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2. SECTIONS STUDIED

2.1. American sections

2.1.1. JOIDES Blake Plateau cores

In 1965 six cores were taken on the Florida continental shelf, on the Florida-Hatteras Slope, and on the Blake Plateau by the drilling vessel M. V. Caldrill while involved in the JOIDES Deep Earth Sampling Programme (BUNCE & al. 1965). The thickest Oligocene section was encountered in Hole 5 (30° 23' N, 80° 08' W) between 67.1 and 229.2 meters drilled in the Florida-Hatteras slope. It consists of whitish-grey calcilutites with a high content of silicious microfossils. Sediments of Upper Oligocene and Miocene age are missing and the Middle Oligocene beds are covered with Post-Miocene foraminiferal sands. In Hole 3 (28° 30' N, 77° 31 W) and Hole 6 (30° 05' N, 79° 15' W) which were drilled in the Blake Plateau, the Oligocene consists of white Coccolith-Globigerina oozes. Winnowing seems to have left only the larger nannofossils, so that it was not always possible to find the small Lower Oligocene markers. Only a few samples from these two sections were studied. The Upper Oligocene is well represented in Hole 3 but somewhat condensed.

Samples studied:

Hole 5:

Sample	Depth below sea floor	Sample	Depth below sea floor
J510	248′ 9″	J517	500′
J509	260′ 2″	J502	519′ 2″
J508	303′11″	J516	530
J507	337′11″	J501	554′10″
J506	374	J515	589′11″
J505	410′	J514	625′
J519	429′ 9″	J513	657′10″
J504	445′	J512	730′
J518	460′ 5 1/2″	J511	800′
J503	484′		

Hole 6:

Sample	Depth below sea floor
J605	143′ 9″
J604	149′ 7″
J603	162′11″
J602	188′ 4″
J601	199′11″

Hole 3:

Sample	Depth below sea floor
J3-270	271 5″
J3-286	286′
J3-306	306′
J3-323	323′11″
J3-397	397′11″
J3-475	475′11″
J3-494	494′

2.1.2. Alabama

A very complete section through the U.S. Gulf Coast Oligocene was collected with Prof. W. W. Hay in the Lone Star Cement Company Quarry near St. Stephens, Clark County, Alabama, U.S.A. For a geological sketch map and stratigraphical section see LEVIN and JOERGER (1967) and JONES (1967); for more stratigraphical detail see MURRAY (1961). The entire section from the Upper Eocene to the Upper Oligocene is marine and most of it very fossiliferous. The Upper Eocene Yazoo Clay consists of blue-grey sandy and somewhat glauconitic marls. It contains *Cribrohantkenina inflata* (see DEBOO 1965), *Discoaster barbadiensis* and *Discoaster saipanensis* indicating an Upper Eocene age. The Red Bluff Clay is composed of 13.5 feet of interbedded greenish-grey limestones and olive to gray glauconitic marls. Eocene markers are absent except for occasional damaged specimens of Upper Eocene foraminifera. No trace of reworked Eocene nannoplakton could be found in any part of this section. Above the Red Bluff is 9 feet of brown carbonaceous sparingly fossiliferous sandy clays, the Forest Hill Sand. This is overlain by 59 feet of soft cream colored limestones containing *Lepidocyclina mantelli* (MORTON). The Byram Formation begins with 12 feet of Glendon Limestone, a white irregularly indurated skeletal limestone, practically devoid of nannofossils. On top of the Glendon Limestone lies an unnamed Clay Member consisting of 1 foot of olive, glauconic marl with nannofossils. The Bucatunna Clay Member which follows above is composed of 26 feet of grey to black gypsiferous clays, completely barren of nannofossils. The Oligocene part of the section ends with the Chickasawhay Limestone, an alternation of grey marls and marly limestones, 19 feet thick. Information on the Alabama Tertiary can be found in the guidebooks edited by COPELAND (1966) and by JONES (1967).

