Planktonic Foraminifera from the Eocene Navet and San Fernando Formations of Trinidad, B. W. I.

By Hans M. Bolli [1]

Introduction

THIS PAPER CONTAINS the results of a study of planktonic Foraminifera and their stratigraphic distribution in the Eocene Navet and San Fernando formations. It represents the link between similar investigations in the Paleocene-lower Eocene Lizard Springs formation and the Oligocene-Miocene Cipero and Lengua formations. Planktonic Foraminifera have been chosen for the biostratigraphic subdivision of the Navet and San Fernando formations on account of their abundance and the short life ranges of many species. The species and subspecies of the genera *Hantkenina*, *Cribrohantkenina*, *Chiloguembelina* and related genera are omitted because they have previously been described in detail by Bronnimann (1950a, b) and by Beckmann (1957). The stratigraphic distribution of the Chiloguembelinae given by Beckmann is based on the same zonation as is proposed here; that of the Hantkeninae and Cribrohantkeninae was given in more generalized terms by Bronnimann and a few remarks on how the more characteristic species fit into the present zonation are made.

The smaller Foraminifera of the Navet formation have previously been described by Cushman and Renz (1948). The Orbulinidae were purposely left out by these authors, and of the Globorotaliidae only 4 species were included. The Ramdat marl, which is now placed in the Lizard Springs formation (Bolli, 1957a), was regarded as the basal part of the Navet formation and the Hospital Hill marl, now included in the Navet formation, was treated as a formation of its own. The fauna described by Cushman and Renz was collected from several isolated outcrops in the Central Range and Naparima area of Trinidad, each containing a distinct foraminiferal assemblage based on which the authors proposed a tentative stratigraphic sequence.

Unlike the Upper Cretaceous formations, the Paleocene-lower Eocene Lizard Springs formation, and the Oligocene-Miocene Cipero and Lengua formations, in all of which some comparatively undisturbed surface or subsurface sections are known, the Navet and San Fernando formations outcrop only in small, isolated masses in tectonically strongly disturbed areas. At the present time not one reasonably complete surface or subsurface section is known.

Because of this virtual absence of continuous sections the present investigations had to be confined to isolated outcrops and subsurface samples, altogether about 50 in number. This was found to be a great handicap for detailed biostratigraphic and evolutionary studies. Only because many planktonic species have a short life range or show rapid morphological changes during their evolution has it been possible to establish the proposed zonation of the middle and upper Eocene of Trinidad. It still remains doubtful whether the zones given here represent a complete sequence of beds.

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Stratigraphy

Navet Formation

The term Navet formation was introduced by Renz (1942) for the characteristic light grey to greenish-grey, khaki-weathering, nodular marls occurring between the Paleocene-lower Eocene Lizard Springs formation and the upper Eocene San Fernando formation. They contain a very rich fauna of smaller Foraminifera, especially planktonic forms, and at some levels are also rich in Radiolaria.

In their paper on the Eocene Foraminifera of the Navet and Hospital Hill formations of Trinidad, Cushman and Renz (1948) described the fauna from seven isolated localities. Tentative stratigraphic positions based on faunistic evidence for these localities were given from top to bottom as follows:

Penitence Hill marl
Fitt Trace—Navet River—Nariva River marls
Friendship Quarry—Dunmore Hill marls
Ramdat marl

For faunistic and lithologic reasons the Ramdat marl has been moved to the Lizard Springs formation (Bolli, 1957a, p. 64). No clear break has been recognized between the Lizard Springs and Navet formations. The *Globorotalia palmerae* zone, here placed in the basal Navet, occupies a somewhat transitional position between the two formations. The calcium carbonate content as measured at the type localities does not exceed 10 to 15 percent in the lower Lizard Springs and 25 percent in the upper Lizard Springs but increases to 36 percent in the *Globorotalia palmerae* zone and between 50 and 70 percent in the higher Navet beds.

The Hospital Hill marl was treated by Cushman and Renz as a separate formation. However, it is lithologically so similar to the Navet formation that it is here considered to represent its topmost zone. To the author's knowledge, no contacts are exposed between the marls of the Navet formation and the clays, silts, sands, and boulder beds of the younger San Fernando formation. The Navet formation is here regarded as comprising the uppermost part of the lower Eocene, the middle Eocene, and the lower part of the upper Eocene.

The complete absence of continuous sections in the Navet formation and the difficulty in establishing biostratigraphic sequences from isolated, small outcrops and subsurface occurrences has already been pointed out in the introduction. The large number of samples studied has counterbalanced these unfavourable conditions to some degree. The additional material studied has enabled the erection of two more zones to the subdivisions suggested by Cushman and Renz (1948):

The *Globorotalia palmerae* zone: This zone shows affinities to the *Globorotalia aragonensis* zone of the uppermost Lizard Springs but contains in addition *Globorotalia aspensis* (Colom) and the short-lived *Globorotalia palmerae* Cushman and Bermudez. The genera *Hantkenina* and *Clavigerinella*, both restricted to the middle and upper Eocene are not found here. It is regarded as uppermost lower Eocene (basal Navet).

The *Truncorotaloides rohri* zone: This zone still contains the spinose forms of the *Truncorotaloides rohri* Bronnimann and Bermudez group and small specimens of *Globorotalia lehneri* Cushman and Jarvis but no longer *Globigerapsis kugleri* Bolli, Loeblich, and Tappan and the zonal marker of the *Porticulasphaera mexicana* zone. Some species known in the upper Eocene and lower Oligocene begin to appear, but the zonal marker of the *Globigerapsis semiinvoluta* zone (Hospital Hill marl) is not yet present. It is considered to be of uppermost middle Eocene age.

Seven zones, based on the distribution of planktonic Foraminifera, are distinguished in the proposed biostratigraphic subdivision of the Navet formation. The following tabulation (see also text-figures 25 and 26) shows the Navet marl localities described by Cushman and Renz in relation to the new zonation. They are from top to bottom:

Globigerapsis semiinvoluta zone	Hospital Hill formation
Truncorotaloides rohri zone	
Porticulasphaera mexicana zone	Penitence Hill marl
Globorotalia lehneri zone	Fitt Trace marl–Navet River marl
Globigerapsis kugleri zone	Dunmore Hill marl–Nariva River marl
Hantkenina aragonensis zone	Friendship Quarry marl
Globorotalia palmerae zone	

Some of the Navet marl localities given by Cushman and Renz contain poorly preserved faunas, this is especially true for the Friendship Quarry marl. One of them, the Penitence Hill marl locality, is no longer accessible. Therefore, in addition to the Cushman and Renz localities which are here maintained as type localities, a number of outcrops which contain better preserved faunas are proposed as cotype localities. A very suitable area for such outcrops is found between mileposts 12 and 12¾ of the Brasso-Tamana Road and the Navet River in the Central Range (see text-fig. 25). All but one zone of the Navet formation, including a new type locality, are here exposed in a very restricted and comparatively easily accessible area. Most of the outcrops lie in two small ravines leading into the Navet River. A few are found along the Navet River and two more are situated further north, one on the Brasso-Tamana Road, near milepost 12¾, the other west of the road, on the slope of a small marl hill. Although almost every zone is represented in this area, they are not in any normal stratigraphic sequence, the Navet being present as slip-masses in the upper Oligocene-lower Miocene Nariva formation.

Globorotalia palmerae Zone

TYPE LOCALITY: Trinidad Petroleum Development well Esmeralda 1, eastern Central Range, Trinidad (coordinates N:270297 links; E:415893 links), type sample: core 9,386–9,405 feet (TTOC 228911).

SKETCH MAP
SHOWING
EXPOSURES OF NAVET
IN THE
CENTRAL RANGE, TRINIDAD
by K. Rohr

LEGEND

Zones of the Navet Formation

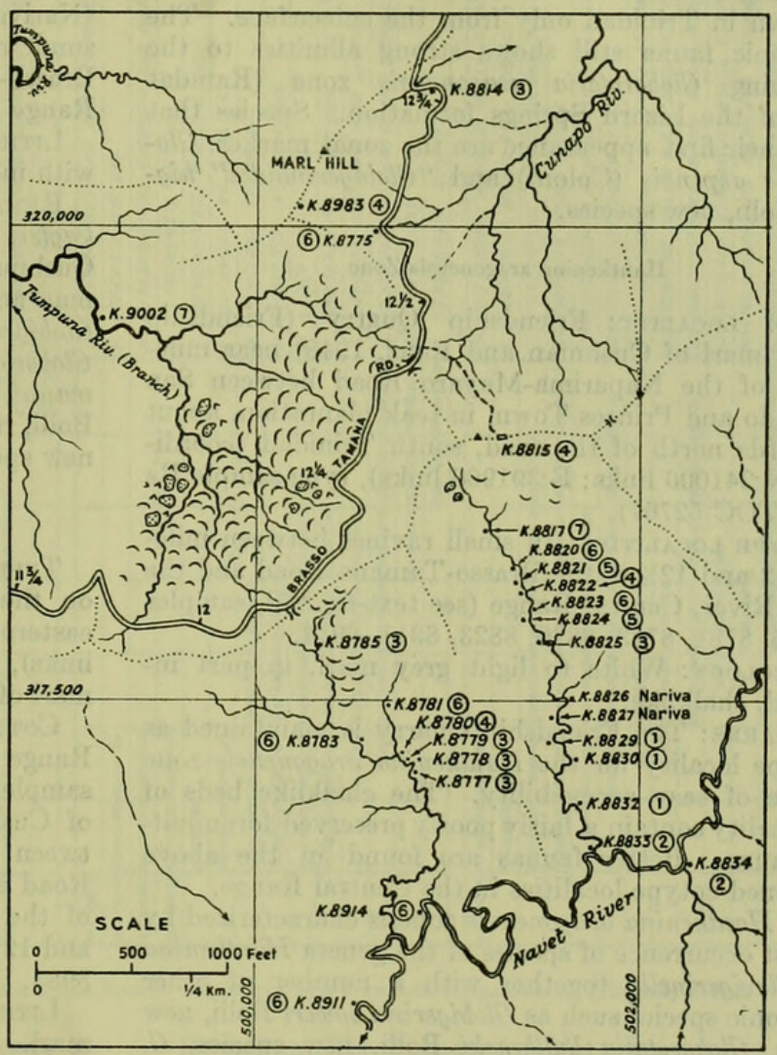
① *Globigerapsis semiinvoluta*
② *Truncorotaloides rohri*
③ *Porticulasphaera mexicana*
④ *Globorotalia lehneri*
⑤ *Globigerapsis kugleri*
⑥ *Hantkenina aragonensis*
⑦ *aff. Hantkenina aragonensis*

Area under review

Eocene Plaisance conglomerate blocks

Extensive landslips in argillaceous areas

Hill tops
Saddles on watersheds
Old test pit
Mile Post



KEY MAP

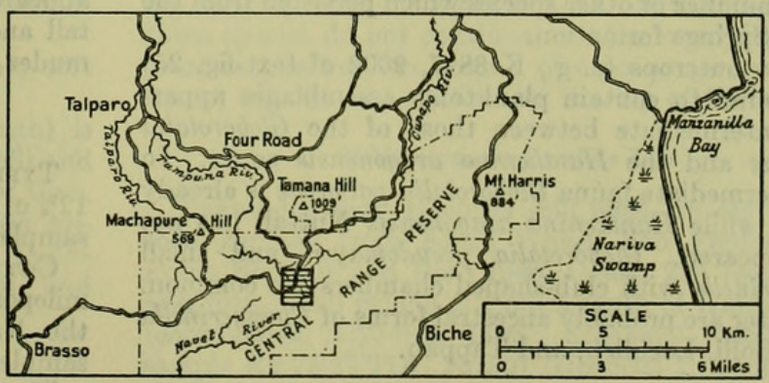


FIGURE 25.—Exposures of the Navet formation in the Central Range, Trinidad, B.W.I.

