Zonation of the oligocene

Objekttyp: **Chapter**

Zeitschrift: **Eclogae Geologicae Helvetiae**

Band (Jahr): **63 (1970)**

Heft 2

PDF erstellt am: **24.07.2024**

Samples studied:

Sample number	Approximate stratigraphical distance from base of Scaglia cinerea
PB 349	94 m
PB 346	88 m
PB 343	82 m
PB 339	74 m
PB 336	68 m
PB 333	62 m
PB 330	56 m
PB 328	52 m
PB 326	48 m
PB 325	46 m
PB 323	42 m
PB 321	38 m
PB 317	30 m
PB 107	28 m
PB 105	24 m
PB 103	20 m
PB 101	16 m
PB 99	12 m
PB 96	6 m
PB 95	4 m
PB 94	2 m
PB 93	base
PB 92: top of Scaglia variegata	

3. ZONATION OF THE OLIGOCENE

The Eocene-Oligocene boundary can be defined by the last occurrence of *Discoaster barbadiensis* and *Discoaster saipanensis*, the latter usually being more abundant near this boundary. The disappearence of these species coincide with the last occurrence of the genus *Hantkenina*. The Oligocene-Miocene boundary is more difficult to define using nannoplankton. The *Comité du Néogène* (Bologna 1967) recommended the first occurrence of *Globigerinoides* as base of the Miocene. This level lies within the *Globorotalia kugleri* Zone of Bolli (1957) or at the base of Zone N4 (*Globigerinoides quadrilobatus primordius*/*Globorotalia* (*Turborotalia*) *kugleri* Concurrent-range Zone) of Blow (1969). Continuous sections with well preserved nannoplankton for this interval are still unknown, and at the present time it can only be demonstrated that the Oligocene-Miocene boundary falls within or lies at the base of *Triquetrorhabdulus carinatus–Sphenolithus belemnos* Zone (as defined in this paper). In the following paragraph a short definition of all the Oligocene zones is given and the important species that can be used to recognize each zone are listed. Long-ranging species with little stratigraphic value are not mentioned. There are many more species present and more information can be found in the range charts. The Lower Oligocene can be divided into two intervals if only light microscopy is used: the lower interval is delimited by the last occurrence of *Discoaster barbadiensis* at its base and by the last occurrence of *Cyclococcolithus formosus* at its top. *Lanternithus minutus* and *Isthmolithus recurvus* also disappear at about the same level. This lower interval coincides with the *Ericsonia subdisticha* Zone and the lowermost part of the *Cyclococcolithus*

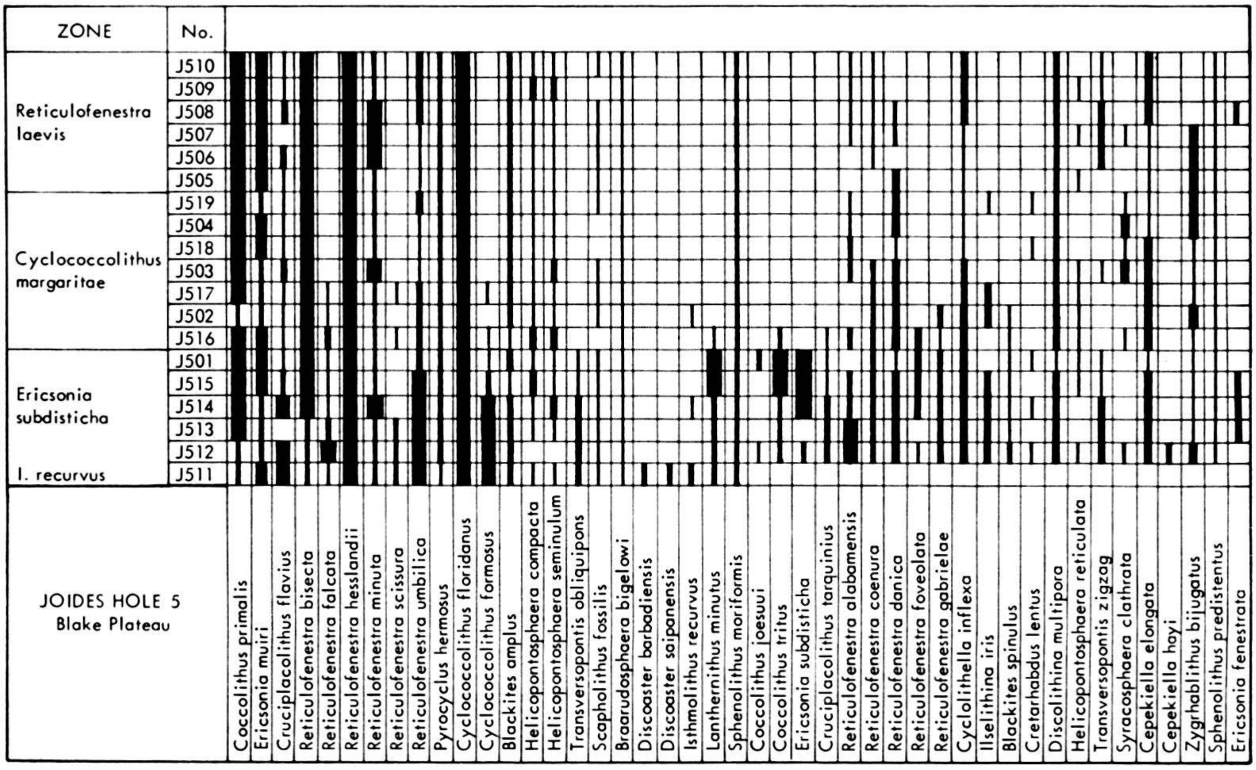


Fig. 6. Distribution of calcareous nannofossils in the Upper Eocene-Oligocene of JOIDES Hole 5, 30° 23′ N, 80° 08′ W, Blake Plateau, Western Atlantic.

margaritae Zone. The upper interval lies above the last occurrence of *Cyclococcolithus formosus* and below the first occurrence of *Sphenolithus distentus* which is very close to the last occurrence of *Reticulofenestra umbilica*. It corresponds to most of the *Cyclococcolithus margaritae* Zone and the *Reticulofenestra laevis* Zone. The Upper Oligocene Zones based on *Sphenolithus* can easily be recognized using only light microscopy. The *Helicosphaera reticulata* Zone of Bramlette & Wilcoxon (1967) approximates the *Ericsonia subdisticha* Zone–*Reticulofenestra laevis* Zone interval.

