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far in the north that it is difficult to correlate it with tropical and subtropical sediments. Calcareous plankton fossils are rare in the Neochattian and the rich benthonic fauna is not yet usable for worldwide correlation. Thus, the Neochattian, apart from its unacceptable name, is not very useful as an Upper Oligocene stage either.

6.6. Vicksburgian

The Vicksburg deposits of Alabama, which can be correlated with the type Vicksburg of Mississippi (see DEBOO 1965) contain the nannoflora of the *Ericsonia subdisticha*, *Cyclococcolithus margaritae* and *Reticulofenestra laevis* Zones. Preservation of the nannofossils is good and planktonic foraminifera are present along with larger foraminifera, molluscs, echinoids, ostracods. The Vicksburgian seems to be the best Oligocene stage available.

6.7. Chickasawhay

The *Sphenolithus distentus*-*Sphenolithus ciperoensis* Zone was found in the Chickasawhay Limestone of Alabama. The Chickasawhay sequence thickens towards the western part of the Gulf Coast and might contain more than one nannoplankton zone.

7. SYSTEMATIC PALEONTOLOGY

Of a total of 122 species encountered in the Oligocene sections studied, 29 species are new, 25 new combinations are made and remarks are presented on 23 species because of differences in species concepts. The remaining 49 species are not described in this paper because they were well covered in previous literature. For those species not described in this paper the author presents a check list (pp. 871-872) where the type reference, other good illustrations, and descriptions are mentioned. Mainly electron micrographs of carbon replicas of the new species are presented here because some species prove to be too small to obtain light micrographs which could be assigned to the same species with certainty. The method described by PERCH-NIELSEN (1967) which allows examination of the same specimen in the light and electron microscope was not used because it was published after the greater part of the electron microscope work for this paper was already finished. For the suprageneric classification the system proposed by PARKE & DIXON (1964) for recent algae is mainly followed here. It differs considerably from the one used by HAY & al. (1967).

Kingdom Plantae

Subkingdom Contophora

Division Chromophyta

Class Haptophyceae, Christensen, 1962

Unicellular flagellates which possess a haptonema.

Order Prymnesiales, Christensen, 1962

Motile phase with an obvious haptonema.

Family Coccolithaceae
Rhabdosphaeraceae
Pontosphaeraceae
Syracosphaeraceae
Zygosphaeraceae
Braarudosphaeraceae
Discoasteraceae
Lithostromationaceae
Triquetrorhabdulaceae
Sphenolithaceae

Family Coccolithaceae KAMPTNER, 1928

Genus *Coccolithus* Schwarz, 1894

Coccolithus crater n. sp.

pl. 1, fig. 2

Definition: A small species of *Coccolithus* with 9–12 elements and a simple central depression.

Description: The distal shield is composed of 9–12 wedge-shaped elements with slight sinistral imbrication. Sutures on the distal shield are straight and radial. In the center of the distal shield is a narrow crater-shaped depression, about a fourth the diameter of the coccolith, with steep smooth walls and triangular cross-section.

Remarks: *Coccolithus crater* n. sp. differs from *Coccolithus litos* HAY, MOHLER & WADE in its smaller size and in having fewer elements and a smooth depression. *Coccolithus paralitos* ROTH & HAY is about the same size but has about 25 elements and the central depression is surrounded by a cycle of granules.²⁾

Holotype: IMS-A 809 004, [A 808].

Length of holotype: 5 μ .

Type locality: St. Stephens Quarry, Alabama.

Type level: Marianna Ls., 9 feet above base.

Distribution: JOIDES Hole 5, Alabama and Barbados: *Cc. margaritae* Zone. JOIDES Hole 6: From the *E. subdisticha* through the *Cc. margaritae* Zone.

Coccolithus primalis n. sp.

pl. I, fig. 3

Definition: A very small species of *Coccolithus* consisting of 14–22 elements.

Description: The distal shield is constructed of 14–22 tabular dextrally imbricate elements. The sutures are radial over the greater part of the distal shield and curve strongly counterclockwise near the periphery. The central depression which is about half as long as the whole shield, is a shallow crater filled with tabular elements and coarse angular blocks.

Remarks: *Coccolithus primalis* n. sp. is distinguished from *Coccolithus sarsiae* BLACK by its smaller size and relatively smaller central area. *Coccolithus paralitos*

²⁾ This species resembles *Biscutum castorum* BLACK & BARNES, but the complete lack of other Cretaceous species in the samples where it was found makes roworking highly unlikely.

ROTH & HAY possesses a greater number of elements, and a ring of granules around the central depression which is not present in *Coccolithus primalis* n.sp. *Coccolithus litos* HAY, MOHLER & WADE is larger and has more elements. *Coccolithus crater* n.sp. has fewer elements and a smooth central depression with a sharp angular bottom.

Holotype: IMS-J 506377, [A 809].

Length: 2,7 μ .

Type locality: JOIDES Hole 5, Blake Plateau, Lat. 30°23' N, Long. 80°08' W.

Type level: 374' below top. Oligocene.

Occurrence: JOIDES Hole 5, Alabama, Monte Cagnero (Italy), Boom Clay (Belgium), Helmstedt and Glimmerode: throughout the section. Barbados: *Cc. margaritae* Zone. Trinidad: *Sph. predistentus*–*Sph. distentus* Zone and *Sph. distentus*–*Sph. ciproensis* Zone.

Coccolithus tritus n.sp.

pl. I, fig. 1

Definition: A species of *Coccolithus* with a distal shield consisting of two cycles of about 30 elements each.

Description: The distal shield is broadly elliptical and is composed of two cycles of elements. The outer cycle consists of 30–35 tabular dextrally imbricate elements with straight radial sutures. The inner cycle slopes towards the slot at the bottom of the central depression and is built of 28–30 tabular elements which are imbricate dextrally. The sutures of the inner cycle are S-shaped and inclined counterclockwise near the central slot, clockwise in the middle and counterclockwise again near the margin. While the margin of the outer cycle is smooth the margin of the inner cycle is serrate. The inner cycle overlaps the elements of the outer cycle. The length of the central depression is about $\frac{2}{3}$ of the whole coccolith.

Remarks: This species is very similar to *Coccolithus cavus* HAY & MOHLER but it has fewer elements and a more regularly built inner cycle of elements. The lining of the central depression of *Ericsonia muiri* BLACK consists of irregular granules and not of curved tabular elements as in *Coccolithus tritus* n.sp.

Holotype: IMS-A 604225, [A 810].

Length: 6.2 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens Alabama.

Type level: Red Bluff Formation, 4 feet above base, Oligocene.

Distribution: JOIDES Hole 5: *E. subdisticha* Zone to lower part of the *R. laevis* Zone. JOIDES Hole 6: *E. subdisticha* Zone through *Cc. margaritae* Zone. Alabama: *E. subdisticha* Zone. Barbados: *Cc. margaritae* Zone.

Genus *Ericsonia* Black, 1964

Ericsonia bireticulata n.sp.

pl. I, figs. 4, 5

Diagnosis: A species of *Ericsonia* with a central opening spanned by two superimposed grilles the upper one being coarse, the lower one fine.

Description: The distal shield is constructed of 32–38 trapezoidal dextrally imbricate elements. The sutures of the distal shield are radial on the distal side. The central depression, about two-thirds the size of the whole coccolith, is covered with a coarse grille with 8–10 round pores arranged in an elongate ellipsoid. Through these pores the finer grille of the proximal side can be seen. The proximal shield consists of three cycles of elements. The outer cycle is built of 32–38 tabular elements, sinistrally imbricate, with sutures inclined slightly counterclockwise as seen from the proximal side. The middle cycle is composed of short, narrow crystals with sutures more strongly inclined counterclockwise. The central area, about half the size of the proximal shield, is covered with a grille with about 20–31 irregularly shaped pores.

Remarks: *Ericsonia bireticulata* n.sp. differs from *Ericsonia pauciperforata* n.sp. in having two superimposed grilles; this seems to be a unique feature among coccoliths known so far.

Holotype: JS 1847301 [A 811].

Paratype: JS 1847026 [A 812].

Length of holotype: 4.7 μ .

Length of paratype: 5.7 μ .

Type locality: Cipero Coast (sample JS 1847), San Fernando, Trinidad.

Type level: *Gg. ampliapertura* Zone, Cipero Formation.

Distribution: Restricted to the *Sph. predistentus*–*Sph. distentus* Zone Trinidad.

Ericsonia fenestrata (DEFLANDRE & FERT) STRADNER

pl. I, fig. 6

1954 *Discolithus fenestratus* DEFLANDRE & FERT, p. 25, pl. 11, fig. 25, text-fig. 52.

1968 *Ericsonia fenestrata* (DEFLANDRE & FERT) STRADNER in STRADNER & EDWARDS (pro parte), p. 18–19, pl. 10, fig. 4, pl. 11, fig. 1–4 (non pl. 10, fig. 1–3, pl. 11, fig. 5–7).

1968 *Ericsonia fenestrata* (DEFLANDRE & FERT) STRADNER of HAQ (pro parte), p. 22, pl. 1, figs. 11–12 (non pl. 11, fig. 10).

Remarks: In following the original description of DEFLANDRE & FERT (1954) this name is only applied for specimens with many pores (12–20) arranged on lines parallel to the long and the short axis of the ellipse. Specimens with a longitudinal central ridge and few pores either belong to the species *Ericsonia subdisticha* (ROTH & HAY) or to *Ericsonia pauciperforata* n.sp.

Hypotype: IS 1847624 [A 813].

Distribution: JOIDES 5 and Alabama: *E. subdisticha* Zone. JOIDES 6: *Cc. margaritae* Zone. Italy: *I. recurvus* Zone to lower part of *Cc. margaritae* Zone. Trinidad: *Sph. predistentus*–*Sph. distentus* Zone through *Sph. ciperoensis*–*Trq. carinatus* Zone (perhaps reworked).

Ericsonia muiri (BLACK) n. comb.

1964 *Coccolithus muiri* BLACK, p. 309, pl. 50, figs. 3–4.

1964 *Ericsonia ovalis* BLACK, p. 312, pl. 52, figs. 5–6.

1967 *Coccolithus* sp. aff. *C. eopelagicus* (BRAMLETTE & RIEDEL) of LEVIN & JOERGER, p. 165, pl. 1, figs. 2a, b.

1967 *Coccolithus* sp. cf. *C. pelagicus* (WALLICH) of LEVIN & JOERGER, p. 165, pl. 1, figs. 4a, b.

1967 *Coccolithus eopelagicus* (BRAMLETTE & RIEDEL) of GARTNER & SMITH, p. 3, pl. 3, figs. 1–5.

1968 *Ericsonia ovalis* BLACK of STRADNER in STRADNER & EDWARDS, p. 17, pl. 8, 9.

Remarks: *Coccolithus muiri* BLACK has page priority over *Ericsonia ovalis* BLACK which is the proximal view of *Coccolithus muiri*. STRADNER (in STRADNER & EDWARDS, 1968) has given a thorough description of this species. It is not possible to distinguish *Ericsonia muiri* from *Coccolithus eopelagicus* (BRAMLETTE & RIEDEL) in the uppermost Eocene and Oligocene because there is little variation in size and intergrading forms can be found between the two extreme types (see BRAMLETTE & WILCOXON, 1967). *Coccolithus pelagicus* (WALLICH) shows a different construction of the proximal shield with only one cycle of elements and sometimes a cover of plates over the central opening. In *Coccolithus pelagicus* the central crater of the distal plate is covered with smooth small elongate crystals whereas *Ericsonia muiri* has a layer of irregular granules in the crater.

Distribution: From the Upper Eocene through the Oligocene in all the studied sections.

Ericsonia pauciperforata n. sp.

pl. II, fig. 1

1954 *Discolithus* cf. *fenestrata* DEFLANDRE & FERT, Text-fig. 18 (left).

1968 *Ericsonia fenestrata* (DEFLANDRE & FERT) of STRADNER in STRADNER & EDWARDS (pro parte), p. 18, pl. 10, figs. 1–3, pl. 11, figs. 5–7 (non pl. 10, fig. 4, pl. 11, figs. 1–4).

1968 *Ericsonia fenestrata* (DEFLANDRE & FERT) of HAQ (pro parte), p. 22, pl. 1, fig. 10 (non pl. 1, figs. 11–12).

Diagnosis: A species of *Ericsonia* with 5–15 perforations in the central area.

