Description of the larger foraminifera localities

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The study of the Trinidad larger foraminifera is inseparably linked to that of Soldado Rock, the tiny islet situated between Trinidad's southwestern point and the Venezuelan coast (Kugler & Caudri 1975; Caudri 1975). It is recommended that these two publications be used alongside the present one.

Apart from the main fossil localities there are in our collection a great number of erratic blocks and boulders. Although their origin can not always be traced, they have in certain cases proved to be of great importance. Most of them are from the Late Eocene San Fernando Formation or from the Oligocene as we know it from the Mejias and Kapur quarries. Some are the only indications that certain formations, which are no longer found in situ, did exist in Trinidad as they do in other places in the Caribbean region. Examples are the solid *Ranikothalia* limestone of the Paleocene and the *Proporocyclina tobleri* limestone of the earliest Middle Eocene (Boca de Serpiente Formation), both known from the Soldado Rock section, and also the uppermost Oligocene *Spiroclypeus* limestone of which isolated blocks are all that remains.

Erratica are especially common in the southern part of Trinidad: Erin Point and Erin Bay, Tapara Point, Chagonary Point, Point Bontour, the Marac River, the Karamat mud volcanoes, the Lizard Springs and Navette River areas and Charuma. They are described there under the locality where they have been found; in the Distribution Chart (Fig. 7) they are entered according to their age.

3. Description of the larger foraminifera localities

List of localities in alphabetical order, with corresponding numbers on key map Fig. 1:

A.E.G.6616, Central Range, locality of *Miogypsinoides complanata*	22
Biche Village Quarry	12
Boussignac well-1, West of Biche	23
Brasso Quarry	8
Concord Quarry	7
Corozal Quarry	4
Dunmore Hill marl, type locality	13
Gasparillo Quarry	2
Hermitage Quarry	1
Kapur Quarry	20
Lizard Springs Formation, type locality (Mky. 102b III)	21
Machapure Quarry	10
Marac Quarry	17
Marac well 1	18
Martin Quarries	9
Mayo Quarry	3
Mejias Quarry	19
Morichal Quarry	5
Morne Diablo Quarry	16
Morne Roche Quarry	6
Nariva Quarry	11
Roussillac well-1, near Pitch Lake	15
Ste. Croix Quarry	14
Type section of Charuma silt	24

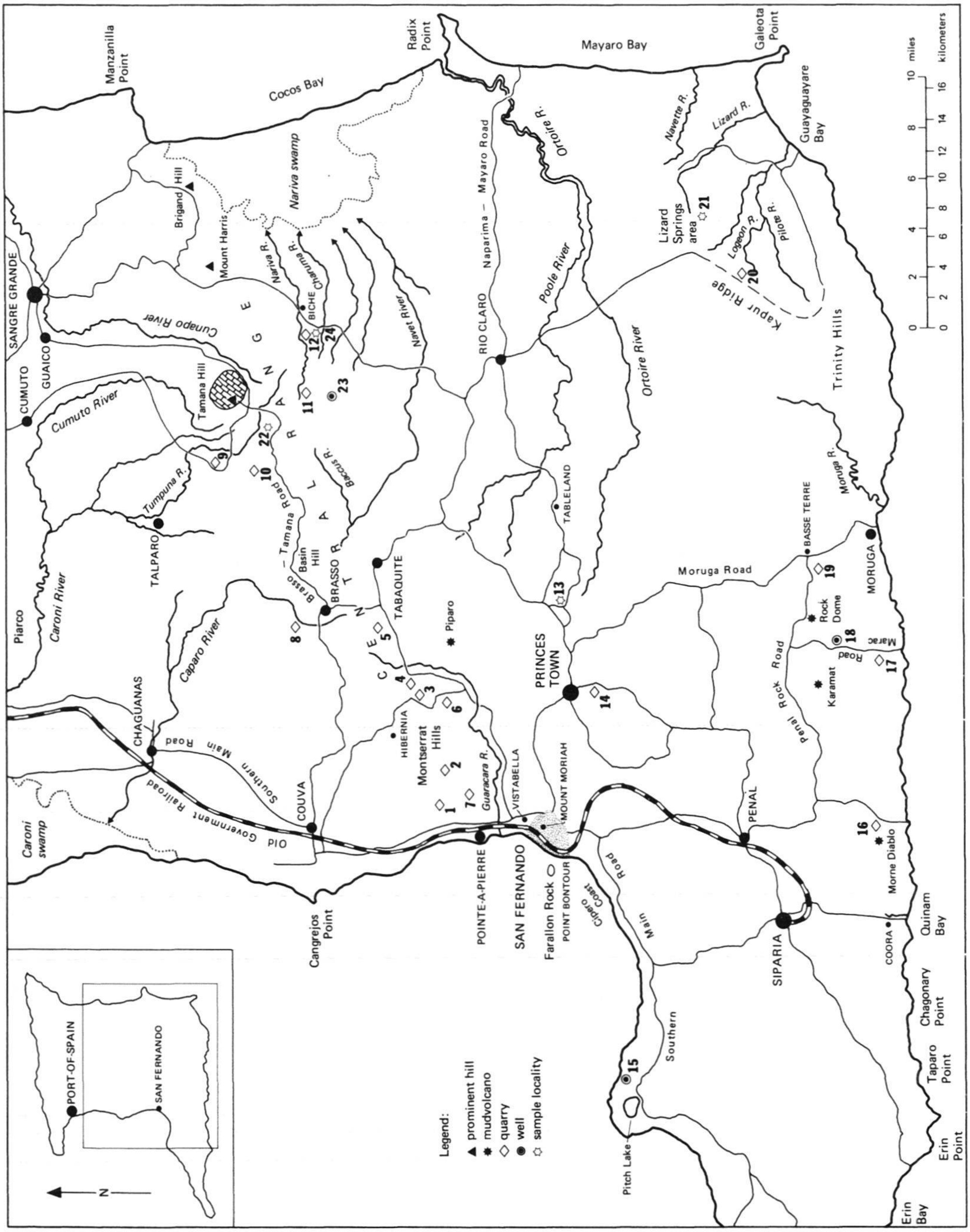

Fig. 1. Map showing larger foraminifera localities 1–24.

3.1. *Cretaceous*

Cretaceous larger foraminifera have been found in Trinidad only in isolated blocks. Vaughan & Cole (1941) mention the occurrence of *Orbitolina* cf. *texana* (Roemer) in a huge boulder of caprinid limestone (the so-called Stackrock (K. 2945d) on the sea shore of the former Bon Accord Estate at Pointe-a-Pierre (now removed and set up as a protected natural monument farther inland). This information is not quite correct; the Orbitolinas were not found in the caprinid limestone itself but in a boulder in the Bon Accord conglomerate from the same locality K. 2945d, a dense bluish foraminiferal limestone. Its age is given by Vaughan & Cole (1941) as Early Cretaceous (probably Albian). An even better sample of an *Orbitolina* limestone was found at Quinam (B. 6035) on the South coast, in the river near auger hole Hg. 769. In this boulder occur better preserved Orbitolinas in rock-building abundance, together with great quantities of Miliolids (Pl. 10:18). The species seems to be the same as in K. 2945d. This is the only species of larger foraminifera known from the Trinidad Cretaceous.

3.2. *Paleocene*

Marac Quarry (Locality 17)

Location: Quarry on West-side of the North-South running Marac Road, about 2,5 km from the coast.

Lithology: Deeply weathered lumpy limonitic shell limestone rich in Venericardias and Nautiloids. In fresh condition dark grey, glauconitic, with blackish fossils. The quarry itself lies as a slump mass within the Miocene Karamat Formation which carries frequent reworked material including *Spiroclypeus bullbrooki*, *Miogypsina* and *Lepidocyclina*.

Fauna: The authochthonous fauna of the limestone can be directly correlated with that of the Paleocene Soldado Rock Bed 2 (Kugler & Caudri 1975). The only trace of larger foraminifera in the limestone is that mentioned by van de Geyn & van der Vlerk (1935): A fragment of a *Lepidocyclina* in a fresh dark grey limestone which may also be assigned to *Neodiscocyclina*.

Age: Paleocene.

Marac Well-1 (Locality 18)

Location: On East side of the North-South running Marac Road, about 4 km South of its junction with the Penal Rock Road. Core at 7452–7458 feet.

Lithology: A block within the Oligo-Miocene Cipero Formation of hard grey algal limestone of the Marac Quarry type.

Fauna: A specimen of a thick walled low chambered *Amphistegina* with straight septa was identified. Further two orbitoids: *Neodiscocyclina* cf. *barkeri* and *N.* cf. *mestieri*, both Paleocene forms also known from Soldado Rock.

Age: Paleocene.

Lizard Springs (Locality 21)

Location: Ravine of the Ampelu River, a small tributary of the Ortoire River. For a detailed description and map reference is made to Cushman & Renz (1946). The name given to the formation by Cushman & Jarvis (1928) derives from the Lizard River, East of the type locality in the Guayaguayare area, South East Trinidad.

Lithology: Dark greenish-grey compact and nodular poorly stratified marl and calcareous clay.

Fauna: The rich smaller foraminiferal fauna was described by Cushman & Jarvis (1928, 1929, 1932) and more detailed by Cushman & Renz (1946). Based on two distinctly different assemblages in the type area the Lizard Springs Formation was devided by Cushman & Renz into an Upper and Lower zone. One of the samples collected at the type locality (Mky. 102b III) yielded larger foraminifera. At the time they were investigated by the author (private reports), Vaughan (1945) and Cushman (1932). The locality from which the rich larger foraminiferal fauna was collected could at later surveys not been found again. It is assumed that the larger foraminifera were washed in from a contemporary reef.

The following larger foraminifera from the Maerky sample were listed by Cushman & Renz (1946): *Discocyclina (Discocyclina) aguerreverei* Caudri; *Discocyclina (Discocyclina) caudriae* Vaughan; *Discocyclina (Discocyclina) grimsdalei* Vaughan & Cole; *Discocyclina (?Discocyclina) meandrica* (Caudri); *Lepidorbitoides* cf. *planasi* M.G. Rutten; *Miscellanea antillea* (Hanzawa); *Miscellanea catenula* (Cushman & Jarvis); *Miscellanea* cf. *soldadensis* Vaughan & Cole; *Miscellanea tobleri* Vaughan & Cole; *Pseudophragmina (Athecocyclina) soldadensis* Vaughan & Cole; *Pseudophragmina (Proporocyclina)* cf. *tobleri* Vaughan & Cole.

Of these *Miscellanea catenula; Lepidorbotoides* cf. *planasi* and *Pseudophragmina (Proporocyclina) tobleri* should be left out as they apparently do not come from the Maerky sample.

From information available to the author the larger foraminiferal assemblage of the Maerky sample consists of *Ranikothalia antillea* (Hanzawa), abundant; *Ranikothalia tobleri* (Vaughan & Cole), common; *?Ranikothalia soldadensis* (Vaughan & Cole), very rare; *Athecocyclina soldadensis* (Vaughan & Cole), scarce; *Hexagonocyclina meandrica* Caudri (also very thick-walled specimens), scarce; *Hexagonocyclina inflata* (Caudri), scarce; *Neodiscocyclina caudriae* (Vaughan), abundant; *Neodiscocyclina grimsdalei* (Vaughan & Cole), one or two doubtful specimens; *Neodiscocyclina aguerreverei* (Caudri), one specimen; *Neodiscocyclina fonslacertensis* (Vaughan), common; *Stenocyclina* sp. [cf. *advena* (Cushman)], two specimens.

Age: According to Cushman & Renz (1946) the Lizard Springs Formation occupies a transitional position between the Late Cretaceous and Early Tertiary or, likely Late Maastrichtian to Danian. Based on planktic foraminifera by which the Lizard Springs Formation is subdivided into about a dozen zones, the age of the Lower Lizard Springs is Paleocene, that of the Upper Lizard Springs Early Eocene.

Note: Vaughan & Cole did not have access to this material in 1941, but afterwards some of the Discocycliniformes and Ranikothalias from our collection were sent to Washington and are included in Vaughan (1945).

Because of its particularly interesting nature, parts of the type material was sent to various specialists and is now divided over four different depositories: The Geological Laboratory of TTOC in Pointe-a-Pierre, Trinidad; the National Museum of Geology and Mineralogy in Leyden, Netherlands; the Natural History Museum Basel, Switzerland; the U.S. National Museum in Washington, D.C. A superficial report was published by van de Geyn & van der Vlerk (1935) on the part that was sent to the Netherlands. This material, loaned to the author by the Leyden Museum for comparison, poses some problems and should be carefully re-studied for all its contents. It is a highly calcareous slightly glauconitic marl like the sample in Pointe-a-Pierre, but its fauna seems to differ from that described from the Lizard Springs Formation by Cushman & Renz (1946). The marl is rich in echinoid remains, benthic and planktic foraminifera and other organisms, unsorted as to size. The fauna seems to be a mixture, composed primarily of large *Lenticulina, Nodosaria, Saccammina* and *Clavulina* specimens. The sample rather belongs to the lower part of the formation as its contains *Neoflabellina* and *Rzehakina epigona* var. *lata*.

3.3. Eocene and transition Eocene-Oligocene

3.3.1. The San Fernando area

The town of San Fernando (Fig. 2) was built on very uneven terrain around the old Naparima or San Fernando Hill, once a high, steep, very conspicuous landmark of hard Late Cretaceous argilline, today nearly entirely quarried away for road metal. The topography of the town is due to the alternation of soft marls and more resistent limestone lenses, conglomerates and sandstone banks that surround this hill. Based on smaller foraminifera, some of the marls have been determined as Paleocene and Middle Eocene in open marine facies (Lizard Springs and Navet formations) devoid of larger foraminifera. The rest of the marls, and the limestones, silts, sandstones and conglomerates, belonging to the Eo-Oligocene cycle of sedimentation (San Fernando and Cipero formations), tend to be more neritic and often contain a wealth of fossils amongst which many larger foraminifera.

Topographically the most prominent of these Eo-Oligocene elements are the Mount Moriah conglomerate and sandstone ridge in the northwestern part of the town, and the Hospital Hill in the Southwest. Both are cut off abruptly by the sea and end in a steep coast which is interrupted only over a short distance in the middle, leaving room for the little fish market and the disused station building of the old Government Railway which ran along the entire shoreline, partly on reclaimed land. The northwestern flank of the Mount Moriah ridge, the former Vistabella Estate, slopes down gradually towards the Marabella River. The Hospital Hill, the top of which is also known as Paradise Pasture or Paradise Gate and on which are built the hospital and the Naparima Club, terminates in the Southwest in a fairly high and conspicuous silty limestone cliff, which is called Point Bontour. Beyond this point, the coastline first assumes a southeasterly course but soon swings back to southwest to form the low Cipero coast.

The present chapter deals with the western part of the San Fernando area, from the Marabella River in the North to Point Bontour in the South. The sketch maps (Fig. 1, 2) were copied from unpublished geological maps compiled by H.G. Kugler in 1959. A detailed description is given of the following localities: Hospital Hill marl, Top of Mount Moriah, Mount Moriah Boulder Bed, Vistabella Quarry, Calyx wells 59, 57, Schlumberger office section, San Fernando Railway Station, Point Bontour.

Apart from the Hospital Hill marl, which lithologically belongs to the Navet Formation, they represent the neritic San Fernando Formation of Late Eocene to Early Oligocene age. The discussions on the San Fernando area closes with comments on the problem of reworking, the base of the Late Eocene and the transition Late Eocene to Oligocene.

