite overgrowth features occur mainly on the discoasters, thus confirming their greater susceptibility to this phenomenon.

There are ten discolith and discolith-related species in the Claiborne Group. Scanning electron photomicrographs reveal at least five basic structural types, which can be used to place species into various genera. Each species must be observed with the electron microscope before it can be properly classified but, once this has been accomplished, it ameliorates the confusion and generic shuffling these forms have been subjected to in previous studies.

The first structural type, as exhibited by *Transversopontis obliquipons* (Deflandre) (Pl. 21, Figs. 1-4), is flat on both the proximal and distal sides. The slightly smaller proximal side has radiating calcite laths, but the distal side has concentrically arranged cycles of elements. Normally there are two central perforations.

Discolithina multipora (Kamptner) (Pl. 20, Figs. 1,4) is representative of the second structural type, which has a concave proximal side with radiating laths and a convex distal side with concentrically arranged elements. The surface bears numerous small perforations. A third structural form is basket-shaped with thin high walls and radiating laths on both sides. Specimens may or may not have a flange and may have up to two central basal perforations. *Transversopontis exilis* (Bramlette and Sullivan) (Pl. 21, Fig. 5) falls within this category.

A fourth type as seen in *Discolithina wechesensis* Bukry and Percival (Pl. 20, Fig. 2) is also basket-shaped, but has thick walls that normally have a series of interior vertical struts. Calcite elements are of the radiating type and specimens may have no central perforation, one perforation, or two.

These four structural types are all represented in the middle Eocene Claiborne Group. Neogene discolith forms possess a fifth type of structure, which is similar to the basal portion of species of the genus *Scyphosphaera*. The concave proximal side has radiating laths while the nearly flat distal side has concentrically arranged crystals. The thick walls rise vertically, ending as a broad, flat upper rim and the base has numerous small perforations.

The species *Trochoaster operosus* (Deflandre), *Marthasterites reginus* Stradner, and *Trochoaster simplex* Klumpp are placed in the genus *Lithostromation* along with *Lithostromation perdurum* Deflandre. Scanning electron photomicrographs reveal that all four species have a similar structure: multiple, circular depressions, each surrounded by a knobby hexagonal ridge and three-fold symmetry (or a multiple, 6, 9 or 12). Their similarity makes it impractical to place them in separate genera with other dissimilar forms.

VIII. ZONATION OF THE CLAIBORNE GROUP

The Claiborne Group at Little Stave Creek is correlated with the middle Eocene section. These sediments, however, previously have not been related to any standard zonation scheme. Martini (1971b) published a calcareous nannofossil zonation, but it cannot be related to Little Stave Creek sediments because the majority of his zonal markers are not found in the Claiborne Group.

Gartner (1971) also published a zonation for the Eocene which can be applied to the coccolithophores of the study area. Gartner recognized five middle Eocene calcareous nannofossil zones:

1. *Discoaster tani* s. l. – *Sphenolithus radians* Zone – Interval from the first occurrence of *Discoaster tani* s. l. to the first occurrence of *Reticulofenestra umbilica* (Levin). This zone is roughly equivalent to Blow's P10 zone.
2. *Reticulofenestra umbilica* – *Sphenolithus furcatolithoides* Zone – Interval from the first occurrence of *Reticulofenestra umbilica* to the first occurrence of *Pemma papillatum* Martini. This zone is approximately equivalent to Blow's P11 zone. The holococcolith *Lanternithus*

minutus Stradner first occurs in this zone.

3. *Pemma papillatum* Zone – Interval from the first occurrence of *Pemma papillatum* to the first occurrence of *Bramletteius serraculoides* Gartner. This zone is roughly equivalent to Blow's P12 zone.
4. *Bramletteius serraculoides* Zone – Interval from the first occurrence of *Bramletteius serraculoides* to the first occurrence of *Helicopontosphaera compacta* (Bramlette and Wilcoxon). This zone is approximately equivalent to Blow's P13 zone.
5. *Helicopontosphaera compacta – Chiasmolithus grandis* Zone – Interval from the first occurrence of *Helicopontosphaera compacta* to the first occurrence of *Hayella situliformis* Gartner. This zone is roughly equivalent to Blow's P14 zone.

Sporadic calcareous nannofossil occurrences at Little Stave Creek make zonation difficult and there may be an error of a few samples on either side of the zonal boundaries. Of Gartner's five zones, three are recognized in the Claiborne. These are the *Reticulofenestra umbilica – Sphenolithus furcatolithoides* Zone, *Pemma papillatum* Zone, and the *Helicopontosphaera compacta – Chiasmolithus grandis* Zone. The *Discoaster tani* s. l. – *Sphenolithus radians* Zone cannot be recognized in the Claiborne since the lowest coccolithophore-bearing sediment in the Tallahatta has abundant *Reticulofenestra umbilica* (Levin), thus placing it in the P11 zone. *Bramletteius serraculoides* Gartner is an open ocean form and there is only one questionable occurrence in the hemipelagic sediments at Little Stave Creek. Therefore, this zone is not identifiable.

N. J. Tartamella of Chevron Oil Company is familiar with the Gulf Coast Eocene. He examined Bandy's foraminiferal range chart and agreed that the upper Lisbon and Gosport formations are in Blow's P14 zone. The base of the Lisbon Formation has previously been identified as the base of the P11 zone using the oyster *Ostrea lisbonensis.* The foraminifers in the Tallahatta are long-ranging species and could not help to resolve the proper placement of the Tallahatta. For the purpose of this paper, the upper Tallahatta is placed in the P11 zone.

Several species of calcareous nannofossils at Little Stave Creek have longer ranges than those indicated by previous authors. Upward extension of extinction levels may be due to reworking, but lowest occurrences were also extended downward. *Daktylethra punctulata* Gartner has previously been restricted to the *Pemma papillatum* Zone, but at Little Stave Creek it extends down into the *Reticulofenestra umbilica – Sphenolithus furcatolithoides* Zone (P11) and up into the *Helicopontosphaera compacta – Chiasmolithus grandis* Zone (P14). *Chiasmolithus solitus* (Bramlette and Sullivan) and *Campylosphaera dela* (Bramlette and Sullivan) have longer ranges in Alabama than indicated previously.

The middle Eocene calcareous nannofossil assemblage at Little Stave Creek is both abundant and diverse. Some samples contain as many as 60 species. Assemblages from open ocean sediments, however, include fewer species and lack entirely many diagnostic forms which are present in nearshore deposits. Middle Eocene sediments collected by the Deep Sea Drilling Project and examined by Bukry usually contain fewer than 20 species (JOIDES reports, Legs 1-8). Bukry, *et al.,* 1971, in a comparison of oceanic and nearshore assemblages list 22 oceanic species and 44 nearshore species. Twenty species are restricted to the hemipelagic realm. The widespread abundance of these provincial forms in the middle Eocene nearshore deposits throughout the world offers the potential for an even closer zonation than is possible for open ocean sediments. The ultimate goal indicated is separate zonations for these two environments incorporating cosmopolitan species wherever possible and, then, refinements made using provincial forms.

IX. CONCLUSIONS

Sediments of the Claiborne Group at Little Stave Creek contain a rich assemblage of coccolithophores with many representatives of the forms which are normally restricted to hemipelagic sediments and hence not usable for zoning oceanic pelagic ooze. But provincialism among these forms is quite different from that commonly understood for other provincial groups. The difference is that, although restricted to shelf or inland seas in any single area, the same "provincial" forms are found in hemipelagic sediments on all continents. Thus, when applied to biostratigraphy, the same markers are used whether the section to be dated is in Europe or North America. Though the cosmopolitan coccoliths are indeed very abundant and useful in oceanic deposits, the sediments along the margins of continents generally contain better developed assemblages of pentaliths, rhabdoliths, discoliths, holococcoliths, and other similarly restricted forms, and the usefullness of these can by no means be ignored. They offer a potential for a finer zonation than is possible for sediments deposited in the open ocean.

X. ACKNOWLEDGEMENTS

I wish to thank Stefan Gartner of the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, for his unfailing assistance and patience while this study was being conducted. I also wish to thank W. H. Akers of Chevron Oil Company for helpful suggestions concerning the manuscript and for making possible the use of the Chevron scanning electron microscope. Paul Koeppel is to be thanked for operating the scanning electron microscope and taking such excellent photomicrographs. C. M. Quigley provided constant encouragement and made available the use of Chevron Oil Company facilities and additional samples from the Little Stave Creek locality. I also want to thank N. J. Tartamella of Chevron for valuable discussions concerning the stratigraphy and paleontology of the Gulf Coast region. This research was supported by American Chemical Society Petroleum Research Fund Grant 5063-AC2 and National Science Foundation Grant GA-12943.

XI. SYSTEMATIC PALEONTOLOGY

Kingdom PLANTAE
Class HAPTOPHYCEAE
Christensen 1962

Order PYRMNESIALES
Christensen 1962
Family BRAARUDOSPHAERACEAE
Deflandre 1947
Genus BRAARUDOSPHAERA
Deflandre 1947

Type species: *Braarudosphaera bigelowi* (Gran and Braarud)

BRAARUDOSPHAERA BIGELOWI
(Gran and Braarud)

Plate 7, Figures 1-3

Pontosphaera bigelowi GRAN and BRAARUD, 1935, text-fig. 67; Recent Atlantic.

Braarudosphaera bigelowi (Gran and Braarud). DEFLANDRE, 1947, text-figs. 1-5; Recent, Atlantic. DEFLANDRE *in* GRASSÉ, 1952, figs. 358-C,D; figs. 362-P-R; Eocene, France. KLUMPP, 1953, pl. 16, figs. 1-2; text-figs. 2-1, 2-4; Eocene, Germany. BRAMLETTE and RIEDEL, 1954, pl. 38, fig. 6. DEFLANDRE and FERT, 1954, pl. 10, figs. 8-13; pl. 13, figs. 7-9. GARDET, 1955, in part; pl. 7, fig. 64; Neogene, Atlantic. MARTINI, 1958, pl. 2, fig. 6; Eocene, Germany. MANIVIT, 1959, in part; pl. 4, fig. 1; Eocene, Algeria. STRADNER, 1959b, text-figs. 63, 68. BÁLDI-BEKE, 1960, p. 14, fig. 8; Miocene, Hungary. MARTINI, 1960, pl. 8, fig. 1; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 8, figs. 1-5; Eocene, California. MARTINI, 1961c, text-figs. 1-4, 6; Eocene-Oligocene, Germany. STRADNER and PAPP, 1961, pl. 37, figs. 1-3; text-fig. 22; Eocene, Mexico. LEVIN, 1965, pl. 42, figs. 4-5; Eocene, Mississippi. LOCKER, 1965, pl. 2, fig. 3; Eocene, Germany. GARTNER and SMITH, 1967, pl. 9, figs. 1-3; Eocene, Louisiana. HAY and MOHLER, 1967, pl. 202, figs. 12, 16, 20; Eocene, France. LEVIN and JOERGER, 1967, pl. 3, fig. 5; Eocene, Alabama. BLACK, 1968, pl. 147, fig. 5; Eocene, Mississippi. HAQ, 1968, pl. 11, figs. 3-4; Eocene, Germany. BYSTRICKÁ, 1969, pl. 63, fig. 14; Paleogene, Czechoslovakia. MARTINI, 1969b, pl. 27, figs. 9-10; Miocene, Africa. IACCARINO and FOLLINI, 1970, pl. 40, fig. 10; Cretaceous-Paleocene, Italy. BLACK, 1971, pl. 45.3, fig. 24; Eocene, England. HAQ, 1971a, pl. 6, fig. 3; Eocene, Pakistan. HAQ, 1971b, pl. 5, fig. 13; pl. 11, fig. 6; Oligocene, Germany. BLACK, 1972, pl. 93, figs. 3-4; Eocene, Mississippi, England. BYBELL and GARTNER, 1972, pl. 1, figs. 1-2; Eocene, Alabama. LOCKER, 1972, pl. 12, figs. 3-4.

Braarudosphaera bigelowi (Gran and Braarud). BOUCHÉ, 1962, pl. 4, figs. 1-5; Eocene, France.

Braarudosphaera bigelowi parvula Stradner. BOUCHÉ, 1962, pl. 4, fig. 9; Eocene, France.

Braarudosphaera discula Bramlette and Riedel. BYSTRICKÁ, 1969, pl. 63, fig. 13; Paleogene, Czechoslovakia.

Remarks: This common, easily identified species has, unlike most pentaliths, a considerable size range in any one locality. Samples containing pentaliths will generally include specimens of *B. bigelowi.*

Occurrence: B. bigelowi occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

BRAARUDOSPHAERA DISCULA
Bramlette and Riedel 1954

Braarudosphaera discula BRAMLETTE and RIEDEL, 1954, pl. 38, fig. 7; Eocene, Cuba. STRADNER, 1959b, text-fig. 64; Paleocene, Austria. BRAMLETTE and SULLIVAN, 1961, pl. 8, figs. 6-7; Eocene, California. Not STRADNER, 1961, text-fig. 43. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 4, figs. 6-7; Eocene, Czechoslovakia. Not STRADNER, 1962a, pl. 2, fig. 13. SULLIVAN, 1964, pl. 8, fig. 2; Paleocene, California. SULLIVAN, 1965, pl. 8, fig. 1; Eocene, California. HAY and MOHLER, 1967, pl. 202, figs. 13-15; Eocene, France. Not BYSTRICKÁ, 1969, pl. 63, fig. 13. BLACK, 1972, pl. 93, fig. 2; Eocene, France. SHERWOOD, 1974, pl. 6, fig. 12; Eocene, Texas.

Braarudosphaera bigelowi (Gran and Braarud). MANIVIT, 1959, pl. 4, fig. 2; Eocene, Algeria.

Braarudosphaera cf. *B. discula* Bramlette and Riedel. STRADNER and PAPP, 1961, pl. 37, fig. 5; Eocene, Austria. BILGÜTAY, *et al.*, 1969, pl. 3, fig. 16; Eocene, France. HAQ, 1971c, pl. 17, fig. 3; Oligocene, Syria.

Remarks: The few specimens of *B. discula* observed in the Little Stave Creek area agree well with other illustrated examples. *B. discula* is thinner than *Braarudosphaera rosa* Levin and Joerger, and has a more nearly circular outline. Both of these species have curved sutures, unlike the straight sutures of *Braarudosphaera irregularis* Bybell and Gartner.

Occurrence: B. discula occurs in the middle Eocene (Blow's P12-P14) of Alabama.

BRAARUDOSPHAERA IRREGULARIS
Bybell and Gartner 1972

Plate 7, Figure 4

Micrantholithus flos Deflandre. STRADNER and PAPP, 1961, in part; pl. 39, fig. 4.

Braarudosphaera irregularis BYBELL and GARTNER. 1972, pl. 1, figs. 3-4; Eocene, Alabama.

Remarks: B. irregularis differs from *Braarudosphaera discula* Bramlette and Riedel in having a crenulate rather than a smooth margin, a less circular outline, and straight rather than curved sutures.

Occurrence: B. irregularis occurs in the upper middle Eocene (Blow's P14) of Alabama.

BRAARUDOSPHAERA CHELOMA
Bybell and Gartner 1972

Plate 7, Figure 5

Braarudosphaera cheloma BYBELL and GARTNER, 1972, pl. 1, figs. 5-6; Eocene, Alabama.

Remarks: B. cheloma differs from *Braarudosphaera bigelowi* (Gran and Braarud) in having notches in its outline. This species has straight sides, unlike the lobate outer margin of each segment of *Micrantholithus concinnus* Bramlette and Sullivan.

Occurrence: B. cheloma occurs in the upper middle Eocene (Blow's P14) of Alabama.

BRAARUDOSPHAERA cf. B. ROSA
Levin and Joerger 1967

Plate 7, Figure 6

Braarudosphaera rosa LEVIN and JOERGER, 1967, pl. 3, figs. 6-7; Oligocene, Alabama. Not LOCKER, 1972, pl. 12, figs. 5-6.

Braarudosphaera cf. *B. rosa* Levin and Joerger. BYBELL and GARTNER, 1972, pl. 1, figs. 13-14; Eocene, Alabama.

Remarks: Specimens from the Little Stave Creek area closely resemble those of *B. rosa* with a rounded, lobate outline and irregular surface markings. The Eocene specimens are moderately thick and each segment tapers with increasing height, a characteristic not mentioned in the original description. This form is thicker than *Braarudosphaera discula* Bramlette and Riedel and has a more lobate outline.

Occurrence: Braarudosphaera cf. *B. rosa* occurs in the upper middle Eocene (Blow's P14) of Alabama.

BRAARUDOSPHAERA STYLIFER
Troelsen and Quadros 1971
Plate 8, Figures 1-2

Braarudosphaera cf. *B. bigelowi* (Gran and Braarud). BOUCHÉ, 1962, pl. 4, fig. 3; Eocene, France.

Braarudosphaera stylifer TROELSEN and QUADROS, 1971, pl. 1, figs. 8-14; Eocene, Brazil.

Braarudosphaera orthia BYBELL and GARTNER, 1972, pl. 1, figs. 7-12; Eocene, Alabama.

Remarks: Although *B. stylifer* in plan view is similar to *B. bigelowi* (Gran and Braarud), most specimens of *B. stylifer* have a more irregular outline and rounded apices. In some specimens the sides of the pentagon are bowed inward slightly, unlike the straight sides of *B. bigelowi.* The great thickness of *B. stylifer* is a diagnostic feature, and in plan view both pentagonal ends can be viewed by over-focusing and under-focusing with the microscope. On specimens in which the smaller end has been broken off, the irregular fracture surface is visible.

Occurrence: B. stylifer occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus MICRANTHOLITHUS
Deflandre 1950
Type species: *Micrantholithus flos* Deflandre

MICRANTHOLITHUS ALTUS
Bybell and Gartner 1972
Plate 11

Micrantholithus altus BYBELL and GARTNER, 1972, pl. 2, figs. 1-10; Eocene, Alabama.

Remarks: M. altus has three prominent terminal lobes and a base, but *Micrantholithus procerus* Bukry and Bramlette has only shallow, marginal indentations, or none at all, and lacks a base. *M. altus* varies in thickness, but *M. procerus* is always quite thick.

Occurrence: M. altus occurs in the middle Eocene (Blow's P12-P14) of Alabama.

MICRANTHOLITHUS ANGULOSUS
Stradner and Papp 1961
Plate 9, Figures 1-4

Micrantholithus flos angulosus STRADNER, 1959b, text-figs. 61-62.

Micrantholithus angulosus STRADNER and PAPP, 1961, pl. 39, figs. 1-2; Eocene, Mexico. BYBELL and GARTNER, 1972, pl. 2, figs. 11-14; Eocene, Alabama. Not LOCKER, 1972, pl. 12, figs. 9-10.

Remarks: Both *M. angulosus* and *Micrantholithus altus* Bybell and Gartner have varying thicknesses and a trilobate termination for each arm. The former, however, lacks the diagnostic base of *M. altus.*

Occurrence: M. angulosus occurs in the middle Eocene (Blow's P12-P14) of Alabama.

MICRANTHOLITHUS ORNATUS
Sullivan 1965
Plate 7, Figure 7

Micrantholithus ornatus SULLIVAN, 1965, pl. 8, fig. 7; Eocene, California. CHANG, 1969, pl. 1, fig. 12; Eocene, England, India. BÁLDI-BEKE, 1971, pl. 4, fig. 5; Eocene, Hungary. BYBELL and GARTNER, 1972, pl. 1, figs. 15-16; Eocene, Alabama. LOCKER, 1972, pl. 13, figs. 5-6; Eocene, Europe. SHERWOOD, 1974, pl. 7, figs. 5-6; Eocene, Texas.

Remarks: Occasional specimens of this species in the Little Stave Creek area agree closely with the type specimens and other illustrated examples.

Occurrence: M. ornatus occurs in the middle Eocene (Blow's P12-P14) of Alabama.

MICRANTHOLITHUS PROCERUS
Bukry and Bramlette 1969
Plate 9, Figures 5-8

Micrantholithus procerus BUKRY and BRAMLETTE, 1969, pl. 2, figs. 12-15; Eocene, France, Indian Ocean, Louisiana, Alabama, Mexico, Brazil, Blake Plateau. BYBELL and GARTNER, 1972, pl. 3, figs. 1-6; Eocene, Alabama. SHERWOOD, 1974, pl. 7, figs. 11-12; 15-16; Eocene, Texas.

Remarks: Most specimens of *M. procerus* at Little Stave Creek closely resemble those figured by Bukry and Bramlette (1969). A few specimens have narrower arms and no medial indentations, and some specimens may also have two shallow indentations at the tip of each arm. All specimens are thick and resemble a long tapering dome in side view. *M. procerus* has indentations which are very shallow or absent, but *Micrantholithus altus* Bybell and Gartner is characterized by three prominent terminal lobes. In side view these two species are difficult to differentiate with the light microscope, although the numerous peripheral incisions of *M. altus* appear as grooves running from the base to the top of the specimen.

Occurrence: M. procerus occurs in the upper middle Eocene (Blow's P14) of Alabama.

MICRANTHOLITHUS VESPER
Deflandre 1954

Micrantholithus vesper DEFLANDRE *in* GRASSÉ, 1952, invalid. DEFLANDRE and FERT, 1954, pl. 13, fig. 17; text-figs. 115-116. MARTINI, 1958, pl. 1, fig. 3; Eocene, Germany. MANIVIT, 1959, pl. 4, fig. 4; Eocene, Algeria. STRADNER, 1959b, text-fig. 59; Eocene, Miocene, Austria. BÁLDI-BEKE, 1960, pl. 14, fig. 10; Miocene, Hungary. MARTINI, 1960, pl. 8, fig. 5; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 9, fig. 10; Eocene, California. MARTINI, 1961a, in part; pl. 1, fig. 9; Eocene, France. STRADNER and PAPP, 1961, pl. 39, figs. 5-6; Eocene, Austria, Mexico. Not BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 2, fig. 10; Miocene, Czechoslovakia. LOCKER, 1965, pl. 2, fig. 5; Eocene, Germany. SULLIVAN, 1965, in part; pl. 9, fig. 4, 6-7; Eocene, California. HAY, MOHLER, and WADE, 1966, pl. 12, fig. 4; Eocene, USSR. HAY and MOHLER, 1967, pl. 202, figs. 17-19; Eocene, France. HAQ, 1968, pl. 7, fig. 11; Eocene, Germany. LOCKER, 1968, pl. 2, fig. 11; Eocene, Germany. PERCH-NIELSEN, 1971b, pl. 56, fig. 8; Eocene, Denmark. BRATU and GHETA, 1972, pl. 4, fig. 45; Eocene, Czechoslovakia. BYBELL and GARTNER, 1972, pl. 5, figs. 14-15; Eocene, Alabama. LOCKER, 1972, pl. 13, figs. 9-11; Eocene, Europe.

Micrantholithus cf. *M. vesper* Deflandre. BRAMLETTE and RIEDEL, 1954, pl. 38, fig. 8; Eocene, California.

Remarks: Disarticulated specimens of *M. vesper* are common at Little Stave Creek. The ray ends are often broken off and specimens with uniformly broken rays may be confused with *Micrantholithus flos* Deflandre.

Occurrence: M. vesper occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus PEMMA Klumpp 1953
Type species : *Pemma rotundum* Klumpp

PEMMA BALIUM Bybell and Gartner 1972
Plate 8, Figures 3-5

Pemma balium BYBELL and GARTNER, 1972, pl. 4, figs. 7-9; Eocene, Alabama.

Remarks: In *P. balium* the sutural thickenings do not extend all the way to the periphery and there is no continuous rim. *Micrantholithus altus* Bybell and Gartner also has a base, but it is less developed and the arms of this species extend completely to the periphery. The flattened margin of one segment also distinguishes *P. balium* from similar species.

Occurrence: P. balium occurs in the middle Eocene (Blow's P11-P14) of Alabama.

PEMMA BASQUENSE BASQUENSE
(Martini) 1959b
Plate 10, Figures 1-5

Micrantholithus basquensis MARTINI, 1959b, in part; pl. 1, figs. 9-10; 12; Eocene, France. MARTINI, 1960, pl. 8, fig. 2; Oligocene, Germany. MARTINI, 1961a, pl. 5, fig. 46; Eocene, France. SULLIVAN, 1965, pl. 8, figs. 4-5; Eocene, California. SALES, 1966, pl. 6, fig. 4; LEVIN and JOERGER, 1967, pl. 3, fig. 10; Eocene-Oligocene, Alabama. BILGÜTAY, *et al.,* 1969, pl. 5, figs. 1-4; Eocene, France. BUKRY and KENNEDY, 1969, figs. 4-6; Eocene, California. PERCH-NIELSEN, 1971b, pl. 56, fig. 1; Eocene, Denmark.

Micrantholithus basquensis basquensis Martini. BOUCHÉ, 1962, pl. 2, fig. 11; Eocene, France.

Pemma snavelyi BUKRY and BRAMLETTE, 1969, in part; pl. 2, figs. 16-18; Eocene, Louisiana, Alabama, Oregon.

Pemma basquensis (Martini). BÁLDI-BEKE, 1971, in part; pl. 4, figs. 11-14; Eocene, Hungary.

Pemma stradneri (Chang). PERCH-NIELSEN, 1971b, pl. 56, figs. 2-3; Eocene, Denmark.

Pemma rotundum Klumpp. PERCH-NIELSEN, 1971b, pl. 56, figs. 5-6; Eocene, Denmark.

Pemma basquense basquense (Martini). BYBELL and GARTNER, 1972, pl. 3, figs. 7-14; Eocene, Alabama. Not SHERWOOD, 1974, pl. 7, figs 19-20.

Remarks: In *P. basquense basquense* the apices of the pentalith are located midway between the sutures, but the apices of *Pemma stradneri* (Chang) coincide with the sutures. The outline of *P. basquense basquense* is sharp and distinct, but that of *P. stradneri* is indistinct due to the slightly different locations for the marginal projections at various levels on the pentalith.

Occurrence: P. basquense basquense occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

PEMMA BASQUENSE CRASSUM
(Bouché) 1962
Plate 10, Figures 6-9

Micrantholithus basquensis MARTINI, 1959b, in part; pl. 1, fig. 11; Eocene, France. MARTINI, 1960, pl. 8, fig. 7; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 8, figs. 14-15; Eocene, California. LOCKER, 1968, pl. 2, fig. 13; Eocene, Germany.

Pemma rotundum Klumpp. MARTINI, 1959b, pl. 1, fig. 7; Eocene, Germany.

Pemma angulatum MARTINI, 1959b, in part; pl. 1, fig. 3; Eocene, Germany. MARTINI, 1960, pl. 8, fig. 7; Oligocene, Germany. LOCKER, 1972, pl. 13, fig. 13; Eocene, Europe.

Micrantholithus basquensis crassus BOUCHÉ, 1962, pl. 2, figs. 3,9-10; Eocene, France.

Micrantholithus parisiensis parisiensis Bouché. BUKRY and KENNEDY, 1969, fig. 4-8; Eocene, California.

Pemma basquensis (Martini). BÁLDI-BEKE, 1971, in part; pl. 5, figs. 1-2; pl. 4, fig. 9; Eocene, Hungary.

Pemma basquense crassum (Bouché). BYBELL and GARTNER, 1972, pl. 4, figs. 1-6; Eocene, Alabama. SHERWOOD, 1974, pl. 7, figs. 13-14; pl. 8, figs. 2-3; Eocene, Texas.

Micrantholithus angulosus Stradner and Papp. LOCKER, 1972, pl. 12, figs. 9-10; Eocene, Europe.

Pemma bulbosus (Bouché). SHERWOOD, 1974, pl. 7, figs. 17-18; pl. 8, fig. 8; Eocene, Texas.

Pemma major(Bouché). SHERWOOD, 1974, pl. 7, figs. 23-24; Eocene, Texas.

Remarks: P. basquense crassum includes thin, subcircular pentaliths with a discontinuous margin, formed by incisions occurring midway between sutures. The five sutural arms are of varying width and have lateral extensions along the margin which do not overlap and commonly do not touch. Some intermediate forms may be found between this subspecies and *Pemma basquense basquense* (Martini) in which one or more of the lateral, sutural extensions overlap.

Occurrence: P. basquense crassum occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

PEMMA PAPILLATUM Martini 1959a

Pemma papillatum MARTINI, 1959a, text-fig. 1; Eocene, Louisiana, California, Atlantic. STRADNER, 1959b, text-figs. 67, 69; Eocene, Mexico, France. MARTINI, 1961a, pl. 2, fig. 15; Eocene, France. STRADNER and PAPP, 1961, in part; pl. 38, fig. 4-6; Eocene, Mexico. LEVIN, 1965, pl. 42, figs. 7-8; Eocene, Mississippi. GARTNER and SMITH, 1967, pl. 10, figs. 1-3; Eocene, Louisiana. LEVIN and JOERGER, 1967, pl. 3, fig. 11; Eocene, Alabama. BLACK, 1968, pl. 147, fig. 6; Eocene, Mississippi. BÁLDI-BEKE, 1971, pl. 5, figs. 2-3; Eocene, Hungary. BLACK, 1971, pl. 45.3, fig. 25; Eocene, England. HAQ, 1971a, pl. 6, figs. 5-7; pl. 7, figs. 3-4; pl. 8, figs. 2, 4-5; Eocene, Pakistan. BLACK, 1972, pl. 94, figs. 3-4; Eocene, England. BYBELL and GARTNER, 1972, pl. 1, figs. 17-20; Eocene, Alabama. LOCKER, 1972, pl. 13, fig. 14; Eocene, Europe. SHERWOOD, 1974, pl. 7, figs. 21-22; pl. 8, fig. 5; Eocene, Texas.

Micrantholithus floridus CHANG, 1969, pl. 2, figs. 9-11; Eocene, England, India.

Remarks: The knobs along the periphery are diagnostic for this species and facilitate identification even when only a few knobs are present. Identification is often difficult, however, when all of the knobs are missing. The irregular outline, shallow marginal indentations, and a central depression in each segment of *Micrantholithus floridus* Chang indicate that it belongs in the species *P. papillatum.*

Occurrence: P. papillatum occurs in the middle Eocene (Blow's P12-P14) of Alabama.

PEMMA ROTUNDUM Klumpp 1953

Pemma rotundum KLUMPP, 1953, in part; text-figs. 2-3; pl. 16, fig. 3; Eocene, Germany. MARTINI, 1958, pl. 2, fig. 7; Eocene, Germany. MARTINI, 1959b, in part; pl. 1, fig. 6; Eocene, France. STRADNER, 1959b, text-fig. 66; Eocene, Austria. Not MARTINI, 1960, pl. 8, fig. 6. STRADNER and PAPP, 1961, pl. 38, fig. 1; Eocene, Austria. HAY and TOWE, 1962, figs. 4-5; Eocene, France. LOCKER, 1965, pl. 2, fig. 6; Eocene, Germany. SALES, 1966, pl. 6, fig. 5. BÁLDI-BEKE, 1971, pl. 4, fig. 10; Eocene, Hungary. HAQ, 1971a, pl. 7, fig. 10; Eocene, Pakistan. Not PERCH-NIELSEN, 1971b, pl. 56, figs. 5-6. BLACK, 1972, pl. 95, figs. 1-3; Eocene, Britain.

Braarudosphaera sp. STRADNER, 1961, text-fig. 43.

Micrantholithus parisiensis major BOUCHÉ, 1962, pl. 2, figs. 17, 19-21, 25; Eocene, France. CHANG, 1969, pl. 1, figs. 19-20; Eocene, England, India.

Remarks: P. rotundum and occasional circular forms of *Pemma serratum* (Chang) are similar. *P. rotundum* is larger and thinner and has a greater number of irregular peripheral crenulations and a more nearly circular outline. In cross-polarized light *P. rotundum* commonly shows a rim which is not found on *P. serratum.* At Little Stave Creek these two species do not occur together. The circular varieties of *P. serratum* may be an intermediate form between *P. rotundum* and the pentagonal forms of *P. serratum.*

Occurrence: P. rotundum occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

PEMMA SERRATUM (Chang) 1969
Plate 12, Figures 1-6

Micrantholithus serratus CHANG, 1969, pl. 1, figs. 5-6, 15-16; Eocene, England, India.

Pemma serratum (Chang). BYBELL and GARTNER, 1972, pl. 5, figs. 5-13; Eocene, Alabama.

Remarks: The margin of *P. serratum* is not as well defined as that of *Pemma basquense basquense* (Martini) because the crenulations have a different spacing in the several layers that make up the pentalith, while in *P. basquense basquense* the crenulations are aligned. In *P. serratum* the apices of the pentagon coincide with the sutures, but in *P. basquense basquense* the apices are located between the sutures.

Occurrence: P. serratum occurs in the upper middle Eocene (Blow's P14) of Alabama.

PEMMA STRADNERI (Chang) 1969
Plate 12, Figures 7-8

Pemma snavelyi BUKRY and BRAMLETTE, 1969, in part; pl. 2, fig. 19; Eocene, Louisiana, Alabama, Oregon.

Micrantholithus stradneri CHANG, 1969, pl. 1, figs. 1-4; Eocene, England, India.

Pemma stradneri (Chang). Not PERCH-NIELSEN, 1971b, pl. 56, figs. 2-3. BYBELL and GARTNER, 1972, pl. 5, figs. 1-4; Eocene, Alabama.

Pemma basquense basquense (Martini). SHERWOOD, 1974, pl. 7, figs. 19-20; Eocene, Texas.

Remarks: Most specimens of *P. stradneri* from the Little Stave Creek area agree closely with those figured by Chang (1969) and by Bukry and Bramlette (1969). A few specimens have a distinct double projection between the sutures due to the incomplete overlap of adjacent sutural thickenings. *P. stradneri* is similar to *Pemma serratum* (Chang) and they probably are closely related. *P. stradneri* has more prominent extensions at the apices of the pentagon than *P. serratum,* but their basic structures seem to be similar.

Occurrence: P. stradneri occurs in the middle Eocene (Blow's P12-P14) of Alabama.

PEMMA sp. A
Plate 7, Figure 8

Remarks: In this form the apices of the pentagon coincide with the intersection of the sutures and the margin. The sides of the pentagon are nearly straight and tend to bow inward slightly. Each segment has a very small circular pore halfway between the center and the margin and quite close to a suture line. Specimens are somewhat thicker at the suture and the center, thinning toward the margin and between sutures. This species is similar in outline to *Micrantholithus flos* Deflandre, but the latter lacks the small pores, has a more localized thickening near the sutures, and a more irregular periphery.

Occurrence: Pemma sp. A occurs in the upper middle Eocene (Blow's P14) of Alabama.

Genus PENTASTER Bybell and Gartner
Type species: *Pentaster lisbonensis* Bybell and Gartner

PENTASTER LISBONENSIS
Bybell and Gartner 1972
Plate 13, Figures 1-2

Pentaster lisbonensis BYBELL and GARTNER, 1972, pl. 4, figs. 10-14; Eocene, Alabama.

Remarks: This distinctive and ornate species has no known close relative among the Braarudosphaeraceae and is always easily indentified.

Occurrence: P. lisbonensis occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family COCCOLITHACEAE Kamptner 1928
Genus CAMPYLOSPHAERA Kamptner 1963
Type species: *Campylosphaera bramletti* Kamptner

CAMPYLOSPHAERA DELA
(Bramlette and Sullivan) 1961
Plate 14, Figures 4-6

Coccolithites delus BRAMLETTE and SULLIVAN, 1961, pl. 7, figs. 1-2; Paleocene-Eocene, California. SULLIVAN, 1964, pl. 1, figs. 8-9; Paleocene, California.

Coccolithites aff. *C. delus* BRAMLETTE and SULLIVAN, 1961, pl. 7, figs. 3-4; Eocene, California. SULLIVAN, 1964, pl. 1, figs. 7; Paleocene, California.

Cyathosphaera crux (Deflandre and Fert). HAY and TOWE, 1962, pl. 2, fig. 1; Eocene, France.

Coccolithus delus (Bramlette and Sullivan). HAQ, 1967, pl. 6, fig. 7; Eocene, Pakistan. PERCH-NIELSEN, 1967, pl. 1, figs. 1-3; Eocene, Denmark.

Campylosphaera dela (Bramlette and Sullivan). HAY and MOHLER, 1967, pl. 198, fig. 14; Paleocene, France. BUKRY and KENNEDY, 1969, fig. 3-1; Eocene, California.