3.1. Lower Oligocene

3.1.1. Ericsonia subdisticha Zone

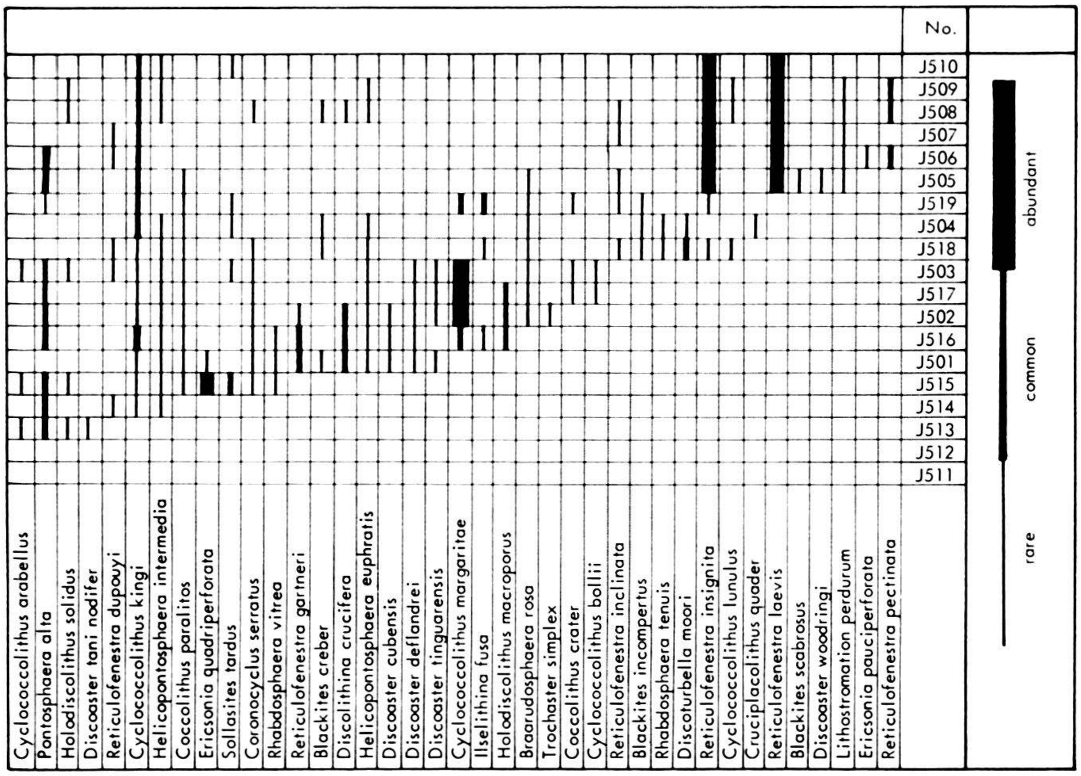
(= *Ellipsolithus subdistichus* Zone Roth & Hay, in: Hay et al., 1967)

Definition: Interval from the last occurrence of *Discoaster barbadiensis* Tan Sin Hok to the first occurrence of *Cyclococcolithus margaritae* Roth & Hay.

Authors: Roth & Hay, 1967.

Type locality: JOIDES Hole 5, Lat. 30° 23′ N, Long. 80° 08′ W, Blake Plateau. (Samples J 512–J 501, most representative sample J 501, see fig. 1)

Important species: *Ericsonia subdisticha* (Roth & Hay) Roth, *Cyclococcolithus formosus* Kamptner (= synonym: *Coccolithus lusitanicus* Black). *Lanternithus minutus* Stradner, *Isthmolithus recurvus* Deflandre, *Sphenolithus tribulosus* n.sp., *Sphenolithus predistentus* Bramlette & Wilcoxon (first occurrence in the upper part



(N.B. All the species listed as *Discolithina* in figs. 6, 7, 9, 11–16 are assigned to the genus *Pontosphaera*, see pp. 860–861)

of the *Isthmolithus recurvus* Zone), *Reticulofenstra gartneri* ROTH & HAY, *Reticulofenstra gabrielae* n. sp., *Coccolithus joensuui* ROTH & HAY.

Remarks: This zone is characterized by the lack of Eocene discoasters such as *Discoaster barbadiensis* and *Discoaster saipanensis.* There are still very many species that range from the Eocene into this Zone, viz. *Isthmolithus recurvus, Lanternithus minutus, Coccolithus formosus* and *Ericsonia subdisticha* which makes its first occurrence in the upper Middle to lower Upper Eocene (personal communication by W. W. Hay and K. Perch-Nielsen, 1969). Thus the presence of *Ericsonia subdisticha* proves an early Oligocene age only if Eocene discoasters are absent and other species typical for the *Ericsonia subdisticha* Zone are present. Samples from JOIDES Hole 5 show very rich and well preserved assemblages belonging to this zone. Even richer and better preserved nannofloras from this zone are found in the Red Bluff Formation and the basal 5 feet of the Marianna Limestone of Alabama. On the island of Barbados, the type level of Zone P. 18 (samples JS 1066) belongs to the uppermost part of the *Ericsonia subdisticha* Zone as well. The Silberberg Formation in the coal pit Treue IV near Helmstedt, Northern Germany, belongs to the *Ericsonia subdisticha* Zone, only the very top of the Silberberg Formation in the Clay Pit on the Silberberg is already in the *Cyclococcolithus margaritae* Zone.

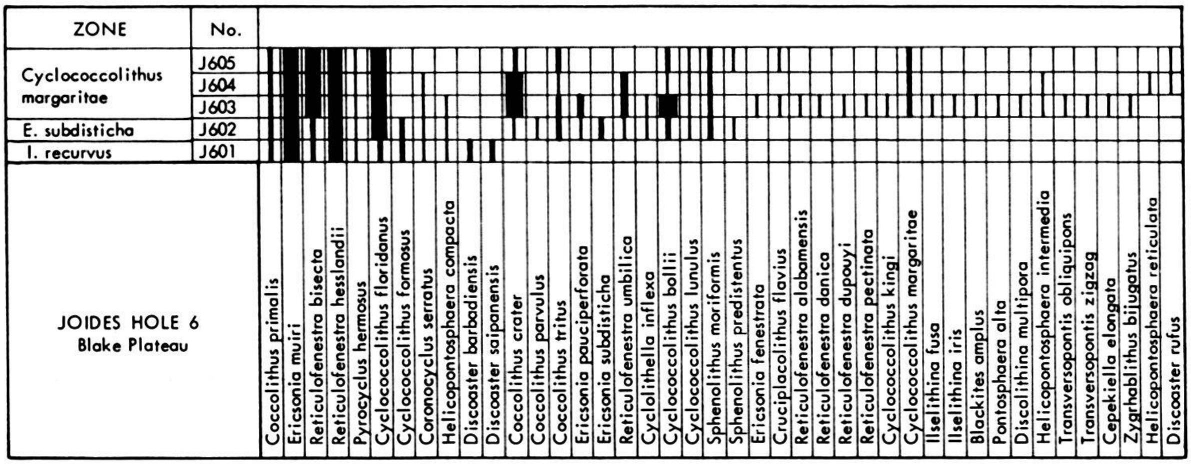


Fig. 7. Distribution of calcareous nannofossils in the Upper Eocene-Oligocene of JOIDES Hole 6, 30° 05′ N, 79° 15′ W, Blake Plateau, Western Atlantic.