Hospital Hill marl (Fig. 2)

The composition of the entire Hospital Hill area is heterogeneous and confused. Most of the samples collected from the surface, pit and auger lines are of the neritic type, but also the pelagic facies of the Late Eocene is present as a yellowish to light-grey nodular marl, the Hospital Hill marl. Though more extensively recognized in subsurface sections, this marl is known at the surface only from a few poorly exposed slipmasses surrounded by Oligocene marls of the Cipero Formation. Also, its original type sample (Rz. 75) comes

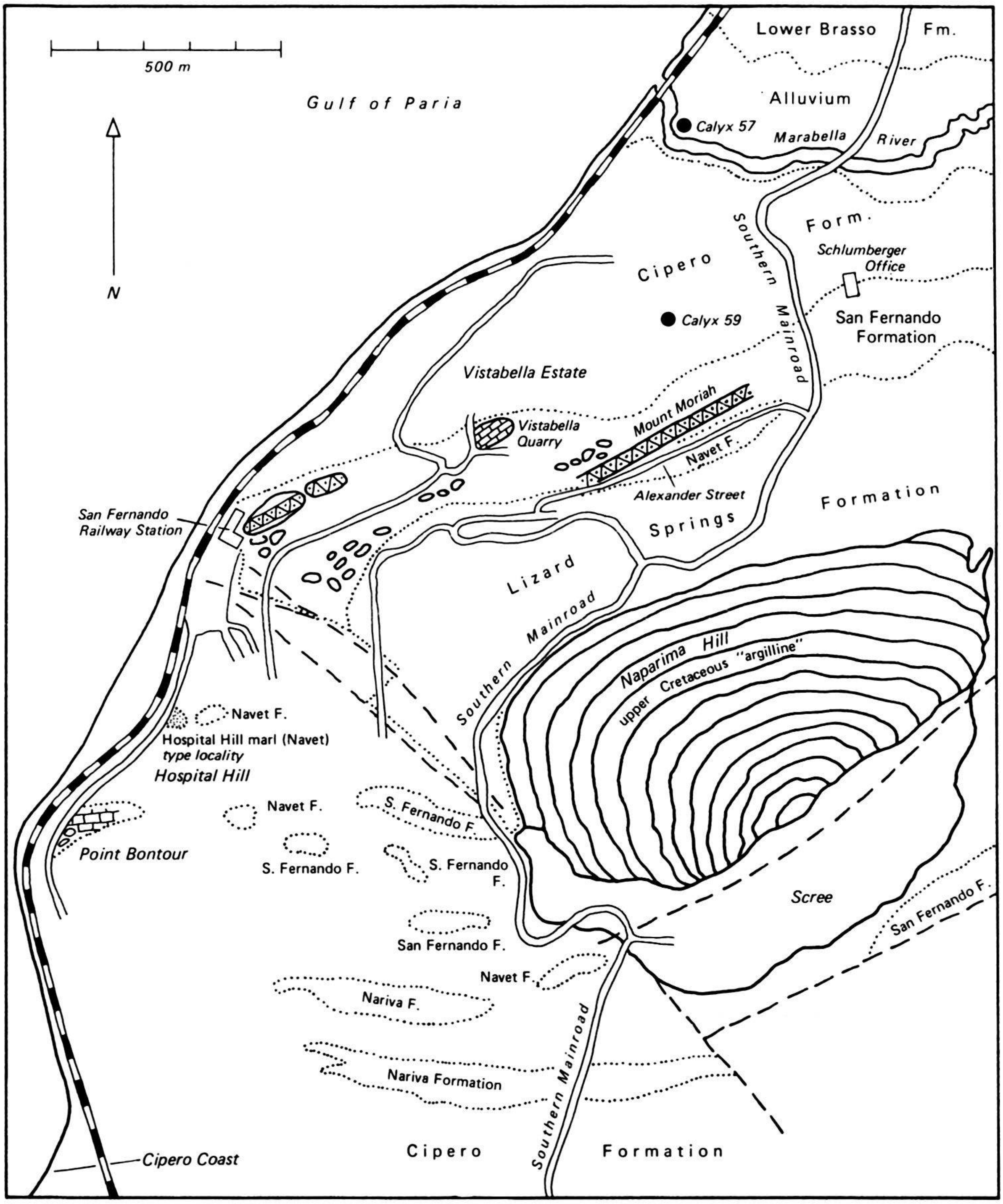

Fig. 2. Geological sketch- and locality map of San Fernando area.

from such a slipmass at the foot of the cliff on the shore road to Point Bontour, but this locality has since been obliterated by a landslide. A new outcrop has been chosen to the North of it, behind the Norwegian Seamen's church.

Lithologically, the Hospital Hill marl belongs to the Navet Formation, which is mainly Middle Eocene. In wells, it seems to be in normal contact with the rest of the Navet.

However, its rich fauna of smaller foraminifera, described by Cushman & Renz (1948) as transitional between Navet and Cipero, indicates a Late Eocene age, in terms of the modern planktic zonation the *Globigerinatheka semiinvoluta* Zone (Bolli 1957b).

In this type of marl one would hardly expect to find larger foraminifera but they do occur in it, and are even representative of a complete fauna. About twenty pounds of the type sample yielded 184 small specimens of them, chiefly *Asterocyclina, Lepidocyclina pustulosa* s.l. and *Operculinoides* cf. *kugleri*. The complete list is given on Fig. 7. Special attention is drawn to the presence of *Helicosteginopsis soldadensis*. The same fauna was also found in a second outcrop, just North of the old hospital buildings (G.F. 4153).

On the strength of this assemblage a direct correlation can be made between the Hospital Hill marl and the neritic San Fernando Formation and more specifically with the *Hantkenina* marl which is intercalated in that formation in the section of Soldado Rock (Kugler & Caudri 1975: Bed 7).

According to Bolli, the *Globigerinatheka semiinvoluta* Zone is Late Eocene but slightly older than the main body of the San Fernando Formation (*Turborotalia cerroazulensis* Zone). Judging by the larger foraminifera, however, it does not seem to be the base of the Late Eocene as we know it from the top of Mount Moriah and from Soldado Rock, as the fauna already contains *Helicosteginopsis soldadensis*, which is absent in those basal sediments. In this respect, the marl corresponds with the Late Eocene of Point Bontour and Vistabella. Also, in the Gulf States *Globigerinatheka semiinvoluta* is recognized as early Late Eocene.

As in the case of the *Hantkenina* marl of Soldado Rock, this shows that the open marine Navet facies did not only continue locally into the Late Eocene, but that from time to time it alternated with the neritic phase. In a stratigraphic section one therefore cannot just place the Navet, including the Hospital Hill marl, below the bulk of the San Fernando Formation. The two appear to interfinger in a much more complicated way.

Top of Mount Moriah (Fig. 2, 3)

Mount Moriah is the steep hill to the Northwest of the Naparima Hill, entirely within the built-up area of the town of San Fernando. Between the two hills the softer deposits of the Lizard Springs and Navet formations from the valley in which, parallel to each other, run the Southern Main Road and Alexander Street, a little higher up the slope of Mount Moriah. Just above that street, the crest of the hill, which consists of resistant Late Eocene sandstones and conglomerates, has offered the best exposures we have in Trinidad of the transgressive base of the Late Eocene.

During the excavation of the foundations and driveways of the row of big houses which adorn the crest (early 1938), a careful survey of all the trenches and road cuts was carried out by Shell's geologist A.G. Hutchison. The exposed section, which shows a dip of nearly 40°, starts with a series of marls, silts and glauconitic sands and sandstones, including a thin orbitoid bed about halfway up, that lie concordantly over the Navet marls of Alexander Street. These basal beds are followed by a conglomerate, the Mount Moriah Boulder Bed, which consists mainly of argilline debris from the Naparima Hill, and which overlaps the glauconitic sandstones, cutting out the orbitoid bed from East to West. This conglomerate thus clearly represents a second phase of transgression, the sequel of which are the younger Late Eocene beds towards Vistabella and the coast, which contain the typical Late Eocene assemblages of the *Turborotalia cerroazulensis* Zone.

The basal beds of the first stage were later distinguished by the Trinidad Leaseholds Ltd. Geological Department as the Mount Moriah glauconitic sandstone member of the San Fernando Formation. Though at first sight very similar to the Vistabella Eocene, it has proved to carry a slightly different larger foraminifera fauna.

Hutchison's material is generally very glauconitic and in part calcareous and contains a large amount of clastic material, chiefly argilline. Most of the samples are either barren or carry a poorly preserved and indeterminable planktic fauna, but the three samples taken from the orbitoid bed, which is practically non-clastic, yielded a rich and well-preserved fauna of larger and benthic smaller foraminifera. Traces of larger foraminifera were found in four other samples. The survey was later taken up by T.L.L. (H.H. Renz and R. Mühlemann). In total one had at disposal 136 samples, 23 of which yielded larger foraminifera and seven more at least some Amphisteginas. Of all these, only A.G.H. 5550, A.G.H. 5583, A.G.H. 5584, M. 122282 and M. 12283a contained a really representative complete assemblage.

The type sample of the Mount Moriah sandstone member is A.G.H. 5550 (Fig. 2). This sample was taken from the orbitoid bed exposed in the lefthand bank of the driveway to Mr. Farban's house on the very top of the hill, and is stratigraphically about 30 feet below the conglomerate. Unfortunately, all the exposures on the crest became walled up and inaccessible. T.L.L., therefore, chose a safer new type locality for this stratigraphic unit, roughly along the strike of the same bed: P.J. 239 (= Cd. 205) in the steep bank below Dr. Krogh's house at the northeastern end of the ridge. But there the deposit is more contaminated, full of various clastic fragments and, though it carries essentially the same orbitoid fauna as Hutchison's locality, it is not as good as the original material. Paleontologically, at least as far as the larger foraminifera are concerned, A.G.H. 5550 must remain the type sample of this particular biozone.

This sample is described in Hutchison's field book as a green unbedded rubbly glauconitic orbitoidal sandstone. The inorganic residue after washing is composed of 95% glauconite and for the rest of quartz grains (no argilline). The larger foraminifera are unsorted as to size and give the impression of being in situ.

The fauna consists of: *Asterocyclina* asterisca (Guppy), abundant (nearly all 4-rayed); *Proporocyclina mirandana* (Hodson), scarce; *Lepidocyclina pustulosa* (Douvillé), s.s., common; *Lepidocyclina pustulosa trinitatis* (Douvillé), abundant; *Lepidocyclina pustulosa compacta* Caudri, scarce; *Lepidocyclina pustulosa* (Douvillé), B-forms, scarce; *Lepidocyclina peruviana* Cushman, A-form abundant, B-form scarce; *Lepidocyclina (Polylepidina) vichayalensis* L. Rutten, quite frequent; *Lepidocyclina* (*Polylepidina*) *nitida* Caudri n. sp., A-and B-form, scarce; *Helicolepidina spiralis* Tobler, also B-form, scarce; *Helicolepidina* aff. *nortoni* Vaughan, very rare; *Helicolepidinoides intermedius* Caudri n. sp., rare; *Operculinoides soldadensis* Vaughan & Cole, common; *Operculinoides ocalanus* (Cushman), very rare; *Operculinoides kugleri* Vaughan & Cole, common; *Operculinoides spiralis* Caudri, rare; *Amphistegina grimsdalei* Caudri, common. Smaller Foraminifera, practically all benthic, common Bryozoans, Echinoids, Fish vertebrae and teeth, Algae; all scarce.

This fauna, though closely related to the Late Eocene assemblages of Vistabella and Point Bontour, is strikingly different in the following aspects: total absence of *Helicosteginopsis soldadensis* and *Lepidocyclina pustulosa tobleri*, high frequency of *Polylepidina vichayalensis,* abundance of *Lepidocyclina peruviana,* predominance of the 4-rayed form of *Asterocyclina asterisca* over the 5-rayed one, and of the primitive uni-serial form of *Helicolepidina spiralis* over the form with two auxiliary chambers.

In addition to the stratigraphic arguments mentioned above, this difference in fauna also distinguishes the Mount Moriah glauconitic sandstone as a separate unit. The same horizon, in which *Helicosteginopsis soldadensis* is not yet present, has been recognized in the section of Soldado Rock (Kugler & Caudri 1975: Beds 3–4 and 10, especially its lower part in which also *Lepidocyclina tobleri* is still absent).

The larger foraminifera assemblage of the Mount Moriah glauconitic sandstone, though not yet typical is clearly Late Eocene in age. This is confirmed by the presence of a rich but strikingly monotonous fauna of smaller foraminifera in the orbitoid bed: Large *Lenticulina, Marginulina* and *Frondicularia*, several forms of large ribbed *Nodosaria*, *Bulimina jacksonensis* (elongate variety), *Siphogenerina, Eponides*, various species of *Gaudryina* and a few Miliolids. Trinidad Leaseholds geologists assigned this sandstone member, together with the beds above the conglomerate, to the *Turborotalia cerroazulensis* Zone, but actually the planktic zone has never been established specifically. Hutchison's type samples did not carry any significant planktics. Most other samples show evidence of a once very rich planktic fauna, generally reduced to hardly recognizable casts. It is somewhat better preserved in A.G.H. 5545–5548 and in the soft calcareous sand layer M. 12279, in which floods of Middle Eocene forms from the Navet Formation were determined. Along with a great deal of clastic material from that formation, this whole planktic fauna is reworked. For a correct age determination we can therefore only rely on the benthic forms as there seem to be no reworked larger foraminifera, or hardly so. For instance, the Paleocene forms which cause so much confusion at Point Bontour are here totally absent. There exists however some doubt about the presence of *Helicolepidinoides intermedius* and *Polylepidina nitida*, both predominant elements of the uppermost Middle Eocene Farallon fauna.

Mount Moriah Boulder Bed (Fig. 3)

This conglomerate, which overlies the Mount Moriah sandstone with such a marked discordance, forms the base of the series. Usually, it can be correlated with the conglomerates of the quarries in Point-a-Pierre and farther north, at the southwestern end of the Central Range (Bon Accord, Plaisance, Hermitage, Stollmeyer, etc.) and consequently also with the grit of the Morne Roche Quarry which is often considered as a locally developed equivalent.

However, because the exact stratigraphic position of these boulderbeds is doubtful and no informative foraminiferal fauna was found in their matrix, it remains open whether they represent the first or the second transgression of the Late Eocene sea. On the other hand, the Morne Roche grit, which carries a good fauna but in which *Helicosteginopsis soldadensis* is absent, is pre-Late Eocene and does not correlate with the boulder bed on Mount Moriah.

Vistabella (Fig. 2)

From a paleontologic as well as a stratigraphic point of view, the former Vistabella Estate, now transformed into the northern residential area of San Fernando, has proved to be of great importance. It not only furnished the classical fossil material of the Late Eo-

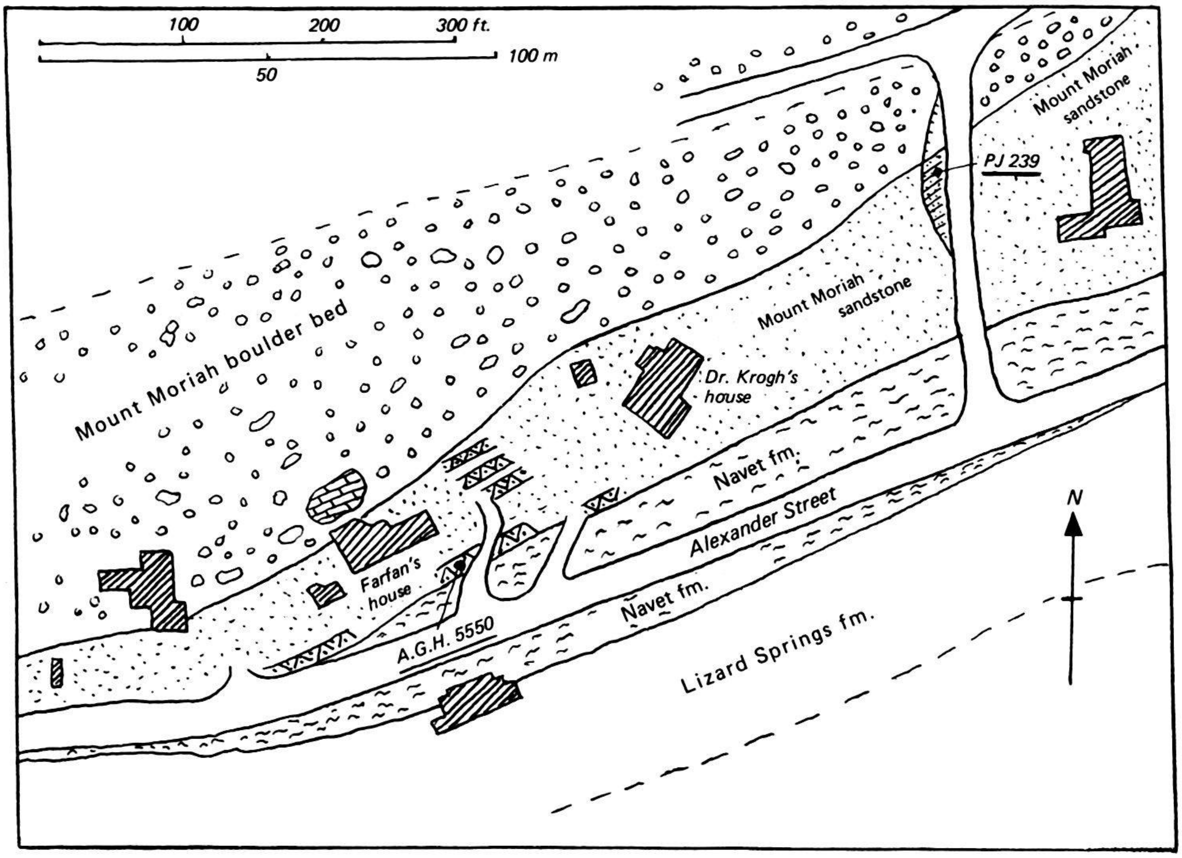

Fig. 3. Geological sketch map of the top of Mount Moriah.

cene in this part of the Caribbean region (Vistabella marl, including the Vistabella Quarry), but also covers the transition from the Late Eocene to the Oligocene, including the intermediate zone for which the name of Marabella marl is here proposed. The biostratigraphic data obtained from the Vistabella section should be considered together with those from the exposures at the former San Fernando Railway Station and at Point Bontour.

Vistabella Quarry (Fig. 3)

The now completely obliterated Vistabella Quarry used to be one of the richest Late Eocene fossil localities in the Caribbean region. It consisted of a body of very steeply north-dipping limestones and highly calcareous glauconitic marls full of algae nodules, orbitoids and megafossils, indicating a Late Eocene age (Rutsch 1939). Sampling has at first been done indiscriminately, but later more carefully, bed for bed. Those in the southwestern corner of the quarry are supposed to be the oldest, but the entire package is probably a slump mass in this sequence.

The section contains two prominent hard dense limestone banks and, immediately below each of them, a particularly rich orbitoid bed, but also the other marls are highly fossiliferous. Most conscpicuous in the fauna are very large orbitoids with a diameter often exceeding 20 mm, *Tubulostium* and Echinoids. The surrounding marls, in which the quarry limestone lies embedded, carry the same larger foraminifera, only less abundant and generally of smaller size, which shows that the bioherm, though slumped from its original position, belongs to the same deposit (Vistabella marl). As in the Mount Moriah sandstone, the smaller foraminiferal fauna contains conspicuously large *Nodosaria, Lenticulina, Vaginulina* and *Frondicularia*, also *Bulimina jacksonensis* and other forms typical for the Late Eocene. In terms of planktics, the Vistabella marl belongs to the *Turborotalia cerroazulensis* Zone.