Description: The distal shield contains two cycles of elements, an outer one of 30–35 trapezoidal elements, dextrally imbricate with straight radial suture lines and an inner cycle of the same number of tabular elements, dextrally imbricate, with strongly counterclockwise inclined suture lines. The central area, about half the size of the coccolith, is pierced by 5–15 pores. They are arranged irregularly. In some specimens they surround an area lacking perforations which is never as distinctly elevated as in *Ericsonia subdisticha* (ROTH & HAY).

Remarks: This species differs from *Ericsonia fenestrata* (DEFLANDRE & FERT) as described by DEFLANDRE & FERT 1954 by the irregular arrangement of the perforations. *Ericsonia fenestrata* has pores arranged parallel to the long and short axes of the ellipse. STRADNER's description is too general and he includes specimens that can be referred to the present species in *Ericsonia fenestrata*. In *Ericsonia subdisticha* (ROTH & HAY) two pores are at the end of an distinctly elevated ridge in the long axis of the ellipse and 4 pairs of pores to either side of the central ridge.

Holotype: IMS-A 608 157 [A 814].

Length: 5.2 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens Alabama.

Type level: Red Bluff Formation, 8 feet above base.

Occurrence: New Zealand: Upper Eocene, *I. recurvus* Zone. Denmark: Middle to Upper Eocene (personal communication from K. Perch-Nielsen). JOIDES Hole 5: Lower part of the *R. laevis* Zone. JOIDES Hole 6 and Barbados: *Cc. margaritae* Zone. Alabama and Helmstedt, Germany: *E. subdisticha* Zone and *Cc. margaritae* Zone.

Ericsonia quadriperforata n. sp.

pl. II, fig. 2

Diagnosis: A species of *Ericsonia* with four round, large pores in the center.

Description: The distal shield is composed of two cycles of elements; the outer one contains 28–30 trapezoidal dextrally imbricate elements with radial sutures; the inner cycle is built of the same number of tabular elements with broken suture lines, which as a whole are inclined slightly counterclockwise. The center, about $\frac{1}{3}$ the size of the distal shield, is occupied by four large round pores.

Remarks: This species differs from *Ericsonia pauciperforata* n. sp. in having only four central pores whereas *Ericsonia pauciperforata* n. sp. has 5–15 smaller pores. *Ericsonia fenestrata* (DEFLANDRE & FERT) and *Ericsonia subdisticha* (ROTH & HAY) have more pores.

Holotype: IMS-J 515234 [A 815].

Length: 5 μ .

Type locality: JOIDES Hole 5, Blake Plateau, Lat. 30° 23' N, Long. 81° 08' W.

Type level: 589' 11" below sea floor, Oligocene.

Distribution: JOIDES Hole 5 and Alabama: *E. subdisticha* Zone.

Ericsonia subdisticha (ROTH & HAY) ROTH, 1969

pl. II, figs. 3, 4

1967 *Ellipsolithus subdistichus* ROTH & HAY in HAY et al., pp. 446–447, pl. 6, fig. 7.

1969 *Ericsonia subdisticha* (ROTH & HAY) ROTH in BAUMANN & ROTH, p. 319.

1969 *Ellipsolithus subdistichus* ROTH & HAY, MARTINI, pp. 135–136, pl. 2, figs. 26–27, pl. 4, figs. 38–39.

New diagnosis: A species of *Ericsonia* with four pairs of pores on either side of the long axis, and one hole at each end of the central area.

New description: The coccolith is broadly elliptical. The distal shield is composed of about 31 subtrapezoidal segments which are dextrally imbricate. The sutures have a slight counterclockwise inclination over most of the surface, but curve more strongly in the same direction peripherally. The central area has a longitudinal ridge flanked by four pairs of pores; two additional pores lying in the long axis delimit the ends of the ridge. The proximal shield shows a shallow central depression with 10 pores similarly arranged as on the distal shield, but the central ridge is less pronounced. This central depression is surrounded by a cycle of square crystal blocks which are slightly dextrally imbricate with suture lines inclined slightly counterclockwise. The marginal segments, subtrapezoidal in shape, are dextrally imbricate and the sutures are inclined clockwise. These rings of elements with suture lines of different inclination are typical for genus *Ericsonia*. *Ellipsolithus subdistichus* was therefore transferred to this genus. The general construction of coccolith seems to be of greater taxonomic importance than modification of the central area.

Remarks: This species differs from *Ellipsolithus distichus* (BRAMLETTE & SULLIVAN) in having two shields. *Ericsonia fenestrata* (DEFLANDRE & FERT) has more numerous pores arranged parallel to the axis of the ellipse. In *Ericsonia subdisticha* the pores lie on a narrow ellipse. *Ericsonia pauciperforata* n. sp. shows an irregular distribution of variable numbers of pores without a pronounced central ridge.

Hypotypes: IMS-J 515374 [A 816];
IMS-N1 241 [A 817].

Distribution: *E. subdisticha* Zone in JOIDES Hole 5, Alabama. Monte Cagnero, Italy, Helmstedt (Northern Germany). According to W. W. Hay (personal communication 1969) *Ericsonia subdisticha* also occurs throughout the Upper Eocene.

Genus *Cruciplacolithus* HAY & MOHLER, 1967

Synonym: *Crucilithus* STRADNER, 1968

Cruciplacolithus flavius n. sp.

pl. II, figs. 5, 6

Diagnosis: A small species of *Cruciplacolithus* with a wide central opening and a slim central cross.

Description: The distal shield is narrow elliptical and contains an outer cycle of 25–30 wedge-shaped elements which are dextrally imbricate. The sutures are inclined clockwise near the center and turn sharply counterclockwise peripherally. The inner cycle slopes towards the central depression and is built of about the same number of tabular elements as the outer cycle. The imbrication is dextral and the suture lines are strongly inclined counterclockwise. The cross in the central hole is aligned parallel to the long and short axis of the ellipse. It sometimes shows a central ridge and the arms are always very slim. The proximal shield consists of two cycles as well. The elements of the outer one, 25–30 in number, are wedge-shaped and dextrally imbricate and the suture lines are inclined counterclockwise. The inner cycle has the same number of tabular elements sloping towards the central depression with dextral imbrication. The sutures are inclined strongly counterclockwise. The ridge on the central cross cannot be seen from the proximal side.

Remarks: This species differs from *Cruciplacolithus crux* (DEFLANDRE & FERT) n. comb. [= *Discolithus crux* DEFLANDRE & FERT, 1954, p. 143, pl. 14, fig. 4] in having fewer elements and in being much smaller. *Cruciplacolithus cruciformis* (HAY & TOWE) n. comb. [= *Cyathosphaera cruciformis* HAY & TOWE, 1962, p. 508, pl. 2, fig. 6] is more broadly elliptical; its margin is notched and the cross shows a rather large central knob which is not present in *Cruciplacolithus flavius* n. sp. *Cruciplacolithus tarquinius* ROTH & HAY has a smaller central opening and the inner cycle shows a distinctly serrate margin.

Holotype: IMS-J 504107 [A 818].

Paratype: IMS-J 503229 [A 819].

Length: Holotype: 3.5 μ , Paratype: 2.5 μ .

Type locality: JOIDES Hole 5, Lat. 30°23' N, Long. 80°08' W, Blake Plateau. *Type level:* 445' below top, Oligocene.

Distribution: JOIDES Hole 5: From the *I. recurvus* Zone through the *R. laevis* Zone. JOIDES Hole 6 and Barbados: *Cc. margaritae* Zone. Alabama: From the *E. subdisticha* Zone through the *R. laevis* Zone.

Cruciplacolithus quader n. sp.

pl. III, fig. 1

Diagnosis: A species of *Cruciplacolithus* having a central cross with broad arms and a cube in its center.

Description: The distal shield is broadly elliptical and consists of about 22 very strongly dextrally imbricate tabular segments. The sutures are straight and radial. The steep slope of the central area is covered with two cycles of elements. The upper cycle contains 22 sinistrally imbricate tabular elements separated by radial suture lines. The lower cycle which extends somewhat higher than the attachment of the cross bars has the same number of flat plates and radial suture lines. The sutures of the two cycles are offset by less than a quarter of an element. The arms of the central cross which lie in the axis of the ellipse are broad and carry a cube in the center with sides parallel to the arms of the cross. The inter-spaces between the arms of the cross are filled with parallel laths forming a triangular plate leaving only a narrow slit open along the margin of the central depression.

Remarks: This species is distinguished from *Cruciplacolithus cruciformis* (HAY & TOWE) by the relatively smaller central area, the smooth margin of the shield, and by having three cycles in the distal shield. *Cruciplacolithus tarquinius* ROTH & HAY does not have a cube in the center of the cross and the marginal elements are less strongly imbricate.

Holotype: IMS 504101 [A 820].

Length: 3.5 μ .

Type locality: JOIDES Hole 5, Lat. 30°23' N, 80°08' W, Blake Plateau.

Type level: 44' below top, Oligocene.

Distribution: Restricted to the *Cc. margaritae* Zone of JOIDES Hole 5.

Genus *Sollasites* BLACK, 1967Synonym: *Costacentrum* BUKRY, 1969*Sollasites tardus* n. sp.

pl. III, figs. 2, 3

Diagnosis: A species of *Sollasites* with 22–26 elements in the proximal and distal shield and an elliptical ring connecting the arms of the central cross.

Description: The distal shield is composed of an outer cycle with 22–26 wedge-shaped elements which are dextrally imbricate; the sutures are inclined clockwise. The inner cycle slopes towards the central depression and is built of 22–26 tabular elements which are dextrally imbricate and with sutures that are inclined counterclockwise. The central depression is spanned by a cross aligned in the long and the short axis of the ellipse. The arms of the cross are connected with each other by an elliptical ring which lies in the middle of the central opening. The proximal shield consists of two cycles of segments, the outer cycle containing 22–26 wedge-shaped dextrally imbricate elements with radial suture lines. The inner cycle is only half as wide as the outer one and slopes towards the central depression. It has the same number of dextrally imbricate elements with sutures inclined counterclockwise.

Remarks: This is the only Tertiary species of the genus *Sollasites* which was thought to be restricted to the Upper Cretaceous. The general construction is so similar to other members of this genus that there is no need to create a new genus. *Sollasites lowei* (BUKRY) n. comb. [= *Costacentrum lowei* BUKRY, 1969, p. 44, pl. 22, figs. 5–6] has more numerous elements (32–36) and in proximal view the inner cycle of elements surrounding the central area is more clearly separated from the outer cycle of elements.

It is impossible that *Sollasites tardus* n. sp. was reworked from older strata because no other Cretaceous nannofossils were present in the samples where it was found.

Holotype: IMS-J 505427 [A 821].

Paratype: IMS-J 510471 [A 822].

Length: Holotype: 3.7 μ . Paratype: 4 μ .

Type locality: JOIDES Hole 5, Lat. 30° 23' N, Long. 81° 08' W, Blake Plateau.

Type level: Oligocene, 410' below top.

Distribution: JOIDES Hole 5 and Alabama: *E. subdisticha* Zone and *R. laevis* Zone. Trinidad and Glimmerode (Germany): *Sph. predistentus*–*Sph. distentus* Zone.

Genus *Reticulofenestra* HAY, MOHLER & WADE, 1966

Synonyms: *Dictyococcites* BLACK, 1967

Apertapetra HAY, MOHLER & WADE, 1966

Reticulofenestra alabamensis n. sp.

pl. III, figs. 4, 5

Diagnosis: A small species of *Reticulofenestra* with narrow slits along the outer margin of the central grille.

Description: The distal shield is composed of two cycles of elements. The outer cycle contains 35–40 tabular elements which are strongly dextrally imbricate. The suture lines are radial at the periphery and bend sharply counterclockwise towards the center. The inner cycle is built of sinistrally imbricate tabular elements which are continuous with the bars of the central grille. There are slits between the bars of the grille along the periphery. These bars join in the center and form a slightly elevated area with irregular perforations. The central area is about half as large as the whole coccolith. The proximal shield is only a little smaller than the distal shield and is constructed of 35–40 wedge-shaped segments which are sinistrally imbricate. About every other element extends inwards as one of the grid bars. The intercalated elements end at the margin of the central area and form a slit.

Remarks: This species is distinguished from *Reticulofenestra foveolata* (REINHARDT) by a relatively smaller central grille area and by having an outer cycle of narrow slits and some very small pores in the elevated central portion of the grille. The pores in *Reticulofenestra insignita* ROTH & HAY are more numerous and the grille is more clearly separated from the marginal elements.

