MIDDLE EOCENE CALCAREOUS NANNOFOSSILS
AT LITTLE STAVE CREEK, ALABAMA

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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

Calcereous 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 calcereous 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* Byrell and Gartner and *Pentaster lisbonensis* Byrell 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 stratigraphic 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 nannoliths. 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 coccolithophores 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-
### Claiborne Group Nannofossils

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>39-37</td>
<td>Green, glauconitic, sandy clay</td>
</tr>
<tr>
<td>36-35</td>
<td>Brown, ferruginous sand</td>
</tr>
<tr>
<td>34-33</td>
<td>Grey sand</td>
</tr>
<tr>
<td>32-31</td>
<td>Blocky, grayish, lenticular, micaceous clay</td>
</tr>
<tr>
<td>30-29</td>
<td>Glauconitic, sandy clay</td>
</tr>
<tr>
<td>28-27</td>
<td>Blue to green, slightly glauconitic, sandy marl</td>
</tr>
<tr>
<td>26-25</td>
<td>Greenish, calcareous sand</td>
</tr>
<tr>
<td>24-23</td>
<td>Light brownish, calcareous sand</td>
</tr>
<tr>
<td>22-21</td>
<td>Blue-gray, glauconitic sand</td>
</tr>
<tr>
<td>20-19</td>
<td>Blocky, blue-gray, silty clay</td>
</tr>
<tr>
<td>18-17</td>
<td>Argillaceous silt and sand</td>
</tr>
<tr>
<td>16-15</td>
<td>Greenish, glauconitic sand, concretion locally</td>
</tr>
<tr>
<td>14-13</td>
<td>Bluish, argillaceous sand</td>
</tr>
<tr>
<td>12-11</td>
<td>Gray, silty, micaceous clay, partly glauconitic</td>
</tr>
<tr>
<td>10-9</td>
<td>Gray, glauconitic silts and sand</td>
</tr>
<tr>
<td>8-7</td>
<td>Glauconitic, silty clay</td>
</tr>
<tr>
<td>6-5</td>
<td>Limy sand</td>
</tr>
<tr>
<td>5-4</td>
<td>Siliceous claystone</td>
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<td>3-2</td>
<td>Brownish, silty clays with indurated ledges</td>
</tr>
<tr>
<td>1</td>
<td>Gray, glauconitic, silty clay</td>
</tr>
</tbody>
</table>

**EXPLANATION**

- *Collecting localities*
- **Calcireous concretions**

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 non-calcifying 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. *Rhodosphaera 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 Crystalloolithus 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
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.

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**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, *Pemna 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 occurring 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 synonymy. 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*...
minsitus Stradner first occurs in this zone.

3. Pemna papillatum Zone — Interval from the first occurrence of *Pemna 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, *Pemna papillatum* Zone, and the *Helicopontosphaera compacta* — *Chiasmolithus grandis* Zone. The *Discocaster 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. *Dactylethra punctulata* Gartner has previously been restricted to the *Pemna papillatum* Zone, but at Little Stave Creek it extends down into the *Reticulofenestra umbilica* — *Sphenolithus furcatolithoides* Zone (P11) and up into the *Helicopontosphaera umbilica* — *Chiasmolithus grandis* Zone (P14). *Chiasmolithus solitus* (Bramlette and Sullivan) and *Campylosphera delia* (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 usefulness 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.

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XI. SYSTEMATIC PALEONTOLOGY

Kingdom PLANTAE

Class HAPTOPHYCEAE

Christensen 1962

Order PYRMEESIALES

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 GRASSE, 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. BĂLDI-BEKE, 1960, p. 14, fig. 8; Miocene, Hungary. MARTINI, 1960, pl. 8, fig. 1; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 1, 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. BYSTRICK, 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, BYSTRIK  
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, 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; BENEŠOVA and HANZLÍKOVA, 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 BYSTRIK, 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. BILGUTAY, 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). BOUCHE, 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 P12-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 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.

**MIRCANTHOLITHUS 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 BENESOVA 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. HÁQ, 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. BILGUTAY, 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.


**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. BRAMLETT 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. 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 periph-
eral 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

*Penna 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.

*Penna 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:** *Penna 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.

Campylospphaera del a (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. del a 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 Campylospphaera 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.