Of the two rich orbitoid horizons, the lowest one (from which sample Cd. 218 was taken, and probably all the old samples which found their way into paleontological collections all over the world) yielded by far the most complete and best developed larger foraminifera assemblage. The presence of floods of very small specimens side by side with the biggest forms of the same species (for instance of *Asterocyclina, Lepidocyclina pustulosa* and *Operculinoides*) shows that entire undisturbed populations are preserved in these deposits. The quarry, and particularly this lower orbitoid bed, thus presents an extraordinarily reliable picture of the fauna of the Caribbean Late Eocene: *Nummulites striatoreticulatus* (L. Rutten), rare; *Operculinoides soldadensis* Vaughan & Cole, abundant; *Operculinoides ocalanus* (Cushman), abundant; *Operculinoides kugleri* Vaughan & Cole, abundant; *Operculinoides trinitatensis* (Nuttall), abundant; *Operculinoides suteri* Caudri n. sp., scarce; *Operculinoides spiralis* Caudri, rare; *Operculinoides* sp. div., juvenile forms, abundant; *Asterocyclina asterisca* (Guppy), 4- and 5-rayed A-forms, abundant, floods of juvenile forms; *Asterocyclina asterisca*, B-form, scarce; *Asterocyclina soldadensis* Caudri, rare, juvenile forms locally common; *Proporocyclina mirandana* (Hodson), few; *Lepidocyclina pustulosa* (Douvillé), s.s., abundant; *Lepidocyclina pustulosa trinitatis* (Douvillé), abundant; *Lepidocyclina pustulosa compacta* Caudri, locally abundant; *Lepidocyclina pustulosa tobleri* (Douvillé), unevenly distributed, locally abundant (Cd. 218); *Lepidocyclina pustulosa* (Douvillé), s.l., B-forms, abundant; *Lepidocyclina peruviana* Cushman, A-and B-forms, common; *Lepidocyclina spatiosa* Caudri, rare; *Lepidocyclina* sp. ind. l, A-form, very rare (Caudri 1975); *Lepidocyclina (Polylepidina) vichayalensis* L. Rutten, few; ?*Lepidocyclina* (Polylepidina) *nitida* Caudri n. sp., very rare; *Helicolepidina spiralis* Tobler, A- and B-forms, abundant; *Helicolepidinoides intermedius* Caudri n. sp., A- and B-forms, rare; *Heterosteginopsis soldadensis* (Grimsdale), A-form, floods; *Heterosteginopsis soldadensis*, B-form, scarce; *Amphistegina grimsdalei* Caudri, abundant; *Amphistegina* cf. *farallonensis* Caudri, very rare; *Sphaerogypsina globulus* s.l., rare.

Smaller foraminifera, locally in floods; *Tubulostium leptosoma clymenoides* (Guppy), abundant (Rutsch 1939). Oysters and other Pelecypods, Brachiopods, Ostracods, Bryozoans, Echinoids (common), Corals (few), fish teeth, Algae (abundant). The distribution of the individual species is variable as can be expected in a reefal deposit, but no distinction can be made between older and younger beds. This fauna of the second phase of the Late Eocene distinguishes itself chiefly from the first phase (Mount Moriah sandstone) by the appearance of *Helicosteginopsis soldadensis* and *Lepidocyclina tobleri*, by the development of 5-rayed *Asterocyclina asterisca* (in some samples even predominant over the 4-rayed form) and of a symmetric nepiont in *Helicolepidina*, and by the scarcity of *Polylepidina*.

The Vistabella Quarry is remarkably free of reworking as far as the larger foraminifera are concerned, though reworked Cretaceous and Paleocene smaller foraminifera seem to occur in this material. Often the specimens are badly eroded but this is obviously due to recent surface weathering: frequently they still have open air-filled chambers. The only indication of reworking may be the presence of rare *Helicolepidinoides intermedius* (A- and B-forms) in four samples from the lower orbitoid bed and one doubtful specimen of *Polylepidina nitida*. Though the top of their range is still uncertain, reworking is the most acceptable explanation of their presence in the Late Eocene (see Point Bontour).

Several samples collected in the neighbourhood carry the same fauna as the quarry (St. 45, with abundant *Lepidocyclina tobleri*; E.L. 1437, E.L. 1438). A beautifully weathered showpiece of this orbitoid limestone, on which the foraminifera stand out in bold relief, was found on the railway track along the coast; it is now kept in Texaco's office at Pointe-a-Pierre (Rz. 511a).

Vistabella Calyx wells (Fig. 2, 5)

Two calyx wells drilled in this area, 59 on the Vistabella Estate Northeast of the quarry and 57 at the mouth of the Marabella River, have disclosed the best section we have in Trinidad of the transition Eocene to Oligocene. Both wells are carefully cored. The bit penetrated a continuous sequence of detrital silts, with intercalactions of Nariva flysch. Apart from an unconformity in well 59, no sudden changes were noticed during drilling but, especially in 59, a gradual change takes place from the Cipero marls towards the characteristic Mount Moriah silt.

The larger foraminifera in these wells are in an excellent state of preservation, with undamaged thin walls and air-filled chambers, which is an indication that they are in situ and guarantee a reliable foundation for our biostratigraphic conclusions. Though throughout the entire section reworking of smaller foraminifera from the Middle and Lower Navet, the Paleocene and the Late Cretaceous is allegedly considerable, there is no reason to suspect reworking also from the Late Eocene into the Oligocene within this smooth cycle of sedimentation.

Calyx well 59

This well reached a depth of 815 feet. Larger foraminifera occur regularly from 40 down to 696 feet, with the exception of the interval between 100–240 feet. There are two rich horizons in the lower part of the well; for the rest, the fauna is rather poor but constant.

Apart from the already mentioned unconformity, at 670 feet, the lithology remains more or less uniform, but there is a clear break in the fauna at 370 feet. Below that depth, the larger foraminifera assemblage (particularly rich at 370–410 and at 500–510 feet) corresponds with that of the quarry (Vistabella marl). At 350 feet, just after the higher zone of the rich Late Eocene zones, the fauna is notably impoverished, though the usual Late Eocene forms continue without interruption. But at the same time there is at this point a sudden influx of two new elements: *Lepidocyclina subglobosa* Nuttall and *Helicocyclina paucispira* (Barker & Grimsdale). They are particularly frequent at 270–280 and 300–310 feet, and indicate a new, post-Late Eocene biozone. For this unit, a silty marl, the Name Marabella marl is here proposed. This same horizon has been recognized in Calyx 57, but the type section of the Marabella marl is the upper part of Calyx 59.

Below the unconformity at 670 feet the only clue to the age of the formation is the sporadic occurrence of *Lepidocyclina* cf. *pustulosa* and *Operculinoides* cf. *ocalanus* at 680–696 feet, suggesting that at least that level is not older than late Middle Eocene.

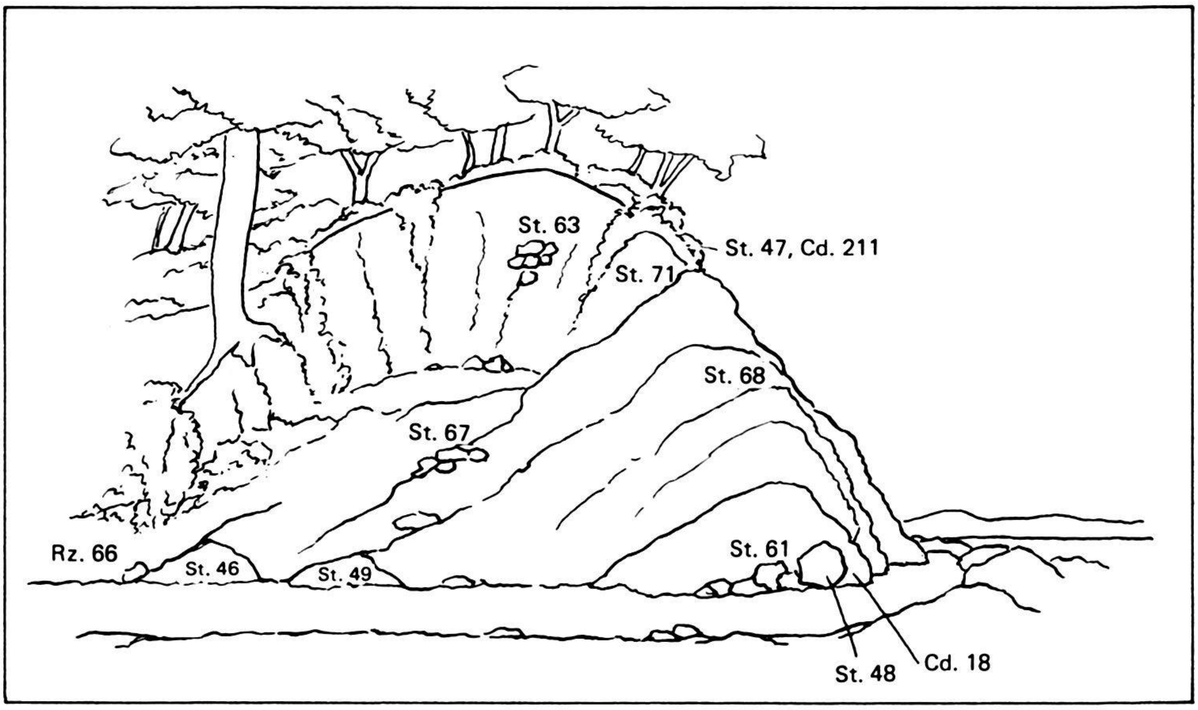

Fig. 4. The cliff of Point Bontour as it appeared 1940, seen from the West.

Calyx well 57

This well, spudded in the alluvium of the Marabella River and soon reaching the Oligocene, was drilled to a depth of 1020 feet. Larger foraminifera were found in the cores taken between 680 and 790 and 900 and 1010 feet. In most of these samples they are sporadic, only those from 780–790, 900–910 and 1000–1010 feet give a more complete picture of the faunas concerned. There is a striking difference between the fauna in the first interval (680–790 feet) and that from below 900 feet. Because of the absence of larger foraminifera in the cores between these two levels it is difficult to say where exactly the faunal change should be placed, but it probably lies around 840 feet, as from that depth on the samples contain *Hantkenina* (Grimsdale, private report; see also van den Bold (1960) who found a facies change between the Cipero and the «Mount Moriah» formations at 800 feet).

The first fauna mentioned is of Oligocene age. It contains *Lepidocyclina yurnagunensis, supera* and *undosa-favosa, Operculinoides semmesi ciperensis* and *Halkyardia*, and no Late Eocene forms. The second group carries an impoverished but typical Late Eocene fauna but also contains *Helicocyclina paucispira* and *Lepidocyclina subglobosa*, and some small specimens of *Lepidocyclina yurnagunensis*. This level corresponds to the Upper Mount Moriah or Marabella marl of well 59 mentioned above.

The distribution of the larger foraminifera in both wells, 59 and 57, is shown in Figure 5. For comparison see also van den Bold's (1960) study on the Ostracods in these wells.

	Calyx well no 57												
Age	Oligocene							Uppermost Eocene					
Formation	Cipero marl							Marabella marl					
Depth of core (in feet)	680	690	730	740	750	770	780	900	920	923	940	980	1000
Operc. semmesi ciperoensis	?	•			cf.	cf.	•						
Lep. yurnagunensis		•	•	•		•	○						•
Halkyardia						•							
Lepidocyclina undosa-favosa		cf.	cf.	cf.			•						
Lep. sanfernandensis		cf.	cf.	cf.			cf.						
Lepidocyclina subglobosa								•			•		○
Helicocyclina paucispira								•					•
Helicosteg. soldadensis A								•		•			•
Amphistegina grimsdalei								•				•	•
Operculinoides suteri								•					
Asterocyclina asterisca									•		•		•
Lep. pustulosa s. s.													•
Operculinoides kugleri													•
Operculinoides ocalanus													
Lep. peruviana													
Operculinoides soldadensis													
Helicolepidina spiralis													
Helicolepidina cf. *nortoni*													
Proporocyclina mirandana													
Lep. pustulosa trinitatis													
Asterocyclina soldadensis													
Asterocyclina cf. *vaughani*													
Lep. pustulosa tobleri													
Helicosteg. soldadensis B													
Operculinoides spiralis													
Operculinoides trinitatensis													
Polylepidina vichayalensis													

	Calyx well no 59													
Age	Uppermost Eocene													
Formation	Marabella marl													
Depth of core (in feet)	40	50	60	70	90	240	260	270	280	290	300	320	340	350
Operc. semmesi ciperoensis														
Lep. yurnagunensis														
Halkyardia														
Lepidocyclina undosa-favosa														
Lep. sanfernandensis														
Lepidocyclina subglobosa		•	•	•		•	•	○	○		○		•	•
Helicocyclina paucispira	•						•	○	•		○		•	
Helicosteg. soldadensis A		•		•			•	•	•	•	•			
Amphistegina grimsdalei		•	?		•				•	•		•		•
Operculinoides suteri			•	•							•			
Asterocyclina asterisca		•							•		•		•	•
Lep. pustulosa s. s.		•			•						•		•	
Operculinoides kugleri											•		•	
Operculinoides ocalanus		•												
Lep. peruviana					•		•						?	
Operculinoides soldadensis					•		•							•
Helicolepidina spiralis							?							
Helicolepidina cf. *nortoni*							?							
Proporocyclina mirandana											•			
Lep. pustulosa trinitatis														
Asterocyclina soldadensis														
Asterocyclina cf. *vaughani*														
Lep. pustulosa tobleri														
Helicosteg. soldadensis B														
Operculinoides spiralis														
Operculinoides trinitatensis														
Polylepidina vichayalensis														

	Calyx well no 59																			
Age	Jacksonian Upper Eocene																			
Formation	Vistabella marl																			
Depth of core (in feet)	370	390	400	410	420	430	440	460	470	480	490	500	540	560	570	580	620	660	680	690
Operc. semmesi ciperoensis																				
Lep. yurnagunensis																				
Halkyardia																				
Lepidocyclina undosa-favosa																				
Lep. sanfernandensis																				
Lepidocyclina subglobosa																				
Helicocyclina paucispira																				
Helicosteg. soldadensis A	○	○	○	•	•	•		○	•	•	○	○						•		
Amphistegina grimsdalei	•	○	○		•	•	•	•	•	•	•	○	•	•	•	•				
Operculinoides suteri	○	•	•				•				•	•		cf.	•					
Asterocyclina asterisca	○	●	○	•	•	•	•	•	•	•	○	●			•			•		
Lep. pustulosa s. s.	•	•	cf.		?		cf.	•		?		•			•			•		cf.
Operculinoides kugleri	•	•	•		•	•	•		•		•	○			•		?	•		
Operculinoides ocalanus	•	•			?							•							cf.	
Lep. peruviana	cf.	•					•		cf.		?									
Operculinoides soldadensis		•			•		•	•	•	cf.	•	•								
Helicolepidina spiralis	•	•	•							?	?	•			?					
Helicolepidina cf. *nortoni*		?					•					•								
Proporocyclina mirandana		•										•								
Lep. pustulosa trinitatis	•	•																		
Asterocyclina soldadensis		•							•											
Asterocyclina cf. *vaughani*	•	•																		
Lep. pustulosa tobleri		○										•								
Helicosteg. soldadensis B		•																		
Operculinoides spiralis		cf.										cf.								
Operculinoides trinitatensis	•	•	•		•	•	•	•		•		•			•					
Polylepidina vichayalensis							•													

Legend: • present; ○ frequent; ● common

Fig. 5. Distribution chart Calix wells 57 and 59

Schlumberger Office Section (Fig. 2)

From road cuts to the Southeast of the Schlumberger office in Vistabella, R.M. Stainforth collected a series of glauconitic marls and clays (St. 145–155), which form a more or less continuous ascending section along a Southeast-Northwest line. They were taken close together, near to the boundary between the San Fernando and Lizard Springs formations. Lithologically, no discontinuity has been observed in this surface section, but in the same way as in the calyx wells, a faunal subdivision can be made into a lower and an upper part corresponding with the Vistabella and the Marabella marl, the break lying between St. 151 and St. 154. Possibly the presence of gypsum in the residues of samples St. 148–151 is a further indication of this break. St. 145, St. 147, St. 148, St. 151 and St. 155 carry a good larger foraminiferal fauna; also St. 154, though poor, carries larger foraminifera.

The fauna in the Vistabella marl is the same as that of the Vistabella Quarry; also *Tubulostium* is represented (St. 148). It does, however, contain neither *Helicolepidinoides* nor *Polylepidina nitida*. On the other hand, reworked larger foraminifera from the Paleocene (*Neodiscocyclina barkeri*) and the early Middle Eocene (*Proporocyclina* cf. *tobleri*) occur in St. 148, as do smaller foraminifera from the Navet Formation. Especially in the predominance of 5-rayed *Asterocyclina asterisca* and the relative frequency of the heavily-ribbed variety of *Operculinoides ocalanus*, the fauna of St. 148 shows a remarkable resemblance to Kugler's Bed 9a (K. 2854) of the Soldado section.