Holotype: IMS-A 600360 [A 823].

Paratype: IMS-A 600257 [A 823].

Length: Holotype: 3.2 μ , Paratype: 3.2 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Base of Red Bluff Fm.

Distribution: From the *E.subdisticha* Zone through the *R.laevis* Zone in JOIDES Hole 5. Restricted to the *Cc.margaritae* Zone in JOIDES Hole 6 and on Barbados. From the *E.subdisticha* Zone into the *Cc.margaritae* Zone in Alabama and Helmsstedt (Latdorfian). Rare in the *Sph.predistentus*–*Sph.distentus* Zone of Trinidad.

Reticulofenestra bisecta (HAY, MOHLER & WADE) n.comb.

pl. III, fig. 6

- 1966 *Syracosphaera bisecta* HAY, MOHLER & WADE, p. 393, pl. 10, figs. 1–6.
 1967 *Coccolithus stavenis* LEVIN & JOERGER, p. 165, pl. 1, figs. 7a–d.
 1967 *Coccolithus bisectus* (HAY, MOHLER & WADE) BRAMLETTE & WILCOXON, p. 102, pl. 4, figs. 11–13.
 1968 *Reticulofenestra dictyoda* (DEFLANDRE & FERT) of STRADNER in STRADNER & EDWARDS, pp. 19–20 (pro parte), pl. 13, figs. 1–2, pl. 14, figs. 2–4 (non pl. 12, figs. 1–3, pl. 14, fig. 1).
 1968 *Stradnerius dictyodus* (DEFLANDRE & FERT) HAQ, pp. 31–32 (pro parte), pl. 2, figs. 7–8, pl. 3, figs. 1, 4–6 (non pl. 2, fig. 2, pl. 4, figs. 3–6).
 1968 *Cycloplacolithella simplex* HAQ, pp. 25–26 (pro parte), pl. 8, fig. 8 (non pl. 8, figs. 9–10).
 1969 *Dictyococcites dictyodus* (DEFLANDRE & FERT) MARTINI, pp. 133–134, pl. 1, fig. 5–6 (non pl. 4, fig. 35).

Remarks: Electron micrographs of the proximal side and etched specimens seen from the distal side prove that this species has a grille in the central hole, which is usually completely hidden below the plates covering the central area on the distal side, but visible in proximal view. The central opening as seen from the proximal side is small, about a third of the length of the whole coccolith. It is covered by a grille consisting of thick bars, each one being continuous with about every third shield element and meeting along the major axis of the ellipse.

Cycloplacolithella simplex HAQ is the isolated distal shield of *Reticulafenestra bisecta* with the plates which usually cover the center broken out. *Reticulafenestra bisecta* is similar to *Reticulofenestra hesslandii* (HAQ) but is distinguished from it by having more elements, regular crystal plates covering the central area, and by the smaller size of the coccolith.

Hypotypes: IMS-J 6–397–12–7 [A 825].

Distribution: From the upper Eocene through the Oligocene.

Reticulofenestra bisecta disappears close to the Oligocene-Miocene boundary and can be used to determine this boundary.

Reticulofenestra coenura (REINHARDT, 1966) n.comb.

- 1966 *Coccolithus coenurus* REINHARDT, p. 516–517, pl. 1, fig. 7, Text-fig. 6.
 1967 *Coccolithus coenurus* REINHARDT, p. 207, pl. 2, figs. 2, 6, pl. 5, fig. 7.
 1968 *Reticulofenestra dictyoda* (DEFLANDRE & FERT) of STRADNER in STRADNER & EDWARDS (pro parte), pl. 12, fig. 4 (non pl. 12, figs. 1–3, pl. 13, figs. 1–2, pl. 14, figs. 1–5).

Remarks: It is possible to distinguish the very similar species *Reticulofenestra coenura* (REINHARDT) from *Reticulofenestra umbilica* (LEVIN) which is larger, more broadly elliptical and has more elements in the shields.

Occurrence: Throughout the Oligocene except for the *Sphenolithus ciperoensis*–*Triquetrorhabdulus carinatus* Zone; more abundant in the lower Oligocene.

Reticulofenestra danica (BLACK) n. comb.

pl. IV, fig. 2

1967 *Dictyococcites danicus* BLACK, p. 141, fig. 2.

Remarks: Distal views of this species show clearly that it can be assigned to the genus *Reticulofenestra*. The central opening is surrounded by a cycle of imbricate wedge-shaped elements that can only be seen from the distal side. This is typical of the genus *Reticulofenestra*. The central area of *Reticulofenestra danica* is relatively larger than in *Reticulofenestra scissura* HAY, MOHLER & WADE and the grille bars are straighter, do not anastomose, and merge along the long axis of the ellipse whereas in *Reticulofenestra scissura* the grille bars are quite irregular, anastomosing to produce elongate perforations. *Reticulofenestra bisecta* (HAY, MOHLER & WADE) is considerably larger than *Reticulofenestra danica*.

Hypotype: IMS-J 512389 [A 826].

Occurrence: JOIDES Hole 5: From the *E. subdisticha* Zone into the *R. laevis* Zone. JOIDES Hole 6: *Cc. margaritae* Zone. Alabama: *E. subdisticha* Zone. Glimmerode, N Germany: *R. laevis* through *Sph. predistentus*–*Sph. distentus* Zone. German Rupel, Clay pit Alversdorf, near Helmstedt: *Cc. margaritae* Zone.

Reticulofenestra falcata (GARTNER & SMITH) n. comb.1967 *Coccolithus falcatus* GARTNER & SMITH, p. 3, pl. 1, figs. 5, 6.

Remarks: This species is rare from the Upper Eocene into the *Cyclococcolithus margaritae* Zone.

Reticulofenestra foveolata (REINHARDT) n. comb.1966 *Coccolithus foveolatus* REINHARDT, p. 517, pl. 1, fig. 10.1967 *Coccolithus foveolatus* REINHARDT, p. 208, pl. 5, figs. 6–9.1969 *Reticulofenestra insignita* ROTH & HAY of MARTINI, pp. 135–136 (pro parte), pl. 4, fig. 41 (non pl. 2, figs. 15–16).

Remarks: This species differs from *Reticulofenestra insignita* ROTH & HAY in being smaller, in having a narrower rim with fewer elements and fewer and more elongate pores in the relatively larger central grille. *Reticulofenestra foveolata* is common from the upper Eocene into the *Cyclococcolithus margaritae* Zone whereas *Reticulofenestra insignita* first occurs in the uppermost part of the *Cyclococcolithus margaritae* Zone and ranges into the upper Oligocene.

Reticulofenestra gabriellae n. sp.

pl. IV, fig. 1

Diagnosis: A very small species of *Reticulofenestra* with relatively large central grille with about 50 round pores.

Description: The coccosphere seems to consist of about 20 coccoliths. The distal shields is composed of 18–22 wedge-shaped segment which are imbricate dextrally and separated by radial suture lines, which are not always straight but may be jagged. The central area is covered with a grille with about 50 perforations arranged in regular order more or less parallel to the ellipse. Proximal views are not known yet.

Remarks: As in *Reticulofenestra inclinata* n. sp. the wedges around the central grille are absent. It might be possible to create a new genus for these species but too much splitting does not seem advisable at the present time. All the species having a central grille consisting of bars are considered to belong to the genus *Reticulofenestra* whether they have a cycle of wedges surrounding the central hole or not. This species differs from *Reticulofenestra foveolata* (REINHARDT) in being smaller, and in having fewer elements but more small circular perforations.

Holotype: IMS-A 613010 [A 827].

Diameter of Coccosphere: 5 μ .

Length of Coccolith: 1.8 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm., 13' above base. Oligocene.

Distribution: JOIDES Hole 5: *E. subdisticha* Zone to lower *Cc. margaritae* Zone. Alabama: Upper *E. subdisticha* Zone.

Reticulofenestra hesslandii (HAQ) n. comb.

pl. IV, figs. 3–5

1966 *Ericsonia hesslandii* HAQ, pp. 32–33, pl. 1, fig. 6, pl. 3, fig. 1, pl. 4, fig. 3, pl. 5, figs. 3, 5.

?1969 *Dictyococcites dictyodus* (DEFLANDRE & FERT) MARTINI, pp. 133–134 (pro parte), pl. 4, fig. 7 (non pl. 1, figs. 5–6).

Remarks: This species displays a great variability in shape, size and number of elements. It is distinguished from *Cyclococcolithus floridanus* (ROTH & HAY) by having a coarse central grille, which can be seen in etched specimen and proximal views, and by the less broadly elliptical shape. The proximal shield consists of about 60 elements. The central depression, about one-fifth the size of the whole shield, is covered with a grille consisting of irregular twisted bars.

Hypotypes: IMS-A 815110 [A 828]; IMS-A 600407 [A 829]; IMS-A 600470 [A 830].

Distribution: This species is one of the most abundant coccoliths in all the Oligocene sections studied so far and is found throughout the whole interval.

Reticulofenestra inclinata n. sp.

pl. V, fig. 2

Diagnosis: A species of *Reticulofenestra* consisting of a distal shield with chevron-shaped elements and a central grille with nearly straight bars and long intermediate slits.

Description: The narrowly elliptical shield consists of 34–40 tabular elements which are dextrally imbricate and form a chevron pattern. The suture lines are inclined counterclockwise in the outer half of the shield and turn sharply clockwise in the inner half of the shield. The central area, about two-thirds the size of the coccolith, is covered with a grill with straight bars which are continuous with elements of the shield and meet in the long axis of the ellipse. There are long wide slits between the bars.

Remarks: This species does not have the cycle of wedges around the central opening, which can be found in many other species of *Reticulofenestra*. *Reticulofenestra danica* (BLACK) does not have strongly bent suture lines causing a chevron-pattern.

Holotype: IMS-J 503480 [A 831].

Length: 3.8 μ .

Type locality: JOIDES Hole 5, Lat. 31° 23' N, Long. 80° 08' W, Blake Plateau.

Type level: 484' below top, Oligocene.

Distribution: JOIDES Hole 5; Upper part of the *Cc. margaritae* Zone and *R. laevis* Zone.

Reticulofenestra laevis ROTH & HAY

pl. V, fig. 5

1969 *Reticulofenestra laevis* ROTH & HAY, HAY et al., p. 449, pl. 7, fig. 11.

Remarks: Only the proximal side was described in HAY & al., 1967. The distal shield consists of an outer cycle of 60–80 dextrally imbricate elements (not 140 elements as stated by ROTH & HAY, which was based on observation of etched and somewhat recrystallized specimens). The margin of the shield is finely serrate and creates the impression that the shield contains more shield elements than it does. The suture lines are inclined counterclockwise. The inner cycle of elements is composed of the same number of sinistrally imbricate plates which form a distinctly raised ring around the central opening.

Hypotype: IMS-A 100280 [A 832].

Distribution: *Reticulofenestra laevis* Zone to the middle of the *Sphenolithus distentus*–*Sphenolithus ciperoensis* Zone in Oligocene sections on both sides of the Atlantic.

Reticulofenestra minuta n. sp.

pl. V, figs. 3, 4

Diagnosis: A very small species of *Reticulofenestra* with 10–15 pores in the central grille.

Description: The distal shield is constructed of two cycles of elements. The outer one consists of 16–26 wedge-shaped elements which are dextrally imbricate. The sutures are inclined clockwise. The inner cycle contains the same number of dextrally imbricate plates separated by clockwise inclined suture lines. The margin of the inner cycle is serrate. The central depression, about one third the size of the coccolith is covered by a coarse grille with twisted bars. The proximal shield is of nearly the same size as the distal shield. It consists of 16–26 wedge-shaped elements with curved suture lines which are inclined counterclockwise.

Remarks: *Reticulofenestra foveolata* (REINHARDT) has a larger central area and more numerous pores.

Holotype: IMS-A 610130 [A 833].

Paratype: IMS-J 504136 [A 834].

Length: Holotype: 1.5 μ , Paratype: 2.0 μ .

Type locality: The Lone Star Cement Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm., 10' above base. Oligocene.

Distribution: JOIDES Hole 5 and Alabama: *E. subdisticha* Zone through *R. laevis* Zone. Trinidad: *Sph. predistentus*–*Sph. distentus* Zone.