Samples studied:

Rock unit	Sample number	Stratigraphical distance from base of rock unit
Chickasawhay	A 128	8′
Limestone	A 124	4′
Unnamed Clay Member	A 100	0
Marianna	A 853	53′
Limestone	A 848	48′
	A 843	43′
	A 839	39′
	A 833	33′
	A 827	27′
	A 821	21′
	A 815	15′
	A 809	9′
	A 805	5′
	A 800	0
Red Bluff Clay	A 613	13′
	A 610	10′
	A 608	8′
	A 606	6′
	A 604	4′
	A 600	0

2.1.3. Barbados

A short section through the Oligocene part of the Oceanic Formation at the Bath Cliff was collected by Roth, Saunders and Hay in 1967. The sediments are white foraminiferal marls which sometimes have a chalky appearance. The stratigraphy and the planktonic foraminifera were described by SAUNDERS & CORDEY (1969) and mentioned by BLOW (1969). The bottom part of the Bath Cliff section is rich in radio-

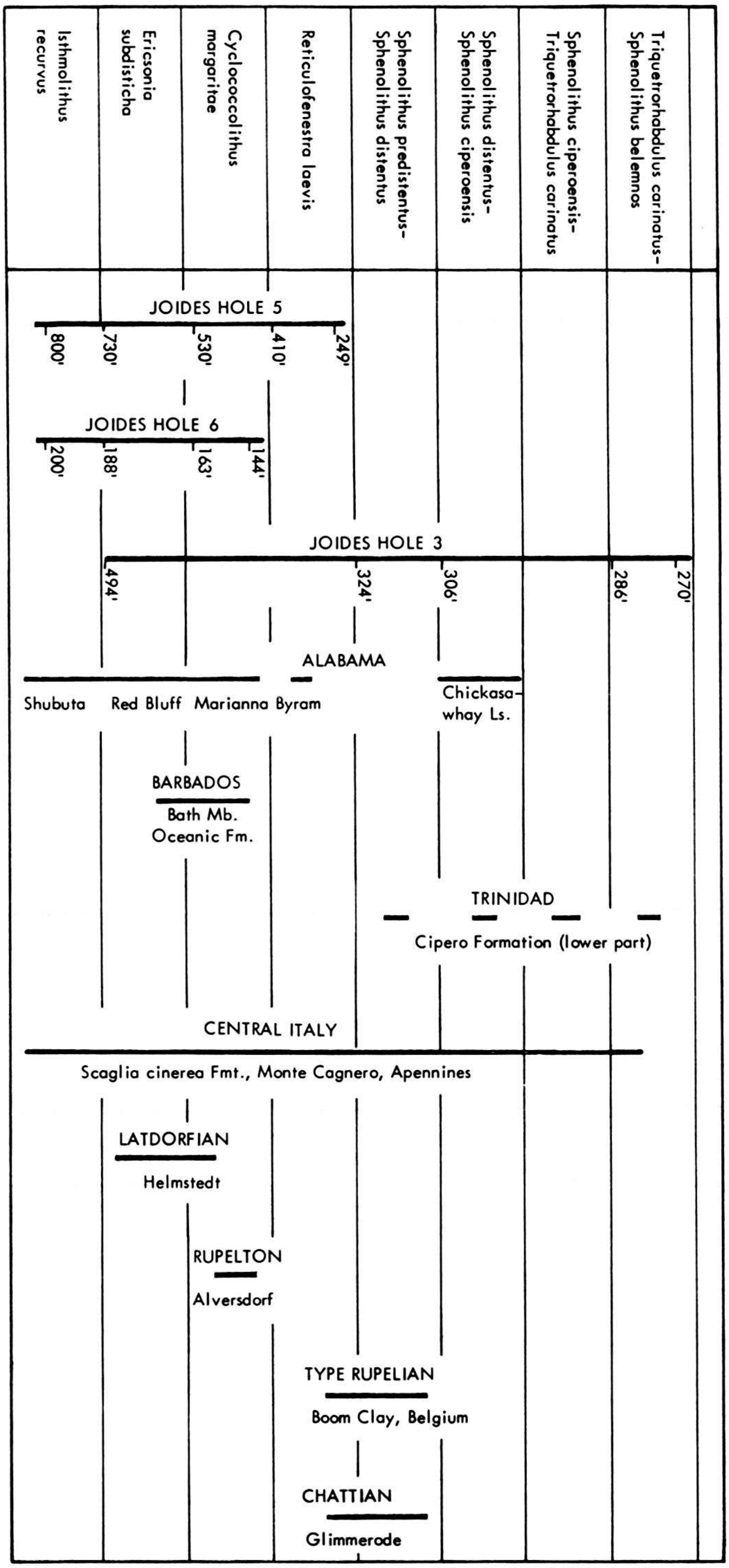

Fig. 4. Biostratigraphic extent of the studied sections.

laria and contains several volcanic ash beds. In the upper half of the lower section at Bath Cliff planktonic foraminifera become more abundant. They are of Uppeɪ Eocene age and the sediments also contain an Upper Eocene nannoflora (cf. HAY & al., 1967).

