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The larger Foraminifera of Trinidad (West Indies)

C.M. BRAMINE CAUDRI[1]

Key words: Larger Foraminifera, Trinidad, Early Cretaceous to Miocene, biostratigraphy, taxonomy

ABSTRACT

The present investigations are a follow up to Vaughan & Cole's Preliminary Report on the Cretaceous and Tertiary Larger Foraminifera of Trinidad, British West Indies. They are based on considerable additional faunal material and more advanced stratigraphic information for dating the investigated Cretaceous to Miocene sediments that contain larger foraminifera. Special attention is paid to the Late Eocene transgression in the San Fernando area where it took place in two phases, and to a transgressive interval (Marabella marl) between the Late Eocene and the Oligocene. So far this interval could not be recognized by means of planktic foraminifera but stands out clearly for its larger foraminifera. As such it is correlatable over great distances in the Caribbean region. 24 localities that contain larger foraminifera are described. Their locations are shown on Figure 1. Special attention in the study of the Trinidad larger foraminifera was given to the San Fernando area (Fig. 2–4) which is of particular interest for the abundance of larger foraminifera and their detailed stratigraphic record.

120 taxa were investigated with their ranges shown on distribution charts (Fig. 5–7). They are illustrated on Plates 1–30.

The following taxa are described as new: *Operculina bontourensis, O. bontourensis* var. *ornata, Operculinoides ocalanus* var. *decoratus, O. suteri, Heterostegina indicata, Lepidocyclina* (*Polylepidina*) *nitida, L. yurnagunensis* var. *inflata, L. sanfernandensis* var. *depressata, L. asterocolumnata, Eoconuloides senni* var. *conicus, Helicolepidinoides intermedius, Amphistegina farallonensis.*

ZUSAMMENFASSUNG

Die vorliegenden Untersuchungen sind eine Ergänzung zu Vaughan & Cole's Preliminary Report on the Cretaceous and Tertiary Larger Foraminifera of Trinidad, British West Indies (1941). Sie stützen sich auf bedeutendes zusätzliches Faunenmaterial und fortgeschrittenere stratigraphische Information zur Datierung der untersuchten Kreide- bis Miozänsedimente, die Grossforaminiferen enthalten. Figur 1 zeigt die besprochenen 24 Lokalitäten. Wegen der Häufigkeit von Grossforaminiferen und ihrer stratigraphischen Bedeutung wurde besonders Gewicht auf die obereozäne Transgression im Gebiet von San Fernando gelegt (Fig. 2–4). Diese erfolgte hier in zwei Phasen sowie einem transgressiven Abschnitt (Marabella Mergel) zwischen Obereozän und Oligozän. Dieser konnte bisher mittels planktonischer Foraminiferen nicht festgestellt werden, während er mit Grossforaminiferen klar erkennbar ist. Als solcher kann er in der karibischen Region über grosse Distanzen verfolgt werden.

Die stratigraphische Verbreitung der 120 untersuchten Taxa ist auf den Figuren 5–7 dargestellt. Sie sind auf den Tafeln 1–30 illustriert.

Die folgenden Taxa werden als neu beschrieben: *Operculina bontourensis, O. bontourensis*var. *ornata, Operculinoides ocalanus* var. *decoratus, O. suteri, Heterostegina indicata, Lepidocyclina* (*Polylepidina*) *nitida, L. yurnagunensis* var. *inflata, L. sanfernandensis* var. *depressata, L. asterocolumnata, Eoconuloides senni* var. *conicus, Helicolepidinoides intermedius, Amphistegina farallonensis.*

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[1] † 2nd of February 1991

CONTENTS

NOTE

Bramine Caudri completed her manuscript on the larger foraminifera of Trinidad consisting of 501 typewritten pages, 30 plates and 7 figures and range charts in 1985. Together with the illustrated specimens the manuscript was deposited for eventual publication at the Museum of Natural History, Basel. Because of its size, in particular the systematic part, it proved difficult to fund its publication. It was therefore decided to condense its size without however loosing pertinent data including illustrations and charts. Basically the reductions affected the systematic part. While the newly proposed taxa remain fully documented, synonymy lists, detailed descriptions and discussions of already published forms were curtailed. In numerous instances reductions concerned taxa that were already treated by Caudri in her 1975 Soldado Rock publication. For additional information references to this paper is therefore recommended, and also to the Preliminary Report on the Cretaceous and Tertiary Larger Foraminifera of Trinidad British West Indies by Vaughan & Cole (1941). Together with these two publications Caudri's present contribution substantially complements the documentation on the systematics and the stratigraphic distribution of the larger foraminifera of the main island of Trinidad and nearby Soldado Rock.
An original unabbreviated copy of Caudri's manuscript is deposited in the geological library of the Museum of Natural History, Basel, where it is available for consultation. The manuscript as published here was edited by H.M. Bolli in collaboration with J.P. Beckmann.

1. Introduction

Vaughan & Cole's comprehensive work of 1941 on Trinidad larger foraminifera was presented as «preliminary» because the material at their disposal consisted of rather haphazardly collected samples without a sufficient stratigraphic background. Today, we have more advanced information on the stratigraphy and moreover are now more alert to the important factor of reworking. Consequently we are in a better position to report on the occurrence of the larger foraminifera and their place in the stratigraphic sequence of Trinidad.

Our material consists of a great number of samples collected over many years by geologists of the former Trinidad Leaseholds Ltd. (T.L.L.), later taken over by Texaco Trinidad, Inc. and now nationalized. The collection was supplemented by the Shell subsidiary United British Oilfields of Trinidad (U.B.O.T.), a number of other oil companies and by the Government Geological Survey.

Our collection did not comprise the specimens described by Vaughan & Cole (1941) which are deposited at the U.S. National Museum, Washington D.C. However, from many of the localities mentioned by these authors duplicate material was left in the laboratory at Pointe-a-Pierre, where the greater part of the technical work for this paper was carried out. Most of the examined material is now stored at the Museum of Natural History in Basel where it is catalogued under the numbers C 31049–31259 and C 35911–36130. Also stored there are detailed fossil lists for each locality.

2. Localities and Biostratigraphy

Many formations in Trinidad are highly fossiliferous, but the island is not blessed with good exposures of continuous geological sections. A great number of its limestone quarries carry larger foraminifera, but most of them are rootless slipmasses. A few Calyx wells provided useful information in this respect, but for many one had to rely on restricted exposures, test pits, roadcuts and building sites. Further on isolated boulders found mainly in river beds and along the coast, or brought to surface by the many mud volcaneous from unknown depths. Credit must be given to the field geologists and the paleontologists who by their conscienscious work have, from the scant observations, managed to lay the foundations for the stratigraphy of Trinidad as we know it today, and thus made it possible to construct a more or less continuous sequence of larger foraminifera in this part of the Caribbean region.

In the following Trinidad formations there occur intervals of shallow water facies that contain larger foraminifera:

Formation	*Facies*	*Age*
Manzanilla	Montserrat sands	Late Miocene
	San José silts	
Tamana	Guaracara limestone	Middle Miocene
	Tamana limestone	
Brasso	Quarries in the Central Range	Oligo-Miocene
	Ste. Croix Quarry	Early Miocene
Cipero	Morne Diablo Quarry	Early Miocene
	erratic blocks (Erin)	Late Oligocene
	Kapur Quarry	Middle to Late Oligocene
	Mejias Quarry	early Middle Oligocene
	Flat Rock tongue	Early Oligocene
San Fernando	Marabella marl	uppermost Late Eocene
	Vistabella marl	Late Eocene
	Mount Moriah glauconitic sandstone	pre-Late Eocene
Navet	Hospital Hill marl	Late Eocene
	Farallon limestone	uppermost Middle Eocene
	Dunmore Hill marl	late Middle Eocene
	Charuma silt	early Middle Eocene
Boca de Serpiente	erratic blocks	basal Middle Eocene
Lizard Springs	Lizard Springs marl erratics	Paleocene
Albian?	erratic blocks	Early Cretaceous

In the following are described the localities of larger foraminifera as they existed around 1940. Most of them are now obliterated by erosion, exploitation or bulldozing, and their description here is the last information we can document about the environment of our fossil species and their connections and age. The planktic zonation used is that of Bolli (1957). Localities 1 to 24 refer in the following text to the numbers on the Locality Map (Fig. 1).

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

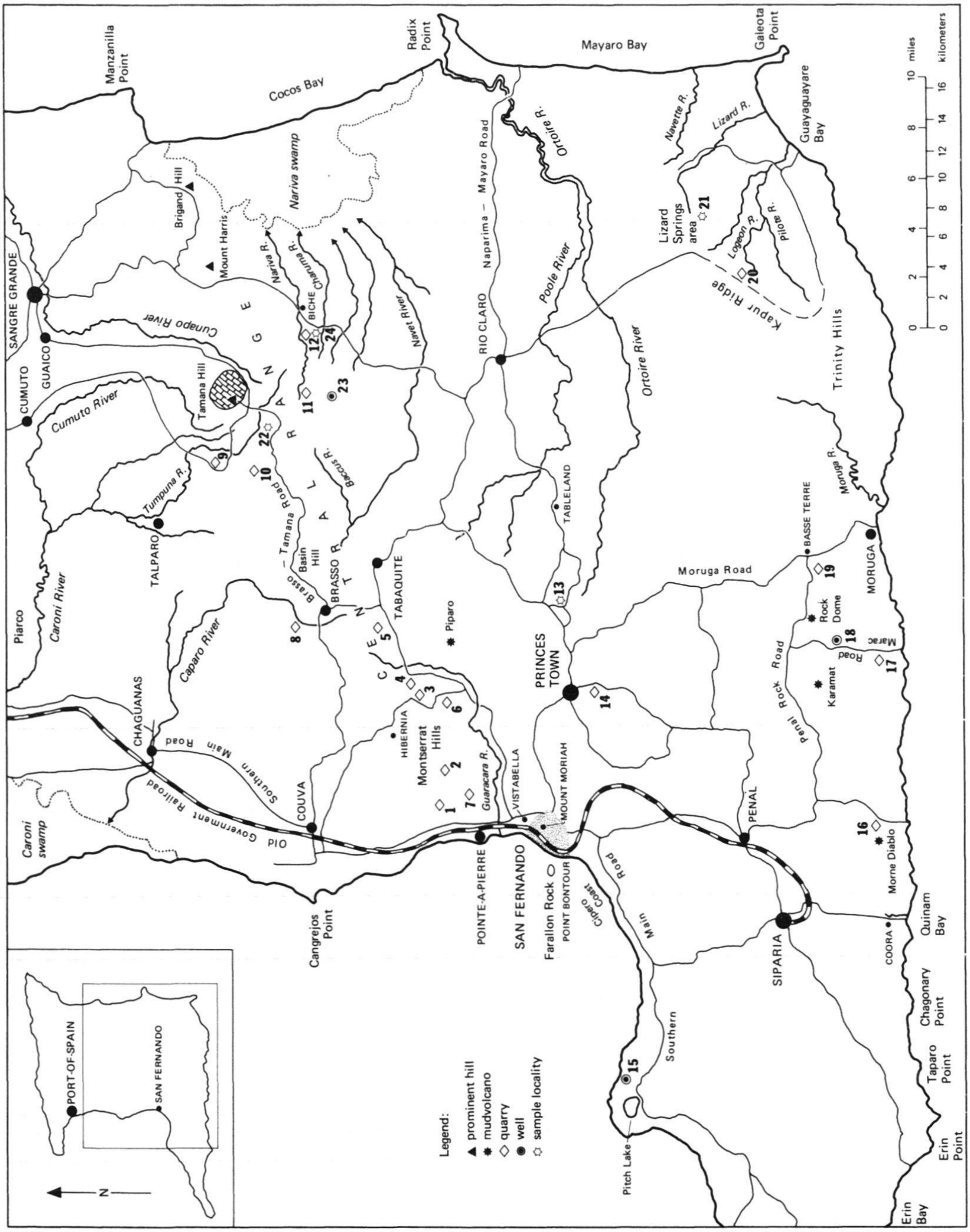


Fig. 1. Map showing larger foraminifera localities 1–24.