Reticulofenestra pectinata n. sp.

pl. V, fig. 1

Diagnosis: A small species of *Reticulofenestra* with a wide central opening, covered with a coarse grille.

Description: The distal shield is constructed of two cycles of elements; the outer one has 50–60 wedge-shaped dextrally imbricate elements. The suture lines are inclined clockwise. The margin of the shield is serrate. An inner cycle of 40–50 wedge-shaped sinistrally imbricate elements forms an elevated ring around the central depression. About every other element is continuous with a grid bar of the central grille. There are long slits between bars. The length of the central opening amounts to about two thirds of the length of the whole coccolith.

Remarks: *Reticulofenestra pectinata* n.sp. is distinguished from *Reticulofenestra alabamensis* n.sp. by a relatively larger central opening and more numerous elements in the shield. *Reticulofenestra insignita* ROTH & HAY is smoother and has a smaller central grille area with smaller, more regularly arranged pores.

Holotype: IMS-A 613664 [A 835].

Length: 3.5 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm., 13' above base. Oligocene.

Distribution: From the *E. subdisticha* Zone through the *R. laevis* Zone of JOIDES Hole 5, 6, of Alabama, Clay pit. Alversdorf (Rupelton); Glimmerode, both N Germany.

Reticulofenestra scissura HAY, MOHLER & WADE, 1966

1966 *Reticulofenestra scissura* HAY, MOHLER & WADE, p. 387, pl. 5, figs. 1–6.

1968 *Reticulofenestra dictyoda* (DEFLANDRE & FERT) of STRADNER in STRADNER & EDWARDS, pp. 19–20 (pro parte), pl. 12, figs. 1–3, pl. 14, fig. 1 (non pl. 12, fig. 4, pl. 13, figs. 1–2, pl. 14, figs. 2–4).

1969 *Stradnerius dictyodus* (DEFLANDRE & FERT) HAQ, pp. 31–32 (pro parte), pl. 2, figs. 5–6, pl. 3, fig. 2, pl. 4, figs. 3, 6 (non pl. 2, figs. 7–8, pl. 3, figs. 1, 4–6).

?1969 *Reticulofenestra* cf. *insignita* ROTH & HAY of MARTINI, pl. 2, figs. 15–16.

Remarks: The author does not follow the opinions of STRADNER (1968) and HAQ (1968) who lumped many species of *Reticulofenestra* into the species *Reticulofenestra dictyoda* (DEFLANDRE & FERT). *Reticulofenestra scissura* is a distinct species and differs from the lectotype of *Reticulofenestra dictyoda* (DEFLANDRE & FERT) as selected by HAY, MOHLER & WADE, 1966, in having a more narrowly elliptical shape and a relatively larger central grille which is often not as well separated from the marginal elements as in *Reticulofenestra dictyoda* (DEFLANDRE & FERT). *Reticulofenestra dictyoda* (DEFLANDRE & FERT) of STRADNER (1968) and *Stradnerius dictyodus* (DEFLANDRE & FERT) of HAQ (1968) do not correspond with the lectotype of *Reticulofenestra dictyoda* (DEFLANDRE & FERT) (= specimen from Donzacq, DEFLANDRE &

FERT, 1954, Text-fig. 15). Therefore they must be assigned partly to *Reticulofenestra scissura* and partly to *Reticulofenestra bisecta* (HAY, MOHLER & WADE). *Reticulofenestra scissura* is similar to *Reticulofenestra bisecta* (HAY, MOHLER & WADE) but it is distinguished by its wider grille when seen from the proximal side and by its somewhat smaller size. Well preserved specimens of both species show a cover of plates over the central opening but the central area is relatively larger in *Reticulofenestra scissura*. This species is abundant from the Upper Eocene through the Middle Oligocene of many sections on both sides of the Atlantic.

Reticulofenestra umbilica (LEVIN) MARTINI & RITZKOWSKI, 1968

- 1965 *Coccolithus umbilicus* LEVIN, p. 265, pl. 41, fig. 2.
 1966 *Reticulofenestra caucasica* HAY, MOHLER & WADE, pp. 386–387 (pro parte), pl. 2, fig. 5, pl. 3, figs. 1–2, pl. 4, figs. 1–2 (non pl. 2, figs. 6–8).
 1966 *Apertapetra samodurovi* HAY, MOHLER & WADE, p. 387 (pro parte), pl. 6, figs. 1–3 (non pl. 6, figs. 4–7).
 1967 *Coccolithus pelycomorphus* REINHARDT, p. 515, pl. 1, figs. 2, 6.
 1968 *Reticulofenestra placomorpha* (KAMPTNER), STRADNER in STRADNER & EDWARDS, pp. 22–24 (pro parte), pl. 19, figs. 1–2, pl. 20, figs. 1–2, pl. 21, figs. 1–2, pl. 22, figs. 1–4, pl. 23, figs. 1–2, pl. 24, figs. 1–4, pl. 25, figs. 1a, 2 (non pl. 25, fig. 1b).
 1968 *Discolithina cuvillieri* LÉZAUD, p. 22, pl. 2, figs. 1–4.
 1968 *Reticulofenestra umbilica* (LEVIN) MARTINI & RITZKOWSKI, p. 245, pl. 1, figs. 11–12.
 1969 *Reticulofenestra umbilica* (LEVIN) of MARTINI, pp. 137–138.

Remarks: STRADNER in STRADNER & EDWARDS (1968) gives a thorough description of this species but the author does not agree with his synonymy because he included too many species which can easily be distinguished and because it is not possible to prove that *Reticulofenestra umbilica* is identical with *Tremalithus placomorpha* KAMPTNER of which only a schematic drawing exists (see MARTINI, 1969). *Reticulofenestra bisecta* HAY, MOHLER & WADE is somewhat smaller, has a more elliptical grille made of stout bars and on the distal side the central area covered with plates is relatively smaller. Its range is also longer, i.e. into the *Triquetrorhabdulus carinatus*–*Sphenolithus belemnus* Zone, whereas *Reticulofenestra umbilica* disappears at the top of the *R. laevis* Zone. *Reticulofenestra coenura* (REINHARDT) is smaller and the pores in the central grille are more circular than in the elongate slits in *Reticulofenestra umbilica*. *Reticulofenestra samodurovi* (HAY, MOHLER & WADE) n.comb. [= *Apertapetra samodurovi* HAY, MOHLER & WADE, 1966, p. 387, pl. 6, figs. 4–7 (non pl. 6, figs. 1–3)] differs from *Reticulofenestra umbilica* in being smaller, having a relatively smaller central opening and having two shields of approximately the same size. *Reticulofenestra umbilica* can have a cover of plates over the central opening on the distal side which is typical for many species of the genus *Reticulofenestra*. The disappearance of *Reticulofenestra umbilica* is a good marker horizon to separate the middle from the upper Oligocene. It is abundant from the upper Eocene through the middle Oligocene.

Genus *Cyclococcolithus* KAMPTNER, 1954

pl. VI, figs. 1, 2

Cyclococcolithus arabellus n. sp.

Diagnosis: A small species of *Cyclococcolithus* consisting of 3 cycles of elements in the distal shield.

Description: The circular distal shield is constructed of an outer cycle with 42–46 narrow wedge-shaped elements which are dextrally imbricate and separated by sutures with a clockwise inclination on the inner third of the shield and a radial direction on the outer part of the shield. The middle cycle which surrounds a shallow central depression is built of strongly dextrally imbricate plates which are separated by radial suture lines. The central depression, about a third the size of the whole coccolith, is covered with a cycle of narrow tabular elements, sinistrally imbricate and with clockwise inclined sutures. The center can be pierced by a small hole less than one-tenth the diameter of the whole shield or it can be filled in completely. The proximal shield is of nearly the same size as the distal shield, which can be seen on distal views where the proximal side can be seen through the replica. Proximal views of this species are not known yet.

Remarks: The species differs from *Cyclococcolithus acclinis* LEVIN & JOERGER in being much smaller and in having a relatively smaller central opening. *Cyclococcolithus formosus* KAMPTNER has straight radial sutures, only two cycles in the distal shield, and is much larger.

Holotype: IMS-A 613443 [A 836].

Paratype: IMS-J 507364 [A 837].

Diameter: Holotype 3.6 μ , Paratype: 3.6 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm. 13' above base.

Distribution: From the *E.subdisticha* Zone into the *Cc.margaritae* in JOIDES Hole 5 and in Alabama.

Cyclococcolithus ciperensis n. sp.

pl. VI, figs. 3, 6

Diagnosis: A small species of *Cyclococcolithus* with 2 cycles of elements in the distal shield and a coarse central grille.

Description: The distal shield is composed of an outer cycle of 20–30 wedge-shaped elements which are dextrally imbricate, separated by curved suture lines, clockwise inclined near the center and counterclockwise inclined periphally. The inner cycle is built of 20–30 sinistrally imbricate narrow tabular crystals. The sutures are inclined strongly counterclockwise. The central opening as seen from the distal side is about a third the size of the coccolith. The proximal shield consists of 20–30 wedge-shaped segments, sinistrally imbricate, with suture lines inclined counterclockwise. An inner cycle contains about 20 granules which do not overlap each other but are separated by radial to slightly counterclockwise inclined suture lines. The central opening, about half the size of the distal shield if seen from the proximal side, is partly obstructed by bars forming a coarse grille. They are continuous with elements of the inner cycle.

Remarks: This species is distinguished from *Cyclococcolithus margaritae* ROTH & HAY by the greater number of elements, by the curved sutures on the distal shield, the flatter appearance of the whole coccolith, and the central grille. *Cyclococcolithus kingi* n.sp. is much larger and has a relatively larger central opening that can be covered

completely by polygonal plates. In the center of *Cyclococcolithus ciproensis* n.sp. there are only few thick bars separated by wide gaps.

Holotype: ETH – 291A–399 [A 838].

Paratype: ETH – 291A–510 [A 839].

Diameter: Holotype: 2.9 μ , Paratype: 2.75 μ .

Type locality: Cipro coast, Trinidad, Type locality of the *Gg. ciproensis* Zone of BOLLI, 1957.

Type level: Cipro Fm. *Gg. ciproensis* Zone.

Distribution: Only found in Trinidad from the *Sph. distentus*–*Sph. ciproensis* Zone through the *Triquetrorh. carinatus*–*Sph. belemnus* Zone.

Cyclococcolithus floridanus (ROTH & HAY) n. comb.

pl. V, fig. 6

1967 *Coccolithus floridanus* ROTH & HAY in HAY et al., 1967, p. 445, pl. 6, figs. 1–4.

1967 *Cyclococcolithus neogammation* BRAMLETTE & WILCOXON, 1967, p. 104, pl. 1, figs. 1–3, pl. 4 figs. 3–5.

Remarks: A well preserved specimen seen from the distal side shows two cycles of elements covering the central depression. The outer cycle consists of strong dextrally imbricate tabular elements, the inner cycle of stout blocks of irregular shape. Typical of *Cyclococcolithus floridanus* is the nonobstructed central opening when seen from the proximal side. The type of *Cyclococcolithus neogammation* BRAMLETTE & WILCOXON is a specimen illustrated in a light micrograph and no count of the elements is possible. However, the paratype illustrated in an electron micrograph by BRAMLETTE & WILCOXON (1967) is definitely the same as *Cyclococcolithus floridanus* which has priority as it was published a few weeks before *Cyclococcolithus neogammation*.

Hypotype: IMS J 3–397–12–11 [A 840].

Distribution: Throughout the upper Eocene to Oligocene in all the sections studied.

Cyclococcolithus formosus KAMPTNER

1963 *Cyclococcolithus formosus* KAMPTNER, p. 163, pl. 2, fig. 8.

1964 *Coccolithus lusitanicus* BLACK, p. 308, pl. 50, figs. 1–2.

1966 *Cyclococcolithus lusitanicus* (BLACK), HAY, MOHLER & WADE, p. 390, pl. 7, figs. 3–6.

1967 *Cyclococcolithus orbis* GARTNER & SMITH, p. 4, pl. 4, figs. 1–3.

1968 *Umbilicosphaera formosa* (KAMPTNER) REINHARDT in COHEN & REINHARDT, p. 295.

Remarks: The specimens observed agree well with the published descriptions and illustrations. *Cyclococcolithus formosus* disappears in the lowermost part of the *Cyclococcolithus margaritae* Zone in all the sections studied by the author and not in the upper part of the *Ericsonia subdisticha* Zone as mentioned by MARTINI (1969). The disappearance of the species forms a good marker horizon (datum level) which can be found worldwide. It separates the lower from the middle Oligocene.