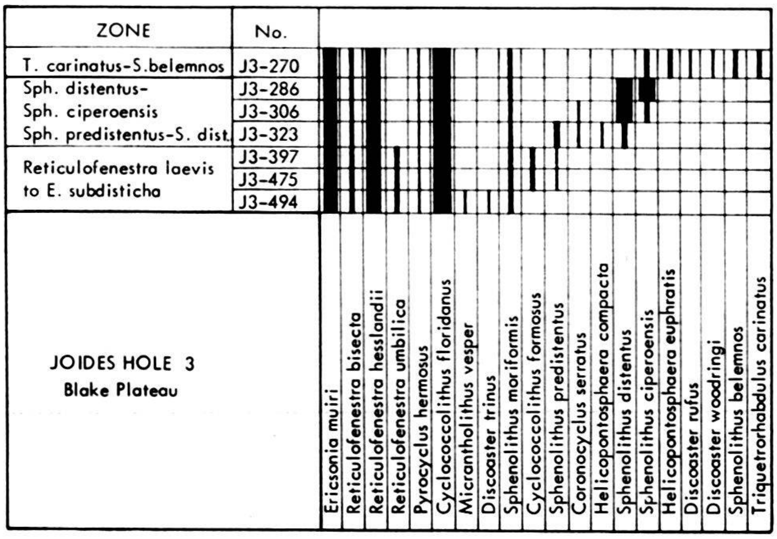


Fig. 8. Distribution of calcareous nannofossils in the Oligocene-Lower Miocene of JOIDES Hole 3, 28° 30′ N, 77° 31′, Blake Plateau, Western Atlantic.

The samples from the Silberberg Formation are not as rich as the Red Bluff samples from Alabama but the assemblage is strikingly similar and all the important markers are present. *Corannulus germanicus* STRADNER, found in the Silberberg Formation, was not found in any other lower Oligocene section.

MARTINI & MOORKENS (1969) showed that the sands of Grimmertingen (Tongrien) belong to the *Ericsonia subdisticha* Zone. The *Ericsonia subdisticha* Zone was also found in the Scaglia cinerea of the Monte Cagnero Section in Central Italy. It is represented by only about 6 meters of sediment. The preservation is poor and therefore an accurate zonation is difficult to establish.

3.2. Middle Oligocene

3.2.1. *Cyclococcolithus margaritae* Zone

Definition: Interval from the first occurrence of *Cyclococcolithus margaritae* ROTH & HAY to the first occurrence of *Reticulofenestra laevis* ROTH & HAY.

Authors: ROTH & HAY, 1967, emend. ROTH, 1969a.

Type locality: JOIDES Hole 5, Lat. 30°23' N, Long. 80°08' W, Blake Plateau (samples J 516–J 519, most representative sample: J 502; see fig. 6).

Important species: Cyclococcolithus margaritae ROTH & HAY, *Cyclococcolithus bollii* ROTH, *Coccolithus crater* n.sp. (the last 2 species first occur in the uppermost part of the underlying zone), *Braarudosphaera rosa* LEVIN & JOERGER (more abundant in shallow water deposits). Disappearing near the base of this zone is *Lanternithus minutus* STRADNER, *Cyclococcolithus formosus* KAMPTNER, and *Isthmolithus recurvus* DEFLANDRE. Near the top of this Zone *Reticulofenestra insignita* ROTH & HAY has its lowest occurrence.

Remarks: The richest and best preserved nannoflora from this zone discovered thus far is found in the type section, in JOIDES Hole 5. In JOIDES Hole 6 the *Cyclococcolithus margaritae* Zone is represented but the smaller coccoliths are missing. The same is the case in JOIDES Hole 3, where the Lower Oligocene nannoplankton zones could not be separated from each other. The Marianna Limestone of Alabama, from 5 feet above the base up to the top, contains a rich assemblage belonging to this zone. The upper part of the Marianna Limestone shows more recrystallization and the coccoliths are less well preserved. The upper part of the Bath Member of the Oceanic Formation contains nannofossil assemblages typical for the *Cyclococcolithus margaritae* Zone. *Cyclococcolithus margaritae* was found in the uppermost part of the Silberberg Formation in the Clay Pit on Silberberg near Helmstedt and in the Rupelton in the nearby Clay Pit Alversdorf. The German Rupelton contains many reworked Cretaceous forms and it is difficult to find the important autochthonous forms. MARTINI (1960) reported mainly reworked nannofossils from the "Rupelton" in the Mainz basin.

In the Monte Cagnero section the *Cyclococcolithus margaritae* Zone is 26 m thick.

3.2.2. *Reticulofenestra laevis* Zone

Definition: Interval from the first occurrence of *Reticulofenestra laevis* ROTH & HAY to the first occurrence of *Sphenolithus distentus* (MARTINI).

Authors: ROTH & HAY, 1967, modified in this paper.

Type locality: JOIDES Hole 5, Lat. 30°23' N, Long. 80°08' W, Blake Plateau (samples J 505–J 510, most representative sample: J 507).

Important species: Reticulofenestra laevis ROTH & HAY, *Reticulofenestra insignita* ROTH & HAY (much more abundant than in the underlaying zone), *Cyclococcolithus bollii* ROTH (rare); the following 5 species do not occur above the *Reticulofenestra laevis* Zone: *Helicopontosphaera reticulata* (BRAMLETTE & WILCOXON), *Reticulofenestra umbilica* (LEVIN), *Reticulofenestra pectinata* n.sp., *Reticulofenestra inclinata* n.sp., and *Lithostromation perdurum* DEFLANDRE.