Genus ind. sp. *delus* (Bramlette and Sullivan). REINHARDT, 1967, pl. 2, fig. 16; Eocene, Germany.

Cruciplacolithus delus (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 13, figs. 7-8; Eocene, Denmark. PERCH-NIELSEN, 1972, pl. 4, fig. 2; Paleocene, Atlantic. SHERWOOD, 1974, pl. 2, figs. 9-10; pl. 3, figs. 7-10; Eocene, Texas.

Chiasmolithus delus (Bramlette and Sullivan). LOCKER, 1972, pl. 9, fig. 2; Paleocene, Europe.

Remarks: C. dela has a large open central area with two crossbars, one aligned with the long axis and the other aligned with the short axis of the shields. The proximal shield forms a broad square arch and the transverse axis serves as the axis of curvature. The distal shield similarly bends along the transverse axis, but it also arches in the opposite direction along the longitudinal axis. *C dela* and *Campylosphaera eodela* Bukry and Percival have similar shield constructions, but *C. dela* is larger, has a more rectangular outline and a larger central area.

Occurrence: C. dela occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus CHIASMOLITHUS
Hay, Mohler, and Wade 1966
Type species: *Tremalithus oamaruensis* Deflandre

CHIASMOLITHUS GRANDIS
(Bramlette and Riedel) 1954
Plate 23, Figure 3

"coccolith" JUKES-BROWN and HARRISON, 1892, text-fig. 7.

Coccolithus cretaceus DEFLANDRE *in* GRASSÉ, 1952, text-fig. 360D; Eocene, France.

Coccolithus grandis BRAMLETTE and RIEDEL, 1954, pl. 38, fig. 1; Eocene, Barbados, California. DEFLANDRE and FERT, 1954, text-fig. 48; Eocene, France. BRAMLETTE and SULLIVAN, 1961, pl. 2, figs. 1-3; Eocene, California. BACHMANN, PAPP and STRADNER, 1963, pl. 23, figs. 1-3; Austria. BYSTRICKÁ, 1963, pl. 1, figs. 4-6; Eocene, Czechoslovakia. SULLIVAN, 1964, pl. 2, figs. 1-2; Paleocene, California.

Coccolithos cf. *C. grandis* Bramlette and Riedel. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 4, fig. 11; Eocene, Czechoslovakia.

Chiasmolithus grandis (Bramlette and Riedel). RADOMSKI, 1968, pl. 44, figs. 3-4; Paleocene-Eocene, Poland. BILGÜTAY, *et al.*, 1969, pl. 2, figs. 3-4; Eocene, France. BUKRY and KENNEDY, 1969, fig. 3-2; Eocene, California. GARTNER, 1970, fig. 11-3; fig. 14; Eocene. BÁLDI-BEKE, 1971, pl. 3, figs. 1,4; Eocene, Hungary. BUKRY, 1971, pl. 5, fig. 5; Eocene, Pacific. PERCH-NIELSEN, 1971b, pl. 9, figs. 1-2; pl. 10, fig. 4; pl. 60, figs. 1-2; Eocene, Denmark. BRATU and GHETA, 1972, pl. 2, figs. 16-17; Paleocene-Eocene, Czechoslovakia. LOCKER, 1972, pl. 9, figs. 1-2; Eocene, Europe. PERCH-NIELSEN, 1972, pl. 3, fig. 4; Eocene, Atlantic. SHERWOOD, 1974, pl. 3, figs. 1-2; Eocene, Texas.

Chiasmolithus expansus (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 9, fig. 3; Eocene, Denmark.

Remarks: This large distinctive species has toothlike projections which extend into the central opening between the crossbars. These bars resemble two broad U's which have a common base. There is a fine grillwork in the central opening that on many specimens is partially or completely broken out. This grillwork is visible only with the electron microscope.

Occurrence: C. grandis occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

CHIASMOLITHUS SOLITUS
(Bramlette and Sullivan) 1961

Plate 14, Figures 1-2

Coccolithus solitus BRAMLETTE and SULLIVAN, 1961, pl. 2, fig. 14; Eocene, California. SULLIVAN, 1964, pl. 1, fig. 13; Paleocene, California.

Chiasmolithus solitus (Bramlette and Sullivan). Not LOCKER, 1967, pl. 1, figs. 5-6. RADOMSKI, 1968, pl. 45, figs. 13-14; Paleocene-Eocene, Poland. GARTNER, 1970, fig. 16; Eocene. BÁLDI-BEKE, 1971, pl. 3, figs. 2-3; Eocene, Hungary. MARTINI, 1971a, pl. 2, figs. 10-11; Eocene. PERCH-NIELSEN, 1971b, pl. 11, fig. 1; pl. 12, fig. 1-5; pl. 13, fig. 5; pl. 14, fig. 11; pl. 60, figs. 19-20; Oligocene, Denmark. LOCKER, 1972, pl. 9, figs. 3-4; Eocene, Europe. SHERWOOD, 1974, pl. 1, figs. 15-16; Eocene, Texas.

Remarks: The central arm of *C. solitus* is spanned by an X-shaped structure which is formed by two S-shaped bars. *Chiasmolithus bidens* (Bramlette and Sullivan) is similar, cut lacks the diagnostic curve to the crossbars.

Occurrence: C. solitus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

CHIASMOLITHUS TITUS Gartner 1970
Plate 14, Figure 3

Coccolithus consuetus Bramlette and Sullivan. LEVIN and JOERGER, 1967, pl. 1, fig. 1; Eocene, Alabama.

Chiasmolithus titus GARTNER, 1970, fig. 17; Eocene. SHERWOOD, 1974, pl. 1, figs. 19-20; Eocene, Texas.

Remarks: In *C. titus* the central area is spanned by two crossbars which form an "X." One bar is straight and diagonal across the area and the other bar is S-shaped. This species is somewhat smaller than most species of the genus and the shape of the crossbar is diagnostic.

Occurrence. C. titus occurs in the middle Eocene (Blow's P11-P14) of Alabama.

Genus COCCOLITHUS Schwarz 1894
Type species: *Coccolithus oceanicus* Schwarz

COCCOLITHUS CRASSIPONS Bouché 1962
Plate 22, Figure 6

Coccolithus crassipons BOUCHÉ, 1962, pl. 1, fig. 14; text-fig. 3; Eocene, France. LOCKER, 1972, pl. 6, figs. 5-6; Eocene, Europe.

Coccolithus staurion Bramlette and Sullivan. REINHARDT, 1967, pl. 4, fig. 3; Eocene, Germany.

Remarks: C. crassipons is similar to *Birkelundia jugata* (Perch-Nielsen), but the latter has a larger central opening and a straight crossbar, which is not distinct optically from the rest of the placolith.

Occurrence: C. crassipons occurs in the lower middle Eocene (Blow's P11) of Alabama.

COCCOLITHUS SARSIAE Black 1962
Plate 15, Figure 6

Coccolithus sarsiae BLACK, 1962, pl. 8, fig. 2; pl. 9, figs. 2-6; Upper Tertiary, Atlantic. HAY, MOHLER, and WADE, 1966, pl. 1, figs. 2-5; Eocene, USSR. CLOCCHIATTI, 1971, pl. 3, fig. 2; Miocene-Pliocene, Africa, SHERWOOD, 1974, pl. 1, figs. 5-7; pl. 2, fig. 3; Eocene, Texas.

Coccolithus aff. *C. sarsiae* Black. IACCARINO and FOLLINI, 1970, not pl. 41, fig. 28.

Coccolithus cf. *C. sarsiae* BLACK, 1971, pl. 45.1 (6); Oligocene, Denmark.

Remarks: C. sarsiae has a narrow, elliptical central perforation. *Coccolithus pelagicus* (Wallich) normally has two small central perforations. There are fewer shield segments on *C. sarsiae* than on *C. pelagicus* and individual segments can be discerned with the light microscope. In phase contrast the distal shield is dark and distinct and it exhibits low birefringence in cross-polarized light.

Occurrence: C. sarsiae occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

COCCOLITHUS sp. A
Plate 22, Figure 7

Ericsonia muiri (Black). SHERWOOD, in part; pl. 3, figs. 21-22; Eocene, Texas.

Remarks: In this species the distal and the proximal shield are almost the same size and the elliptical central area is large. Only the proximal shield and collar are bright in cross-polarized light and individual shield segments are visible with a light microscope. *Coccolithus* sp. A is similar to *Coccolithus pelagicus* (Wallich), but has a much larger central area and fewer shield segments.

Occurrence: Coccolithus sp. A occurs only in the upper middle Eocene (Blow's P14) of Alabama.

Genus CRUCIPLACOLITHUS
Hay and Mohler 1967
Type species : *Heliorthus tenuis* Stradner

CRUCIPLACOLITHUS STAURION
(Bramlette and Sullivan) 1961
Plate 20, Figure 7

Coccolithus staurion BRAMLETTE and SULLIVAN, 1961, pl. 2, figs. 5-6; Eocene, California, Texas, France. BENEŠOVÁ and HANZLÍKOVÁ, 1962, in part; pl. 3, fig. 3; Miocene, Czechoslovakia. SULLIVAN, 1964, pl. 3, figs. 2-3; Paleocene, California. SULLIVAN, 1965, pl. 3, fig. 7; Eocene, California. Not REINHARDT, 1967, pl. 4, fig. 3; Eocene, Germany.

Coccolithus aff. *C. staurion* Bramlette and Sullivan. HAQ, 1967, pl. 6, fig. 9; Eocene, Pakistan.

Coccolithus cf. *C. staurion* Bramlette and Sullivan. PERCH-NIELSEN, 1967, pl. 1, figs. 4-5, 12-13; Eocene, Denmark.

Chiasmolithus staurion (Bramlette and Sullivan). Not BUKRY and KENNEDY, 1969, figs. 3-3, 3-4. LOCKER, 1972, pl. 9, figs. 9-10; Eocene, Europe.

Cruciplacolithus staurion (Bramlette and Sullivan). GARTNER, 1971, Eocene, Blake Plateau. SHERWOOD, 1974, pl. 3, figs. 5-6; Eocene, Texas.

Birkelundia staurion (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 15, figs. 1, 3-6; pl. 61, figs. 16-17; Eocene, Denmark.

Remarks: C. staurion is distinguished from other similar placoliths by its large size and very slender crossbars.

Occurrence: C. staurion occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus CYCLOCOCCOLITHINA
Wilcoxon 1970
Type species: *Coccosphaera leptoporas*
Murray and Blackman

CYCLOCOCCOLITHINA FORMOSA
(Kamptner) 1963
Plate 16, Figures 4-5

Cyathosphaera diaphragma HAY and TOWE, 1962, in part; pl. 6, figs. 2, 5-6; Eocene, France.

Cyclococcolithus formosus KAMPTNER, 1963, pl. 2, fig. 8, Eocene, Pacific. REINHARDT, 1966, pl. 21, fig. 8; Eocene, Germany. REINHARDT, 1967, pl. 1, figs. 3-4; 7-8; pl. 6, figs. 3, 6; Eocene, Germany. RADOMSKI, 1968, pl. 44, figs. 7-8; Eocene-Oligocene, Poland. MARTINI, 1969a, pl. 1, figs. 1-2; Oligocene, Switzerland. BÁLDI-BEKE, 1971, pl. 1, figs. 18-19; Eocene, Hungary. MARTINI, 1971a, pl. 3, figs. 1-2; Eocene-Oligocene. POZARYSKA and LOCKER, 1971, pl. 2, figs. 11-12; Eocene, Poland. ROTH, BAUMANN, and BERTOLINO, 1971, figs. 6-9. BRATU and GHETA, 1972, pl. 4, figs. 55-56; Eocene, Czechoslovakia. LOCKER, 1972, pl. 7, figs. 7-8; Eocene, Europe.

Coccolithus lusitanicus BLACK, 1964, pl. 50, figs. 1-2; Eocene, Atlantic.

Cyclococcolithus lusitanicus (Black). HAY, MOHLER, and WADE, 1966, pl. 7, figs. 3-6; Eocene, USSR. BRAMLETTE and WILCOXON, 1967, pl. 3, figs. 16-17; Eocene-Oligocene, Trinidad. BUKRY and KENNEDY, 1969, pl. 3, fig. 5; Eocene, California.

Cyclococcolithus annulatus REINHARDT, 1966, pl. 1, figs. 3-4; text-fig. 2; Eocene, Germany.

Cyclococcolithus orbis GARTNER and SMITH, 1967, pl. 4, figs. 1-3; Eocene, Louisiana.

Coccolithus diaphragma (Hay and Towe). HODSON and WEST, 1970, pl. 1, fig. 7; Eocene, England.

Ericsonia formosa (Kamptner). HAQ, 1971a, pl. 4, figs. 7-8; Eocene, Pakistan. HAQ, 1971b, in part; pl. 7, figs. 11-12; pl. 9, figs. 5-6; pl. 10, fig. 8; pl. 16, fig. 2; Eocene, Germany.

Ericsonia cf. *E. formosa* (Kamptner). HAQ, 1971a, pl. 1, fig. 1; pl. 4, fig. 6; pl. 5, figs. 11-12; Paleocene, Persia, Pakistan.

Ericsonia alternans Black. PERCH-NIELSEN, 1971b, pl. 1, figs. 9-11; Eocene, Denmark.

Cyclococcolithina formosa (Kamptner). SHERWOOD, 1974, pl. 1, figs. 21-22; pl. 4, fig. 2; Eocene, Texas.

Remarks: C. formosa has a wide collar and a small, circular central perforation. The collar and shield elements are joined distally along a serrate line. In cross-polarized light only the proximal shield is bright, a feature which distinguishes this species from other circular placoliths.

Occurrence: C. formosa occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

CYCLOCOCCOLITHINA RETICULATA
(Gartner and Smith) 1967
Plate 16, Figures 1-3

Cyclococcolithus reticulatus GARTNER and SMITH, 1967, pl. 5, figs. 1-4; Eocene, Louisiana.

Cyclococcolithus cf. *C. reticulatus* Gartner and Smith. RADOMSKI, 1968, pl. 44, figs. 11-12; Eocene, Poland.

Cyclococcolithus neogammation Bramlette and Wilcoxon. BÁLDI-BEKE, 1971, in part; pl. 1, fig. 21; Eocene, Hungary.

Cribrocentrum reticulatum (Gartner and Smith). PERCH-NIELSEN, 1971b, pl. 25, figs. 4-9; Eocene, Denmark.

Reticulofenestra dictyoda dictyoda (Deflandre and Fert). LOCKER, 1972, pl. 8, figs. 1-2; Eocene, Europe.

Remarks: The central area of *C. reticulata* is pierced by numerous circular pores and has a distinctive pattern in cross-polarized light. The shield sutures are almost radial and overlap slightly. Each shield segment normally forms a point at the periphery of the shields. Pores on some specimens are slit-like, the slits radiating outward from the central area. *C. reticulata* is similar to *Reticulofenestra dictyoda* (Deflandre and Fert), but it has fewer segments per shield and fewer, more rounded perforations.

Occurrence: C. reticulata occurs in the middle Eocene (Blow's P11-P14) of Alabama.

Genus ERICSONIA Black 1964
Type species: *Ericsonia occidentalis* Black

ERICSONIA FENESTRATA
(Deflandre and Fert) 1954
Plate 21, Figure 7

Discolithus fenestratus DEFLANDRE and FERT, 1954, pl. 11, fig. 25; text-fig. 52; Oligocene, New Zealand.

Ericsonia fenestrata (Deflandre and Fert). HAQ, 1968, in part; pl. 1, figs. 11-12; Eocene, Germany. STRADNER and EDWARDS, 1968, in part; pl. 10, fig. 4; pl. 11, figs. 1-4; Eocene, New Zealand. LOCKER, 1970, figs. 1-2; Paleocene-Eocene, Germany. ROTH, 1970, pl. 1, fig. 6; Oligocene, Alabama, Italy, Trinidad; Eocene, Italy. HAQ, 1971b, in part; pl. 3, fig. 9; Eocene, Germany. PERCH-NIELSEN, 1971b, in part; pl. 5, figs. 4-6; pl. 6, figs. 10-11; Eocene, Denmark.

Ericsonia? singularis PERCH-NIELSEN, 1971b, pl. 7, figs. 1-3, 5; Eocene, Denmark, Germany.

Ericsonia cf. *E. fenestrata* (Deflandre and Fert). PERCH-NIELSEN, 1971b, in part; pl. 6, figs. 1-2, 5; Eocene, Denmark.

Remarks: This placolith has more than two rows of numerous, small, circular pores in the central area and curved shield segments. Specimens with only one ring of pores belong in the species *Ericsonia subdisticha* (Roth and Hay) and *Ericsonia quadriperforata* Roth has only four pores.

Occurrence: E. fenestrata occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus MARKALIUS
Bramlette and Martini 1964
Type species: *Cyclococcolithus leptoporus* Murray and Blackman var. *inversus* Deflandre

MARKALIUS INVERSUS
(Deflandre) 1954

Plate 15, Figure 7

Cyclococcolithus leptoporus var. *inversus* Deflandre. DEFLANDRE and FERT, 1954, in part; pl. 9, figs. 4-5; Oligocene, New Zealand.

Markalius inversus (Deflandre). EDWARDS, 1966, fig. 26; table 1. IACCARINO and FOLLINI, 1970, pl. 40, fig. 36; Cretaceous-Paleocene, Italy. MARTINI, 1971a, pl. 1, figs. 1-2, Cretaceous-Oligocene. PERCH-NIELSEN, 1971b, pl. 2, figs. 6-7; Eocene, Denmark. PERCH-NIELSEN, 1972, pl. 5, figs. 4, 6; Eocene, Atlantic.

Cyclococcolithus inversus (Deflandre). HAY, MOHLER, and WADE, 1966, pl. 7, fig. 2; Eocene, USSR. REINHARDT, 1967, pl. 1, figs. 9, 13; pl. 2, fig. 11; pl. 6, fig. 4; Eocene, Germany. HAQ, 1968, in part; pl. 8, fig. 1; Eocene, Germany. STRADNER and EDWARDS, 1968, pls. 26-27; Eocene, New Zealand. MARTINI, 1969b, pl. 1, figs. 3-4; Oligocene, Switzerland. HAQ, 1971b, pl. 9, figs. 1-3; pl. 18, figs. 3-4; Eocene, Germany. HAQ, 1971c, pl. 19, figs. 6, 8; Oligocene, Syria. LOCKER, 1972, pl. 7, fig. 4; Eocene, Europe.

Cyclococcolithus sp. LEVIN and JOERGER, 1967, pl. 1, figs. 10-11; Eocene, Alabama.

Markalius cf. *M. inversus* (Deflandre). BLACK, 1968, pl. 144, fig. 6; Cretaceous, Britain.

Cyclococcolithus astroporus Stradner. RADOMSKI, 1968, pl. 46, figs. 1-2; Eocene, Poland.

Remarks: M. inversus has curved distal shield segments, but the segments of the proximal shield are almost straight. Small, radiating wedge-shaped segments entirely fill the central area and in cross-polarized light these segments have an X-shaped extinction pattern which does not continue out onto the shield area. Gartner (1971) separates *Markalius inversus* and *Markalius astroporus* (Stradner) according to the number of shield segments. *M. inversus* has 27-18 elements per shield and Little Stave Creek specimens fall within this designation.

Occurrence: M. inversus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus RETICULOFENESTRA Hay, Mohler, and Wade 1966

Type species: *Reticulofenestra caucasica* Hay, Mohler, and Wade

RETICULOFENESTRA BISECTA (Hay, Mohler, and Wade) 1966

Plate 15, Figure 5

Syracosphaera bisecta HAY, MOHLER, and WADE, 1966, pl. 10, figs. 1-6; Eocene, USSR.

Coccolithus pseudocarteri HAY, MOHLER, and WADE, 1966, in part; pl. 2, figs. 2-4; Eocene, USSR.

Coccolithus bisectus (Hay, Mohler, and Wade). BRAMLETTE and WILCOXON, 1967, pl. 4, figs. 11-13; Oligocene, Trinidad. RADOMSKI, 1968, pl. 45, figs. 19-20; Eocene, Poland. BUKRY, 1971, pl. 5, fig. 2; pl. 6, fig. 1; Eocene, Pacific. CLOCCHIATTI, 1971, pl. 3, figs. 3-5; fig. 2; Eocene-Oligocene, Africa. PERCH-NIELSEN, 1972, pl. 6, figs. 4, 6; Oligocene, Atlantic.

Coccolithus stavensis LEVIN and JOERGER, 1967, pl. 1, fig. 7; Eocene-Oligocene, Alabama.

Stradnerius dictyodus (Deflandre and Fert). HAQ, 1968, in part; pl. 2, figs. 7-8; pl. 3, figs. 4-8; Eocene, Germany.

Reticulofenestra dictyoda (Deflandre and Fert). STRADNER and EDWARDS, 1968, in part; pl. 13, figs. 1-2; pl. 14, figs. 2-5; Eocene, New Zealand.

Dictyococcites dictyodus (Deflandre and Fert). MARTINI, 1969b, in part; pl. 1, figs. 5-6; pl. 4, fig. 40; Oligocene.

Reticulofenestra bisecta (Hay, Mohler, and Wade). ROTH, 1970, pl. 3, fig. 6; Oligocene. POZARYSKA and LOCKER, 1971, pl. 2, figs. 15-16; Eocene, Poland. LOCKER, 1972, pl. 8, figs. 5-6; Eocene, Europe.

Dictyococcites bisectus (Hay, Mohler, and Wade). BUKRY and PERCIVAL, 1971, pl. 2, figs. 12-13; Eocene-Oligocene, Gulf Coast, Europe, Atlantic, Pacific.

Reticulofenestra placomorpha (Kamptner). BRATU and GHETA, 1972, pl. 5, figs. 63-64; Eocene, Czechoslovakia.

Remarks: In this subcircular placolith the central area is filled with tabular crystals which radiate out from a medial line. In some specimens these crystals do not meet and there is a central slit or two small pores. The numerous shield segments overlap slightly and there is little or no bending along the suture lines. In cross-polarized light both shields and the central area are bright, the individual shield segments are not visible, and the extinction lines are somewhat obscure in the center of the placolith. In phase contrast, specimens are very dim, a typical feature of the genus *Reticulofenestra.*

Occurrence: R. bisecta occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

RETICULOFENESTRA CALLIDA (Perch-Nielsen) 1971b n. comb.

Plate 21, Figure 8

Dictyococcites callidus PERCH-NIELSEN, 1971, pl. 22, figs. 1-4; pl. 23, fig. 3; pl. 61, figs. 30-31; Eocene, Denmark.

Reticulofenestra scissura Hay, Mohler, and Wade. HAQ, 1971b, in part; pl. 15, figs. 2-4; Oligocene, Germany.

Remarks: This placolith has a diagnostic elliptical knob in the central area. Slender radiating struts connect this knob to the collar. Each collar crystal merges into a strut such that they occur at several levels on the placolith. The distal shield has two separate layers of segments, one much smaller and above the other. Each shield segment forms a point at its periphery. In cross-polarized light the struts of the central area are visible and are distinctive for this species.

Occurrence: R. callida occurs in the upper middle Eocene (Blow's P14) of Alabama.

RETICULOFENESTRA HILLAE Bukry and Percival 1971

Plate 15, Figure 4

Reticulofenestra hillae BUKRY and PERCIVAL, 1971, pl. 6, figs. 1-3; Eocene-Oligocene, Atlantic, Pacific, Gulf Coast.

Remarks: This elliptical placolith resembles *Reticulofenestra umbilica* (Levin), but is smaller and more uniformly-sized, with a thicker collar and a smaller central area. It possesses the typical *Reticulofenestra* extinction pattern in cross-polarized light and is dim in phase contrast.

Occurrence: R. hillae occurs in the upper middle Eocene (Blow's P14) of Alabama.

RETICULOFENESTRA UMBILICA (Levin) 1965

Plate 15, Figures 1-3

Coccolithus sp. BOUCHE, 1962, pl. 1, figs. 17, 21-22; Eocene, France.

Coccolithus placomorphus (Kamptner). STRADNER, 1964, text-fig. 10; Eocene, Austria.

Coccolithus umbilicus LEVIN, 1965, pl. 41, fig. 2; Eocene, Mississippi. GARTNER and SMITH, 1967, pl. 1, figs. 3-4; pl. 2, figs. 1-3; Eocene, Louisiana.

Reticulofenestra caucasica HAY, MOHLER, and WADE, 1966, in part; pl. 3, figs. 1-2; pl. 2, fig. 5; pl. 4, figs. 1-2; Eocene, USSR. PERCH-NIELSEN, 1967, pl. 1, figs. 9-11; Eocene, Denmark.

Apertapetra samodurovi HAY, MOHLER, and WADE, 1966, in part; pl. 6, figs. 1-3; Eocene, USSR.

Apertapetra umbilicus (Levin). BRAMLETTE and WILCOXON, 1967, pl. 5, figs. 1-2; Oligocene, Trinidad. LEVIN and JOERGER, 1967, pl. 1, fig. 9; Eocene-Oligocene, Alabama. RADOMSKI, 1968, pl. 45, figs. 1-2; Eocene, Poland.

Coccolithus coenurus REINHARDT, 1967, pl. 2, figs. 2, 6; pl. 5, fig. 5; Eocene, Germany.

Coccolithus pelicomorphus REINHARDT, 1967, pl. 1, figs. 10-11; pl. 5, fig. 10; Eocene, Germany.

Reticulofenestra umbilica (Levin). MARTINI and RITZKOWSKI, 1968, pl. 1, figs. 11-12; Eocene, Germany. BUKRY, 1971, pl. 6, fig. 6; Eocene, Pacific. HAQ, 1971b, pl. 7, figs. 5-6; pl. 10, figs. 12-13; Eocene-Oligocene, Germany. MARTINI, 1971a, pl. 2, figs. 18-19; Eocene-Oligocene. PERCH-NIELSEN, 1971b, pl. 21, fig. 7; pl. 23, figs. 1-2; pl. 24, figs. 1-3; Eocene, Denmark. PERCH-NIELSEN, 1972, pl. 9, fig. 6; Eocene, Atlantic. SHERWOOD, 1974, pl. 3, figs. 3-4; Eocene, Texas.

Reticulofenestra placomorpha (Kamptner). STRADNER and EDWARDS, 1968, in part; pl. 19; pl. 20; pls. 23-24; pl. 25, figs. 1-2; Eocene-Miocene, New Zealand. LOCKER, 1972, pl. 8, figs. 7-8; pl. 17, fig. 5; Eocene.

Reticulofenestra cf. *R. umbilica* (Levin). Not HAQ, 1971c, pl. 13, figs. 13-14.

Ericsonia samodurovi (Hay, Mohler, and Wade). HAQ, 1971c, pl. 13, fig. 12; Oligocene, Syria.

Reticulofenestra samodurovi (Hay, Mohler, and Wade). LOCKER, 1972, pl. 17, figs. 4, 6; Eocene.

Remarks: This elliptical placolith has a large central area that is covered with a fine grid at the level of the proximal shield. The central part of the grid has numerous, small, circular pores, which elongate into slits near the margin. The numerous segments of each shield are indiscernible under the light microscope. The collar appears as a ring of overlapping, square elements on the distal shield. In cross-polarized light this species exhibits the typical *Reticulofenestra* extinction pattern: both shields and the collar exhibit birefringence. There is considerable size variation within this species.

Occurrence: R. umbilica occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family DISCOASTERACEAE
Tan Sin Hok 1927

Genus DISCOASTER Tan Sin Hok 1927

Type species: *Discoaster pentaradiatus* Tan Sin Hok

DISCOASTER BARBADIENSIS
Tan Sin Hok 1927
Plate 17, Figure 3

"Krystaldrusen" EHRENBERG, 1854, pl. 24, figs. 67; pl. 25, figs. 13-15.

"Crystalloids" JUKES-BROWN and HARRISON, 1892, text-figs. 4-6.

Discoaster barbadiensis TAN SIN HOK, 1927. BRAMLETTE and RIEDEL, 1954, pl. 39, fig. 5; Eocene, Barbados, California, Saipan. GARDET, 1955, pl. 7, fig. 68; Neogene, Algeria. MARTINI, 1958, pl. 5, fig. 24; Eocene, Germany. MANIVIT, 1959, pl. 10, figs. 1-5; Eocene, Africa, France. BÁLDI-BEKE, 1960, pl. 14, fig. 16; Oligocene-Miocene. MARTINI, 1960, pl. 8, fig. 10; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 11, fig. 2; Eocene, California. STRADNER and PAPP, 1961, pl. 2, fig. 1; pl. 3, figs. 7, 17; Miocene, Czechoslovakia. BOUCHÉ, 1962, pl. 3, figs. 1-4; Eocene, France. Not HAY and TOWE, 1962, pl. 10, figs. 3, 5. STRADNER, 1962a, pl. 2, figs. 6-7; Eocene, Yugoslavia. BYSTRICKÁ, 1963, pl. 2, figs. 1-4; Eocene, Czechoslovakia. SULLIVAN, 1964, pl. 10, figs. 1-2; Paleocene, California. LEVIN, 1965, pl. 43, fig. 1; Eocene, Mississippi. LOCKER, 1965, pl. 1, fig. 1; Eocene, Germany. GARTNER and SMITH, 1967, pl. 12, figs. 1-3; Eocene, Louisiana. HAY, *et al.*, 1967, pl. 1, figs. 9-11; Eocene, Barbados. LEVIN and JOERGER, 1967, pl. 3, fig. 17; Eocene, Alabama. RADOMSKI, 1968, pl. 47, fig. 11; Eocene, Poland. BILGÜTAY, *et al.*, 1969, pl. 3, fig. 4; Eocene, France. BYSTRICKÁ, 1969, pl. 59, figs. 2-4; Eocene, Czechoslovakia. HODSON and WEST, 1970, pl. 1, fig. 5; Eocene, England. IACCARINO and FOLLINI, 1970, pl. 43, figs. 4-8; Paleocene, Italy. BÁLDI-BEKE, 1971, pl. 6, figs. 5-6; Eocene, Hungary. BUKRY, 1971, pl. 5, fig. 2; Eocene, Pacific. CLOCCHIATTI, 1971, pl. 30, figs. 1-4; Miocene-Pliocene, Africa. HAQ, 1971a, pl. 8, figs. 6-7; pl. 10, figs. 11-12; Paleocene, Persia. PERCH-NIELSEN, 1971b, pl. 51, fig. 5; Eocene, Denmark. LOCKER, 1972, pl.

14, figs. 1-2; pl. 17, fig. 3; Eocene, Europe. BUKRY, 1973, pl. 4, figs. 4-5; Eocene, Pacific. SHERWOOD, 1974, pl. 9, fig. 12; pl. 10, fig. 1; Eocene, Texas.

Heliodiscoaster barbadiensis (Tan Sin Hok). DEFLANDRE, 1934, text-figs. 22-23, 29-31. DEFLANDRE *in* GRASSÉ, 1952, text-fig. 362-V,V'; Miocene.

Actiniscus ilvensis PARÉJAS, 1934, text-fig. 29; Cretaceous, Elba.

Actiniscus decapetalus PARÉJAS, 1934, text-figs. 30-31; Cretaceous, Elba.

Actiniscus vernandi PARÉJAS, 1934, text-fig. 32; Cretaceous, Elba.

Remarks: D. barbadiensis is a robust asterolith with nine to fourteen rays which are connected for most of their length. Specimens are basket-shaped with a slender stem in the center. Ray terminations can be either rounded or pointed. The species lacks the concentric banding of *Discoaster elegans* Bramlette and Sullivan.

Occurrence: D. barbadiensis occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOASTER ELEGANS
Bramlette and Sullivan 1961

Plate 17, Figures 1-2

Discoaster elegans BRAMLETTE and SULLIVAN, 1961, pl. 11, fig. 16; Eocene, California. STRADNER and PAPP, 1961, pl. 28, fig. 16; text-fig. 9/8; Eocene, Mexico. BOUCHÉ, 1962, pl. 3, figs. 5-7; text-figs. 18-20; Eocene, France. BYSTRICKÁ, 1963, pl. 3, figs. 2-6. SULLIVAN, 1964, pl. 10, figs. 5-6; Paleocene, California. BUKRY and KENNEDY, 1969, figs. 3-7; Eocene, California. BYSTRICKÁ, 1969, pl. 59, figs. 7-10; Eocene, Czechoslovakia. BÁLDI-BEKE, 1971, pl. 6, fig. 9; Eocene, Hungary. LOCKER, 1972 pl. 14, figs. 12-14; pl. 15, fig. 1; Eocene, Europe. PERCH-NIELSEN, 1971b, pl. 51, figs. 2-3; Eocene, Denmark. SHERWOOD, 1974, pl. 10, figs. 2, 4; pl. 11, figs. 1-2; Eocene, Texas.

Discoaster barbadiensis Tan Sin Hok. HAY and TOWE, 1962, pl. 10, figs. 3, 5; Eocene, France.

Remarks: This robust, basket-shaped asterolith has 11 to 15 rays, which are joined for most of their length. There is a tall, slender knob in the center of the asterolith and several bands of concentric depressions parallel to the periphery. Each ray forms a fairly sharp peak at the periphery. *D. elegans* is similar to *Discoaster barbadiensis* Tan Sin Hok, but *D. barbadiensis* lacks the concentric depressions and has more rounded ray terminations.

Occurrence: D. elegans occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOASTER NODIFER
(Bramlette and Riedel) 1954

Plate 17, Figure 4

Discoaster tani nodifer BRAMLETTE and RIEDEL, 1954, pl. 39, fig. 2; Eocene, Alabama. MANIVIT, 1959, pl. 9, figs. 1-3; Eocene, France. MARTINI, 1960, pl. 9, fig. 19; Oligocene, Germany. NOËL, 1960, pl. 2, fig. 13; Eocene. LEVIN, 1965, pl. 43, figs. 5; Eocene, Mississippi. HAY, *et al.*, 1967, pl. 1, fig. 2; Eocene, Barbados. LEVIN and JOERGER, 1967, pl. 4, figs. 4-6; Oligocene, Alabama. Not HAQ, 1968, pl. 10, fig. 7. BYSTRICKÁ, 1969, pl. 62, fig. 2; Eocene, Czechoslovakia. ROTH, 1970, pl. 12, fig. 4; Oligocene. BÁLDI-BEKE, 1971, pl. 6, figs. 1-2; Eocene, Hungary. Not CLOCCHIATTI, 1971, pl. 38, fig. 2; Miocene, Africa. HAQ, 1971a, pl. 10, fig. 13; Eocene, Pakistan. HAQ, 1971b, pl. 12, fig. 4; Eocene-Oligocene, Germany. LOCKER, 1972, pl. 14, fig. 3; Eocene, Europe. SHERWOOD, 1974, pl. 11, fig. 5; Eocene, Texas.

Discoaster tani Bramlette and Riedel. DEFLANDRE and FERT, 1954, in part; pl. 11, figs. 13-15; Eocene, New Zealand.

Discoaster tani cf. *D. nodifer* Bramlette and Riedel. MARTINI, 1958, pl. 3, fig. 14; Eocene, Germany.

Discoaster binodosus hirundinus Martini. HAY, MOHLER, and WADE, 1966, pl. 13, fig. 2; Eocene, USSR.

Discoaster binodosus Martini. POZARYSKA and LOCKER, 1971, in part; pl. 3, fig. 32; Eocene, Poland. PERCH-NIELSEN, 1972, pl. 13, figs. 1-2; Eocene, Atlantic.

Discoaster nodifer (Bramlette and Riedel). BUKRY, 1973, pl. 4, fig. 23; Eocene-Oligocene, Pacific.

Remarks: D. nodifer normally has six rays, but may have five or seven. Each ray has a terminal medial notch and two nodes, one on each side of a ray and halfway down the unjoined portion. *Discoaster binodosus* Martini lacks the terminal notch. Little Stave Creek specimens have thicker rays than most illustrated specimens.