LITHOLOGY: Dark red, indurated marl type with pale green blotches.

REMARKS: At present the *Globorotalia palmerae* zone is known in Trinidad only from the subsurface. The planktonic fauna still shows strong affinities to the underlying *Globorotalia aragonensis* zone (Ramdat marl) of the Lizard Springs formation. Species that make their first appearance are the zonal marker, *Globorotalia aspensis* (Colom) and *"Globigerinoides" higginsi* Bolli, new species.

Hantkenina aragonensis Zone

TYPE LOCALITY: Friendship Quarry (Friendship Quarry marl of Cushman and Renz, 1948) near milepost 5 of the Naparima-Mayaro Road between San Fernando and Princes Town, in teak plantation, about 100 yards north of the road, south Trinidad (coordinates N:241000 links; E:391900 links), type sample Rz 336 (TTOC 52767).

COTYPE LOCALITIES: In small ravines between mileposts 12 and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text-fig. 25), samples K 8775, 8781, 8783, 8820, 8823, 8911, 8914.

LITHOLOGY: White to light grey marl, in part indurated, chalklike.

REMARKS: The Friendship Quarry is maintained as the type locality for the *Hantkenina aragonensis* zone because of easy accessibility. The chalklike beds of this locality contain a fairly poorly preserved foraminiferal fauna. Better faunas are found in the above mentioned cotype localities in the Central Range.

The *Hantkenina aragonensis* zone is characterized by the first occurrence of species of the genera *Hantkenina* and *Clavigerinella* together with a number of other planktonic species such as *Globigerina boweri* Bolli, new species, *Globorotalia bullbrooki* Bolli, new species, *G. spinulosa* Cushman, *G. pseudomayeri* Bolli, new species, and *G. spinuloinflata* (Bandy). *G. palmerae* Cushman and Bermudez, which is typical for the underlying *Globorotalia palmerae* zone, has disappeared together with a number of other species which persisted from the Lizard Springs formation.

A few outcrops (e. g., K 8817, 9002 of text-fig. 25) were found to contain planktonic assemblages apparently intermediate between those of the *Globorotalia palmerae* and the *Hantkenina aragonensis* zones. In this intermediate fauna *Globorotalia palmerae* is already extinct while *Hantkenina aragonensis* Nuttall has not yet appeared. *Globorotalia pseudomayeri* and small *Clavigerinella* with club-shaped chambers are common. The latter are probably ancestral forms of *Clavigerinella akersi* Bolli, Loeblich, and Tappan.

Globigerapsis kugleri Zone

TYPE LOCALITY: Hindustan-Monkey Town Road Junction, Dunmore Hill area, south Trinidad (coordinates N:229700 links; E:434500 links), type sample Rz 476 (TTOC 63610) (Dunmore Hill marl of Cushman and Renz, 1948).

COTYPE LOCALITIES: Nariva River, eastern Central Range (coordinates N:314460 links; E:486945 links), samples Gunther 7865, 7200–7204 (Shell Trinidad) (Nariva River marl of Cushman and Renz, 1948); in small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text fig. 25), samples K 8821, 8824.

LITHOLOGY: Light grey, yellowish weathering marl, with indurated layers.

REMARKS: *Globigerapsis index* (Finlay), *Globigerapsis kugleri* Bolli, Loeblich, and Tappan, *Globorotalia lehneri* Cushman and Jarvis, and *Globorotalia centralis* Cushman and Bermudez make their first appearance in the *Globigerapsis kugleri* zone, while several species, e. g., *Globorotalia aragonensis* Nuttall, *Globorotalia broedermanni* Cushman and Bermudez, *Globigerina boweri* Bolli, new species, and *"Globigerinoides" higginsi* Bolli, new species, become extinct at the top of this zone.

Globorotalia lehneri Zone

TYPE LOCALITY: Outcrop on roadside near Fitt Trace on the Cunapo Southern Road, near milepost 17¼, eastern Trinidad (coordinates N:311300 links; E:528110 links), type sample KS 233 (TTOC 18360) (Fitt Trace marl of Cushman and Renz, 1948).

COTYPE LOCALITIES: Navet River, eastern Central Range (coordinates N:317120 links; E:500660 links), sample KR 4347a (TTOC 1285). (Navet River marl of Cushman and Renz, 1948). In small ravines between mileposts 12 and 12½ of the Brasso-Tamana Road and the Navet River, Central Range, and west of the Brasso-Tamana Road, between mileposts 12½ and 12¾ (see text-fig. 25), samples K 8780, 8815, 8822, 8983.

LITHOLOGY: Light grey, yellowish weathering, soft marl.

REMARKS: In addition to the zonal marker the *Globorotalia lehneri* zone is characterized by *Globigerapsis kugleri* Bolli, Loeblich and Tappan and *Globigerinatheka barri* Bronnimann which makes its first appearance in this zone. *Globorotalia aragonensis* Nuttall and *Globorotalia broedermanni* Cushman and Bermudez do not extend into this zone.

Porticulasphaera mexicana Zone

TYPE LOCALITY: Outcrop in road cut near milepost 12¾ of the Brasso-Tamana Road, Central Range, type sample K 8814 (see text-fig. 25).

COTYPE LOCALITIES: In small ravines between the mileposts 12 and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text-fig. 25), samples K 8777, 8778, 8779, 8785, 8825.

The Penitence Hill marl of Cushman and Renz (1948) which falls in the *Porticulasphaera mexicana* zone is no longer accessible. It was described from the foundation of the Town Hall, Penitence Hill, San Fernando, south Trinidad.

A small block of *Porticulasphaera mexicana* zone, Navet, containing an exceptionally well preserved

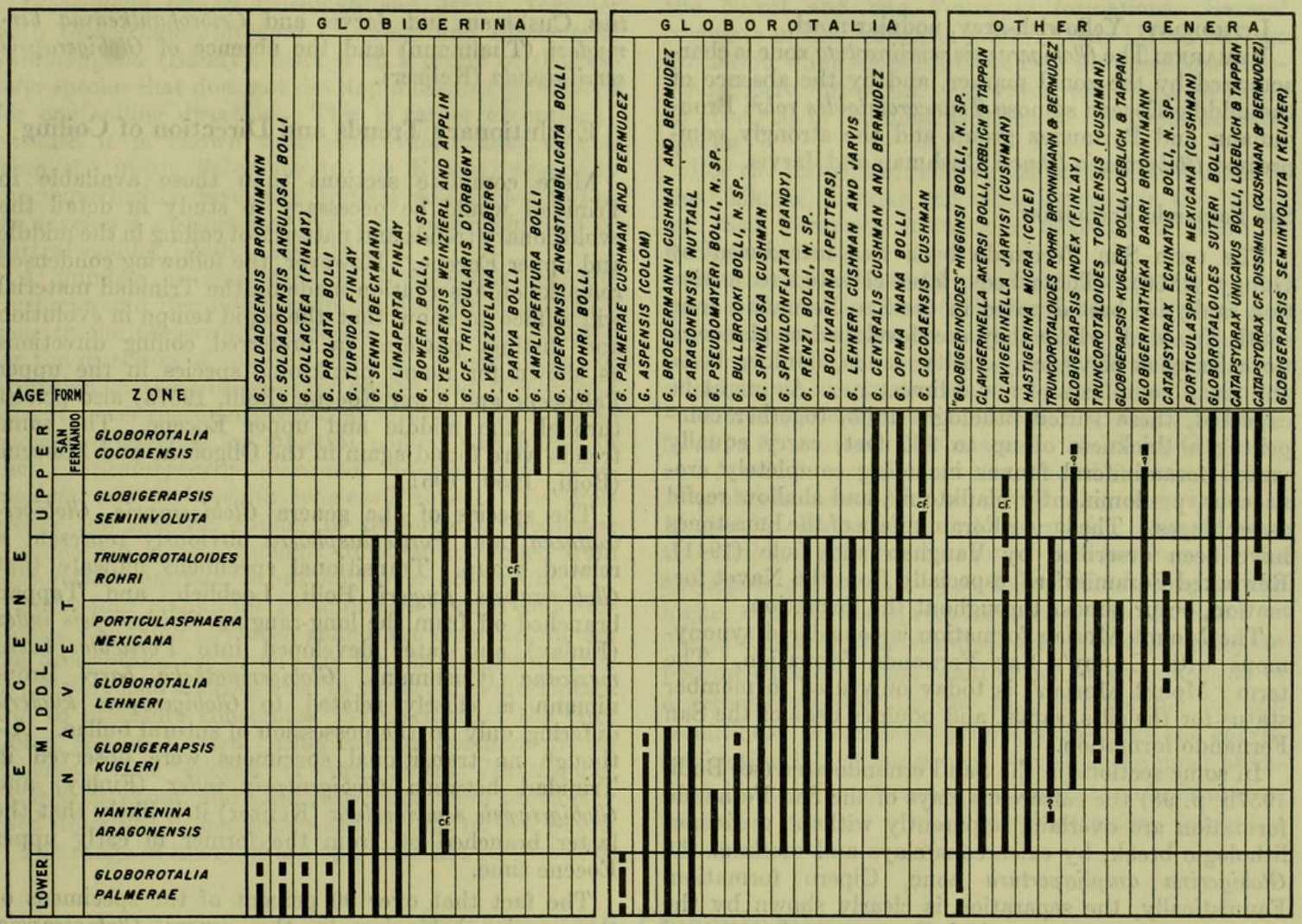


FIGURE 26.—Distribution of planktonic Foraminifera in the Eocene Navet and San Fernando formations of Trinidad, B.W.I.

fauna was found reworked in the upper Oligocene to lower Miocene Nariva formation in the cutting west of tank 127, situated south of The Avenue and 850 feet west of its junction with Bon Accord Road, Pointe-a-Pierre. Many of the specimens illustrated in this paper are from this block, which is no longer existant. (Sample Hg 8581, TTOC 215782).