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

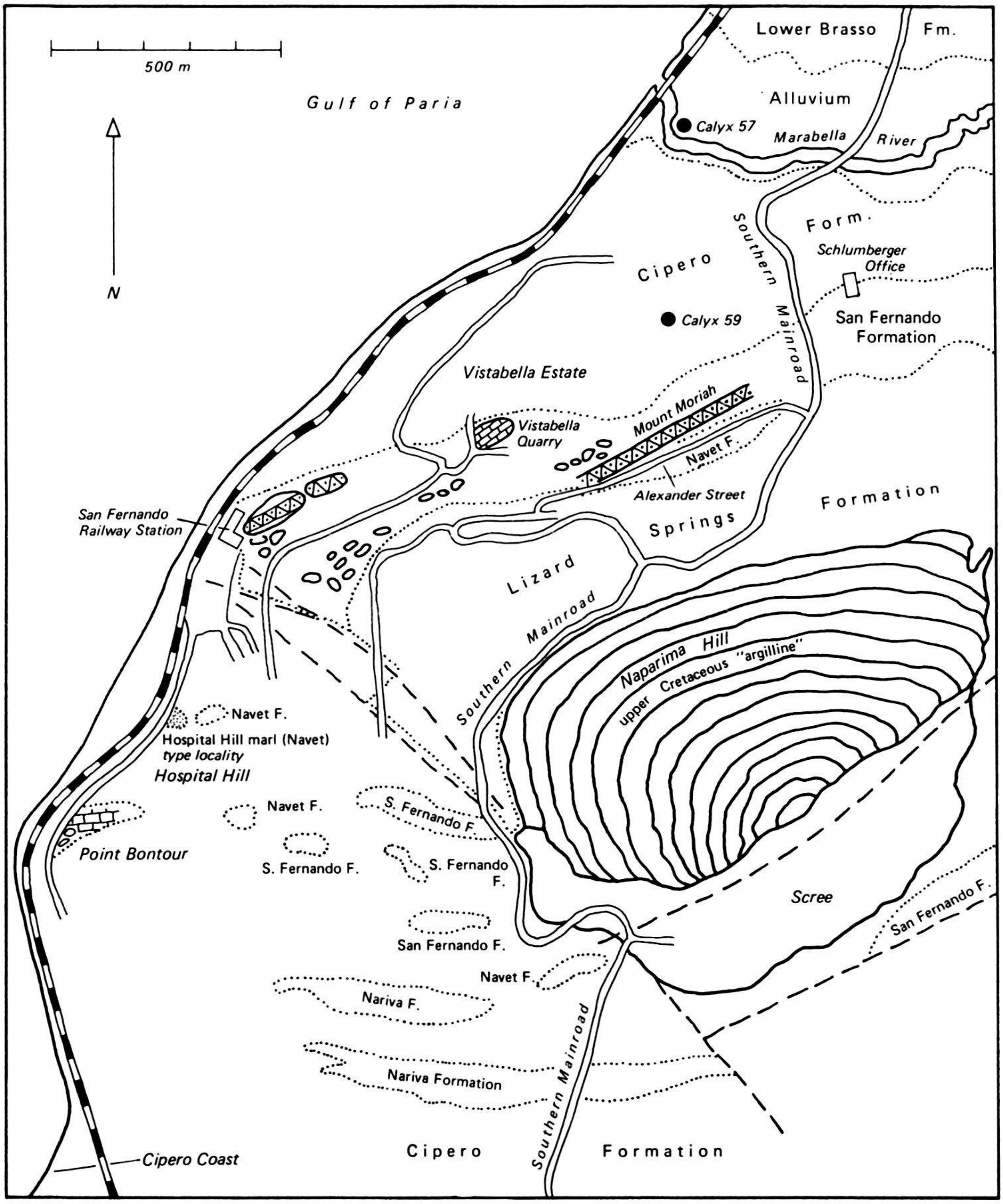


Fig. 2. Geological sketch- and locality map of San Fernando area.

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-

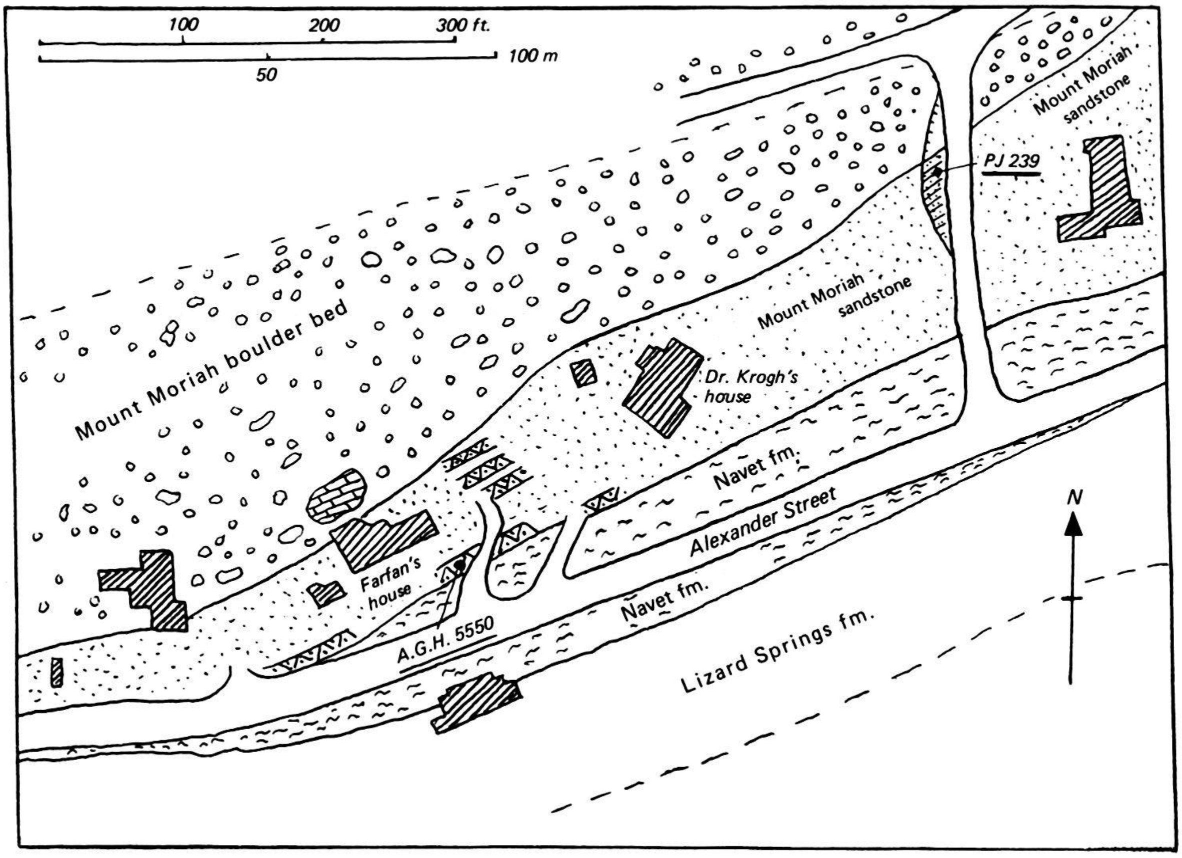


Fig. 3. Geological sketch map of the top of Mount Moriah.

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.

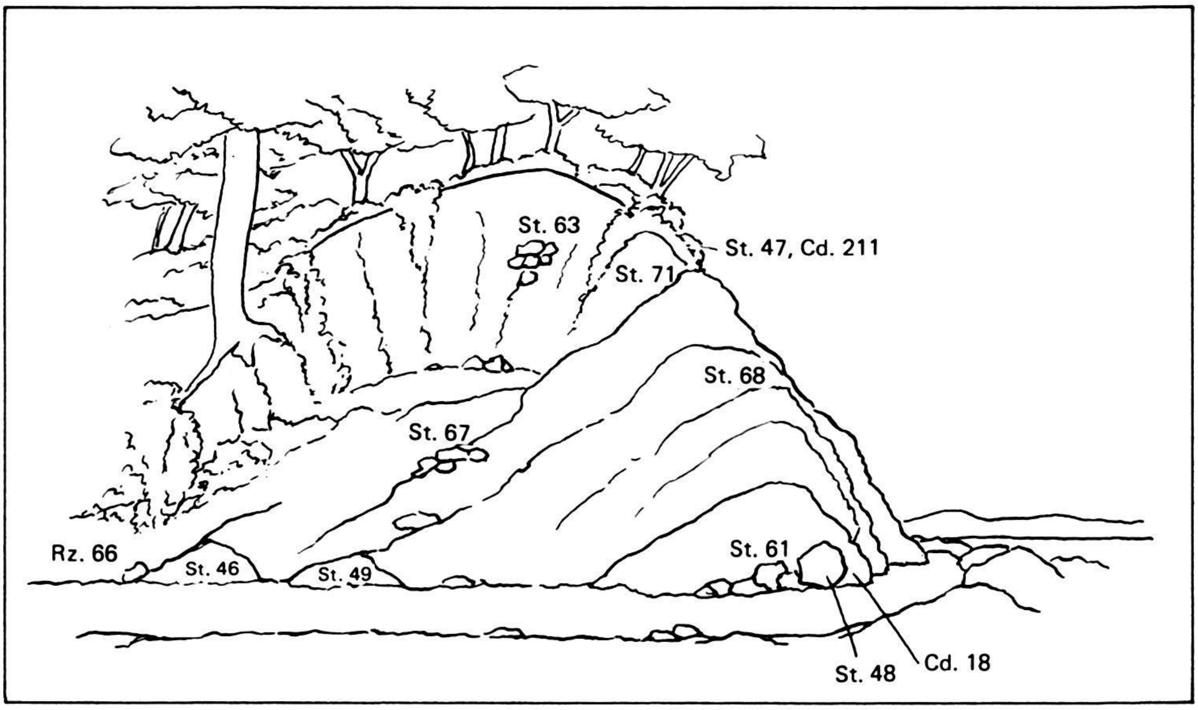


Fig. 4. The cliff of Point Bontour as it appeared 1940, seen from the West.