The Eocene-Oligocene boundary is not exposed at Bath Cliff but is covered by vegetation (between the lower and middle parts of the section). The middle part of the section (JS 1066–JS 1068), consisting of white foraminiferal marl, belongs to the Oligocene and contains the type locality JS 1066 for Zone P18 (*Globigerina tapuriensis* Zone of BLOW, 1969). Another covered interval separates this from the upper part of the section (JS 1069–JS 1072). The lithology is the same as in the middle part. All the samples collected are listed below. Only five samples (indicated with an asterisk) contain nannofossils which are sufficently well preserved for detailed studies. All the samples which are underlined in the list below are on the map and chart of SAUNDERS & CORDEY (1969). For more details on the stratigraphy of Barbados we refer to SAUNDERS & CORDEY (1969) and to the excursion guide by SAUNDERS (1969).

Bath Cliff section

Part of section	Sample number	Nannofossil content	Stratigraphical distance from top of part
Upper	JS 1072	poor	4′
	JS 1854*	rich	10′
	JS 1855	poor	16′
	JS 1071	poor	20′
	JS 1070	poor	28′
	JS 1856*	rich	33′
	JS 1069	poor	38′
Middle	JS 1857	poor	1′
	JS 1068*	rich	3′
	JS 1067	poor	6′
	JS 1858*	rich	9′
	JS 1066*	rich	15′ (= base of middle part)

2.1.4. Trinidad

Five samples from the Upper Oligocene part of the Cipero Formation of Trinidad were studied in detail with the electron and light microscope. They were collected with Prof. W. W. Hay and J. B. Saunders during a visit to Trinidad in 1967 shortly before most of the Cipero Section was destroyed. The sample from the *Globigerina ampliapertura* Zone is a dark grey marl, the remaining samples consist of brownish to grey foraminiferal marls. Details on the Cipero Formation and the geology of the Cipero Coast can be found in BOLLI (1957), pp. 103–105, BARR & SAUNDERS (1969) and in SAUNDERS & CATER (1969).

Samples studied:

PR 67* from the *Globorotalia kugleri* Zone, San Fernando by-pass, close to JS 267, type locality of the *Catpsydrax dissimilis* Zone of BOLLI (1957) (see SAUNDERS & CARTER, p. 434, fig. 2, stop 5), Bo 291 A′ type locality of the *Globigerina ciperoensis ciperoensis* Zone of BOLLI (1957), Cipero Coast, now destroyed. JS 20, type locality of the *Globorotalia opima opima* Zone of BOLLI (1957), Cipero Coast, now destroyed. JS 1847, *Globigerina ampliapertura* Zone, about 90 m south of locality JS 20, tidal flat, Cipero Coast, now destroyed.

2.2. European sections

2.2.1. Silberbeıg Formation (Latdorfian)

A section of the Silberberg Formation was collected with the help of Dr. F. Gramann and Dr. S. Ritzkowski in the coal pit Treue Baufeld IV, near Helmstedt, Northern Germany (for a map of the locality see fig. 5, for more stratigraphic information see MARTINI & RITZKOWSKI, 1968, and ANDERSON & al., 1969). Above the Middle Eocene coal beds occur the sands, marls and conglomerates of the Annenberg Formation (= lower part of the Helmstedter Gründsand, "Lage mit Pleurotomarien" of MARTINI & RITZKOWSKI). These sediments contain a nannoflora typical for the *Chiphragmalitus alatus* Zone. They grade into the overlying Gehlberg Formation, which consists of glauconitic sands with phosphatic nodules lacking any calcareous fossils. The Gehlberg Formation is overlain by grey, sandy marls of the Silberberg Formation which contain fairly rich nannoplankton and foraminifera assemblages. Another exposure of the Silberberg Formation is at the clay pit on the Silberberg (see MARTINI & RITZKOWSKI, 1968). Unfortunately the section is terminated by Pleistocene glacial drift as in the case of the section in coal pit Treue IV. Middle Oligocene beds do not occur above the Lower Oligocene Silberberg beds at this locality. This factor along with the sterility of the glauconitic sands at the base are the main disadvantages of this section. But it is still one of the best Lower Oligocene sections directly comparable with the type section of the Latdorfian (see MARTINI & RITZKOWSKI, 1968, and MARTINI, 1969). Not far away from the exposures of the Silberberg Formation, the Rupelton which is only slightly younger than the top of the Silberberg Formation in the Silberberg clay pit (both belonging to the *Cyclococcolithus margaritae* Zone), crops out in a clay pit (Brick yard Alversdorf).