LITHOLOGY: Light grey, yellowish weathering, soft marl.

REMARKS: *Porticulasphaera mexicana* (Cushman) is restricted to this zone. *Globorotaloides suteri* Bolli and *Globigerina venezuelana* Hedberg occur for the first time, while *Globorotalia spinulosa* Cushman, *Globorotalia spinuloinflata* (Bandy), *Truncorotaloides topilensis* (Cushman), and *Globigerapsis kugleri* Bolli, Loeblich, and Tappan become extinct at the top of the zone.

Truncorotaloides rohri Zone

TYPE LOCALITY: Outcrop (see text-fig. 25) in Navet River, Central Range (coordinates N:316640 links; E:502260 links), type sample K 8834 (TTOC 177773), outcrop K 8833 contains an identical fauna.

LITHOLOGY: Yellowish grey, soft marl.

REMARKS: The *Truncorotaloides rohri* zone is characterized by the persistence of the spinose *Truncorotaloides rohri* Bronnimann and Bermudez group and small specimens of the strongly compressed *Globorotalia lehneri* Cushman and Jarvis. In contrast to *Globigerapsis index* (Finlay) and *Globigerinatheka barri* Bronnimann, these species do not continue into the overlying *Globigerapsis simiinvoluta* zone. *Globigerina senni* (Beckmann) also becomes extinct at the top of the zone.

Globigerapsis semiinvoluta Zone

TYPE LOCALITY: Hospital Hill marl, on east side of road running from Kings Wharf, San Fernando, to Point Bontour and the Cipero Coast, 235 feet northeast from small bridge, 0.2 miles south of Kings Wharf (coordinates N:234850 links; E:355650 links), type sample Rz 75 (TTOC 23130) (Hospital Hill formation of Cushman and Renz).

COTYPE LOCALITIES: In small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text-fig. 25), samples K 8829, 8830, 8832 (TTOC 177769, 177770, 177771).

LITHOLOGY: Yellowish-grey, nodular marl.

REMARKS: The *Globigerapsis semiinvoluta* zone is characterized by the zonal marker, and by the absence of the middle Eocene spinose *Truncorotaloides rohri* Bronnimann and Bermudez group and the strongly compressed *Globorotalia lehneri* Cushman and Jarvis.

San Fernando Formation

The term San Fernando beds was introduced by Guppy (1866). These beds, later elevated to formation rank, are best exposed in the San Fernando area, south Trinidad, where they are developed as glauconitic calcareous clays, clays, silts, sands, boulder beds, and small complexes of reefal limestone. As might be expected, these varied lithologic units, together comprising a thickness of up to 800 feet, carry equally varied foraminiferal faunas including completely arenaceous, predominantly planktonic, and shallow reefal assemblages. The larger Foraminifera of the limestones have been described by Vaughan and Cole (1941). Reworked Foraminifera, especially from the Navet formation, occur almost throughout the formation.

The Mount Moriah formation is considered synonymous with Guppy's San Fernando formation. The term "Mount Moriah" is today only used in member status for the silts, sands, and boulder beds of the San Fernando formation.

In some sections in the San Fernando area (see Bolli, 1957b, p. 98) the calcareous clays of the San Fernando formation are overlain, apparently without a distinct lithologic break, by calcareous clays and marls of the *Globigerina ampliapertura* zone, Cipero formation. Faunistically, the separation is clearly shown by the disappearance of the typical Eocene planktonic and benthonic marker Foraminifera such as *Hantkenina, Globorotalia cocoaensis* Cushman, *Globorotalia centralis* Cushman and Bermudez, *Bulimina jacksonensis* Cushman etc. The only planktonic species which appear for the first time in the basal Cipero are *Globigerina ciperoensis ciperoensis* Bolli and *Cassigerinella chipolensis* (Cushman and Ponton).

In the San Fernando area the San Fernando formation rests unconformably on the lower part of the Navet formation or on the Lizard Springs formation.

Because of the varied foraminiferal assemblages in the San Fernando formation and the strong reworking of Foraminifera from older formations, no subdivision into biozones is possible with the sections available at the present time.

Globorotalia cocoaensis Zone

TYPE LOCALITY: Steep bank on east (waiting rooms) side of San Fernando Railway Station (coordinates N:237060 links; E:356425 links), type sample KR25684 (TTOC 238769).

LITHOLOGY: Dark grey-brown calcareous silt.

REMARKS: The zone is characterized by the presence of *Globorotalia cocoaensis* Cushman, *Hantkenina primitiva* Cushman and Jarvis and *Cribrohantkenina bermudezi* (Thalmann) and the absence of *Globigerapsis semiinvoluta* (Keijzer).

Evolutionary Trends and Direction of Coiling

More complete sections than those available in Trinidad would be necessary to study in detail the evolutionary trends and patterns of coiling in the middle and upper Eocene. However, the following condensed remarks on observation made on the Trinidad material will suffice to show that the rapid tempo in evolution and distinct patterns in preferred coiling directions as shown for many planktonic species in the upper Paleocene and lower Eocene (Bolli, 1957a) also persist through the middle and upper Eocene. The same trends were found again in the Oligocene and Miocene (Bolli, 1950, 1951).

The species of the genera *Globigerapsis, Globigerinatheka,* and *Porticulasphaera* obviously represent a related group. Transitional specimens indicate that *Globigerapsis kugleri* Bolli, Loeblich, and Tappan branched off from the long-ranging *Globigerapsis index* (Finlay) and later developed into *Porticulasphaera mexicana* (Cushman). *Globigerinatheka barri* Bronnimann is closely related to *Globigerapsis kugleri,* differing only in the possession of sutural bullae. Although no transitional specimens were observed in Trinidad between *Globigerapsis index* (Finlay) and *Globigerapsis semiinvoluta* (Keijzer) it is likely that the latter branched off from the former in early upper Eocene time.

The fact that over 90 percent of the specimens of the species belonging to the genera *Globigerapsis, Globigerinatheka,* and *Porticulasphaera* coil dextrally is further proof for close genetic relationship.

The earliest recorded species of *Truncorotaloides* in the upper Paleocene coil almost exclusively dextrally. This trend seems to persist throughout the lower Eocene. The lower middle Eocene *Globorotalia bullbrooki* Bolli, new species, (probably a *Truncorotaloides*) still shows a preference for dextral coiling, although this is much less pronounced than in the older *Truncorotaloides.* A rapid change towards sinistral coiling in *Truncorotaloides* apparently occurs at the end of the *Hantkenina aragonensis* zone. The ratio of sinistral to dextral coiling of *T. rohri* Bronnimann and Bermudez and *T. topilensis* (Cushman) in the *Globigerapsis kugleri* to *Truncorotaloides rohri* zones is over 90 percent.

The strong preference for sinistral coiling (over 90 percent) shown by *Globorotalia aragonensis* Nuttall and *Globorotalia broedermanni* Cushman and Bermudez in the uppermost Lizard Springs (Bolli, 1957a) is found to continue in the Navet formation until the two species become extinct at the top of the *Globigerapsis kugleri* zone. Of approximately 100 specimens of *Globorotalia renzi* Bolli, new species, counted in samples throughout the recorded range, all were found to coil dextrally.

Globorotalia lehneri Cushman and Jarvis, together with *Globorotalia spinulosa* Cushman and *Globorotalia spinuloinflata* (Bandy), belongs to a group of *Globorotalia* species that does not develop a distinct preference for one coiling direction. This is rather exceptional, because it is known that most *Globorotalia* species from the upper Paleocene to the Recent, especially the more highly developed angular and keeled forms, do develop a distinct preference for either sinistral or dextral coiling (Bolli, 1950, 1957a).

A number of specimens of *Globorotalia centralis* Cushman and Bermudez, from the *Globigerapsis kugleri* zone to the *Globorotalia cocoaensis* zone, were checked for the direction of coiling. During the early stage of evolution in the *Globigerapsis kugleri* and *Globorotalia lehneri* zones specimens coiled at random, but a 60–80 percent preference for sinistral coiling was found in the *Porticulasphaera mexicana*, *Globigerapsis semiinvoluta* and *Globorotalia cocoaensis* zones. The preference for sinistral coiling in *Globorotalia cocoaensis* Cushman, a species thought to have developed from *Globorotalia centralis*, is probably over 80 percent.

Forty-four planktonic Foraminifera species and subspecies belonging to eleven genera are recorded though full descriptions are given only for the six new species. Synonymy lists are restricted to the original description and to literature concerning the Caribbean, the Gulf Coast region, Central America and northern South America. The species of the genera *Hantkenina*, *Cribrohantkenina*, and *Chiloguembelina* have previously been described in detail and are left out of this paper.

The range of many of the species is not restricted to the Navet and San Fernando formations. Several originate in the Paleocene-lower Eocene Lizard Springs formation while some continue into the Oligocene-Miocene Cipero formation. However, the complete range as observed in Trinidad is given in the notes on each species.

For the description and stratigraphic distribution of the Chiloguembelinae and related genera in the Navet and San Fernando formations reference is made to Beckmann (1957).