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														Jacksonian Upper Eocene																			
Formation	Marabella marl														Vistabella marl																			
Depth of core (in feet)	40	50	60	70	90	240	260	270	280	290	300	320	340	350	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 a very poor but significant fauna containing *Eoconuloides* and in well 50A *Neodiscocyclina anconensis*, an assemblage that can be traced over great distances. It can be directly correlated with the Upper Scotland Formation (Murphys beds) of Barbados and with the San Eduardo limestone of southwestern Ecuador and its equivalent in northwestern Peru; further with the early Middle Eocene part of the Corinto well 1 in Campeche (Yucatan), the Peñon Seep of Cuba and the base (zone 1) of the Lake City Formation of Florida.

The Navet Formation, which follows after this silt, is developed in a marly facies without neritic phases or reefs. There are no limestones comparable to the Cuicas and El Cumbe limestones in western Venezuela, and also the *Polylepidina antillea* Zone of the Late Middle Eocene in other places did not develop in this environment. The only horizon which contains larger foraminifera, in part obviously reworked, is the controversial Dunmore Hill marl, which shows already some affinity to the Late Eocene. At the end of the Middle Eocene the sea became shallower which resulted in the development, somewhere near Trinidad, of an *Operculina-Polylepidina* reef, of which nowadays only the isolated Farallon rock off the San Fernando coast is left as an olistostrom remnant, and one boulder on Coora beach.

In most places, however, the Late Eocene sets in with a general change from the open marine marls of the Navet to the neritic sediments of the San Fernando Formation which transgresses over the Navet and older marls with a marked unconformity. This transgression, which is shown very clearly in the San Fernando area, took place in more than one phase, the glauconitic calcareous sandstone of the top of Mount Moriah being the first sediment to be deposited, followed (again with an unconformity) by the Mount Moriah conglomerate and the Vistabella marl which are Late Eocene in age. In this area, the transition from the Vistbella marl to the Oligocene Cipero marls is clearly indicated by a special zone of the Eocene, the Marabella marl or *Helicocyclina paucispira* Zone, which is not clearly defined by means of its planktic fauna but is recognized by its larger foraminifera and can be traced to other places in the Caribbean Region, northern South America, Mexico and the Gulf States.

The Cipero marl facies persisted in the southern part of Trinidad throughout the Oligocene and into the Miocene. Larger foraminifera are, however, only found in a very restricted horizon in the Early Oligocene of the type section on the Cipero coast, the so-called Flat Rock tongue (*Globigerina ampliapertura* Zone), and also in such slumped bioherms as the limestones in the Mejias and Kapur quarries (early Middle Oligocene and late Middle Oligocene, respectively) and numerous erratic blocks. To the Miocene belongs the rootless mass of limestone and marl of the Morne Diablo Quarry, which contains the last Lepidocyclinas and Miogypsinas and the first Planorbulinellas. In the nearly contemporaneous Ste. Croix Quarry the Orbitoids are already absent.

In the central part of the island the marls of the Cipero Formation are towards the end of the Oligocene replaced by the neritic Brasso Formation, which continues till the middle of the Middle Miocene and contains many bioherms. The stratigraphic sequence of these limestones ties in with Bolli's planktic zonation. At first, the reefs carry a rather complete fauna with *Lepidocyclina* and *Miogypsina*. Higher up in the section, in the *Globigerinatella insueta* Zone, after first *Lepidocyclina* and then also *Miogypsina* had died out, the open marine environment changes to a very shallow lagoonal one, characterized by a rich but monotonous fauna of *Amphistegina,* large *Operculinoides (tamanensis, tux-*

pamensis) and *Planorbulinella*, locally with *Sorites* and some *Archaias*. This fauna continues throughout the late Middle Miocene (Tamana Formation) and the first part of the Late Miocene (Manzanilla Formation). No larger foraminifera occur higher up in the section. Younger reefs carry only *Amphistegina*.

5. Taxonomy

Family Orbitolinidae
Genus *Orbitolina* D'ORBIGNY
Orbitolina cf. *texana* ROEMER
Pl. 10:18

1941 *Orbitolina* sp. cf *texana*, Vaughan & Cole, p. 3, 7, 24, 31, pl. 8:2–4.
1961 *Orbitolina oculata* Douglass, p. 143, 149, pl. 65:1–3.

This species has been found in rock-building quantity in two limestone boulders, one in Pointe-a-Pierre, the other in the river bed at Quinam. According to Vaughan & Cole it probably indicates an Early Cretaceous (Albian) age. Douglass (1961) places the specimens from Pointe-a-Pierre in *Orbitolina occulata*.

Family Nummulitidae
Although familiar with Cole's arguments for uniting all the genera of this group under one name because all their characteristics are only of a gradual nature, the present author prefers for practical and in part stratigraphic reasons, to distinguish *Ranikothalia*, *Operculina*, *Operculinoides* and *Nummulites* as separate genera. In Trinidad, *Ranikothalia* occurs in the Late Paleocene, an evolute *Operculina* was found in the late Middle Eocene and reworked in the Late Eocene. *Nummulites* is very sparingly present in the Late Eocene, whereas *Operculinoides* in all its different forms ranges from Middle Eocene to top Miocene.

Heterostegina seems to be restricted to the later part of the Oligocene in this area, but has an incompletely developed precursor in the early Late Eocene. *Spiroclypeus* is probably the same species that is so spectacularely developed in western Venezuela (Falcón). In Trinidad it is not found in situ, but occurs occasionally in mud flow erratica near the South Coast.

Genus *Ranikothalia* CAUDRI

General remarks

Ever since the name *Ranikothalia* was proposed for the peculiar «nummulites cordelées» of the Paleocene in both the Old and the New World, it has been turned down by some paleontologists who, for purely morphologic and statistic reasons, refused to separate these forms from *Nummulites, Operculinoides, Operculina* or even *Miscellanea*, as the case may be, whereas it was accepted by others who saw in them in first place a genetically close-knit group, generally recognizable at sight and limited in geological time. The clearest discussion in defence of a separation was presented by Drooger (1960). In 1966, Arni introduced the genus *Chordoperculinoides* (genotype *Operculina bermudezi* Palmer), which is a synonym of *Ranikothalia* (see also Cole 1969b).

The type species of the genus is *Nummulites nuttalli* (Nuttall) Davies from the Upper Ranikot beds of Sind, Pakistan, which are solidly established as Late Paleocene (Nuttall 1926; Davies 1927, 1949; Gill 1953). For the description of this species reference is made to Nuttall 1926 (114, pl. 10:1–2, textfig. 1), Davies 1927 (266, pl. 18:3–4; pl. 19:1–9) and Caudri 1934 (57, pl. 1:9; horizontal section). Our Venezuelan material (1944), which consists of hard limestones in which *Ranikothalia* is well preserved and in situ, was entirely adequate to prove the presence of this type of fossils also in the Caribbean Paleocene (in the Caramate member of the Guárico Formation near San Juan de los Morros; see Peirson, Salvador & Stainforth 1966).

Between certain latitudes, the geographic distribution of *Ranikothalia* is practically worldwide. In the West, it has been reported from eastern and central Venezuela (Caudri 1944; de Cizancourt 1951), Trinidad and Soldado Rock (Cushman & Jarvis 1932; Vaughan & Cole 1941; Vaughan 1945; Caudri 1975), Surinam, French Guayana and off-shore Guyana Basin (Drooger 1960; Wong 1976; Blondeau 1977; van Voorthuyzen 1979), Barbados (Vaughan 1945; de Cizancourt 1948; Caudri 1972b), Puerto Rico, Loisy Quarry (det. Caudri), Hispaniola (Hanzawa 1937; Butterlin & Bonet 1960a, 1960b), Jamaica (Robinson 1968), Cuba (Palmer 1934; Bermudez 1950; Cole 1953; Sachs 1957; Brönnimann & Rigassi 1963; Seiglie 1965; Butterlin 1976), Florida and Alabama, Georgia (Cole & Herrick 1953), Mexico, general (Butterlin 1977), Veracruz (Barker 1939), and Yucatan (Butterlin & Bonet 1960a, 1960b).

In the Eastern Hemisphere *Ranikothalia* occurs in Senegal (de Cizancourt & Cuvillier 1954; Blondeau 1977; Butterlin 1977), the Ivory Coast, Nigeria and Cameroon (Blondeau 1977), Togo (Davies 1949), probably Spain (Alicante and Catalonia), the French Pyrenees and Upper Egypt (Hottinger 1962), Libya (Arni 1966), Somalia and Arabia (verbal information; see also Silvestri's *Miscellanea assilinoides* from Somalia), Iran, Horassan and N.W. Saitan (Rahaghi 1978), Pakistan (Nuttall 1926; Davies 1927, 1949; Caudri 1934, 1944), Tibet, Assam, Coastal India and further East into Southern Burma (Nagappa 1959) and possibly Indonesia and New Guinea in the Tertiary-a of van der Vlerk (1955).

According to Glaessner, the equivalents of the Ranikot and Laki stages of Pakistan (Paleocene and Early Eocene, respectively) are missing in the Far East, which would make this Tertiary-a Middle Eocene (Nagappa 1959). The presence of *Ranikothalia* in Indonesia and New Guinea that high in the section should be checked.

Into how many species the genus *Ranikothalia* can be divided is still an open question. The variability in habitus as well as in interior features is so great that one can split the population in any given locality into a dozen or more different species or lump it into one. This is best illustrated by the comparison of de Cizancourt's work on Barbados (1951), in which eight or ten different species are recognized, to that of Sachs (1957), who by statistical methods came to the conclusion that they all belonged to one and the same species which he placed in *Operculina bermudezi* Palmer. For morphological reasons, Cole had already come to the same conclusion (Cole 1953, 1958, 1959b), but named the species *Operculina catenula* Cushman & Jarvis, which according to the rules should have priority over *O. bermudezi*. The tendency of several authors to ignore *O. catenula* lies in the circumstances that its type material seemed rather inadequate. It consists of one single intact specimen from Lizard Springs (Trinidad), in which the internal characteristics, necessary for the specific diagnosis, are not revealed (Butterlin 1977). The present author does not doubt the identity of this obscure holotype and agrees to name the Caribbean species *O.*

catenula. As in Caudri (1975) we follow Vaughan & Cole's names for the three Trinidad varieties. These are *Ranikothalia antillea* for the closely wound robust lenticular A-form, *R. tobleri* for the more flaring form with elongated, slightly curved round-topped chambers (A and B) and *R. soldadensis* for the large compressed heavy-rimmed fullgrown B-form (see illustrations in Caudri 1975, which also include material from Lizard Springs).

Drooger (1960) distinguishes two separate species: the very flattened individuals that make up the entire populations in Guayana and Georgia (*Ranikothalia soldadensis*) and the robust lenticular form which is usually associated with elsewhere (*R. bermudezi*). These two extremes are, however, linked by so many transitional forms that they most probably can never be separated. The present writer feels, on the other hand, that if after all the genus should get split up into more than one species it would be the small flat thin walled form from Georgia (*Operculinoides georgianus* Cole & Herrick) that would jump out of line first. It might represent a juvenile stage of our robust *Ranikothalia soldadensis*, or be a peculiar geographic variety, but it certainly is not typical of the species.