Chiasmolithus grandis
(Bramlette and Riedel) 1954
Plate 23, Figure 3

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

Coccolithus cretaceus DEFLANDRE in GRASSE, 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.

Coccolithus cf. C. grandis Bramlette and Riedel. BENEŠOVÁ and HANZLÍKOVÁ, 1964, pl. 2, fig. 11; Eocene, Czechoslovakia.

Chiasmolithus grandis (Bramlette and Riedel). RADOMSKI, 1968, pl. 44, figs. 3-4; Paleocene-Eocene, Poland. BILGUTAY, 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, 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.

Genus CHIASMOLITHUS
Hay, Mohler, and Wade 1966
Type species: Tremalithus oamaruensis Deflandre
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; RADOVSKI, 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 conusetus 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 BoučÉ 1962 Plate 22, Figure 6

Coccolithus crassipons BOUČÉ, 1962, pl. 1, fig. 14; text-fig. 3; Eocene, France. LOCKER, 1972, pl. 6, figs. 5-6; Eocene, Europe. Coccolithus stauri i on 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 **Cruziplacolithus**
Hay and Mohler 1967

Type species: *Heliorthus tenius* Stradner

**Cruziplacolithus Staurion**
(Bramlette and Sullivan) 1961

Plate 20, Figure 7

*Coccolithus staurion* Bramlette and Sullivan

*Coccolithus* staurion

Birkelundia staurion

*Coccolithus* Cruciplacolithus staurion

Cyathosphaera diaphragma

*Coccolithus* leptoportas

Alabama.

No. 4

from other similar

out the middle Eocene (Blow's

*Cyclococcolithus formosus* CYCLOCOCCOLITHINA FORMOSA

Type species: *Coccosphaera leptoporas* Murray and Blackman

*Cyclococcolithina* Cyathosphaera diaphragma HAY and TOWE, 1962, in part; pl. 6, figs. 2-5; 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. BALDIBEKE, 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.

*Cyclococcolithus 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.

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

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

*Cyclococcolithina* formosai (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.

*Eriksenia* alternans (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* neogammatum Bramlette and Wilcoxon. BALDI-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, 1966, 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 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 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 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, figs. 5; pl. 4, figs. 1-2; Eocene, USSR. PERCH-NIELSEN, 1967, pl. 1, figs. 9-11; Eocene, Denmark.

Reticulofenestra samodurovi (Levin) BRAMLETTE and RIEDEL, 1954, pl. 39, fig. 10-11; pl. 5, fig. 10; Eocene, Yugoslavia.

Perch-Nielsen, 1971b, pl. 21, fig. 18-19; Eocene, Denmark. PERCH-NIELSEN, 1972, pl. 9, fig. 10-11; Eocene, Germany.

Reticulofenestra umbilica (Levin). MARTINI and HARRISON, 1967, pl. 1, figs. 9-11; pl. 5, figs. 1-3; Eocene, Mississippi. LOCKER, 1965, 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

Genus DISCOASTER
Tan Sin Hok 1927

Type species: Discoaster pentaradiatus Tan Sin Hok

DISCOASTER BARBADIENSIS
Tan Sin Hok 1927

Plate 17, Figure 3

Kristaldrusen" 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. BALDIBEKE, 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. BOUCHE, 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.

BYSTRICKA', 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.

Remarks: Both shields and the collar exhibit birefringence. There is considerable size variation within this species.
Heliodycoaster barbadiensis (Tan Sin Hok).
DEFLANDRE, 1934, text-figs. 22-23, 29-31.
DEFLANDRE in GRASSE, 1952, text-fig. 362-V; Miocene.

Actiniscus ilvensis
Actiniscus decapetalus

No. 4
Specimens are basket-shaped with a slender asterolith with nine to fourteen rays which Bramlette and Sullivan.
the concentric banding of either rounded or pointed. The species lacks are connected for most of their length.
Pll-P14)
throughout the middle Eocene (Blow's P11-P14) of Alabama.