Occurrence: D. nodifer occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOASTER SAIPANENSIS
Bramlette and Riedel 1954
Plate 17, Figure 5

Discoaster saipanensis BRAMLETTE and RIEDEL, 1954, pl. 39, fig. 4; Eocene, Saipan. MARTINI, 1958, pl. 6, fig. 29; Eocene, Germany. MANIVIT, 1959, pl. 6, figs. 1-3; Eocene, France. STRADNER, 1959a, text-fig. 3; Eocene, Austria. BÁLDI-BEKE, 1960, pl. 14, fig. 20; Oligocene. MARTINI, 1960, pl. 8, fig. 12; Oligocene, Germany. NOËL, 1960, pl. 1, fig. 13; Eocene. STRADNER and PAPP, 1961, pl. 22, figs. 5-7; Eocene, Austria. STRADNER, 1962a, pl. 2, figs. 4-5; Eocene, Yugoslavia. LEVIN, 1965, pl. 43, fig. 2; Eocene, Mississippi. LOCKER, 1965, pl. 1, figs. 8-9; Eocene, Germany. HAY, MOHLER, and WADE, 1966, pl. 13, fig. 1; Eocene, USSR. GARTNER and SMITH, 1967, pl. 12, figs. 4-5; Eocene, Louisiana. HAQ, 1967, pl. 8, figs. 4, 6-7; Eocene, Pakistan. LEVIN and JOERGER, 1967, pl. 3, fig. 16; Eocene, Alabama. LOCKER, 1968, pl. 1, fig. 17; Eocene, Germany. RADOMSKI, 1968, pl. 48, fig. 2; Eocene, Poland. BILGÜTAY, *et al.,* 1969, pl. 3, fig. 5; Eocene, France. BYSTRICKÁ, 1969, pl. 59, figs. 11-13; Eocene, Czechoslovakia. BÁLDI-BEKE, 1971, pl. 6, figs. 3-4; Eocene, Hungary. CLOCCHIATTI, 1971, pl. 31, figs. 1-3; pl. 32, fig. 3; text-fig. 18; Miocene, Africa. MARTINI, 1971a, pl. 2, fig. 16; Eocene. PERCH-NIELSEN, 1971b, pl. 51, fig. 4; pl. 52, fig. 4; Eocene, Denmark. POZARYSKA and LOCKER, 1971, pl. 2, fig. 33; Eocene, Poland. BRATU and GHETA, 1972, pl. 2, figs. 27; Paleocene-Eocene, Czechoslovakia. LOCKER, 1972, pl. 15, fig. 10; Eocene, Europe. BUKRY, 1973, pl. 4, fig. 28; Eocene, Pacific. SHERWOOD, 1974, pl. 9, fig. 16; pl. 12, fig. 4; Eocene, Texas.

Discoaster cf. *D. saipanensis* Bramlette and Riedel. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 3, fig. 9; Miocene, Czechoslovakia.

Remarks: D. saipanensis normally has seven straight rays which are joined for one-half their length and then taper to a point. A small stem rises from the center of this species and irregularly-shaped depressions cover the surface. This species has fewer, more pointed rays than *Discoaster barbadiensis* Tan Sin Hok and *Discoaster elegans* Bramlette and Sullivan.

Occurrence: D. saipanensis occurs in the middle Eocene (Blow's P11-P14) of Alabama.

DISCOASTER sp. A

Plate 17, Figures 6-7

Remarks: This asterolith has six fairly long rays which widen near the periphery and then bifurcate. There is a small knob or stem in the central area. *Discoaster distinctus* Martini also is six-rayed with terminal bifurcations, but it has two knobs on each ray just behind the bifurcation.

Occurrence: Discoaster sp. A occurs only in the upper middle Eocene (Blow's P14) of Alabama.

Family GONIOLITHACEAE Deflandre 1957
Genus GONIOLITHUS Deflandre 1957
Type species: *Goniolithus fluckigeri* Deflandre

GONIOLITHUS FLUCKIGERI
Deflandre 1957
Plate 15, Figure 8

Goniolithus fluckigeri DEFLANDRE, 1957, text-figs. 1-4; Eocene, Germany. DEFLANDRE, 1962, text-figs. G-I. MARTINI, 1964, pl. 6, figs. 1-9; Maastrichtian-Oligocene. BLACK, 1968, pl. 151, fig. 6; Maastrichtian, Alabama. STRADNER and EDWARDS, 1968, pl. 41, text-figs. 8/1, 8/2; Eocene, New Zealand. MARTINI, 1969b, pl. 3, figs. 34-35; Oligocene, Switzerland. PERCH-NIELSEN, 1969, pl. 6, figs. 7-8; Danian-Oligocene, Europe. PERCH-NIELSEN, 1971b, pl. 46, fig. 7; Eocene, Den-

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PLATE 1

Figures Page

1-2. *Blackites* sp. aff. *B. creber* (Deflandre) Sample B-30 224
 1. Electron micrograph, X17,400 Distal view
 2a. Electron micrograph, X16,500 46° Tilt
 2b. Electron micrograph, X17,400

3-4. *Blackites creber* (Deflandre) Sample B-30 224
 3. Electron micrograph, X8,700
 4. Electron micrograph X8,400

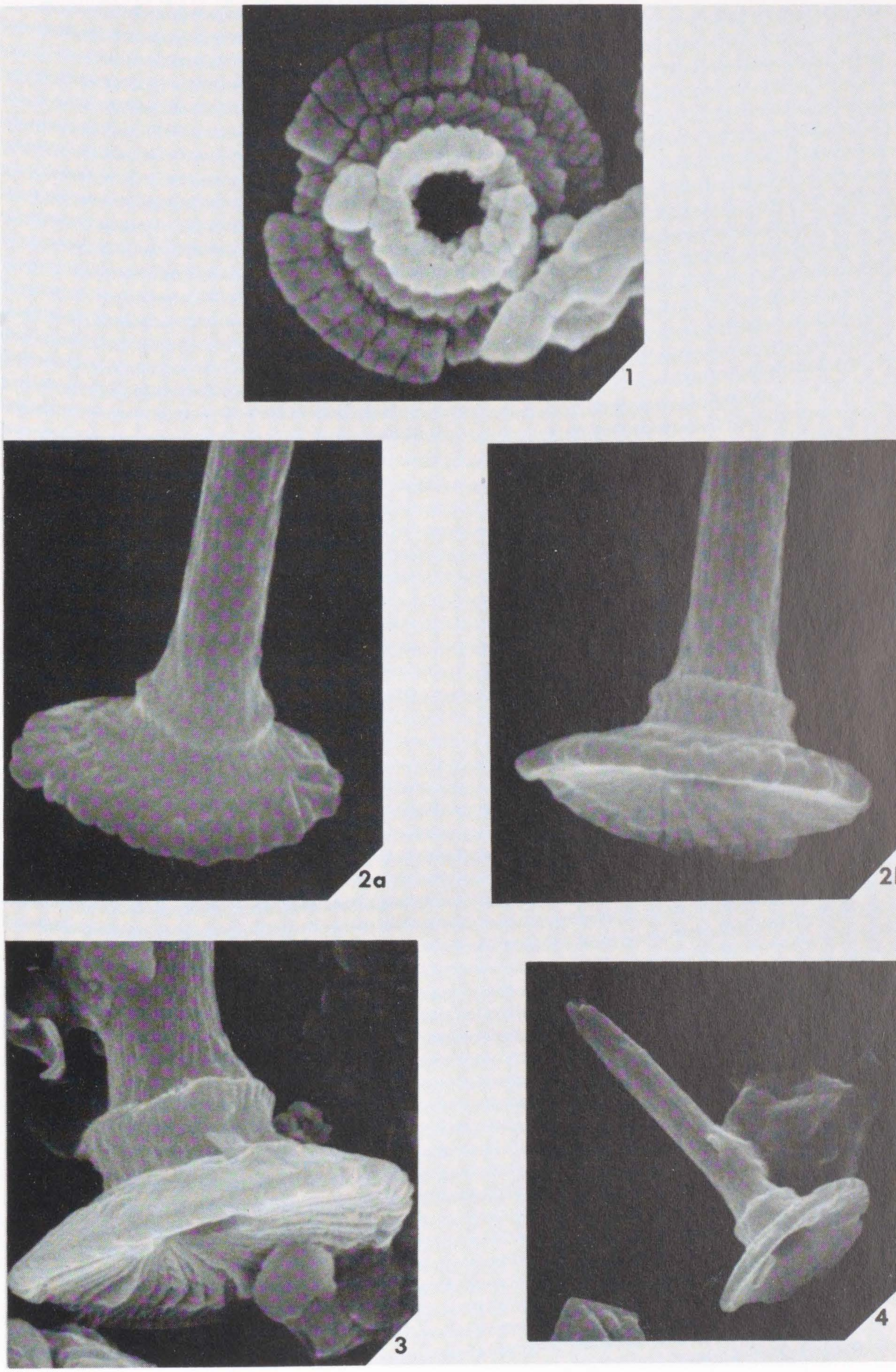

PLATE 1

mark. LOCKER, 1972, pl. 11, figs. 7-9; Maastrichtian-Oligocene.

Goniolithus cf. *G. fluckigeri* Deflandre. HAY and MOHLER, 1967, pl. 202, figs. 4-5; Paleocene, France.

Braarudosphaera sp. HAQ, 1968, pl. 11, figs. 5-6; Eocene, Germany.

Remarks: The broad rim and unusual construction of the central area of *G. fluckigeri* distinguish it from other pentagonal species.

Occurrence: G. fluckigeri occurs in the upper middle Eocene (Blow's P14) of Alabama.

Family LITHOSTROMATIONACEAE
Deflandre 1959
Genus LITHOSTROMATION
Deflandre 1942

Type species: *Lithostromation perdurum* Deflandre

Remarks: Deflandre (1942) gave a single description for this genus and the type species *Lithostromation perdurum* Deflandre. The species *Trochoaster operosus* (Deflandre), *Marthasterites reginus* Stradner and *Trochoaster simplex* Klumpp are placed in this genus because all four species have numerous circular depressions with a surrounding hexagonal ridge, no discernible crystals, and three-way symmetry (or a multiple).

LITHOSTROMATION OPEROSUM
(Deflandre) 1954 n. comb.
Plate 19, Figures 1, 3-4

Polycladolithus operosus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 12, figs. 3-6; text-fig. 125; Oligocene, New Zealand; Eocene, France. STRADNER, 1959b, text-fig. 73; Eocene, Austria. BRAMLETTE and SULLIVAN, 1961, pl. 14, fig. 13; Eocene, California. SULLIVAN, 1964, pl. 9, fig. 8; Paleocene, California.

Trochoaster operosus (Deflandre). STRADNER and PAPP, 1961, pl. 41, fig. 6; Eocene, Austria. BOUCHÉ, 1962, pl. 4, figs. 7-8; Eocene, France. BILGÜTAY, *et al.*, 1969, pl. 5, figs. 5-7; Eocene, France. HODSON and WEST, 1970, pl. 4, fig. 8; Eocene, England. BÁLDI-BEKE, 1971, pl. 6, figs. 10, 17; Eocene, Hungary. LOCKER, 1972, pl. 16, fig. 15; Eocene, Europe.

Remarks: This species has a spherical body with an irregular, knobby surface and numerous circular depressions. Each depression is surrounded by a hexagonal ridge with a knob at each corner of the hexagon. Some specimens have six large projections evenly spaced around the equator of the sphere. There are no discernible crystal elements and *L. operosum* is dark under cross-polarized light.

Occurrence: L. operosum occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

LITHOSTROMATION PERDURUM
Deflandre 1942
Plate 19, Figure 6

Lithostromation perdurum DEFLANDRE, 1942, text-figs. 1-9. DEFLANDRE *in* GRASSÉ, 1952, figs. 364-F-H; Eocene, France. STRADNER, 1959b, figs. 70-72; Eocene, Austria. BACHMANN, PAPP, and STRADNER, 1963, pl. 24, fig. 12; Austria. MARTINI and BRAMLETTE, 1963, pl. 102, fig. 8; Pliocene, Italy. LEVIN and JOERGER, 1967, pl. 3, figs. 12-13; pl. 4, fig. 14; Eocene-Oligocene, Alabama. MARTINI, 1969a, pl. 28, fig. 9; Miocene, Africa. HODSON and WEST, 1970, pl. 3, fig. 5; Eocene, England. ROTH, 1970, pl. 13, figs. 1-2; Oligocene, Alabama, JOIDES 5. BÁLDI-BEKE, 1971, pl. 6, fig. 18; Eocene, Hungary. CLOCCHIATTI, 1971, pl. 21, figs. 1-2; Miocene-Pliocene, Africa. LEHOTAYOVÁ, 1971, pl. 5, fig. 2; Miocene, Yugoslavia. PERCH-NIELSEN,

PLATE 2

Figures Page

1-5. *Blackites spinosus* (Deflandre) Sample B-30 226
1. Electron micrograph, X8,700 Distal view
2. Electron micrograph, X8,700 Proximal view
3a. Cross-polarized light, X2,200
3b. Phase contrast, X2,200
4. Electron micrograph, X5,200
5. Electron micrograph, X15,900

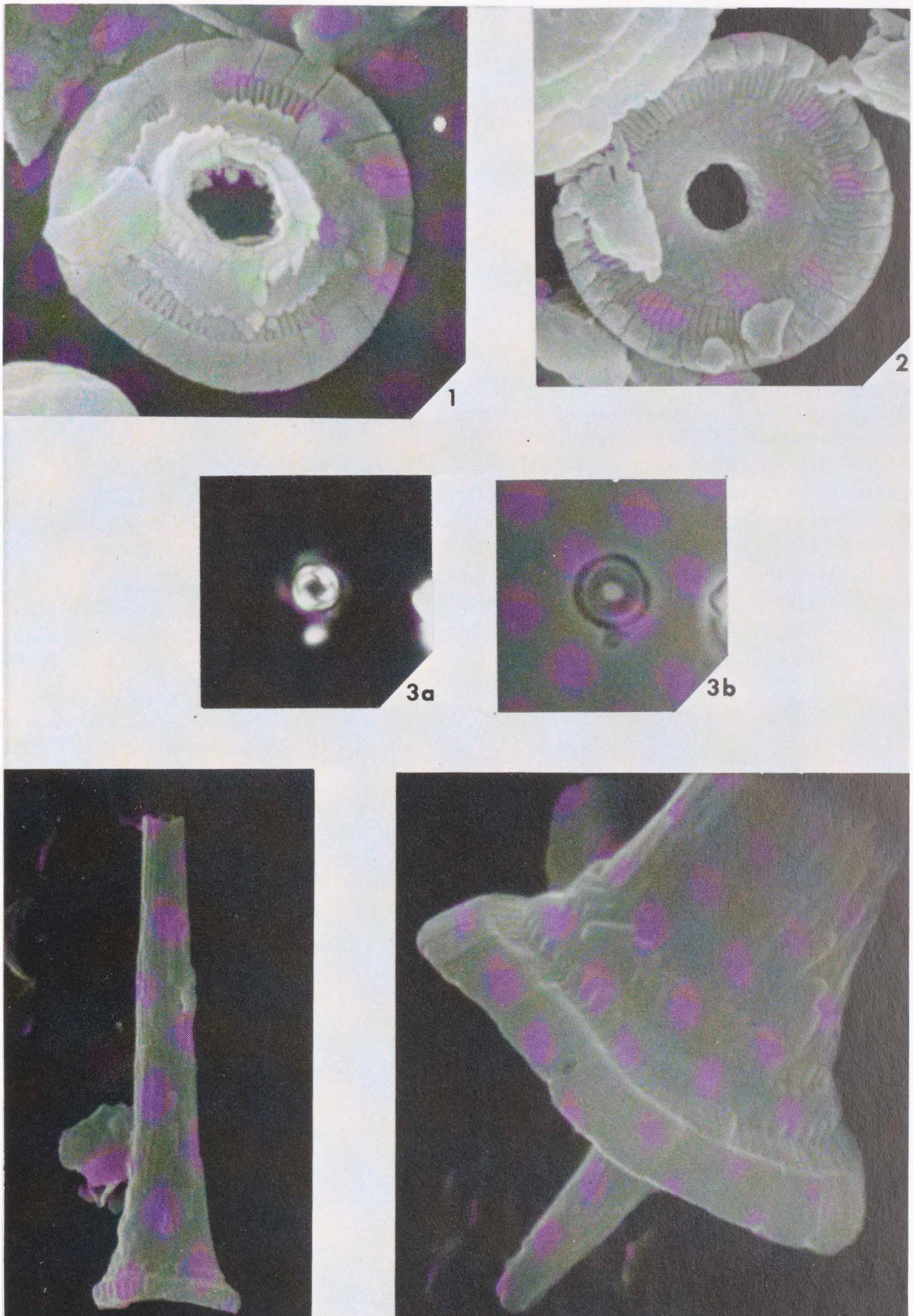

PLATE 2

1971b, pl. 57, fig. 6; Eocene, Denmark. POZARYSKA and LOCKER, 1971, pl. 16, figs. 12-14; Eocene, Europe.
Lithostromation reticulum GARDET, 1955, pl. 11, fig. 1-3; Miocene, Algeria.
Lithostromation triangularis GARDET, 1955, pl. 11, fig. 1-2; Miocene, Algeria. LEHOTAYOVÁ, 1970, pl. 30, figs. 1, 3; Miocene, Yugoslavia.
Trochoaster triangularis (Gardet). BÁLDI-BEKE, 1960, pl. 14, fig. 21; Miocene, Hungary.
Lithostromation robustum MARTINI, 1961b, fig. 1; Oligocene, Germany. MARTINI, 1971a, pl. 1, fig. 3; Oligocene, Germany.
Lithostromation sp. HAQ, 1967, pl. 6, fig. 6; Eocene, Pakistan.

Remarks: L. perdurum has a triangular body which thickens toward its center. The irregular, knobby surface is covered with numerous, circular depressions. Each depression is surrounded by a hexagonal, knobby ridge. There are no discernible crystal elements. The structure of the species is similar to *Lithostromation simplex* (Klumpp) and *Lithostromation operosum* (Deflandre), but has a triangular outline, while the others have hexagonal and circular outlines respectively.

Occurrence: L. perdurum occurs in the upper middle Eocene (Blow's P14) of Alabama.

LITHOSTROMATION REGINUM
(Stradner) 1962b n. comb.
Plate 19, Figure 5

Marthasterites reginus STRADNER, 1962b, pl. 3, figs. 6-10; Eocene.

Remarks: This species has six long, slender rays arranged in the same pattern as the playing pieces for the children's game of jacks. There are six knobs at the termination of each ray. The surface is covered with circular depressions which are surrounded by hexagonal, knobby ridges. The perforations become more shallow and more oval toward the ray ends. *L. reginum* is similar to *Marthasterites spineus* Shafik and Stradner, which is distinguished by its lack of terminal nodes and the presence of small projections on either side of each ray.

Occurrence: L. reginum was observed only in the upper middle Eocene (Blow's P14) of Alabama.

LITHOSTROMATION SIMPLEX
(Klumpp) 1953 n. comb.

Plate 19, Figure 2

Trochoaster simplex KLUMPP, 1953, pl. 16, fig. 7; text-fig. 4 (2); Eocene, Germany. MARTINI, 1958, pl. 5, fig. 25; Eocene, Germany. MARTINI, 1960, pl. 10, fig. 35; Oligocene, Germany. MARTINI and STRADNER, 1960, fig. 19. STRADNER and PAPP, 1961, pl. 42, figs. 1-4, 6; Eocene, Austria. BOUCHÉ, 1962, pl. 4, fig. 6; Eocene, France. LEVIN, 1965, pl. 43, figs. 7-9; Eocene, Mississippi. LOCKER, 1965, pl. 2, fig. 2; Eocene, Germany. LEVIN and JOERGER, 1967, pl. 3, figs. 20-21; Eocene-Oligocene, Alabama. HAQ, 1968, pl. 11, figs. 7-8; Eocene, Germany. BYSTRICKÁ, 1969, pl. 64, fig. 10; Paleogene, Czechoslovakia. MARTINI, 1971b, pl. 1, fig. 2; Eocene, Germany. PERCH-NIELSEN, 1971b, pl. 57, fig. 8; Eocene, Denmark. LOCKER, 1972, pl. 16, figs. 17-18; Eocene, Europe. SHERWOOD and LEVIN, 1972, text-fig. 1. SHERWOOD, 1974, pl. 8, figs. 9-10; pl. 9, fig. 8; Eocene, Texas.
Trochoaster duplex KLUMPP, 1953, pl. 16, fig. 10; text-fig. 4 (3); Eocene, Germany.
Discoaster bramlettei MARTINI, 1958, pl. 3, fig. 11; Eocene, Germany.

Remarks: This species has a hexagonal outline which thickens towards its center. The surface is pitted with circular perforations which are surrounded by knobby, hexagonal ridges. Each apex of the hexagon ends in a short ray. The planar hexagonal shape distinguishes *L. simplex* from other species in this genus.

PLATE 3

Figures	Page
1-4. *Blackites spinosus* (Deflandre) Sample B-30	226

1. Electron micrograph, X8,700
2. Electron micrograph, X8,700
3. Electron micrograph, X1,700

4a. Cross-polarized light, X2,200
4b. Phase contrast, X2,200

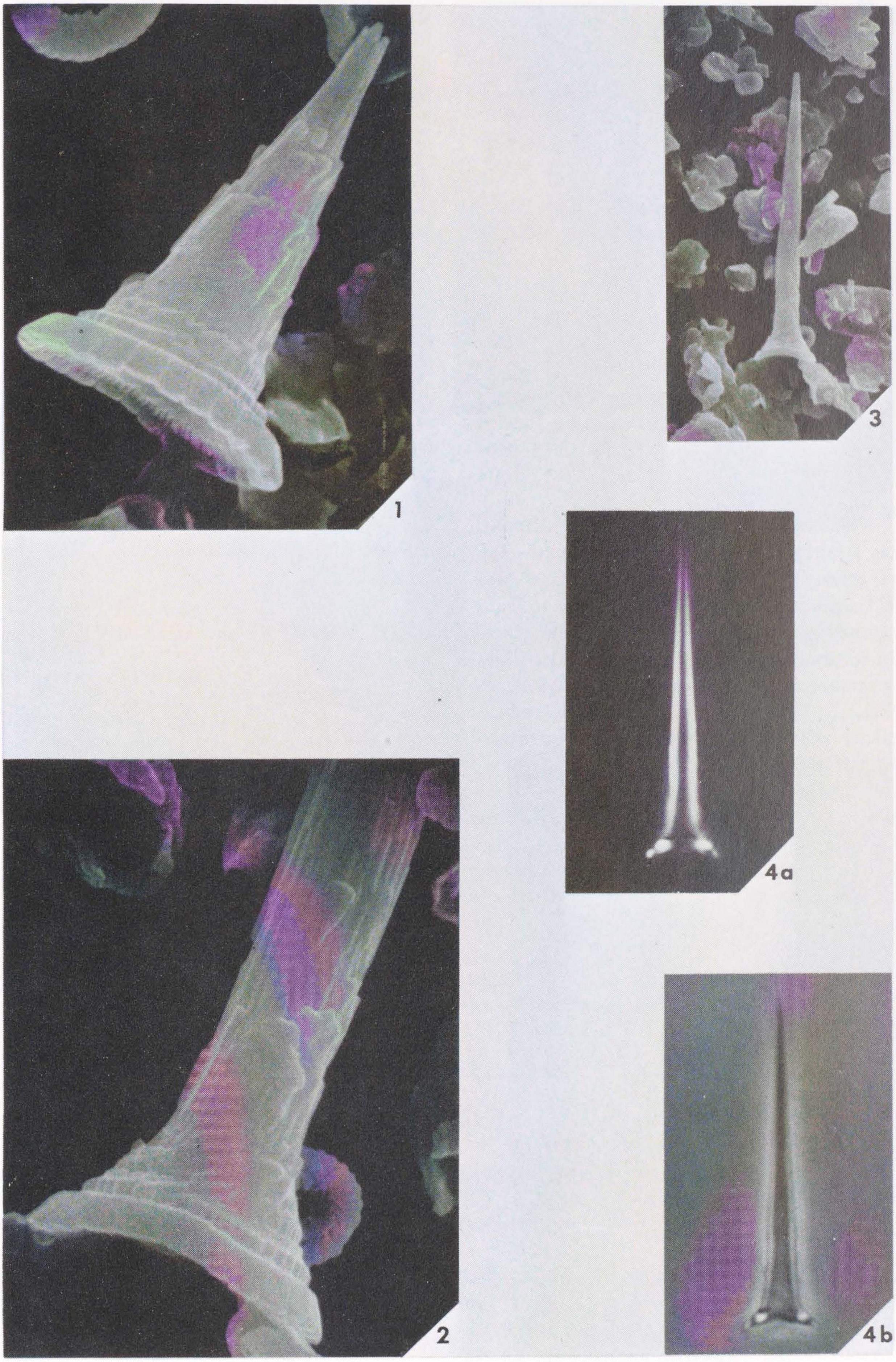

PLATE 3

Occurrence: L. simplex occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family PONTOSPHAERACEAE
Lemmermann 1908

Genus DISCOLITHINA
Loeblich and Tappan 1963
Type species: *Discolithus vigintiforatus* Kamptner

DISCOLITHINA BICAVEATA
Perch-Nielsen 1967

Plate 21, Figure 6

Discolithina bicaveata PERCH-NIELSEN, 1967, pl. 4, figs. 8-10; Eocene, Denmark. PERCH-NIELSEN, 1971b, pl. 27, fig. 7; Eocene, Denmark.

Remarks: This basket-shaped discolith has a fairly high, slanting rim and two small, irregularly-shaped holes in the central area. A fissure connects the two holes and also extends outward beyond each hole. Little Stave Creek specimens have the holes slightly farther apart than those figured by Perch-Nielsen. The base is composed of rods of calcite that radiate from the center toward the periphery; these rods then spiral outward and upward to form the sides of the discolith. *D. bicaveata* differs from *Discolithina ocellata* (Bramlette and Sullivan) in having a basket shape and the structure of the base consists of radiating rods rather than the narrow layers of crystals parallel to the margin found in *D. ocellata.*

Occurrence: D. bicaveata occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOLITHINA CRIBRARIA
Perch-Nielsen 1967

Plate 20, Figure 3

Discolithina cribraria PERCH-NIELSEN, 1967, pl. 2, figs. 1-3; Eocene, Denmark.
Pontosphaera rothi HAQ, 1971b, pl. 4, figs. 1-2; pl. 5, figs. 6-7; Oligocene, Germany.
Pontosphaera cribraria (Perch-Nielsen). HAQ, 1971c, pl. 11, figs. 1-4; Oligocene, Syria.

Remarks: This discolith has circular pores in the central portion of the base and around the margin are larger, circular to rectangular perforations. The structure is similar to *Discolithina multipora* (Kamptner), although that species has smaller, more uniformly-sized pores. The bases of discoliths of this type have the narrow layers of crystals parallel to the periphery in the distal view and radiating laths on the concave proximal side. Because of nearly vertical sides, *D. cribraria* appears to have little or no rim under the light microscope.

Occurrence: D. cribraria occurs in the middle Eocene (Blow's P11-P14) of Alabama.

DISCOLITHINA MULTIPORA
(Kamptner) 1948
Plate 20, Figures 1, 4

Discolithus multiporus KAMPTNER, 1948, pl. 1, fig. 9; Miocene, Austria. STRADNER, 1962, text-figs. 4-8; Oligocene, Austria. STRADNER and ADAMIKER, 1966, pl. 3, fig. 1; Eocene, Austria. CLOCCHIATTI, 1971, in part; text-fig. 6; pl. 12, figs. 1-6; Miocene-Pliocene, Africa.
Discolithus vigintiforatus KAMPTNER, 1948, pl. 1, fig. 8; Miocene, Austria.
Discolithus lineatus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 10, figs. 17-18; text-fig. 50; Miocene-Pliocene, France.
Discolithus sp. B BÁLDI-BEKE, 1960, pl. 14, fig. 3; Oligocene-Miocene, Hungary.

PLATE 4

Figures		Page
1-5.	*Blackites tenuis* (Bramlette and Sullivan) Sample B-30	228
	1. Electron micrograph, X1,700	
	2a. Cross-polarized light, X2,200	
	2b. Phase contrast, X2,200	
	3. Electron micrograph, X17,400	
	4. Electron micrograph, X17,400	
	5a. Electron micrograph, X4,300	
	5b. Electron micrograph, X8,700	

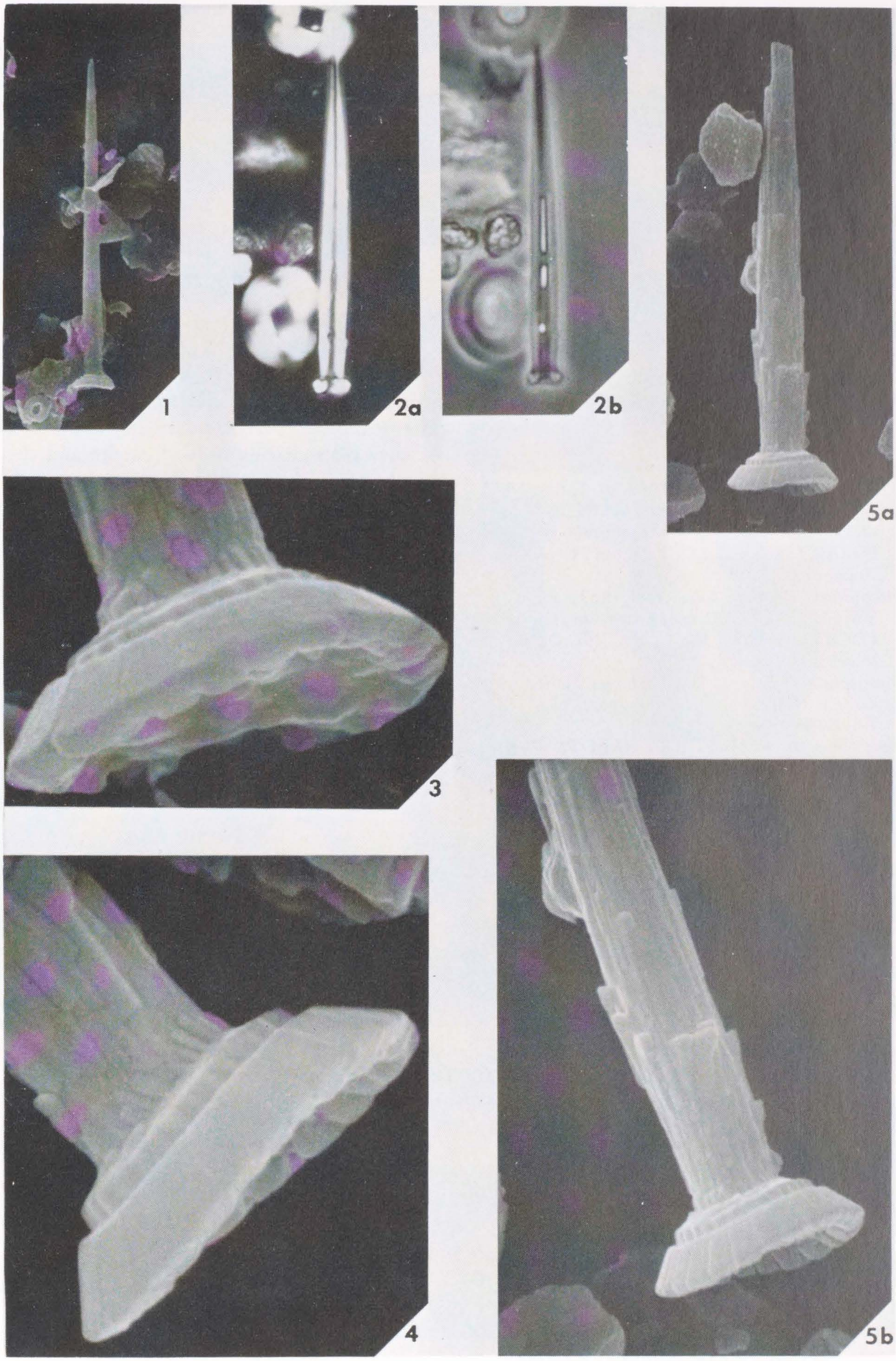

PLATE 4

Discolithus distinctus BRAMLETTE and SULLIVAN, 1961, in part; pl. 2, fig. 9; Eocene, California, Texas, Trinidad, France. SULLIVAN, 1964, pl. 4, fig. 4; Paleocene, California. SULLIVAN, 1965, pl. 4, figs. 1-6; Eocene, California. REINHARDT, 1967, pl. 3, fig. 4; Eocene, Germany. LOCKER, 1972, pl. 1, figs. 4-5; Oligocene, Europe.

Cribrosphaerella sp. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 2, fig. 9; Eocene, Czechoslovakia.

Discolithina confossa HAY, MOHLER, and WADE, 1966, in part; pl. 9, fig. 1; Eocene, USSR. HAY, *et al.*, 1967, pl. 7, figs. 7-8. LOCKER, 1968, pl. 1, fig. 18; Eocene, Germany.

Discolithina vigintiforata (Kamptner). BRAMLETTE and WILCOXON, 1967, pl. 5, figs. 3-4; Oligocene-Miocene, Trinidad.

Discolithina aff. *D. distincta* (Bramlette and Sullivan). GARTNER and SMITH, 1967, pl. 6, figs. 4-6; Eocene, Louisiana.

Discolithina distincta (Bramlette and Sullivan). LEVIN and JOERGER, 1967, pl. 1, figs. 14-15; Eocene-Oligocene, Alabama. MARTINI, 1969b, pl. 1, figs. 7-8; Eocene-Oligocene, Germany. POZARYSKA and LOCKER, 1971, pl. 3, fig. 2; Eocene, Poland.

Discolithina enormis LOCKER, 1967, pl. 2, figs. 5-6; pl. 1, fig. 4; Miocene-Oligocene, Germany. LOCKER, 1968, pl. 1, fig. 19; Oligocene-Miocene, Germany.

Pontosphaera vadosa Hay, Mohler, and Wade. PERCH-NIELSEN, 1967, in part; pl. 2, figs. 7-8; Eocene, Denmark.

Discolithus distinctoides REINHARDT, 1967, pl. 3, figs. 2-3; text-fig. 13; Eocene, Germany.

Discolithina multipora (Kamptner). HAQ, 1968, pl. 6, figs. 4-9; Eocene, Germany. STRADNER and EDWARDS, 1968, in part; pl. 32; pl. 34; pl. 35, figs. 1-4; Eocene, New Zealand. MARTINI, 1969a, pl. 26, figs. 5-6; Miocene, Africa. LEHOTAYOVÁ, 1970, pl. 24, figs. 1-3; Miocene, Yugoslavia. BÁLDI-BEKE, 1971, pl. 1, figs. 2-4; Eocene, Hungary. LEHOTAYOVA, 1971, pl. 1, fig. 2; Miocene, Yugoslavia. PERCH-NIELSEN, 1971b, pl. 26, figs. 1-5; Eocene, Denmark.

Discolithus confossa (Hay, Mohler, and Wade). HODSON and WEST, 1970, pl. 2, fig. 7; Eocene, England.

Pontosphaera multipora (Kamptner). HANZLÍKOVÁ, 1971, pl. 2, fig. 1; Oligocene, Czechoslovakia. HAQ, 1971b, pl. 4, figs. 4-6, 8-9; pl. 7, figs. 3-4; pl. 14, figs. 4-5; Eocene-Oligocene, Germany. Not ELLIS, LOHMAN, and WRAY, 1972, pl. 6, figs. 4-7; pl. 7, figs. 1-2. SHERWOOD, 1974, in part; pl. 3, figs 15-16; pl. 4, fig. 9; Eocene, Texas.

Remarks: This species has circular pores of uniform size on its surface, which are arranged in rows parallel to the periphery. The proximal side is concave and composed of outward radiating rods of calcite and the distal side is larger with bands of crystals parallel to the periphery. Ridges between the pores give the distal side an irregular, bumpy surface. *D. multipora* has larger holes than *Discolithina vesca* (Sullivan) and lacks the outer ring of large perforations present in *Discolithina cribraria* Perch-Nielsen.

Occurrence: D. multipora occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOLITHINA VESCA
(Sullivan) 1965 n. comb.

Plate 20, Figure 2

Discolithus vescus SULLIVAN, 1965, pl. 4, fig. 9; Paleocene-Eocene, California.