Samples studied:

Treue Baufeld IV. coal pit:

Sample number	Distance from base of Silberberg Formation
PR 68/63	18 m
PR 68/62	16 m
PR 68/61	14 m
PR 68/60	12 m
PR 68/59	10 m
PR 68/58	8 m
PR 68/57	5 m
PR 68/56	4 m
PR 68/55	3 m
PR 68/54	2 m

Silberberg clay pit:

PR 68/70	1 m above limestone bed (Clays with *Ostrea queteleti*)
PR 68/69	0.5 m below limestone bed
PR 68/68	2 m below limestone bed

2.2.2. Rupelton of Germany

Only two samples from the German Middle Oligocene were studied (PR 68/64, PR 68/67). They were collected in the clay pit Alversdorf (see fig. 5) Helmstedt and

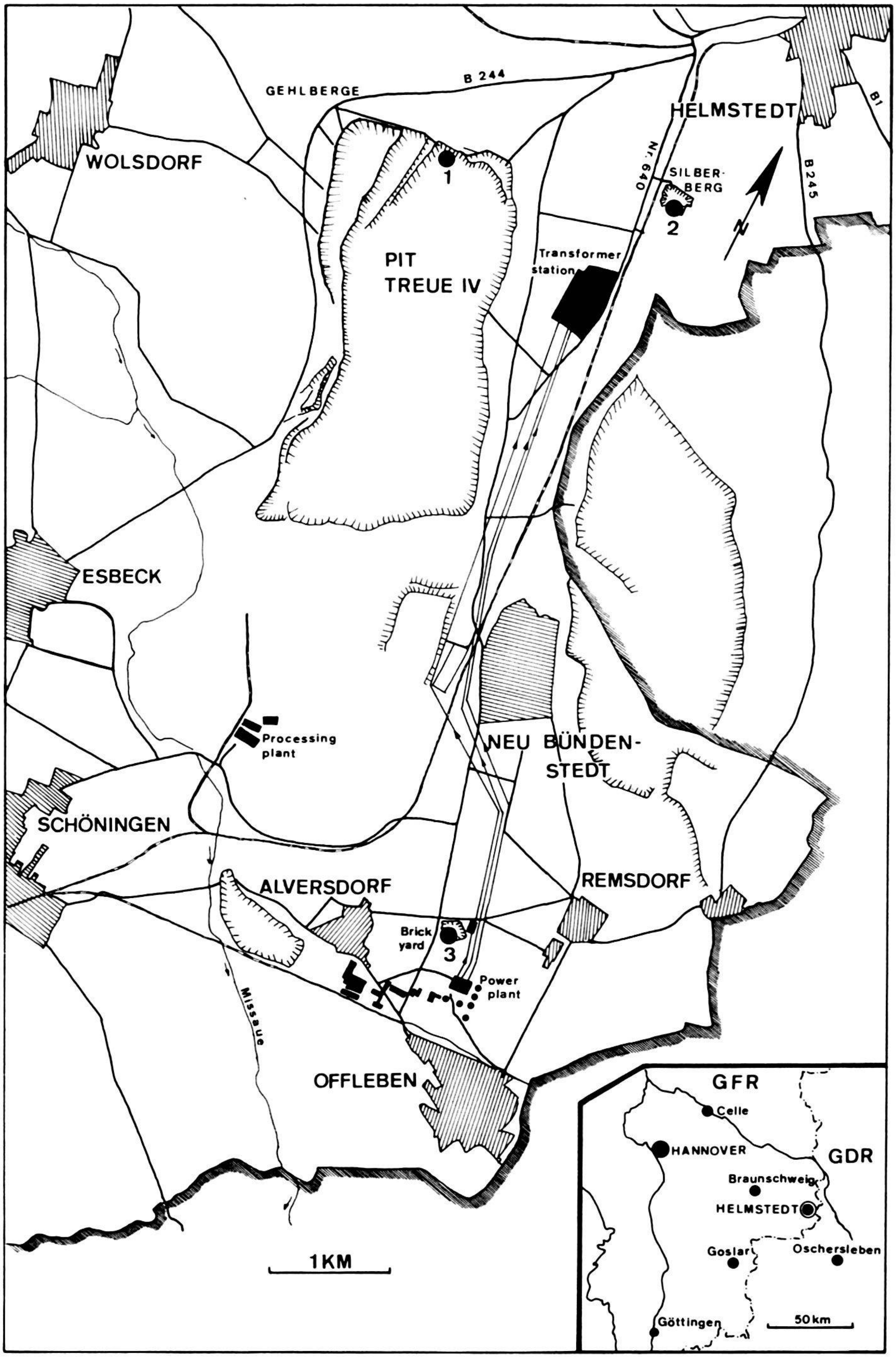

Fig. 5. Sketch map of the Oligocene localities in the Helmstedt area.
1: Latdorfian section at the coal pit Treue IV.
2: Latdorfian section at the clay pit Silberberg.
3: Section of Rupelton at the clay pit Alversdorf.

consist of grey, slightly sandy clay. The exact stratigraphic position of the two samples could not be determined; they were taken from the wall of the shallow pit (ca. 3 m deep) about 10 m apart. Accurate correlation of the Northern German Rupelton with the Boom Clay has not been possible up to the present (see SPIEGLER 1965). These two samples proved to be somewhat older than the Type Rupelian (Boom Clay), and contain many reworked Cretaceous coccoliths.

2.2.3. Boom Clay (Belgium)

Eleven samples from the type Rupelian Boom Clay of Belgium, collected by Prof. H. Schaub (Basel) were studied. For details on the Oligocene stratigraphy of Belgium, see BATJES (1958). The samples from the Brick Yard "Scheerders-Van Kerkhoven (S.V.K.)" near St. Nicolas were so poor in nannoplankton that detailed study was not possible. The samples from the Brick Yard "De Roeck & Verstrepen" proved to be fairly rich in nannoplankton. They consist of grey to bluish-grey clays and silty clays (see BATJES, 1958, fig. 8, section M. W).