Also the Old World *Ranikothalia* are often considered as specifically the same as the American ones. Drooger (1960), quoting Davies (1927), suggests that *Operculina sindensis* and *Nummulites nuttalli* from Pakistan may prove to be conspecific with *Ranikothalia soldadensis* and *R. bermudezi*, respectively. This is an oversimplified conclusion as there are in the Pakistan Paleocene still other species to be considered: *Nummulites kohaticus*, *N. thalicus* and *Operculina gwynae*. Rahaghi (1979) uses the West Indian nomenclature, like *Ranikothalia soldadensis* and *Operculina catenula*, for his material from Iran. This has also been done in the work of Davies (1949), de Cizancourt & Cuvillier (1954) and Blondeau (1977). The last-mentioned author determined specimens from the Caribbean and Senegal as *Ranikothalia bermudezi-nutalli* and those from French Guyana, the Ivory Coast, Nigeria and Cameroon as *R. sindensis-soldadensis*. Over a smaller distance, Cole (1960b) puts *Nummulites nuttalli* and its A-form (*thalicus*) in synonymy with the European pair *N. elegans-planulatus*. Continental drift is sometimes mentioned as the cause of this peculiar global distribution, but it is not easily explained why this movement should affect only *Ranikothalia* and not its associated fauna as well. Blondeau 1982) thinks in first place of both-ways migration, with perhaps Senegal as the point of origin. All this needs careful further study.

Generally speaking, *Ranikothalia* is typical for Late Paleocene worldwide. In the West it forms the most conspicuous element in Cole's *Operculina catenula* fauna which has been traced throughout the Caribbean and Gulf regions and which Cole (1959b) considers as indicative for Late Paleocene also here.

In Trinidad this assemblage is composed of: *Ranikothalia antillea, tobleri* and *soldadensis, Neodiscocyclina barkeri, caudriae, grimsdalei, aguerreverei, fonslacertensis* and *mestieri, Athecocyclina soldadensis, Hexagonocyclina inflata* and *meandrica,* and *Actinosiphon barbadensis.* For other localities, *Discocyclina weaveri, Athecocyclina stephensoni, Hexagonocyclina cristensis* and *Actinocyclina semmesi* should be included. Hottinger (1973) correlates its range with zones P_3 to P_5 of Blow's 1969 planktic zonation. According to Peirson, Salvador & Stainforth (1966), de Cizancourt's zones of Paleocene a, b and c in the area of San Juan de los Morros carry *Ranikothalia*, whereas her zone d, which is Early Eocene, is devoid of them. In 1951, however, she intimates that in western Venezuela many of her species occur also in the lower part of the Early Eocene (chart on p. 62). Also in Jamaica the genus seems to be restricted to the Paleocene (Robinson 1965).

There are, however, also a few rather isolated indications that the genus may continue into the Early Eocene. Butterlin traced its occurrence from the Late Paleocene (Bolli's *Morozovella pseudomenardii* Zone) to high in the Early Eocene (zones of *Morozovella aragonensis* and *Acarinina pentacamerata*). Similar observations were made by de Cizancourt (1951), Bermudez (1950), Sachs (1957), Butterlin & Bonet (1960), Brönnimann & Rigassi (1963), Seiglie (1965) and Bolli (1966), especially in Cuba, Mexico and the Gulf States. Nagappa (1959) writes also that in the Old World the genus is in general restricted to the Late Paleocene, but that in rare cases it may perhaps extend into the Early Eocene in South Asia.

One has to be careful when evaluating these cases of a post-Paleocene occurrence of *Ranikothalia*, especially when mentioned in association with such Middle Eocene markers as *Helicostegina dimorpha* and *Discocyclina anconensis*. Both these forms have more than once been identified incorrectly, this and reworking of *Ranikothalia* are likely the causes for post-Paleocene identifications of the genus. A striking example for that is the assemblage in the Middle Eocene Murphy's beds of Barbados, where *Neodiscocyclina anconensis* is the predominant and diagnostic species and the *Operculina catenula* fauna, no matter how well preserved, is reworked (Vaughan 1945; de Cizancourt 1948; Caudri 1972b).

Occurrence in Trinidad

In Trinidad, *Ranikothalia* occurs in a semi-authochthonous state in only one place: at the type locality Maerky 102b III of the Lower Lizard Springs Formation (*Morozovella velascoensis* Zone), in the bank of a tributary of the Ravine Ampelu. A pit in the immediate neighbourhood of this exposure yielded the isolated type specimen of *Operculina catenula* (Cole 1953) re-deposited from a contemporaneous bioherm, the *Ranikothalia* limestone of the Soldado Formation (Kugler & Caudri 1975).

This *Ranikothalia* limestone is not found in situ in Trinidad, but remnant blocks are frequently scattered in the southern part of the Island, especially in the Lizard Springs area and along the South coast in the mud-volcano effusiva, and in conglomerates around San Fernando and Pointe-a-Pierre. Detached specimens of *Ranikothalia* are very common in the clastic Late Eocene San Fernando Formation and, to a lesser degree, in the Middle Eocene Charuma silt and the Navet marls at Dunmore Hill (Caudri 1975).

The best material is that from Maerky 102b III, where *Ranikothalia* of the *antillea* and *tobleri* type are abundant, together with various Discocyclinidae. *Ranikothalia soldadensis* was represented by only one juvenile specimen and a few fragments (Caudri 1975, pl. 1:1–7; pl. 2:1–8).

In 1975 the present author announced a more extensive description of the Trinidad *Ranikothalia* following the study of the Lizard Springs material. It is unfortunate that Vaughan & Cole did not have access to this material for their 1941 paper and thus were not able to study the typical Lizard Springs fauna as a whole.

They had to describe their new species *Miscellanea tobleri* and *Discocyclina fonslacertensis*, which belong to this assemblage, from a Late Eocene erratic block in the nearby Ravine Djalan and consequently assigned them to the Late Eocene instead to the Paleocene. For his intended closer study of these forms, Vaughan afterwards received from the Pointe-a-Pierre laboratory a number of choice specimens and thin sections from

Maerky 102b III. His observations on them are, however, not mentioned in his 1945 Barbados paper. Only a preliminary report on the Lizard Springs *Ranikothalia* is kept, along with the material, in the U.S. National Museum in Washington (Caudri 1975).

As it turns out, the vague diagnosis and the good illustrations given then seem already clear enough for our purpose without adding more than a few photographs (Pl. 5:1–4; Pl. 9:1–2,4–9). What is still lacking, both in the type descriptions by Vaughan & Cole (1941) and in Caudri (1975) is a detailled description of *Ranikothalia soldadensis*, a species originally based only on a couple of off-center vertical sections in hard rock. The following species description is based on the best material available from Soldado Rock (samples K. 2951B and Rz. 248), illustrated in Caudri (1975, pl. 1:1; pl. 2:1, 8; pl. 6:1, 3; pl. 7:1–5).

Ranikothalia soldadensis (VAUGHAN & COLE)
Pl. 5:4; Pl. 9:1

1941 *Miscellanea soldadensis*, Vaughan & Cole, Geol. Soc. Amer., Spec. Pap. 30, 36, pl. 4:8–9.
1975 *Ranikothalia soldadensis*, Caudri, pl. 1:1, 4; pl. 2:6, 9; pl. 6:1, 3; pl. 7:1–5; pl. 8:1–3.

Exterior: Diameter of weathered specimens at K. 2951B 4–8 mm, up to at least 13 mm in well-preserved specimens in hard rock (Rz. 248). Test flat, discoid, with a thick protruding marginal cord, visible on the surface as a complete spiral; lateral walls sunken-in between the coils of the spiral, especially in the later whorls. No large pillars, except perhaps in the juvenile stage, septal filaments running across the surface right up to the center (see also the vertical section), often irregularly granulated, surface between the filaments also very finely granulated.

The same feature of evolute chambers without alar prolongations of the lumen but with the lateral sheet extending as a thin film over the older coils has been illustrated by de Cizancourt (1951) for the Barbados form of *Ranikothalia bermudezi*. It was also observed in *Operculina bontourensis* Caudri n. sp. Marginal cord especially in the later whorls magnificently developed, characterized by a conspicuous fan of wide canals radiating from the top of the chambers; the whole marginal complex clearly separated from the chamber lumina by a solid wall (compare *Miscellanea* which lacks such a wall). Lateral wall of the chambers also pierced by wide canals, thick in the inner whorls but becoming very thin in the last ones, sunken into the extent of sometimes nearly suppressing the lumen.

The smaller specimens from K. 2951B fall within the measurements given by Vaughan & Cole (1941) for the microspheric form of *Ranikothalia tobleri*.

Typical *Ranikothalia soldadensis* are very rare in Trinidad. Apart from the above mentioned juvenile specimen and a few fragments at Lizard Springs it has been found fully developed only in the Paleocene blocks of the conglomerate in the Hermitage Quarry near Pointe-a-Pierre.

Genus *Operculina* D'ORBIGNY
Operculina bontourensis CAUDRI, n. sp.
Pl. 1:1–4; Pl. 9:3, 10

Exterior: Diameter up to 4.5 mm; thickness 0.3–0.5 mm. Test flat, smooth, evolute, with a rounded edge (no marginal cord developed); entire coil visible from the outside, accentuated by a thickening of the wall along the spiral suture. Septa as a rule only faintly visible, flush or with at the most very fine granulations, but in exceptional cases heavily decorated (variety *ornata* n. var., Pl. 5:7).

Horizontal section: Nucleoconch small (70–115 μ), megalospheric in all observed specimens. Spiral high, but not very rapidly increasing in height; number of whorls 3.5 to 4.5. Number of chambers in the last whorl 26–30 (in one large specimen 24 in the last half whorl). Septa in centered sections more or less radial near the center but strongly bent backwards in their distal part (in off-center sections often appearing more evenly curved).

Vertical section: Test flat, no central boss, edge thin, without a trace of a marginal cord. Chamber lumina without alar prolongations, but sometimes each new whorl adds a thin film of shell material over the previous ones right up to the center.

Holotype: Pl. 1:1 (C 36023).

Type locality: Point Bontour, St. 63, Late Eocene; material reworked.

Type level: Uppermost Middle Eocene (Farallon limestone).

Occurrence: *Operculina* limestone Farallon Rock; Coora beach (Hg. 39aA, *Operculina* limestone block); Point Bontour (reworked in the Eocene: St. 61A, 63, 68a, 71, 85, 77, 89, 90, Cd. 18: reworked in the Oligocene: Cd. 211).

This conspicuous evolute *Operculina* was first reported from the Late Middle Eocene of Farallon Rock where it occurs in situ in rockbuilding quantities in a hard limestone. Detached specimens occur, however, in the Late Eocene marl from Point Bontour just opposite Farallon on the San Fernando coast. Although there they are most probably reworked, the types for the species have been selected from that locality, hence the proposed name.