In the Marabella marl (St. 154, St. 155) the Late Eocene forms continue without interruption but, apart from *Asterocyclina asterisca*, they are scarce. The predominant species is *Lepidocyclina subglobosa*; *Helicocyclina paucispira* is scarce. The subdivision of the section is to a certain extent also expressed in the planktic assemblage. The lower part (St. 148) clearly belongs to the *Turborotalia cerroazulensis* Zone, the upper part is either *Turborotalia cerroazulensis* or *Globigerina ampliapertura* Zone age.

San Fernando Railway Station (Fig. 2)

At the time the Government Railway Station of San Fernando was built, the hill behind it on the east side (behind the former waiting rooms) had to be cut back, which resulted in a high vertical exposure of foraminiferal silts, the face of which was protected at its base by a retaining wall.

Sample Cd. 208 was taken from this reasonably undeteriorated surface, about 1.5 m above the retaining wall, and corresponds entirely with Bolli's type sample of the *Globorotalia cocoaensis* Zone (K.R. 25684; Bolli 1957b, 160). The complete larger foraminifera fauna of Cd. 208, and by inference also of K.R. 25684, consists of: *Operculinoides ocalanus* (Cushman); *Operculinoides soldadensis* Vaughan & Cole; *Operculinoides kugleri* Vaughan & Cole; *Operculinoides trinitatensis* (Nuttall); *Operculinoides suteri* Caudri n. sp.; *Asterocyclina asterisca* (Guppy); *Proporocyclina mirandana* (Hodson); *Lepidocyclina pustulosa* (Douvillé) s.s.; *Lepidocyclina pustulosa compacta* Caudri; *Lepidocyclina pustulosa tobleri* (Douvillé); *Lepidocyclina peruviana* Cushman; *Lepidocyclina subglobosa* Nuttall; *Helicolepidina spiralis* Tobler; *Helicolepidina nortoni* Vaughan; *Helicocyclina paucispira* (Barker & Grimsdale); *Helicosteginopsis soldadensis* (Grimsdale); *Amphistegina grimsdalei* Caudri. Smaller foraminifera abundant and very well preserved, rich fauna of planktic foraminifera. Ostracods, small Gastropods and Echinoids are rare.

No trace of reworking was observed in the larger foraminifera of the San Fernando Railway Station section. The presence of numerous juvenile specimens side by side with larger, fully developed individuals of the same species indicates that the assemblage is composed of entirely undisturbed populations which are in situ. The predominant species are *Asterocyclina asterisca* (4- and 5-rayed forms), *Lepidocyclina tobleri, Operculinoides ocalanus* and *Helicosteginopsis soldadensis*, which occurs in floods (also rare B-forms). Rather common are also *Operculinoides soldadensis, Helicolepidina spiralis, Lepidocyclina pustulosa* s.s., *Amphistegina grimsdalei* and *Helicocyclina paucispira. Lepidocyclina subglobosa* is very rare.

Age of the Railway Station silt:

The presence of *Helicocyclina paucispira* and *Lepidocyclina subglobosa* shows that the Railway Station silt is of the same age as the Marabella marl of Vistabella, which we have placed in the uppermost Eocene. This is in agreement with Bolli's views (1957b). He encountered *Globorotalia cocoaensis, Hantkenina primitiva* Cushman & Jarvis, *Cribrohantkenina bermudezi* (Thalmann) and other Late Eocene forms in the planktic fauna, but no *Globigerinatheka semiinvoluta* (Keijzer) which is typical of early Late Eocene (Hospital Hill marl). He therefore considered the age of the Railway Station locality to be very late Eocene, but not yet Oligocene, as the Oligocene (*Globigerina ampliapertura* Zone) no longer carries typical Eocene planktics like those mentioned above and is characterized by the appearance of *Globigerina ciperoensis ciperoensis* Bolli and *Cassigerinella chipolensis* (Cushaman & Ponton).

This age determination is, however, challenged by Jenkins (1964), who claims to have found four specimens of *Cassigerinella chipolensis* in material of the same sample K.R. 25684 and consequently called the Railway Station silt post-Eocene. According to him, the absence of *Globigerina ciperoensis ciperoensis* may mean that the horizon is of a pre-*Globigerina ampliapertura* Zone age, but still Oligocene. Judging from the larger foraminifera, there is no doubt that this silt, which lithologically belongs to the San Fernando Formation, is Eocene, and it is by means of the larger foraminifera that it can be recognized as its uppermost biozone.

Point Bontour (Fig. 2, 4, 6)

Point Bontour is the name of the vertical cliff at the End of the Hospital Hill (and of the corresponding nose in the coastline) southwest of San Fernando. This conspicuous exposure of disorderly highly fossiliferous, glauconitic, in part oil-impregnated silts and limestones attracted the attention of geologists and paleontologists as far back as 1860 (Wall & Sawkins). Here, in 1863, Guppy collected his megafossil fauna of Echinoids, Gastropods, Brachiopods and crustaceans and the intriguing microfossil we now call *Asterocyclina asterisca.* A few years later he attached the name of San Fernando beds to the outcrop and thus Point Bontour, besides being the type locality of a number of fossil species, is also the type locality of the San Fernando Formation as a whole (see also Harris' (1921) review of Guppy's papers).

The choice of Point Bontour as a formational type locality is unfortunate in more than one respect. First the cliff face not only suffered from natural erosion but has also repeatedly been subjected to human interference, which every time changed its aspect.

To complicate things, the exposed beds are chaotic and show very little of a continuous section. Already Harris (1926, 103) remarked that «the folding and thrusting has been so intense that only large masses and fragments of beds are brought in juxtaposition. With each new excavation of the cliff front shreds or fragments of new beds are brought to light, while the material of the old is exhausted». The original field data, as well as those gathered around 1914 by Tobler, Zyndel, Jarvis and Kugler, and even those obtained in 1922 when the whole hill side was cut down in order to fill the swampy strip between cliff and railroad track, were all of fleeting value. In 1940, when T.F. Grimsdale, R.M. Stainforth, K.W. Barr and the author joined forces in a renewed effort to unravel the section, the aspect had changed again. Finally, in 1965, the whole exposure was found buried below rubble thrown over the cliff top by earthmoving equipment, and a retaining wall had been built along its foot. Of Guppy's type locality nothing is thus left today.

Though the transgressive nature of the San Fernando Formation is illustrated by perfection by the heterogeneous composition of the deposits at Point Bontour, there is no other place where there is such a confusing mixture of autochthonous and foreign material as here. Unless one realizes the extent of reworking in this spot, the faunal data are highly misleading. Point Bontour can be understood only in combination with other localities like Soldado Rock, Mount Moriah, Vistabella and Farallon Rock.

The very rich foraminiferal fauna of Point Bontour has been described in several earlier publications. Smaller foraminifera were already mentioned by Guppy in 1892 and later have been described in detail by Cushman & Jarvis (1929), Renz (1942), Brönnimann (1950), Bolli (1957b) and others. The larger foraminifera were noticed by Guppy (1863, 1866, 1892) and later given full attention by Douvillé (1915, collection Tobler 1917; collection Zyndel 1924), Hodson (1926), Harris (1926), van de Geyn & van der Vlerk (1935), Vaughan & Cole (1941), Caudri (1944), Vaughan (1945), Eames et al. (1962) and Caudri (1975). Apart from the last mentioned, no attention was paid in these studies to a faunal differentiation of the beds, as they were generally regarded as uniform in age (Late Eocene).

In 1940, however, Grimsdale discovered that some of the silts on the extreme South flank of the bluff contained foraminifera typical for Basal Oligocene. This lead to a new project of careful field work and systematic sampling by Stainforth (1948a) and to the present study of the larger foraminifera. This work, combined with Stainforth's examination of the smaller foraminifera, made it clear that, first, Grimsdale was right, and second, that at least part of the beds exposed at that time represented a stratigraphic section grading from Late Eocene (*Turborotalia cerroazulensis* Zone) into Oligocene via a transitional interval faunistically comparable with the Marabella marl of the Vistabella Calyx wells.

This section could not be traced across the entire face of the cliff. The series of steep beds was divided into a northern and a southern block, disconnected slump masses leaning against each other in a matrix of so-called Wildflysch without any structural connection (Kugler, private information). It is in the southern block that the above-mentioned partial but coherent section is preserved. The northern block, as a whole the equivalent of the older part of the southern one, is of little stratigraphic interest. On the other hand, it is highly important from a paleontologic point of view, as it carries (especially in sample St. 63) some of the richest and most varied larger foraminifera assemblages of the entire San Fernando Formation. Much of the material used for previous publications must

	Southern Block														Northern Block							Boulders									
	Oligocene						Upper Eocene								Upper Eocene							Upper Eocene						Paleocene			
	St 85	St 84	St 82	St 47	Cd 211	St 80	St 79	St 71	St 68	St 68a	St 90	St 61a	St 67	Cd 18	St 75	St 77	St 63	St 89	St 49	St 46	Rz 66	St 63a	St 67a	St 68b	St 76	Rz 64	Rz 64a	GF 4122	St 48	St 63b	St 46a
Lepidocyclina yurnagunensis	●	●	●	●	●	●	●																								
Lepidocyclina subglobosa	?	●	●		●		●																								
Helicocyclina paucispira	○		○		○		●																								
Lepidocyclina sanfernandensis	cf	cf			●																										
Lepid. sanfernandensis depressata					●																										
Ranikothalia antillea	○				○				○					○			○	○										●	●	●	●
Helicosteginoides soldadensis	○				○	○	●	●	●		●		●		?		●	●	●	●					●						
Lepidocyclina pustulosa trinitatis	○																●														
Lepidocyclina pustulosa s. s. and s. l.		○			○			●	●	●	●		●	●		●	●		?	●	●	●	●	●			cf				
Amphistegina grimsdalei		○			○				●	●	●	?	●	?	?	●		●	●		●		cf	●	●	●	●				
Hexagonocyclina inflata		?			?				○	○		○	○	○	○	○	○		○									?	●	cf	cf
Lepidocyclina sp. ind. 3			●		●	●																									
Halkyardia sp.				●		●																									
Asterocyclina asterisca					○			●	●	●	●	●		●	●		●	●	●	●	●	●	●		●		cf				
Lepidocyclina peruviana					○			?					●				●				●										
Helicolepidina spiralis					○			●	?	●	●	●		●			●	●	●	●	●	●									
Operculinoides kugleri					○			●	●		●		●	●	●	cf	●	●	cf	●		cf	cf	cf	●						
Operculinoides trinitatensis					○			cf	●	●					cf		●			●											
Helicolepidinoides intermedius					○			○	○	○		○					○	○	○												
Neodiscocyclina barkeri					cf									○				○										●	●		cf
Operculina bontourensis					○			○	○	○	○	○		○	○	○	○	○													
Helicolepidina nortoni					○												●														
Operculinoides soldadensis					○				●	●							●														
Lepidocyclina pustulosa tobleri					○			●			●																				
Ranikothalia tobleri					cf																								●		
Neodiscocyclina grimsdalei					○																								●		cf
Neodiscocyclina fonslacertensis					○																							●			
Cycloloculina jarvisi					○																										
Lepidocyclina sp. ind. (thickwalled)							●																								
Operculinoides ocalanus								●	●	●	●	●		●			●	cf	cf	●	●	cf	cf			●					
Asterocyclina soldadensis								●			?		●																		
Sphaerogypsina globulus s. l.								●						●			●			●											
Polylepidina nitida								○	○	○			○																		
Proporocyclina mirandana									●				●				●			●			●								
Proporocyclina tobleri											?																				
Neodiscocyclina bullbrooki A													○			○															
Actinosiphon barbadensis													○	○				○											●		
Neodiscocyclina aguerreverei													○	○															●		
Asterocyclina vaughani																	cf														
Lepidocyclina pustulosa compacta																	●														
Polylepidina vichayalensis																	●														
Polylepidina proteiformis																	●														
Nummulites striatoreticulatus																	●														
Gypsina sp.																	●														
Eoconuloides cf. *lopeztrigoi*																		○													
Pseudphragmina bainbridgensis																				●											
Operculinoides spiralis																				●											
Amphistegina sp. (thickwalled)																												●	●		
Hexagonocyclina meandrica																												●			
Athecocyclina soldadensis																													●		cf
Neodiscocyclina sp. (robust form)																															●
Archaeolithothamnium																													●		

Legend: ● autochthonous
○ reworked

Fig. 6. Distribution chart Point Bontour.

have come from the equivalent of this horizon. Because of the excellence of the Point Bontour fauna, it has served as type material for many species, even for some that were described for the first time from other localities with less favourable material, like *Hexagonocyclina inflata* and *Lepidocyclina pustulosa compacta* from Soldado Rock and *Operculina bontourensis* and *Helicolepidinoides intermedius*, which are most probably not in situ here but belong to the Middle Eocene assemblage of Farallon Rock.

The present study is based on the samples that were collected in 1940 and are solidly linked to Stainforth's field data. A rough sketch of the cliff as it appeared in 1940 is given here to support our discussion (Fig. 4) and also a detailed distribution chart (Fig. 6) showing the stratigraphic range of the species and the influence of reworking. The sketch is not to scale, but it shows the relative position of the samples to each other.

According to Stainforth, the dividing line between the northern and the southern block should be drawn between St. 63–49 and St. 71–67. The corrected thickness of the coherent section in the southern block, from St. 67–85, is about 200 feet. In 1965, the old location of Grimsdale's Basal Oligocene (St. 47) in the upper right corner of the exposure was the only spot still left intact and was then carefully re-sampled (Cd. 211). St. 47 was chosen as the type sample of this Basal Oligocene.

The problem of reworking

It was at Point Bontour that the present author began to realize the full importance of reworking in the Trinidad area (see also Kugler & Caudri 1975). Throughout the cliff the silts are riddled with blocks and boulders of various origin, in some places in such quantities that they form nests of conglomerates (near St. 48, St. 63, St. 67; Fig. 4). Erosion has caused many of them to slide down to road level, at the nose of the bluff (St. 48) and along the road to San Fernando. They comprise such elements as *Roudairia*- and *Hamulus*-sandstones of Late Cretaceous age, foraminiferal and algal limestones, echinoid breccias and coquinas from the Paleocene, but also fragments of massive Late Eocene reef limestone which slumped into the silty matrix from contemporary bioherms. For most of them, exposure and transportation must have been minimal as they are large and in remarkably fresh condition. For instance, a block of fresh Paleocene coquina was collected just South of the Norwegian Seamen's church, which is the best example of the Soldado Formation found anywhere, including the type locality on Soldado Rock itself (Bed 2, Kugler & Caudri 1975).

Besides these large-sized erratica, the silts naturally also contain a great amount of finer detritus in the form of detached allochthonous fossils. Taking our clue from a solid limestone boulder like St. 48 and the adjacent rubble (Cd. 18) into which it has spilled its eroded specimens of larger foraminifera, it is not difficult to spot the Paleocene interlopers. From the lowermost Middle Eocene came such forms as *Neodiscocyclina bullbrooki* and *Proporocyclina tobleri* (compare Bed 11 of the Soldado section). A younger level of the Middle Eocene, the *Neodiscocyclina anconensis* Zone, furnished one worn and recrystallized glauconite-filled specimen of *Amphistegina* cf. *lopeztrigoi*. Reworking from various horizons of the Middle Eocene is confirmed also by smaller foraminifera in most samples.

Other forms for which reworking is less obvious are *Operculina bontourensis, Helicolepidinoides intermedius* and *Polylepidina nitida*, all new species of which little is known concerning their range. They are the rockbuilding elements of the limestone of Farallon Rock. It can be assumed that this sizable reef limestone and the detached fossils at Point Bontour have, at the time of the Late Eocene transgression, come from the same disintegrating cliff. The uneven distribution of the three species in the Trinidad Late Eocene, present in the San Fernando area and Charuma, absent on Soldado Rock, in the rich fauna of the Navette area and in the compact Late Eocene reef blocks at Point Bontour, seems to mean that they do not figure amongst the regular elements of the Late Eocene fauna. A rather positive argument in favour of their being reworked is offered by St. 49, where the specimens of *Helicolepidina spiralis* and *Helicosteginopsis soldadensis* are oil-impregnated whereas the chambers of the structurally similar *Helicolepidinoides intermedius* are not.

Higher in the section, around the Eocene-Oligocene boundary, we are confronted with the problematic range of *Helicocyclina paucispira*. The species makes its appearance in the Marabella marl and its silty equivalents (St. 79), together with *Lepidocyclina subglobosa-yurnagunensis*, and is believed to be restricted to this zone. In the lowest Oligocene samples at Point Bontour, characterized by a rich *Lepidocyclina yurnagunensis* fauna (St. 80, St. 47) and *Halkyardia*, it is absent, reason why we consider it reworked in the other Oligocene samples. Its continuation into the Oligocene can, however, not be entirely dismissed, as it occurs also in the still controversial Playa Rica Formation of Ecuador, which is supposed to be Oligocene, and even the Marabella marl itself is placed by some authorities in the Oligocene. *Lepidocyclina subglobosa*, up to now considered a marker for Late Eocene, presents no such problems. It crosses into the Oligocene, where it continues as one of the main elements of the fauna, alongside its more conspicuous relative *Lepidocyclina yurnagunensis*.

The striking difference between the Point Bontour samples St. 47 and Cd. 211 (Fig. 4) which were collected at the same spot, shows how irregular and locally restricted the influx of foreign material can be. Still, St. 47 is not entirely free from reworking either, its planktic contents were reported as probably *Globigerina ampliapertura* Zone, but with reworked Navet and Late Eocene forms.