Remarks: It is impossible to separate the *Cyclococcolithus margaritae* Zone from the *Reticulofenestra laevis* Zone using light microscopy because *Reticulofenestra laevis*

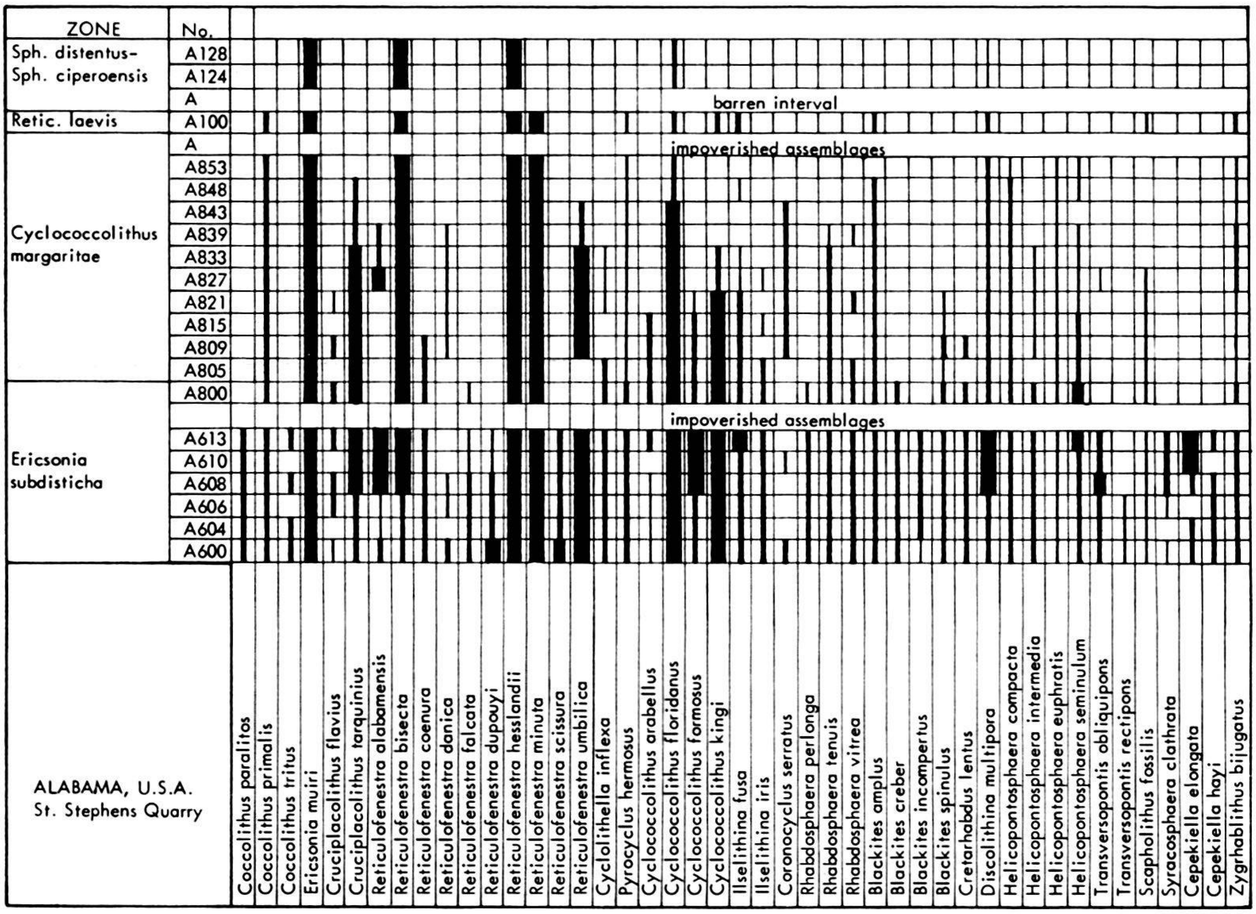
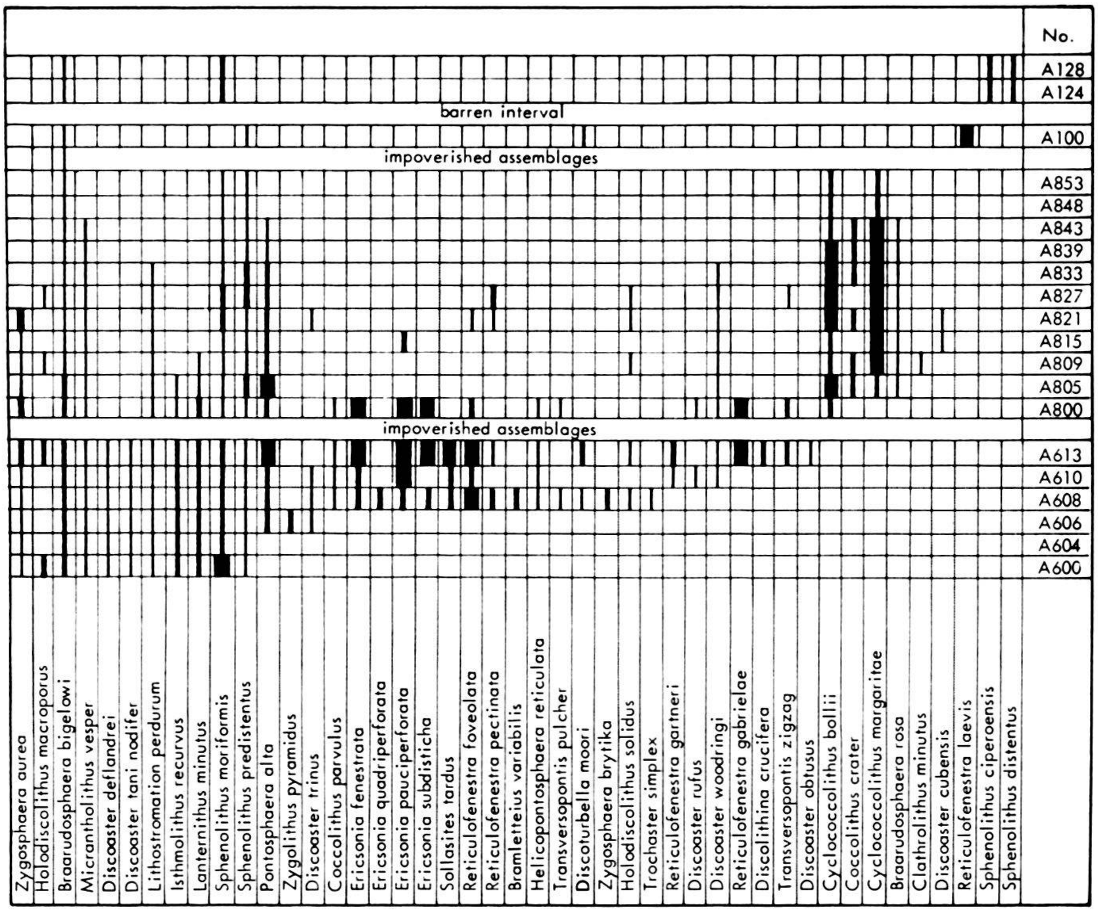


Fig. 9. Distribution of calcareous nannofossils in the Oligocene section at St. Stephens Quarry, Clark County, Alabama, USA.

cannot be identified with that method. The interval covering the two zones is characterized by the absence of *Lanternithus minutus* and *Cyclococcolithus formosus* which only occur in the underlying zone and basal part of the *Cyclococcolithus margaritae* Zone.