True evolute Operculinas are uncommon in the Caribbean area, and limestones formed by them are rare. In South America the only examples known in the literature are the Caus and the Cuicas limestone, both in the Chejendé and Rio Carache areas of Trujillo, western Venezuela. The former lies stratigraphically between the Escuque Formation and the Pauji shale (Stratigraphical Lexicon of Venezuela 1956) and is thought to be of the same age as the Farallon limestone. It contains banks exclusively consisting of Operculinas repeatedly mentioned as *Operculina cookei* but which have probably never been described or figured. The Cuicas limestone is of an earlier date, it occurs below the *Polylepidina antillea* Zone and was assigned to the early Middle Eocene (de Cizancourt 1951). The rockbuilding *Operculina* in this limestone has erroneously been determined as *Operculinoides oliveri*.

Thin sections of a sample of typical Cuicas limestone in the author's collection, from the Puente Gomez area between La Cuchilla and La Concepcion, just S.E. of de Cizancourt's type locality in the La Paz section (collected by J.W. Durham, location No. 19151) show many examples of the truly *complanata* nature of this *Operculina*.

Operculina has also been mentioned by Tobler from the Rio San Pedro limestone of Zulia, Venezuela. Because this limestone and that from Farallon and the Rio Caus are of the same age, the Operculinas in all three localities may well be the same species. Specimens of the Cuicas limestone seem to have a wider spiral.

Operculina bontourensis var. *ornata* CAUDRI, n. var.
Pl. 5:7

Exterior: Large flaring involute form, heavily decorated.
Holotype: Pl. 5:7 (C 36045).
Type locality: Point Bontour, San Fernando area, Trinidad, Sample St. 63, specimens reworked.
Type level: Uppermost Middle Eocene (Farallon limestone).
Occurrence: Predominant at Farallon locality F.Z. 37, occurs also at Point Bontour and in a limestone boulder from Coora beach.

The new variety resembles *Operculinoides ocalanus* but is larger and may actually be much closer to *Operculina bontourensis*, apart from being involute. They are large flaring forms with the same rate of opening of the spiral and the same number and curvature of the septa as in *O. bontourensis*.

Genus *Operculinoides* HANZAWA
The Eocene species
Operculinoides ocalanus (CUSHMAN)
Pl. 5:5; Pl. 9:11–13

1921 *Operculina ocalana*, Cushman, Prof. Pap. U.S. Geol. Surv., 128-E. p. 129, pl. 19:4, 5.
1928 *Operculina trinitatensis*, Nuttall, textfig. 8.
1941 *Operculinoides ocalanus*, Vaughan & Cole, p. 38, pl. 8:8–9; pl. 9:1–4; pl. 10:1.
1975 *Operculinoides ocalanus*, Kugler & Caudri, p. 398–402, 404, 408.
1975 *Operculinoides ocalanus*, Caudri, p. 537, 538, 540, pl. 1:12; pl. 8:4, 9.

The species is abundant in the Middle Eocene limestone of Farallon Rock and common in the Late Eocene of the Navette area.

Operculinoides ocalanus var. *decoratus* CAUDRI, n. var.
Pl. 3:4

Exterior: Granulated.
Holotype: Pl. 3:4 (C 36030).
Type Locality: Point Bontour, San Fernando area, Trinidad, sample St. 68, specimen reworked.
Type level: Middle to Late Eocene.

The new variety differs from *Operculinoides ocalanus* in its granulated exterior appearance. The new variety is based on a single specimen which was not sectioned.

Operculinoides soldadensis VAUGHAN & COLE
Pl. 5:6; Pl. 9:14–15

1928 *Operculina trinitatensis*, Nuttall, textfig. 9.
1941 *Operculinoides soldadensis*, Vaughan & Cole, p. 18, 27, 40, pl. 9:5–8; pl. 10:1–2.

1975 *Operculinoides soldadensis*, Kugler & Caudri, p. 398–400, 402, 404, 407–408, 417(cf.), 419(cf.) and chart.
1975 *Operculinoides soldadensis*, Caudri, p. 537–538, 540, pl. 1:11, 19; pl. 8:5–8, 10(cf.).

Originally described from Bed 10 of the Soldado Rock section (Late Eocene). *Operculinoides soldadensis* has the same range as *O. ocalanus*.

Occurrence: Farallon Rock (common), Dunmore Hill, top of Mount Moriah, Morne Roche, Charuma (abundant), Hospital Hill marl, Point Bontour, Vistabella Quarry, Calyx 59 (upper and lower part), Schlumberger office section (lower part), San Fernando Railway Station (Marabella marl), Soldado Rock.

Operculinoides trinitatensis (NUTTALL)
Pl. 5:11; Pl. 9:16–17

1928 *Operculina trinitatensis*, Nuttall, p. 102–103, pl. 8:10–11, textfig. 7 (not 8 and 9).
1941 *Operculinoides trinitatensis*, Vaughan & Cole, p. 47–50, 52–53, pl. 10:3?, 12; pl. 13:4–14.
1975 *Operculinoides trinitatensis*, Kugler & Caudri, p. 398, 400, 402, 408.
1975 *Operculinoides trinitatensis*, Caudri, p. 541, pl. 1:10, 16; pl. 8:14–15.

The type material of *Operculinoides trinitatensis* came from a depth of 570 feet in test-well-A on Tarouba Estate, Naparima area. Also present in this interval is *Lepidocyclina subglobosa*, an indicator for the uppermost Late Eocene (Marabella marl), which is the type level of *Operculinoides trinitatensis*.

Vaughan & Cole (1941) mentioned the close relationship between *O. trinitatensis* of the Eocene and *Operculinoides semmesi* which abounds in the Early Oligocene of the same area and suggested that Nuttall may have included the latter in his description. Though the horizontal sections of the two species are practically the same, *O. semmesi* distinguishes itself in vertical section by a flattening of the axial region, and its variety *ciperensis* is altogether a flatter form than *O. trinitatensis*. For its lack of prominent features *O. trinitatensis* is difficult to determine, which makes it unsuitable as a guide fossil.

Occurrence: San Fernando area, chiefly in the Late Eocene: Point Bontour, Hospital Hill marl, Vistabella Quarry, Calyx 57 and 59, Marabella marl only at the San Fernando Railway Station and at the type locality, Morne Roche Quarry, Navette area (abundant), ?Charuma (Late Eocene), Dunmore Hill marl, ?Farallon Rock, Soldado Rock.

Operculinoides kugleri VAUGHAN & COLE
Pl. 5:9; Pl. 10:1, 3

1941 *Operculinoides kugleri*, Vaughan & Cole, p. 18, 42, pl. 10:3?,4–5,7–8; pl. 13:1–2.
1952 *Operculinoides kugleri*, Cole, p. 9, pl. 3:1–7.
1975 *Operculinoides kugleri*, Kugler & Caudri, p. 398, 400, 402, 408.

For the external view of this common species reference is made to Vaughan & Cole (1941) and Cole (1952). It ranges from late Middle to uppermost Late Eocene (Marabella marl).

Occurrence: Soldado Rock (beds, 7, 9, 9a, 10), San Fernando area: Mount Moriah (common), Point Bontour (lower part), ?Hospital Hill marl, Vistabella Quarry, Calyx

57 (Marabella marl), Calyx 59 (Vistabella and ?Marabella marls), San Fernando Railway Station (Marabella marl), Morne Roche Quarry, Charuma (Late Eocene), Farallon Rock (late Middle Eocene).

Operculinoides spiralis CAUDRI

Pl. 5:8; Pl. 9:18

1975 *Operculinoides spiralis*, Caudri, p. 542, pl. 1:7; pl. 8:13.

The type level of *Operculinoides spiralis* is the uppermost bed of the Soldado Eocene (K. 2651), which presumably corresponds with the Marabella marl in Trinidad. On the main island, however, it was found only in the lower part of the Late Eocene (Mount Moriah sandstone and Vistabella marl).

Occurrence: Soldado Rock (K. 2651, K. 2854), top of Mount Moriah, North of Mount Moriah, Point Bontour, Vistabella Quarry, Vistabella Calyx well 59 (lower part), Schlumberger office section (lower part), Charuma (Late Eocene part of section).

Operculinoides suteri CAUDRI, n. sp.

Pl. 1:5–8; Pl. 10:19

Exterior: Diameter about 2.5 mm, maximal 2.8 mm; test thin, discoid, with flush irregular filamental lines which overlap each other at odd angles and do not properly converge on the axis.

Horizontal section: Rapidly widening *Operculina*-like spiral; septa numerous, up to 30 in the last whorl, evenly curved.

Vertical section: Spiral sheet relatively thick: successive whorls tightly packed so that there is hardly any room for any alar prolongations of the chambers, but definitely involute.

Holotype: Pl. 1:5 (C 35961).

Type locality: Vistabella Calyx well 59, 390–400 feet.

Type level: Late Eocene, Marabella marl.

Occurrence: Regularly present throughout the Late Eocene of San Fernando area (Vistabella Quarry, Calyx 57 and 59, Marabella 1, San Fernando Railway Station, scarce in Vistabella marl, locally common in Marabella marl of San Fernando Railway Station, Cd. 208).

Named after Dr. H.H. Suter, chief geologist with T.L.L. in Pointe-a-Pierre, at the time the material was collected.

This is a nearly always poorly preserved species but still easily recognizable for its particular filamental lines. Its test is thin discoid, with smooth irregular sutures, which tend to reach the central area but overlap each other at an angle and do not converge into a single axis. In horizontal section it looks like *Operculina* because of its rapidly widening spiral, in vertical section one notices that the successive whorls are so tightly packed that there is no room left for the lumina of the alar prolongations of the chambers. Because the spiral sheet is involute, the species is placed in the genus *Operculinoides*.

The Oligo-Miocene species

Over the years 1957 to 1966, Cole has devoted a great deal of detailed work trying to establish the natural relationship between the different species of *Operculinoides* in the American Oligocene and Miocene, especially in connection with the stratigraphic level at which they occur. But the variability of all their features and the abundance of transitional forms proved so confusing that in the end he came to the conclusion that there were only two valid all-embracing species: *Operculinoides* (*Camerina*) *panamensis* for the Oligocene (including *Operculinoides dia, bullbrooki, semmesi* and *semmesi ciperensis*, to mention only the species that are of interest for Trinidad), and *Operculinoides (Camerina) cojimarensis* (with as synonyms *tuxpamensis* and *tamanensis*) for the Miocene.

Unfortunately, the original descriptions and illustrations of the key species under discussion (*dia, panamensis* and *cojimarensis*) are all unsatisfactory. Cole, therefore, published new photographs of topotype material of the three. For *O. panamensis* we can turn to Vaughan & Cole (1941, pl. 10:12–13; pl. 11:1–4) and Cole (1964b, pl. 14:2, 6, 9–10, 14); topotypes of *O. dia* were figured in 1961 (1961b, pl. 8:4–5; pl. 17:4, 11) and in 1964 (1964b, pl. 14:1, 5, 11) and of *O. cojimarensis* in 1958 (1958b, pl. 29:5; 1958c, pl. 34:7). That way, Cole's trend of thought is easily followed.

However, it remains a fact that in a paleontologic study a certain degree of subjectivity cannot always be avoided and this leads to a difference of opinion. For instance Cole (1964) supports his lumping of *Operculinoides panamensis, O. dia* and *O. bullbrooki* with a series of illustrations of topotypes, claiming that there are no important differences between them, but the present writer, being less statistically minded and admittedly perhaps less objective, does not find it difficult to pick out *O. bullbrooki* from the lot for its visual aspect alone, and also the other two look to her different from each other.