Stratigraphy of the San Fernando area

The Late Eocene in this area was recognized at an early date. Guppy (1863, 1866) collected the first fossils from the silts of Point Bontour: *Echinolampas ovumserpentis, Terebratula trinitatensis, carneoides* and *lecta, Tubulostium leptosoma clymenioides, Ranina porifera* and *Asterocyclina asterisca*, all of them considered as Late Eocene in age. In 1866 he called these silts the San Fernando beds and compared them with similar deposits on Mount Moriah. Tobler (1922) determined them as Late Eocene and Senn (1933) correlated them with the Ledian of Europe.

The chaotic condition of the Point Bontour beds at their type locality incited Waring (1926) to choose the better exposures farther north as the type locality of the Late Eocene under the name of the Mount Moriah Formation, a term which has been in use in reports and publications for several decades. However, it is a synonym of the San Fernando beds and to avoid further confusion it was officially decided in 1955 to apply the name «Mount Moriah» in a strictly local sense for the deposits on Mount Moriah itself and give it member status only, within the San Fernando Formation (Kugler 1956).

The type locality thus remains Point Bontour, but the only good sections are, for the bottom part of the formation, the sequence on the top of Mount Moriah and, for the higher part, the two Vistabella Calyx wells, supported by the samples from the Schlumberger office at Vistabella and by the temporarily exposed section at Point Bontour. Together they show that the San Fernando Formation is composed of three members: The basal Mount Moriah glauconitic sandstone, the Late Eocene Vistabella marl which comprises the Mount Moriah conglomerate at its base, and the Marabella marl which forms the transition to the Oligocene.

A totally different view of the age and the position of the San Fernando Formation has been given by Eames et al. (1962). Their conception calls for a big hiatus between the San Fernando and Cipero formations, or the total absence of any Oligocene sediments in the section, which is contradictory to our observation of the transitional fauna of the Marabella marl in the Vistabella Calyx wells and other places.

Outside the San Fernando area the only occurrence of the San Fernando Formation of stratigraphic importance is the section of Soldado Rock. The formation is also encountered in wells and as isolated slump masses and erratic blocks (Plaisance conglomerate, Morne Roche, Charuma, Navette area, Lizard Springs area, Moruga, etc.). This proves that it once had a much wider expansion than exposed on the surface today. Characteristic for the formation are the Vistabella Quarry and the Late Eocene of Soldado Rock. Of interest is a silty marl found in the Navette area (R.M. 1337; see below): Though composed of the same species known from San Fernando and Soldado Rock, the fauna looks totally different because of the abundance of very large megalospheric and microspheric specimens of *Asterocyclina soldadensis* and *Lepidocyclina spatiosa* which usually are sporadic elements. The only other localities known where both species (in their megalospheric form only) are common, are K. 2651 and K. 2854 on Soldado Rock, in Bed 9a, high in the Late Eocene or perhaps already in the equivalent of the Marabella marl.

Around San Fernando the silty facies of the San Fernando Formation is better developed in the South (Point Bontour, San Fernando Railway Station, Mount Moriah) than in the North (Vistabella) where it is replaced to a great extent by marls of the Cipero type. It has, however, now become clear that the silty formation locally continues into the Oligocene. The interfingering of silt and marl makes drafting of the geological map very difficult, and opinions about it are divided.

The Marabella marl (a silty marl in Vistabella, silty in all other localities) can not be mapped as a separate unit, but as a biozone it definitely should be recognized as the *Helicocyclina paucispira* Zone, and entered in the stratigraphic column. As explained below, it represents the uppermost horizon of the Late Eocene transition to the Oligocene.

The geographic distribution of the *Helicocyclina paucispira* Zone

Apart from its occurrence in Calyx wells 57 and 59, in the surface section near the Schlumberger office, the Railway Station of San Fernando and at Point Bontour, the *Helicocyclina paucispira* Zone was recognized in several samples collected at random in the Vistabella area: K. 3762, E.S. 4620, E.S. 4622, E.L. 1207, E.L. 1431c, E.L. 1434 and E.L. 1435. In some of them, *Lepidocyclina subglobosa* and *Helicocyclina paucispira* are predominant, whereas the general Late Eocene species are sporadic or even absent. K. 3762, E.L. 1207 and E.L. 1435 contain *Lepidocyclina sanfernandensis*, the fourth species indicative of this zone. E.L. 1207 (Vistabella Reservoir) has a fair number of *Helicocyclina* and abundant *Lepidocyclina subglobosa*, but here also *Lepidocyclina yurnagunensis*, which has its main development in the Early Oligocene, is abundant, emphasizing the transitional character of this biozone.

Farther North, the horizon was encountered in T.P.D. Marabella well 1, in a screen sample at 2100 feet. East of San Fernando, *Lepidocyclina subglobosa*, in combination with *Lepidocyclina pustulosa trinitatis* and *pustulosa tobleri, Helicolepidina spiralis* and *Operculinoides trinitatis*, occurred in the Eocene Mount Moriah Formation in Testwell A at Tarouba Estate and Testwell 1 at Palmyra Estate (Nuttall 1928).

Towards the South, the *Helicocyclina paucispira* Zone is represented by the San Fernando Railway Station silt (*Turborotalia cerroazulensis* Zone) and by a bed in the section at Point Bontour as was exposed in 1940. The coherent section of Soldado Rock touches at its top the very bottom of this horizon: in Bed 9a one convincing specimen of *Lepidocyclina subglobosa* was found together with very doubtful traces of *Helicocyclina paucispira* and *Lepidocyclina sanfernandensis* (Kugler & Caudri 1975; Caudri 1975).

The *Helicocyclina* fauna is known from various localities outside Trinidad and Soldado. *Helicocyclina paucispira* was originally described from the top of the Late Eocene of the Tampico Embayment in Mexico (Barker & Grimsdale 1936). The species has further been reported by Cole from Florida (Leon County), Georgia (Coffee County) and from the island of Grenada. It also occurs in the Peñas Blancas limestone of northern Venezuela, the Playa Rica Formation of northwestern Ecuador and at a locality South of Jipijapa, southwestern Ecuador (coll. Sigal). Finally, the author found *Helicocyclina paucispira* to be a constant element in the uppermost part of the Late Eocene of nortwestern Colombia.

The age of the *Helicocyclina paucispira* Zone

It was chiefly on account of the larger foraminifera that Grimsdale distinguished a lower and an upper part of the Mount Moriah Formation in the Vistabella Calyx wells, units which are now called the Vistabella and the Marabella marls, respectively, and which correspond to the Late Eocene faunal assemblage and the *Helicocyclina paucispira* biozone.

The zone is characterized by the appearance of four typical species of larger foraminifera: *Lepidocyclina subglobosa, yurnagunensis* and *sanfernandensis*, and *Helicocyclina paucispira*. One of the most complete examples of this biozone is the San Fernando Railway Station silt, which was determined, both on evidence of larger foraminifera and the planktic fauna as Late Eocene *Turborotalia cerroazulensis* Zone.

Lepidocyclina subglobosa, originally considered as typical for Late Eocene, continues without interruption into the Early Oligocene, whereas *Lepidocyclina yurnagunensis* and *sanfernandensis* are only hesitatingly making their first appearance but have their main development in the Oligocene. *Helicocyclina paucispira* has obviously developed from *Helicosteginopsis soldadensis* by a reduction of the spiral in favour of a circular growth pattern of the chamberlets and by the addition of lateral chambers, thus suggesting a higher stratigraphic level than Late Eocene. Still, from the general aspect of the accompanying fauna (*Lepidocyclina pustulosa* and *peruviana, Helicolepidina spiralis, Helicosteginopsis soldadensis, Asterocyclina asterisca*, etc.) we would rather adhere to an Eocene age. On planktic foraminifera, however, Saunders (private report 1959) found that Calyx well 57 down to 670 feet passes successively through the *Globigerina ciperoensis ciperoensis*, and the *Globorotalia opima opima* zones. The rest of the section, from 670–1200 feet (roughly from where the first larger foraminifera were found) lies entirely within the *Globigerina ampliapertura* Zone. Likewise, Calyx 59 begins in the *Globigerina ampliapertura* Zone to reach the Late Eocene *Turborotalia cerroazulensis* Zone at 360 feet.

This concept was followed in 1960 by van den Bold. He places the entire section of

Calyx 57 into the Oligocene, but at the same time suggests that the lower part of this Oligocene belongs to the Upper Mount Moriah silt and not to the Cipero Formation. The boundary between the two formations is placed in the middle of the *Globigerina ampliapertura* Zone at 800 feet which is close to Grimsdale's top of *Hantkenina* in this well. Calyx 59 shows the break between Upper and Lower Mount Moriah at 360 feet. In other words, van den Bold clearly recognizes the Upper Mount Moriah as a separate zone, just like Grimsdale did on account of the larger foraminifera, with the difference, that he places it in the Oligocene instead of the Eocene.

It is difficult to choose between these different ways of approaching the problem. The method of using open marine planktic faunas in preference to restricted coastal assemblages is in general more reliable, but in this case the larger foraminifera seem to be a more sensitive tool. To assume, as some suggest, that the Late Eocene larger foraminifera in the Marabella marl are all reworked is too easy an explanation. They are much too perfectly preserved for that, and there is no reason to assume an important break in the sedimentation to cause reworking to such an extent. In places like Vistabella, where there was uninterrupted sedimentation there is no sharp and definitve boundary line between the Eocene and the Oligocene. Rather arbitrarily we would place the zone with the Late Eocene larger foraminifera in the Eocene, though admitting that it grades into the Oligocene. *Helicocyclina paucispira* itself is a short-ranged species which may cross the boundary but does not continue far into the Oligocene like *Lepidocyclina subglobosa-yurnagunensis* and *sanfernandensis*. It is no longer present in the rich Early Oligocene of the Cipero coast which is still within the *Globigerina ampliapertura* Zone. In Trinidad, the range of *Helicocyclina paucispira* does not overlap that of *Lepidocyclina undosa*.

In Trinidad, the *Helicocyclina paucispira* Zone does not stand out as a lithologic unit, it just grades from the San Fernando Railway Station silt into the marls of the Cipero Formation in Vistabella. In Florida, however, in the City of Tallahassee water well (Cole 1945, 17–19), where the zone carries *Helicocyclina paucispira* and a variety of *Lepidocyclina sanfernandensis*, it is clearly separated from the Oligocene and was determined as a special phase of the Ocala limestone or a new unit of Late Eocene age.

3.3.2. Other localities

Boca de Serpiente Formation

Location:	Type locality on Soldado Rock (Bed 11 of Kugler & Caudri 1975). So far not found in situ on the island of Trinidad, but present there as erratic blocks, probably brought to the surface by mud volcanoes. The term Boca de Serpiente has been declared obsolete and is now included in the San Fernando Formation (Kugler 1956).
Lithology:	Silty glauconitic limestone, same as Bed 11 on Soldado Rock.
Fauna:	*Proporocyclina tobleri* limestone, from Lizard Springs and Erin on the South coast.
Age:	Early Early to early Middle Eocene.

Charuma Silt

Location:	Type section along the Cunapo Southern Road between Biche and Charuma (no details on type section nor on bore holes in the Biche area are given). The Charuma silt is a member of the Pointe-a-Pierre Formation.
Lithology:	Imbrications of silty and sandy beds with a typical *Gaudryina* species. Regarded as transitional between Early Eocene grits and marly Navet. Comparable to the Upper Scotland Formation of Barbados.

Fauna: *Eoconuloides senni* (Cushman); *Eoconuloides senni conica* Caudri n. var.; *Amphistegina* sp. indet.; *Neodiscocyclina fonslacertensis* (Vaughan), obviously reworked.

Age: Early to Middle Eocene.

Biche (Locality 24)

Location: Biche village area, eastern Central Range. The material available originates from the following sources: Calyx wells 50 and 50A, West of Biche village (exact locality lost), Calyx well 45 and the limestone quarry of Biche. Only the faunas of Calyx 50 and 50A are discussed here. For the others reference is made to the Oligo-Miocene reef limestones of the Central Range.

Lithology: Limestone.

Fauna: The larger foraminiferal fauna is very poor in both wells. It is characterized by the presence of *Neodiscocyclina anconeneis* and *Eoconuloides*.

Calyx well 50 (cores 31–54 feet):

31–44 feet: *Eulinderina*? sp. (one light-brown split specimen, subsequently lost; very flat form, heavily pillared, without lateral chambers; with a well-developed uniserial nepionic spiral); *Helicolepidina* sp. (provisionally identified as *H. spiralis*; specimen lost); *Neodiscocyclina* sp. (not unlike *N. grimsdalei*; one badly recrystallized and pyritized specimen); *Actinosiphon barbadensis* (Vaughan) (one dark-brown specimen).

44–54 feet: ?*Eoconuloides* sp. (yellowish grey specimens, not pyritized); *Ranikothalia antillae* (Hanzawa) (one pyritized specimen); ?*Actinosiphon barbadensis* (Vaughan) (one badly pyritized specimen).

Calyx well 50A (cores 101–233 feet):

101–102 feet: *Lepidocyclina* sp., one specimen (subsequently lost) with small pillars and small rounded to elongate lateral chambers with sub-equal embryonic chambers; *Eoconuloides* cf. *senni* (Cushman).

194–199 feet: *Eoconuloides* cf. *senni* (Cushman).

232–233 feet: *Neodiscocyclina anconensis* (Barker), few; *Eoconuloides wellsi* (Cole & Bermudez), four specimens; *Eoconuloides senni* (Cushman); *Eoconuloides senni conica* n.var.; *Operculinoides* sp. ind. (small, aff. *kugleri*); ?*Amphistegina* sp. (small subglobular closely-wound form); ?*Gypsina* sp.; smaller foraminifera.

Age: Middle Eocene. *Neodiscocyclina, Actinosiphon* and *Ranikothalia* from Calyx 50 are considered reworked from the Paleocene. The Biche fauna is the only one in Trinidad that can be compared with the early Middle Eocene Upper Scotland Formation of Barbados (Vaughan 1945; Caudri 1972) and with the San Eduardo Limestone of Ecuador which is the type level of *Neodiscocyclina anconensis* (Stainforth 1948b). Correlation with the Middle Eocene of Cuba is possible by means of *Eoconuloides wellsi*.

Note: After a first preliminary examination several specimens from the two wells were accidentaly lost.

Dunmore Hill area (Locality 13)

Location: The type locality is a roadside exposure about 6 km East of Princes Town, at the junction of the Hindustan-Monkey Town roads. Several scattered other locations in the Dunmore Hill area East of San Fernando, olistoliths as at the type locality are embedded in younger Cipero and Lengua marls.

Lithology: Dunmore Hill marl Member of the Early Eocene to Late Eocene Navet Formation, a hard, light grey yellowish weathering argillaceous marl.

Fauna: The combining of the larger foraminiferal taxa from the various localities assigned to the Dunmore Hill marl resulted in the following stratigraphically heterogenous association:

Ranikothalia antillea (Hanzawa); *Ranikothalia tobleri* (Vaughan & Cole); *Operculinoides soldadensis* Vaughan & Cole; *Asterocyclina asterisca* (Guppy), one typical specimen (R.C.M. 2932) and one without the characteristic large periembryonic chambers; *Neodiscocyclina grimsdalei* (Vaughan & Cole); *Neodiscocyclina aguerreverei* (Caudri); *Neodiscocyclina fonslacertensis* (Vaughan); *Neodiscocyclina barkeri* (Vaughan & Cole); *Neodiscocyclina caudriae* (Vaughan); *Neodiscocyclina bullbrooki* (Vaughan & Cole), A-form; *Neodiscocyclina* sp. ind., B-form; *Proporocyclina tobleri*

(Vaughan & Cole), in part well preserved but often badly recrystallized; *Proporocyclina* sp. ind., related to *P. tobleri* but with thick radial walls; *Proporocyclina mirandana* (Hodson); *Stenocyclina* cf. *advena* (Cushman); *Athecocyclina soldadensis* (Vaughan & Cole); *Actinosiphon barbadensis* (Vaughan); *Lepidocyclina pustulosa* (Douvillé) s.s.; *Lepidocyclina peruviana* Cushman; *Helicolepidina spiralis* Tobler; *Amphistegina undecima* Caudri.

Amongst this collection, some species point to a Paleocene age (*Ranikothalia antillea* and *tobleri*, *Neodiscocyclina grimsdalei*, *aguerreverei*, *fonslacertensis*, *barkeri* and *caudriae*, *Athecocyclina soldadensis*, *Actinosiphon barbadensis*), others to earliest Middle Eocene (*Proporocyclina tobleri* limestone, Bed 11 of the Soldado section: *Proporocyclina tobleri*, *Neodiscocyclina bullbrooki*, *Amphistegina undecima*), and still another group to very late Middle to early Late Eocene (*Asterocyclina asterisca*, *Lepidocyclina peruviana* and *pustulosa*, *Helicolepidina spiralis*, *Proporocyclina mirandana*, *Operculinoides soldadensis*).

It is this last group which indicates the real age of the Dunmore Hill marl at its type locality; the others are reworked from a variety of older deposits.

Age: The type locality of the Dunmore Hill Marl Member (Rz. 476) at the Hindustan-Monkey Town Road junction was on planktic foraminifera placed into the Middle Eocene *Globigerapsis kugleri* Zone (Bolli 1957) now *Globigerinatheka subconglobata* Zone. Samples collected as Dunmore Hill Marl from other localities in the vicinity contain larger foraminifera, partly reworked from other levels within the Navet Formation, ranging in age from Paleocene to early Late Eocene (see above). This led to the different age assignments of the Dunmore Hill Marl Member.