Samples studied:

Ru 11:	exact location in the pit not known
Ru 9b:	5.1 m above the base of pit
Ru 7:	2.0 m above the base
Ru 6:	1.0 m above the base
Ru 5:	base of pit

2.2.4. Höllkopf near Glimmerode (Chattian)

It was difficult to find a suitable Chattian section because most of them lie above the ground water level and have been leached of calcium carbonate. RITZKOWSKI (1967), however, has described a section from the Höllkopf near Glimmerode where the Kasseler Meeressand is not leached. The sediments are sands, sandy marls and silts with four layers of concretions (layers A–D) and three shell beds (see fig. 10 in RITZKOWSKI, 1967). Correlation with the type locality of the Chattian, the Gelbe Berg near Niederkaufung has not yet been attempted. Many reworked Cretaceous coccoliths occur.

The following samples were studied:

PR 68/13:	about 5 m above Concretion layer D
PR 68/12:	about 0.5 m above Concretion layer D
PR 68/11:	about 0.5 m below Concretion layer D
PR 68/18:	about 1 m above Concretion layer A

2.2.5. Monte Cagnero, Central Italy

Samples from a section of the Scaglia cinerea collected by P. Baumann were studied. The strata consist of grey to brown-grey calcareous shales. The locality and stratigraphy are described in detail in BAUMANN & ROTH (1969) and in BAUMANN (1970). The nannoflora is only poorly preserved but it was possible to recognize the important zonal markers and correlate the nannofossil zones with BAUMANN's planktonic foraminiferal Zones (see BAUMANN & ROTH, 1969, fig. 2).

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*