Dicoaster saundersi and *Sphenolithus distentus* do not occur below the next higher *Sphenolithus predistentus- Sphenolithus distentus* Zone. The *Reticulofenestra laevis* Zone in JOIDES Hole 5 comprises 50 m of sediment, the lower part containing many siliceous microfossils. The assemblages are fairly rich, but discoasters are rare and limited to long-ranging species of the *D. deflandrei*-group. In Alabama *Reticulofenestra laevis* occurs in the unnamed Clay Member at the base of the Bucutunna Clay. The underlying Glendon Limestone is too poor in nannofossils to be assigned to any Zone and the Bucatunna Clay is completely barren of nannofossils.

In Europe the lower part of the Boom Clay (brick clay pit De Roek & Verstrepen) belongs to the *Reticulofenestra laevis* Zone. The zonal marker *Sphenolithus predistentus* is present, but *Sphenolithus distentus* is still missing, and occurs only in the upper part of the section. The lower part of the Kasseler Meeressande of the now abandonned coal pit on the Höllkopf near Glimmerode belongs to the *Reticulofenestra laevis* Zone.



There are many reworked Cretaceous nannofossils in these deposits, but the marker fossil and *Reticulofenestra umbilica* are present. In the Monte Cagnero section only 4–5 m of the Scaglia cinerea belong to this zone. Perhaps *Reticulfenestra laevis* does not occur below because of the very poor preservation of nannofossils in this part of the section. On the other hand sedimentation might have been very slow during the time of deposition of sediments belonging to the *Reticulofenestra laevis* Zone.

3.2.3. *Sphenolithus predistentus–Sphenolithus distentus* Zone

Definition: Interval with *Sphenolithus predistentus* BRAMLETTE & WILCOXON and *Sphenolithus distentus* (MARTINI) from the first occurrence of *Sphenolithus distentus* (MARTINI) to the first occurrence of *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON.

Authors: BRAMLETTE & WILCOXON, 1967, modified by ROTH, in BAUMANN & ROTH, 1969, modified in this paper.

Type locality: Sample TTOC 193785, near the type locality of the *Globigerina ampiapertura* Zone of BOLLI (1957), Trinidad.

Cotype locality: Samples PB 328–PB 330, most representative sample PB 328, Monte Cagnero, Central Italy.

Important species: Sphenolithus predistentus BRAMLETTE & WILCOXON, *Sphenolithus distentus* (MARTINI), *Discoaster saundersi* HAY, *Ericsonia bireticulata* n.sp.,

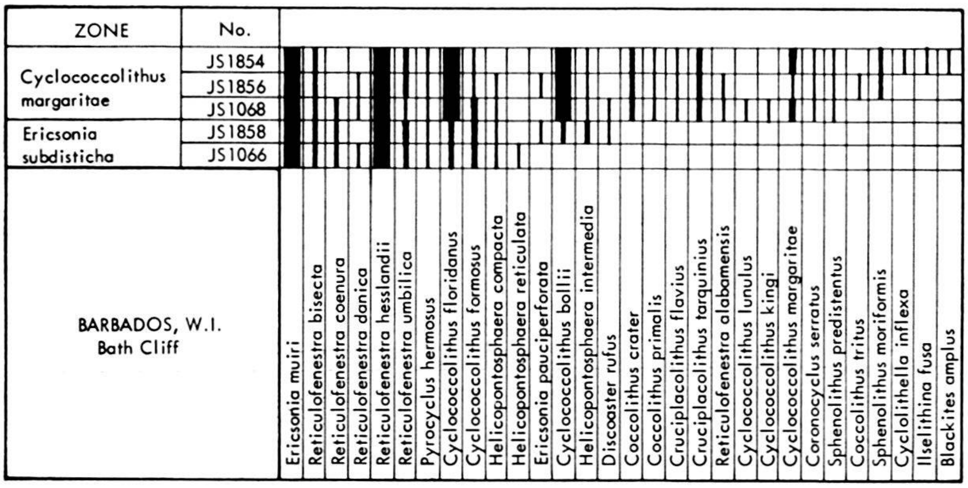


Fig. 10. Distribution of calcareous nannofossils in the Oligocene section at Bath Cliff, Barbados.

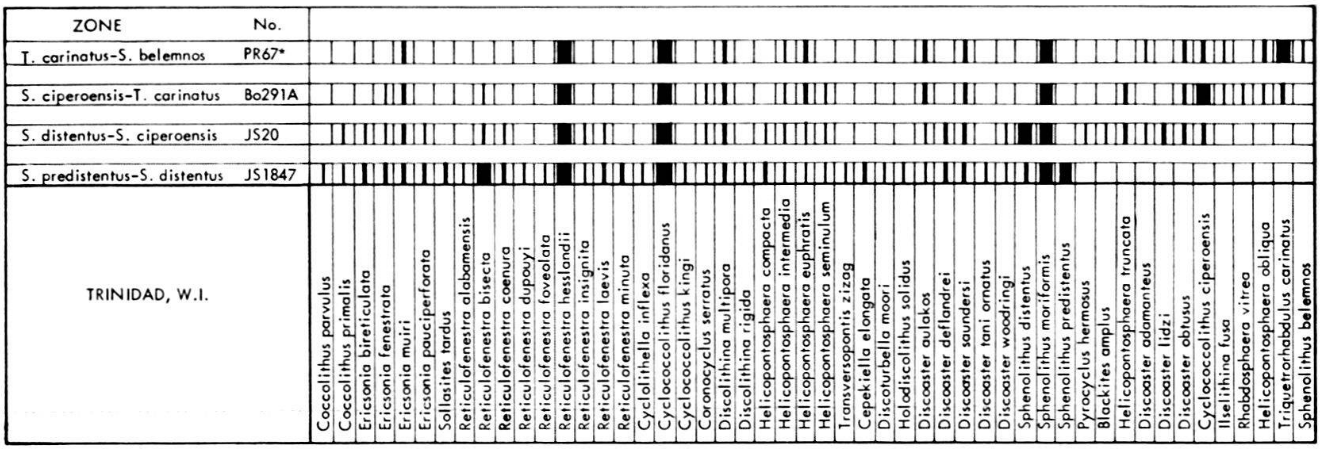


Fig. 11. Distribution of calcareous nannofossils in samples from the type localities or type areas of the planktonic foraminiferal zones of Bolli (1957).

Pontosphaera rigida n.sp. The following species make their last occurrence in this zone: *Cruciplacolithus tarquinius* ROTH & HAY, *Sollasites tardus* n.sp., *Reticulofenestra alabamensis* n.sp., *Reticulofenestra scissura* HAY, MOHLER & WADE, *Reticulofenestra foveolata* (REINHARDT). *Cyclococcolithus kingi* n.sp., *Transversopontis zigzag* ROTH & HAY.