PLATE 5

Figures | Page

1-3. *Rhabdosphaera vitrea* (Deflandre) Sample B-30 230
 1. Electron micrograph, X8,700 Distal view
 2. Electron micrograph, X8,400
 3. Electron micrograph, X17,400

4. *Blackites* sp. A Sample B-30 230
 4a. Cross-polarized light, X2,200
 4b. Phase contrast, X2,200

5-6. *Cepekiella lumina* (Sullivan) Sample B-30 236
 5a. Cross-polarized light, X2,200
 5b. Phase contrast, X2,200
 6a. Cross-polarized light, X2,200
 6b. Phase contrast, X2,200

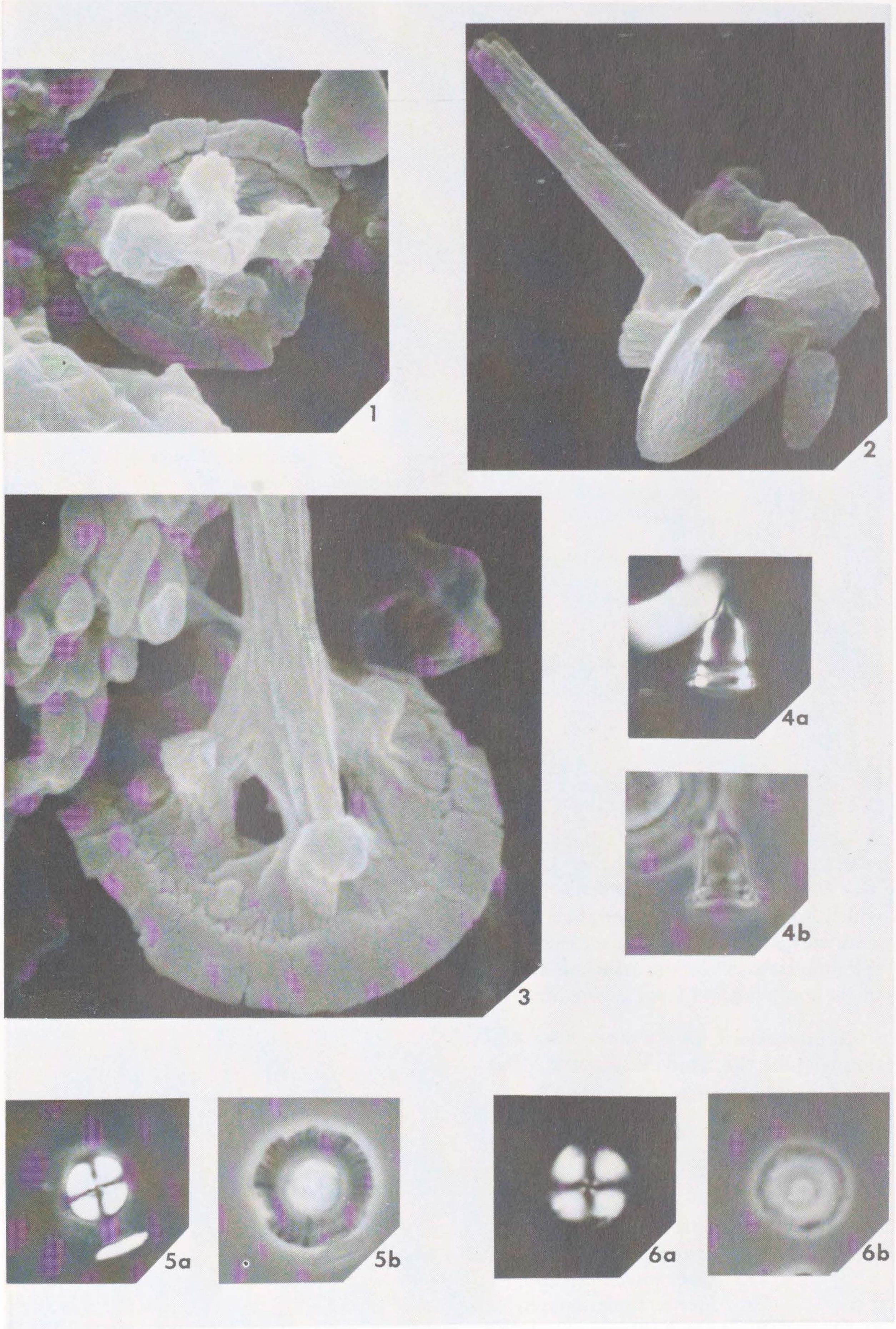

PLATE 5

Remarks: D. vesca has numerous, small, circular pores on its surface, which are arranged in concentric rows. There may be a row of larger triangular pores along the outer margin and the rim is thin. This species closely resembles *Discolithina multipora* (Kamptner), differing from it mainly in possessing more numerous and smaller pores. The crystal structure is probably similar to that of *D. multipora,* but there are no electron photo micrographs of *D. vesca* to confirm this similarity.

Occurrence: D. vesca occurs in the middle Eocene (Blow's P11-P14) of Alabama.

DISCOLITHINA WECHESENSIS
(Bukry and Percival) 1971 n. comb.

Plate 22, Figure 2

Syracosphaera? wechesensis BUKRY and PERCIVAL, 1971, pl. 7, figs. 7-10; Eocene, Texas, USSR.
Discolithina amphitheatralis LEVIN and SHERWOOD, 1971, text-fig. 1; Eocene, Texas.
Discolithina aperta PERCH-NIELSEN, 1971b, pl. 30, fig. 1; Eocene, Denmark.
Koczyia excelsa PERCH-NIELSEN, 1971b, pl. 28, figs. 1-5; pl. 60, fig. 16; Eocene, Denmark.
Koczyia wechesensis (Bukry and Percival). SHERWOOD, 1974, p. 4, figs. 5-6; pl. 5, figs. 5-6; Eocene, Texas.

Remarks: This lopadolith has one fairly large, elliptical to subcircular central opening and high walls. A series of regularly spaced vertical struts line the inside wall; between each strut is a circular depression in the base. This base is formed of thin bands of calcite, which are parallel to the periphery, and the sides are constructed of upward and outward spiraling laths. The sides flare out at the top of the specimen and form a wide rim.

Occurrence: D. wechesensis occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

DISCOLITHINA sp. A
Plate 20, Figure 5

Remarks: The base of this lopadolith is covered with very small pores. The walls are thick and a depression is incised into their flat, upper surface. This depression has the appearance of inner and outer wall bands, the inner portion higher than the other. Individual calcite crystals are not visible on Little Stave Creek specimens and it is not possible to ascertain to which discolith category this form belongs.

Occurrence: Discolithina sp. A was observed only in the upper middle Eocene (Blow's P14) of Alabama.

DISCOLITHINA sp. B
Plate 22, Figure 4

Discolithus fimbriatus Bramlette and Sullivan. SULLIVAN, 1965, pl. 5, fig. 1; Eocene, California.

Remarks: This lopadolith has high walls and a long narrow slit running lengthwise across its base. There appears to be a series of struts around the periphery of the base similar to those found on *Discolithina wechesensis* (Bukry and Percival), but only electron microscopy can confirm this. At the top of the lopadolith the wall flares out to form a broad rim. This species is similar to *Discolithina wechesensis,* which has one large opening in its base and to *Transversopontis fimbriatus* (Bramlette and Sullivan), which has two basal openings.

Occurrence: Discolithina sp. B occurs in the upper middle Eocene (Blow's P14) of Alabama.

Genus HELICOPONTOSPHAERA
Hay and Mohler 1967
Type species: *Helicopontosphaera kamptneri* Hay and Mohler

PLATE 6

Figures | Page

1-3. *Blackites trochos* n.sp. Sample B-30 230
 1. Electron micrograph, X8,700 Distal view
 2a. Electron micrograph, X9,600 59° Tilt
 2b. Electron micrograph, X10,400 10° Tilt Distal view
 3. Electron micrograph, X8,700

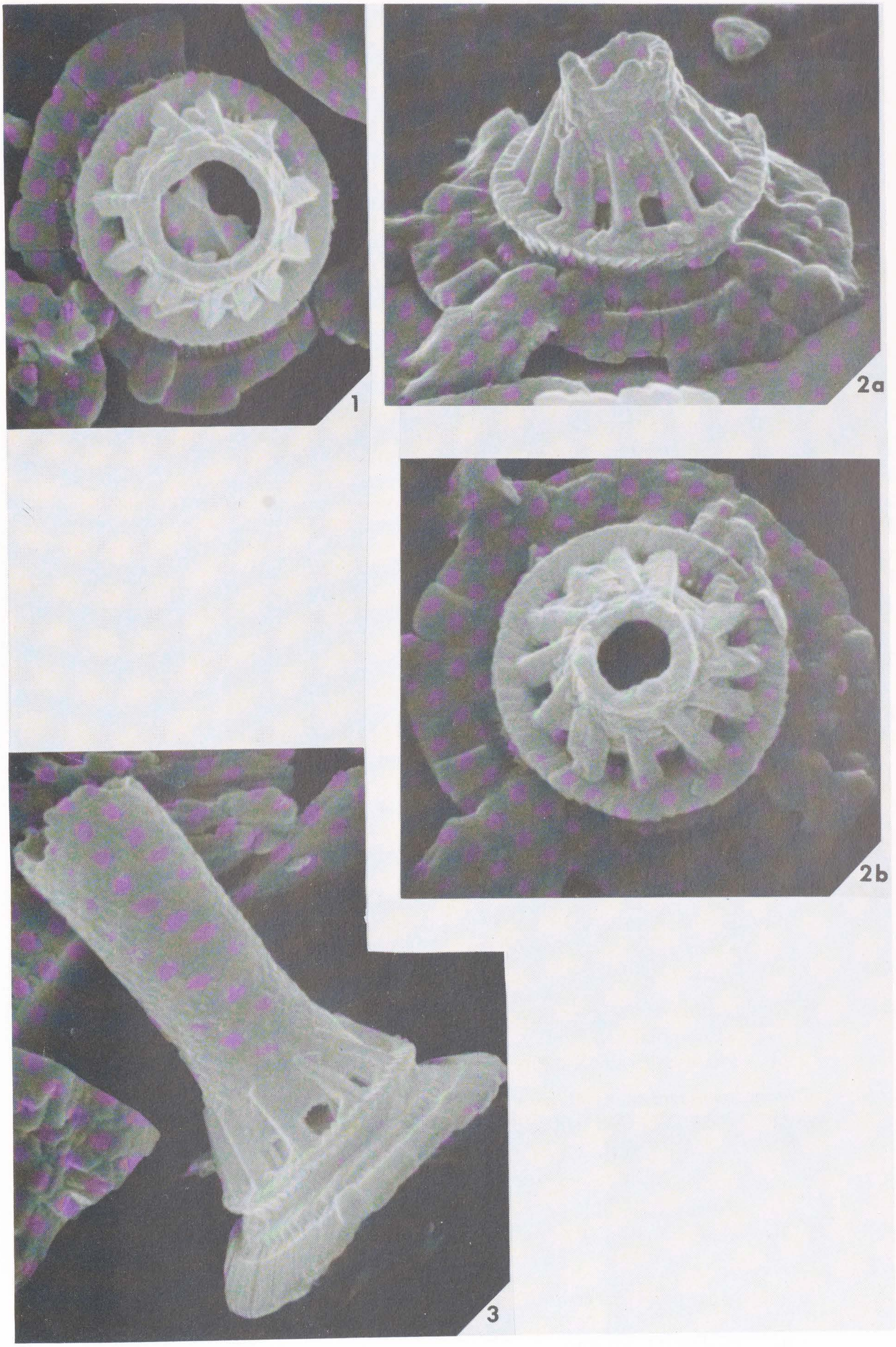

PLATE 6

HELICOPONTOSPHAERA COMPACTA
(Bramlette and Wilcoxon) 1967
Plate 18, Figure 4

Helicosphaera compacta BRAMLETTE and WILCOXON, 1967, pl. 6, figs. 5-8; Oligocene, Trinidad. LOCKER, 1972, pl. 9, figs. 16-19; Eocene, Europe.

Helicopontosphaera compacta (Bramlette and Wilcoxon). ROTH, 1970, pl. 10, figs. 2, 4?; Eocene-Oligocene, Alabama, Trinidad, Italy, JOIDES 5-6. HAQ, 1971c, pl. 6, figs. 6-7; pl. 7, figs. 4-5; pl. 8, figs. 6-8; pl. 9, figs 1-3; Oligocene, Syria. Not PERCH-NIELSEN, 1971b, pl. 34, fig. 6. HAQ, 1973, pl. 2, fig. 6; pl. 7, figs. 1-2?; Eocene-Oligocene.

Helicopontosphaera rhomboidalis (Locker). POZARYSKA and LOCKER, 1971, pl. 2, figs. 22-23; Eocene, Poland.

Remarks: H. compacta is ovoid in outline and the terminal flange of the distal shield merges into the previous whorl. The central area has two small oval openings with the long axes parallel to the longitudinal axis of the specimen. The small proximal shield is bright and distinct under the light microscope.

Occurrence: H. compacta occurs in the upper middle Eocene (Blow's P14) of Alabama.

HELICOPONTOSPHAERA LOPHOTA
(Bramlette and Sullivan) 1961

Helicosphaera seminulum lophota BRAMLETTE and SULLIVAN, 1961, pl. 4, figs. 3-4; Eocene, California, Texas, France. SULLIVAN, 1964, pl. 5, fig. 2; Paleocene, California. SULLIVAN, 1965, pl. 6, fig. 5; Eocene, California. Not PERCH-NIELSEN, 1967, pl. 3, figs. 1-3. BUKRY and KENNEDY, 1969, figs. 4-2, 4-3; Eocene, California. BÁLDI-BEKE, 1971, pl. 3, fig. 9; Eocene, Hungary.

Helicosphaera seminulum Bramlette and Sullivan. GARTNER and SMITH, 1967, in part; pl. 7, figs. 1-4; Eocene, Louisiana.

Helicopontosphaera cf. *H. lophota* (Bramlette and Sullivan). HAQ, 1971a, pl. 3, fig. 2; Paleocene, Persia; Eocene, Pakistan.

Helicopontosphaera lophota (Bramlette and Sullivan). HAQ, 1971b, pl. 3, fig. 12; Oligocene, Germany. Not HAQ, 1971c, pl. 10, figs. 8-9. PERCH-NIELSEN, 1971b, in part; pl. 34, figs. 1-2; pl. 36, fig. 2; Eocene, Denmark. HAQ, 1973, pl. 1, figs. 1-3; pl. 3, figs. 3-4; Eocene.

PLATE 7

Figures		Page
1-3.	*Braarudosphaera bigelowi* (Gran and Braarud) Sample B-30	187
	1. Electron micrograph, X5,200	
	2a. Cross-polarized light, X2,200	
	2b. Phase contrast, X2,200	
	3a. Transmitted light, X2,200 Plan view	
	3b. Transmitted light, X2,200 Side view	
4.	*Braarudosphaera irregularis* Bybell and Gartner Sample B-30	188
	4a. Cross-polarized light, X2,200	
	4b. Phase contrast X2,200	
5.	*Braarudosphaera cheloma* Bybell and Gartner Sample B-30	188
	5a. Cross-polarized light, X2,200	
	5b. Phase contrast, X2,200	
6.	*Braarudosphaera* sp. cf. *B. rosa* Levin and Joerger Sample B-30	188
	6a. Cross-polarized light, X2,200	
	6b. Phase contrast, X2,200	
7.	*Micrantholithus ornatus* Sullivan Sample B-30	189
	7a. Cross-polarized light, X2,200	
	7b. Phase contrast, X2,200	
8.	*Pemma* sp. A Sample B-30	192
	8a. Cross-polarized light, X2,200	
	8b. Phase contrast, X2,200	
	8c. Dark field, X2,200	

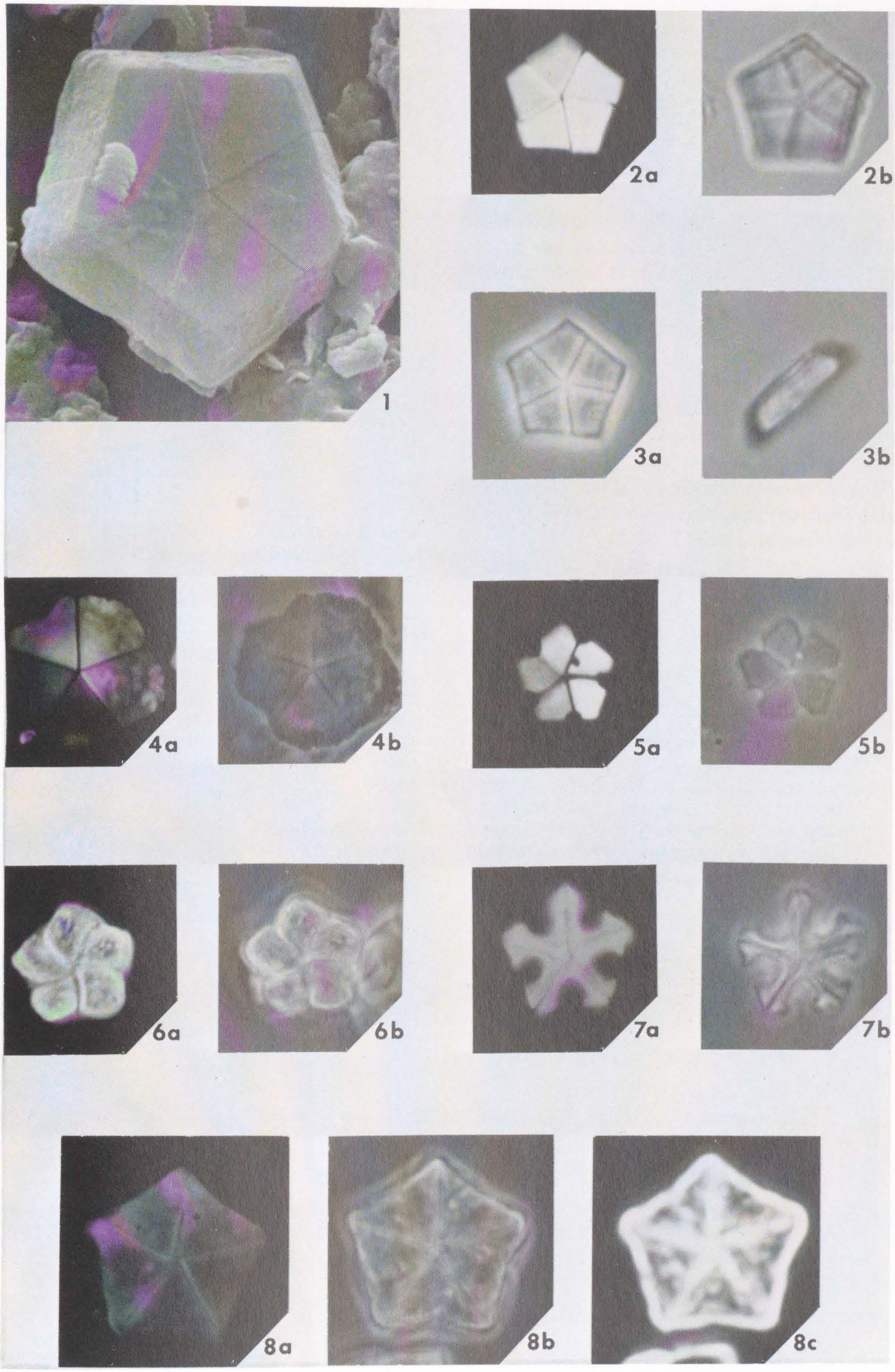

PLATE 7

SHERWOOD, 1974, pl. 5, figs. 13-14; Eocene, Texas.
Helicopontosphaera seminulum (Bramlette and Sullivan). POZARYSKA and LOCKER, 1971, pl. 2, fig. 24; Eocene, Poland.
Helicosphaera lophota (Bramlette and Sullivan). LOCKER, 1972, pl. 9, figs. 14-15; Eocene, Europe.

Remarks: One end of the distal shield of *H. lophota* is much more rounded than the other. There is a broad, double bar across the central opening that is more closely aligned to the longitudinal than to the transverse axis. The outer whorl, which has segments discernible in the light microcsope, merges into the previous whorl and there is no flange. *H. lophota* is similar to *Helicopontosphaera wilcoxoni* Gartner, but the latter has a definite protruding flange. In *Helicopontosphaera seminulum* (Bramlette and Sullivan) the crossbar is oriented parallel to the transverse axis.

Occurrence: H. lophota occurs in the lower middle Eocene (Blow's P11) of Alabama.

HELICOPONTOSPHAERA RETICULATA (Bramlette and Wilcoxon) 1967

Plate 18, Figure 8

Helicosphaera reticulata BRAMLETTE and WILCOXON, 1967, pl. 6, fig. 15; Eocene-Oligocene, Mississippi; Oligocene, JOIDES. GARTNER, 1971, pl. 1; Eocene-Oligocene, Blake Plateau. HAQ, 1973, pl. 2, fig. 1; pl. 3, figs. 1-2; Eocene-Oligocene. MARTINI, 1971b, pl. 3, figs. 3-4; Eocene-Oligocene.
Helicopontosphaera reticulata (Bramlette and Wilcoxon). ROTH, 1970, pl. 10, fig. 5; Oligocene, Alabama, Barbados, Blake Plateau.
Helicopontosphaera salebrosa PERCH-NIELSEN, 1971b, pl. 34, fig. 5; pl. 36, figs. 5, 10; pl. 61, figs. 8-9; Eocene, Denmark.

Remarks: This species is subrhomboid in outline with an oblique central bridge, which is surrounded by two rows of small pores. There is little or no extension of the outer whorl into a flange. *H. reticulata* is similar to *Helicopontosphaera dinesenii* Perch-Nielsen, but the latter has a more ovoid outline and the central area has several rows of small pores, instead of the two rows found in *H. reticulata.*

Occurrence: H. reticulata occurs in the upper middle Eocene (Blow's P14) of Alabama.

HELICOPONTOSPHAERA SEMINULUM (Bramlette and Sullivan) 1961

Plate 18, Figure 5

Helicosphaera seminulum seminulum BRAMLETTE and SULLIVAN, 1961, pl. 4, figs. 1-2; Eocene, California, France. HAY and TOWE, 1962, pl. 1, figs. 1-3, 5; Eocene, France. SULLIVAN, 1964, pl. 5, fig. 1; Paleocene, California. PERCH-NIELSEN, 1967, pl. 3, figs. 4-5; Eocene, Denmark. Not CLOCCHIATTI, 1971, pl. 17, figs. 2-4; Miocene-Pliocene, Africa.
Helicosphaera seminulum Bramlette and Sullivan. GARTNER and SMITH, 1967, pl. 7, figs. 1-4; Eocene, Louisiana. Not STRADNER and EDWARDS, 1968, pls. 39-40. LOCKER, 1972, pl. 10, figs. 1-3.

PLATE 8

Figures		Page
1-2.	*Braarudosphaera stylifer* Troelson and Quadros Sample B-30	188
	1. Electron micrograph, X4,400	
	2a. Phase contrast, X2,200 Side view	
	2b. Transmitted light, X2,200 Side view	
	2c. Transmitted light, X2,200 Plan view	
	2d. Transmitted light, X2,200 Plan view	
3-5.	*Pemma balium* Bybell and Gartner Sample B-30	190
	3a. Cross-polarized light, X2,200	
	3b. Phase contrast, X2,200	
	4a. Cross-polarized light, X2,200	
	4b. Phase contrast, X2,200	
	5. Electron micrograph, X8,500	

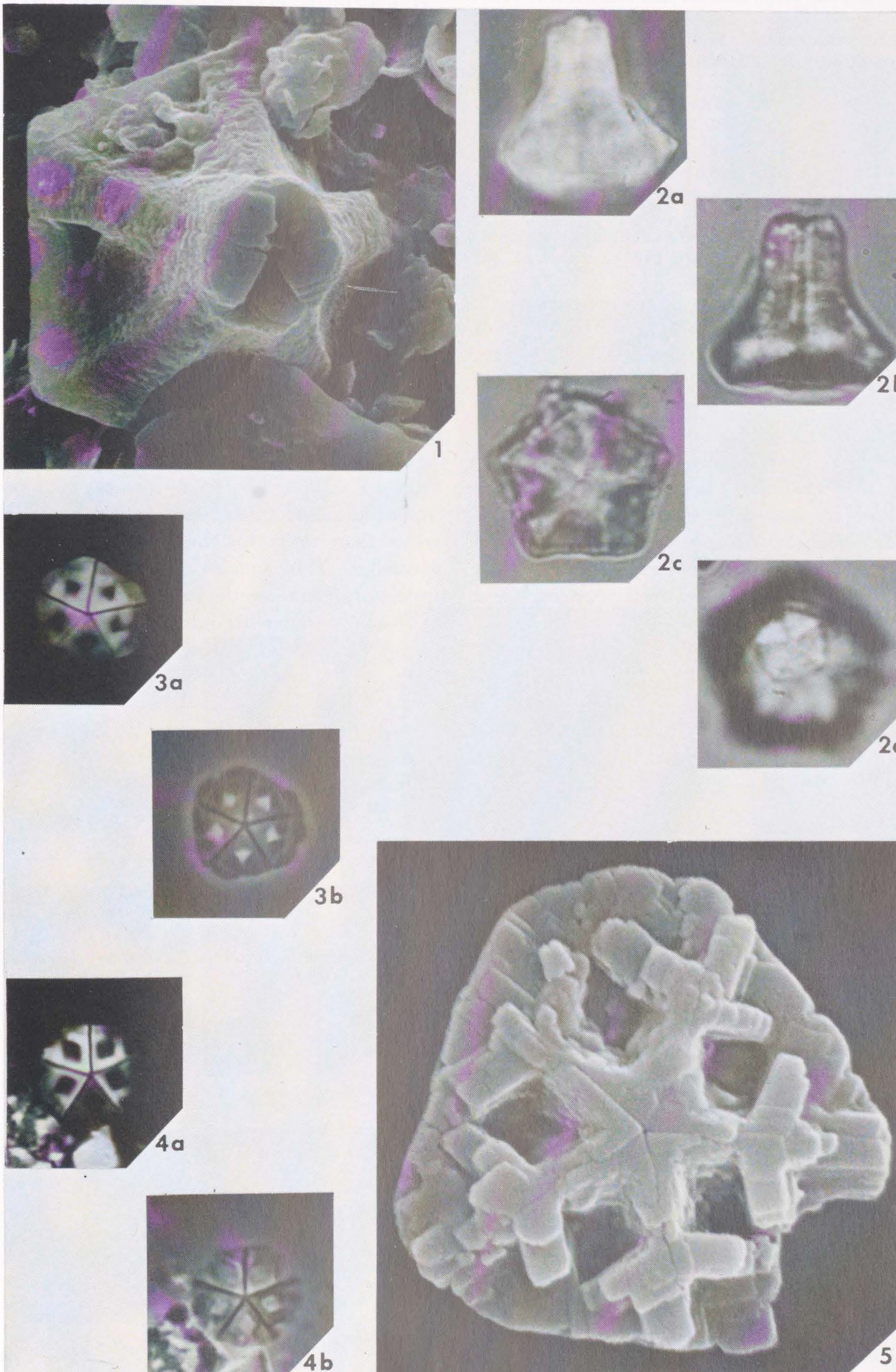

PLATE 8

Helicosphaera sp. BUKRY and KENNEDY, 1969, fig. 4-1; Eocene, California.
Helicopontosphaera seminulum (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 34, fig. 4; pl. 35, figs. 1-2, 5-6; pl. 37, fig. 6; Eocene, Denmark. Not POZARYSKA and LOCKER, 1971, pl. 2, fig. 24. PERCH-NIELSEN, 1972, pl. 18, figs. 7, 10; Eocene, Atlantic. HAQ, 1973, pl. 1, fig. 4; pl. 3, figs. 7-8; Eocene. SHERWOOD, 1974, pl. 5, figs. 9-10; pl. 6, fig. 8; Eocene, Texas.
Helicopontosphaera lophota (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, in part; pl. 36, fig. 1; Eocene, Denmark.

Remarks: This broadly elliptical species has a large, elliptical central area spanned by a wide double bridge that is parallel to the transverse axis. There is no flange and the outer whorl merges into the previous whorl. The bridge is optically distinct from the rest of the specimen. Segments of the outer whorl are normally visible with phase contrast. *Helicopontosphaera lophota* (Bramlette and Sullivan) has the crossbar aligned with the short axis and *Helicopontosphaera wilcoxoni* Gartner has a less rounded outline, a distinct flange, and a slightly angled crossbar.

Occurrence: H. seminulum occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

HELICOPONTOSPHAERA WILCOXONI Gartner 1971

Plate 18, Figures 6-7

Helicosphaera aff. *H. seminulum* Bramlette and Sullivan. BRAMLETTE and WILCOXON, 1967, pl. 5, figs. 11-12; Oligocene, Trinidad.
Helicopontosphaera wilcoxoni GARTNER, 1971, pl. 2; Eocene, Blake Plateau. HAQ, 1973, pl. 5, figs. 1-2; Eocene-Oligocene.
Helicopontosphaera lophota (Bramlette and Sullivan). HAQ, 1971c, pl. 10, figs. 8-9; Oligocene, Syria.

Remarks: This species has a central open area spanned by a crossbar that is parallel to the transverse axis or at a slight angle to it. This bar is optically distinct in cross-polarized light. The final whorl flares into a broad flange, which has an abrupt termination. The final flange segments are much wider than those for the remainder of the specimen. This species differs from *Helicopontosphaera seminulum* (Bramlette and Sullivan) in its less rounded outline, normally slightly angled crossbar and distinct flange.

Occurrence: H. wilcoxoni occurs in the upper middle Eocene (Blow's P14) of Alabama.

PLATE 9

Figures | Page

1-4. *Micrantholithus angulosus* Stradner and Papp Sample B-30 189
  1. Electron micrograph, X5,200
  2a. Cross-polarized light, X2,200
  2b. Phase contrast, X2,200
  3a. Cross-polarized light, X2,200
  3b. Phase contrast, X2,200
  4. Electron micrograph, X8,700

5-8. *Micrantholithus procerus* Bukry and Bramlette Sample B-30 189
  5a. Cross-polarized light, X2,200
  5b. Phase contrast, X2,200
  6a. Cross-polarized light, X2,200
  6b. Phase contrast, X2,200
  7a. Cross-polarized light, X2,200
  7b. Phase contrast, X2,200
  8a. Transmitted light, X2,200 Plan view
  8b. Transmitted light, X2,200 Side view

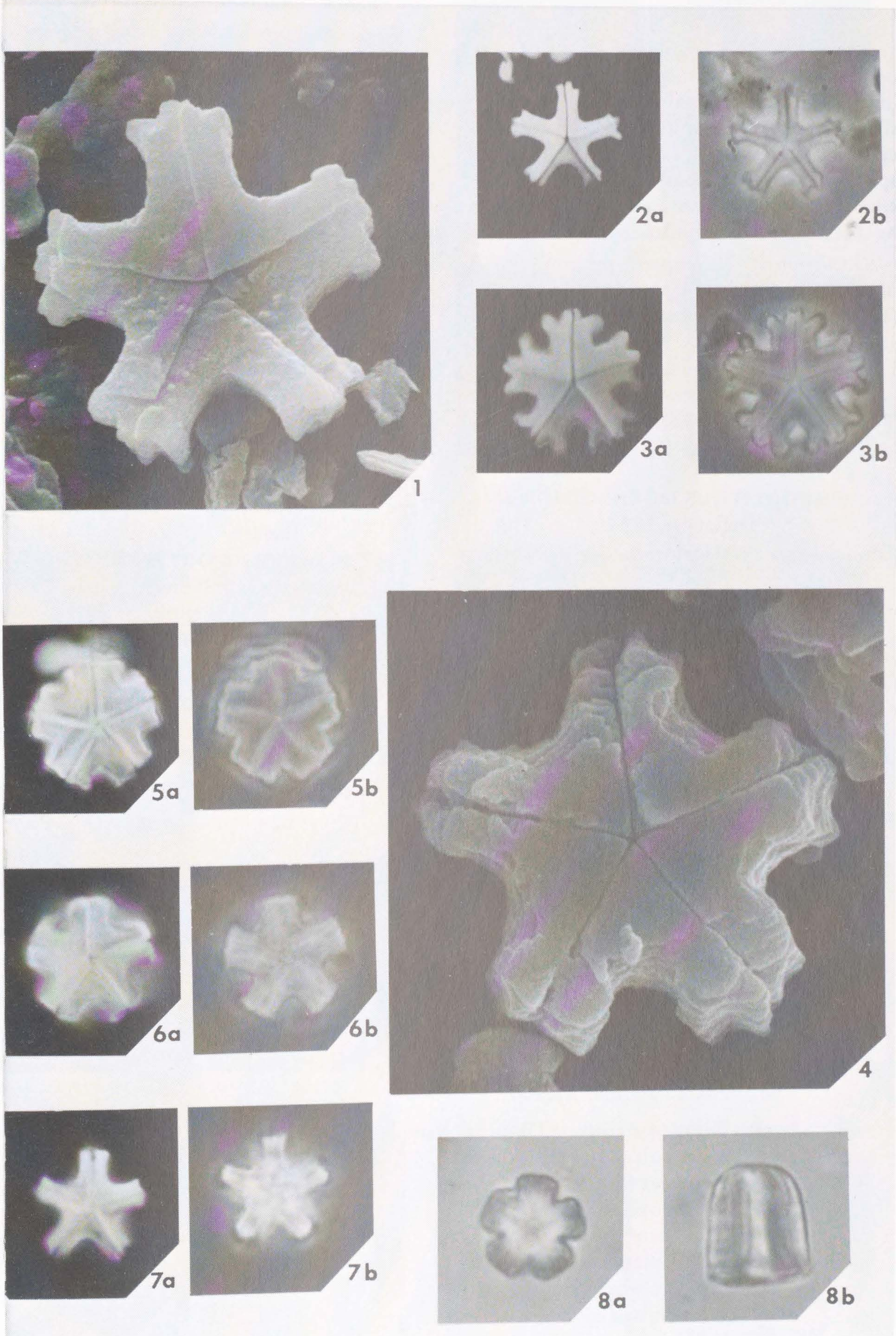

PLATE 9

HELICOPONTOSPHAERA sp. A
Plate 18, Figure 9

Remarks: This small species of *Helicopontosphaera* has a flattened elliptical outline. The flange is small and only protrudes slightly. A broad double bar crosses the central area at an angle. *Helicopontosphaera* sp. A is the only member of this genus in which the double nature of the crossbar can be discerned in cross-polarized light.

Occurrence: Helicopontosphaera sp. A occurs only in the upper middle Eocene (Blow's P14) of Alabama.

Genus LOPHODOLITHUS
Deflandre 1954

Type species: *Lophodolithus mochlophorus* Deflandre

LOPHODOLITHUS MOCHLOPHORUS
Deflandre 1954

Lophodolithus mochlophorus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 12, figs. 20-23; text-figs. 69-71; Eocene, France. BRAMLETTE and SULLIVAN, 1961, pl. 4, fig. 6; Eocene, California, Texas, France. SULLIVAN, 1964, pl. 6, fig. 9; Paleocene, California. SULLIVAN, 1965, pl. 6, figs. 1-3; Eocene, California. MANIVIT, 1965, pl. 2, fig. 11; Cretaceous, Eocene, France. BUKRY and KENNEDY, 1969, figs. 4-4, 4-5; Eocene, California. PERCH-NIELSEN, 1971b, pl. 38, fig. 1; Eocene, Denmark. LOCKER, 1972, pl. 10, fig. 4; Eocene, Europe.

Remarks: L. mochlophorus is ovoid in outline and the wider end has a large flaring flange. Across the large central opening is a straight slender bar, which is parallel to the short axis. Individual flange segments are visible with the light microscope. *Lophodolithus nascens* Bramlette and Sullivan has a much smaller flange, no visible flange segments in the light microscope, and a more uniformly elliptical outline.

Occurrence: L. mochlophorus occurs in the lower middle Eocene (Blow's P11) of Alabama.

Genus TRANSVERSOPONTIS
Hay, Mohler, and Wade 1966

Type species: *Discolithus obliquipons* Deflandre

TRANSVERSOPONTIS EXILIS
(Bramlette and Sullivan) 1961
Plate 21, Figure 5

Discolithus exilis BRAMLETTE and SULLIVAN, 1961, pl. 2, fig. 10; Eocene, California. SULLIVAN, 1965, pl. 5, fig. 7; Eocene, California. REINHARDT, 1967, pl. 3, figs. 20, 24; Eocene, Germany.