Bronnimann (1950a,b) described the species of the genera *Hantkenina* and *Cribrohantkenina* fully but discussed their stratigraphic distribution only in a generalized way. Within the new zonation the range of some of the better known species was found to be as follows:

Hantkenina aragonensis Nuttall, a species closely related to *H. mexicana* Cushman and *H. lehneri* Cushman and Jarvis, is restricted to the zone of the same name. A probable descendant of *Hantkenina aragonensis* is *H. dumblei* Weinzierl and Applin which succeeds it in the *Globigerapsis kugleri* zone. *Hantkeninae* of the *longispina-alabamensis* type follow *H. dumblei* in the higher zones of the Navet formation. In the San Fernando formation the *Hantkeninae* have a tendency to become smaller. This could either be an indication of a gerontic stage or be due to less favorable ecologic conditions. *Hantkenina primitiva* Cushman and Jarvis, originating in the uppermost Navet, is the most abundant *Hantkenina* species in the San Fernando formation where it occurs with *Cribrohantkenina bermudezi* (Thalmann).

Systematic Descriptions

Family Hantkeninidae Cushman, 1927
Subfamily Hastigerininae Bolli, Loeblich, and Tappan, 1957

Genus Hastigerina Thomson

Hastigerina micra (Cole)

PLATE 35, FIGURES 1a–2b

Nonion micrus COLE, Bull. Amer. Paleontol., vol. 14, No. 51, p. 22, pl. 5, fig. 12, 1927.
Globigerinella micra (Cole), GLAESSNER, Publ. Lab. Paleontol. Moscow Univ., vol. 1, fasc. 1, p. 30, pl. 1, figs. 4a–b, 1937.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone, Navet formation to *Globorotalia cocoaensis* zone, San Fernando formation.

LOCALITY: Figured hypotypes (USNM P5698a,b) from the *Porticulasphaera mexicana* zone, Navet formation; block in the upper Oligocene-lower Miocene Nariva formation, in cutting west of tank 127, north of The Avenue and 850 feet west of its junction with Bon Accord Road, Pointe-a-Pierre. Sample Hg 8581 (TTOC 215782). The block is no longer existant.

REMARKS: With the exception of the *Globorotalia palmerae* zone, *Hastigerina micra* (Cole) occurs throughout the Navet and San Fernando formations but does not continue into the Oligocene-Miocene Cipero formation. Glaessner (1937) changed the generic status of this species to *Globigerinella* which is now regarded as a junior synonym of *Hastigerina* (Bolli, Loeblich, and Tappan, 1957, p. 29).

Genus Clavigerinella Bolli, Loeblich, and Tappan, 1957

Clavigerinella akersi Bolli, Loeblich, and Tappan

PLATE 35, FIGURE 4

Clavigerinella akersi BOLLI, LOEBLICH, and TAPPAN, U. S. Nat. Mus. Bull. 215, p. 30, pl. 3, figs. 5a-b, 1957.
Hastigerinella eocanica Nuttall, CUSHMAN AND RENZ, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 38, pl. 7, fig. 17, 1948.—WEISS, Micropaleontology, vol. 1, No. 4, p. 309, pl. 2, figs. 11, 13, 1955.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Figured topotype (USNM P5699) from the *Hantkenina aragonensis* zone, Navet formation; in small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text-fig. 25). Sample HGK 8820 (TTOC 177760).

Remarks: *Clavigerinella akersi* Bolli, Loeblich, and Tappan is distinguished from *C. jarvisi* (Cushman) by having the later, elongate chambers distinctly inflated at the outer ends. It is more restricted in its range and may be regarded as a characteristic index fossil.

Petters (1954, p. 40) described *Hastigerinella columbiana* from the middle Eocene Carreto formation of Colombia. The figures for the species show the chambers to be club-shaped though not as distinctly so as in *Clavigerinella akersi;* the aperture is not visible on the figure, but is described as "a rather wide arched slit with a slight lip at base of last-formed chamber, slightly ventrally of periphery." Similar or identical forms possessing an equatorial aperture which occur in the middle Eocene of Trinidad could possibly represent a juvenile stage of *Clavigerinella akersi* or an intermediate stage between *C. jarvisi* and *C. akersi.* (See pl. 35, figs. 3a,b; specimen (USNM P5700) from the *Hantkenina aragonensis* zone, Navet formation, between mileposts 12½ and 12¾ of the Brasso-Tamana Road, Central Range, sample K 8775 (TTOC 177647).) It may also be assumed that *Hastigerinella eocanica* Nuttall belongs to *Clavigerinella,* although the aperture is not preserved on the types figured by Nuttall.

Clavigerinella jarvisi (Cushman)

Plate 35, Figures 5–6

Hastigerinella jarvisi Cushman, Cushman Lab. Foram. Res., vol. 6, p. 18, pl. 3, figs. 8–11, 1930.
Hastigerinella eocanica var. *aragonensis* Nuttall, Journ. Paleontol., vol. 4, No. 3, p. 290, pl. 24, figs. 16, 17, 1930.

Stratigraphic range: *Hantkenina aragonensis* zone to *Globigerapsis semiinvoluta* zone, Navet formation.

Locality: Figured hypotypes (USNM P5701a,b) from the *Globorotalia lehneri* zone, Navet formation; Navet River marl and Fitt Trace marl (see Cushman and Renz, 1948, p. 3); samples KR 4347, KS 233 (TTOC 1285, 18360).

Family Orbulinidae Schultze, 1854

Subfamily Globigerininae Carpenter, 1862

Genus Globigerina d'Orbigny, 1826

Globigerina soldadoensis Bronnimann

Plate 35, Figures 9a–c

Globigerina soldadoensis Bronnimann, Bull. Amer. Paleontol., vol. 34, No. 143, pp. 9–11, pl. 1, figs. 1–9, 1952.—Bolli, U. S. Nat. Mus. Bull. 215, p. 71, pl. 16, figs. 7–12, 1957.

Stratigraphic range: *Globorotalia velascoensis* zone, Lizard Springs formation to *Globorotalia palmerae* zone, Navet formation.

Locality: Figured hypotype (USNM P5704) from the *Globorotalia palmerae* zone, Navet formation; Pit sample from a block reworked in the Oligocene-Miocene Cipero formation; 2,900 feet south of the Naparima-Mayaro Road and Corial Road junction, Malgretout Estate, west of Princes Town, south Trinidad (coordinates N:235390 links; E:398620 links); sample KTO 145 (TTOC 143701).

Globigerina soldadoensis angulosa Bolli

Plate 35, Figures 8a–c

Globigerina soldadoensis angulosa Bolli, U. S. Nat. Mus. Bull. 215, p. 71, pl. 16, figs. 4–6, 1957.

Stratigraphic range: *Globorotalia formosa formosa* zone, Lizard Springs formation to *Globorotalia palmerae* zone, Navet formation.

Locality: Figured hypotype (USNM P5703) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann; sample KTO 145 (TTOC 143701).

Remarks: Transitional forms indicate that *Globigerina soldadoensis angulosa* is likely to be the ancestor of *Globorotalia aspensis* (Colom).

Globigerina collactea (Finlay)

Plate 35, Figures 18a–b

Globorotalia collactea Finlay, Trans. Proc., Roy. Soc. New Zealand, vol. 69, p. 37, pl. 29, figs. 164–165, 1939.
Globigerina collactea (Finlay), Bronnimann, Bull. Amer. Paleontol., vol. 34, No. 143, pp. 13–14, pl. 1, figs. 13–15, 1952.—Bolli, U. S. Nat. Mus. Bull. 215, p. 72, pl. 15, figs. 21–23, 1957.

Stratigraphic range: *Globorotalia rex* zone, Lizard Springs formation to *Globorotalia palmerae* zone, Navet formation.

Locality: Figured hypotype (USNM P5710) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann; sample KTO 145 (TTOC 143701).

Globigerina prolata Bolli

Plate 35, Figures 7a–b

Globigerina prolata Bolli, U. S. Nat. Mus. Bull. 215, p. 72, pl. 15, figs. 24–26, 1957.
Globigerina pseudobulloides Plummer, Bronnimann, Bull. Amer. Paleontol., vol. 34, No. 143, pp. 21–23, pl. 3, figs. 7–9, 1952.

Stratigraphic range: *Globorotalia formosa formosa* zone, Lizard Springs formation to *Globorotalia palmerae* zone, Navet formation.

Locality: Figured hypotype (USNM P5702) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann; sample KTO 145 (TTOC 143701).

Globigerina turgida Finlay

Plate 35, Figures 13a–c

Globigerina turgida Finlay, Trans. Proc., Roy. Soc. New Zealand, vol. 69, p. 125, 1939.—Bronnimann, Bull. Amer. Paleontol., vol. 34, No. 143, pp. 19–21, pl. 3, figs. 1–3, 1952.—Bolli, U. S. Nat. Mus. Bull. 215, p. 73, pl. 15, figs. 3–5, 1957.

Stratigraphic range: *Globorotalia aragonensis* zone, Lizard Springs formation to *Hantkenina aragonensis* zone, Navet formation.

Locality: Figured hypotype (USNM P5706) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann; sample KTO 145 (TTOC 143701).

Globigerina senni (Beckmann)

PLATE 35, FIGURES 10a–12

Sphaeroidinella senni BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, pp. 394–95, pl. 26, figs. 2–4, text-fig. 20, 1953.

STRATIGRAPHIC RANGE: *Globorotalia palmerae* zone to *Truncorotaloides rohri* zone, Navet formation.

LOCALITY: Figured hypotypes (USNM P5705a–c) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: *Globigerina senni* was originally described by Beckmann as a *Sphaeroidinella*. Sutural supplementary apertures and chamber flanges, which are typical for the genus *Sphaeroidinella*, do not exist in this species. It is therefore placed in *Globigerina*. The species is found in all Navet zones except the highest. It is likely that it developed from the upper Lizard Springs *Globigerina taroubaensis* Bronnimann, a species lacking the granular particles usually seen surrounding the umbilical area in *Globigerina senni*.

Globigerina linaperta Finlay

PLATE 36, FIGURES 5a–b

Globigerina linaperta FINLAY, Trans. Proc. Roy. Soc. New Zealand, vol. 69, p. 125, pl. 13, figs. 54–57, 1939.—BRONNIMANN, Bull. Amer. Paleontol., vol. 34, No. 143, pp. 16–17, pl. 2, figs. 7–9, 1952.—BOLLI, U. S. Nat. Mus. Bull. 215, p. 70, pl. 15, figs. 15–17, 1957.

STRATIGRAPHIC RANGE: *Globorotalia pseudomenardii* zone, Lizard Springs formation to *Globigerapsis semiinvoluta* zone, San Fernando formation.