Remarks: The definition of this zone was changed after it was realized that *Sphenolithus distentus* (MARTINI) is more abundant in most sections and can be recognized more easily than *Discoaster saundersi* HAY in poorly preserved samples. A satisfactory section to study this and the following zones in greater detail has not been found. The Cipero Coast section in Trinidad is completely destroyed. Only one sample from the *Sphenolithus predistentus–Sphenolithus distentus* Zone on the Cipero Coast was available (JS 1847); it contains a fairly rich and well preserved assemblage. In Alabama this zone is missing since the unnamed clay member at the base of the

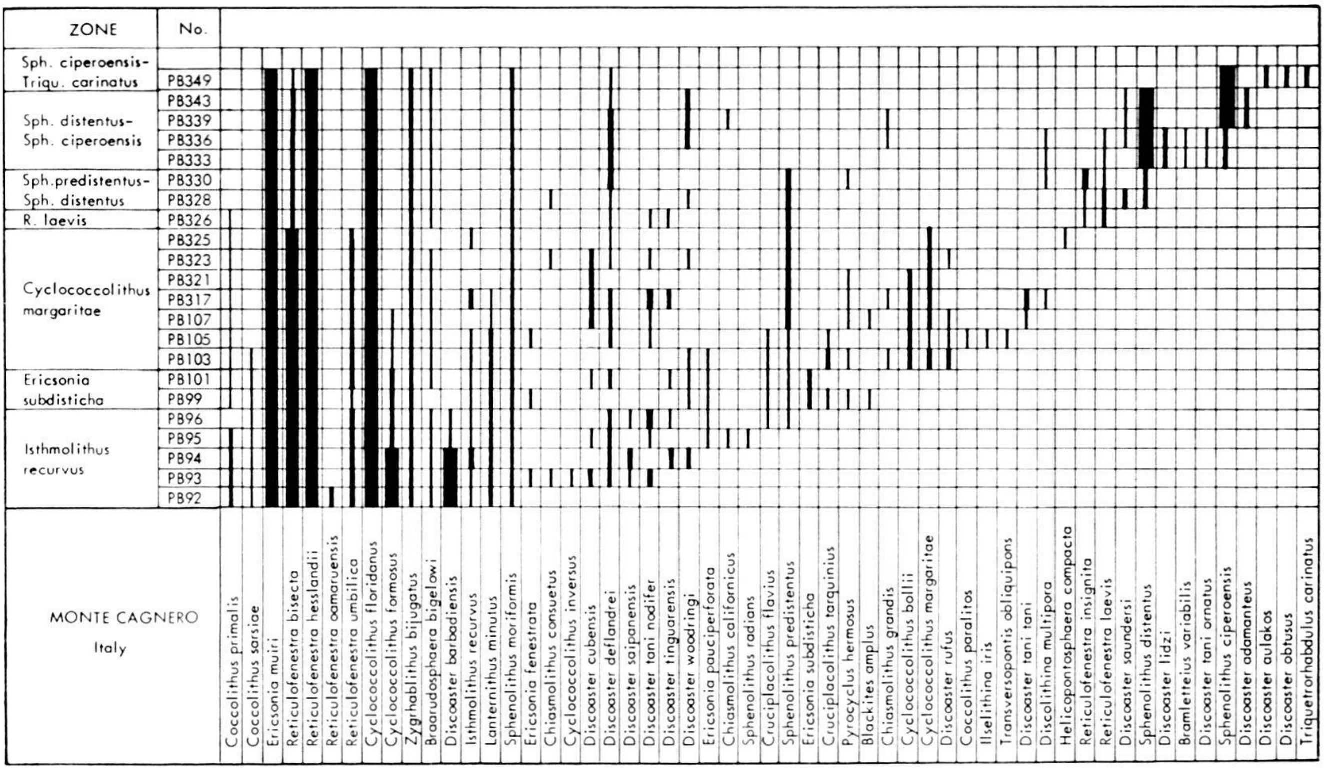


Fig. 12. Distribution of calcareous nannofossils in the Upper Eocene-Oligocene section at the Monte Cagnero, Central Apennines, Italy.

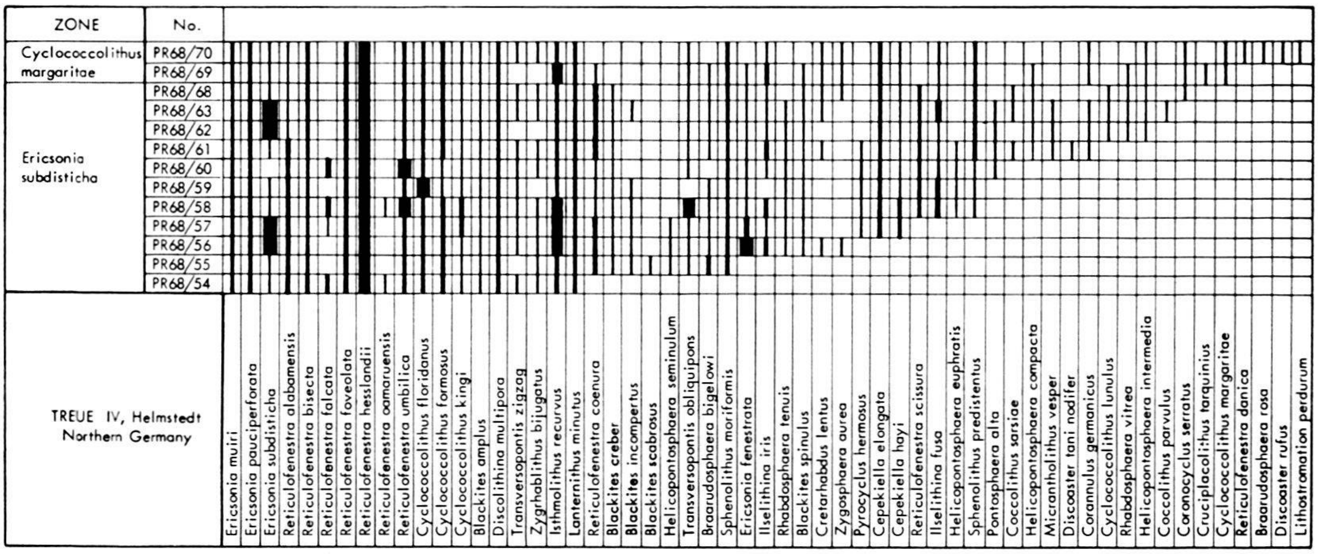


Fig. 13. Distribution of calcareous nannofossils in the Lower Oligocene (Latdorfian) section at the coal pit Treue IV, near Helmstedt, Northern Germany.