Cole's subdivision between Oligocene and Miocene forms is thrown off balance by the more recent observations that the Morne Diablo limestone, which contains *O. bullbrooki* and *O. semmesi*, is not Oligocene but Early Miocene in age according to its planktic fauna. As far as *O. bullbrooki* is concerned, this is of no consequence as this form should anyway be placed in the group of *O. cojimarensis* instead of *O. panamensis*, but *O. semmesi* cannot be considered as typical of the Oligocene.

Taking all this into consideration, the present author prefers to fall back on the old names used by Vaughan & Cole (1941) for the Trinidad species *Operculinoides semmesi, semmesi ciperensis, bullbrooki, tuxpamensis*, and *tamanensis*, to which we should perhaps add *cojimarensis*. *O. bullbrooki, tuxpamensis* and *tamanensis*, each have in turn played a dominant role in the Trinidad Miocene. Maybe typical *O. cojimarensis* does not occur in Trinidad, but it is here included in the discussion for comparison.

Operculinoides semmesi VAUGHAN & COLE
Pl. 5:14; Pl. 10:5–6

1936 *Operculinoides semmesi*, Vaughan & Cole, p. 491, pl. 37:10–13, 14?; pl. 38:1–2, 5?, 6?.
1941 *Operculinoides semmesi*, Vaughan & Cole, p. 50, pl. 14:5–9; pl. 15:1–2, 9.

The species was first described by Vaughan & Cole from the Oligocene Meson Formation of Mexico which later was placed by Barker & Blow (1976) into the Early Miocene.

There seems to be no difference between the Oligocene and the Miocene specimens of Trinidad, but judging from the figures given in Vaughan & Cole's table (1941), those from Morne Diablo (K. 2907) have a longer spiral than the Mexican types and are, accordingly, slightly larger and have more chambers in the last whorl.

It is sometimes difficult to distinguish the *Operculinoides semmesi* in the Morne Diablo material at first sight from small specimens of the more common *O. bullbrooki*, but in both horizontal and vertical section the two forms are clearly different. *O. semmesi* is more closely related to the Eocene *O. trinitatensis*, the only difference being that the test of *O. semmesi* is slightly flattened in the axial area, whereas *O. trinitatensis* has a central boss. Like in *O. trinitatensis* the characteristics of *O. semmesi* are difficult to define and the form can therefore not be used as a reliable index fossil.
Occurrence: Mejias Quarry, Erin Point, Taparo Point, Morne Diablo Quarry.

Operculinoides semmesi ciperensis VAUGHAN & COLE
Pl. 5:10; Pl. 10:7–9

1941 *Operculinoides semmesi* var. *ciperensis*, Vaughan & Cole, p. 51, 53, pl. 15:3–8

This form, which in horizontal section is practically indistinguishable from *Operculinoides semmesi* and *O. trinitatensis*, is somewhat flatter and has a more protracted margin than either of them. There is a wide range of variation in the external features within the same population, e.g. that from the Cipero coast, but as a whole, such a population is different from an Eocene assemblage.
Occurrence: Cipero coast (floods), Mejias Quarry (common), Kapur Quarry (few, chiefly in sample Lz. 3475).

Operculinoides bullbrooki VAUGHAN & COLE
Pl. 5:12,15; Pl. 10:13–14

1941 *Operculinoides bullbrooki*, Vaughan & Cole, p. 44, pl. 11:6–7; pl. 12:4–5.

This is the common species of *Operculinoides* in the Early Miocene Morne Diablo limestone Quarry, present in nearly all of the more calcareous beds, often in floods. Externally, it is not very different from *O. semmesi* from the Early Oligocene of the Cipero coast but it is flatter and the last whorl tends to flare out in a broad round-edged margin.

Operculinoides cojimarensis (PALMER)
Pl. 10:10–12

1934 *Operculinella cojimarensis*, Palmer, p. 259–260, pl. 15:1, 3–4, textfig. 18.

Amongst the common megalospheric specimens of *Operculinoides bullbrooki* in the Early Miocene Morne Diablo Quarry occur small B-forms that do not seem to belong to this species but rather to *O. cojimarensis*.

The specimens are only 1.5 to 2.1 mm in diameter. In part they are juvenile forms and for the rest fragments of larger pieces. They are very flat and smooth and the axis is marked by a small prominent tubercle. The smaller ones are so transparent that the inner coils are clearly visible through the walls, but they are completely involute as the hairlines of the septal filaments can be traced right to the center. The spiral is very high and opens rapidly; it consists of a great many chambers, the septa of which are strongly and evenly curved backwards. The vertical section is compact and distinctly diamond-shaped. Occurrence: Morne Diablo Quarry.

Operculinoides tuxpamensis (THALMANN)
Pl. 6:1; Pl. 11:1,3–4

1935 *Operculina tuxpamensis*, Thalmann, p. 603, textfig. a–b.
1941 *Operculinoides tuxpamensis*, Vaughan & Cole, p. 45–46, pl. 14:1–4.

Operculinoides tuxpamensis, first described from the Early Miocene Tuxpan Formation of Mexico, is a medium large, smooth, very thin form with a rather high spiral and close-set evenly curved septa. Barker (1939) and Vaughan & Cole (1941) later determined the abundant *Operculinoides* specimens of the Biche Quarry in Trinidad as belonging to this species.

Thalmann stated that some of the largest individuals in his material were microspheric. In Biche, however, even the large ones are megalospheric, but with a very small nucleoconch. The protoconch measures 70–128 μ.

Occurrence: Biche Village Quarry (Middle Miocene, together with *Planorbulinella trinitatensis*).

Operculinoides tamanensis VAUGHAN & COLE
Pl. 6:2; Pl. 11:2,5–7

1941 *Operculinoides tamanensis*, Vaughan & Cole, p. 43, pl. 10:9–10; pl. 11:8–10; pl. 12:1–3.

Operculinoides tamanensis is a fairly large form (up to 6.3x5.6 mm) with a somewhat inflated test and a conspicuous central knob. In vertical section it proves to be thin-walled, with spacious well-developed alar prolongations of the chambers (compare *O. tuxpamensis* and *O. cojimarensis*).

Occurrence: Tamana-Carmichael Road, Guaico-Tamana Road at 13 1/2, 13 5/8, and 13 1/4 miles from Guaico (with *Planorbulinella trinitatensis*).

Genus *Nummulites* LAMARCK

Nummulites striatoreticulatus (L. RUTTEN)
Pl. 5:13; Pl. 10:2

1928 *Nummulites striatoreticulatus*, L. Rutten, p. 8–10, pl.:F–I (not J), textfig. 41–50.
1941 *Camerina striatoreticulata*, Vaughan & Cole, p. 31, pl. 8:5–7.

Amongst the Trinidad Nummulitidae, this robustly inflated form stands out for its notable size (up to 6 mm) and the larger number of whorls in its spiral.

Occurrence: Point Bontour (St. 63), Vistabella Quarry (rare), Morne Roche Quarry.

Genus *Heterostegina* D'ORBIGNY

Heterostegina indicata CAUDRI, n. sp.

Pl. 1:9–10

Exterior: Large flat *Operculina*-like form with a rapidly opening coil and a very thin flange; maximal diameter exceeding 15 mm, thickness not over 1 mm; septal filaments continuing right up to the center, beaded; no trace of secondary chamberlets visible on the surface.

Horizontal section: Rapidly increasing spiral of about 2.5 to 3 whorls; rather heavy keel; primary septa numerous, evenly curved in the beginning, later becoming straighter and more or less radial but strongly bent backwards distally; nucleoconch megalospheric, followed by about five operculine chambers, from there on a secondary sub-division of the chambers is indicated along the primary septa. The secondary septa are very incompletely developed or are absent.

Vertical section: Test very flat but central portion definitely involute though too compact to leave room for alar prolongations of the chambers; flange with very low lumen; intersections with the septa protruding (beaded).

Holotype: Pl. 1:10 (C 35965).

Type locality: Morne Roche Quarry, K.S. 167.

Type level: Basal Upper Eocene (Mount Moriah sandstone level).

Occurrence: Known only from incidental sections of hard rock. It is common in one of the limestone samples from Morne Roche quarry, but as good as absent in all others from the same locality.

This species is one of the transition forms between the morphological genera *Operculina* and *Heterostegina* that have made their appearance from time to time during their long history. It compares with *Heterostegina heterostegina* (Silvestri) from the Helvetian of Turin, the Early Miocene of the Aquitanian Basin and from the Priabonian and the Early Oligocene of Alicante, or with *Operculina canalifera gomezi* from the Biarritzian of Catalonia (Hottinger 1972), and with the microspheric generation of *Heterostegina operculinoides*, a living form in the eastern part of Indonesia, of which the megalospheric generation has fully developed secondary chamberlets (Hofker 1927, 1933). Both authors refer also to the group of *Heterostegina costata* of the Vienna Basin (Miocene) which shows a similar transition between the two genera.

All these transitional forms developed independently along parallel lines. There is no genetic or stratigraphic relation between them. True *Heterostegina* is reported from the Paleocene up (*Planorotalites pseudomenardii* Zone) from Somalia (Eames & Clarke 1967) and from the Middle Eocene of Cuba (Beckmann 1959).

Genus *Spiroclypeus* H. DOUVILLÉ

Spiroclypeus bullbrooki VAUGHAN & COLE

Pl. 8:7

1917 *Spiroclypeus* sp. Douvillé, p. 845–847.
1941 *Spiroclypeus bullbrooki* Vaughan & Cole, p. 54, pl. 17.

In Trinidad *Spiroclypeus* occurs in considerable numbers in three erratic limestone blocks near the South coast (Douvillé 1917; Vaughan & Cole 1941), and was described as *Spiroclypeus bullbrooki*. It is associated with *Lepidocyclina parvula-giraudi, yurnagunensis* (or *vaughani*), *tempanii, sanluisensis* and *gigas*, *Miogypsina hawkinsi* and *Heterostegina antillea*, which points to an Oligocene age. As in Venezuela, the genus is absent in the Early Oligocene of the Cipero section and in the limestones of the Mejias Quarry and the Kapur Ridge, here placed in the Middle Oligocene. For this reason, and also for the presence of *Miogypsina hawkinsi* in the fauna, which shows the close relation to the Miocene reef of Morne Diablo, the *Spiroclypeus* horizon in Trinidad is here regarded as Late Oligocene.

Occurrence: Erin Point (common, z. 2), Marac River (K. 482, later re-numbered K. 911), Chagonary Point (J.A.B. 27).

Group Discocycliniformes

Classification

In the present study, Vaughan & Cole's (1941) subdivision of the Family Discocyclinidae is replaced by the new classification proposed by Caudri (1972a).