Farallon Rock (Fig. 1)

Farallon Rock is an olistostrome exposed in the shallow sea about one kilometer off the San Fernando coast. It is a steep-sided rock, consisting of sandy limestones and foraminiferal limestones, about 35 m in diameter, just large enough for the house built on it. The construction of this house, for which the islet had to be levelled off, distroyed the fossil localities. Sufficient samples had been collected in time to prove that this isolated rock is different from the San Fernando Formation and may, in fact, be the only remnant of its kind in the entire Caribbean region.

The first material was collected around 1910 by A.C. Veatch and studied by R.M. Bagg (Mauri 1912, S. 31, and Harris in: Waring 1926, S. 103). Bagg noticed that it was filled with *Operculina complanata* and assigned it an Eocene age. Douvillé (1917) tried to tie Farallon in with nearby Point Bontour and called it Late Eocene.

Rutsch (1939, S. 239) was of the same opinion because of the common occurrence of *Tubulostium*, a fossil known in Trinidad also from Point Bontour, Vistabella and Morne Roche. He mentions various other authors (Maury 1925; Harris 1926; Liddle 1928) who came to the same conclusion based, apart from *Tubulostium*, on the presence of *Echinolampas ovumserpentis* and the decapod *Ranina porifera* in all four localities.

Maury (1912, S. 107) at first expressed a certain doubt about this direct correlation because of the lithologic difference between her material and that from San Fernando, but later agreed for paleontological reasons. The study of the larger foraminifera of Farallon Rock shows, however, that her doubts were justified. The fauna in fact differs much from the Late Eocene assemblages on the main island and Soldado Rock.

The samples at our disposal consisted in part of a mixture of hard sandy or silty limestones that were studied in thin sections and on polished surfaces, but there were also softer silty or marly parts that furnished some good detached specimens. The material was collected between 1916 and 1939 by Zyndel (F.Z. loc. 37 Nos. 416–423c), Lee (S.L. 99, several pieces), Kugler (K. 340), Rutsch (1939) and a few unnumbered pieces. Of these, F.Z. loc. 37 No. 423c was chosen as the lithologic type sample of the Farallon reef limestone.

The fauna in all samples was essentially the same: *Operculina bontourensis* Caudri n. sp., abundant; *Operculinoides* aff. *Operculina bontourensis*, locally abundant; *Operculinoides ocalanus* (Cushman), locally abundant; *Operculinoides soldadensis* Vaughan & Cole, common; *Operculinoides* cf. *trinitatensis* (Nuttall), rare; *Asterocyclina soldadensis* Caudri, very rare; *Asterocyclina* cf. *barbadensis* Vaughan, very rare; *Lepidocyclina (Polylepidina) nitida* Caudri n. sp., abundant; *Lepidocyclina (Polylepidina)* sp., with two auxiliar chambers, very rare; *Lepidocyclina* cf. *peruviana* Cushman, few; *Helicolepidinoides intermedius* Caudri n. sp., entire populations; *Helicolepidina* cf. *nortoni* Vaughan, locally frequent; *Amphistegina pregrimsdalei* Caudri, abundant in the hard rock; *Amphistegina farallonensis* Caudri n. sp., scarce; *Sphaerogypsina globulus* s. l. Smaller Foraminifera few and very small, except for some large *Lenticulina* sp., *Tubulostium leptosoma clymenioides* (Guppy). Locally common Crustaceans (*Ranina*?), locally concentrated Bryozoans, Gastropods, Pelecypods, Echinoids, Algae.

Van de Geyn & van der Vlerk (1935) report *Lepidocyclina pustulosa trinitatis* from Farallon Rock (their locality 11), and also Vaughan & Cole (1941) mention the presence of *Lepidocyclina pustulosa* in a sample that supposedly came from the same place.

The Farallon fauna differs from the Late Eocene fauna in two respects:

1. Abundance of *Operculina bontourensis, Helicolepidinoides intermedius* and *Polylepidina nitida*, which in Trinidad are sporadic and probably reworked and absent in the Soldado section.
2. Absence of *Asterocyclina asterisca*, Lepidocyclinas of the *pustulosa*-group (see above), *Helicolepidina spiralis* and *Helicosteginopsis soldadensis*, which form the bulk of the Late Eocene assemblage in Trinidad and on Soldado Rock.

Because of the abundance of typical Polylepidinas and the presence of an *Asterocyclina* with solid radial rays on its surface (*A.* cf. *barbadensis*), the fauna gives the impression of being of Middle rather than Late Eocene age. It should be remembered that the gastropod genus *Tubulostium*, which seemed such a convincing indication of a Late Eocene age, occurs in certain places also in the Middle Eocene, for instance in the Scotland Formation of Barbados (Murphys and Chalky Mount beds, Rutsch 1939, 240) and in the Yellow Limestone of Jamaica (Petersfield Gap Member of the Preston Hill Formation at its type section, in the *Hantkenina nuttalli* Zone).

The three dominant species in the Farallon fauna are all new and therefore of little value for an age determination. *Operculina bontourensis* is not the first *Operculina* to be mentioned from the New World, but it is the first to be described as a species. There exists no information on its range. The other two can at least be compared with known marker fossils. *Helicolepidinoides intermedius* is closely related to *Helicolepidina polygyralis*, which is known from the late Middle Eocene (Stainforth 1948b; Caudri 1974), but is more primitive in its nepionic development and its lack of lateral chambers. *Polylepidina nitida*, with its well-developed lateral tissue, should belong to a slightly higher horizon than the dense *Polylepidina antillea*, but its geographic distribution seems so severely restricted that no real conclusion can be based on it.

Of the other forms Farallon and San Fernando have in common, *Operculinoides soldadensis* and *Operculinoides ocalanus*, are known to straddle the boundary between Middle and Late Eocene. They are equally common in the San Fernando Formation and in the late Middle Eocene of Margarita Island (Upper Punta Mosquito Formation, Caudri 1974). The small *Amphistegina* which is present in such quantities in the harder part of the Farallon limestone is probably the same species as in Margarita Island (*Amphistegina pregrimsdalei* Caudri).

Arguments are in favour of a late Middle Eocene age for the Farallon Rock fauna. This lagoonal limestone must have developed very locally at the turn of Middle to Late Eocene, preceding the Hospital Hill marl, which is Late Eocene. Such facies shifts make it clear that in this area there was no important hiatus in the sedimentation just prior to the Late Eocene transgression, but a continuous play of give and take of the coastline.

The short period of regression was, however, all that was needed to destroy this thin limestone bank so thoroughly that nothing has been left of it but this one erratic block off the San Fernando coast. In its typical form, it has nowhere been found in situ, but maybe it is a variant of the insufficiently known «Caus limestone», a reefal development in the Pauji Formation of Trujillo, western Venezuela. This limestone, which lies in the transitional contact between the Esquque Formation and the Pauji shale, is allegedly rich in *Operculina cookei* and *Discocyclina* (Stratigraphical Lexicon of Venezuela 1956). Via a remarkable pebble of *Operculina limestone* found on the beach in the Coora area (South Trinidad; Quinam Bay?, Hg. 398A, Texaco Trinidad cat. no. 66817) which apart from abundant *Operculina bontourensis, Amphistegina* cf. *pregimsdalei* and some *Polylepidina nitida*, contains also *Lepidocyclina pustulosa, L. peruviana* and common *Asterocyclina* sp. ind., the Farallon limestone could be linked to this Caus limestone. Incidentally, it would then also correspond with the Rio San Pedro limestone in Baralt, western Venezuela (Tobler 1922a; van Raadshooven 1951). Both of these limestones are today considered Middle Eocene.

Time equivalents of the Farallon limestone would thus be: The Caus limestone, the Rio San Pedro limestone and the upper part of the Punta Mosquito Formation of Margarita, though all carry a different foraminiferal assemblage. On the other hand, the superficially similar Cuicas limestone of Trujillo, a lumachelle of very flat foraminifera (*Operculina* sp. and *Proporocyclina renzi* together with some rare undetermined Lepidocyclinas (de Cizancourt 1951), is older than the *Polylepidina antillea* Zone (the El Cumbe limestone) and does not correspond with Farallon.

The Hermitage quarries (Locality 1)

Location: Several small quarries on Stollmeyer's Hermitage Estate, about 1 km North Northeast of the former Pointe-a-Pierre Railway Station and in Pointe-a-Pierre itself. They were known as Plaisance Conglomerate from the Hermitage quarries, the Stollmeyer Quarry, or in Pointe-a-Pierre as Bon Accord Quarry.

Lithology: The conglomerate consists of boulders of Cretaceous and Paleocene origin, dense *Guembelina* and *Radiolaria* limestones, Cretaceous ammonites, foraminiferal limestones, etc. The conglomerates from the different localities are essentially identical.

Fauna: The larger foraminifera consist of *Ranikothalia* in limestones, comparable to those of the Paleocene on Soldado Rock. Rare Late Eocene orbitoids occur in the matrix of the conglomerate (Kugler 1953). For the complete larger foraminiferal content see Figure 7.

Age: Basal Late Eocene with reworked Cretaceous and Paleocene.

Morne Roche Quarry (Locality 6)

Location: Quarry about 9 km East of Pointe-a-Pierre.

Lithology: Limestones and grits forming a rootless slipmass in the Nariva Formation. The individual components consist of light and dark grey grits of colorless or blue quartz grains, highly calcareous grits, dark and light grey coarse or fine grained limestones and clumps of calcareous algae.

Fauna: The foraminiferal fauna, identified only in thin sections and polished surfaces is the same in all samples investigated. Nummulitidae predominate in the coarse grained limestones and grits. *Asterocyclina* is particularely abundant in algal limestones, *Lepidocyclina* and *Helicolepidina* in the pure orbitoidal limestones. For species determinations see Distribution Chart (Fig. 7).

Age: Eocene.

Note: The Morne Roche fauna is remarkable in the following respects:

1. The presence in one of the dark coarse-grained limestones (KS 167) of the very large primitive *Heterostegina indicata*, described here as new and so far not observed elsewhere.
2. Absence of *Heterosteginopsis soldadensis*, an indication that the deposits of Morne Roche are pre-Late Eocene and correspond with the glauconitic sandstones on the top of Mount Moriah and the lowest level of the Late Eocene on Soldado Rock (Beds 3, 4, 10; Kugler & Caudri 1975). Like the sandstones of Mount Moriah the grits and limestones of Morne Roche are void of reworked Paleocene larger foraminifera.
3. The megafossil contents with *Tubulostium* cf. *leptosoma clymenioides, Echinolampas ovumserpentis* and *Ranina porifera* link Morne Roche to the Late Eocene of Point Bontour and the Bellavista Quarry, but also to the Middle Eocene of Farallon Rock. The vertical range of these organisms are still enigmatic.

Navette area

Location: Isolated test pit in the Navette area North of Guayaguayare, Southeast point of Trinidad (RM 1337). Locality 89 of van de Geyn & van der Vlerk (1935).

Lithology: Highly fossiliferous silty marl of San Fernando facies aspect, over and underlain by a rich globigerinid marl of Late Eocene Hospital Hill marl age.

Fauna: The rich globigerinid marl of Hospital Hill aspect with reworked Paleocene and Early Eocene forms contains some small fragments of *Asterocyclina* and *Lepidocyclina*.

The two orbitoid horizons within the silty marl interval carry essentially the same fauna, though the lower one is much richer and more complete. Both carry *Helicosteginoides soldadensis* of Late Eocene age. The latter is exceedingly rich in larger foraminifera comparable with he Vistabella Quarry and the erratic block (Rz. 511a) from the same area.

The assemblage consists of the same species that occur in the San Fernando Formation but differs for the predominance of very large foraminifera. They are the megalosperic and microspheric forms of *Asterocyclina soldadensis* and *Lepidocyclina spatiosa*, the B-form of which reaches over 25 mm in diameter, rare elsewhere, and the very larger B-forms of *Lepidocyclina pustulosa*.

Abundant are further large A-forms of *Asterocyclina asterisca, Lepidocyclina tobleri, L. trinitatensis, Operculinoides soldadensis, O. trinitatensis, Helicosteginopsis soldadensis* and *Amphistegina grimsdalei*, all in situ. For the complete fauna reference is made to the Distribution Chart (Fig. 7).

Remarkable is the common occurrence of the B-form of *Helicosteginopsis soldadensis*, rare in all other localities. There is no trace of reworked larger foraminifera such as *Operculina bontourensis, Helicolepidinoides intermedius* or *Polylepidina nitida*. Also absent is the gastropod *Tubulostium*, in the San Fernando area closely linked with these species.

Van de Geyn & van der Vlerk (1935) list from this pit, apart of *Lepidocyclina trinitatensis* and *L. tobleri*, also *L. macdonaldi* and *L. supera*, which in part may correspond to our *L. spatiosa*. *Lepidocyclina supera* was not seen in the material used for the present study.

Age: Late Eocene.

Boussignac area (Locality 23)

Locality: Two localities are given: Boussignac area, Cush River (exact location lost) and Boussignac well 1, West of Biche. Two surface samples were investigated: Rz. 383 (from about 8 miles North-East of Tabaquite Field) and K. 8756, assumedly from the first listed locality, and both from erratic blocks.

Lithology: Rz. 383: dark-brown marl; K. 8756: hard, highly fossiliferous limestone breccia.

Fauna: Both samples contain a rich fauna including *Helicosteginopsis soldadensis*. Rz. 383 is remarkable for a few microspheric specimens of *Helicosteginopsis soldadensis* and *Asterocyclina asterisca*. Amongst the abundant A-forms of the latter species 4- and 5-rayed specimens occur in equal numbers. Van de Geyn & van der Vlerk (1935) quote the same material as Boussignac limestone and associated silts, their localities 30 and 32.

3.4. Oligo-Miocene

Apart from Point Bontour, where the silty facies of the San Fernando Formation continued for a while beyond the close of the Eocene, the transition from Eocene to Oligocene in Trinidad is characterized by a change from neritic silts and reefs to the bathyal clays and marls of the Cipero Formation.

During the Oligocene, the Central Range was an active high which divided the area into two different basins. In the South the marl facies continued through the Oligocene and into the Miocene, as high as the *Globorotalia fohsi robusta* Zone. In the Central Range, however, conditions changed back to neritic around the *Globorotalia kugleri* Zone (Hunter 1974). The marls of the Cipero were replaced by the calcareous clays, silts and reef limestones of the Brasso Formation. Good correlation exists between the Brasso and Cipero formations by means of planktic foraminifera. In the Southern Basin the Cipero marls are overlain by the calcareous clays of the Lengua Formation, in the Southern Range by the clays of the Karamat Formation. In the Central Range the Brasso Formation is unconformably overlain by the limestones of the Tamana Formation. These younger formations in the Southern Basin and the Central Range fall within the *Globorotalia mayeri* and *Globorotalia menardii* zones.

3.4.1. Southern Basin

In this part of the island the entire Oligocene and Miocene is developed in a marly facies, in which larger foraminifera are rare. They are restricted to one or two neritic layers in the Cipero type section, several rootless slumpmasses of fringing bioherms and some scattered limestone blocks, most of which brought to the surface by the action of mud volcanoes.

3.4.1.1. Oligocene

Type section of the Cipero Formation

The series of marls exposed along the low coastal cliff south-west of San Fernando, between the point where the old railway line turned inland and the mouth of the Cipero River, was chosen as the type section of this formation. Unfortunately, instead of being an undisturbed coherent section, it later turned out to be a chaotic set of steep, fractured and perhaps even imbricated beds, complicated by slumping, the true chronological order of which could be unravelled only by means of an accurate study of their planktic contents (Bolli 1957c) including a discussion of older literature (Renz 1942; Cushman & Stainforth 1948a). Bolli found that at the southwestern end of the cliff there was (from Southwest to Northeast) a normal series of Cipero beds belonging to the Miocene part of the formation (*Catapsydrax stainforthi* to *Globorotalia fohsi robusta* zones) and that, separated from this by an interval of slumpmasses, another coherent series was exposed towards the northeastern end of the cliff, this time of Oligocene age (*Globigerina ampliapertura* to *Globigerina ciperoensis ciperoensis* zones), again from Southwest to Northeast.

It is in the latter, northeastern, corner that there is, intercalated between the normal Cipero marls, a layer of silts and banks of calcareous algae, of a pronounced reefal nature, in private reports first named Bamboo clay. In 1948, Stainforth gave this layer the more official name of Flat Rock tongue, on the tentative assumption that it was a tongue of the highest horizon of the San Fernando Formation, the Basal Oligocene of the Point Bontour section. This Flat Rock tongue is the only deposit in the Cipero section that carries larger foraminifera, and that in profusion. Bolli describes this bed as a predominantly dark-brown silty clay with streaks of mudstone and marl pebbles and a couple of more or less conspicuous layers of reef deposits. Its fauna of smaller foraminifera is quite different from that of the typical Cipero marls, but Bolli nevertheless considers it as the equivalent of the *Globigerina ampliapertura* Zone of the Early Oligocene as it is apparently in normal contact with the overlying *Globorotalia opima opima* Zone. 27 feet farther southwest, after an interval of slump masses, there is a repetition of this neritic bed and, according to Bolli, it is from this bed that Stainforth collected the rich orbitoid fauna mentioned in 1948.

The present study of the larger foraminifera is not based on that material but on samples collected in 1941 or even before by the author and others. Samples Rz. 104, Gr. 2, C.S. 11, collected by H. Naegeli and P.W. Jarvis, and Cd. 26 are presumably from Bolli's first bed, and Rz. 138 from the second one, though that cannot be stated with certainty. The strong marine erosion of this coast causes the aspect of the cliff to change from year to year, and the details given in 1957 do not correspond with the impression R.M. Stainforth and the author got when re-sampling the locality in Juli 1941 (in the wet season and at low tide).