LOCALITY: Figured hypotype (USNM P5715) from the *Porticulasphaera mexicana* zone, Navet formation; Brasso-Tamana Road, near milepost 12¾, Central Range (see text-fig. 25); sample K 8814 (TTOC 177755).

Globigerina boweri Bolli, new species

PLATE 36, FIGURES 1a–2b

Shape of test low trochospiral; equatorial periphery distinctly lobate (trilobate); axial periphery rounded. Wall calcareous, perforate, surface very finely pitted. Chambers spherical, early ones somewhat compressed and slightly subangular; about 12, arranged in about 2½ whorls; the 3–3½ chambers of the last whorl increase rapidly in size. Sutures on spiral side: in early stage radial to slightly curved, in late stage radial or oblique, depressed; on umbilical side radial, depressed. Umbilicus narrow. Aperture a distinct arch, commonly with a short lip or rim; interiomarginal, umbilical, with a tendency to become umbilical-extraumbilical. Coiling predominantly dextral (90 percent or more) in the *Hantkenina aragonensis* and *Globigerapsis kugleri* zone, Navet formation. Largest diameter of holotype 0.4 mm.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Holotype (USNM P5711) from the *Hantkenina aragonensis* zone, Navet formation; outcrop on left side of right branch of Nariva River, about 450 feet from its junction, Central Range, Trinidad (coordinates N:314350 links; E:487360 links); sample K 9077 (TTOC 178166). Figured paratype (USNM P5712) from the *Hantkenina aragonensis* zone, Navet formation; in small ravine between mile posts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text fig. 25); sample HGK 8820 (TTOC 177760).

REMARKS: *Globigerina boweri*, new species, differs from *G. linaperta* Finlay in having a higher arched aperture which has the tendency to be slightly extraumbilical in position. Especially the earlier chambers are somewhat compressed which gives them a slightly subangular aspect.

The species is named for Mr. T. H. Bower, senior exploitation geologist of The Trinidad Oil Company.

Globigerina yeguaensis Weinzierl and Applin

PLATE 35, FIGURES 14a–15c

Globigerina yeguaensis WEINZIERL and APPLIN, Journ. Paleontol., vol. 3, No. 4, p. 408, pl. 43, figs. 1a–b, 1929.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone, Navet formation to *Globorotalia cocoaensis* zone, San Fernando formation.

LOCALITY: Figured hypotype (USNM P5708) from the type locality of *Globigerapsis semiinvoluta* zone, Navet formation (see p. 159); sample Ky 7 (TTOC 144343). Figured hypotype (USNM P5707) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: There is considerable variation in the specimens regarded as belonging to *Globigerina yeguaensis*. All forms are distinctly lobate, display a fairly open umbilicus and have the apertures of the last, occasionally also of earlier chambers protected by a fragile lip.

In typical forms the 3–3½ chambers of the last whorl increase rapidly in size (fig. 14a–c); in others with 4 chambers the increase is more moderate (figs. 15a–c). *G. venezuelana* Hedberg is a more compact form than *G. yeguaensis*. It has a less open umbilicus and shows no apertural lips. *G. yeguaensis* has not been seen with a rudimentary final chamber, a feature often present in *G. venezuelana*.

Globigerina cf. trilocularis d'Orbigny

PLATE 36, FIGURES 3a–b

STRATIGRAPHIC RANGE: *Globorotalia lehneri* zone, Navet formation to *Catapsydrax dissimilis* zone, Cipero formation.

LOCALITY: Figured specimen (USNM P5713) from the *Globorotalia cocoaensis* zone, San Fernando formation; Soldado Rock Island (see Kugler, 1938); sample K3741 (TTOC 190838).

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Globigerina venezuelana Hedberg

PLATE 35, FIGURES 16a–17

Globigerina venezuelana HEDBERG, Journ. Paleontol., vol. 11, No. 8, p. 681, pl. 92, figs. 7a–b, 1937.—CUSHMAN and STAINFORTH, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 67, pl. 12, figs. 13a–b, 1945.—BERMUDEZ, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 280, pl. 21, figs. 39–40, 1949.—BOLLI, U. S. Nat. Mus. Bull. 215, p. 110, pl. 23, figs. 6a–8b, 1957.

Globigerina conglomerata Schwager, BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 391, pl. 25, figs. 6–9, 1953.

STRATIGRAPHIC RANGE: *Porticulasphaera mexicana* zone, Navet formation to *Globorotalia menardii* zone, Lengua formation, probably continuing into younger beds.

LOCALITY: Figured hypotypes (USNM P5709a–b) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

Globigerina parva Bolli

PLATE 36, FIGURES 7 a–c

Globigerina parva BOLLI, U. S. Nat. Mus. Bull. 215, p. 108, pl. 22, figs. 14 a–c, 1957.

?*Globigerina ouachitaensis* HOWE and WALLACE, Geol. Surv. Bull. Louisiana Dep. Conserv., No. 2, p. 74, pl. 10, figs. 10 a–b, 1932.

STRATIGRAPHIC RANGE: *Truncorotaloides rohri* zone, Navet formation to *Globigerina ampliapertura* zone, Cipero formation.

LOCALITY: Figured hypotype (USNM P5717) from the type locality of the *Globigerapsis semiinvoluta* zone, Navet formation (see p. 159); sample Ky 7 (TTOC 144343).

REMARKS: This small, strongly lobate, fairly high spired form with four chambers in the last whorl is typical for the upper Eocene and basal Oligocene. *Globigerina ouachitaensis* Howe and Wallace, described from the upper Eocene is probably very close to this species.

Globigerina ampliapertura Bolli

PLATE 36, FIGURES 8 a–c

Globigerina ampliapertura BOLLI, U. S. Nat. Mus. Bull. 215, p. 108, pl. 22, figs. 4a–7b, 1957.

STRATIGRAPHIC RANGE: *Globorotalia cocoaensis* zone, San Fernando formation to *Globigerina ampliapertura* zone, Cipero formation.

LOCALITY: Figured hypotype (USNM P5718) from the *Globorotalia cocoaensis* zone, San Fernando formation; augerhole, Jarvis Street, San Fernando; sample KR 25636 (TTOC 238132).

REMARKS: *Globigerina ampliapertura*, which appears in the uppermost Eocene and continues into the basal Oligocene, seems to be genetically related to *Globorotalia centralis* Cushman and Bermudez. Intermediate forms (USNM P5719a,b) showing the aperture in a transitional position, are commonly found in the *Globorotalia cocoaensis* zone (pl. 36, figs. 9, 10). The species might represent a gerontic stage of the *G. centralis-G. cocoaensis* strain, reverting before its extinction to a globigerinid form and also to random coiling.

Globigerina ciperoensis angustiumbilicata Bolli

PLATE 36, FIGURES 6a–b

Globigerina ciperoensis angustiumbilicata BOLLI, U. S. Nat. Mus. Bull. 215, p. 109, pl. 22, figs. 12a–13c, 1957.

STRATIGRAPHIC RANGE: *Globorotalia cocoaensis* zone (probably upper part), San Fernando formation to *Catapsydrax dissimilis* zone, Cipero formation.

LOCALITY: Figured hypotype (USNM P5716) from the *Globorotalia cocoaensis* zone, San Fernando formation; Soldado Rock Island (see Kugler, 1938); sample K 3741 (TTOC 190838).

Globigerina rohri Bolli

PLATE 36, FIGURES 4a–b

Globigerina rohri BOLLI, U. S. Nat. Mus. Bull. 215, p. 109, pl. 23, figs. 1a–4b, 1957.

Globigerina venezuelana Hedberg, BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 392, pl. 10, figs. 12–13, 1953.

STRATIGRAPHIC RANGE: *Globorotalia cocoaensis* zone, San Fernando formation to *Catapsydrax dissimilis* zone, Cipero formation.

LOCALITY: Figured hypotype (USNM P5714) from the *Globorotalia cocoaensis* zone, San Fernando formation, Kern Trinidad Oilfields well C–609, core 4,425–36 feet (TTOC 192784).

"Globigerinoides" higginsi Bolli, new species

PLATE 36, FIGURES 11a–13b

Shape of test high trochospiral; equatorial periphery distinctly lobate. Wall calcareous, perforate, surface finely pitted, in well preserved specimens with very minute spines. Chambers spherical, later ones often somewhat ovate, 12–15, arranged in about 2½ whorls; the last whorl of about 4 chambers increasing moderately in size, the ultimate chamber may be smaller than the penultimate (see fig. 12). Sutures on spiral side radial, deeply incised; on umbilical side radial, deeply incised. Umbilicus narrow, deep. Primary aperture a high arch, interiomarginal-umbilical; in well preserved specimens a supplementary sutural aperture is seen between the penultimate and ultimate chambers and occasionally also between earlier chambers of the last whorl. Coiling random in the *Globorotalia palmerae* zone; a preference for dextral coiling of over 90 percent in the *Hantkenina aragonensis* and *Globigerapsis kugleri* zone, Navet formation. Largest diameter of holotype 0.5 mm.

STRATIGRAPHIC RANGE: *Globorotalia palmerae* zone to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Holotype (USNM P5720) from an Eocene core, lat. 30° 43′ N., long. 62° 28′ W.; depth of water 1,554 meters; depth of sample in core, 120–122 cm. Figured paratypes (USNM P5721a, b) from the *Hantkenina aragonensis* zone, Navet formation; outcrop on left side of right branch of Nariva River, about 450 feet

from its junction, Central Range, Trinidad (coordinates N:314300 links; E:487360 links); sample K 9077 (TTOC 178166).

Remarks: According to the generic definition of *Globigerinoides*, *"Globigerinoides" higginsi*, new species, should be included here. This is only done provisionally because no genetic relation is apparent between this lower-middle Eocene form and the main group of *Globigerinoides* species which appears only at the close of the Oligocene or in the early Miocene. More detailed studies on well preserved material might reveal differences that justify a generic separation of *"Globigerinoides" higginsi* from *Globigerinoides*. It has been thought that *"Globigerinoides" higginsi* might possibly be the ancestor of the *Globigerapsis* group. However, it differs from *Globigerapsis index* (Finlay), which is the oldest representative of that genus, in the possession of a large umbilical aperture, higher spire, and more globular chambers.

Through the courtesy of Dr. A. R. Loeblich, U. S. National Museum, an excellently preserved specimen from an Eocene core from the Atlantic Ocean was made available to the author (pl. 36, figs. 11a–b). It possesses two sutural supplementary apertures, and the surface is covered with very minute spines. It has been chosen as the holotype.