PLATE 10

Figures Page

1-5. *Pemma basquense basquense* (Martini) Sample B-30 190
- 1. Electron micrograph, X5,200
- 2a. Cross-polarized light, X2,200
- 2b. Phase contrast, X2,200
- 3a. Cross-polarized light, X2,200
- 3b. Phase contrast, X2,200
- 4a. Cross-polarized light, X2,200
- 4b. Phase contrast, X2,200
- 5a. Cross-polarized light, X2,200
- 5b. Phase contrast, X2,200

6-9. *Pemma basquense crassum* (Bouché) Sample B-30 191
- 6a. Cross-polarized light, X2,200
- 6b. Phase contrast, X 2,200
- 7a. Cross-polarized light, X2,200
- 7b. Phase contrast, X2,200
- 8a. Cross-polarized light, X2,200
- 8b. Phase contrast, X2,200
- 9a. Cross-polarized light, X2,200
- 9b. Phase contrast, X2,200

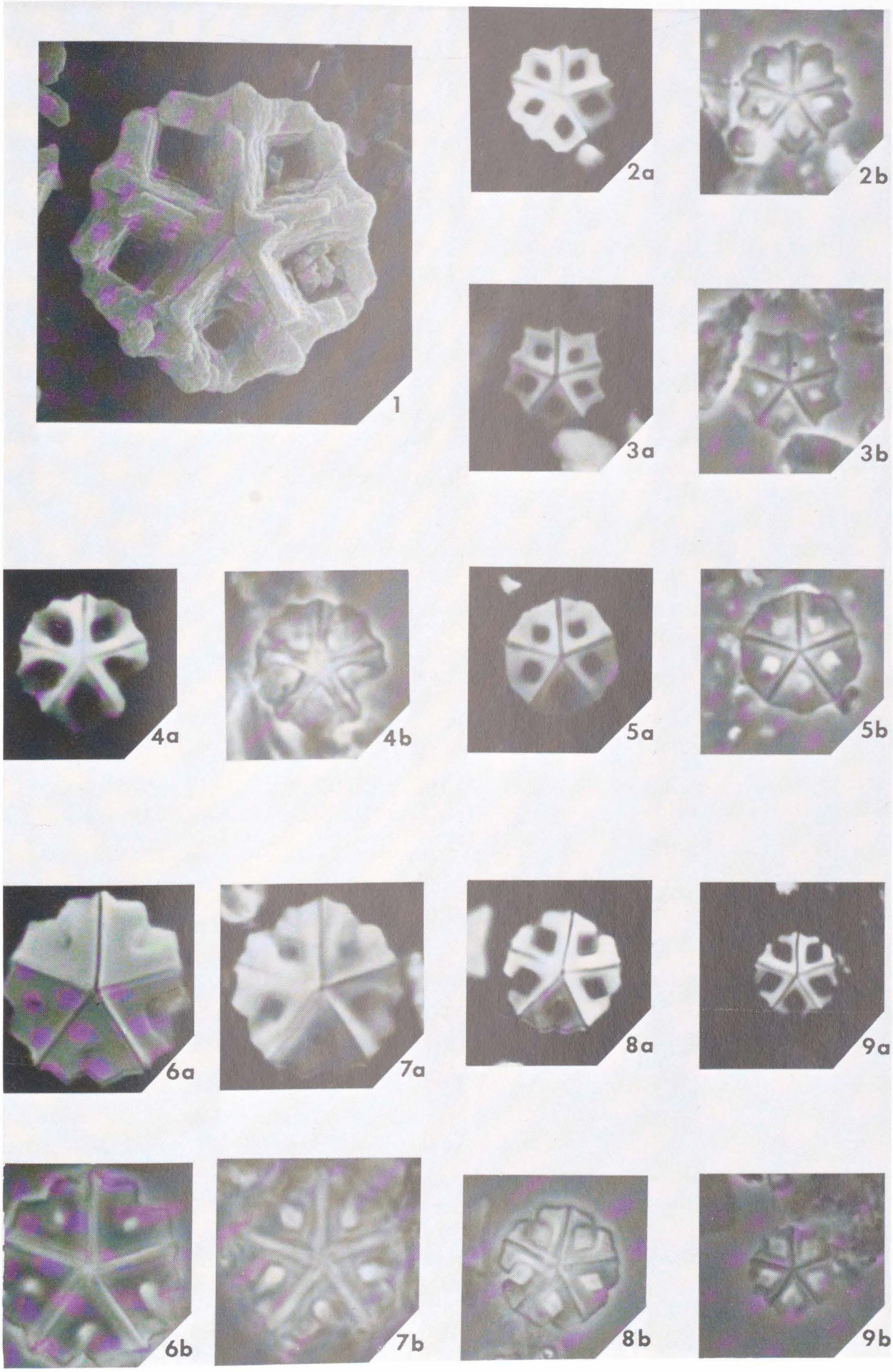

PLATE 10

Discolithus aff. *D. pulcher* (Sullivan). BRAMLETTE and SULLIVAN, 1961, pl. 3, figs. 9-10; Eocene, California.

Transversopontis exilis (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 27, figs. 3, 5-6; pl. 31, fig. 4; Eocene, Denmark.

Remarks: This discolith has an elliptical base with a high outward sloping wall and two large circular holes in the base. The base, as viewed from both sides, has rods running from the periphery toward the center. These rods can be seen indistinctly under cross-polarized light. The wall laths spiral upward and around the specimens. *T. exilis* lacks the scalloped and perforated pattern of *T. pulcher* (Deflandre). *Transversopontis fimbriatus* (Bramlette and Sullivan) has smaller holes and a different type of wall and basal structure; the walls are higher and there is a thick, flat upper rim.

Occurrence: T. exilis occurs in the middle Eocene (Blow's P11-P14) of Alabama.

TRANSVERSOPONTIS FIMBRIATUS
(Bramlette and Sullivan) 1961

Plate 22, Figures 1, 3

Discolithus fimbriatus BRAMLETTE and SULLIVAN, 1961, pl. 3, fig. 1; Eocene, California, Texas. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 3, fig. 12; Miocene, Czechoslovakia. SULLIVAN, 1964, pl. 3, fig. 9; Paleocene, California. SULLIVAN, 1965, pl. 5, figs. 1-3; Eocene, California. Not REINHARDT, 1967, pl. 3, figs. 1, 5.

Koczyia fimbriata (Bramlette and Sullivan). PERCH-NIELSEN, 1971b, pl. 27, fig. 1; pl. 29, figs. 1-2; Eocene, Denmark.

Transversopontis fimbriatus (Bramlette and Sullivan). LOCKER, 1972, pl. 1, fig. 13; Eocene, Europe.

Remarks: This large lopadolith has two circular perforations in its base. The walls rise almost vertically and then spread laterally, forming a wide flat rim. Little Stave Creek specimens appear to have layers of crystals parallel to the periphery, but specimens illustrated by Perch-Nielsen (1971b) have radiating laths. Further study may prove these to be separate species. *Transversopontis pectinatus* (Bramlette and Sullivan) also has two circular perforations, but lacks the broad rim.

Occurrence: T. fimbriatus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

TRANSVERSOPONTIS OBLIQUIPONS
(Deflandre) 1954

Plate 21, Figures 1-4

Discolithus obliquipons DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 11, figs. 1-2; Oligocene, New Zealand.

Discolithus pulcher Deflandre. BACHMANN, PAPP, and STRADNER, 1963, pl. 23, fig. 10; Austria.

Zygolithus cf. *Z. obliquipons* (Deflandre). STRADNER, 1964, text-fig. 19.

Discolithus pulcheroides SULLIVAN, 1964, pl. 4, fig. 7; Eocene, California. REINHARDT, 1967, in part; pl. 3, fig. 18; Eocene, Germany.

Discolithina pulchra (Deflandre). LEVIN, 1965, pl. 41, fig. 6; Eocene, Mississippi.

Discolithina cf. *D. pulcheroides* (Sullivan). GARTNER and SMITH, 1967, pl. 6, figs. 1-3; Eocene, Louisiana.

PLATE 11

Figures | Page

1-7. *Micrantholithus altus* Bybell and Gartner Sample B-30 189
- 1a. Cross-polarized light, X2,200
- 1b. Phase contrast, X2,200
- 2. Electron micrograph, X5,200
- 3a. Transmitted light, X2,200 Plan view
- 3b. Transmitted light, X2,200 Side view
- 4a. Transmitted light, X2,200 Plan view
- 4b. Transmitted light, X2,200 Side view
- 5. Electron micrograph, X5,200
- 6. Electron micrograph, X5,200
- 7. Electron micrograph, X5,200

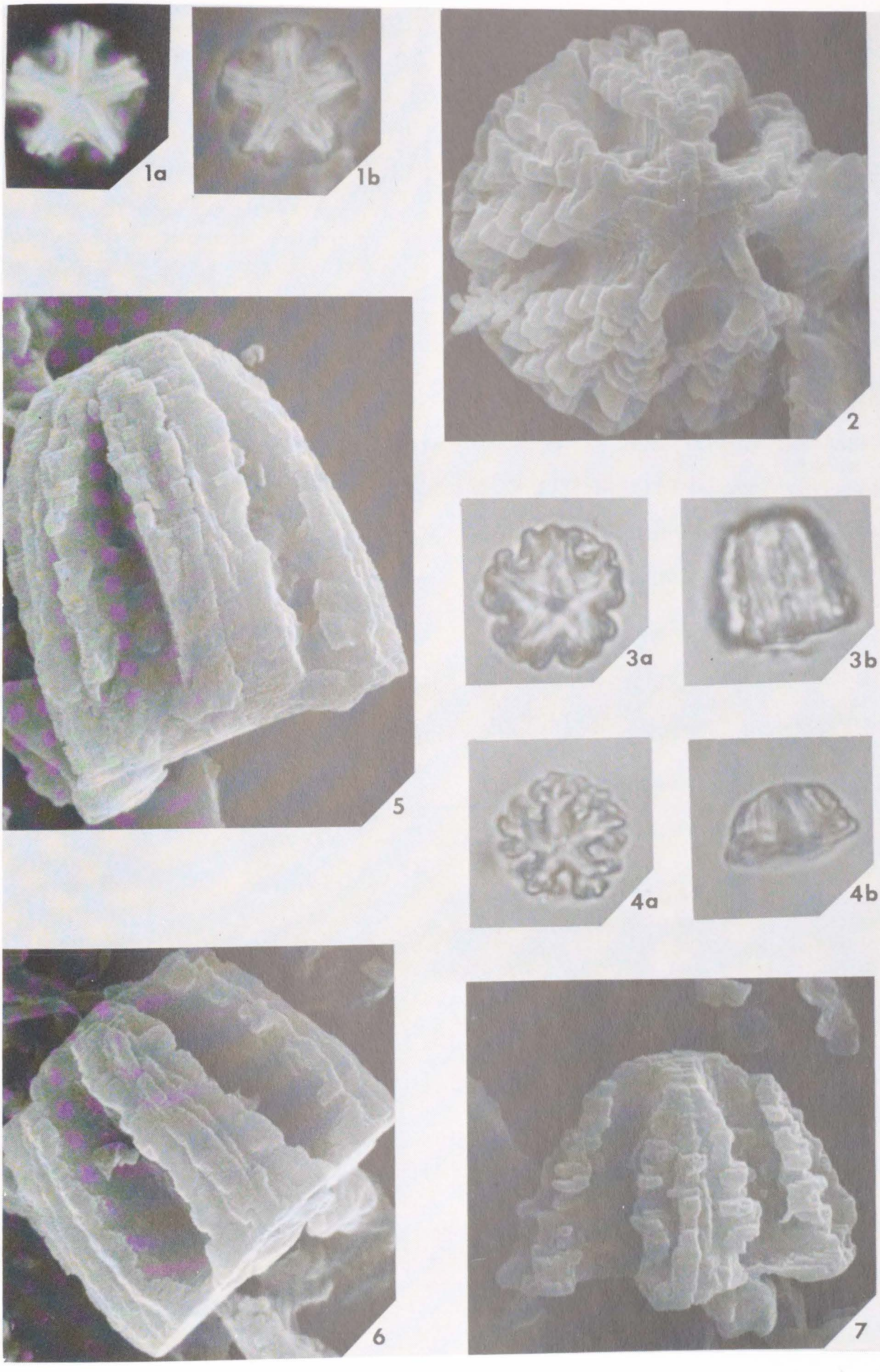

PLATE 11

Transversopontis obliquipons (Deflandre). HAY, MOHLER, and WADE, 1966, pl. 8, fig. 5; Eocene, USSR. PERCH-NIELSEN, 1967, pl. 3, figs. 6-8; Eocene, Denmark. MARTINI, 1969b, pl. 2, figs. 22-23; Eocene-Oligocene, Switzerland. HODSON and WEST, 1970, pl. 1, fig. 4; pl. 2, fig. 4; Eocene, England. HAQ, 1971b, pl. 7, figs. 5-6; pl. 8, figs. 1-3; pl. 8, figs. 8-9; pl. 17, fig. 2; Eocene-Oligocene, Germany. Not POZARYSKA and LOCKER, 1971, pl. 2, fig. 3. not Locker, 1972, pl. 1, fig. 20.

Discolithina pulcheroides (Sullivan). LEVIN and JOERGER, 1967, pl. 2, fig. 8; Eocene-Oligocene, Alabama. HAQ, 1968, in part; pl. 7, figs. 2-3; Eocene, Germany. STRADNER and EDWARDS, 1968, pl. 38, figs. 6-10; Eocene, New Zealand. MARTINI, 1969b, pl. 1, figs. 9-10; Oligocene, Switzerland.

Transversopontis prava LOCKER, 1967, pl. 2, fig. 5; pl. 1, fig. 1; Oligocene, Germany. PERCH-NIELSEN, 1971b, pl. 33, figs. 1-2, 4-6; Eocene, Denmark.

Discolithus pulchriporus REINHARDT, 1967, in part; pl. 7, fig. 5; Eocene, Germany.

Discolithina obliquipons (Deflandre). Not HAQ, 1968, pl. 7, figs. 4-6; pl. 11, fig. 2.

Discolithus aff. *D. obliquipons* Deflandre. CLOCCHIATTI, 1971, pl. 18, figs. 3-5; Oligocene, Africa.

Transversopontis pulcheroides (Sullivan). PERCH-NIELSEN, 1971b, pl. 33, figs. 3, 7; Eocene, Denmark. SHERWOOD, 1974, pl. 5, figs. 15-16; Eocene, Texas.

Transversopontis pulchra (Deflandre). POZARYSKA and LOCKER, 1971, pl. 2, fig. 5; Eocene, Poland.

Transversopontis pulcher (Deflandre), LOCKER, 1972, pl. 1, figs. 18-19; Eocene, Europe.

Transversopontis pulchriporus (Reinhardt). SHERWOOD, 1974, pl. 5, figs. 17-18; pl. 6, fig. 6; Eocene, Texas.

Remarks: This species has an elliptical rim, which is spanned at an angle by a broadly S-shaped crossbar. Small circular pits are evenly spaced along the inner periphery of the rim and the outer part of the crossbar normally bears a pore on each end. These pores are visible only on the distal surface. Small knobs at the level of the distal surface line the two large openings. On the distal surface the crystallites are arranged in concentric bands, but on the proximal surface the rods radiate outward from the center. The proximal surface is smaller than the distal and in proximal view the outward and upward spiraling laths of the walls are visible. *T. obliquipons* is similar to *Transversopontis pulcher* (Deflandre), but has an angled rather than straight crossbar. There is some variation in this species and the crossbar can be very curved or almost straight. The number of pores normally forms a single row around the periphery, but in some specimens there may be a double row (Plate 21, Figure 3). In some forms the shallow pores are filled in or the pores are so shallow that

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PLATE 12

Figures		Page
1-6.	*Pemma serratum* (Chang) Sample B-30	192
	1a. Cross-polarized light, X2,200	
	1b. Phase contrast, X2,200	
	2a. Cross-polarized light, X2,200	
	2b. Phase contrast, X2,200	
	3a. Cross-polarized light, X2,200	
	3b. Phase contrast, X2,200	
	4a. Cross-polarized light, X2,200	
	4b. Phase contrast, X2,200	
	5a. Electron micrograph, X5,200	
	5b. Electron micrograph, X4,800 Tilted specimen	
	6. Electron micrograph, X4,400	
7-8.	*Pemma stradneri* (Chang) Sample B-30	192
	7a. Cross-polarized light, X2,200	
	7b. Phase contrast, X2,200	
	8a. Cross-polarized light, X2,200	
	8b. Phase contrast, X2,200	

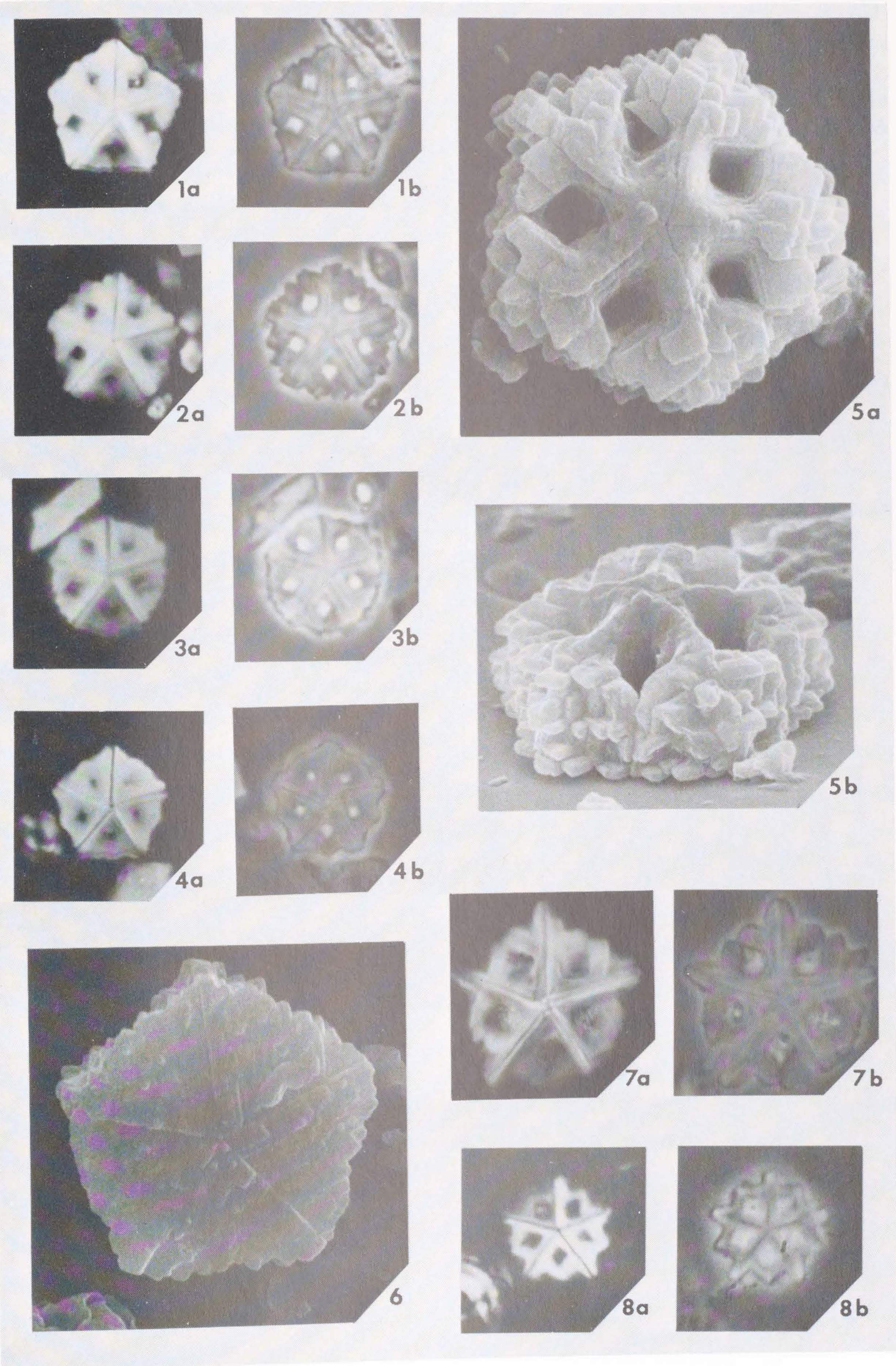

PLATE 12

they cannot be seen with the light microscope.

Occurrence: T. obliquipons occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family RHABDOSPHAERACEAE
Lemmermann 1908
Genus BLACKITES
Hay and Towe 1962

Type species: *Discolithus spinosus* Deflandre and Fert

BLACKITES CREBER (Deflandre) 1954
Plate 1, Figures 3-4

Rhabdolithus creber DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 12, figs. 31-33; text-figs. 81-82; Eocene, France. BOUCHÉ, 1962, pl. 1, fig. 6; Eocene, France. BYSTRICKÁ, 1963, pl. 1, fig. 13; Eocene, Czechoslovakia.

Rhabdosphaera crebra (Deflandre). BRAMLETTE and SULLIVAN, 1961, pl. 5, figs. 1-3; Eocene, California. HAY and TOWE, 1963, pl. 1, figs. 2-5; pl. 2, figs. 1-5; Eocene, France. SULLIVAN, 1964, pl. 7, fig. 3; Eocene, California. SULLIVAN, 1965, pl. 7, figs. 4-5; Eocene, California. REINHARDT, 1967, pl. 2, fig. 20; pl. 3, figs. 7-8; pl. 7, fig. 1; Eocene, Germany. BUKRY and KENNEDY, 1969, pl. 4, figs. 9-10; Eocene, California. LOCKER, 1972, p. 2, figs. 2-3; Eocene, Europe.

Rhabdosphaera vitrea (Deflandre). HAY and TOWE, 1963, pl. 1, fig. 1; Eocene, France.

Rhabdolithes creber (Deflandre). HODSON and WEST, 1970, pl. 2, figs. 2-3; pl. 3, fig. 3; text-fig. 3; Eocene, Britain.

Blackites spinosus (Deflandre and Fert). PERCH-NIELSEN, 1971b, in part; pl. 44, figs. 3-5, 7-8; Eocene, Denmark.

Blackites creber (Deflandre) SHERWOOD, 1974, pl. 5, figs. 25-26; Eocene, Texas.

Blackites tenuis (Bramlette and Sullivan). SHERWOOD, 1974, in part; pl. 6, fig. 7; Eocene, Texas.

Remarks: the basal disc of *Blackites creber* has four cycles of crystals and is surmounted by a circular tapering stem. There is a distinct collar surrounding the basal part of the stem. In previously illustrated specimens the distal view of the base is almost identical to that of *Blackites spinosus* (Deflandre and Fert), the major difference being in the oblique rather than radiating laths of the second cycle. *B. creber* is rare in Little Stave Creek samples and no distal views were seen to confirm the similarity with *B. spinosus.* However, specimens of *Blackites* sp. aff. *B. creber,* which are common at Little Stave Creek, do closely resemble *B. spinosus.* This four-cycled basal construction is similar for most species in the genus *Blackites* and more diagnostic features for *B. creber* are a distinct flaring collar and only slightly tapering stem. The proximal view of *B. creber,* with only a small portion of the outer rim of crystals visible, has more affinities with *Rhabdosphaera vitrea* (Deflandre) than *B. spinosus.* The remainder of the base is made of imbricate, radiating, wedge-shaped segments. All four segment cycles are visible in a proximal view of *B. spinosus.*

Occurrence: B. creber occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

BLACKITES sp. aff. B. CREBER
(Deflandre) 1954

Plate 1, Figures 1-2

Remarks: Both *Blackites* sp. aff. *B. creber* and *B. creber* (Deflandre) possess an arched

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PLATE 13

Figures		Page
1-2.	*Pentaster lisbonensis* Bybell and Gartner Sample B-30	192
	1a. Electron micrograph, X5,000 11° Tilt	
	1b. Electron micrograph, X4,400 45° Tilt	
	2a. Cross-polarized light, X2,200	
	2b. Interference contrast, X2,200	
	2c. Transmitted light, X2,200	
3.	*Orthozygus aureus* (Stradner) Sample B-30	242
	3a. Electron micrograph, X8,700 55° Tilt	
	3b. Electron mcirograph, X8,700	

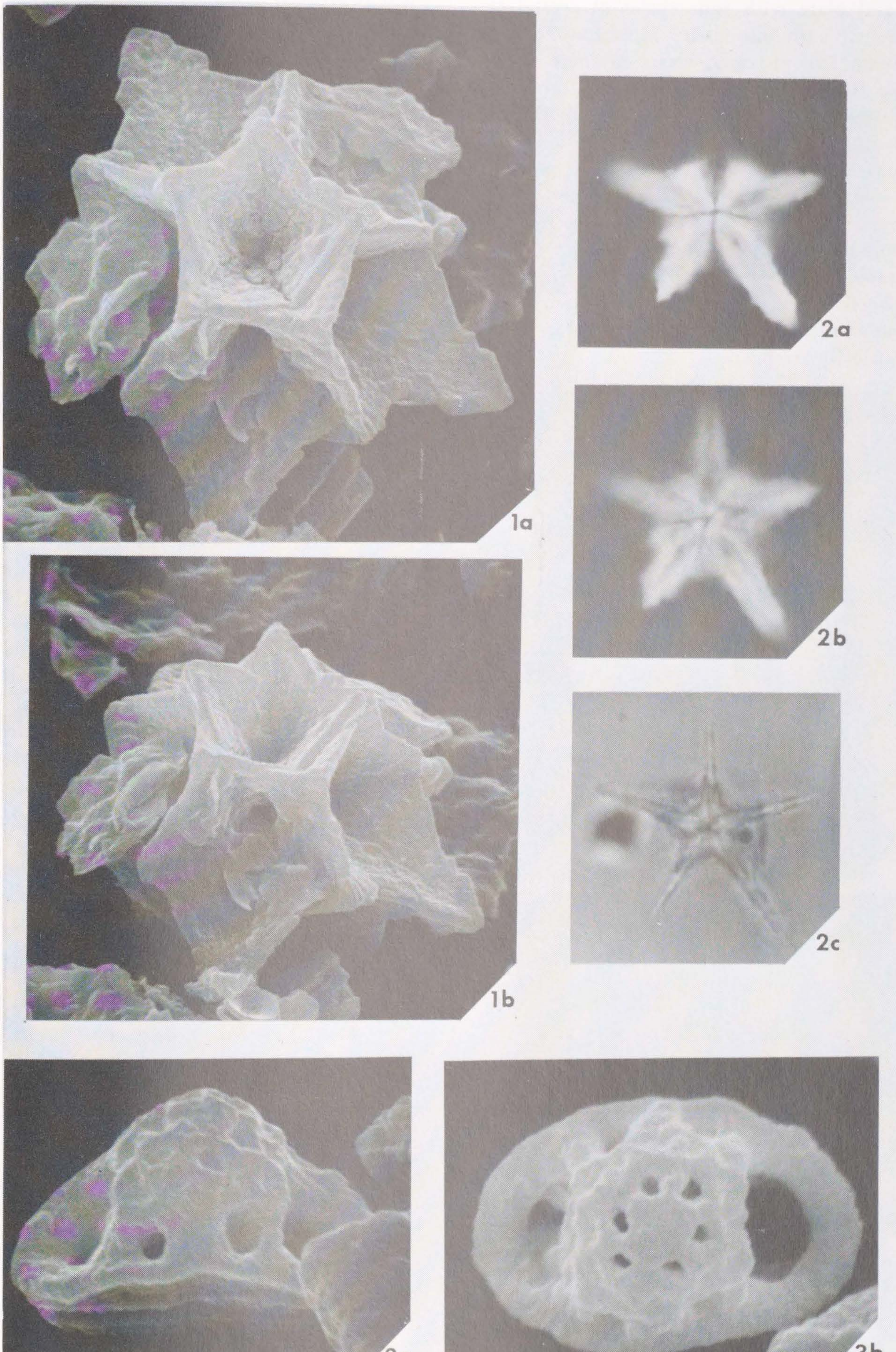

PLATE 13

basal plate with four cycles of crystal elements, surmounted by a narrow tapering stem. The proximal views of these species are also similar, with only the outer rim of elements being visible from the distal side. *Blackites* sp. aff. *B. creber*, however, is only one-half the size of *B. creber*. The collar of *Blackites* sp. aff. *B. creber* is formed of two layers of crystallites, one higher on the stem than the other. The plates of the lower layer are offset and at an angle to the upper layer. The collar of *B. creber* also has two layers, but they are aligned and the crystals are all vertically arranged.

Occurrence: Blackites sp. aff. *B. creber* occurs in the upper middle Eocene (Blow's P14) of Alabama.

BLACKITES SPINOSUS
(Deflandre and Fert) 1954
Plates 2-3

Discolithus spinosus DEFLANDRE and FERT. 1952, nomen nudum; text-fig. 4. DEFLANDRE and FERT, 1954, pl. 14, figs. 13-15; Eocene, France; Oligocene, New Zealand.

Blackites spinosus (Deflandre and Fert). HAY and TOWE, 1962, pl. 4, figs. 5; Eocene, France. BLACK, 1965, fig. 17; Paleocene, Denmark. HODSON and WEST, 1970, pl. 2, fig. 5; text-fig. 3; Eocene, Britain. HAQ, 1971a. pl. 5, figs. 8-9; Eocene, Pakistan. HAQ, 1971b, pl. 11, figs. 1-2; pl. 17, fig. 7; in part; Eocene, Germany. PERCH-NIELSEN, 1971b, pl. 45, figs. 6-7; Eocene, Denmark.

Rhabdosphaera spinula LEVIN, 1965, pl. 42, fig. 3; Eocene, Mississippi. GARTNER and SMITH, 1967, pl. 1, figs. 1-2; Eocene, Mississippi. HAQ, 1967, pl. 3, figs. 1-3; Eocene, Pakistan. LEVIN and JOERGER, 1967, pl. 2, fig. 15; Eocene-Oligocene, Alabama. MARTINI, 1969b, pl. 3, figs. 28-29; Eocene-Oligocene, Germany. HAQ, 1971, pl. 10, fig. 14; Eocene, Pakistan. POZARYSKA and LOCKER, 1971, pl. 2, fig. 28; Eocene, Poland. LOCKER, 1972, pl. 2, fig. 13; pl. 3, fig. 9; Eocene, Europe.

Blackites amplus Roth and Hay. HAY, *et al.*, 1967, pl. 7, fig. 10; Oligocene, Blake Plateau. ROTH, 1970, pl. 7, fig. 6; Oligocene, Blake Plateau, Alabama, Barbados, Trinidad, Germany, Belgium, Italy. SHERWOOD, 1974, pl. 6, figs. 9-10; pl. 7, figs. 3-4; Eocene, Texas.

Rhabdosphaera recta (Deflandre). HAQ, 1968, pl. 9, fig. 8; pl. 11, figs. 17-18; Eocene, Germany.

Blackites rectus (Deflandre). STRADNER and EDWARDS, 1968, in part; pl. 30, figs. 1-4, Eocene, New Zealand.

Blackites spinulus (Levin). ROTH, 1970, pl. 8, fig. 4; Oligocene, Germany, Alabama.

Blackites tenuis (Bramlette and Sullivan). SHERWOOD, 1974, in part; pl. 5, figs. 19-22; pl. 6, fig. 5; Eocene, Texas.

Remarks: This rhabdolith has a long, normally uniformly tapering, circular stem which is attached to a basal shield with four cycles of crystal segments. The outer cycle consists of large, slightly overlapping, trapezoidal crystals and a series of radiating laths forms the second cycle. The third cycle consists of inclined and imbricate crystals which are arranged around an inner cycle. In cross-polarized light these third cycle crystals have a distinctive swasticoid extinction pattern. The inner cycle has similar crystals, but they differ in their orientation, are higher, and grade directly into the stem. The three outer cycles are visible from the proximal side, but in *Blackites creber* (Deflandre)

PLATE 14

Figures		Page
1-2.	*Chiasmolithus solitus* (Bramlette and Sullivan)	193
	1. Electron micrograph, X8,700 Sample B-30	
	2a. Cross-polarized light, X2,200 Sample B-12	
	2b. Phase contrast, X2,200	
3.	*Chiasmolithus titus* Gartner Sample B-30	194
	3a. Cross-polarized light, X2,200	
	3b. Phase contrast, X2,200	
4-6.	*Campylosphaera dela* (Bramlette and Sullivan) Sample B-30	193
	4a. Cross-polarized light, X2,200	
	4b. Phase contrast, X2,200	
	5. Electron micrograph, X8,700 Distal view	
	6. Electron micrograph, X10,400 Proximal view	

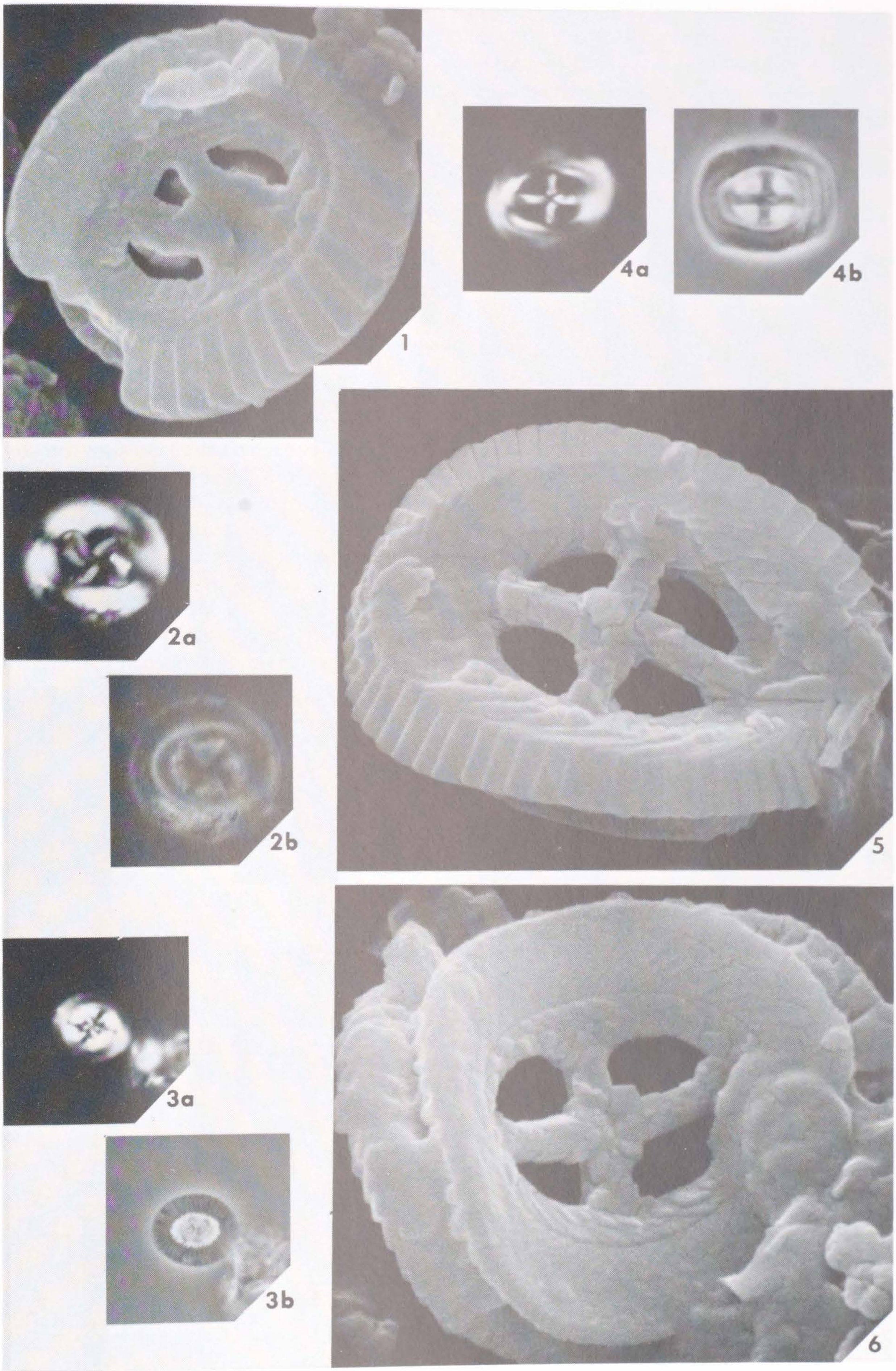

PLATE 14

only the outer cycle is visible. Specimens of this species are often incomplete; parts of the stem or the entire stem may be broken off and, frequently, the outer two rings of the crystals of the base are missing. *B. creber* has a more pronounced collar which is distinct and flares out from the stem. The collar of *B. spinosus* tapers into the stem.