In 1941, the Flat Rock tongue appeared as a seemingly undisturbed silt bed contrasting by its brownish colour with the light-grey marls on either side of it, a contrast which was even more strikingly marked on the muddy beach in front of the cliff. In it, one thin but conspicuous orbitoid layer, more resistant to erosion than the rest, stood out as a steep bed in the cliff and as a ridge running obliquely across the beach and jutting out into the sea. This was the only orbitoid layer observed on that data.

Paleontologically, the second bed (Rz. 138) is the same as the first (Rz. 104), both in regard to the foraminifera and to the mollusks (R. Rutsch, see Renz 1942). The complete list of larger foraminifera in the first bed (the Flat Rock tongue s.s.) is: *Operculinoides semmesi ciperensis* Vaughan & Cole, several externally different varieties, very abundant; *Lepidocyclina yurnagunensis* Cushman, A-form, flood; *Lepidocyclina yurnagunensis*, B-form, common; *Lepidocyclina yurnagunensis morganopsis* Vaughan, scarce; *Lepidocyclina yurnagunensis inflata* Caudri n. var., scarce; *Lepidocyclina subglobosa* Nuttall, abundant; *Lepidocyclina sanfernandensis* Vaughan & Cole forma *depressata* Caudri n. var. , rather frequent; *Lepidocyclina undosa* Cushman, abundant; *Lepidocyclina favosa* Cushman, rather frequent; *Lepidocyclina* sp. sp. indet., several varieties, probably all conspecific with *L. undosa* Cushman, frequent; *Lepidocyclina gigas duncanensis* Cole, common, mostly broken up into small fragments; *Lepidocyclina supera* (Conrad), rare; *Lepidocyclina* cf. *supera*, large form, very rare; *Lepidocyclina parvula* Cushman, A- and B-forms, rare; *Lepidocyclina* cf. *canellei* Lemoine & Douvillé, one doubtful specimen; *Lepidocyclina* aff. *canellei*, pillared form, rare; *Lepidocyclina waylandvaughani* Cole, small A- and B-forms, rare.

In addition to these, the other samples yielded: *Lepidocyclina asterocolumnata* Caudri n. sp., one specimen in Gr. 2; *Gypsina* sp., rare in C.S. 11; *Planorbulinella* sp. indet., one specimen in Gr. 2; *Carpenteria* sp., rare in C.S. 11; *Cycloloculina* sp., frequent in Gr. 2, probably overlooked in the other rich samples.

The foraminiferal fauna is accompanied by minor amounts of Pelecypods, Gastropods, Scaphopods, Bryozoans, Ostracods, crab claws, Echinids, Corals, fish Otoliths and Algae.

No trace of reworking has been observed in this fauna.

The peculiarity of this fauna is that it is mostly composed of two species: *Lepidocyclina yurnagunensis-subglobosa* and *Operculinoides semmesi ciperensis*, with the *Lepidocyclina undosa* group a much less important third.

Age and stratigraphic position:

The presence of *Lepidocyclina undosa-favosa* and a variety of *L. gigas* places the Flat Rock tongue within the Oligocene. That the horizon is low in the Oligocene can be deduced from the predominance of *L. yurnagunensis-subglobosa* and the locally common occurrence of *L. sanfernandensis*, both species already known in the latest Eocene (Marabella marl) and, at the same time, the extreme scarcity of the more modern forms such as *L. parvula, canellei* and *waylandvaughani*, and the total absence of *Miogypsina* and *Heterostegina*. The larger foraminifera fauna, therefore, fits into the *Globigerina ampliapertura* Zone.

The Flat Rock tongue is, however, not the lowest orbitoid horizon in the Oligocene. It is younger than the Basal Oligocene of Point Bontour, which was deposited before the advent of *Lepidocyclina undosa* and *Operculinoides semmesi ciperensis*, contains *Halkyardia* and is, moreover, full of Eocene detritus and reworked fossils because of its intimate contact with the Late Eocene.

In the exposures at Point Bontour the silty San Fernando Formation reaches up into the Oligocene. For those uppermost beds, Cushman & Stainforth (1945) cite from private reports, the following larger foraminifera: *Operculinoides semmesi ciperensis* and *Lepidocyclina supera, yurnagunensis, morganopsis, favosa, gigas* and *undosa*. This is based on a misunderstanding as these records refer to the orbitoid bed in the Cipero section (Flat Rock tongue). The species in question do not occur either at Point Bontour or at Vistabella, which is also mentioned in that paper.

This proves that the two silt exposures, though lithologically similar, do not represent the same deposit. In the field, the interval between Point Bontour and the Cipero section is largely overgrown and it is impossible to trace their connection, which in any case must be very complicated (Bolli 1957c, map on p. 105). But it is clear that the Flat Rock tongue has never been in such immediate contact with the Eocene: it is pure Oligocene and in place between the marls, a real tongue of silt developed along the edge of the basin and probably re-deposited by turbidity currents.

Slump masses of Oligocene limestones

Scattered through South Trinidad occur within younger deposits, several isolated limestone quarries, now for the greater part exhausted. The limestones, of Oligocene or Miocene age, are considered as remnants of bioherms formed along the edges of the basin or on immersed diapiroid rises within it (Kugler 1953). They are lying as large rootless bodies in the Miocene flysch of the Karamat Formation, and are the coastal equivalent of the marls of the Cipero Formation and of the calcareous clays of the overlying Lengua Formation. The most important ones amongst these limestones are the Mejias Quarry near Moruga on the Penal-Rock Road, and the Kapur Quarry at Logeon in the Guayaguayare area, both of Oligocene age, and the Miocene Morne Diablo Quarry South of Penal.

Mejias Quarry (Locality 19)

Location: Southwest of Basse Terre, about 4 km Northwest of Moruga, on the south side of the Penal-Rock Road near its junction with the Moruga Road. Smaller remnants of the same limestone were located further along that road and on the Mejias Trace at Moruga.

Lithology: Hard, compact brownish-grey algal limestone, with pockets of softer sediments.

Fauna: Mostly studied on polished surfaces and in haphazard thin sections: *Operculinoides semmesi* Vaughan & Cole; *Operculinoides semmesi ciperensis* Vaughan & Cole, common; *Heterostegina antillea* Cushman, common; *Lepidocyclina yurnagunensis* Cushman, abundant; *Lepidocyclina yurnagunensis morganopsis* Vaughan; *Lepidocyclina subglobosa* Nuttall, few; *Lepidocyclina undosa* Cushman, abundant; *Lepidocyclina favosa* Cushman, scarce in the quarry itself, but abundant in limestone blocks along the Mejias Trace; *Lepidocyclina gigas* Cushman, typical form, abundant; *Lepidocyclina ? supera* (Conrad); *Lepidocyclina asterodisca* Nuttall; *Lepidocyclina* cf. *canellei* Lemoine & Douvillé; *Lepidocyclina ? parvula* Cushman; *Lepidocyclina* sp. ind., small lenticular pillard B-form; *Miogypsina (Miogypsinoides) complanata* Schlumberger, few; *Miogypsina (Miogypsina) gunteri* Cole, few; *Amphistegina lessonii* s.l., few; *Gypsina* sp. ind.; *Carpenteria* sp., common. Bryozoans; Echinids, common; Algae, abundant.

Note: This fauna, characterized by the abundance of typical *Lepidocyclina yurnagunensis*, the group of *Lepidocyclina undosa (undosa, favosa, gigas* s.s.) and *Operculinoides semmesi* and its varieties and, on the other hand, the scarcity of smaller Lepidocyclinas *(parvula, canellei)* is very similar to the fauna of the Flat Rock tongue in the Cipero section, but differs from it by the presence of *Heterostegina antillea, Lepidocyclina asterodisca* and the first Miogypsina. It is younger than the Early Oligocene Flat Rock tongue, but seems definitely older than the Kapur Quarry limestone where *Lepidocyclina yurnagunensis* is replaced by the nephrolepidine forms *vaughani* and *tempanii*. This comparison suggests a Middle Oligocene age for the Mejias limestone. Such an age, based on evolutionary trends, is, however, still controversial. Drooger (1950) identified a few isolated *Miogypsina* specimens from the quarry as *Miogypsina basraensis* and *Miogypsina ? tani*, suggesting that the former species was reworked. It is true that the Lepidocyclinas of the *undosa* group, originally widely used to indicate the Middle Oligocene in the Caribbean and Gulf regions, are possibly not as reliable as thought before and may continue to the top of the Oligocene in Trinidad as also in Antigua. But the similarity between the Mejias Quarry and the Cipero Flat Rock tongue fauna is too strong to allow for a Late Oligocene assignments on such an argument.

An objection comes from the comparison with Mexico (Barker & Blow 1976). The Mejias fauna corresponds to a remarkable extent to that of the Upper Palma Real, the Alazan, the Meson and the Coatzintla formations in the Tampico-Misantla Embayment (*Operculinoides semmesi, Heterostegina antillea, Miogypsinoides complanata, Miogypsina gunteri, Lepidocyclina undosa, gigas, asterodisca, tempanii*, etc.). These authors place all these formations into the Early Miocene on the strength of the planktic foraminifera. Further study is required before deciding whether this should also apply to the Mejias limestone. Before accepting an extension of the *undosa* group into the Miocene, one has to consider reworking, which has occurred on a large scale also in Mexico (Grimsdale 1959). For the time being, therefore, it seems preferable to assign an Oligocene age for the Mejias fauna.

Roussillac well 1 (Locality 15)

Location: National Mining Company well Roussillac-1, Southwest of San Fernando between St. Mary's and Brighton, East of Pitch Lake; screen sample from 3790 feet.

Fauna: Large numbers of *Miogypsinoides complanata* (Drooger 1951, 360).

Age: Middle Oligocene.

Note: Based on the joint presence of *Miogypsinoides complanata*, the Rossillac-1 level is correlated with the limestone of the Mejias Quarry.

Kapur Quarry (Locality 20)

Location: The Kapur Ridge, also known as Logeon Spur, is located about 10 km West-Northwest of the Pilot River mouth, Guayaguayare. The limestone of the quarry, exploited for road metal, is exhausted and today overgrown.

Lithology: A rootless mass of hard limestone slumped into rubbly deposits of the Karamat Formation. Three samples collected by P. Leuzinger (Lz. 3464, Lz. 3465, Lz. 3475) represent a typical heterogeneous reef deposit, a hard, gritty glauconitic, dense and recrystallized limestone; a washable glauconitic grit and fragments of a less glauconitic dense limestone, also re-crystallized.

Fauna: The samples are rich of conspicuous and in part very large Lepidocyclinas, Molluscs, Corals, Echinoids and nodulous Algae. Because of the hardness of the material identifications of the fauna from the three samples had to be based on thin sections. In the softer parts also Ostracods have been found.

The fauna of these three samples contains: *Operculinoides* cf. *semmesi ciperensis* Vaughan & Cole, few; *Heterostegina* cf. *antillea* Cushman, few; *Lepidocyclina* undosa Cushman, locally abundant; *Lepidocyclina gigas* Cushman, flat and undulated forms, abundant; *Lepidocyclina favosa* Cushman, locally common; *Lepidocyclina vaughani* Cushman, locally common; *Lepidocyclina tempanii* Vaughan & Cole, abundant, also rare microspheric forms; *Lepidocyclina parvula* Cushman, microspheric form, rare; *Lepidocyclina* cf. *canellei* Lemoine & Douvillé, few; *Lepidocyclina* ind., small heavily pillared B-form, abundant; *Amphistegina* sp., few.

Some of the larger foraminifera in the limestone (coll. Zyndel) have been mentioned by Douvillé (1917, 1924) and by van de Geyn & van der Vlerk (1935), but their nomenclature has since been superseded by that used by Vaughan & Cole (1941).

Age: The character of the larger foraminifera is Oligocene. Based on planktic foraminifera, sample Lz. 3464 is of *Globigerina ciperoensis ciperoensis* Zone age, sample Lz. 3473 falls into the *Globorotalia kugleri* Zone, both Late Oligocene. On the strength of the coral fauna J.W. Wells (private report) correlated the Kapur limestone with the Middle Oligocene San Luis limestone in Falcon, Northwest Venezuela. Suter (1960) mentions the Middle Oligocene coral *Antiguastrea cellulosa* (Duncan) from this limestone.

Note: The fauna is characterized by an abundance of Lepidocyclinas of the *undosa*-group (*undosa*, *favosa*, *gigas*) and *Lepidocyclina tempanii*. Common are further *L. vaughani* and cf. *canellei* and other small Lepidocyclinas. *Operculinoides* and *Heterostegina* are present but not very frequent. The reef limestones at hand do not carry any Miogypsinas; the marly sample Lz. 3473, contains no Lepidocyclinas at all, but some specimens of *Miogypsina gunteri*.

On the other hand, Drooger (1951) later received from the Pointe-a-Pierre office some isolated specimens of *Miogypsina (basraensis)* allegedly coming from a duplicate sample of Lz. 3464 (marked as *Catapsydrax dissimilis* Zone). According to Cole, *M. basraensis* is a synonym of *M. gunteri*. Two other samples from the same quarry (S.L. 26, S.L. 27) contained *M. tani* and *M. tanibrönnimanni* (*M. antillea*, according to Cole), which would indicate a slightly higher level, but neither Drooger nor Cole mention the planktic zone corresponding with these samples.

The material of this quarry seems to be mixed. Both the *Globigerina ciperoensis ciperoensis* and the *Globorotalia kugleri* Zone are placed into the Late Oligocene. But apart from the presence of *Lepidocyclina vaughani* and *L. tempanii* replacing the older form *yurnagunensis*, the larger foraminifera of the hard limestone do not differ much from that of the Mejias Quarry and is of an Oligocene aspect. The Kapur limestone is not regarded as the highest level of the Oligocene. It must be older than the limestone with *Miogypsina hawkinsi* and *Spiroclypeus* which is found in scattered blocks along the South coast.

Erratic blocks of Oligocene limestones

Many of the erratic blocks found in southern Trinidad are of Oligocene age, but are not all the same. Some samples from the Lizard Springs-Navette area represent the Early Oligocene *Lepidocyclina yurnagunensis-undosa* horizon also known from the Cipero Coast section. Most of them, however, correspond to the Kapur Quarry (Middle to Late Oligocene). Their larger foraminifera assemblage consists of *Lepidocyclina tempanii, yurnagunensis* and/or *vaughani, pancanalis, parvula, waylandvaughani, undosa, favosa, gigas, Operculinoides semmesi, Heterostegina antillea*, and in the Rock area, near the South coast rare *Lepidocyclina asterodisca*. As in the Kapur Quarry, this reef limestone does not carry *Miogypsina*, but from the Karamat area comes a *Miogypsina-Amphistegina* limestone (Hg. 2511) with very few *Lepidocyclina* (cf. *tempanii*, fragments of *undosa*); the *Miogypsina* are probably all *M. gunteri*.

Finally, there are limestones which together with this *Lepidocyclina tempanii* assemblage also carry *Miogypsina hawkinsi* and *Spiroclypeus*: Blocks at Chagonary Point (with *Lepidocyclina giraudi*), Marac River, Rock area and Erin point, all near the South coast (Douvillé 1917). Locality K. 482 (later re-numbered K. 911), Marac River, is the type locality of *Spiroclypeus bullbrooki* Vaughan & Cole. The limestone they came from and of which there is nothing left than these few remnants, is considered as younger than the Kapur limestone and should represent Late Oligocene. As was the case with the previous group, a variation with a *Miogypsina* fauna was also found: A limestone from the Mejias Trace, Goudron Ravine (Zyndel 12c) which carries *Miolepidocyclina* sp. in abundance. *Lepidocyclina tempanii* continues right to the top of the Oligocene; *Spiroclypeus* seems here to be restricted to this youngest horizon. The genus is placed at the bottom of the Late Aquitanian by Butterlin (1976), but Andrieff (1985) shows it ranging through nearly the whole Early Miocene.

It should be emphasized that *Lepidocyclina undosa*, long considered a reliable marker for the Middle Oligocene, is not only already well developed in the Early Oligocene (Cipero Coast), but seems to continue in Trinidad to the top of the Oligocene, as it does in Antigua. There it was found in the upper part of the Antigua Formation, which Vaughan (1933) placed in the Late rather than in the Middle Oligocene.

3.4.1.2 Miocene

The only good example of Miocene reefs in the Southern Basin are the limestone and calcareous clay deposits of the Morne Diable Quarry near the South coast South of Penal and the Ste. Croix Quarry South of Princes Town. The Ste. Croix limestone lies in situ, whereas the Morne Diable limestone is a large erratic block, an olistostrome on top of the Cruse Formation, its original relationship unknown. It contains the richest and most complete fauna of Miocene larger foraminifera found in Trinidad. The Morne Diablo reef with its characteristic fauna of larger foraminifera has no counterpart in the Miocene of the Central range, and in the South its distribution must have been very restricted.

Morne Diablo Quarry (Locality 16)

Location: Close to the South coast, about 9 km South of Penal. Before it was levelled through extensive quarrying the locality was a significant landmark within the soft landscape of mudflows and Cruse clays.

Lithology: Crumbly limestone and calcareous clays, steeply South dipping.