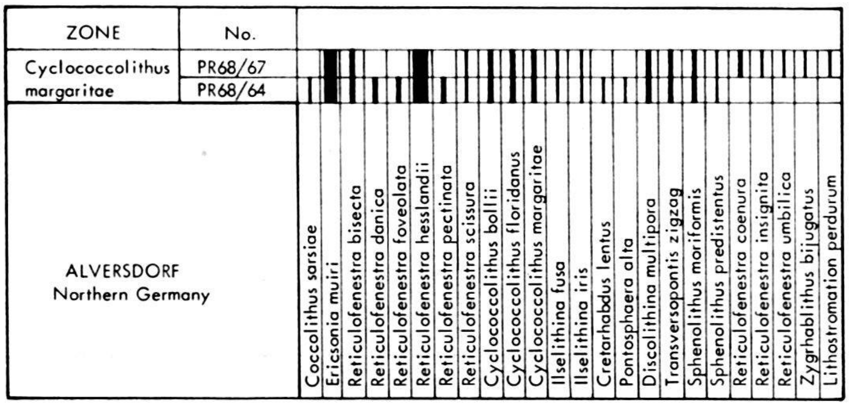


Fig. 14. Distribution of calcareous nannofossils in the Middle Oligocene (Rupelian) section at the clay pit Alversdorf, near Helmstedt, Northern Germany.

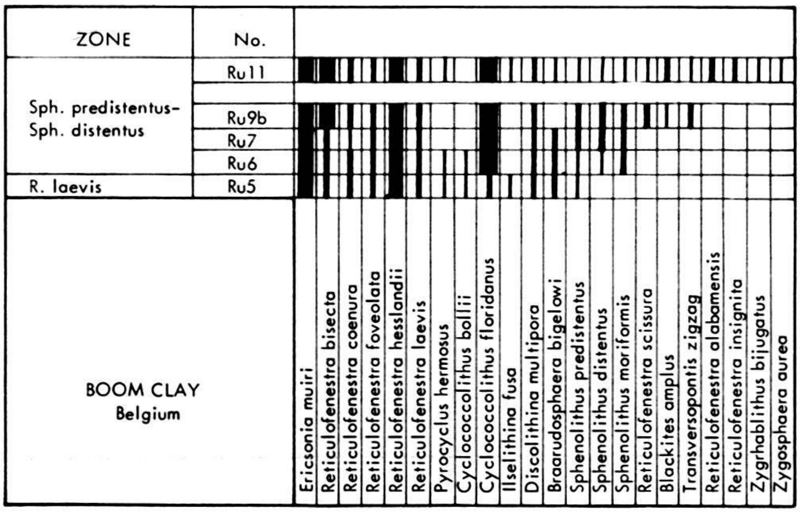


Fig. 15. Distribution of calcareous nannofossils in the type Rupelian section, clay pit "De Roeck & Verstrepen", Boom, Belgium.

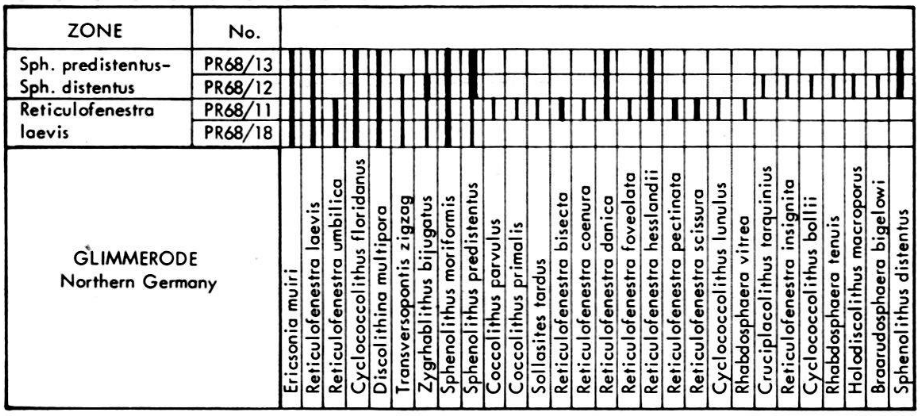


Fig. 16. Distribution of calcareous nannofossils in the Middle Oligocene (Chattian) section at the coal pit Höllkopf, near Glimmerode, Northern Germany.

Bucatunna Clay belongs to the *Reticulofenestra laevis* Zone and the next higher horizon yielding nannofossils, the Chickasawhay Limestone, belongs to the succeeding *Sphenolithus distentus–Sphenolithus ciperoensis* Zone. JOIDES Hole 5 does not contain this zone but post-Miocene deposits rest on top of sediments belonging to the *Reticulofenestra laevis* Zone. In JOIDES Hole 3 the *Sphenolithus predistentus–Sphenolithus distentus* Zone was found at 323' below sea floor; according to BRAMLETTE & WILCOXON, 1967, from 328' to 417' below sea floor. The nannoflora in JOIDES Hole 3 is reduced in number of species because many small forms are missing due to winnowing. Discoasters are very rare in this section, but sphenoliths are abundant and well preserved. Most of the Boom Clay in the Clay Pit De Roek & Verstrepen near Boom (Belgium) belongs to the *Sphenolithus predistentus–Sphenolithus distentus* Zone. BRAMLETTE & WILCOXON have mentioned the fact that it is difficult to find *Sphenolithus distentus* and *Sphenolithus predistentus* in the Boom Clay and an extensive search is required to find a few specimens. Discoasters are practically absent from these deposits; whether this is due to climatic reasons or to some sort of facies control cannot be decided at present. The upper part of the Kasseler Meeressande in the abandoned coal pit on the Höllkopf near Glimmerode also belongs to the *Sphenolithus predistentus- Sphenolithus distentus* Zone. *Sphenolithus distentus* and *Sphenolithus predistentus* are quite rare and not easily found. In the Monte Cagnero Section about 10 m of sediment belong to the *Sphenolithus predistentus–Sphenolithus distentus* Zone.

3.3. Upper Oligocene

3.3.1. *Sphenolithus distentus–Sphenolithus ciperoensis* Zone

Definition: Interval with *Sphenolithus distentus* (MARTINI) and *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON from the first occurrence of *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON to the first occurrence of *Triquetrorhabdulus carinatus* MARTINI.

Authors: BRAMLETTE & WILCOXON, 1967, modified by ROTH, in BAUMANN & ROTH, 1969.

Type locality: Sample TTOC 193265, type locality of the *Globorotalia opima* Zone of BOLLI 1957, Cipero Coast, Trinidad (destroyed).

Cotype locality: Monte Cagnero, Italy, samples PB 333–PB 343, most typical sample PB 333.