The species is named for Mr. G. E. Higgins, senior exploration geologist of The Trinidad Oil Company.

Subfamily Orbulininae Schultze, 1854

Genus Globigerapsis Bolli, Loeblich and Tappan, 1957

Globigerapsis index (Finlay)

Plate 36, Figures 14a–18b

Globigerinoides index Finlay, Trans. Proc., Roy. Soc. New Zealand, vol. 69, pt. 1, p. 125, pl. 14, figs. 85–88, 1939.

Stratigraphic range: *Globigerapsis kugleri* zone to *Globigerapsis semiinvoluta* zone, Navet formation; ?*Globorotalia cocoaensis* zone, San Fernando formation.

Locality: Figured hypotypes (figs. 14, 15; USNM P5722a–b) from the *Globigerapsis kugleri* zone, Navet formation; in small ravine between mileposts 12¼ and 12½ of the Brasso–Tamana Road and the Navet River, Central Range (see text-fig. 25); sample HGK 8824 (TTOC 177764). Figured hypotypes (figs. 16–18; USNM P5723–5725) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

Remarks: *Globigerapsis index* differs from *G. kugleri* Bolli, Loeblich, and Tappan in having a smaller final chamber covering the umbilicus and in higher arched sutural supplementary apertures.

Globigerapsis kugleri Bolli, Loeblich, and Tappan

Plate 36, Figures 21a–b

Globigerapsis kugleri Bolli, Loeblich, and Tappan, U. S. Nat. Mus. Bull. 215, p. 34, pl. 6, figs. 6a–b, 1957.

Globigerinoides mexicana (Cushman), Beckmann, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 393, pl. 25, figs. 15, 17, 1953.

Stratigraphic range: *Globigerapsis kugleri* zone to *Porticulasphaera mexicana* zone, Navet formation.

Locality: Figured hypotype (USNM P5727) from the *Globorotalia lehneri* zone, Navet formation; Nariva River, Central Range; sample K 9071 (TTOC 178160).

Globigerapsis semiinvoluta (Keijzer)

Plate 36, Figures 19–20

Globigerinoides semiinvolutus Keijzer, Univ. Utrecht Geogr. Geol. Med., Phys.-Geol. Reeks, ser. 2, No. 6, p. 206, pl. 4, figs. 58a–e, 1945.

Globigerinoides index Finlay, Beckmann, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 392, pl. 25, fig. 14, 1953.

Globigerapsis semiinvoluta (Keijzer), Bolli, Loeblich, and Tappan, U. S. Nat. Mus. Bull. 215, p. 34, pl. 6, figs. 7a–c, 1957.

Stratigraphic range: *Globigerapsis semiinvoluta* zone, Navet formation.

Locality: Figured hypotypes (USNM P5726a–b) from the type locality of the *Globigerapsis semiinvoluta* zone, Navet formation (see p. 159); sample Ky 7 (TTOC 144343).

Genus Porticulasphaera Bolli, Loeblich and Tappan, 1957

Porticulasphaera mexicana (Cushman)

Plate 37, Figures 1a–b.

Globigerina mexicana Cushman, Contr. Cushman Lab. Foram. Res., vol. 1, No. 3, p. 6, pl. 1, figs. 8a–b, 1925.—Weiss, Micropaleontology, vol. 1, No. 4, p. 309, pl. 2, fig. 15, 1955.

Globigerinoides mexicana (Cushman), Beckmann, Eclog. Geol. Helvetiae, vol. 46, No. 2, pp. 393–394, pl. 25, fig. 19, 1953.

Porticulasphaera mexicana Bolli, Loeblich, and Tappan, U. S. Nat. Mus. Bull. 215, p. 35, pl. 6, figs. 8, 9a–b, 1957.

Stratigraphic range: *Porticulasphaera mexicana* zone, Navet formation.

Locality: Figured hypotype (USNM P5728) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

Genus Catapsydrax Bolli, Loeblich, and Tappan, 1957

Catapsydrax echinatus Bolli, new species

Plate 37, Figures 2a–5b

Shape of test low to medium trochospiral; equatorial periphery lobate; axial periphery rounded, more rarely becoming slightly subangular. Wall calcareous, perforate, surface covered with short, thin spines. Chambers spherical or slightly compressed, 10–15 in about 2½ whorls; the last whorl of about 4 chambers increasing fairly rapidly in size. Sutures on spiral side radial or slightly oblique, depressed; on umbilical side radial, depressed. Umbilicus fairly narrow, covered by a bulla. Primary aperture covered by umbilical bulla, interiomarginal, umbilical; accessory apertures of bulla very small medium to low arches, one or two in number, occasionally more, infralaminal, situated above sutures between earlier chambers. Coiling in over 90 percent

of specimens sinistral in the *Porticulasphaera mexicana* zone. Largest diameter of holotype 0.37 mm.

STRATIGRAPHIC RANGE: *Globorotalia lehneri* zone to *Truncorotaloides rohri* zone, Navet formation.

LOCALITY: Holotype (USNM P5729) and figured paratypes (USNM P5730a–c) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: *Catapsydrax echinatus*, new species, is distinguished from *C. dissimilis* (Cushman and Bermudez) and *C. unicavus* Bolli, Loeblich, and Tappan by having a distinctly spinose surface. This type of surface ornamentation is characteristic for many upper Paleocene to middle Eocene planktonic species. The bulla, which varies considerably in size may be smooth (see fig. 5b) or spinose (see figs. 2b, 3b). Most specimens observed are smaller than the average size of *C.* cf. *dissimilis* found in the upper part of the Navet and San Fernando formations.

Catapsydrax unicavus Bolli, Loeblich, and Tappan

PLATE 37, FIGURES 7a–b

Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN. U. S. Nat. Mus. Bull. 215, p. 37, pl. 7, figs. 9a–c, 1957.

STRATIGRAPHIC RANGE: *Truncorotaloides rohri* zone, Navet formation to *Catapsydrax stainforthi* zone, Cipero formation.

LOCALITY: Figured specimen (USNM P5732) from the *Truncorotaloides rohri* zone, Navet formation; near junction of small ravine with Navet River (see text fig. 25); sample K 8833 (TTOC 177772).

Catapsydrax cf. dissimilis (Cushman and Bermudez)

PLATE 37, FIGURES 6a–b

STRATIGRAPHIC RANGE: *Truncorotaloides rohri* zone, Navet formation to *Catapsydrax stainforthi* zone, Cipero formation.

LOCALITY: Figured specimen (USNM P5731) from the type locality of the *Globigerapsis semiinvoluta* zone, Navet formation (see p. 159); sample Ky 7 (TTOC 144343).

REMARKS: The middle and upper Eocene forms differ from the *Catapsydrax dissimilis* of the Oligocene-lower Miocene in having somewhat more globular chambers. The umbilical bullae have commonly only two and more rarely only one infralaminal accessory aperture, whereas the bullae of Oligocene-lower Miocene specimens often display three or four accessory apertures. *C. unicavus* Bolli, Loeblich, and Tappan, whose bulla has one accessory aperture, is smaller in size and its chambers are less inflated than those found in *C.* cf. *dissimilis*. The direction of coiling in the Eocene specimens is apparently random, whereas the Oligocene-lower Miocene specimens show a strong preference for dextral coiling

Genus Globigerinatheka Bronnimann, 1952

Globigerinatheka barri Bronnimann

PLATE 37, FIGURES 8–9

Globigerinatheka barri BRONNIMANN, Contr. Cushman Found. Foram. Res., vol. 3, pt. 1, pp. 27–28, text figure 3a, 1952.—BOLLI, LOEBLICH, and TAPPAN, U. S. Nat. Mus. Bull. 215, p. 38, pl. 7, figs. 12a–c, 1957.

Globigerinoides mexicana (Cushman), BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 393, pl. 25, fig. 16, 1953.

STRATIGRAPHIC RANGE: *Globorotalia lehneri* zone to *Globigerapsis semiinvoluta* zone, Navet formation, ?*Globorotalia cocoaensis* zone, San Fernando formation.

LOCALITY: Figured hypotypes (USNM P5733a,b) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole), p. 161, sample Hg 8581 (TTOC 215782).

Genus Globorotaloides Bolli, 1957

Globorotaloides suteri Bolli

PLATE 37, FIGURES 10a–12

Globorotaloides suteri BOLLI, U. S. Nat. Mus. Bull. 215, p. 117, pl. 27, figs. 9a–13c, 1957.

STRATIGRAPHIC RANGE: *Porticulasphaera mexicana* zone, Navet formation to *Globigerinatella insueta* zone, Cipero formation.

LOCALITY: Figured hypotypes (USNM P5734a-c) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

Family Globorotaliidae Cushman, 1927

Genus Globorotalia Cushman, 1927

Globorotalia palmerae Cushman and Bermudez

PLATE 38, FIGURES 2a–c

Globorotalia palmerae CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 13, p. 26, pl. 2, figs. 51–53, 1937.—BERMUDEZ, Mem. Soc. Cubana Hist. Nat., vol. 11, p. 167, 1937; vol. 12, p. 11, 1938.—CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 25, pt. 2, pp. 31–32, pl. 6, figs. 4–6, 1949.

STRATIGRAPHIC RANGE: *Globorotalia palmerae* zone, Navet formation.

LOCALITY: Figured hypotype (USNM P5740) from the type locality of the *Globorotalia palmerae* zone, Navet formation (see p. 156); sample from core 9,386–9,405 feet (TTOC 228911).

REMARKS: The preservation of the specimens found so far in Trinidad is poor; the characteristic *Hantkenina*-like peripheral spines are partially eroded.

Globorotalia aspensis (Colom)

PLATE 37, FIGURES 18a–c

Globigerina aspensis COLOM, Bol. Inst. Geol. y Min. España, vol. 66, pp. 151–54, pl. 3, figs. 1–5, pl. 4, figs. 1–3, 1954.

STRATIGRAPHIC RANGE: *Globorotalia palmerae* zone to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Figured hypotype (USNM P5738) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann (p. 162); sample KTO 145 (TTOC 143701).