Cyclococcolithus lunulus n. sp.

pl. VI, fig. 4

Diagnosis: A large species of *Cyclococcolithus* with a small central opening and 32–25 elements.

Description: The distal shield is very smooth and is composed of 32–25 wedge-shaped elements which are dextrally imbricate. The suture lines are radial near the central hole and turn sharply counterclockwise and maintain the same inclination over the rest of the shield. The shield is flat and slopes from the center towards the periphery. Proximal views are not yet known.

Remarks: This species is distinguished from *Cyclococcolithus inversus* (DEFLANDRE) in having sutures inclined in the opposite direction. *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN) has a convex distal shield with more curved lines.

Holotype: IMS-J 518099 [A 841].

Diameter: 10 μ .

Type locality: JOIDES Hole 5, lat. 30° 23' N, Long. 80° 08' W, Blake Plateau.

Type level: 460' 5 $\frac{1}{2}$ " below top, Oligocene.

Distribution: *Cc. margaritae* and *R. laevis* Zones of JOIDES Hole 5, *Cc. margaritae* Zone of JOIDES Hole 6 and Barbados.

Cyclococcolithus kingi n. sp.

pl. 6, fig. 5, pl. 7, fig. 1

Diagnosis: A species of *Cyclococcolithus* with a very wide central area.

Description: The distal shield consists of two cycles of elements, an outer with about 50 tabular elements dextrally imbricate and separated by suture lines inclined counterclockwise near the center, spiraling clockwise peripherally. The inner cycle is constructed of 40–50 tabular segments which show a strong dextral imbrication. The sutures are inclined clockwise near the opening, bend sharply counterclockwise in the outer two thirds of the cycle. The central area is about half the size of the whole coccolith. The proximal and distal shields are composed of the same number of wedge-shaped segments. The sutures are inclined counterclockwise near the center and turn radially on the peripheral portion of the proximal shield. The central area is plugged by polygonal shaped plates arranged in an irregular manner; these seem to be delicate because they tend to break out and leave a big central hole that is more commonly observed in this species than the plugged center.

Remarks: This species differs from *Cyclococcolithus inversus* (DEFLANDRE) in having considerably larger central area and more strongly curved sutures.

Holotype: IMS-A 815022 [A 842].

Paratype: IMS-A 606025 [A 843].

Diameter: Holotype: 6 μ , Paratype: 5 μ .

Type locality: The Lone Star Cement Company Quarry St. Stephens, Alabama.

Type level: Marianna Lst., 15' above base.

Distribution: From the *E. subdisticha* Zone through the *R. laevis* Zone in JOIDES Hole 5 and in Alabama, in the *Cc. margaritae* Zone of JOIDES Hole 6 and in the *Sph. predistentus*–*Sph. distentus* Zone of Trinidad.

Genus *Iselithina* STRADNER, 1966Synonym: *Hayella* ROTH, 1969 (non *Hayella* GARTNER, 1969)*Iselithina fusa* n. sp.

pl. VII, figs. 2, 3

Diagnosis: A species of *Iselithina* having a distal shield with T-shaped elements and a proximal shield with overlapping tabular elements.

Description: The circular distal shield consists of 6–10 T-shaped elements with short cross pieces. It is delicate and usually damaged. The proximal shield is conical and opens towards the proximal side. It is composed of 10–15 tabular elements which are imbricate dextrally. The overlapping flange is distinctly raised on the distal side of the proximal shield as is the peripheral margin of the segment. The segments are thus interlocked like the tiles on a roof. These ridges merge in the center and form a central core which is pierced by a hole. The sutures on the proximal side of the proximal shield are straight and radial but twisted near the center.

Remarks: This species is distinguished from *Iselithina iris* STRADNER by the lack of slots in the proximal shield and by the longer and more slender elements in the distal shield. It is also somewhat larger.

Holotype: IMS-A 608 372 [A 844].

Paratype: IMS-A 600 162 [A 845].

Diameter: Holotype: 2.4 μ , Paratype: 3 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm., 8 above base, Oligocene.

Distribution: From the *E. subdisticha* Zone through the *Cc. margaritae* Zone in JOIDES Hole 5, in the *Cc. margaritae* Zone in JOIDES Hole 6 and on Barbados. From the *E. subdisticha* Zone through the *R. laevis* Zone in Alabama. *E. subdisticha* Zone in the Silberberg beds, Helmstedt. *Cc. margaritae* Zone, Clay pit Alversdorf, near Helmstedt. *R. laevis* Zone into *Sph. predistentus*–*Sph. distentus* Zone Boom Clay, Belgium. *R. laevis* Zone, Kasseler Meeressande, Glimmerode.

Iselithina iris STRADNER, 1966

1966 *Iselithina iris* STRADNER in STRADNER & ADAMIKE, p. 339, Text-fig. 3a–d, pl. 3, fig. 5.

1968 *Iselithina iris* STRADNER in STRADNER & EDWARDS, pl. 26–28, Text-fig. 3, pl. 28, figs. 1–6, pl. 29, figs. 1–6.

1969 *Hayella elegans* ROTH, p. 464, pl. 1, figs. 1–2.

Remarks: STRADNER (1968) has given a very thorough description of this species. It is common in the Upper Eocene and rare in the Middle Oligocene. It can be easily overlooked in the light microscope because it is small and lacks distinct features.

Genus *Coronocyclus* HAY, MOHLER & WADE, 1966*Coronocyclus serratus* HAY, MOHLER & WADE

pl. VII, fig. 4

1966 *Coronocyclus serratus* HAY, MOHLER & WADE, p. 194, pl. 11, figs. 1–5.

Remarks: A well preserved specimen of this species shows that it actually consists of two superimposed cycles of elements. The upper ring is composed of 29 wedge-

shaped elements which are imbricate dextrally. The lower cycle is built of about the same number of tabular elements, but these are sinistrally imbricate. As can be seen in the electron micrograph of a proximal side of this species there is an inner cycle of dextrally imbricate elongated crystal cubes. The specimens figured by HAY, MOHLER & WADE are corroded and misleading because the structure could not be determined exactly.

Hypotype: IMS J 3-4 22-20-11 [A 846].

Distribution: Throughout the Oligocene. Rare in most sections.

Family Rhabdosphaeraceae LEMMERMANN, 1908

Genus *Rhabdosphaera* HAECKEL, 1894

Rabdosphaera vitrea (DEFLANDRE)

pl. VIII, fig. 6, pl. IX, fig. 1

1954 *Rhabdolithus vitreus* DEFLANDRE in DEFLANDRE & FERT, p. 157-158, pl. 12, figs. 28-29, Text-figs. 83-84.

1961 *Rhabdosphaera vitrea* (DEFLANDRE) BRAMLETTE & SULLIVAN, p. 147, pl. 5, figs. 16-17.

Non 1963 *Rhabdosphaera vitrea* (DEFLANDRE) of HAY & TOWE, p. 952-953, pl. 1, fig. 1.

Remarks: The form figured by HAY & TOWE 1963 is considered to belong to *Blackites creber* (DEFLANDRE) n. comb. [= *Rhabdolithus creber* DEFLANDRE in DEFLANDRE & FERT, p. 157, pl. 12, figs. 31-33, Text-figs. 81, 82]. The basal disc consists of a whirl of laths which are curved in a clockwise direction if seen from the proximal side. The slender stem is supported by four buttresses which are attached to the side of short bases. In the light microscope the thick basal pillar with the struts attached to the side gives the impression of a protruding ring and a short tapering ring above. The structure of this species is quite different from the species of *Blackites*.

Hypotypes: IMS-A 600 269 [A 847], IMS-A 608 189 [A 848].

Distribution: *E. subdisticha* Zone and *Cc. margaritae* Zone of JOIDES Hole 5, Alabama; *R. laevis* Zone, Glimmerode, N Germany.

Genus *Blackites* HAY & TOWE, 1962

Blackites amplus ROTH & HAY

pl. VII, fig. 6

1969 *Blackites amplus* ROTH & HAY in HAY et al., p. 445, pl. 7, fig. 10.

Remarks: Only the proximal view was described by ROTH & HAY, 1967. The distal view shows four distinct cycles. The outermost consists of radial trapezoidal elements. The second cycle contains strongly sinistrally imbricate plates showing clockwise inclined sutures that overlap the struts connecting these two outermost cycles forming a serrate margin. The third cycle consists of clockwise imbricate elements that end below the outer margin of the forth cycle. This innermost cycle consists of approximately 20 crystals and forms a collar for the circular opening (base of the spine). *Blackites spinosus* (DEFLANDRE) has a narrower third cycle (counted from the periphery).

Hypotype: IMS-J 503 189 [A 849].

Distribution: From the *E.subdisticha* through the *Sph.distentus*–*Sph.ciperoensis* Zone in nearly all the Oligocene sections studied. *Blackites amplus* is a delicate species readily destroyed by recrystallization.

Blackites incompertus n. sp.

pl. VII, fig. 5, pl. VIII, figs. 1, 2

Diagnosis: A species of *Blackites* with a conical disc which is well separated from the stem.

Description: The basal disc as seen from the proximal side consists of an outer cycle of about 24 trapezoidal elements. The next inner cycle is composed of 50–60 strongly sinistrally imbricate plates separated by sutures which are inclined clockwise in the outer third and turn strongly counterclockwise in the inner part. They are continuous with laths building the stem. A third cycle surrounding the base of the stem and consisting of square crystals can only be seen in side view. The basal plate is clearly separated from the stem and the disc is conical. The stem thickens slightly in the lower third and then tapers regularly to form a sharp point.

Remarks: *Blackites incompertus* n. sp. differs from *Blackites creber* (DEFLANDRE) in having a flatter basal disc and in lacking a distinct collar at the base of the stem. *Blackites scabrosus* (DEFLANDRE) n. comb. has a smaller disc that protrudes only a little at the base of the fairly thick stem. *Rhabdosphaera perlonga* (DEFLANDRE) has a blunt rounded termination of the stem which is much thicker in the top third than near the base.

Holotype: IMS-A 610358 [A 850].

Paratypes: IMS-A 610105 [A 851]; IMS 610266 [A 852].

Length of the stem of holotype: 13 μ .

Diameter of disc of holotype: 3 μ .

Distribution: *E.subdisticha* Zone of Alabama. *Cc.margaritae* Zone through *R.laevis* Zone in JOIDES Hole 5. *E.subdisticha* Zone Pit Treue IV, near Helmstedt.

Blackites scabrosus (DEFLANDRE) n. comb.

1954 *Rhabdolithus scabrosus* DEFLANDRE in DEFLANDRE & FERT, p. 158, pl. 12, fig. 30, Text-fig. 85.

1961 *Rhabdosphaera scabrosa* (DEFLANDRE) BRAMLETTE & SULLIVAN, p. 147, pl. 5, figs. 11a–b.

1967 *Rhabdosphaera scabrosa* (DEFLANDRE) REINHARDT, p. 215, pl. 4, fig. 23, pl. 7, fig. 2.

Remarks: The electron micrograph published by REINHARDT (1967) proves that this species must be assigned to the genus *Blackites* since the basal disc contains several cycles of elements.

Distribution: Rare in the Silberberg formation near Helmstedt (Oligocene); found by LEVIN & JOERGER in the Oligocene of Alabama.

Blackites spinulus (LEVIN) n. comb.

pl. VIII, fig. 4

1965 *Rhabdosphaera spinula* LEVIN, p. 267, pl. 42, fig. 3.

1967 *Rhabdosphaera spinula* LEVIN, GARTNER & SMITH, p. 5, pl. 1, figs. 1–2a, b.

Remarks: Most specimens observed agree well with the original description and the electron micrographs given by GARTNER & SMITH (1967). The basal disc consists of three cycles of elements. Thus, this species is assigned to the genus *Blackites*. Some specimens like the one illustrated here have a larger base and a more conical trumpet-shaped stem which is thickest at the base and tapers uniformly.

Hypotype: IMS-A 600271 [A 853].

Distribution: From the *E.subdisticha* Zone into the *Cc.margaritae* Zone in Alabama, in JOIDES Hole 5; Silberberg Fm. near Helmstedt.