Fauna: Very rich, chiefly in larger foraminifera, but also in smaller benthic and planktic ones. Present are also Ostracods, Molluscs, Echinoids and Algae. The most conspicuous fossiliferous bed is a four feet thick slab of *Lepidocyclina-Miogypsina* limestone in the South corner of the exhausted quarry. It is distiguished by an abundance of *Lepidocyclina forresti*, large *Miogypsina hawkinsi*, *M. staufferi*, *Planorbulinella*, *Amphistegina* and Pecten. Absent are representatives of *Eulepidina*, *Nephrolepidina*, *Spiroclypeus* and *Heterostegina*, apparently already extinct at this level. The following larger foraminifera are from the Morne Diablo locality: *Operculinoides bullbrooki* Vaughan & Cole, A-form, abundant; *Operculinoides cojimarensis* (Palmer), small B-form, rare; *Operculinoides semmesi* Vaughan & Cole, few; *Lepidocyclina forresti* Vaughan, A- and B-forms, juvenile and adult, regularly present, abundant in the *forresti* bed; *Lepidocyclina canellei* Lemoine & R. Douvillé; *Lepidocyclina parvula* Cushman, A-form and small B-form; *Lepidocyclina giraudi* R. Douvillé; *Miogypsina hawkinsi* Hodson, abundant in the *forresti* bed; chiefly in the northern part of the quarry; *Miogypsina bramletti* Gravell, regularly present; *Miogypsina (Miolepidocyclina) staufferi* Koch, typical form and the lenticular form called *mexicana* Nuttall, chiefly in the northern part, abundant in the *forresti* bed; *Miogypsina* sp. sp. indet., A- and B-forms, externally atypical, abundant in all limestone beds; *Amphistegina* cf. *lessonii* s.l., everywhere predominant; *Planorbulinella trinitatensis* (Nuttall), regularly present, locally common.

Age: Originally regarded as Oligocene like the Mejias and Kapur quarries. Later, planktic foraminifera present indicated a Middle Miocene *Globigerinatella insueta* to *Globorotalia fohsi peripheroronda* Zone age, about the same as assigned to the Ste. Croix Quarry fauna in the Central Range, but with quite a different larger foraminiferal association.

Ste. Croix Quarry (Locality 14)

Location: The now abandonned quarry is situated about 2 km South of Princes Town.

Lithology: The lenticular body of the shallow water *Amphistegina* limestone and calcareous clays is embedded in the planktic, open sea Cipero Formation.

Fauna: In addition to larger foraminifera occur common Miliolids, planktic foraminifera, at certain levels in floods, Molluscs, Bryozoans, Echinoid fragments and small Algae. The following larger foraminifera from the Ste. Croix Quarry are present: *Operculinoides* sp., one poor specimen; *Amphistegina lessonii* s.l., predominant; *Planorbulinella trinitatensis* (Nuttall), common in one sample, scarce in all others; *Planorbulinella* sp. ind., very rare; *Gypsina* sp. ind., abundant fragments in one sample, scarce in all others; *Sphaerogypsina globulus* s.l.; *Peneroplis*, *Archaias*, *Sorites*; *Cycloloculina* sp., in four samples.

Age: Regarded as Oligocene by Cushman & Renz (1947) the Ste. Croix is, based on planktic foraminifera of Middle Miocene age. The lower part of the section falls into the *Globigerinatella insueta* Zone, the top part into the *Globorotalia fohsi peripheroronda* Zone. The age is thus similar to that of the Morne Diable Quarry but the composition of the larger foraminifera in the two localities is distinctly different. Limestones of the Ste. Croix Quarry type occur commonly in the Central Range, where they are associated with the neritic Brasso Formation.

Erratic blocks of Miocene limestones

Miocene erratica are rare in southern Trinidad. The only examples found are fragments of Morne Diablo limestone with abundant *Lepidocyclina forresti* in the Marac area (K. 409) and a piece of *Planorbulinella* limestone with some *Operculinoides* and fish otoliths, similar to the Ste. Croix Quarry limestone, in the Lizard Springs area (Z. 5849).

3.5 Central Range

In the Central Range open marine conditions continued during the Oligocene and reefs were formed even less frequently than in the South. In the Miocene, however, renewed orogenic movements turned the Central Range into an unstable area of islands, shoals and lagoons. Wherever there was an opportunity, small bioherms and lagoonal limestones were formed at one time or another, especially along the southern flank of what is now the Central Range. They occur as a string of quarries from Pointe-a-Pierre to Biche, running from Southwest to Northeast forming such conspicuous landmarks as the Tamana Hill and Brigand Hill. These limestones were at first correlated with those of South Trinidad (Mejias, Kapur, Morne Diablo, Ste. Croix) and were considered Oligocene in age. On planktic evidence most of the central Range limestones are now recognized as Miocene (Suter 1960; Higgins in an appendix of the same paper). Individually, they show considerable differences and represent various stages within the Miocene.

Three separate formations are involved: the Brasso, Tamana and Manzanilla. The Brasso Formation has its roots already in the Oligocene but in general embraces the *Catapsydrax dissimilis* to the *Globorotalia fohsi robusta* zones. It corresponds in age with the Cipero Formation of the Southern Basin. The Tamana Formation (*Globorotalia mayeri* and *menardii* zones) is equivalent to the Lengua Formation, the Late Miocene Manzanilla Formation to the *Globorotalia acostaensis* and *Neogloboquadrina dutertrei* zones, the equivalent of the Cruse, Forest and lower Morne l'Enfer formations of the Southern Basin.

The Brasso and the Tamana formations contain a number of conspicuous limestone banks: The so-called Coelestin, Tamanaquita, Cumuto, Basin Hill and Biche limestones in the Brasso, and the Tamana and Guaracara limestones in the Tamana Formation. However, because of the strictly local development of these bioherms they are stratigraphically of little interest. The Guaracara limestone accounts for many conspicuous but incoherent outcrops in the western part of the Central Range. In the Mayo Quarry, the Tamana and the Guaracara limestones are exposed together, clearly separated by an unconformity.

All through this time, the sea remained too shallow and too land-locked to allow for the development of a full larger foraminiferal fauna. Throughout the Miocene, the typically shallow-water form *Amphistegina* is the prominent element in the reefs. At first, already in the Oligocene, and as high in the Miocene as the *Globigerinatella insueta* Zone, more or less complete bioherms with *Lepidocyclina* and *Miogypsina* continued to occur.

From this level onwards only *Amphistegina* banks were formed in combination with Corals, Echinoids and Algae, alternating with deposits consisting of an almost pure assemblage of *Operculinoides* and *Planorbulinella*, and *Sorites* in the more silty horizons. This kind of alternation between reef and lagoon went on for a considerable period of time, during which no appreciable change took place between the larger foraminifera. There is, for instance, no difference in the *Operculinoides-Planorbulinella* fauna in one of the Brasso limestones (R. 7377) and that in a very similar sample from the Tamana limestone (R. 7541). Distinction between the two can only be made by means of the planktic assemblages they carry.

Abrupt facies changes like that can in some cases mask the true stratigraphic top of certain species. Their scarcity and disappearance may be due to a change in environment rather than to their extinction in time. In certain favourable spots, for instance, *Operculinoides* and *Planorbulinella* occur in floods in the Tamana Formation (Tamana limestone), but in the overlying Guaracara limestone *Planorbulinella* is found in quantities in only a few spots. Of the presence of *Operculinoides* we have only one, so far unconfirmed record (van de Geyn & van der Vlerk, locality 4, Gasparillo Quarry). This does not necessarily mean that these two forms are really disappearing in the *Globorotalia menardii* Zone, unless they prove to be reworked. They in fact re-appear in the Manzanilla Formation as soon as the environment turns favourable for them again.

The disappearance of *Lepidocyclina* and *Miogypsina* towards the end of the Early Miocene corresponds with their extinction.

Brasso Formation

Oligocene

Location: Central Range.

Lithology: Neritic calcareous clays.

Fauna: Locality 22 in the eastern Central Range contains *Miogypsinoides complanata* Schlumberger and fragments of *Lepidocyclina yurnagunensis* Cushman which association compares with the Middle Oligocene limestone of the Mejias Quarry in South Trinidad (Locality 19). Vaughan & Cole (1941) recorded *Lepidocyclina yurnagunensis, Heterostegina antillea* and *Miogypsina hawkinsi* from the Cunapo River in the eastern Central Range, a fauna comparable to that of the Kapur Quarry reef limestone of Southeast Trinidad (Locality 20). To this group belong also scattered Oligocene limestones from the Charuma area (Locality 24) with *Lepidocyclina yurnagunensis* and *Lepidocyclina undosa*, and in part also correlatable with the Kapur Quarry limestone (Locality 20) with *Lepidocyclina tempanii, Heterostegina antillea*.

Age: Middle Oligocene.

Miocene

Location: Central Range.

Lithology: Neritic calcareous clays with limestone intercalations.

In the following the larger foraminifera occurring in the Miocene part of the Brasso Formation are stratigraphically grouped based on the plankton foraminiferal zonal scheme by which the Brasso Formation is subdivided.

Catapsydrax dissimilis Zone (Early Miocene):

The following larger foraminifera have been recorded from the Cunapo River (northeastern Central Range): *Heterostegina antillea, Lepidocyclina pancanalis, L.* cf. *parvula, Miogypsina staufferi-mexicana, Operculinoides semmesi.* The presence of *H. antillea* is considered to be of limited stratigraphic significance for the Oligocene and Early Miocene within the Caribbean region. In South Trinidad the species occurs only in the Oligocene, together with Lepidocyclinas of the *undosa* group, with *Miogypsina complanata, M. gunteri* or *M. hawkinsi*. It is absent there in the rich Morne Diablo fauna of the *Globigerinatella insueta/Globorotalia fohsi peripheroronda* Zone.

Globigerinatella insueta Zone (Early Miocene):

The zone is represented by the so-called Coelestin Limestone exposed on the Guaico-Tamana Road at 8,5 miles from Guaico. It is an ironstained grey gritty *Amphistegina* limestone with nests of Algae with *Miogypsina staufferi-mexicana* and a flat form of *Operculinoides* (? cf. *bullbrooki*) in great quantities along with some small *Lepidocyclina* (cf. *pancanalis*). It roughly corresponds with the Morne Diable Quarry fauna of South Trinidad (Locality 16). Miogypsina limestones but without Lepidocyclinas occur in the Spring Branch (Tumapuna River) and on Basin Hill of the Caparo River area.

Within the *Globigerinatella insueta* Zone a complete change in larger foraminifera from open marine to shallow water and lagoonal forms took place. Corals, Echinoids and Algae were in general not much affected by the change. *Operculinoides* and *Amphistegina* became more frequent, joined by *Carpentaria* as a reef-building element. *Lepidocyclina* and *Miogypsina* became replaced by *Planorbulinella* and *Sorites*. *Operculinoides* became represented by a different species (*O. tamanensis*).

The entire Basin Hill limestone contains rich *Sorites-Amphistegina* horizons, sometimes with *Archaias*, finegrained *Sorites* sandstones, siltstones with *Amphistegina* and sporadic *Operculinoides*, a sandy *Planorbulinoides-Amphistegina* limestone with large *Lenticulina* and *Textularia* and a Coral-*Amphistegina* bank.

The disappearance of *Lepidocyclina* and *Miogypsina* within the *Globigerinatella insueta* Zone indicates their real extinction in time rather being the result of a facies change. Robinson (1968a) shows for Jamaica the same top for *Lepidocyclina* and an end of *Miogypsina* just above that level. The same extinction levels for the two genera were also observed in Cuba, Japan and Australia. This applies also to Trinidad. While in Jamaica also *Operculinoides* disappears in the *Globorotalia fohsi fohsi* Zone, no larger foraminifera occur any more from there onwards, while in Trinidad *Operculinoides* together with *Planorbulinella* seem to continue into the early Late Miocene (Manzanilla Formation, *Globorotalia acostaensis* Zone).

Globigerinatella insueta to *Globorotalia fohsi peripheroronda* Zone:
To this zone into which the Ste. Croix Quarry (Locality 14) falls belongs the reef limestone of the Machapure Quarry (Locality 10). It consists of Corals, Algae, *Amphistegina* and some *Sorites*. Included in this zone is also the shallow water limestone exposed along the Guaico-Tamana Road between 13,5 and 13,75 miles from Guaico. It consists of floods of *Operculinoides tamanensis* and *Planorbulinella trinitatensis*. This assemblage continues into the Tamana Formation.

Globorotalia fohsi peripheroronda Zone:
Into this zone falls the very rich fauna of the Biche Village Quarry (Locality 12), one of the best exposed reefs in the Central Range. At its top the exposure consists of solid brown limestone and marls consisting dominantly of *Operculinoides* and *Planorbulinella*. The lower part is characterized by intersperced coral and algal banks and layers with gritty and sandy limestone with *Sorites* and rare *Archaias*. *Amphistegina* is present throughout.

Globorotalia fohsi peripheroronda to *Globorotalia fohsi robusta* Zone:
The Cumuto Limestone is exposed along the Cumuto Road and exploited in the two Martin quarries (Locality 9). Both yielded coral- and *Amphistegina* limestones with some *Sorites*. The limestone can probably be correlated with the top of the Brasso Formation in the Mayo Quarry (Locality 3) where it is discordantly overlain by the Tamana Formation. At Mayo the Brasso Formation consists mainly of *Amphistegina, Planorbulinella* and small Mollusks.

Tamana Formation

The Tamana limestone and the Guaracara limestone are included in the Tamana Formation.

Tamana Limestone

Location:	Tamana Hill, along the Tamana-Carmichael Road (Type locality for *Operculinoides tamanensis*).
Lithology:	Yellowish-brown limestone.
Fauna:	*Operculinoides, Planorbulinella.*
Age:	*Globorotalia mayeri* to *Globorotalia menardii* Zone, Middle Miocene.

Guaracara Limestone

Location:	Numerous small reefs, mainly in the western Central Range exposed in the following quarries: Concord (Locality 1), Gasparillo (Locality 2), Mayo, upper part (Locality 3), Corozal Gov. Quarry (Locality 4), Morichal (Locality 5), Brasso (Locality 8), Nariva (Locality 11), and Brigand Hill about 12 km Southeast of Sangre Grande.

Lithology: Often a pure *Amphistegina limestone.*
Fauna: The reefs are built of *Amphistegina*, Corals and Algae with some *Planorbulinella*. *Sorites* is abundant in the Gasparillo Quarry.
Age: *Globorotalia mayeri* to *Globorotalia menardii* Zone, Middle Miocene.

Manzanilla Formation

Location: Hibernia Estate (Montserrat Hills) western Central Range. Road cut outcrop near estate house (Type locality of *Planorbulinella trinitatensis* Vaughan & Cole).
Lithology: Brown *Operculinella* bearing limestone, associated with Montserrat sands considered to be the middle member of the Manzanilla Formation.
Fauna: *Operculinoides*, *Planorbulinella*, both possibly reworked. In the lower member of the formation (San José calcareous silt Member) they are, however, considered to be in situ. Present in the formation are also *Amphistegina* banks.
Age: *Globigerina acostaensis* to *Neogloboquadrina dutertrei* Zone, Late Miocene.

4. Conclusions on the Trinidad larger foraminifera localities

The oldest species of larger foraminifera known in Trinidad is *Orbitolina* cf. *texana*, found in rock-building quantities in two erratic blocks of Early Cretaceous (Albian?) age, in Quinam and at Pointe-a-Pierre. Larger foraminifera of Late Cretaceous age are missing. They apparently never developed here.

The Paleocene can be directly correlated with that of Soldado Rock (Caudri 1975). It is represented by many blocks and detached foraminifera of the *Ranikothalia* limestone, by a semi-autochthonous lens or small slump mass full of the same species of larger foraminifera in the Paleocene Lizard Springs marl at its type locality, and by the rootless mass of Mollusk limestone of the Marac Quarry, which carries the same fauna as Bed No. 2 of the Soldado Formation.

The larger foraminifera of the Paleocene belong to the *Ranikothalia* Zone (= Cole's *Operculina catenula* fauna; = de Cizancourt's zone des Nummulites cordelées). In Trinidad this fauna consists of the following species: *Ranikothalia catenula*, formae *antillea*, *tobleri* and *soldadensis*, *Athecocyclina soldadensis*, *Hexagonocyclina inflata* and *meandrica*, *Neodiscocyclina barkeri*, *caudriae*, *grimsdalei*, *mestieri*, *aguerreverei* and *fonslacertensis*, *Actinosiphon barbadensis*.

The Early Eocene could not be distinguished by means of larger foraminfera the way de Cizancourt was able to do for western Venezuela. In this connection it should be noted that no trace of *Alveolina* has been found in Trinidad. De Cizancourt (1951) mentions its presence in the Early Eocene of the Rio Tocuyo and in the beds of San Francisco de Cara, to our knowledge the only record of *Alveolina* on the South American mainland.

In Trinidad, the problematic *Proporocyclina tobleri* limestone (the Boca de Serpiente Formation of Soldado Rock) is represented by one erratic boulder at Lizard Springs and two in Erin. According to its fauna it should be placed at the turn of the Early to the Middle Eocene, preferably in the Middle Eocene (Caudri 1975). If that is correct, then the entire Early Eocene is devoid of larger foraminifera.

The actual Middle Eocene section begins in eastern Trinidad with the Charuma silt, which lithologically forms the transition between the Early Eocene Pointe-a-Pierre grit and the marly Navet Formation. This horizon, which apart from the surface samples in the type area, was also recognized in the nearby Calyx wells 50 and 50A at Biche, carries