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. BYSTRICKA, 1963, pl. 3, figs. 2-6. SULLIVAN, 1964, pl. 10, figs. 5-6; Paleocene, California. BUKRY and KENNEDY, 1969, figs. 3-7; Eocene, California. BYSTRICKA, 1969, pl. 59, figs. 7-10; Eocene, Czechoslovakia. BALDI-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. NOEL, 1960, pl. 2, fig. 13; Eocene. LEVIN, 1965, pl. 43, figs. 5; Eocene, Mississippi. HAY and RIEDEL, 1967, pl. 4, figs. 4-6; Oligocene, Alabama. Not HAQ, 1968, pl. 10, fig. 7. BYSTRICKA, 1969, pl. 62, fig. 2; Eocene, Czechoslovakia. ROTH, 1970, pl. 12, fig. 4; Oligocene. BALDI-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 hiirundinus 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 SAIPANE NESIS
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. BALDI-BEKE, 1960, pl. 14, fig. 20; Oligocene. MARTINI, 1960, pl. 8, fig. 12; Oligocene, Germany. NOÉL, 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, Germany. MARTINI, 1969b, pl. 3, figs. 34-35; Oligocene, Switzerland. PERCH-NIELSEN, 1969, pl. 46, fig. 7; Eocene, New Zealand. MARTINI, 1969b, pl. 3, figs. 34-35; Oligocene, Switzerland. PERCH-NIELSEN, 1969, pl. 6, figs. 7-8; Danian-Oligocene, Europe.

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-
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 1-4.

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. BOUCHE, 1962, pl. 4, figs. 7-8; Eocene, France. BILGUTAY, et al., 1969, pl. 5, figs. 5-7; Eocene, France. HODSON and WEST, 1970, pl. 4, fig. 8; Eocene, England. BALDI-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 GRASSE, 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, BALDI-BEKE, 1971, pl. 6, fig. 18; Eocene, Hungary. CLOCCHIATTI, 1971, pl. 21, figs. 1-2; Miocene, Yugoslavia. LEHOTAYOVA', 1971, pl. 5, fig. 2; Miocene, Yugoslavia. PERCH-NIELSEN, 1971, pl. 20, fig. 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.
LEHOTAYOVA, 1970, pl. 30, figs. 1, 3; Miocene, Yugoslavia.
Trochoaster triangularis (Gardet). BALDI-BEKES, 1960, pl. 14, fig. 21; Miocene, Hungary.
Lithostromation robustum MARTINI, 1961b, fig. 1; Oligocene, Germany.
MARTINI, 1971a, pl. 51, 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 spinosus 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.
BOUCHE, 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.
BYSTRICKA, 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

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**

*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 cribaria* 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 cribaria* (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. cribaria* appears to have little or no rim under the light microscope.

**Occurrence:** *D. cribaria* 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.

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**PLATE 4**

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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.

Cribrospheara sp. BENESOVÁ and HANZLÍKOVA, 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 vadous 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. LEHOTAYOVA, 1970, pl. 24, figs. 1-3; Miocene, Yugoslavia. BALDI-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). HANZLÍKOVA, 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 cribbraria 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 vesca SULLIVAN, 1965, pl. 4, fig. 9; Paleocene-Eocene, California.

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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.

*Koczayia excelsa* PERCH-NIELSEN, 1971b, pl. 28, figs. 1-5; pl. 60, fig. 16; Eocene, Denmark.

*Koczayia wechesensis* (Bukry and Percival). SHERWOOD, 1974, p. 4, figs. 5-6; pl. 60, fig. 16; 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 HELICOPONTOSPHEREA  
Hay and Mohler 1967

Type species: *Helicopontosphera kamptneri* Hay and Mohler

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**PLATE 6**

**Figures**

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**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). POZAR YSKA 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.

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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. BALDI-BEKE, 1971, pl. 3, fig. 9; Eocene, Hungary.

*Helicopontosphaera 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.

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 microscope, 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 Pl 1) of Alabama.

Helicopontosphaera reticulata (Bramlette and Wilcoxon) 1967
Plate 18, Figure 8

Helicosphaera reticulata Bramlette and Wilcoxon, 1967, p. 6, fig. 15; Eocene-Oligocene, Mississippian; Oligocene, JOIDES. Gartner, 1971, pl. 1; Eocene-Oligocene, Blake Plateau. HAQ, 1973, pl. 2, fig. 1; 3, figs. 1-2; Eocene-Oligocene. Martini, 1971b, pl. 3, figs. 3-4; Eocene-Oligocene.

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.


PLATE 8

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   5. Electron micrograph, X8,500
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. 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.