Genus *Bramletteius* GARTNER, 1969

Bramletteius variabilis n. sp.

pl. VIII, figs. 3, 5

Diagnosis: A species of *Bramletteius* with a symmetrical square or rounded appendage.

Description: The basal disc consists of two cycles with about 15–20 segments each, separated by a V-shaped groove. The flat appendage attached to the distal side of the disc is narrowest in the lowest part. It is symmetrical and either of rounded, oblong, or rectangular shape.

Remarks: *Bramletteius variabilis* n. sp. is distinguished from *Bramletteius serraculoides* GARTNER by the symmetrical shape of the flat appendage, which has rounded or angular corners but not beveled or notched corners.

Holotype: IMS-A 608432 [A 854].

Paratype: IMS-A 608420 [A 855].

Length of appendage of the holotype: 2.3 μ .

Length of appendage of the paratype: 2.8 μ .

Type locality: St. Stephens Quarry, Alabama.

Type level: Red Bluff Fm. 8' above base.

Distribution: Only observed in the *E.subdisticha* Zone of Alabama.

Family Pontosphaeraceae LEMMERMAN, 1908

Genus *Pontosphaera* LOHMANN, 1902

Synonym: *Discolithina* LOEBLICH & TAPPAN, 1963

Pontosphaera alta n. sp.

pl. IX, figs. 2, 3

Diagnosis: A species of *Pontosphaera* with a high straight rim and 60–80 perforations.

Description: The rim consists of about 200 steeply inclined laths. The inclination is clockwise in proximal view. The rim seems to be about one third to half as high as the shield is long. The bottom of the lopadolith is concave when seen from the proximal side, and is composed of about 200 wedge-shaped laths. Only every second lath reaches the center. The 60–80 perforations, about 0.1 μ in diameter are arranged in an ellipse around the periphery and more or less radially in the center.

Remarks: This species is distinguished from *Pontosphaera multipora* (KAMPTNER) (= *Pontosphaera vadosa* HAY, MOHLER & WADE of authors) by a much higher rim. *Pontosphaera discopora* SCHILLER is very similar but the pores are short conical tubular protrusions on the distal side. In *Pontosphaera alta* n.sp. the pores are not surrounded by craterlike depressions and they are relatively smaller.

Holotype: IMS-A 613 138 [A 856].

Paratype: IMS-A 613 386 [A 857].

Length: Holotype: 10 μ , Paratype: 12 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm. 13' above base. Oligocene.

Distribution: *E.subdisticha* Zone through *R.laevis* Zone. JOIDES Hole 6: *Cc. margaritae* Zone Alabama: From the *E.subdisticha* Zone into the *Cc.margaritae* Zone.

Pontosphaera crucifera n.sp.³⁾

pl. IX, figs. 4, 5

Diagnosis: A narrowly elliptical small species of *Pontosphaera* with a cross structure in the central opening and short stubs protruding into it.

Description: The rim is rather low and consists of about 44–50 laths which are inclined clockwise as seen from the proximal side. The bottom of the shield is composed of an outer cycle of about 40–50 granules and an inner cycle of about 30–40 wedge-shaped plates about half of which are continuous with short stubs that project into the central slots. The cross in the center displays a broad arm in the long axis of the ellipse and a less pronounced one in the short axis. On the distal side only a narrow cycle of strongly dextrally inclined laths surrounds the central depression with the cross and the indentations.

Remarks: This species differs from *Transversopontis zigzag* ROTH & HAY in having bridges in the axis of the ellipse, and in being smaller. *Transversopontis zigzag* has a more or less diagonal bridge.

Holotype: IMS-A 613 652 [A 858].

Paratype: IMS-A 613 643 [A 859].

Length: Holotype: 3.5 μ , Paratype: 2.5 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff, Fm. 13' above base. Oligocene.

Distribution: JOIDES Hole 5: From the *E.subdisticha* Zone into the *R.laevis* Zone. Alabama: *E.subdisticha* Zone.

Pontosphaera multipora (KAMPTNER) n. comb.⁴⁾

1948 *Discolithus multiporus* KAMPTNER, p. 5, pl. 1, fig. 9.

1965 *Discolithina multipora* (KAMPTNER ex DEFLANDRE) MARTINI in WHITTARD & BRADSHAW, p. 400.

1966 *Discolithina confossa* HAY, MOHLER & WADE, p. 392, pl. 9, figs. 1–9.

1966 *Pontosphaera vadosa* HAY, MOHLER & WADE, p. 391, pl. 9, fig. 4 (non pl. 8, figs. 1–3).

1967 *Discolithina distincta* (BRAMLETTE & SULLIVAN) LEVIN & JOERGER, p. 166, pl. 1, figs. 14–15.

1968 *Discolithina multipora* (KAMPTNER) of STRADNER & EDWARDS, pp. 35–37, pl. 32–35, Text-figs. 7a–b.

³⁾ On charts listed as *Discolithina crucifera*

⁴⁾ On charts listed as *Discolithina multipora*

Remarks: STRADNER in STRADNER & EDWARDS (1968) gives a very thorough description and a complete synonymy. The Oligocene forms agree well with the description.

Distribution: Throughout the Oligocene in all the studied sections.

Pontosphaera rigida n. sp.⁵⁾

pl. IX, fig. 6, pl. X, fig. 1

Diagnosis: A small species of *Pontosphaera* with 50–60 pores and an elevated central ridge on the distal side.

Description: From the distal side the rim is seen to contain very numerous spirally arranged laths. There are 12–14 notches in the peripheral part of the rim. 50–60 pores are arranged in ellipses around the central ridge in the long axis of the shield ellipse. It consists of parallel laths and is about as high as the rim. In proximal view one can see that a layer of about 60 steeply inclined laths with a clockwise inclination covers the rim. The central area is composed of 50–65 wedge-shaped elements with radial sutures. The round pores lie in a central area which is only about half as long as the whole shield.

Remarks: This species differs from *Pontosphaera multipora* (KAMPTNER) in having a central ridge and in the much smaller pores.

Holotype: IMS-JS 1847 445 [A 860].

Paratype: IMS-JS 1847 576 [A 861].

Length: Holotype: 3.0 μ , Paratype: 3.4 μ .

Type locality: Ciperó Coast Trinidad, W.I.

Type level: Ciperó Fm. *Gg. ampliapertura* Zone.

Distribution: Trinidad: *Sph. predistentus*–*Sph. distentus* Zone.

Genus *Transversopontis* HAY, MOHLER & WADE, 1966

Transversopontis rectipons (HAQ) n. comb.

1968 *Discolithina rectipons* HAQ, p. 39–40, pl. 7, figs. 7–9, pl. 11, fig. 1.

Remarks: This species agrees well with the original description. In the form observed in the Oligocene the two openings separated by the bridge tend to be somewhat smaller.

Distribution: Lower part of the *E. subdisticha* Zone, Alabama.

Genus *Helicopontosphaera* HAY & MOHLER, 1967

Helicopontosphaera compacta (BRAMLETTE & WILCOXON) n. comb.

pl. X, figs. 2, 4

1967 *Helicosphaera compacta* BRAMLETTE & WILCOXON, p. 105, pl. 6, figs. 5–8.

Remarks: The flange of this broadly elliptical lopadolith contains 120–150 tabular elements which are sinistrally imbricate. It surrounds the floor somewhat more than one and one-half times. On the convex side of the lopadolith the floor is notched along

⁵⁾ On charts listed as *Discolithina rigida*

the margin and consists of 70–90 tabular elements separated by radial suture lines; some of those elements pinch out before reaching the center. On the concave side the floor is covered with spirally arranged laths. Two small elliptical holes lie in the center and are separated by a narrow bridge.

Hypotypes: IMS-JS 1847 490 [A 862]; IMS-JS 1847 502 [A 863].

Distribution: From the *I. recurvus* Zone through *Sph. distentus*–*Sph. ciperoensis* Zone in Alabama, Trinidad, Italy, JOIDES Hole 5, 6; Mt. Cagnero (Italy), Silberberg Fm. (Helmstedt).

Helicopontosphaera euphratis (HAQ) MARTINI

1966 *Helicosphaera euphratis* HAQ, p. 33, pl. 3, figs. 1, 3.

1967 *Helicosphaera parallela* BRAMLETTE & WILCOXON, p. 106, pl. 5, figs. 9–10.

1969 *Helicopontosphaera euphratis* (HAQ) MARTINI, p. 136.

Remarks: *Helicopontosphaera euphratis* (HAQ) was originally described from core VB 40, level 9.5 cm in a borehole drilled near the village Taba, NW Syria (see HAQ, 1966). The strata at this level were thought to be of late Eocene age. Further studies of the planktonic foraminifera revealed a late Oligocene age for the type level of this species (Zone P. 19 to N. 3 for the whole core according to HAQ, personal communication, 1969). The specimens observed in samples from Trinidad, Alabama, JOIDES Holes 3 and 5, and Northern Germany agree well with the original description and electron micrographs. Electron and light microscopic investigations of the same samples clearly indicate that *Helicosphaera parallela* BRAMLETTE & WILCOXON (of which only light micrographs were published) and *Helicopontosphaera euphratis* (HAQ) MARTINI (which was based only on electron micrographs) are identical and thus synonymous.

Helicopontosphaera euphratis (HAQ) consists of 80–100 tabular elements which are dextrally imbricate. The flange is more flaring and the overall shape is more narrowly elliptical than in *Helicopontosphaera compacta* (BRAMLETTE & WILCOXON). The central depression is commonly completely covered by parallel laths which are not continuous with the flange elements and which are broader than those. In some specimens two small perforations were observed at the ends of the long axis of the central depression.

Distribution: *E. subdisticha* Zone through *Triq. carinatus*–*Sph. belemnos* Zone.

Helicopontosphaera intermedia (MARTINI)

pl. X, fig. 6

1965 *Helicosphaera intermedia* MARTINI, p. 404, pl. 35, figs. 1–2.

1967 *Helicopontosphaera intermedia* (MARTINI) HAY & MOHLER in HAY et al., p. 448.

Remarks: The floor of the lopadolith contains about 80 elements but about every third one pinches out and does not reach the center. The flange contains about 120 elements and is strongly flaring. The two fairly large holes in the center are separated by an oblique bridge. They are not partly obstructed by a grille as in *Helicopontosphaera seminulum* (BRAMLETTE & SULLIVAN) but completely open.

Hypotype: IMS-JS 20 462 [A 864].

Distribution: Throughout the Oligocene in most of the studied sections.

Helicopontosphaera reticulata (BRAMLETTE & WILCOXON) n. comb.

pl. X, fig. 5

Helicosphaera reticulata BRAMLETTE & WILCOXON, p. 106, pl. 6, fig. 15.

Remarks: The floor of this broadly elliptical lopadolith is built of about 60 laths which meet in the middle of the oblique bridge. It is pierced by about 12 holes which lie in irregular rows on either side of the bridge. The flange does not flare strongly and extends around the floor only about one and one-third times. It contains about 150 elements. This species is rare and thus difficult to use as a zonal marker.

Hypotype: IMS-JS 1066 047 [A 865].

Distribution: *E. subdisticha* Zone in Alabama and Barbados, *E. subdisticha* through *R. laevis* Zone in JOIDES Hole 5.

Helicopontosphaera seminulum (BRAMLETTE & SULLIVAN) n. comb.

1961 *Helicosphaera seminulum* BRAMLETTE & SULLIVAN, p. 144, pl. 4, figs. 1–4.

1962 *Helicosphaera seminulum* BRAMLETTE & SULLIVAN; HAY & TOWE, p. 512, pl. 1, figs. 1, 2 (non pl. 1, figs. 3–6).

1967 *Helicosphaera carteri* (WALLICH), LEVIN & JOERGER, p. 168, pl. 2, figs. 12a–c.

1962 *Helicosphaera seminulum* BRAMLETTE & SULLIVAN; GARTNER & SMITH, p. 5, pl. 7, figs. 1–4.

1968 *Helicosphaera seminulum* BRAMLETTE & SULLIVAN; STRADNER & EDWARDS, pp. 38–39, pl. 39, 40.

Remarks: The forms observed agree well with the original description and the many electron micrographs figured in the literature (esp. GARTNER & SMITH (1967), STRADNER & EDWARDS (1968)). Characteristic is the grille that covers the central pores.

Distribution: Paleocene to Upper Oligocene. Abundant species in the Oligocene of all studied sections.