Important species: Sphenolithus ciperoensis BRAMLETTE & WILCOXON, *Spheolithus distentus* (MARTINI), *Discoaster lidzi* HAY, *Discoaster adamanteus* BRAMLETTE & WILCOXON, *Cyclococcolithus ciperoensis* n. sp., *Helicopontosphaera truncata* (BRAMLETTE & WILCOXON). The following species appear for the last time in this zone: *Ericsonia bireticulata* n. sp., *Reticulofenestra coenura* (REINHARDT), *Reticulofenestra insignita* ROTH & HAY, *Reticulofenestra laevis* ROTH & HAY, *Blackites amplus* ROTH & HAY, *Helicopontosphaera compacta* (BRAMLETTE & WILCOXON), *Discoaster tani ornatus* BRAMLETTE & WILCOXON.

Remarks: Only one sample from Trinidad was vailable (JS 20). It contains a fairly rich but poorly preserved assemblage. The species of the genus *Reticulofenestra* are less abundant than in the underlying zone. An even poorer nannoflora of this zone was found in JOIDES Hole 3 where only the larger species remain, the small species were carried away by currents. Two samples from the Chickasawhay Limestone from Alabama furnished an assemblage of nannofossils that is assigned to the *Sphenolithus distentus–Sphenolithus ciperoensis* Zone since both markers are present and *Triquetrorhabdulus carinatus* was not found.

In Europe the only section where the *Sphenolithus distentus- Sphenolithus ciperoensis* Zone was encountered so far is in the upper part of the Scaglia cinerea of the Monte Cagnero, Italy, where it measures about 20 m. The preservation is very poor but all the markers were recognized.

3.3.2. *Sphenolithus ciperoensis–Triquetrorhabdulus carinatus* Zone

Definition: Interval with *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON and *Triquetrorhabdulus carinatus* MARTINI from the first occurrence of *Triquetrorhabdulus carinatus* MARTINI to the first occurrence of *Sphenolithus belemnos* BRAMLETTE & WILCOXON.

Authors: BRAMLETTE & WILCOXON, modified by ROTH in BAUMANN & ROTH, 1969.

Type locality: Sample TTOC 215656, type locality of the *Globigerina ciperoensis ciperoensis* Zone of BOLLI 1957, Cipero Coast, Trinidad.

Important species: Sphenolithus ciperoensis BRAMLETTE & WILCOXON, *Triquerorhabdulus carinatus* MARTINI, *Cyclococcolithus ciperoensis* n.sp., *Helicopontosphaera truncata* (BRAMLETTE & WILCOXON). *Helicopontosphaera obliqua* (BRAMLETTE & WILCOXON).

Ericosonia fenestrata (DEFLANDRE) and *Reticulofenestra bisecta* (HAY, MOHLER & WADE) were not found in younger zones.

Remarks: Only one sample from Trinidad, collected at the type locality, was studied. It contains a fairly well preserved nannoflora with a large number of species. BRAMLETTE & WILCOXON found this Zone to be less than 6 feet thick in JOIDES Hole 3.

In the Monte Cagnero section the top sample (PB 349) belongs to this Zone since *Triquetrorhabdulus carinatus* and *Sphenolithus ciperoensis* are present.

3.3.3. *Triquetrorhabdulus carinatus–Sphenolithus belemnos* Zone

Definition: Interval with *Triquetrorhabdulus carinatus* (MARTINI) and *Sphenolithus belemnos* BRAMLETTE & WILCOXON from the first occurrence of *Sphenolithus belemnos* BRAMLETTE & WILCOXON to the first occurrence of *Helicopontosphaera ampliaperta* (BRAMLETTE & WILCOXON).

Authors: BRAMLETTE & WILCOXON, modified, this paper.

Type locality: Sample TTOC 206262, close to the type locality of the *Globorotalia kugleri* Zone of BOLLI (1957), Trinidad.

Important species: Triquetrorhabdulus carinatus MARTINI, *Sphenolithus belemnos* BRAMLETTE & WILCOXON (small specimen).

Remarks: The *Triquetrorhabdulus carinatus* Zone of BRAMLETTE & WILCOXON (1967) is more extended than the one defined here which covers only the lower part of the original zone below the first occurrence of *Helicopontosphaera ampliaperta* (BRAMLETTE & WILCOXON) n.comb. [= *Helicosphaera ampliaperta* BRAMLETTE & WILCOXON, 1967, p. 105, pl. 6, figs. 1–4] and *Discoaster druggi* BRAMLETTE & WILCOXON. Sample PR 67* from the San Fernando by-pass in Trinidad with a planktonic foraminiferal fauna characteristic for the *Globorotalia kugleri* Zone was found to belong to this zone. It was collected close to the surface and therefore it is slightly weathered and not very rich. A sample from the type locality of the *Globorotalia kugleri* Zone of BOLLI (1957) examined only in the light microscope, is assigned to the *Triquetrorhabdulus carinatus- Sphenolithus belemnos* Zone. This zone is also present in a sample from JOIDES Hole 3 (270′ below sea floor) where small specimens of *Sphenolithus belemnos* were seen in the electron microscope.

The presence of the *Triquetrorhabdulus carinatus–Sphenolithus belemnos* Zone in Europe has not yet been established.

Until the relation of the Oligocene-Miocene boundary to the *Globorotalia kugleri* Zone is defined, it cannot be decided whether the *Triquetrorhabdulus carinatus–Sphenolithus belemnos* Zone belongs to the Oligocene or to the Miocene or straddles the boundary.

4. BIOSTRATIGRAPHIC DATUM LEVELS

There is growing recognition of the usefulness of datum levels in addition to zones for correlation. A datum level is defined as the surface connecting all the points marked by a certain event in different sections. Events may be the range limits of fossils, geophysical events (e.g. paleomagnetic reversals), lithologic and other stratigraphic marker horizons (e.g. ash beds) or other well defined changes. Ideally these surfaces connecting points marked by events are parallel isochronous planes. In reality this is not always the case as most events observable in nature will not take place everywhere on this planet nor will they necessarily be contemperaneous everywhere. The origin of a new species happens at a distinct time but its first occurrence at different places is not simultaneous due to the spreading time and to ecological barriers which can hinder or prevent migration into areas other than that of the original appearance. Since datum levels are essentially means of dating and correlation, they should be attached to events which are believed to have occurred in the same manner and at the same time in widely spaced areas, and not to a single observation point. Datum levels can only be applied reliably after careful study of many sections and after the overall fossil composition has been taken into consideration. A certain species can be absent or very rare at a certain level and reappear or become more abundant again higher up in the section. This can either be caused by adverse ecological conditions, solution of delicate forms after or during deposition, winnowing by fluctuating currents, or recrystallisation in the sediment. A certain species can also become so rare at a certain level that it can not be detected in a sample of average size. Zones can often be recognized even if the marker species are absent by using other characteristic species. Datum levels can be combined into informal units as suggested by HORNIBROOK (in press). Datum levels form very flexible means for subdivision of strata and long distance correlation. JENKINS (1966) suggested a great number of datum levels based on planktonic