This revision was necessary because both Vaughan (1945) and Caudri observed that many of the American forms usually determined as *Discocyclina (Discocyclina)* sp. sp. possess in the microspheric generation a simple, sometimes clearly trochoid, initial spiral, fundamentally different from the complicated, more nummulitic or heterosteginoid development of true Discocyclinas of the Old World. To these forms Caudri has given the new generic name *Neodiscocyclina* removed from the Discocyclinidae to the new family Orbitoclypeidae, together with *Orbitoclypeus* and *Asterocyclina*. As far as known, all Discocyclinas of Trinidad may belong to this new genus. It is not impossible that all American species will eventually prove to be of the same type, and that the genus *Discocyclina* s. s. is absent in the Americas.

This does not mean that the entire family of the Discocyclinidae is lacking in the New World. Work on the microspheric forms of the other genera and subgenera of Vaughan & Cole's classification is only just beginning, but a complicated discocyclinid spiral has already been observed in the B-form of several species of *Proporocyclina* and *Athecocyclina* from the West Indies and Florida.

On the other hand, *Pseudophragmina* s. s., at least the species *P. bainbridgensis* (Vaughan), seems to have a simple spiral and is tentatively transferred to the Orbitoclypeidae.

As a new element, the Hexagonocyclinas are included in the group of the Discocycliniformes. Their characteristic megalospheric nepiont with its four periembryonic spirals may represent a primitive stage in the evolution of the Orbitoclypeidae, but it may also be that they belong to a third independent family. Nothing is as yet known about their microspheric form.

The following tentative classification is proposed for the American forms:

Group Discocycliniformes (term of no systematic value); Family Discocyclinidae, genus *Athecocyclina*, genus *Proporocyclina*; Family Orbitoclypeidae, ?genus *Hexagonocyclina*, genus *Neodiscocyclina*, ?genus *Stenocyclina*, genus *Pseudophragmina* s. s., genus *Asterocyclina*.

Geographic distribution

For the geographic distribution of the American Discocycliniformes reference is made to Vaughan's (1945) extensive review to which little is to be added.

The southern limits for these forms lie in N.W. Peru (*Neodiscocyclina, Proporocyclina*). Along the northern margin of their habitat the limit for *Discocyclina* s. s. (presumably *Neodiscocyclina*) is set in the Gulf States and California. Only four species have so far been found there: *Discocyclina waltonensis* Cole & Applin (1964) in the Wilcox Formation (Early Eocene) of Florida, *Discocyclina marginata* Cole & Gravell (1952) (?*Orthophragmina marginata* Cushman) in the Middle Eocene of Georgia (Cole & Applin 1964), *Discocyclina blanpiedi* Vaughan 1936 (*Proporocyclina*) in the upper part of the Paleocene Nanafalia Formation of Alabama and *Discocyclina californica* Schenck 1929 in the ? Late Eocene of California. The genus *Proporocyclina* with *Proporocyclina clarki* (Cushman) goes North as far as California, Oregon and Washington (Vaughan 1945, Cole & Appin 1964). Peru is mentioned as the southern limit of this species (Cole & Applin); this refers to *Proprocyclina peruviana* (Cushman), which Cole (1958d) had placed in synonymy of *Proporocyclina clarki.*

Stratigraphic range

In Trinidad, the genera *Athecocyclina, Hexagonocyclina* and *Neodiscocyclina* make their appearance in the Paleocene beds at Lizard Springs, in the southeastern corner of the Island and in equivalent deposits on Soldado Rock, the *Ranikothalia* limestone and its practically contemporaneous reefal counterpart, the *Athecocyclina* limestone (Kugler & Caudri 1975), of which only remnants are found in southern Trinidad. Their upper limit is more difficult to establish. Reworking has dispersed them throughout the Eocene section; often the specimens are enclosed in obviously erratic material, but just as often they are mixed with the autochthonous fauna of these younger beds without a hint at their unreliable nature. Trinidad does not offer a continuous section for the interval between the Paleocene and the Late Eocene transgression, as far as the reef facies is concerned. *Athecocyclina* and *Hexagonocyclina* are typical for the *Ranikothalia* Zone (Paleocene–early Early Eocene). In Trinidad, and generally in the southern Caribbean region, *Neodiscocyclina* does not go beyond the early Middle Eocene.

Athecocyclina

The only cases in which, to our knowledge, *Athecocyclina* is mentioned from beds younger than early Early Eocene are those of *Athecocyclina* cf. *soldadensis* in the upper part of the Early Eocene of Venezuela (beds of San Francisco de Cara, de Cizancourt 1951) and of *Athecocyclina jukes-browni* in the Middle Eocene Chalky Mount beds of Barbados (Vaughan 1945).

At present, the evidence is insufficient to prove that *Athecocyclina* exceeds the range of *Ranikothalia.*

Proporocyclina

The oldest *Proporocyclina* is found in the so-called *Proporocyclina tobleri* limestone (Bed No. 11 of the Soldado Rock section) which is basal Middle Eocene or highest Early Eocene. Various other species are known from the Middle as well as the Late Eocene.

Stenocyclina

This genus was introduced to unite those Proporocyclinas which distinguish themselves by having very narrow rings of equatorial chambers (*advena, cloptoni, palenquenensis, perkensis*, etc.). Most of them occur in the Middle Eocene, but they are also known from the Late Eocene. One single specimen was found in the type material of the Lizard Springs Formation (Paleocene).

Pseudophragmina s. s.

Pseudophragmina s. s. is typical of the Late Eocene (Vaughan 1945; Frost & Langenheim 1974). Also in Trinidad the single specimen came from a Late Eocene sample (Point Bontour, St. 46).

Hexagonocyclina

The genotype of *Hexagonocyclina, Discocyclina cristensis* (Vaughan), comes from the uppermost Paleocene at the base of the Early Eocene of Mexico, Veracruz, Chicontepec Formation (Vaughan 1945). The genus has further been found around the Caribbean in beds of comparable age: Cuba: Type locality of *Ranikothalia bermudezi*; Venezuela: Rio Carache section, San Juan de los Morros area; Trinidad: Lizard Springs, Soldado Rock; Barbados: Joes River blocks. It is regarded as a typical element of the *Ranikothalia* Zone. Its frequent occurrence in the Late Eocene of Trinidad is ascribed to reworking.

This restricted range of the Hexagonocyclinas is contradicted by de Cizancourt (1951) who, in her distribution chart, lists *Hexagonocyclina inflata* as an abundant fossil in the upper part of the Early Eocene of Venezuela (the beds of San Francisco de Cara and the La Paz limestone). Reworking seems to be out of question in this case but, nevertheless, this extension of the vertical range can not be readily accepted. It is already strange that the species does not figure in the column for the early Early Eocene (though it is reported from both Parapara de Ortiz and Paso Lalaha), and then suddenly re-appears in the late part. Checking back on the faunal lists of the various samples, the localities of the individual species and the summary of the fauna (from which *Hexagonocyclina inflata* is omitted) leaves the impression that the author continuously hesitated in her determinations between *Hexagonocyclina inflata* and a similar form called *Discocyclina cristensis*. This is understandable considering the kind of hard rock material she had to deal with. It seems highly probable that the common form in these younger beds is not *Hexagonocyclina inflata* but exclusively *Discocyclina cristensis*.

The question whether the genus *Hexagonocyclina* as such reaches up into the upper apart of the Early Eocene hinges on the systematic place of this Venezuelan *Discocyclina cristensis*. As stated above, the typical *Discocyclina cristensis* (Vaughan) (genotype of *Hexagonocyclina*) occurs, in limited numbers, in the Paleocene or at the very base of the Early Eocene, whereas the Venezuelan form is characteristic for the upper part of the Early Eocene, with a sprinkling of rare specimens as low down as the lower part, and is absent in the Paleocene. This difference in the stratigraphic distribution already sounds a warning against identifying the latter with *Discocyclina cristensis* (Vaughan). De Cizancourt's specific determination was based exclusively on the external appearance and the hexagonal shape of the equatorial chambers but no attention was paid to the crucial point whether or not the nepiont is of the quadriserial type. The illustration is equally inadequate. The present author rather suspects that the form is a species of *Neodiscocyclina*, the equatorial chambers are considerably less elongated than those up to now observed in the true Hexagonocyclinas.

There is no convincing evidence for the occurrence of the genus *Hexagonocyclina* beyond the *Ranikothalia* Zone. An extended study of the Venezuelan material is necessary.

Neodiscocyclina

The genus *Neodiscocyclina* is not restricted to the Paleocene–early Early Eocene. Its type species *Neodiscocyclina anconensis* (Barker) is characteristic of the early Middle Eocene in Ecuador and Barbados and also the other Discocyclinas s. s. from this same level. *Discocyclina harrisoni* Vaughan from Barbados and the identical form from Cuba which was determined by Cole & Gravell (1952) as *Discocyclina marginata* will probably turn out to belong to the same genus. Certain related forms may even go up into the Late Eocene (see below).

Confusing data on the occurrence of nearly all the species of *Neodiscocyclina* have led to the notion that some of them have a long vertical range, across all the hurdles of regression and transgression in the course of the Paleocene and Eocene. This problem is at length discussed in Caudri's paper on Barbados (1972b); the best explanation of such abnormal ranges is reworking. Most probably the individual species have a neatly restricted vertical range and are diagnostic for their type level.

In Trinidad, *Neodiscocyclina* makes its appearance in the Paleocene (Lizard Springs, Soldado Rock). Its highest autochthonous occurrence here is in the Charuma silt member of the Navet Formation (early Middle Eocene: *Neodiscocyclina anconensis*). In the higher part of the Middle Eocene (Dunmore Hill marl member) and in the Late Eocene, the genus is considered reworked.

Vaughan (1945) states that the greatest development of the Discocyclinidae in America is in the Late Eocene. This includes *Asterocyclina* and *Proporocyclina*. He also mentions six species of *Discocyclina (Discocyclina)* as typical of that part of the section: *D. bullbrooki* Vaughan & Cole (Trinidad, Soldado Rock), *D. californica* Schenck (California), *D. crassa* (Cushman) (Cuba, Haiti), *D. cubensis* (Cushman) (Cuba, Haiti; ?Trinidad, ?Soldado Rock), *D. minima* (Cushman) (Trinidad). Of these *D. bullbrooki* should be eleminated because it is reworked in the typical Late Eocene of Trinidad and Soldado Rock. As far as *D. minima* is concerned, Vaughan himself admits that it is an imperfectly known species (Cole transferred it in 1952 to *Asterocyclina*). A presence of *D. cubensis* in the Late Eocene of Trinidad and Soldado Rock can not be confirmed.

This reduces the number of alleged Late Eocene species to two: *Discocyclina crassa* (Cushman) and *D. californica* Schenck, both considered by Vaughan as closely related to *Neodiscocyclina anconensis*. If this is correct, they, too, should be placed in *Neodiscocyclina*. In both, the protoconch is as a rule entirely surrounded by a circular deuteroconch, but a partially embracing second chamber has also been observed. The type description of *D. californica* leaves much to be desired and unfortunately Vaughan does not re-describe or figure this species which, from a stratigraphic viewpoint, is of such particular interest. *D. crassa*, as figured by him, seems to develop very narrow elongated equatorial chambers with a tendency towards alignment of the radial walls in the successive annuli, a feature which may be of specific significance. Careful additional study is necessary for the characteristics of both species, as also of the exact stratigraphic position of their type localities. Vaughan places *D. crassa* tentatively in the early Late Eocene.