Helicopontosphaera truncata (BRAMLETTE & WILCOXON) n. comb.

pl. X, fig. 3

1967 *Helicosphaera truncata* BRAMLETTE & WILCOXON, pp. 106–107, pl. 6, figs. 13–14.

Remarks: This species has a well separated floor containing about 50 segments separated by radial suture lines. The bridge is quite broad and consists of laths which are parallel to it and continuous with rim elements. The flange is composed of about 100 elements and sharply truncate at the end of the flare. *Helicopontosphaera recta* (HAQ) MARTINI is very similar but has somewhat smaller central openings separated by a narrower bridge.

Hypotype: IMS-JS 20 008 [A 866].

Distribution: Rare in the *Sph. distentus*–*Sph. ciperoensis* Zone and in the *Sph. ciperoensis*–*Triq. carinatus* Zone of Trinidad.

Family Syracosphaeraceae LEMMERMAN, 1908

Genus *Cepekiella* n. gen.

Diagnosis: A coccolith consisting of two shields which are connected by short struts. The center is covered with a cupula composed of spirally arranged laths which is attached to the distal shield by struts.

Type species: Cepekiella elongata n. sp.

Discussion: *Cepekiella* n. gen. differs from the Genus *Naninfula* Perch-Nielsen in having an imperforate and much flatter cupula.

Cepekiella elongata n. sp.

pl. XI, figs. 1, 2

Diagnosis: An elliptical species of *Cepekiella* with about 55–65 elements in the distal shield.

Description: The elliptical distal shield is concave distally and is composed of 55–65 tabular elements which are imbricate sinistrally. Every element is connected by a slim strut with the short central tube. The strongly imbricate spirally arranged plates of the central cupula and the 2–3 struts supporting each of the 30–35 trapezoidal elements of the proximal shield are attached to this central tube. It is built of the fused middle section of the angular struts which seem to be continuous from the proximal to the distal shield.

Remarks: This species differs from *Cepekiella hayi* (STRADNER) in being more narrowly elliptical and in having a wider distal shield.

Holotype: IMS-A 613 574 [A 867].

Paratype: ETH-68-60-806 [A 668].

Length of holotype: 4 μ , of paratype: 4.5 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Fm. 13' above base.

Distribution: From the *E. subdisticha* Zone through the *R. laevis* Zone in the JOIDES Blake Plateau cores in Alabama; *Sph. predistentus*–*Sph. distentus* Zone in Trinidad; the *E. subdisticha* Zone in Helmstedt, N Germany.

Cepekiella hayi (STRADNER) n. comb.

pl. XI, fig. 3

1968 *Blackites hayi* STRADNER; STRADNER & EDWARDS, p. 32, figs. 6, 7, Text-figs. 5a, b.

Remarks: The specimens figured by STRADNER & EDWARDS (1968) were badly damaged. On better preserved specimens it can be seen that this species is very broadly elliptical (as is the specimen in STRADNER & EDWARDS, pl. 31, fig. 6) and is composed of a distal shield of 60–71 trapezoidal segments which are imbricate sinistrally and separated by counterclockwise inclined sutures. Short angular struts connect the elements of the distal shield with the 30–35 trapezoidal elements of the proximal shield. In the middle where they bend they are fused to form a short tube. The central cupula is joined to the central tube and consists of elongated crystals from the margin to the centre. *Cepekiella elongata* n. sp. has larger tabular crystals in the peripheral part and narrow laths in the center.

Hypotype: ETH-68-70-855 [A 869].

Distribution: *E. subdisticha* Zone JOIDES Hole 5, Alabama, *E. subdisticha* and *Cc. margaritae* Zone of Helmstedt, Northern Germany.

Genus *Discoturbella* n. gen.

Diagnosis: A coccolith consisting of one elliptical shield and high central cupula made of a whirl of elongate crystals.

Type species: *Discoturbella moori* n. sp.

Discussion: *Naninfula* PERCH-NIELSEN is distinguished from *Discoturbella* n. gen. in having a perforate cupula. *Cepekiella* n. gen. has two shields and a much lower cupula than *Discoturbella* n. gen.

Discoturbella moori n. sp.

pl. XI, fig. 4

Diagnosis: A small species of *Discoturbella* with a high cupula.

Description: The cycle of elements consists of 35–40 trapezoidal segments. Long struts connect it with a central cupula which can be as high as the coccolith is long or much lower. It consists of elongate strongly imbricate plates forming a whirl-pattern.

Remarks: This species differs from *Cepekiella elongata* n. sp. in having only one shield and in having a much higher central cupula. *Calyptrolithus morionium* DEFLANDRE is similar in shape but has a small conical elevation on the cupula. Its ultrastructure is unknown.

Holotype: IMS 608 297 [A 870].

Length of holotype: 2 μ .

Type locality: The Lone Star Cement Company Quarry, St. Stephens, Alabama.

Type level: Red Bluff Formation.

Distribution: JOIDES Hole 5: *Cc. margaritae* Zone. Alabama: *E. subdisticha* Zone and *R. laevis* Zone.

Family Zygosphaeraceae BRAARUD & GAARDER, 1961, emend.

Diagnosis: Holococcoliths formed only of microcrystals of usual crystallographic shape, identical or not. Shape of holococcolith variable, disciform, calypetroform or zygoform.

Type: *Zygosphaera* KAMPTNER.

The following genera can be assigned to this family:

Calyptrosphaera, *Zygosphaera*, *Zygrhablithus*, *Homozygosphaera*, *Holodiscolithus* n. gen., *Clathrolithus*.

Genus *Zygosphaera* KAMPTNER, 1958

Synonym: *Orthozygus* BRAMLETTE & WILCOXON, 1967.

Zygosphaera aurea (STRADNER) STRADNER

1962 *Zycolithus aureus* STRADNER, pp. 368–369, pl. 1, figs. 31–36.

1967 *Orthozygus aureus* (STRADNER) BRAMLETTE & WILCOXON, p. 116, pl. 9, fig. 1–4.

1968 *Zygosphaera aurea* STRADNER, STRADNER & EDWARDS, p. 46, pl. 44, fig. 6.

Remarks: The forms observed are very similar to the original description and figures and to the figure in STRADNER and EDWARDS (1968). The variability of this species is great. Some specimens have 12 or more perforations in the central bridge, others only six. This species is quite abundant in the Alabama section which shows indications of shallow water, but it is missing in the deep water sediments of JOIDES Hole 5.

Zygosphaera brytika n. sp.

pl. XII, fig. 1

Diagnosis: A species of the genus *Zygosphaera* with a high rim and a narrow X-shaped bridge.

Description: The shape of this species is elongate hexagonal. The rim consists of about 12 rows of crystal cubes arranged quincuncially. The narrow X-shaped bridge is broader at the base but consists of only one row of crystals at the top. It is elevated in the center.

Remarks: This species differs from *Zygosphaera aurea* (STRADNER) in having an X-shaped bridge instead of a perforated wide bridge. *Zygoolithus minutus* PERCH-NIELSEN has an H-shaped bridge.

Holotype: A 608 014 [A 871].

Distribution: Restricted to the *E. subdisticha* Zone of Alabama.

Genus *Holodiscolithus* n. gen.

Diagnosis: Elliptical single plate with perforations composed of small crystal cubes in the manner of holococcoliths. Does not exhibit birefringence under crossed nicols.

Type species: *Holodiscolithus macroporus* (DEFLANDRE).

Remarks: The genus *Discolithina* is a heterogeneous collection. LOEBLICH & TAPPAN designated as type species *Discolithina vigintiforatus* (KAMPTNER) which, according to STRADNER & EDWARDS 1968, falls within the variation of *Discolithina multipora*. The proximal surface of *Discolithina multipora* shows radial sutures, the distal surface spiral sutures. Thus, the central area and the bevelled rim consist of two layers of laths like in members of the genus *Pontosphaera* which has priority.

Holodiscolithus n. gen. does not show any of the characteristic features of the type of *Pontosphaera*. Rim and central area are composed of regular crystal cubes as in *Zygrhablithus* and other holococcoliths. This can be seen only in the electron microscope but the result of this construction is the lack of birefringence under crossed nicols in the light microscope. *Zygrhablithus* possesses a bridge and a stem, but is of similar basic construction.

Holodiscolithus macroporus (DEFLANDRE) n. comb.

pl. XI, fig. 6

1954 *Discolithus macroporus* DEFLANDRE in DEFLANDRE & FERT, v. 40, p. 24, pl. 11, fig. 5.

1962 *Discolithus macroporus* DEFLANDRE; STRADNER, p. 365, pl. 1, figs. 1-13.

1964 *Discolithus macroporus* DEFLANDRE; COHEN, p. 236, pl. 3, figs. 5a-c, pl. 4, figs. 6a-b.

1965 *Discolithus macroporus* DEFLANDRE; COHEN, p. 15, pl. 3, figs. u.

1967 *Discolithina macroporus* (DEFLANDRE), LEVIN & JOERGER, p. 167, pl. 2, fig. 5.

Remarks: COHEN 1964 gives a thorough description of this species. He does not discuss the construction of this species, but one can see on the electron micrograph (pl. 4, fig. 6b) that it is built of crystal cubes about $0.1\ \mu$ in diameter.

Hypotype: IMS-A 600 088 [A 872].

Distribution: JOIDES Hole 5: *Cc. margaritae* Zone. Alabama: From the *E. subdisticha* Zone into *Cc. margaritae* Zone. Glimmerode, Northern Germany: *Sph. predistentus*–*Sph. distentus* Zone.

Holodiscolithus solidus (DEFLANDRE) n. comb.

pl. XI, fig. 5

1954 *Discolithus solidus* DEFLANDRE in DEFLANDRE & FERT, p. 141, pl. 12, figs. 14–16.

1961 *Discolithus solidus* DEFLANDRE of BRAMLETTE & SULLIVAN, pp. 143–144, pl. 3, figs. 14a–c, 16.

1965 *Discolithus solidus* DEFLANDRE of SULLIVAN, p. 34, pl. 4, figs. 8a, b.

1967 *Discolithina solida* (DEFLANDRE), LEVIN & JOERGER, p. 168, pl. 2, figs. 12a–c.

Remarks: This elliptical form agrees well with the original description in the general outline and the arrangement of the pores. The elements that make up this species are cubes arranged in layers parallel to the shield.

Hypotype: IMS-A 608 343 [A 873].

Distribution: JOIDES Hole 5: From the *E. subdisticha* Zone through the *R. laevis* Zone. Alabama: From the *E. subdisticha* Zone into the *Cc. margaritae* Zone. Trinidad: *Sph. predistentus*–*Sph. distentus* Zone.

Genus *Clathrolithus* DEFLANDRE, 1954

Clathrolithus minutus BRAMLETTE & SULLIVAN

pl. XII, fig. 2

1961 *Clathrolithus minutus*, BRAMLETTE & SULLIVAN, p. 157, pl. 10, fig. 18.

Remarks: The observed specimens are similar to the original illustrations of the species. The reticulate body consists of crystal cubes and is thus a holococcolith. It is rare in the *E. subdisticha* Zone and in the very base of the *Cc. margaritae* Zone of Alabama.

Hypotype: IMS-A 809 098, [A 874].

Family Discoasteraceae VEKSHINA, 1959

Genus *Discoaster* TAN SIN HOK, 1927

Discoaster rufus n. sp.

pl. XII, fig. 3

1968 *Discoaster* sp. BLACK, pl. 153, fig. 1.

Diagnosis: A small species of *Discoaster* with five rays showing crystal faces.

Description: The rays are short and have rounded ends, and each one consists of a rhombohedron showing crystal faces. The interray spaces are regular. In the center there is a hexagonal crater-like depression. The sutures between the rays are straight and radial.

Remarks: This species differs from *Discoaster aster* BRAMLETTE & RIEDEL in having rays of a more regular shape and in having radial sutures and a central crater.

Holotype: IMS-J 3-397-7-6 [A 875].

Type locality: JOIDES Hole 3, Blake Plateau, Long. 28°30' N Lat. 77°31' W.

Type level: 397' below sea floor, Oligocene.

Distribution: *Cc. margaritae* Zone through *Sph. predistentus*–*Sph. distentus* Zone.

Discoaster tani nodifer BRAMLETTE & RIEDEL

pl. XII, fig. 4

1954 *Discoaster tani nodifer* BRAMLETTE & RIEDEL, pp. 397–398, pl. 39, fig. 2.