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7b. Phase contrast, X2,200
8a. Transmitted light, X2,200 Plan view
8b. Transmitted light, X2,200 Side view
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.
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.

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**Transversopontis fimbriatus** (Bramlette and Sullivan) 1961

Plate 22, Figures 1, 3

Discolithus fimbriatus BRAMLETTE and SULLIVAN, 1961, pl. 3, fig. 1; Eocene, California, Texas. BENESOVA and HANZLIKOVÁ, 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.

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**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.
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. LEVIN and JOERGER, 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 pulchriporus (Reinhardt). PERCH-NIELSEN, 1971b, pl. 33, figs. 3, 7; Eocene, Denmark. SHERWOOD, 1974, pl. 5, figs. 15-16; Eocene, Texas.

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

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

PLATE 12

Figures

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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-legs. 81-82; Eocene, France. BOUCHÉ, 1962, pl. 1, fig. 6; Eocene, France. BY- STRICKA, 1963, pl. 1, fig. 13; Eocene, Czechoslovakia.

Rhabdosphera 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.

Rhabdosphera 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-leg, 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 Rhabdosphera 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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**Figures**

1-2. *Pentaster lisbonensis* Byell and Gartner Sample B-30 .......................... 192

1a. Electron micrograph, X5,000 11° Tilt
1b. Electron micrograph, X4,400 45° Tilt
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2b. Interference contrast, X2,200
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3. *Orthozygus aureus* (Stradner) Sample B-30 .......................... 242

3a. Electron micrograph, X8,700 55° Tilt
3b. Electron micrograph, X8,700
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

*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 tenus** (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**

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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.

Rhabdolithes tenuis (Bramlette and Sullivan). Not Hodson and West, 1970, pl. 3, fig. 1.

Blackites incomptertus ROUTH, 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
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 approximately 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**

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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 LEVIN and JOERGER, 1967, pl. 1, fig. 9; Oligocene, Poland. 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
(Bronnimann and Stradner) 1960
Plate 23, Figure 2

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

Sphenolithus pacificus MARTINI, 1965, pl. 36, figs. 7-10; Miocene-Miocene, Pacific. MARTINI, 1965, pl. 36, figs. 7-10; Miocene-Miocene, Switzerland.

Sphenolithus moriformis (Bronnimann 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.

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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.

Spenolithus radians DEFLANDRE in GRASSE,

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. FRANZE and FERT, 1954, pl. 12, 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. CLOCCHIATI, 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; figs. 47-48, 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.

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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 SYRACOSPHAEACEAE

Genus **CEPEKIella** Roth 1970

Type species: *Cepekiella elongata* Roth

**CEPEKIella lumina** (Sullivan) 1965 n. comb.

*Cyclococcolithus lumina* 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

*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. BALDI-BEKE, 1960, pl. 14, fig. 4; Oligocene-Miocene, Hungary. MARTINI, 1960, pl. 11, fig. 39; Oligocene, Germany. BRAMLETTE and SULLIVAN, 1961, pl. 11, 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

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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. BÅLDI-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. PERCH-NIELSEN, 1971b, pl. 42, 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. BÅLDI-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.

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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. BALDI-BEKE, 1960, pl. 14, fig. 1; Oligocene, France.

Discolithina solida (Deflandre). LEVIN and JOERGER, 1967, pl. 2, fig. 7; Eocene-Oligocene, Alabama. BALDI-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-Oligocene, Alabama. MARTINI, 1969b, pl. 2, figs. 4-18; Eocene-Oligocene, Switzerland. POZARYSKA and LOCKER, 1969b, pl. 2, figs. 24-25; Eocene-Oligocene, Switzerland.
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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

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.
Genus Zygribhoblithus
Deflandre 1959

Type species: Zygolithus bijugatus Deflandre

Zygribhoblithus 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 BRONNIMANN and STRADNER, 1960, text-figs. 25-43; Cuba.

Zygrhablithus bijugatus (Deflandre). BRAMLETTE and SULLIVAN, 1961, pl. 6, figs. 16-18; Eocene, California.

Benešov (and HANZLÍKOVÁ, 1962, pl. 2, fig. 16; Miocene, Czechoslovakia.

BOUCHE, 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. POZARSKA 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.}

Rhabdosphera 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. 12; Paleocene, 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
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**


**PLATE 24**

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