REMARKS: The position of the apertures in the type specimens of *Globigerina aspensis* figured by Colom is interiomarginal, umbilical—extraumbilical. For this reason the species is here placed in *Globorotalia*. Colom's specimens show considerable variation in size, number of chambers in the last whorl (5–7) and shape of chambers (spherical to subangular). A similar range of varieties is found in the lower Navet of Trinidad. It appears likely that the species has developed from *Globigerina soldadoensis angulosa* Bolli. Detailed studies of this group in areas where more complete sections are available might show that differences in the stratigraphic ranges of the varieties justify the erection of a number of subspecies.

Globorotalia broedermanni Cushman and Bermudez

PLATE 37, FIGURES 13a–c

Globorotalia (*Truncorotalia*) *brödermanni* CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 25, pt. 2, p. 40, pl. 7, figs. 22–24, 1949.

Globorotalia broedermanni CUSHMAN and BERMUDEZ. Bolli, U. S. Nat. Mus. Bull. 215, p. 80, pl. 19, figs. 13–15, 1957.

STRATIGRAPHIC RANGE: *Globorotalia rex* zone, Lizard Springs formation to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Figured hypotype (USNM P5735) from the *Globorotalia palmerae* zone, Navet formation; same locality as given for *Globigerina soldadoensis* Bronnimann (p. 162); sample KTO 145 (TTOC 143701).

Globorotalia aragonensis Nuttall

PLATE 38, FIGURES 1a–c

Globorotalia aragonensis NUTTALL, Journ. Paleontol. vol. 4, No. 3, p. 288, pl. 24, figs. 6–8, 10–11, 1930.—CUSHMAN and RENZ, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 40, pl. 8, figs. 1–2, 1948.—BERMUDEZ, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 284, pl. 22, figs. 33–35, 1949.—BOLLI, U. S. Nat. Mus. Bull. 215, p. 75, pl. 18, figs. 7–9, 1957.

Globorotalia (*Truncorotalia*) *aragonensis* Nuttall. CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 25, pt. 2, pp. 38–39, pl. 7, figs. 13–15, 1949.

STRATIGRAPHIC RANGE: *Globorotalia formosa formosa* zone, Lizard Springs formation to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Figured hypotype (USNM P5739) from the *Hantkenina aragonensis* zone, Navet formation; Baccus River, Central Range; sample K 8854 (TTOC 177804).

Globorotalia pseudomayeri Bolli, new species

PLATE 37, FIGURES 17a–c

Shape of test low trochospiral; equatorial periphery slightly lobate; axial periphery rounded. Wall calcareous, perforate, surface very finely pitted. Chambers spherical; 10–12, arranged in about 2½ whorls; The 4 or 5 chambers of the last whorl increase fairly rapidly in size. Sutures on spiral side curved or oblique in early portion, later radial, depressed; on umbilical side radial, depressed. Umbilicus narrow. Aperture a medium to low arch, with or without a faint lip; interiomarginal, umbilical-extraumbilical. Coiling random. Largest diameter of holotype 0.4 mm.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone, Navet formation.

LOCALITY: Holotype (USNM P5737) from the *Hantkenina aragonensis* zone, Navet formation; in upper part of small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River (see text-fig. 25); sample K 8817 (TTOC 177758).

REMARKS: *Globorotalia pseudomayeri*, new species, is morphologically very close to *G. opima nana* Bolli and *G. mayeri* Cushman and Ellisor. It differs from the former in that the chambers of the last whorl increase more rapidly in size. The last whorl consists of 4 to 4½ chambers, whereas in *G. mayeri* it has 5 or 6. *G. pseudomayeri* is restricted to the *Hantkenina aragonensis* zone of the Navet formation, whereas *G. opima nana* is found from the *Truncorotaloides rohri* zone, Navet formation to the *Globigerina ciperoensis ciperoensis* zone, Cipero formation. *Globorotalia mayeri* is restricted to the Cipero formation and lower part of the Lengua formation.

Globorotalia bullbrooki Bolli, new species

PLATE 38, FIGURES 4a–5c

Shape of test on spiral side almost flat or low trochospiral, umbilical side strongly convex, subangular. Wall calcareous, perforate, surface covered with short, blunt spines. Chambers subangular, inflated; about 12–15, arranged in about 2½ whorls; the 4 chambers of the last whorl increase fairly rapidly in size. Sutures on spiral side oblique or radial, depressed; on umbilical side radial, depressed. Umbilicus narrow, deep. Aperture a low arch, interiomarginal, umbilical-extraumbilical. Coiling without distinct pattern in the preliminary study of eight isolated samples belonging to the *Hantkenina aragonensis* zone. In four of these samples, 70-90 percent of the specimens coiled dextrally, in two a preference for sinistral coiling was observed and in two the specimens coiled at random. It may be of interest to note that in the samples with a predominance of dextrally coiled specimens, *Clavigerinella* was found but *Hantkenina* was absent. To gain a clear picture of the coiling pattern in *Globorotalia bullbrooki*, it will be necessary to make further investigations in a more nearly complete stratigraphic section. Largest diameter of holotype 0.5 mm.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone to *Globigerapsis kugleri* zone, Navet formation.

LOCALITY: Holotype USNM P5742) and figured paratype (USNM P5743) from the *Hantkenina aragonensis* zone, Navet formation; holotype from outcrop on left side of right branch of Nariva River, about 450 feet from its junction, Central Range, Trinidad

(coordinates N:314350 links; E:487360 links); paratype from upper part of small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and Navet River (see text-fig. 25); samples K 9077, 8817 (TTOC 178166, 177758).

Remarks: *Globorotalia bullbrooki*, new species, is distinguished from *G. aspensis* (Colom) by its more subangular test and by the presence of 4 chambers in the last whorl instead of the 5–7 of that species.

Globorotalia crassata (Cushman), often referred to in publications, may be close to the new species. The single spiral view of the holotype given by Cushman (1925) is not sufficient for an accurate determination and comparison. *G. crassata* as figured by Cushman and Bermudez (1949) shows 5½ chambers in the last whorl as against the 4 commonly found in *G. bullbrooki*. *G. crassata* var. *densa* (Cushman) is described as differing from *G. crassata* in its more rounded compact form, rounded periphery, and in having only 4 chambers in the last formed coil instead of 5 or 6 as in the typical form. No figure was given by Cushman for this variety. On the basis of the scanty description alone it is not possible to compare it with *Globorotalia bullbrooki* or any other possibly synonymous Navet species.

Specimens found among the middle Eocene foraminiferal fauna of a Mid-Pacific core (see p. 169), are indistinguishable from *Globorotalia bullbrooki*, with the exception that they possess small sutural supplementary apertures on the spiral side, which are typical of the genus *Truncorotaloides*. It is likely that *G. bullbrooki* also possesses such accessory apertures which, however, cannot be seen due to the poor preservation, and should therefore be placed in the genus *Truncorotaloides*.

The species is named for Mr. J. A. Bullbrook, geologist and archeologist, Trinidad.

Globorotalia spinulosa Cushman

Plate 38, Figures 6a–7c

Globorotalia spinulosa Cushman, Contr. Cushman Lab. Foram. Res., vol. 3, p. 114, pl. 23, figs. 4a–c, 1927.—Beckmann, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 397, pl. 26, fig. 13, 1953.

Globorotalia (*Truncorotalia*) *spinulosa* Cushman, Cushman and Bermudez, Cushman Lab. Foram. Res., vol. 25, pt. 2, pp. 40–41, pl. 8, figs. 1–3, 1949.

Stratigraphic range: *Hantkenina aragonensis* zone to *Porticulasphaera mexicana* zone, Navet formation.

Locality: Figured hypotypes (USNM P5744a, b) from the *Hantkenina aragonensis* zone, Navet formation; in small ravine between mileposts 12¼ and 12½ of the Brasso-Tamana Road and the Navet River, Central Range (see text-fig. 25); sample K8820 (TTOC 177760).

Remarks: *Globorotalia spinulosa* Cushman is likely to be the ancestor of *G. lehneri* Cushman and Jarvis. Forms transitional between the two species are common. Typical *G. spinulosa* are umbilicoconvex; *G. lehneri* is very strongly compressed with both sides about equally convex.

Globorotalia spinuloinflata (Bandy)

Plate 38, Figures 8a–c

Globigerina spinuloinflata Bandy, Bull. Amer. Paleontol., vol. 32, No. 131, p. 122, pl. 23, figs. 1a–c, 1949.

Globorotalia crassula Cushman and Stewart, Beckmann, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 397, pl. 26, fig. 12, 1953.

?*Globorotalia crassata* var. *densa* (Cushman), Cushman and Renz, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 40, pl. 8, figs. 7, 8, 1948.

Stratigraphic range: *Hantkenina aragonensis* zone to *Porticulasphaera mexicana* zone, Navet formation.

Locality: Figured hypotype (USNM P5745) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

Remarks: The figure of the holotype of *Globigerina spinuloinflata* Bandy shows a subangular test with an interiomarginal, umbilical-extraumbilical aperture; for these reasons it is placed in *Globorotalia*. Although the Trinidad specimens are often somewhat more angular than the figure given by Bandy (1949), they are here included in this species.

Globorotalia renzi Bolli, new species

Plate 38, Figures 3a–c

Shape of test very low trochospiral; equatorial periphery almost circular, only very slightly lobate; axial periphery angular with a thin keel. Wall calcareous, finely perforate, surface smooth or very finely pitted. Chambers strongly compressed; 15–18, arranged in about 2½ whorls; the chambers of the last whorl, usually 6 in number, increase fairly rapidly in size. Sutures on spiral side curved; on umbilical side radial or very slightly curved, slightly depressed between last chambers. Umbilicus very narrow, shallow. Aperture a low arch, often with a distinct lip, interiomarginal, umbilical-extraumbilical. Coiling almost 100 percent dextral throughout the observed range in the Navet formation. Largest diameter of holotype 0.23 mm.

Stratigraphic range: *Hantkenina aragonensis* zone to *Truncorotaloides rohri* zone, Navet formation.

Locality: Holotype (USNM P5741) from the *Porticulasphaera mexicana* zone, Navet formation; block in the upper Oligocene-lower Miocene Nariva formation, in cutting west of tank 127, north of The Avenue and 850 feet west of its junction with Bon Accord Road, Pointe-a-Pierre; sample Hg 8581 (TTOC 215782). The block is no longer existant.

Remarks: *Globorotalia renzi* Bolli, new species, is distinguished from *G. lehneri* Cushman and Jarvis by its small size and spineless periphery. It usually has 6 chambers in the last whorl compared with 4–5 in small specimens of *G. lehneri*.