Remarks: The specimens encountered in the samples studied are identical with the type species. The central star can be seen clearly. The arms show indications of a ridge. The species is rare in the lower Oligocene.

Hypotype: IMS-A 800 046 [A 876].

Discoaster trinus STRADNER

pl. XII, fig. 5

1959 *Discoaster molengraffi* TAN of STRADNER, pl. 1085, Text-figs. 15, 24.

1961 *Discoaster trinus* STRADNER, p. 85, text-fig. 85.

Remarks: The electron microscope reveals many crystal faces on the rays. It can be seen that it is built like a hemidiscoaster. The species occurs rarely in the lower Oligocene.

Hypotype: IMS-J 3-75-9-1 [A 877].

Discoaster woodringi BRAMLETTE & RIEDEL

pl. XII, fig. 6

1956 *Discoaster woodringi* BRAMLETTE & RIEDEL 1956, p. 400, pl. 39, figs. 8a–b.

Remarks: The forms observed compare well with the original illustration. Some specimens show a less raised center and others deeper grooves between the rays than shown on the original illustrations. The species is found from the *Cc. margaritae* Zone through the *Sph. distentus*–*Sph. ciproensis* Zone in the JOIDES Holes 3, 5 in Trinidad, in Alabama and in Italy.

Holotype: JMS-J 30 005 [A 878].

Family Lithostromationaceae HAQ, 1967

Genus *Lithostromation* DEFLANDRE, 1942

Lithostromation perdurum DEFLANDRE

pl. XIII, figs. 1, 2

1942 *Lithostromation perdurum* DEFLANDRE, pp. 917–919, Text-figs. 1–9.

Remarks: The variability of this species is great. From 5 to more than 15 depressions were counted. No crystal elements could be observed and it seems that this form consists of one crystal.

Hypotypes: IMS-J 509 209 [A 879]; IMS-A 800 072 [A 880].

Distribution: Rare specimens from the *E. subdisticha* Zone to the *R. laevis* Zone in Alabama and JOIDES Hole 5.

Family Triquetrorhabdulaceae LIPPS, 1969

Genus *Triquetrorhabdulus* MARTINI, 1965

Triquetrorhabdulus carinatus MARTINI

pl. XIV, fig. 6

1965 *Triquetrorhabdulus carinatus* MARTINI, p. 408, pl. 26, figs. 1–3.

1969 *Triquetrorhabdulus carinatus* MARTINI; LIPPS, p. 1030, pl. 126, figs. 1–4.

Remarks: The specimens observed agree well with the original description and with the very thorough description by LIPPS (1969).

Hypotype: IMS-Bo 291 A 458 [A 881].

Distribution: *Sph. ciproensis*–*Triq. carinatus* Zone to *Triq. carinatus*–*Sph. belemnos* Zone.

Family Sphenolithaceae VEKSHINA, 1959

Genus *Sphenolithus* DEFLANDRE, 1954

Sphenolithus belemnos BRAMLETTE & WILCOXON

pl. XIII, figs. 5, 6

1967 *Sphenolithus belemnos* BRAMLETTE & WILCOXON, p. 118, pl. 2, figs. 1–3.

Remarks: Only small specimens were observed in the samples studied. The dart-shaped sphenolith has a basal cycle of about 12 elements. The apical spine begins with another cycle of irregular segments and the upper half of the spine is built of about four wedge-shaped elements which taper to form a fairly sharp point.

Hypotypes: IMS-J 3-270-18-8 [A 882]; IMS-JS 267* 083 [A 883].

Distribution: *Triq. carinatus*–*Sph. belemnos* Zone and younger (not studied in this paper).

Sphenolithus ciproensis BRAMLETTE & WILCOXON

pl. XIII, fig. 4, pl. XIV, figs. 1, 2

1967 *Sphenolithus ciproensis* BRAMLETTE & WILCOXON, p. 120, pl. 2, figs. 15–18, and aff. in figs. 19–20.

Remarks: BRAMLETTE & WILCOXON gave only light micrographs of this species. While studying samples from JOIDES Blake Plateau Hole 3, well preserved specimens of this species were observed in the electron microscope. The basal cycle of elements consists of 10–15 wedge-shaped crystals. The apical spine is built of four elongated segments which taper to form a sharp point; two of the segments may continue into the extended bifurcations. The part below the bifurcation is much shorter than in the bifurcated specimens of *Sphenolithus distentus* (MARTINI).

Hypotypes: IMS-J3-306-16-7, [A 884]; IMS-J3-270-18-2 [A 885]; IMS-JS 267* 070 [A 886].

Distribution: From the *Sph. distentus*–*Sph. ciperoensis* Zone into the *Triq. carinatus*–*Sph. belemnus* Zone in Trinidad and JOIDES Hole 3.

Sphenolithus distentus (MARTINI) BRAMLETTE & WILCOXON

pl. XIII, figs. 3, 7

1965 *Furcatolithus distentus* MARTINI, p. 407, p. 135, figs. 7–9.

1967 *Sphenolithus distentus* (MARTINI) BRAMLETTE & WILCOXON, p. 112, pl. 1, fig. 5, pl. 2, figs. 4, 5.

Remarks: Well preserved specimens of this species were found in JOIDES Hole 3 samples and compare well with specimens from the Ciper Coast samples. The basal cycle consists of about 12 wedges, the apical spine seems to be composed of only four wedge-shaped elements, two of which are continuous with the bifurcations. The shaft from the basal cycle to the bifurcation is longer than in *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON and the basal disc is not much broader than the base of the apical spine whereas in *Sphenolithus ciperoensis* it is distinctly wider.

Hypotypes: IMS-J3-397-13-5 [A 887]; IMS-J3-422-10-10 [A 888].

Distribution: From the *Sph. predistentus*–*Sph. distentus* Zone through the *Sph. distentus*–*Sph. ciperoensis* Zone in Trinidad, Alabama, Italy (Monte Cagnero), Belgium (Boom Clay), Northern Germany (Glimmerode, Kasseler Meeressande).

Sphenolithus moriformis (BRÖNNIMANN & STRADNER) BRAMLETTE & WILCOXON

pl. XIV, figs. 3, 4

1960 *Nannoturbella moriformis* BRÖNNIMANN & STRADNER, p. 386, figs. 11–16.

1965 *Sphenolithus pacificus* MARTINI, p. 407, pl. 36, figs. 7–10.

1967 *Sphenolithus moriformis* (BRÖNNIMANN & STRADNER) BRAMLETTE & WILCOXON, pp. 124–125, pl. 3, figs. 1–6.

Remarks: Two different but intergrading forms could be observed in the electron microscope. The two extreme types are illustrated here. One has a basal cycle of 8–10 long slender spines, projecting downward, a middle section of about 20 spines sticking out radially, and 3–4 slender spines on top (Fig. 4). The other has about the same number of spines but they are shorter, blunter and more wedge-shaped. The whole body is shorter and more round, almost hemispherical (Fig. 3).

Hypotypes: IMS-J3-475-11-1 [A 889]; IMS-J3-381-20-5 [A 890].

Distribution: Throughout the Upper Eocene and Oligocene.

Sphenolithus tribulosus n. sp.

pl. XIV, figs. 5, 7, 8

Diagnosis: A species of *Sphenolithus* with a small base and a large apical spine covered with about six serrate longitudinal ridges.

Descriptions: The base is depressed and consists of 10–12 slender elements. The apical spine expands in the lower third and protrudes more than the basal elements. In the upper two thirds it tapers regularly to form a pointed or bifurcated tip which consists of two crystals separated by a depressed suture line. The apical spine carries

six serrate ridges consisting of subparallel laths which point in the direction of the tip of the apical spine and form a 20–45° angle with the axis of the spine. The serrate margin of the apical spine can be discerned in the light microscope.

Remarks: This species differs from *Sphenolithus predistentus* BRAMLETTE & WILCOXON in having serrate ridges on the apical spine and in showing nearly complete extinction between crossed nicols when the apical spine is parallel to either nicol. The surface sculpture of *Sphenolithus predistentus* is smooth, and in polarized light the apical spine is brightly illuminated even when parallel to either nicol.

Holotype: IMS-A 608 504 [A 891].

Paratype: A 613-L 001 A + B [A 892, A 893].

Length of Holotype: 6.5 μ .

Occurrence: *Sphenolithus tribulosus* n. sp. occurs with *Sphenolithus predistentus* in the *E. subdistichus* Zone and in the *Cc. margaritae* Zone of Alabama, but is rare in the *Sph. predistentus*–*Sph. distentus* Zone of Trinidad. (NOTE: *Sphenolithus tribulosus* n. sp. is not listed on the range charts.)

Check list of species

Unless stated otherwise only the type reference is given. If another reference is mentioned, the reason is indicated by the following abbreviations:

EM: good electron micrograph

LM: good light micrograph

D: detailed description

Coccolithus joensuui ROTH & HAY in HAY et al., 1967, pp. 445–446, pl. 6, fig. 5.

Coccolithus paralitos ROTH & HAY in HAY et al., p. 446, pl. 6, fig. 6.

Coccolithus parvulus (DEFLANDRE & FERT) STRADNER [= *Tremalithus parvulus* DEFLANDRE & FERT, 1954, p. 154, pl. 14, fig. 6]. EM: STRADNER & EDWARDS, 1968, p. 16, pl. 7, figs. 1–2.

Coccolithus sarsiae BLACK, 1962, p. 125, pl. 8, fig. 2, pl. 9, figs. 2–6.

Cruciplacolithus tarquinius ROTH & HAY in HAY et al., 1967, p. 446, pl. 6, fig. 8.

Chiasmolithus californicus (SULLIVAN) HAY & MOHLER [= *Coccolithus californicus* SULLIVAN, 1964, p. 180, pl. 1, figs. 7a–d]. EM: HAY & MOHLER, 1967, p. 1527, pl. 196, figs. 18–20, pl. 198, fig. 5.

Chiasmolithus consuetus (BRAMLETTE & SULLIVAN) HAY & MOHLER [= *Coccolithus consuetus* BRAMLETTE & SULLIVAN, 1961, p. 139, pl. 1, figs. 2a–c]. EM: HAY & MOHLER, 1967, p. 1526, pl. 196, figs. 23–25, pl. 198, fig. 16.

Chiasmolithus grandis (BRAMLETTE & RIEDEL) n. comb. [= *Coccolithus grandis* BRAMLETTE & RIEDEL, 1954, p. 391, pl. 38, figs. 1a–b]. LM, D: BRAMLETTE & SULLIVAN, p. 140, pl. 2, figs. 1a–b, 2a–c, 3.

Reticulofenestra dupouyi (DEFLANDRE & FERT) HAY, MOHLER & WADE [= *Discolithus dupouyi* DEFLANDRE & FERT, 1952, p. 2101, Text-fig. 1. DEFLANDRE & FERT, 1954, p. 142, pl. 14, figs. 1, 9, 10, 12]. EM: STRADNER & EDWARDS, 1968, p. 20, pl. 15.

Reticulofenestra gartneri ROTH & HAY in HAY et al., 1967, p. 449, pl. 7, fig. 1.

Reticulofenestra insignita ROTH & HAY in HAY et al., 1967, p. 449, pl. 7, figs. 2–3.

Reticulofenestra oamaruensis (DEFLANDRE) STRADNER [= *Discolithus oamaruensis* DEFLANDRE in DEFLANDRE & FERT, 1954, p. 139, pl. 12, figs. 1–2]. EM: STRADNER & EDWARDS, 1968, pp. 21–22, pl. 16–18, Text-fig. 2B.

Cyclolithella inflexa (KAMPTNER ex DEFLANDRE) LOEBLICH & TAPPAN [= *Cyclolithus inflexus* KAMPTNER ex DEFLANDRE in PIVETAU, 1952, p. 110, fig. 50]. EM: STRADNER & EDWARDS, 1968, p. 25, pl. 7, fig. 4.

Pyrocyclus hermosus ROTH & HAY in HAY et al., 1967, p. 448, pl. 6, figs. 10–12.

Cyclococcolithus bolii ROTH, 1969, p. 465, pl. 1, figs. 3–4.

Cyclococcolithus inversus (DEFLANDRE) HAY, MOHLER & WADE [= *Cyclococcolithus leptoporus* var. *inversus* DEFLANDRE in DEFLANDRE & FERT, 1954, p. 150 (pro parte), pl. 9, figs. 4–5]. EM: STRADNER & EDWARDS, 1968, pp. 25–26, pl. 26–27.