Occurrence: B. spinosus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

BLACKITES TENUIS
(Bramlette and Sullivan) 1961 n. comb.
Plate 4

Rhabdosphaera tenuis BRAMLETTE and SULLIVAN, 1961, pl. 5, fig. 14; Eocene, California. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 4, fig. 2; Eocene, Czechoslovakia. SULLIVAN, 1964, pl. 7, fig. 4; Eocene, California. SULLIVAN, 1965, pl. 7, fig. 10; Eocene, California. LEVIN and JOERGER, 1967, pl. 2, fig. 16; Eocene-Oligocene, Alabama. MARTINI, 1969b, pl. 3, figs. 30-31; Eocene-Oligocene, Germany. HAQ, 1971b, pl. 5, fig. 14; pl. 11, fig. 3?; Eocene-Oligocene, Germany. POZARYSKA and LOCKER, 1971, pl. 2, fig. 27; Eocene, Poland. LOCKER, 1972, pl. 3, figs. 1-2; Eocene, Europe.

Rhabdolithes tenuis (Bramlette and Sullivan). Not HODSON and WEST, 1970, pl. 3, fig. 1.

Blackites incompertus ROTH, 1970, pl. 7, fig. 5; pl. 8, figs. 1-2; Oligocene, Alabama, Germany.

Remarks: The base of this rhabdolith contains several cycles of elements and is surmounted by a very long tapering stem. The stem rises vertically from the base for one-third of its length and then tapers to a point. In some specimens there is a slight thickening of the stem one-third of its length from the base, followed by tapering. According to Roth (1970), the base consists of an outer cycle of trapezoidal elements, a cycle of strongly imbricate plates and an inner cycle of square crystals which are above the basal plate and quite distinct in side view. There is no collar and the stem rises directly from this inner cycle of elements. The distal view is similar to that of *Blackites spinosus* (Deflandre and Fert) and *Blackites creber* (Deflandre), but lacks a cycle of radiating laths and a collar. In proximal view the entire outer cycle is visible, as it is in *B. spinosus,* suggesting that the inner cycles also may be visible. Specimens of *B. creber,* which have only two cycles visible in proxi-

PLATE 15

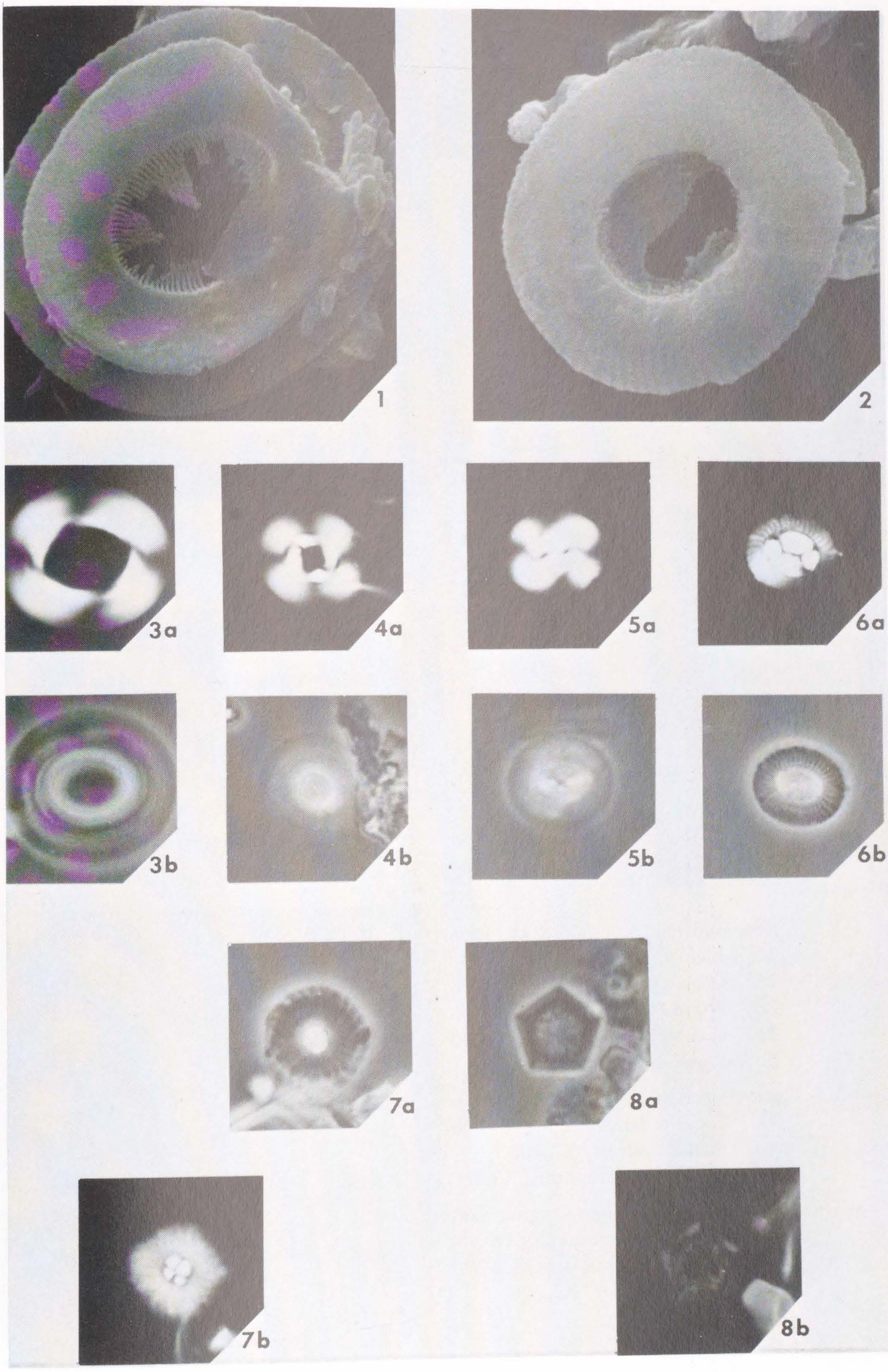

PLATE 15

mal view, expose very little of the outer ring. In many cases the outer cycle of basal crystals is broken off.

Occurrence: B. tenuis occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

BLACKITES TROCHOS n.sp.

Plate 6

Description: This unusual rhabdolith has a circular base of four cycles of elements surmounted by approzimately twelve struts which spiral sinistrally upward and support a broad, hollow stem. The base consists of an outer cycle of trapezoidal segments, a cycle of radiating laths, and a third cycle of imbricate and inclined crystals. A fourth cycle of crystals, similar to the third, but inclined in the opposite direction, rises upward and outward from the base. This cycle forms the base for the struts. The stem is constructed of more or less equidimensional elements, rather than the long laths typical of the stems of most rhabdoliths. All observed specimens had broken stems and the length and amount of taper of the stem is unknown.

Occurrence: Blackites trochos occurs in the upper middle Eocene (Blow's P14) of Alabama.

BLACKITES sp. A

Plate 5, Figure 4

Remarks: This species was not seen with the electron microscope, and it is not possible to describe its construction in detail, although there appears to be some similarity to *Blackites* sp. B. Specimens of *Blackites* sp. A have a large, lower base which is surmounted by an outward extending structure similar to the fourth cycle of elements of *Blackites trochos,* n. sp. A large tubular stem rises from this area and tapers abruptly to a sharp point. *Blackites* sp. A is similar at first glance to *Rhabdosphaera morionum* (Deflandre), but the latter species lacks the complex basal structure and stem and is more bulbous in its upper portion than *Blackites* sp. A.

Occurrence: Blackites sp. A was found in the upper middle Eocene (Blow's P14) of Alabama.

Genus RHABDOSPHAERA
Haeckel 1894
Type species: *Rhabdosphaera claviger* Murray and Blackman

RHABDOSPHAERA VITREA
(Deflandre) 1954
Plate 5, Figures 1-3

PLATE 16

Figures Page

1-3. *Cycloccolithina reticulata* (Gartner and Smith) Sample B-30 195
- 1. Electron micrograph, X10,400 Proximal view
- 2a. Cross-polarized light, X2,200
- 2b. Phase contrast, X2,200
- 3a. Cross-polarized light, X2,200
- 3b. Phase contrast, X22 00

4-5. *Cyclococcolithina formosa* (Kamptner) Sample B-30 195
- 4a. Cross-polarized light, X2,200
- 4b. Phase contrast, X2,200
- 5. Electron micrograph, X8,700 Distal view

6-7. *Daktylethra punctulata* Gartner Sample B-30 238
- 6. Electron micrograph, X8,700
- 7a. Cross-polarized light, X2,200
- 7b. Phase contrast, X2,200

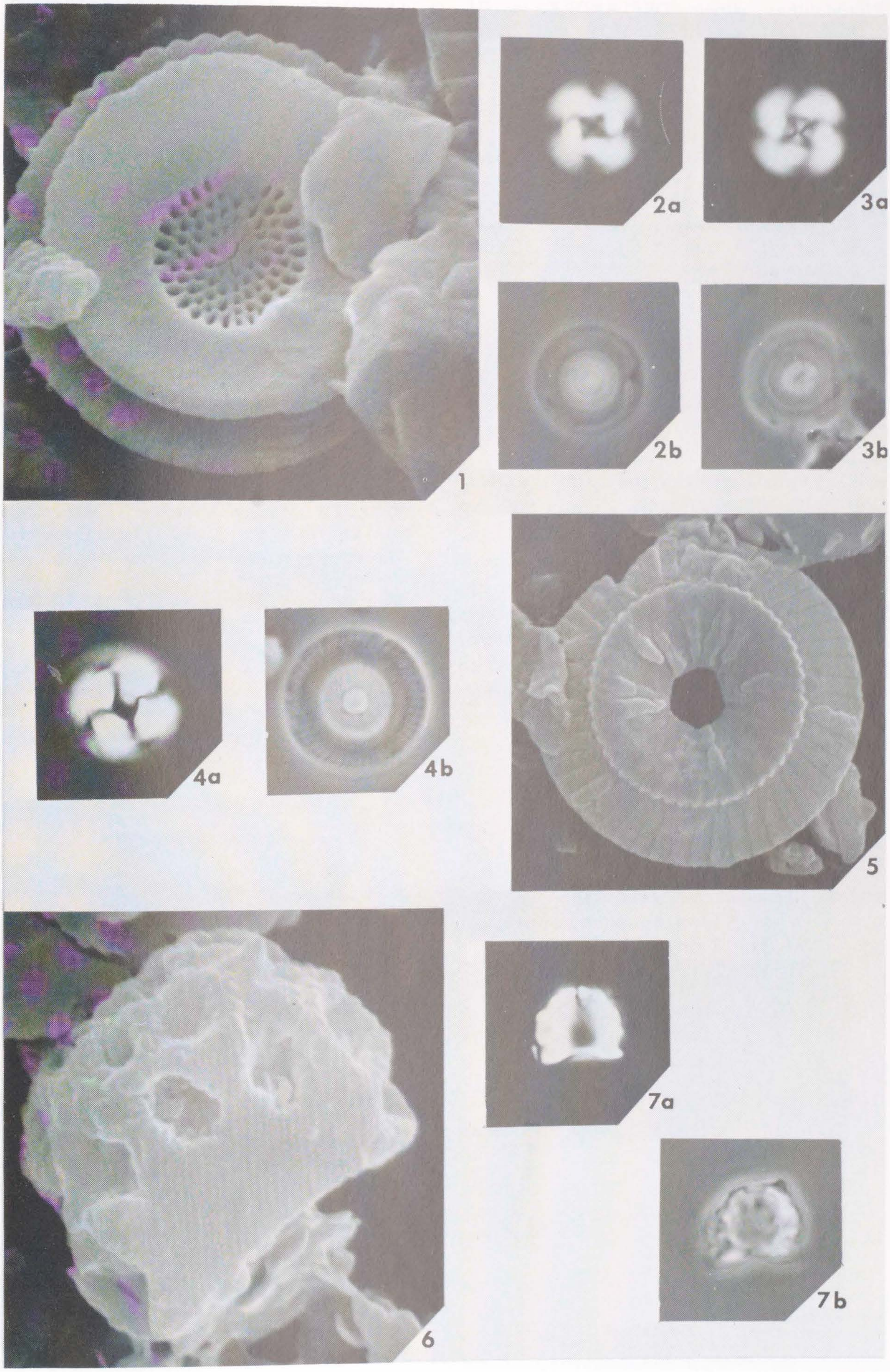

PLATE 16

Rhabdolithus vitreus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 12, figs. 28-29; text-figs. 83-84; Eocene, France. PERCH-NIELSEN, 1971b, pl. 46, figs. 1-6, 9; Eocene, Denmark.

Rhabdosphaera vitrea (Deflandre). BRAMLETTE and SULLIVAN, 1961, pl. 5, figs. 16-17; Eocene, California. Not HAY and TOWE, 1963, pl. 1, fig. 1. Not LEVIN and JOERGER, 1967, pl. 2, fig. 18. MARTINI, 1969b, pl. 3, figs. 32-33; Eocene, Germany. ROTH, 1970, pl. 8, fig. 6; pl. 9, fig. 1; Oligocene, Alabama, Germany. LOCKER, 1972, pl. 2, figs. 14-16; pl. 3, fig. 9; Eocene, Europe.

Remarks: The base of this rhabdolith consists of an outer rim of wedge-shaped elements that rests upon an inner whorl of small irregularly-shaped pieces. On the proximal side only a very small portion of this rim projects beyond the inner whorl and is visible. Four buttresses rise from the inner area and support a slender slightly tapering stem. In side view as seen through a light microscope, the buttresses appear to be a thick protruding collar which rests on the basal plate. In side view the struts flare out slightly unlike *Blackites creber* (Deflandre) in which the collar is essentially parallel to the stem and positioned much closer to it. The base of *R. vitrea* has only two cycles of elements but *B. creber* has a much more complex basal disc containing four cycles.

Occurrence: R. vitrea occurs in the upper middle Eocene (Blow's P14) of Alabama.

Family SPHENOLITHACEAE
Deflandre 1952

Genus SPHENOLITHUS
Deflandre 1952

Type species: *Sphenolithus radians* Deflandre

SPHENOLITHUS MORIFORMIS
(Bronimann and Stradner) 1960
Plate 23, Figure 2

Nannoturbella moriformis BRÖNNIMANN and STRADNER, 1960, text-figs. 11-16; Eocene, Cuba.

Sphenolithus pacificus MARTINI, 1965, pl. 36, figs. 7-10; Miocene, Trinidad, Pacific. MARTINI, 1971b, pl. 2, figs. 13-14; Eocene-Miocene, Switzerland.

Sphenolithus moriformis (Brönnimann and Stradner). BRAMLETTE and WILCOXON, 1967, pl. 3, figs. 1-6; Oligocene-Miocene, Trinidad. RADOMSKI, 1968, pl. 43, figs. 19-20; Paleocene-Miocene, Poland. ROTH, 1970, pl. 14, figs. 3-4; Eocene-Oligocene. BUKRY, 1971, pl. 4, fig. 6; Miocene, Pacific. HAQ, 1971b, pl. 13, figs. 9-10; Eocene-Oligocene, Germany. HAQ, 1971c, pl. 1, figs. 7, 14, 25-26; pl. 2, figs. 9-10; pl. 3, figs. 5-9; Oligocene, Syria. HAQ and LIPPS, 1971, pl. 5, figs. A-B; Oligocene, Pacific. PERCH-NIELSEN, 1971b, pl. 49, figs. 5-10; Eocene, Denmark. ROTH, FRANZ, and WISE, 1971, pl. 5, figs. 4-6; Oligocene, Blake Plateau. PERCH-NIELSEN, 1972, pl. 16, figs. 1, 4-5;

PLATE 17

Figures — Page

1-2. *Discoaster elegans* Bramlette and Sullivan 199
- 1. Electron micrograph, X5,200 Sample B-30
- 2a. Transmitted light, X2,200 Sample B-30
- 2b. Phase contrast, X2,200

3. *Discoaster barbadiensis* Tan Sin Hok Sample B-12 198
- 3a. Cross-polarized light, X2,200
- 3b. Phase contrast, X2,200

4. *Discoaster nodifer* (Bramlette and Riedel) Sample B-30 199
- 4a. Transmitted light, X2,200
- 4b. Phase contrast, X2,200

5. *Discoaster saipanensis* Bramlette and Riedel Sample B-30 200
- 5a. Transmitted light, X2,200
- 5b. Phase contrast, X2,200

6-7. *Discoaster* sp. A Sample B-30 200
- 6a. Transmitted light, X2,200
- 6b. Phase contrast, X2,200
- 7. Electron micrograph, X5,200

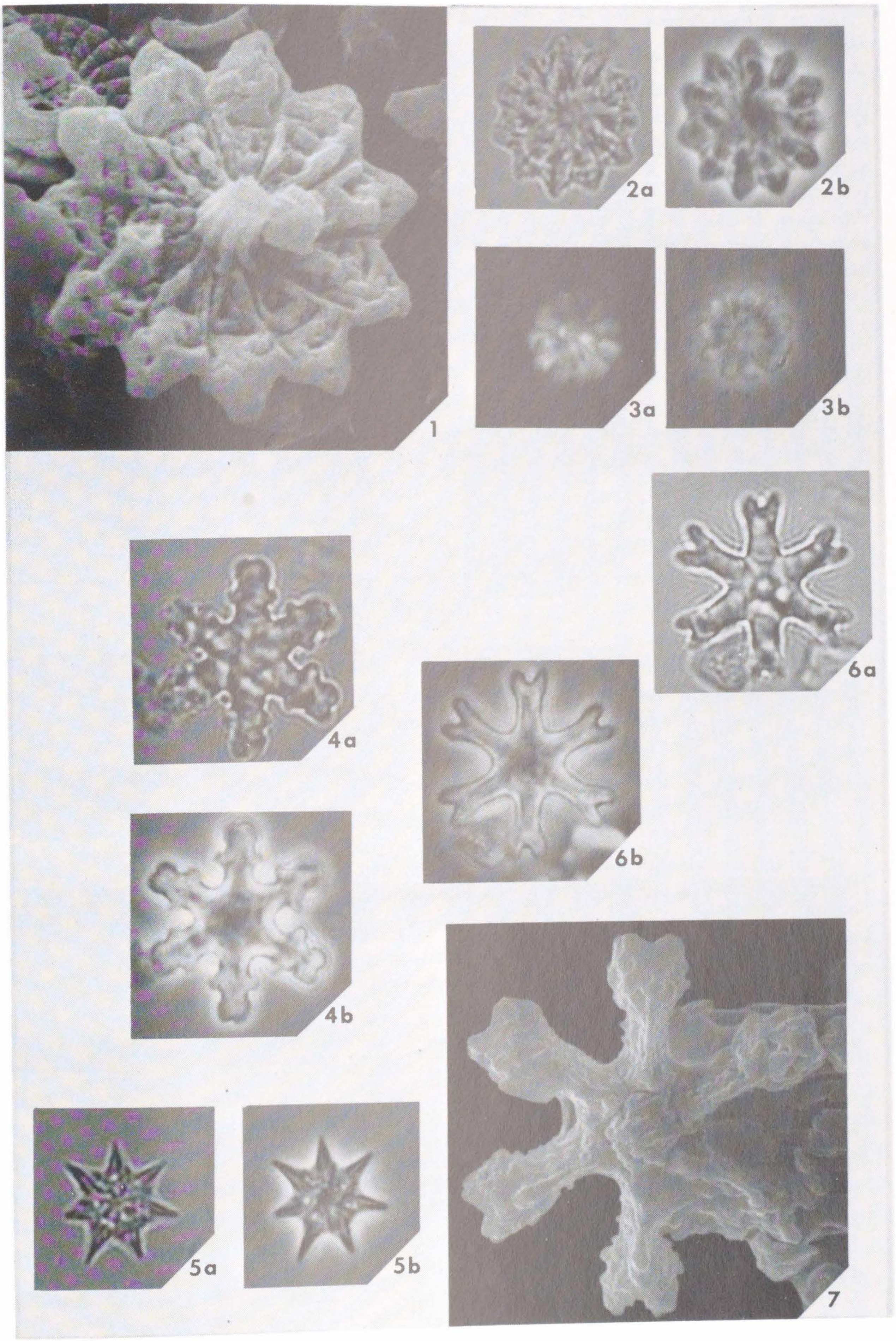

PLATE 17

Miocene, Atlantic. SHERWOOD, 1974, pl. 7, fig. 26; Eocene, Texas.
Sphenolithus spiniger BUKRY, 1971, pl. 6, figs. 10-12; pl. 7, figs. 1-2; Eocene, Pacific.

Remarks: The basal portion of this species has several radiating elements above which numerous wedge-shaped elements extend outward in an irregular radiate pattern. The apical spines are approximately the same length as the lateral elements, giving the species a bulbous form similar to a beehive. Some specimens found at Little Stave Creek have a less rounded outline and a more pronounced apical spine and more closely resemble the Miocene forms which grade into *Sphenolithus abies* Deflandre.

Occurrence: *S. moriformis* occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

SPHENOLITHUS RADIANS
Deflandre 1952
Plate 23, Figure 1

Sphenolithus radians DEFLANDRE *in* GRASSÉ, 1952, text-figs. 343, 363; Eocene, France. DEFLANDRE and FERT, 1954, pl. 12, figs. 36-38; text-figs. 109-112; Eocene, France. MANIVIT, 1959, pl. 3, figs. 9-10; Eocene, Africa, France. BRAMLETTE and SULLIVAN, 1961, pl. 14, figs. 6-8; Eocene, California. SULLIVAN, 1964, pl. 9, fig. 10; Paleocene, California. SULLIVAN, 1965, pl. 11, fig. 3; Eocene, California. RADOMSKI, 1968, pl. 46, fig. 14; Paleocene-Miocene, Poland. CLOCCHIATTI, 1971, pl. 23, fig. 5; Miocene, Africa. HAQ, 1971a, pl. 10, fig. 8; Paleocene, Persia; Eocene, Pakistan. PERCH-NIELSEN, 1971b, pl. 47, figs. 1-9; pl. 48, figs. 1-7; Eocene, Denmark. ROTH, FRANZ, and WISE, 1971, pl. 1, figs. 1-2; Eocene, Blake Plateau. BRATU and GHETA, 1972, pl. 4, figs. 46-47; Eocene, Czechoslovakia. ELLIS, LOHMAN, and WRAY, 1972, pl. 9, fig. 3; Pliocene, Gulf of Mexico. Not PERCH-NIELSEN, 1972, pl. 17, fig. 4; Eocene, Atlantic. LOCKER, 1972, pl. 11, figs. 3-4; Eocene, Europe. SHERWOOD, 1974, pl. 9, figs. 3-4; Eocene, Texas.
Sphenolithus cf. *S. radians* Deflandre. HAQ, 1971a, pl. 10, fig. 9; Eocene, Pakistan.

PLATE 18

Figures		Page
1-2.	*Zygolithus dubius* Deflandre	236
	1. Electron micrograph, X8,700 Sample B-30	
	2a. Cross-polarized light, X2,200 Sample B-28	
	2b. Phase contrast, X2,200	
3.	?*Zygolithus dubius* Deflandre Sample B-12	236
	3a. Cross-polarized light, X2,200	
	3b. Phase contrast, X2,200	
4.	*Helicopontosphaera compacta* (Bramlette and Wilcoxon)	212
	4a. Cross-polarized light, X2,200 Sample B-30	
	4b. Phase contrast, X2,200	
5.	*Helicopontosphaera seminulum* (Bramlette and Sullivan)	214
	5a. Cross-polarized light, X2,200 Sample B-30	
	5b. Phase contrast, X2,200	
6-7.	*Helicopontosphaera wilcoxoni* Gartner	216
	6a. Cross-polarized light, X2,200 Sample B-30	
	6b. Phase contrast, X2,200	
	7a. Cross-polarized light, X2,200 Sample B-28	
	7b. Phase contrast, X2,200	
8.	*Helicopontosphaera reticulata* (Bramlette and Wilcoxon)	214
	8a. Cross-polarized light, X2,200 Sample B-30	
	8b. Phase contrast, X2,200	
9.	*Helicopontosphaera* sp. A Sample B-28	218
	9a. Cross-polarized light, X2,200	
	9b. Phase contrast, X2,200	

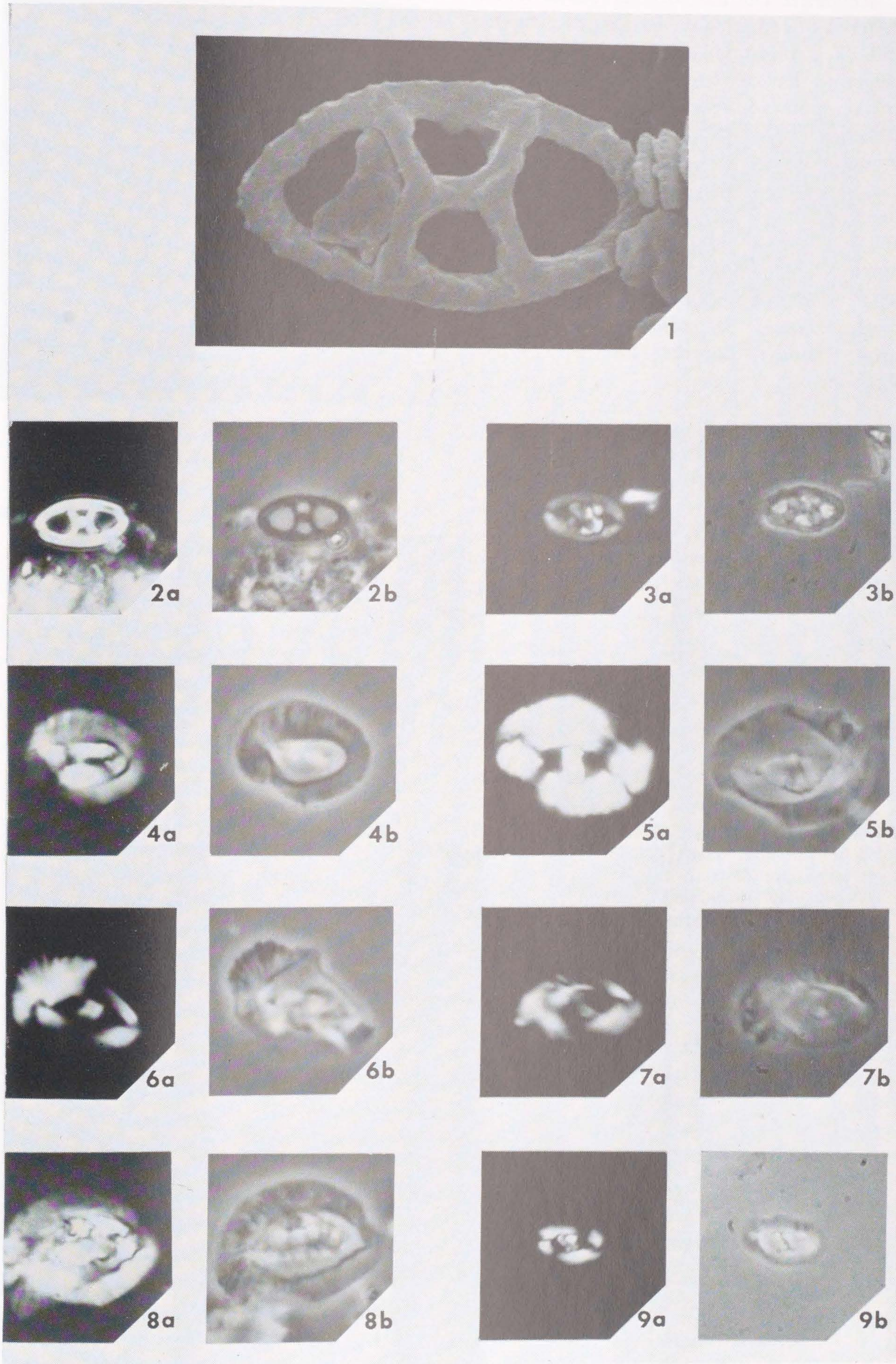

PLATE 18

Remarks: The base of this species is constructed of radiating wedge-shaped elements and is surmounted by several blade-like segments that rise to form a non-bifurcating apical spine. *Sphenolithus heteromorphus* Deflandre has a longer narrower spine, which is rounded instead of blade-like. *S. radians* has a taller narrower base and thinner spines than *Sphenolithus pseudoradians* Bramlette and Wilcoxon. Under the light microscope, however, *S. radians* and *S. pseudoradians* are indistinguishable.

Occurrence: *S. radians* occurs in the upper middle Eocene (Blow's P14) of Alabama.

Family SYRACOSPHAERACEAE
Lemmermann 1908
Genus CEPEKIELLA Roth 1970
Type species: *Cepekiella elongata* Roth

CEPEKIELLA LUMINA
(Sullivan) 1965 n. comb.

Plate 5, Figures 5-6

Cyclococcolithus luminis SULLIVAN, 1965, pl. 3, fig. 9; Eocene, California. LEVIN and JOERGER, 1967, pl. 1, fig. 12; pl. 4, fig. 17; Eocene-Oligocene, Alabama. REINHARDT, 1967, pl. 1, figs. 17-18; pl. 2, fig. 10; Eocene, Germany. POZARYSKA and LOCKER, 1971, pl. 2, fig. 14; Eocene, Poland. LOCKER, 1972, pl. 7, figs. 13-14; Eocene, Europe.
Blackites hayi Stradner. STRADNER and EDWARDS, 1968, in part; pl. 31, fig. 6; text-fig. 5; Eocene, New Zealand.
Cepekiella hayi (Stradner). ROTH, 1970, pl. 11, fig. 3; Oligocene, Alabama, Germany.

Remarks: The distal shield of *C. lumina* consists of an outer cycle of trapezoidal segments and an inner domed structure of crystal laths that spiral inward and upward, terminating in a slender stem. Short angular struts connect the distal shield with the smaller proximal shield. This proximal shield is often partially or completely broken off from the distal shield and the stem may also be missing. The outer cycle of the distal shield may be broken off. *Cepekiella elongata* Roth has a more elliptical base and the stem is not centrally located on the base.

Occurrence: *C. lumina* occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family ZYGOLITHACEAE Noël 1965
Genus ZYGOLITHUS Kamptner 1949
Type species: *Zygolithus dubius* Deflandre

ZYGOLITHUS DUBIUS
Deflandre 1954
Plate 18, Figures 1-2

Zygolithus dubius DEFLANDRE *in* DEFLANDRE and FERT, 1954, text-figs. 43-44; Eocene, France. MARTINI, 1958, in part; pl. 1, fig. 1a, 1c; Eocene, Germany. MANIVIT, 1959, in part; pl. 1, fig. 4; Eocene, Africa, France. BÁLDI-BEKE, 1960, pl. 14, fig. 4; Oligocene-Miocene, Hungary. MARTINI, 1960, pl. 11, fig. 39; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 6, figs. 12-14; Eocene, California. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 2, fig. 12; pl. 4, fig. 15; Eocene, Miocene, Czechoslovakia. Not BOUCHE, 1962, pl. 1, fig. 5. BYSTRICKÁ, 1963, pl. 1, fig. 14; Eocene, Czechoslovakia. BACHMANN, PAPP

PLATE 19

Figures Page

1, 3-4. *Lithostromation operosum* (Deflandre) Sample B-30 202
- 1. Electron micrograph, X5,200
- 3a. Transmitted light, X2,200
- 3b. Phase contrast, X2,200
- 4. Electron micrograph, X4,400

2. *Lithostromation simplex* (Klumpp) Sample B-15 204
- 2a. Transmitted light, X2,200
- 2b. Phase contrast, X2,200

5. *Lithostromation reginum* (Stradner) Sample B-30 204
- 5. Electron micrograph, X5,200

6. *Lithostromation perdurum* Deflandre Sample B-28 202
- 6. Phase contrast, X2,200

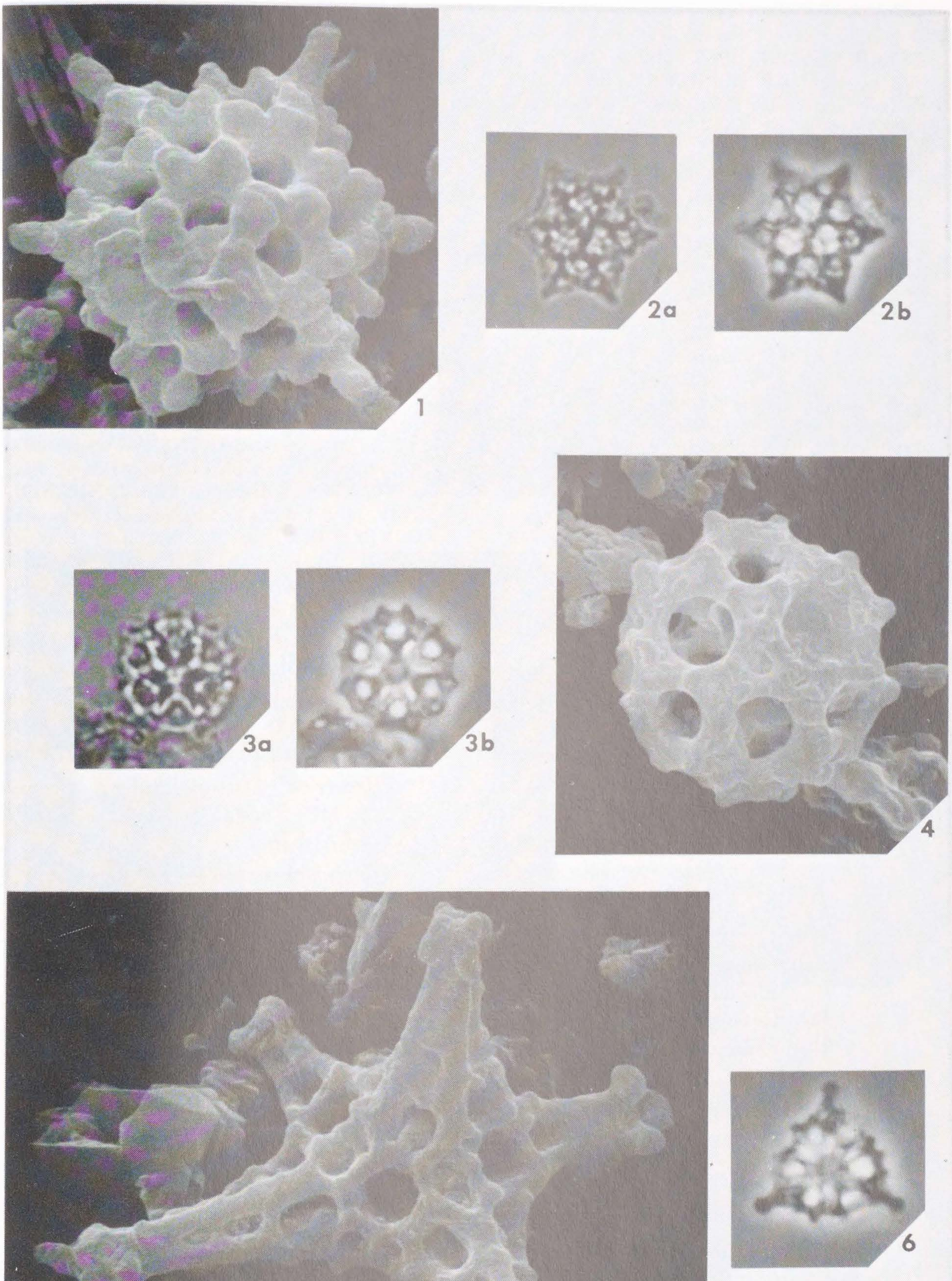

PLATE 19

and STRADNER, 1963, pl. 24, fig. 5. LOCKER, 1965, pl. 2, fig. 9; Eocene, Germany. PERCH-NIELSEN, 1967, pl. 5, figs. 13-14; Eocene, Denmark. REINHARDT, 1967, pl. 4, figs. 14-16, 19-20; Eocene, Germany. LOCKER, 1968, pl. 2, fig. 19; Eocene, Germany. BÁLDI-BEKE, 1971, pl. 1, figs. 14-16; Eocene, Hungary. POZARYSKA and LOCKER, 1971, pl. 2, fig. 6; Eocene, Poland. LOCKER, 1972, pl. 5, fig. 7; Eocene, Europe.