The species is named for Dr. H. H. Renz of the Mene Grande Oil Company, in recognition of his contributions to micropaleontology in the Caribbean region.

Globorotalia bolivariana (Petters)

PLATE 37, FIGURES 14a–16

Globigerina wilsoni Cole subsp. *bolivariana* PETTERS, Contr. Cushman Found. Foram. Res., vol. 5, pt. 1, p. 39, pl. 8, figs. 9a–c, 1954.—WEISS, Micropaleontology, vol. 1, No. 4, p. 309, pl. 2, figs. 6–8, 1955.

Globigerina wilsoni Cole, WEISS, Micropaleontology, vol. 1, No. 4, p. 309, pl. 2, figs. 22–23, 1955.

STRATIGRAPHIC RANGE: *Hantkenina aragonensis* zone to *Truncorotaloides rohri* zone, Navet formation.

LOCALITY: Figured hypotypes (USNM P5736a–c) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: *Globorotalia bolivariana* (Petters), originally described as subspecies of *Globigerina wilsoni* Cole, displays a distinctly interiomarginal, umbilical-extraumbilical aperture; the very narrow slit often extends towards the spiral side. The species differs from the *Globorotalia opima* Bolli in being more involute (chambers of the earlier whorls are almost invisible) and in being almost planispiral. *G. bolivariana* is restricted to the middle Eocene while *G. opima* ranges from the uppermost middle Eocene to the Oligocene.

Globorotalia lehneri Cushman and Jarvis

PLATE 38, FIGURES 9a–13

Globorotalia lehneri CUSHMAN and JARVIS, Contr. Cushman Lab. Foram. Res., vol. 5, p. 17, pl. 3, figs. 16a–c, 1929.—CUSHMAN and RENZ, Cushman Lab. Foram. Res., Spec. Publ. 24, p. 40, pl. 8, figs. 3–4, 1948.—CUSHMAN and BERMUDEZ, Cushman Lab. Foram. Res., vol. 25, pt. 2, p. 32, pl. 6, figs. 7–9, 1949.

STRATIGRAPHIC RANGE: *Globigerapsis kugleri* zone (probably upper part only) to *Truncorotaloides rohri* zone, Navet formation.

LOCALITY: Figured hypotypes from the *Porticulasphaera mexicana* zone, Navet formation: (figs. 9, 10, 12, 13; USNM P5746a–d): same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782); (figs. 11a–b; USNM P5747), block in Moruga River, south Trinidad; sample BB 124 (TTOC 2548).

Globorotalia centralis Cushman and Bermudez

PLATE 39, FIGURES 1a–4

Globorotalia centralis CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res., vol. 13, p. 26, pl. 2, figs. 62–65, 1937.—BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 396, pl. 26, figs. 8, 9, 1953.—BERMUDEZ, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 284, pl. 22, figs. 30–32, 1949.

Globorotalia (*Turborotalia*) *centralis* Cushman and Bermudez, CUSHMAN and BERMUDEZ, Cushman Lab. Foram. Res., vol. 25, pt. 2, pp. 44–45, pl. 8, figs. 19–21, 1949.

STRATIGRAPHIC RANGE: *Globigerapsis kugleri* zone (probably upper part), Navet formation to *Globorotalia cocoaensis* zone, San Fernando formation.

LOCALITY: Figured hypotypes (figs. 1a–3c; USNM P5748a–c) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782). Figured hypotype (fig. 4; USNM P5749) from the *Globorotalia cocoaensis* zone, San Fernando formation; road cut at intersection of Naparima—Mayaro Road and San Fernando Bypass Road, east of San Fernando; sample KR 20521a (TTOC 113248).

REMARKS: *Globorotalia centralis* Cushman and Bermudez shows considerable variation. During the evolution of the species there is a change in chamber shape from rounded towards subangular. The more subangular specimens may be regarded as transitional to *G. cocoaensis* Cushman. High spired specimens (figs. 2a–b) begin to occur in the upper part of the Navet formation. It has already been pointed out (p. 164) that specimens transitional between *G. centralis* and *Globigerina ampliapertura* Bolli are found in the *Globorotalia cocoaensis* zone, San Fernando formation. Further studies on the *Globorotalia centralis* group and related species will have to be carried out before it will be possible to establish definitely the genetic relationships. It may then be possible to erect a number of subspecies of stratigraphic value.

Globorotalia opima nana Bolli

Globorotalia opima nana BOLLI, U. S. Nat. Mus. Bull. 215, p. 118, pl. 28, figs. 3a–c, 1957.

STRATIGRAPHIC RANGE: *Truncorotaloides rohri* zone, Navet formation to *Globigerina ciperoensis ciperoensis* zone, Cipero formation.

Globorotalia cocoaensis Cushman

PLATE 39, FIGURES 5a–7b

Globorotalia cocoaensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 4, pt. 3, p. 75, pl. 10, figs. 3a–c, 1928.—BANDY, Bull. Amer. Paleontol., vol. 32, No. 131, p. 79, pl. 12, figs. 1a–c, 1949.

Globigerina cerro-azulensis COLE, Bull. Amer. Paleontol., vol. 14, No. 53, p. 217, pl. 32, figs. 11–13, 1928.

Globorotalia (*Turborotalia*) *cerro-azulensis* (Cole), CUSHMAN and BERMUDEZ, Cushman Lab. Foram. Res., vol. 25, pt. 2, pp. 42–43, pl. 8, figs. 10–12, 1949.

STRATIGRAPHIC RANGE: *Globigerapsis semiinvoluta* zone, Navet formation to *Globorotalia cocoaensis* zone, San Fernando formation.

LOCALITY: Figured hypotypes (USNM P5750a–c) from the type locality of *Globorotalia cocoaensis* zone (see p. 160); sample KR 25684 (TTOC 238769).

Genus Truncorotaloides Bronnimann and Bermudez, 1953

After completion of the present study on the planktonic Foraminifera of the Navet formation, some excellent preserved material of Eocene and Paleocene age from Mid-Pacific seamounts became available for examination through the courtesy of Dr. E. L. Hamilton, U. S. Navy Electronics Laboratory, San Diego, California, and the Scripps Institution of Oceanography.

The predominantly planktonic fauna of Mid-Pacific

expedition core 25E–1 (19°40′ N., 168°32′ W.) described by Hamilton (1953) is almost identical with that of the *Hantkenina aragonensis* zone or the basal part of the *Globigerapsis kugleri* zone of the Navet formation. Many of the specimens which are otherwise indistinguishable from those described here as *Globorotalia bullbrooki* Bolli, new species, show distinct supplementary sutural apertures on the spiral side, a feature that could not be seen in the Trinidad specimens due to poor preservation. It seems most likely therefore, that *Globorotalia bullbrooki* from the Navet formation should be placed in the genus *Truncorotaloides*.

The fauna of dredge sample 33C (17°45′ N., 174° 16′ W.), described by Hamilton as Paleocene, is comparable with that of the *Globorotalia velascoensis* zone of the Lizard Springs formation of Trinidad (Bolli, 1957a). Another possibility is that it represents a horizon between the Paleocene *Globorotalia velascoensis* zone and the lower Eocene *Globoratalia rex* zone of the Lizard Springs formation, where a stratigraphic break is indicated in the Trinidad section. Together with *Globorotalia velascoensis* (Cushman), numerous *Truncorotaloides* types were found in the well preserved material. The study of the dredge sample would suggest that there are *Truncorotaloides* types identical with or very close to species described under the names *Globorotalia wilcoxensis* Cushman and Ponton, *G. formosa gracilis* Bolli, and *G. aequa* Cushman and Renz.

The fact, that *Truncorotaloides* appears in the Paleocene makes it likely that some lower Eocene species, so far attributed to the genus *Globorotalia*, might also possess supplementary sutural apertures on the spiral side which have not been observed because of poor preservation. One such species likely to belong to *Truncorotaloides* is *Globorotalia quetra* Bolli.

All known *Truncorotaloides* species belong to the group of distinctly spinose forms which appeared in the upper Paleocene and apparently became extinct at the end of the middle Eocene.

Truncorotaloides rohri Bronnimann and Bermudez

PLATE 39, FIGURES 8–12c

Truncorotaloides rohri BRONNIMANN and BERMUDEZ, Journ. Paleontol., vol. 27, No. 6, pp. 818–819, pl. 87, figs. 7–9, 1953.—BECKMANN, Eclog. Geol. Helvetiae, vol. 46, No. 2, p. 396, pl. 26, figs. 10, 11, 1953.—BOLLI, LOEBLICH, and TAPPAN, U. S. Nat. Mus. Bull. 215, p. 42, pl. 10, figs. 5a–c, 1957.

STRATIGRAPHIC RANGE: ?*Hantkenina aragonensis* zone; *Globigerapsis kugleri* zone to *Truncorotaloides rohri* zone, Navet formation.

LOCALITY: Figured hypotypes (USNM P5751a–e) from the *Porticulasphaera mexicana* zone, Navet formation: same locality as given for *Hastigerina micra* (Cole) (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: In addition to *Truncorotaloides rohri*, Bronnimann and Bermudez (1953) described three varieties of this species which illustrate the variation of chamber and test shape ranging from rounded to angular forms. In *T. rohri* var. *guaracaraensis* are included specimens with spherical chambers. *T. rohri* var. *piparoensis* is an intermediate form between *T. rohri* var. *guaracaraensis* and *T. rohri*. The chambers of *T. rohri* var. *mayoensis* are angular conical, the test umbilicoconvex. This variety may be regarded as related to *T. topilensis* (Cushman).

Truncorotaloides topilensis (Cushman)

PLATE 39, FIGURES 13–16b

Globigerina topilensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, No. 3, p. 7, pl. 1, figs. 9a–c, 1925.

STRATIGRAPHIC RANGE: *Globigerapsis kugleri* zone to *Porticulasphaera mexicana* zone, Navet formation.

LOCALITY: Figured hypotypes (USNM P5752 a–d) from the *Porticulasphaera mexicana* zone, Navet formation; same locality as given for *Hastigerina micra* (Cole), (p. 161); sample Hg 8581 (TTOC 215782).

REMARKS: The Trinidad specimens of *Truncorotaloides topilensis* (Cushman) compare closely with the holotype of *Globigerina topilensis* Cushman, except that many specimens possess sutural, supplementary apertures on the spiral side, such as characterize the genus *Truncorotaloides*.

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