Chiphragmalithus dubius (Deflandre). SULLIVAN, 1964, pl. 1, fig. 2; Paleocene, California. SULLIVAN, 1965, pl. 1, figs. 1-2; Eocene, California.

Zygolithus minutus PERCH-NIELSEN, 1967, pl. 5, figs. 6-7; Eocene, Denmark.

Zygolithus pediculatus PERCH-NIELSEN, 1967, pl. 5, figs. 8-11; Eocene, Denmark.

Neococcolithes dubius (Deflandre). RADOMSKI, 1968, pl. 48, fig. 17; Eocene, Poland. HODSON and WEST, 1970, pl. 2, fig. 1; Eocene, England. PERCH-NIELSEN, 1971b, pl. 42, fig. 10-12, 14-15; pl. 43, figs. 1, 3-5; Eocene, Denmark. BRATU and GHETA, 1972, pl. 4, fig. 48, Eocene, Czechoslovakia. SHERWOOD, 1974, pl. 8, fig. 6-7; pl. 11, fig. 20; Eocene, Texas.

Neococcolithes minutus (Perch-Nielsen). PERCH-NIELSEN, 1971b, pl. 42, figs. 1-4; Eocene, Denmark.

Neococcolithes pediculatus (Perch-Nielsen). PERCH-NIELSEN, 1971b, pl. 40, figs. 4-6; pl. 42, figs. 16-18; Eocene, Denmark.

Remarks: Z. dubius consists of a rim in the shape of an elongate ellipse with a delicate H-shaped crossbar. The rim is constructed of a single row of laths. These laths spiral around to form the rim and only their ends are visible in plan view.

Occurrence: Z. dubius occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Family ZYGOSPHAERACEAE
Braarud and Gaarder 1961

Genus DAKTYLETHRA
Gartner 1969

Type species: *Daktylethra punctulata* Gartner

DAKTYLETHRA PUNCTULATA
Gartner 1969
Plate 16, Figures 6-7

Daktylethra punctulata GARTNER *in* GARTNER and BUKRY, 1969, pl. 141, figs. 1-3; pl. 142, fig. 10; Eocene, Alabama. PERCH-NIELSEN, 1971b, pl. 58, figs. 1, 3-5; Eocene, Denmark. LOCKER, 1972, pl. 1, figs. 1-2; Eocene, Europe.

Calyptrolithus? morionum Deflandre. BÁLDI-BEKE, 1971, pl. 1, fig. 1; Eocene, Hungary.

Remarks: D. punctulata is a distinctive helmet-shaped holococcolith with a concave base and an elliptical cross section. The upper half of the helmet has numerous, large, circular pits and spike-like projections.

Occurrence: D. punctulata occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

PLATE 20

Figures		Page
1, 4.	*Discolithina multipora* (Kamptner)	206
	1. Electron micrograph, X5,200 Distal view Sample B-30	
	4a. Cross-polarized light, X2,200 Sample B-28	
	4b. Phase contrast, X2,200	
2.	*Discolithina vesca* (Sullivan) Sample B-30	208
	2a. Cross-polarized light, X2,200	
	2b. Phase contrast, X2,200	
3.	*Discolithina cribraria* Perch-Nielsen Sample B-15	206
	3a. Cross-polarized light, X2,200	
	3b. Phase contrast, X2,200	
5.	*Discolithina* sp. A Sample B-30	210
	5. Electron micrograph, X22,000	
6.	*Bramletteius serraculoides* Gartner Sample B-30	186
	6. Electron micrograph, X10,400	
7.	*Cruciplacolithus staurion* (Bramlette and Sullivan)	195
	7. Cross-polarized light, X2,200 Sample B-30	

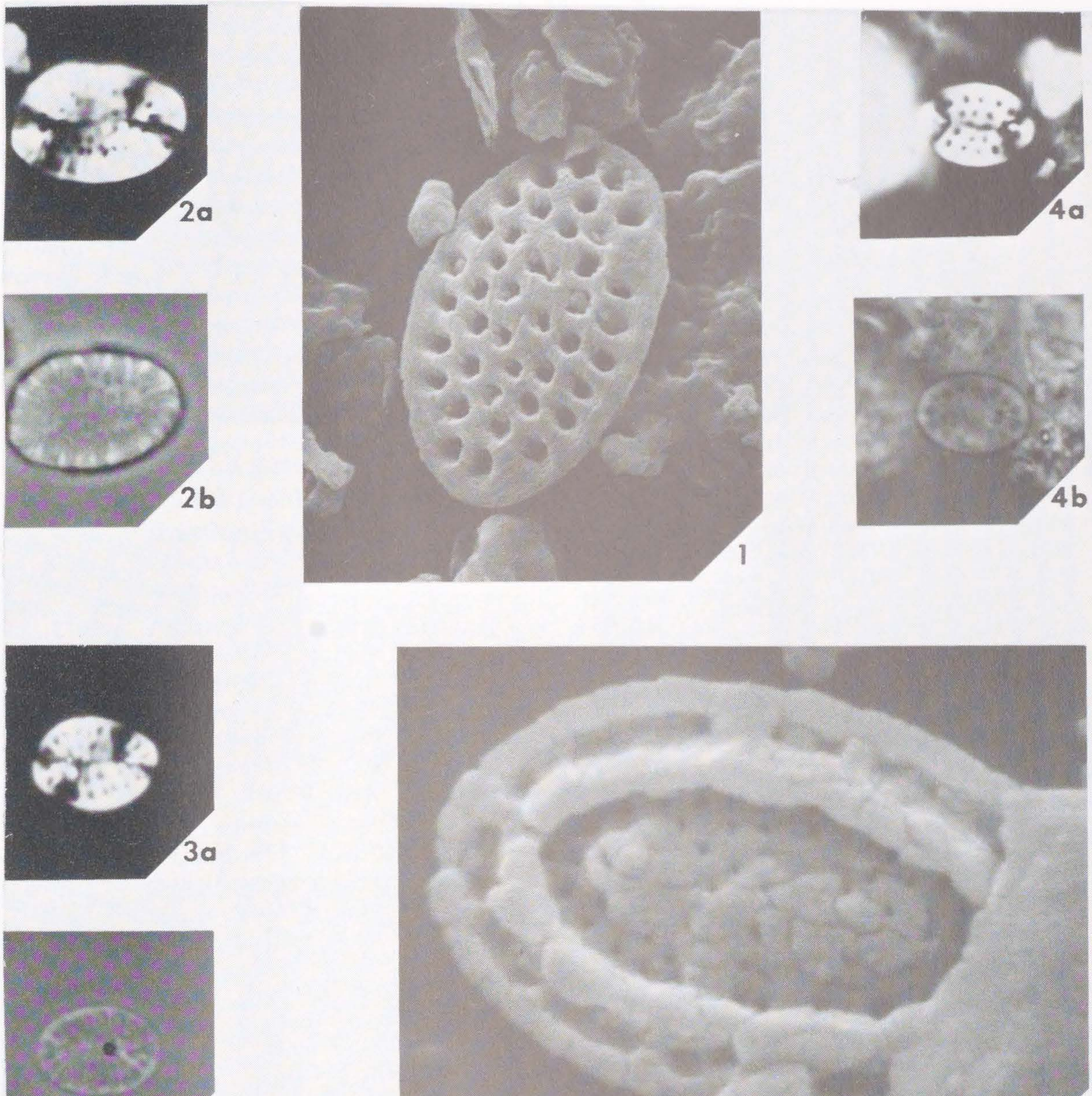

PLATE 20

Genus HOLODISCOLITHUS
Roth 1970
Type species: *Discolithus macroporus* Deflandre

HOLODISCOLITHUS SOLIDUS
(Deflandre) 1954

Plate 22, Figure 5

Discolithus solidus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 12, figs. 14-16; Eocene, France. BRAMLETTE and SULLIVAN, 1961, pl. 3, figs. 14-15; Paleocene-Eocene, California; Eocene, Texas, France. SULLIVAN, 1965, pl. 4, fig. 8; Paleocene-Eocene, California.
Discolithus macroporus Deflandre. BÁLDI-BEKE, 1960, pl. 14, fig. 1; Oligocene, France.
Discolithina solida (Deflandre). LEVIN and JOERGER, 1967, pl. 2, fig. 7; Eocene-Oligocene, Alabama. BÁLDI-BEKE, 1971, pl. 1, fig. 7; Eocene, Hungary.
Holodiscolithus solidus (Deflandre). ROTH, 1970, pl. 11, fig. 5; Oligocene, Alabama, Blake Plateau, Trinidad.

Remarks: This elliptical discolith has six large, circular perforations on its surface. Normally there is one perforation at each end of the ellipse and two pores on each side of the longitudinal axis. Little Stave Creek specimens resemble those illustrated by Levin and Joerger (1967), in which one of the pores is somewhat off center. This species is constructed of several thin layers or crystals parallel to the base of the specimen. It may be a holococcolith. According to Roth (1970), the building blocks are cubes, but their shape is unclear in Little Stave Creek specimens. *H. solidus* is similar to *Holodiscolithus macroporus* (Deflandre) in structure, but has fewer perforations on its surface.

Occurrence: H. solidus occurs in the upper middle Eocene (Blow's P14) of Alabama.

Genus LANTERNITHUS
Stradner 1962
Type species: *Lanternithus minutus* Stradner

LANTERNITHUS MINUTUS
Stradner 1962b

Lanternithus minutus STRADNER, 1962a, no illustration; Eocene, Yugoslavia. STRADNER, 1962b, pl. 2, figs. 12-15; Eocene, Austria. STRADNER, 1964, text-figs. 17-18. LOCKER, 1967, text-figs. 1-3; pl. 1, figs. 1-8; Eocene, Germany. LOCKER, 1968, pl. 2, fig. 7; Eocene, Germany. RADOMSKI, 1968, pl. 46, figs. 24-28; Eocene, Poland. GARTNER and BUKRY, 1969, pl. 139, figs. 4-6; pl. 142, figs. 8-9; Eocene-Oligocene, Alabama. MARTINI, 1969b, pl. 2, figs. 24-25; Eocene-Oligocene, Switzerland. POZARYSKA and LOCKER,

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PLATE 21

Figures — Page

1-4. *Transversopontis obliquipons* (Deflandre) 220
- 1. Electron micrograph, X8,700 Distal view Sample B-30
- 2. Electron micrograph, X8,700 Prox. view Sample B-30
- 3a. Cross-polarized light, X2,200 Sample B-30
- 3b. Phase contrast, X2,200
- 4a. Cross-polarized light, X2,200 Sample B-28
- 4b. Phase contrast, X2,200

5. *Transversopontis exilis* (Bramlette and Sullivan) 218
- 5a. Cross-polarized light, X2,200 Sample B-15
- 5b. Phase contrast, X2,200

6. *Discolithina bicaveata* Perch-Nielsen Sample B-30 206
- 6a. Cross-polarized light, X2,200
- 6b. Phase contrast, X2,200

7. *Ericsonia fenestrata* (Deflandre and Fert) Sample B-30 196
- 7. Electron micrograph, X10,400

8. *Reticulofenestra callida* (Perch-Nielsen) Sample B-28 197
- 8a. Cross-polarized light, X2,200
- 8b. Phase contrast, X2,200

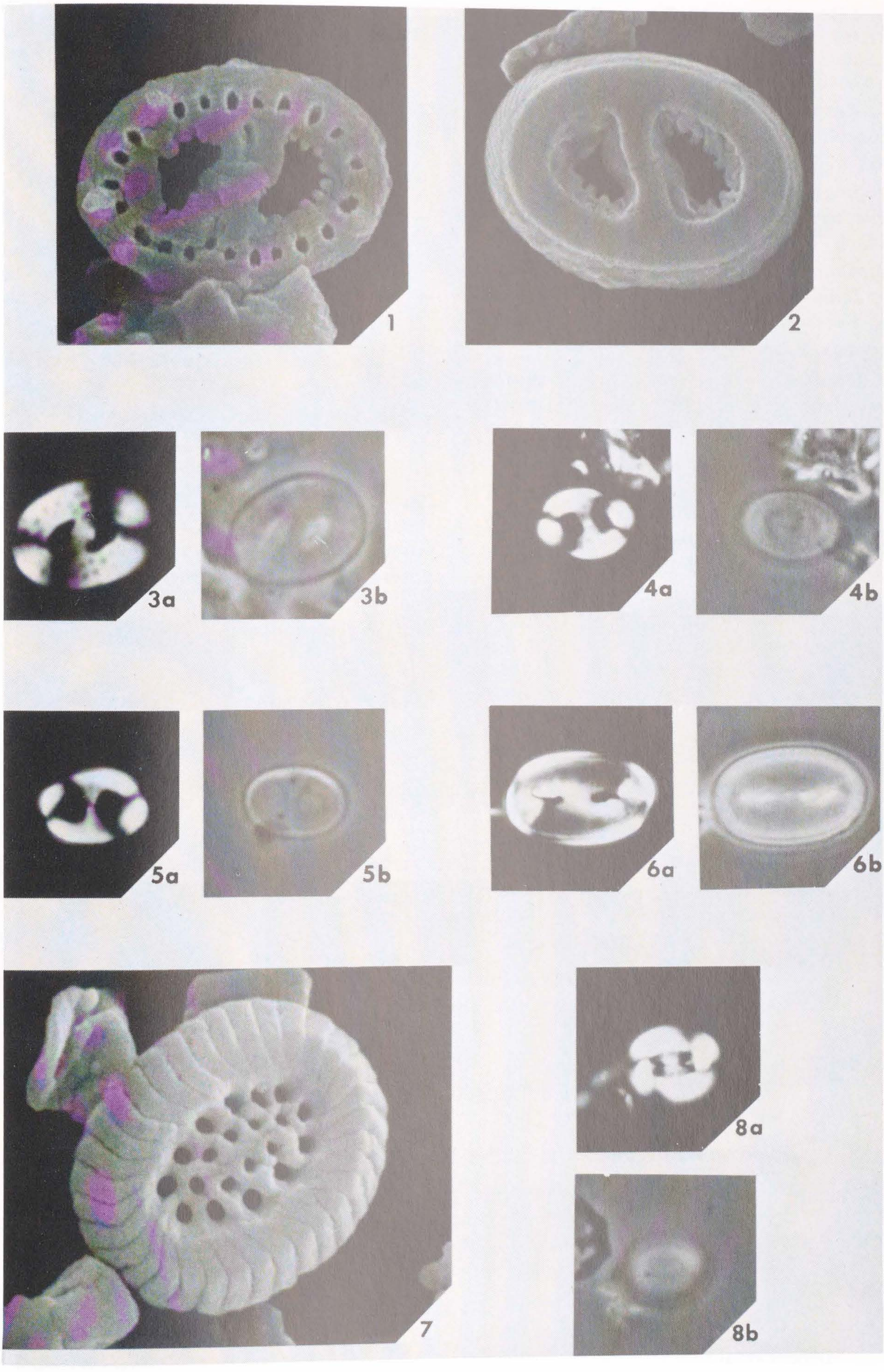

PLATE 21

1971, pl. 2, fig. 30; Eocene, Poland. BRATU and GHETA, 1972, pl. 5, figs. 59, 62; Eocene, Czechoslovakia. LOCKER, 1972, pl. 12, fig. 8; Eocene, Europe.

Remarks: This elongate hexagonal holococcolith (formed of uniform-sized rhombs) has a multiple-layered base and six inward sloping sides, each side a trapezoid in shape. The top appears to have several large pits, which give this surface a hollowed-out appearance. *Lanternithus minutus* is similar to *L. duocavus* Locker, which is distinguished by two large, circular depressions on its upper surface.

Occurrence: L. minutus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Genus ORTHOZYGUS
Bramlette and Wilcoxon 1967
Type species: *Zygolithus aureus* Stradner

ORTHOZYGUS AUREUS
(Stradner) 1962b
Plate 13, Figure 3

Zygolithus aureus STRADNER, 1962b, pl. 1, figs. 31-36; Eocene, Holland. LEVIN, 1965, pl. 41, fig. 10; Eocene, Mississippi. STRADNER and ADAMIKER, 1966, pl. 3, fig. 2; Eocene. LEVIN and JOERGER, 1967, pl. 2, figs. 19-21; pl. 4, fig. 15; Eocene-Oligocene, Alabama.

Orthozygus aureus(Stradner). BRAMLETTE and WILCOXON, 1967, pl. 9, figs. 1-4; Oligocene, Trinidad; Eocene, Mississippi. GARTNER and BUKRY, 1969, pl. 139, figs. 1-3; pl. 142, figs. 5-6; Oligocene, Alabama. MARTINI, 1969b, pl. 2, fig. 21; Eocene-Oligocene, Switzerland. BÁLDI-BEKE, 1971, pl. 1, fig. 17; Eocene, Hungary. PERCH-NIELSEN, 1971b, pl. 59, figs. 11-12; Eocene, Denmark. LOCKER, 1972, pl. 5, figs. 9-10; Eocene, Europe.

Zygosphaera aurea (Stradner). STRADNER and EDWARDS, 1968, pl. 44, fig. 6; Eocene, New Zealand. BILGÜTAY, *et al.,* 1969, pl. 4, fig. 12; Eocene, France.

Remarks: O. aureus is a holococcolith with an elliptical distally flaring ring and a wide complex bridge across the short dimension of the ring. The bridge is dome-shaped with numerous, small, shallow and deep pores which are radially arranged at several levels around the dome. Near the top of the dome Little Stave Creek specimens have six pores in a circle. Specimens illustrated by Perch-Nielsen have a narrow bridge and a less well-developed circular dome.

Occurrence: O. aureus occurs in the upper middle Eocene (Blow's P14) of Alabama.

PLATE 22

Figures — Page

1, 3. *Transversopontis fimbriatus* (Bramlette and Sullivan) 220
- 1. Electron micrograph, X5,200 Sample B-30
- 3a. Cross-polarized light, X2,200
- 3b. Phase contrast, X2,200

2. *Discolithina wechesensis* Bukry and Percival Sample B-16 210
- 2a. Cross-polarized light, X2,200
- 2b. Phase contrast, X2,200

4. *Discolithina* sp. B Sample B-30 210
- 4a. Cross-polarized light, X2,200
- 4b. Phase contrast, X2,200

5. *Holodiscolithus solidus* (Deflandre) Sample B-30 240
- 5. Electron micrograph, X17,400

6. *Coccolithus crassipons* Bouché Sample B-15 194
- 6a. Cross-polarized light, X2,200
- 6b. Phase contrast, X2,200

7. *Coccolithus* sp. A Sample B-30 194
- 7a. Cross-polarized light, X2,200
- 7b. Phase contrast, X2,200

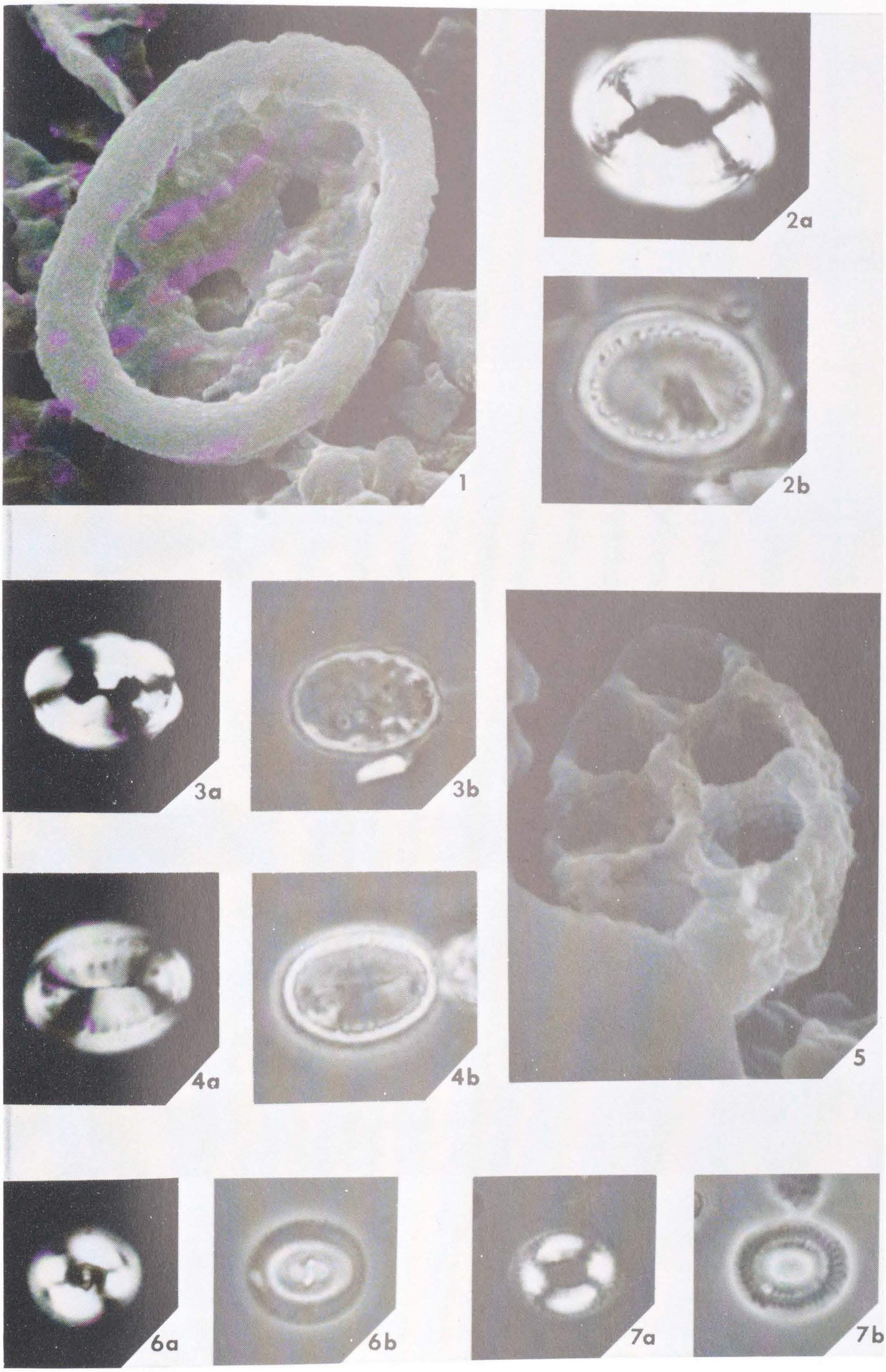

PLATE 22

Genus ZYGRHABLITHUS
Deflandre 1959
Type species: *Zygolithus bijugatus* Deflandre

ZYGRHABLITHUS BIJUGATUS
(Deflandre) 1954
Plate 24

Zygolithus bijugatus DEFLANDRE *in* DEFLANDRE and FERT, 1954, pl. 11, figs. 20-21; text-fig. 59; Oligocene, New Zealand.

Rhabdolithus costatus Deflandre. DEFLANDRE and FERT, 1954, pl. 11, figs. 8-11; text-figs. 41-42; Oligocene, New Zealand.

Isthmolithus claviformis BRÖNNIMANN and STRADNER, 1960, text-figs. 25-43; Cuba.

Zygrhablithus bijugatus (Deflandre). BRAMLETTE and SULLIVAN, 1961, pl. 6, figs. 16-18; Eocene, California. BENEŠOVÁ and HANZLÍKOVÁ, 1962, pl. 2, fig. 16; Miocene, Czechoslovakia. BOUCHÉ, 1962, pl. 1, figs. 4, 9-11; Eocene, France. Not HAY and TOWE, 1962, pl. 2, fig. 2. SULLIVAN, 1964, pl. 7, figs. 9-10; Paleocene, California. LEVIN, 1965, pl. 42, fig. 1; Eocene, Mississippi. REINHARDT, 1966, pl. 21, fig. 12; Eocene, Germany. GARTNER and SMITH, 1967, pl. 8, figs. 1-6; Eocene, Louisiana. LEVIN and JOERGER, 1967, pl. 2, fig. 24; pl. 3, figs. 1-4; Eocene-Oligocene, Alabama. REINHARDT, 1967, pl. 4, figs. 21-22; pl. 7, fig. 5; Eocene, Germany. HAQ, 1968, pl. 7, fig. 10; pl. 9, figs. 10-11; Eocene, Germany. LOCKER, 1968, pl. 2, fig. 20; Eocene-Oligocene, Germany. RADOMSKI, 1968, pl. 43, figs. 11-13; Eocene, Oligocene, Poland. STRADNER and EDWARDS, 1968, pls. 42-43; Eocene-Oligocene, New Zealand. GARTNER and BUKRY, 1969, pl. 140, figs. 3-6; pl. 142, figs. 1-2. MARTINI, 1961b, pl. 2, figs. 19-20; Oligocene, Switzerland. HODSON and WEST, 1970, pl. 3, fig. 2; Eocene, England. HOFFMANN, 1970, pl. 1, fig. 2; pl. 6, figs. 1-8; Eocene, Germany. BÁLDI-BEKE, 1971, pl. 2, fig. 12; Eocene, Hungary. HAQ, 1971a, pl. 10, fig. 7; Eocene, Pakistan. HAQ, 1971b, pl. 12, fig. 5; pl. 13, figs. 11-14; pl. 17, fig. 8; Oligocene-Eocene, Germany. HAQ, 1971c, pl. 17, fig. 5; Oligocene, Syria. PERCH-NIELSEN, 1971b, pl. 58, figs. 7-9; pl. 59, fig. 10; Eocene, Denmark. POZARYSKA and LOCKER, 1971, pl. 2, figs. 7-8; Eocene, Poland. SHERWOOD, 1974, pl. 11, figs. 9-10; 13-14, 17-18; pl. 12, figs. 10-12; Eocene, Texas.

Rhabdosphaera semiformis BRAMLETTE and SULLIVAN, 1961, pl. 5, figs. 8-10; Eocene, California. SULLIVAN, 1964, pl. 7, fig. 7; Paleocene, California. SULLIVAN, 1965, pl. 7, fig. 3; Eocene, California. LEVIN and JOERGER, 1967, pl. 2, fig. 17; Eocene-Oligocene, Alabama.

Lucianorhabdus dispar STRADNER, 1961, figs. 49, 51-52; Eocene, Austria. STRADNER and PAPP, 1961, pl. 40, figs. 1-2, 6-11; Eocene, Austria. LEVIN and JOERGER, 1967, pl. 4, figs. 9-10; Eocene, Alabama.

Zygrhablithus sp. LEVIN, 1965, pl. 41, fig. 11; Eocene, Mississippi.

Sujkowskiella enigmatica HAY, MOHLER, and WADE, 1966, pl. 13, figs. 6-7; Eocene, USSR.

Zygrhablithus bijugatus crassus LOCKER, 1967, pl. 1, fig. 7; pl. 2, figs. 7-8; Eocene-Oligocene, Germany. LOCKER, 1972, pl. 3, fig. 16; Eocene, Europe.

Zygrhablithus bijugatus bijugatus (Deflandre). LOCKER, 1972, pl. 2, fig. 12; pl. 3, fig. 12; Paleocene, Europe.

Zygrhablithus cf. *Z. bijugatus* (Deflandre). PERCH-NIELSEN, 1972, pl. 15, figs. 6-7; Oligocene, Atlantic.

PLATE 23

Figures Page

1. *Sphenolithus radians* Deflandre Sample B-30 234
   1. Electron micrograph, X10,400

2. *Sphenolithus moriformis* (Brönnimann and Stradner) 232
   2a. Cross-polarized light, X2,200 Sample B-16
   2b. Phase contrast, X2,200

3. *Chiasmolithus grandis* (Bramlette and Riedel) Sample B-15 193
   3a. Cross-polarized light, X2,200
   3b. Phase contrast, X2,200

4. *Naninfula* sp. Sample B-30
   4. Electron micrograph, X8,700

5. *Naninfula* sp. Sample B-30
   5. Electron micrograph, X8,700

6. *Gongylis salzwedelensia* Hoffmann Sample B-30 246
   6. Electron micrograph, X4,400

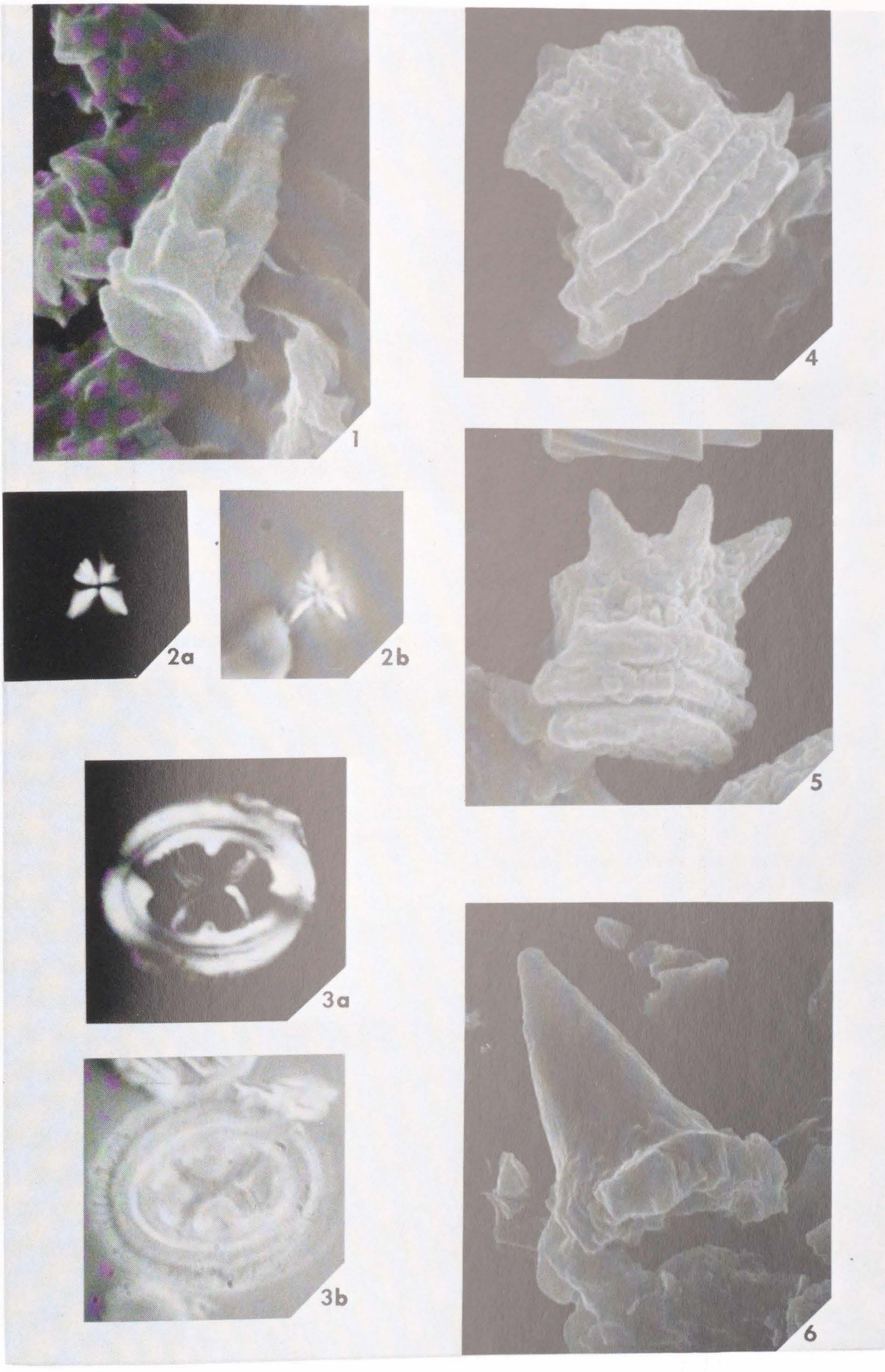

PLATE 23

Remarks: This holococcolith has an upward flaring elliptical base, which is surmounted by a complex stem-like feature. This stem is X-shaped where it joins the basal disc. There is a circular depression in the base between each of the crossbars of the X. The crossbars rise upward as blade-like vanes to form the stem. In some specimens there is a small central knob on the top of the stem and lateral spines at the top of each blade. Other forms have very wide blades (Plate 24, Figure 5) and these were placed in a separate subspecies by Locker (1967). Specimens often break in half along the short axis of the base and these half specimens have been described under several different generic and specific names.

Occurrence: Z. bijugatus occurs throughout the middle Eocene (Blow's P11-P14) of Alabama.

Incertae sedis

Genus GONGYLIS
Hoffmann 1970

Type species: *Gongylis salzwedelensia* Hoffmann

GONGYLIS SALZWEDELENSIA
Hoffmann 1970

Plate 23, Figure 6

Gongylis salzwedelensia HOFFMANN, 1970, pl. 5, figs. 1-4; Eocene, German.

Remarks: This unusual, cone-shaped form has large irregular crystals, which form the base of the cone. Specimens from Little Stave Creek and Germany appear to be broken off from some other structure and this form may be unrelated to the coccolithophores.

Occurrence: G. salzwedelensia was only found in the upper middle Eocene (Blow's P14) of Alabama.

XII. BIBLIOGRAPHY

ADELSECK, C. G., G. W. GEEHAN, and P. H. ROTH, 1973, Experimental evidence for the selective dissolution and overgrowth of calcareous nannofossils during diagenesis: Geol. Soc. Amer. Bull., vol. 84, p. 2755-2762, figs. 1-3.

BACHMANN, A., A. PAPP, and H. STRADNER, 1963, Mikropaläontologische Studien *in* "Badener Tegel" von Frattingsdorf N. Ö.: Mitt. Geol. Gesell. Wien, vol. 56, p. 117-210, pls. 1-24, 3 figs.

BÁLDI-BEKE, M., 1960, Magyarországi miocéne coccolithophoridák rétegtani jelentősége: Földtani Közlöny, vol. 90, p. 213-223, pl. 14.

BÁLDI-BEKE, M., 1971, The Eocene nannoplankton of the Bakony Mountains, Hungary: Ann. Inst. Geol. Publ. Hung., vol. 54, no. 4, p. 13-18, pls. 1-7, 1 fig.

BANDY, O. L., 1949, Eocene and Oligocene foraminifera from Little Stave Creek, Clarke County, Alabama: Bull. Amer. Paleont., vol. 32, no. 131, p. 1-210, pls. 1-27, text-figs. 1-2.

BENEŠOVÁ, E. and E. HANZLÍKOVÁ, 1962, Orientation study of fossil Flagellata in the Czechoslovak Carpathians: Věst. Ústř. Úst. Geol. (Prada), vol. 37, p. 121-125, 4 pls., 1 text-fig.

BERGGREN, W. A., 1971, A Cenozoic time-scale — some implications for regional geology and paleobiogeography: Lethaia, vol. 5, p. 195-215.

PLATE 24

Figures		Page
1-7.	*Zygrhablithus bijugatus* (Deflandre)	244
1a.	Cross-polarized light, X2,200 Sample B-30	
1b.	Phase contrast, X2,200	
2.	Cross-polarized light, X2,200 Sample B-30	
3.	Electron micrograph, X8,400 Sample B-30	
4a.	Cross-polarized light, X2,200 Sample B-28	
4b.	Phase contrast, X2,200	
5a.	Cross-polarized light, X2,200 Sample B-15	
5b.	Phase contrast, X2,200	
6.	Electron micrograph, X10,400 Sample B-30	
7a.	Cross-polarized light, X2,200 Sample B-30	
7b.	Phase contrast, X2,200	

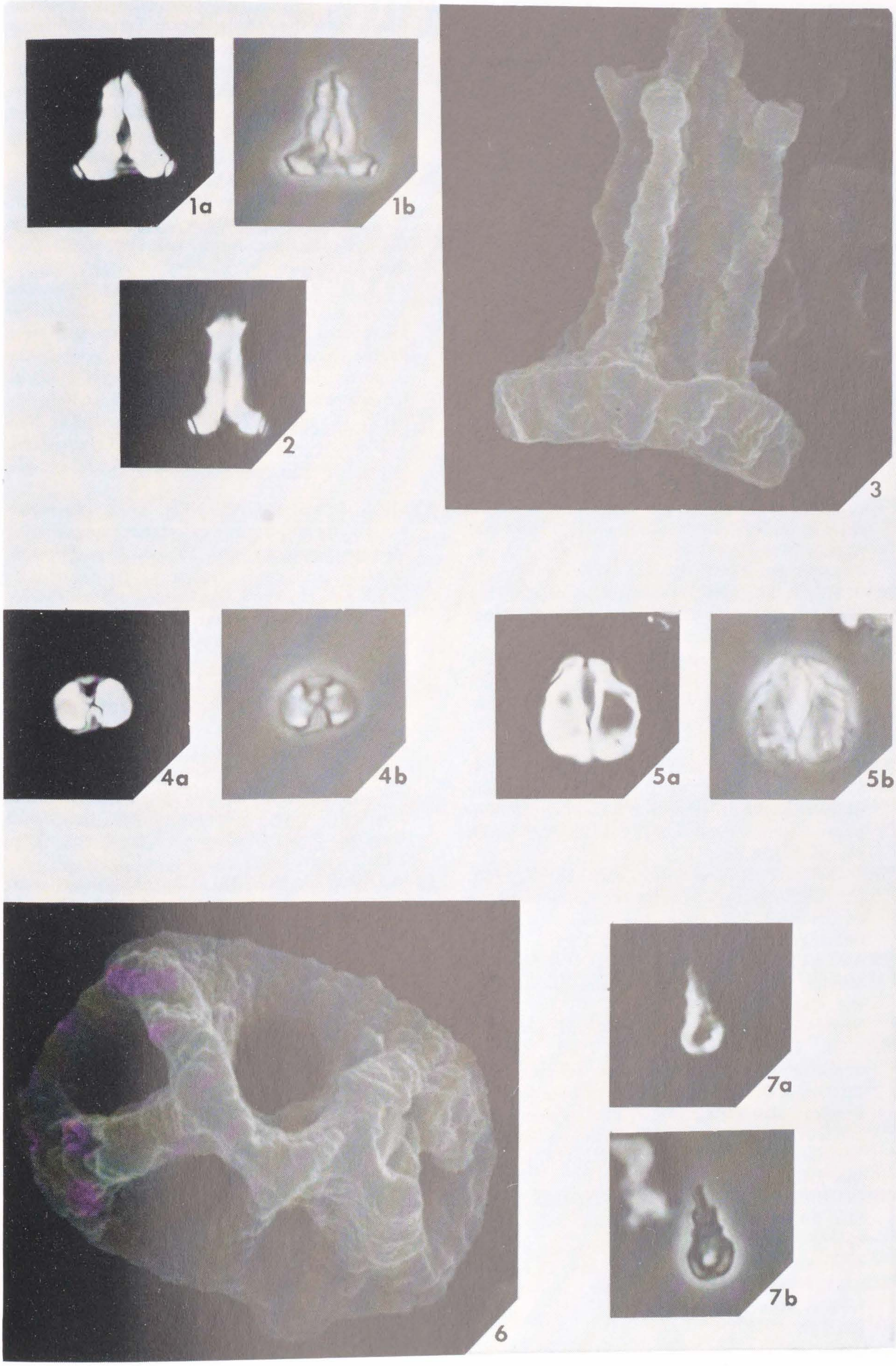

PLATE 24

BILGÜTAY, U., S. A. JAFAR, A. SYED, H. STRADNER, and E. SZOTS, 1969, Calcareous nannoplankton from the Eocene of Biarritz, France: *In* BRÖNNIMANN, P., and H. H. RENZ, (ed.), Proc. First Int. Conf. Plank. Microfossils, Geneva, E. J. Brill, Leiden, vol. 1, p. 167-178, pls. 1-5.

BLACK, M., 1962, Fossil coccospheres from a Tertiary outcrop on the continental slope: Geol. Mag., vol. 99, p. 123-127, pls. 8-9.

BLACK, M., 1965, Cretaceous and Tertiary coccoliths from Atlantic seamounts: Paleontology, vol. 7, p. 306-316, pls. 50-52.

BLACK, M., 1965, Coccoliths: Endeavour, vol. 24, no. 93, p. 131-137, 25 figs.

BLACK, M., 1968, Taxonomic problems in the study of coccoliths: Palaeontology, vol. 11, p. 793-813, pls. 143-154.

BLACK, M., 1971, The systematics of coccoliths in relation to the paleontological record: *In* FUNNELL, B. M., and W. R. RIEDEL, (ed.), The micropaleontology of oceans, Cambridge Univ. Press, p. 611-624, 4 pls.

BLACK, M., 1972, Crystal development in Discoasteraceae and Braarudosphaeraceae (Planktonic Algae): Palaeontology, vol. 15, no. 3, p. 476-489, pls. 87-96, figs. 1-2.

BOUCHÉ, P. M., 1962, Nannofossiles calcaires du Lutétien du Bassin de Paris: Rev. Micropaléontologie, vol. 5, 75-103, pls. 1-4.

BRAMLETTE, M. N. and E. MARTINI, 1964, The great change in calcareous nannoplankton fossils between the Maestrichtian and Danian: Micropaleontology, vol. 10, p. 291-322, pls. 1-7.

BRAMLETTE, M. N. and W. R. RIEDEL, 1954, Stratigraphic value of discoasters and some other microfossils related to Recent coccolithophores: Jour. Paleontology, vol. 28, p. 385-403, pls. 38-39, 26 figs.

BRAMLETTE, M. N. and F. R. SULLIVAN, 1961, Coccolithophorids and related nannoplankton of the Early Tertiary in California: Micropaleontology, vol. 7, p. 129-174, pls 1-14.

BRAMLETTE, M. N. and J. A. WILCOXON, 1967, Middle Tertiary calcareous nannoplankton of the Cipero section, Trinidad, W. I.: Tulane Stud. Geol., vol. 5, no. 3, p. 91-131, pls. 1-10.

BRATU, E. and N. GHETA, 1972, Zonarea depozitelor in facies de sotrile ale Paleocene-Eocenului (Carpatii Orientali), pe baza foraminiferelor planctonice si a nannoplanctonului calcaros: Stud. Cercetari Geol. Geofix. Geograf. Ser. Geol., vol. 17, no. 2, p. 323-334, pls. 1-5, figs. 1-2.

BRÖNNIMANN, P., and H. STRADNER, 1960, Die Foraminiferen- und Discoasteriden-zonen von Kuba und ihre interkontinentale Korrelation: Erdoel-Z., vol. 76, p. 364-369, 44 figs.

BUKRY, D., 1971a, *Discoaster* evolutionary trends: Micropaleontology, vol. 17, p. 43-52, pls. 1-3.

BUKRY, D., 1971b, Cenozoic calcareous nannofossils from the Pacific Ocean: Trans. San Diego Soc. Nat. Hist., vol. 16, p. 303-327, pls. 1-7.

BUKRY, D. and M. N. BRAMLETTE, 1969, Some new and strigraphically useful calcareous nannofossils of the Cenozoic: Tulane Stud. Geol. Paleont., vol. 7, no. 3, p. 131-142, pls. 1-3.

BUKRY, D. and M. P. KENNEDY, 1969, Cretaceous and Eocene coccoliths at San Diego, California: Calif. Div. Mines Geol., Short Contr. Calif. Geol., Spec. Rept., vol. 100, p. 33-43, 4 figs.

BUKRY, D., R. G. DOUGLAS, S. A. KLING, and V. A. KRASHENINNIKIV, 1971, Planktonic microfossil biostratigraphy of the northwestern Pacific Ocean: Deep Sea Drilling Project, Initial Reports, Leg 6, Washington, D. C., U. S. Government Printing Office, p. 1253-1300.

BUKRY, D. and S. F. PERCIVAL, 1971, New Tertiary calcareous nannofossils: Tulane Stud. Geol. Paleont., vol. 8, no. 3, p. 123-146, pls. 1-7.

BYBELL, L. and S. GARTNER, 1972, Provincialism among mid-Eocene calcareous nannofossils: Micropaleontology, vol. 18, no. 3, p. 319-336, pls. 1-5.

BYSTRICKÁ, H., 1963, Die Unter-Eozänen Coccolithophoridae (Flagellata) des Myjavaer Palaeogens: Geol. Sborník, Bratislava, vol. 14, no. 2, p. 269-281, pls. 1-4.

BYSTRICKÁ, H., 1969, Les discoastéridés du Paléogène des Karpates occidentales: Acta Geol. Geogr. Univ. Comenianae (Bratislava), Geol., vol. 17, p. 175-243, pls. 59-64.

CHANG, K. H., 1969, Several new species of middle and upper Eocene nannoplankton related with *Micrantholithus parisiensis* Bouché: Jour. Geol. Soc. Korea, vol. 5, p. 145-155, pls. 1-2.

CLOCCHIATTI, M., 1971, Contribution a l'étude de nannoplancton calcaire du Neogene d'Afrique du Nord: Mém. Museum Nat. Hist. Nat. (N. S.) ser. C, Sci. Terre, vol. 23, p. 1-135, pls. 1-40, text-figs. 1-21.

DEFLANDRE, G., 1934, Les Discoastéridés, microfossiles calcaires incertae sedis: Bull. Soc. Franç. Micropaléontologie, vol. 3, p. 59-67, 31 figs.

DEFLANDRE, G., 1942, Possibilites morphogénétiques comparées du calcaire et de la silice, a propos d'un nouveau type de microfossile calcaire de structure complexe, *Lithostromation perdurum* n. g., n. sp.: C. R. Acad. Sci. (Paris), vol. 214, p. 917-919, 9 figs.

DEFLANDRE, G., 1947, *Braarudosphaera* nov. gen., type d'une famille nouvelle de coccolithophoridées actuels à éléments composites: C. R. Acad. Sci. (Paris), vol. 225, p. 439-441, text-figs. 1-5.

DEFLANDRE, G., 1952, Classe des coccolithophoridés: *In* GRASSÉ, P. P., (ed.), Traité de

Zoologie, Paris, Masson, vol. 1, p. 439-470, figs. 339-364.

DEFLANDRE, G., 1957, *Goniolithus* nov. gen., type d'une famille nouvelle de coccolithophoridés fossiles, à éléments pentagonaux non composites: C. R. Acad. Sci. (Paris), vol. 244, p. 2539-2541, figs. 1-4.

DEFLANDRE, G., 1962, Les nannofossiles de la région de Limans et leur signification: Les Alpes de Lunière, Bull. Cult. Haute-Provence, Saint-Michel-l'Observatoire, no 26, 8 p., figs. A-I.

DEFLANDRE, G. and C. FERT, 1952, Sur la structure fine de quelques Coccolithes fossiles observées au microscope électronique. Signification morphogénétique et application à la systématique: C. R. Acad. Sci. (Paris), vol. 234, p. 2100-2102, 8 figs.

DEFLANDRE, G. and C. FERT, 1954, Observations sur les Coccolithophoridés actuels et fossiles en microscopie ordinaire et électronique: Ann. Paléontologie, vol. 40, p. 115-176, pls. 1-15, figs. 1-127.

EDWARDS, A. R., 1966, Calcareous nannoplankton from the uppermost Cretaceous and lowermost Tertiary of the Mid-Waipara section, South Island, New Zealand: New Zealand Jour. Geol. Geophys., vol. 9, p. 481-490, 37 figs., 1 tabl.

EHRENBERG, C. G., 1854, Mikrogeologie. Das Erden und Felsen shcaffende Wirken des unsichtbar kleinen selbständigen Lebens auf der Erde, Leipzig, Voss, p. 374 + 88, 40 pls.

ELLIS, C. H., W. H. LOHMAN, and J. L. WRAY, 1972, Upper Cenozoic calcareous nannofossils from the Gulf of Mexico (Deep Sea Drilling Project, Leg 1, site 3): Colorado School Mines Quart., vol. 67, no. 3, p. 1-103, pls. 1-18.

GAARDER, K. R., 1954, Coccolithineae, Silicoflagellatae, Pterospermataceae and other forms from the "Michael Sars" North Atlantic Deep-Sea Expedition 1910: Rept. Sci. Results "Michael Sars" North Atlantic Deep Sea Exped., 1910, vol. 2, no. 4, p. 3-20, tabls. 1-5.

GAARDER, K. R., 1971, Comments on the distribution of coccolithophorids in the oceans: *In* FUNNELL, B. M. and W. R. RIEDEL, (ed.), The micropaleontology of oceans, Cambridge Univ. Press, p. 97-103.

GARDET, M., 1955, Contribution à l'étude des coccolithes des terrains Néogenes de l'Algérie: Publ. Serv. Carte Géol. Algérie Bull., (N. S.), vol. 5, p. 477-550, 11 pls., 1 text-fig.

GARDNER, J., 1957, Little Stave Creek, Alabama – Paleoecologic study: *In* LADD, H. S., (ed.), Treatise on marine ecology and paleoecology, vol. 2, Paleoecology, Geol. Soc. Amer. Mem. 67, p. 573-588, pl. 1.

GARTNER, S., 1970, Phylogenetic lineages in the Lower Tertiary coccolith genus *Chiasmolithus:* Proc. North Amer. Paleontology Conv. Sept. 1961, p. 930-957, figs. 1-17.

GARTNER, S. 1971, Calcareous nannofossils from the JOIDES Blake Plateau cores and revision of Paleogene nannofossil zonation: Tulane Stud. Geol. Paleont., vol. 8, no. 3, p 101-121, pls. 1-5, text-figs. 1-5.

GARTNER, S. and D. BUKRY, 1969, Tertiary holococcoliths: Jour. Paleontology, vol. 43, p. 1213-1221, pls. 139-142.

GARTNER, S. and L. A. SMITH, 1967, Coccoliths and related calcareous nannofossils from the Yazoo Formation (Jackson, late Eocene) of Louisiana: Univ. Kansas Paleontologic Contr., Paper 20, p. 1-7, pls. 1-12.

GRAN, H. H. and T. BRAARUD, 1935, A quantitive study of the phytoplankton in the Bay of Fundy and the Gulf of Maine: Jour. Biol. Board Canada, vol. 1, p. 279-467, 69 figs.

HANZLÍKOVÁ, E., 1971, Coccolithen – die neuen Leitfossolien fur die Zonengliederung der braunen Pouzdrany-Mergel (Unteroligozän): Vest. Ustred. Ustava Geol., vol. 46, p. 359-363; pls. 1-2, 1 fig.

HAQ, U. Z. B., 1967, Calcerous nannoplankton from the Lower Eocene of the Zinda Pir, District Dera Ghazi Khan, West Pakistan: Geol. Bull. Panjab Univ., no. 6, p. 55-83, pls. 1-8.

HAQ, U. A. B., 1968, Studies on Upper Eocene calcareous nannoplankton from NW Germany: Stockholm Contr. Geol., vol. 18, p. 13-74, pls. 1-11, 3 figs.

HAQ, U. Z. B., 1971a, Paleogene calcareous nannoflora Part I: The Paleocene of West-Central Persia and the Upper Paleocene-Eocene of West Pakistan: Stockholm Contr. Geol., vol. 25, p. 1-56, pls. 1-14, 2 figs.

HAQ, U. Z. B, 1971b, Paleogene calcareous nannoflora Part II: Oligocene of West Germany: Stockholm Contr. Geol., vol. 25, p. 57-97, pls. 1-18, 1 fig.

HAQ, U. Z. B., 1971c, Paleogene calcareous nannoflora Part III; Oligocene of Syria: Stockholm Contr. Geol., vol. 25, p. 99-127, pls. 1-25, 1 fig.

HAQ, U. Z. B., 1973, Evolutionary trends in the Cenozoic coccolithophore genus *Helicopontosphaera:* Micropaleontology, vol. 19, no. 1, p. 32-52, pls. 1-7.

HAQ, U. Z. B. and J. H. LIPPS, 1971, Calcareous nannoplankton: *In* TRACEY, J. I., *et al.*, Initial Reports Deep Sea Drilling Project, Washington, U. S. Government Printing Office, vol. 8 p. 77-789, pls. 1-6.

HAY, W. W. and H. P. MOHLER, 1967, Calcerous nannoplankton from early Tertiary rocks at Pont Labau, France, and Paleocene-Early Eocene correlations: Jour. Paleontology, vol. 41, p. 1505-1541, pls. 196-206, 5 figs.

HAY, W. W., H. P. MOHLER, P. H. ROTH, R. R. SCHMIDT, and J. E. BOUDREAUX, 1967, Calcareous nannoplankton zonation of the Cenozoic of the Gulf Coast and Caribbean-Antillean area, and transoceanic correlation: Trans. Gulf Coast Assoc. Geol. Soc., vol. 17, p. 428-480, pls. 1-13.

HAY, W. W., H. P. MOHLER, and M. E. WADE, 1966, Calcareous nannofossils from Nal'chik (northwest Caucasus): Eclog. Geol. Helvet., vol. 59, p. 379-399, pls. 1-13.

HAY, W. W. and K. M. TOWE, 1962, Electron microscope examination of some coccoliths from Donzacq (France): Eclog. Geol. Helvet., vol. 55, p. 497-517, pls. 1-10.

HAY, W. W. and K. M. TOWE, 1963, Electromicroscopic examination of some rhabdoliths from Donzacq (France): Eclog. Geol. Helvet., vol. 56, p. 951-955, 2 pls., 1 fig.

HODSON, F. and I. M. WEST, 1970, Calcareous nannoplankton from an Upper Bracklesham horizon at Fawley, Hampshire: Rev. Micropaléontologie, vol. 13, p. 165-187, pls. 1-4, figs. 1-4.

HOFFMANN, N., 1970, Elektronenmikroskopische Untersuchungen an "Stabformigen" Nannofossilien aus der Kreide und dem Palaogen Norddeutschlands: Hercynia, vol. 7, p. 131-162, pls. 1-7, 3 figs.

IACCARINO, S. and M. P. FOLLINI, 1970, Nannoplancton calcareo del Flysch Cretacico di M. Caio e delle "Marne Rosate" Paleoceniche di Tizzano val Parma (Appennino Settentrionale): Riv. Ital. Paleont. vol. 76, p. 579-618, pls. 39-43.

JUKES-BROWNE, A. J. and J. B. HARRISON, 1892, The geology of Barbados. Part II. The oceanic deposits: Geol. Soc. London, Quart. Jour., vol. 48, p. 170-226.

KAMPTNER, E., 1948, Coccolithen aus dem Torton des Inneralpinen Wienar Beckens: Sitz. Ber. Osterr. Akad. Wiss., Math.-Nat. K1. Abt. I, vol. 157, p. 1-16, 2 pls.

KAMPTNER, E., 1954, Untersuchungen über den Feinbau der Coccolithen: Arch. Protistenk., vol. 100, p. 1-90, 50 text-figs.

KAMPTNER, E., 1963, Coccolithineen-Skelettreste aus Tiefseeablangerungen des Pazifischen Ozeans: Ann. Nat. Mus. Wien, vol. 66, p. 139-204, pls. 1-9, 39 figs.

KLUMPP, B., 1953, Beitrag zur Kenntnis der Mikrofossilien des Mittleren und Oberen Eozän: Palaeontographica, vol. 103A, p. 377-406, pls. 16-20, 5 text-figs.

LEADBEATER, B. S. C., 1970, Preliminary observations on the difference of scale morphology at various stages in the life cycle of *Apistonema-Syracosphaera* sense von Stosch: Brit. Phycol. Jour., vol. 5, no. 1, p. 57-69.

LEHOTAYOVÁ, R., 1970, Electron-microscopic examination of calcareous nannoflora from Badenian of western Slovakia: Abor. Geol. Vied, Zapadne Karpaty, red. ZK, vol. 13, p. 157-175, pls. 17-30.

LEHOTAYOVÁ, R., 1971, A comparison of calcareous nannoflora of the Badenian from Devinska Nova Vee and Bajtava, West-Slovakian Neogene: *In* FARINACCI, A., (ed.), Proc. II Plank. Conf. Roma 1970, Rome, Ed. Technoscienze, vol. 2, p. 677-687, pls. 1-6, 1 fig.

LEVIN, H. L., 1965, Coccolithoporidae and related microfossils from the Yazoo Formation (Eocene) of Mississippi: Jour. Paleontology, vol. 39, p. 265-272, pls. 41-43.

LEVIN, H. L. and A. P. JOERGER, 1967, Calcareous nannoplankton from the Tertiary of Alabama: Micropaleontology, vol. 13, p. 163-182, pls. 1-4, 2 figs.

LEVIN, H. L. and R. W. SHERWOOD, 1971, A new Eocene species of *Discolithina* from Texas: Jour. Paleontology, vol. 45, no. 4, p. 731-733.

LOCKER, S., 1965, Coccolithophoriden aus Eozänschollen Mecklenburgs: Geologie (Berlin), vol. 14, p. 1252-1265, 2 pls. 2 figs.

LOCKER, S., 1967, Neue stratigraphisch wichtige Coccolithophoriden (Flagellata) aus dem norddeutschen Alttertiär: Monatsber. Deutsch. Akad. Wiss. Berlin, vol. 9, p. 758-768, pls. 1-2.

LOCKER, S., 1968, Biostratigraphie des Alttertiars von Norddeutschland mit Coccolithophoriden: Monatsber. Deutsch. Akad. Wiss. Berlin, vol. 10, p. 220-229, 2 pls.

LOCKER, S., 1970, Zur Stellung der Latdorf-Serie in der Nannoplankton-Zonengliederung des Alttertiars: Geologie (Berlin), vol. 19, no. 4, p. 469-472.

LOCKER, S., 1972, Coccolithineen aus dem Palaeogen Mitteleuropas: Palaeontol. Abh., Aet. B, vol. 3, no. 5, p. 735-823.

McINTYRE, A. and A. W. H. BÉ, 1967, Modern Coccolithophoridae of the Atlantic Ocean — I. Placoliths and cyrtoliths: Deep-Sea Res., vol. 14, p. 561-597, pls. 1-12, figs. 1-17.

McINTYRE, A., A. W. H. BÉ, M. B. ROCHE, 1970, Modern Pacific Coccolithophorida: a paleontological thermometer: Trans. New York Acad. Sci., ser. II, vol. 32, p. 720-731, 9 figs.

MANIVIT, H., 1959, Contribution à l'étude des coccolithes del'Éocène: Publ. Serv. Carte Géol. Algérie, (N. S.), Bull. 25, Travaux des Collab., p. 331-382, 10 pls.

MANIVIT, H., 1965, Nannofossiles calcaires de l'Albo-Aptien: Rev. Micropaléontologie, vol. 8, p. 189-201, pls. 1-2.

MANTON, I. and G. F. LEEDALE, 1969, Observations on the microanatomy of *Coccolithus pelagicus* and *Cricosphaera carterae,* with special reference to the origin and nature of coccoliths and scales: Jour. Mar. Biol. Assoc. U. K., vol. 49, no. 1, p. 1-16, pls. 1-14.

MARTINI, E., 1958, Discoasteriden und verwandte Formen in NW-deutschen Eozän (Coccolithophorida) I. Taxionomische Untersuchungen: Senck. Lethaea, vol. 39, p. 353-388, 6 pls., 31 figs.

MARTINI, E., 1959a, Der stratigraphische Wert von Nanno-Fossilien im nordwestdeutschen Tertiär: Erdoel u. Kohle, vol. 12, p. 137-140, 1 fig.

MARTINI, E., 1959b, *Pemma angulatum* und *Micrantholithus basquensis,* zwei neue Coccolithophoriden Arten aus dem Eozän: Senck. Lethaea, vol. 40, p. 415-421, 1 pl.

MARTINI, E., 1960, Braarudosphaeraiden, Discoasteriden und verwandte Formen aus dem Rupelton des Mainzer Beckens: Notizbl. Hess. Landesamt. Bodenforsch. Wiss., vol. 88, p. 65-87, pls. 8-11.

MARTINI, E., 1961a, Nannoplankton aus dem Tertiar und der obersten Kreide von SW-Frankreich: Senck. Lethaea, vol. 42, p. 1-32, 5 pls. 3 text-figs.

MARTINI, E., 1961b, Der stratigraphische Wert der Lithostromationidae: Erdoel-Z., vol. 77, p. 100-103, 2 figs.

MARTINI, E., 1961c, Ein Kalkflagellat in den Meeren der Gegenwart und Vorzeit: Nat. Volk, vol. 91, p. 335-339, 6 figs.

MARTINI, E., 1964, Ein vollständiges Gehäuse von *Goniolithus fluckigeri* Deflandre: Neues Jahrb. Geol. Paläont. Abh., vol. 119, p. 19-21, pl. 6.

MARTINI, E., 1965, Mid-Tertiary calcareous nannoplankton from Pacific deep-sea cores: Colston Papers, vol. 17, p. 383-411, pls. 33-37, fig. 153.

MARTINI, E., 1969a, Nannoplankton aus dem Miozan von Gabon (Westafrika): Neues Jahrb. Geol. Palaont. Abh., vol. 132, no. 3, p. 285-300, pls. 26-29.

MARTINI, E., 1969b, Nannoplankton aus dem Latdorf (locus typicus) und weltweite Parallelisierungen im oberen Eozan und unteren Oligozan: Senck. Lethaea, vol. 50, p. 117-159, pls. 1-4, 4 figs.

MARTINI, E., 1970, The Upper Eocene Brockenhurst Bed: Geol. Mag., vol. 107, pp. 225-228.

MARTINI, E., 1971a, The occurrence of pre-Quanternary calcareous nannoplankton in the oceans: *In* FUNNELL, B. M., and W. R. RIEDEL, (ed.), The micropaleontology of oceans, Cambridge Univ. Press, p. 535-544, pls. 39.1-39.4, 1 fig.

MARTINI, E., 1971b, Standard Tertiary and Quaternary calcareous nannoplankton zonation: *In* FARINACCI, A., (ed.), Proc. II. Plank. Conf. Roma 1970, Rome, Ed. Tecnoscienza, vol. 2, p. 739-785, pls. 1-4.

MARTINI, E., 1971c, Die Typen und Typoide des Natur-Museums Seckenberg. 46, Fossiles Nannoplankton: Senck. Lethaea, vol. 52, no. 1, p. 115-126.

MARTINI, E. and M. N. BRAMLETTE, 1963, Calcareous nannoplankton from the experimental Mohole drilling: Jour. Paleontology, vol. 37, p. 845-855, pls. 102-105.

MARTINI, E. and S. RITZKOWSKI, 1968, Was ist das "Unter-Oligocän"? Eine Analyse der Beyrich'schen und v. Koenen'schen Fassung der Stufe mit Hilfe des fossilen Nannoplanktons: Nachr. Akad. Wiss. Göttingen II. Mat.-Phys. Kl., vol. 1968, no. 13, p. 231-250.

MARTINI, E. and H. STRADNER, 1960, *Nannotetraster,* eine stratigraphische bedeutsame neue Discoasteridengattund: Erdoel-Z., vol. 76, p. 266-270, 19 figs.

MAXWELL, A. E., R. P. HERZEN, J. E. ANDREWS, R. E. BOYCE, E. D. MILOW, K. J. HSU, S. R. PERCIVAL, and T. SAITO, 1970, Summary and conclusions: Deep-Sea Drilling Project, Initial Repts., Leg 3, Washington, U. S. Government Printing Office, p. 441-471.

PARÉJAS, E., 1934, Sur quelques *Actiniscus* du Crétacé supérieur des Brasses (Préalpes medianes) et de l'Ile d'Elbe: C. R. Soc. Phys. Hist. Nat. Geneva, vol. 51, p. 100-107, 32 figs.

PARKE, M., 1961, Some remarks concerning the class Chrysophyceae: Brit. Phycol. Bull., vol. 2, p. 47-55, 2 pls.

PARKE, M., 1971, The production of calcareous elements by benthic algae belonging to the Class Haptophyceae (Chrysophyta): *In* FARINACCI, A., (ed.), Proc. II Plank. Conf. Roma 1970, Rome, Ed. Tecnoscienza, vol. 2, p. 929-937, pls. 1-2.

PARKE, M., 1973, Recent planktonic and benthic algae related to fossil forms used by micropaleontologists for oil detection and rock dating: Proc. Challenger Soc., vol. 4, no. 4, p. 155-161.

PARKE, M. and I. ADAMS, 1960, The motile *(Chrystallolithus hyalinus* Gaarder and Markali) and non-motile phases in the life history of *Coccolithus pelagicus* (Wallich) Schiller: Jour. Mar. Biol. Assoc. U. K., vol. 39, p. 263-274, 4 pls.

PERCH-NIELSEN, K., 1967, Nannofossilien aus dem Eozän von Dänemark: Eclog. Geol. Helvet., vol. 60, p. 19-32, pls. 1-7, 1 fig.

PERCH-NIELSEN, K., 1969, Elektronenmikroskopische Untersuchungen der Coccolithophoriden der Dan-Scholle von Katharinenjof (Fehmarn): Neues Jahrb. Geol. Paläont. Abh., vol. 132, p. 317-332, pls. 32-35, 5 figs.

PERCH-NIELSEN, K., 1971, Elektronenmikroskopische Untersuchungen an Coccolithen und verwandten Formen aus dem Eozän von Dänemark: K. Danske Vid. Selskab. Biol. Skr., vol. 18, no. 3, p. 1-76, pls. 1-61, figs. 1-2.

PERCH-NIELSEN, K., 1972, Remarks on late Cretaceous to Pleistocene coccoliths from the North Atlantic: *In* LAUGHTON, BERGGREN, *et al.,* Init. Repts. Deep-Sea Drilling Project, vol. 12, Washington, U. S. Government Printing Office, p. 1003-1069, pls. 1-22.

POZARYSKA, K. and S. LOCKER, 1971, Les organismes planctoniques de l'Éocène supérieur de Siemien, Pologne Orientale: Rev. Micropaléontologie, vol. 14, no. 5, p. 57-72, pls. 1-2.

RADOMSKI, A., 1968, Pozimy nannoplankton wapiennego w Paleogenie Polskich Karpat Zachodnich: Rocz. Polsk. Towarz. Geol., vol. 38, p. 545-605, pls. 43-48, 3 figs.

REINHARDT, P., 1966, Zur Taxionomie und Biostratigraphie der fossilen Nannoplanktons aus dem Malm, der Kreide und dem Alttertiär Mittel-europas: Freib. Forsch. C196 Paläont., p. 5-109, 23 pls., 29 figs.

REINHARDT, P., 1967, Zur Taxionomie und Biostratigraphie der Coccolithineen (Coccolithophoriden) aus dem Eozän Norddeutschlands: Freib. Forsch. C213 Paläont., p. 201-241, pls. 1-7, 20 figs.

ROTH, P. H., 1970, Oligocene calcareous nannoplankton biostratigraphy: Eclog. Geol. Helv., vol. 63, p. 799-881, pls. 1-14, 17 figs.

ROTH, P. H., P. BAUMAN, and V. BERTOLINO, 1971, Late Eocene-Oligocene calcareous nannoplankton from Central and Northern Italy: *In* FARINACCI, A., (ed.), Proc. II PLank. Conf. Roma 1970, Rome, Ed. Tecnoscienza, vol. 2, p. 1069-1097, 13 figs.

ROTH, P. H., H. E. FRANZ, and S. W. WISE, 1971, Morphological study of selected members of the genus *Sphenolithus* Deflandre (incertae sedis, Tertiary): *In* FARINACCI, A., (ed.), Proc. II Plank. Conf. Roma 1970, Rome, Ed. Tecnoscienza, vol. 2, p. 1099-1119, pls. 1-6.

RAYNS, D. G., 1962, Alternation of generations in a coccolithophorid, *Cricosphaera carterae* (Braarud and Fagerland) Braarud: Jour. Mar. Biol. Assoc. U. K., vol. 42, no. 3, p. 481-484, pls. 1-2.

SALES, E., 1966, Les nannofossiles calcaires. Leur application systématique et pratique dans les problèmes de stratigraphie pétrolière: Rev. Tech. Petrole, vol. 177, p. 39-59, 7 pls., 3 text-figs.

SCHILLER, J., 1930, Coccolithineae: *In* L. RABENHORDT, Kryptogamen-Flora von Deutschland, Österreich und der Schweiz., vol. 10, no. 2, Leipzig, p. 89-267, 137 figs.

SCHWARZ, E., 1932, Beitrage zur Entwicklungsgeschichte der Protophyten; IX. Der Formwechsel von *Ochrosphaera neapolitana:* Arch Protistenk., vol. 77, p. 434-462, pls. 1-13, 7 text-figs.

SHERWOOD, R. W., 1974, Calcareous nannofossil systematics, paleon-ecology, and biostratigraphy of the middle Eocene Weches Fromation of Texas: Tulane Stud. Geol. Paleont., vol. 11, no. 1, p. 1-79, pls. 1-12.

SHERWOOD, R. W. and H. L. LEVIN, 1972, A closer look at *Trochoaster simplex* Klumpp: Jour. Paleontology, vol. 46, no. 4, p. 591, 594.

SMAYDA, T. J., 1958, Biogeographical studies of marine phytoplankton: Oikos, vol. 9, no. 2, p. 158-159.

STRADNER, H., 1959a, First report on the discoasters of the Tertiary of Austria and their stratigraphic use: Fifth World Petrol. Congr., Sect. I, Paper 60, p. 1081-1095, 27 figs.

STRADNER, H., 1959b, Die fossilen Discoasteriden Österreichs II. Teil: Erdoel-Z., vol. 75, p. 472-488, 77 figs.

STRADNER, H., 1961, Vorkommen von Nannofossilien in Mesozoikum und Alttertiär: Erdoel-Z., vol. 77, p. 77-89.

STRADNER, H., 1962a, Über das fossile Nannoplankton des Eozän-Flysch von Istrien: Geol. Bundes. Verh., vol. 2, p. 176-187, pls. 1-2.

STRADNER, H., 1962b, Über neue und wenig bekannte Nannofossilien aus Kreide und Alttertiär: Verh. Geol. Bunsanst. Wien, vol. 1962, p. 363-377, 3 pls.

STRADNER, H., 1964, Die Ergebnisse der Aufschlussarbeiten der ÖMV AG in der Molassezone Niederösterreichs in den Jahren 1957-1963. Ergebnisse der Nannofossil-Untersuchungen (Teil III): Erdoel-Z., vol. 80, p. 133-139, 51 figs.

STRADNER, H. and D. ADAMIKER, 1966, Nannofossilien aus Bohrkernen und ihre elektronenmikroskopische Bearbeitung: Erdoel-Z., vol. 82, p. 330-341, pls. 1-3, 16 figs.

STRADNER, H. and A. R. EDWARDS, 1968, Electron microscopic studies on Upper Eocene coccoliths from the Oamaru Diatomite, New Zealand: Jahrb. Geol. Bundesanst. Wien, vol. 13, 66 p., 48 pls., 10 figs.

STRADNER, H. and A. PAPP, 1961, Tertiäre Discoasteriden aus Österreich und deren stratigraphische Bedeutung mit Hinweisen auf Mexiko, Rumänien und Italien: Jahrb. Geol. Bundesanst. Wien, vol. 7, p. 1-159, pls. 1-42.

SULLIVAN, F. R., 1964, Lower Tertiary nannoplankton from the California Coast Ranges. I. Paleocene: Univ. Calif. Publ. Sci., vol. 44, p. 163-228, pls. 1-12, 1 fig.

SULLIVAN, F. R., 1965, Lower Tertiary nannoplankton from the California Coast Ranges. II. Eocene: Univ. Calif. Publ. Sci., vol. 53, p. 1-74, pls. 1-11, 2 figs.

TAKAYAMA, T., 1972, A note on the distribution of *Braarudosphaera bigelowi* (Gran and Braarud) Deflandre in the bottom sediments of Sendai Bay, Japan: Trans. Proc. Palaeont. Soc. Japan, (N. S.), no. 87, p. 429-435, text-figs. 1-4.

TAN SIN HOK, 1927, Discoasteridae incertae sedis: Akad. Wet. Amsterdam, Proc., Sec. Sci., vol. 30, p. 411-419, 14 figs.

TROELSEN, J. C. and L. P. QUADROS, 1971, Three species of Braarudosphaeraceae from Brazil: Bol. Paranaense Geociencias, nos. 28-29, p. 211-217, pl. 1.

WALLICH, G. C., 1877, Observations on the coccosphere: Ann. Mag. Nat. Hist., (ser. 4), vol. 19, p. 342-350, pl. 17.