There are, however, also arguments for a Middle Eocene age of these species. Cole & Gravell (1952) combine *Discocyclina crassa, Discocyclina californica* and *Proporocyclina marginata* (= *Orthophragmina marginata* Cushman from St. Bartholomew) (Vaughan 1945) with their *Discocyclina (Discocyclina) marginata* from the early Middle Eocene of Cuba (Peñon Seep), which undoubtedly is very similar in many respects, including the gradual change from alternating to aligned chambers towards the periphery. The same peculiarity was also observed in *Discocyclina harrisoni* Vaughan from the Middle Eocene of Barbados (Caudri 1972b). The localities of *Discocyclina crassa, D. californica* and *Orthophragmina marginata* may, after all, well prove to belong to the Middle Eocene (Cole & Applin 1964), but until the age has been firmly established there remains a possibility that *D. crassa* and *D. californica* (or their synonyms) really continue, as the final stage in the evolution of the Neodiscocyclinas, into the Late Eocene along the northern margin of their geographic province.

As to the southern part of their habitat (northern South America, southern Caribbean, and especially Trinidad), there is more and more evidence that the frequent occurrence of *Discocyclina (Neodiscocyclina)* sp. sp. in the Late Eocene is always due to reworking.

Asterocyclina

The stratigraphic range of the American Asterocyclinas still needs further study. The upper limit is clear, their extinction marks the end of the Late Eocene. About the base there is less agreement. Mostly, the lower limit is given as Middle Eocene (Vaughan 1945). According to Cole & Applin (1964) the firt species (*Asterocyclina monticellensis*) in the Middle Eocene of Florida and southern Georgia does not appear before their third zone, the Upper Lake City Formation, above the zone of *Lepidocyclina (Polylepidina) antillea*; but they admit that in Jamaica and St. Bartholomew the species occurs in association with *Lepidocyclina antillea*. Also, the locality where *A. monticellensis* was found in Cuba (the Peñon Seep) is Middle Eocene (*Hantkenina nuttalli* Zone), there the species is accompanied by *Amphistegina parvula, Eoconuloides wellsi* and *Helicostegina gyralis*. The same goes for Margarita Island, where the species occurs in combination with *Lepidocyclina antillea* and *Amphistegina parvula* (Caudri 1974).

In Coastal Ecuador, *Asterocyclina* occurs consistently in the remnants of the San Eduardo reef limestone, which lies unconformably on basemennt rocks and represents a very low level of the Middle Eocene (Stainforth 1948).

These data would lead to the conclusion that the origin of the American Asterocyclinas coincides with the beginning of the Middle Eocene. However, on the strength of observations in Jamaica, Robinson believes that they begin lower in the section. In 1968a he reports *Asterocyclina* sp. from the Wagwater Belt Group, from a level between the *Operculina catenula* fauna of Cole and the *Acarinina pentacamerata* Zone, a horizon which he places in the Early Eocene, in spite of the fact that it already carries *Amphistegina (Eoconuloides) lopeztrigoi* and *Yaberinella jamaicensis*.

For Cuba, the occurrence of *Asterocyclina* in the Early Eocene is firmly stated by Beckmann (1958), the possibility is even mentioned that it starts already in the Late Paleocene.

In Trinidad sporadic Asterocyclinas were encountered in the Middle Eocene Dunmore Hill marl, but their full development, often in floods, lies in the Late Eocene.

Description of species

Family Discocyclinidae

Genus *Athecocyclina* Vaughan & Cole

Athecocyclina soldadensis (Vaughan & Cole)

1941	*Pseudophragmina (Athecocyclina) soldadensis*, Vaughan & Cole, p. 62, pl. 19:4–8.
1975	*Athecocyclina soldadensis*, Caudri, p 545, pl. 11:1–5; pl. 12:1.

This thinnest of Athecocyclinas is very rare in Trinidad.

Occurrence: Soldado Rock (*Athecocyclina* limestone and Beds 3, 4), Lizard Springs type locality (Mky. 102b III), Hermitage Quarry (Paleocene blocks in Plaisance conglomerate).

Genus *Proporocyclina* Vaughan & Cole

Proporocyclina tobleri (Vaughan & Cole)

1941	*Pseudophragmina (Proporocyclina) tobleri*, Vaughan & Cole, p. 62, pl. 21:6; pl. 22:3–4.
1975	*Proporocyclina tobleri*, Caudri, p. 547, pl. 1:13–14; pl. 3:5–6; pl. 12:2–5; pl. 13:1–4, 7.

Proporocyclina tobleri is characterized by its narrow rings and square to very broad equatorial chambers with thin wavering, often incomplete radial walls; in vertical section the lateral chambers show up as narrow slits. The species is the predominant element in the fauna of the Boca de Serpiente Formation of Soldado Rock (Bed 11, *Proporocyclina tobleri* limestone). Its age is uppermost early or basal Middle Eocene, probably Middle Eocene (Caudri 1975).

Occurrence: Lizard Springs area (Mky. 99, block), Erin (G. 65B, Br. 67, blocks), Dunmore Hill (type locality, Ha. 215), Hindustan Village (Middle Eocene, reworked), Point Bontour and Vistabella area (Late Eocene, reworked), Soldado Rock (Bed 11, and reworked in the Late Eocene).

Proporocyclina mirandana (HODSON)

1926 *Discocyclina mirandana*, Hodson, p. 8, pl. 1:3, pl. 10:13.
1941 *Pseudophragmina (Proporocyclina) flintensis*, Vaughan & Cole, p. 10, 20, 27, 61, pl. 20:8–9.
1975 *Proporocyclina mirandana*, Caudri, p. 549, pl. 13:5–6.

Megalospheric specimens occur regularly in the Late Eocene, but never in great numbers. From Soldado Rock (Caudri 1972a, 1975) we had one microspheric specimen with the complicated initial pattern typical for the family Discocyclinidae.

Family Orbitoclypeidae

Genus *Hexagonocyclina* CAUDRI (tentatively placed in this family)

1944 *Hexagonocylina*, Caudri, p. 362.
1975 *Hexagonocyclina*, Caudri, p. 543.

The genus *Hexagonocyclina* was erected 1944 for a group of *Discocyclina*-like forms from the Paleocene of Trinidad and Venezuela, which are distinguished by a quadriserial nepionic development and a strong tendency towards a hexagonal rather than rectangular shape of the equatorial chambers.

The validity of the genus has been questioned ever since, chiefly for nomenclatural reasons but also because of the dubious diagnosis of its genotype *Orbitoclypeus*? *cristensis* Vaughan 1929b, pl. 2:1 (lectotype). The following discussion may help towards its final recognition.

The Venezuelan material of *Hexagonocyclina meandrica*, described 1944, was unsatisfactory as type material for a new genus. For that reason, a Mexican form, *Discocyclina cristensis* Vaughan, which showed the same characteristics was designated as the genotype. The choice of the name *Hexagonocyclina* was an unfortunate one. Not only is it nearly a homonym of *Exagonocyclina* Checchia-Rispoli, which stands for a similar, though different, form from the Eocene of Sicily, but *Exagonocyclina* is, in an oblique way, involved in the synonymy of *Discocyclina cristensis*. To make matters worse, several authors, amongst whom in first place Vaughan himself, stuck to the view that *D. cristensis* is a true *Discocyclina* s. s. and placed *Hexagonocyclina* into the synonymy with *Discocyclina*. In an effort to remedy this confusion, a new genus: *Bontourina* Caudri (genotype: *B. inflata* Caudri) was introduced in 1948 to cover the forms from Trinidad and Venezuela only, leaving out the controversial *Discocyclina cristensis*. This was, however, not a satisfactory solution. After due consideration, *Hexagonocyclina* proves to be valid after all, and *Bontourina* is to be repressed as a synonym. The nomenclatural complications can be summed up as follows:

Originally, Vaughan determined the holotype of *Discocyclina cristensis* as *Orbitoclypeus? cristensis* (1924b). *Orbitoclypeus* is a badly defined genus from the Late Eocene of

Palermo, Sicily, proposed by Silvestri in 1907. Its type species *Orbitoclypeus himerensis* is described as a *Discocyclina*-like organism with hexagonal equatorial chambers, but no illustrations were given. Later, Silvestri published a figure of another species of the same genus, *Orbitoclypeus tellini* (1924, pl. 1:14). It is because of the similarity in form of the median chambers of *Orbitoclypeus tellini* and *Discocyclina cristensis* that Vaughan originally referred the latter to the genus *Orbitoclypeus*.

Similar forms from the same area (Palermo) were better described by Checchia-Rispoli (1907–1909) as a subgenus of *Orbitoides*, under the name of *Exagonocyclina*. Silvestri (1910) placed this subgenus in synonymy with *Orbitoclypeus*. A thorough discussion of this subject, citing all the pertinent literature, is given in Brönnimann (1945a) on *Discocyclina* and *Asterocyclina*.

In the original diagnosis of *Exagonocyclina*, the thin-walled hexagonal chambers are mentioned as the characteristic feature, but nothing of value is said about the embryonic apparatus. However, for one of the species, *Orbitoides schopeni*, the nucleoconch is well illustrated and is described as consisting of a loose protoconch enclosed in a much larger circular deuteroconch, which in turn is surrounded by a complete ring of equal-sized equatorial chambers. This same feature was also reported from *Orbitoclypeus himerensis* (= *Orbitoides schopeni*) by Brönnimann (1945a).

From the above it becomes clear that the genus *Exagonocyclina (Orbitoclypeus)* is not identical with the Hexagonocyclinas of the Western Hemisphere with their quadriserial nepiont.

As to the question of its genotype: Vaughan (1945) admits that one species of *Hexagonocyclina (Hexagonocyclina meandrica* from Venezuela and Trinidad) may represent a different subgenus of *Discocyclina*, but he insists that the genotype, *Discocyclina cristensis*, is a true *Discocyclina* s. s. and consequently *Hexagonocyclina* a synonym of *Discocyclina*. His arguments remain, however, unconvincing because the characteristic quadriserial nepiont is not taken into consideration.

The holotype of *Discocyclina cristensis* (Vaughan 1924b, pl. 36:8) is of little value for the generic determination as the section does not pass through the center of the early chambers.

In 1929b Vaughan repeated that description verbatim, in spite of the fact that by then he had a much better specimen at disposal (pl. 2:1), which he himself designated as a plesiotype, but never really analysed.

In fact, this latter illustration is, so far, the only good representative picture of *Discocyclina cristensis* in existence. The photograph shows a quadriserial nepiont such as has never been found in *Discocyclina* s. s., and it is this specimen which was chosen by Caudri as a sort of co-genotype of *Hexagonocyclina*.

In 1945, Vaughan goes into great detail describing two other topotypes, unfortunately without giving illustrations. One of these (a badly oriented section) seems to have an enlarged auxiliar chamber, which is certainly not typical for *Discocyclina*; the other one may be a true *Discocyclina* or rather a *Neodiscocyclina*. But even if additional topotype material should prove to contain specimens of *Neodiscocyclina*, this plesiotype of 1929 continues to be a type specimen of *Discocyclina cristensis* Vaughan and for its quadriserial nepiont it has to be recognized as a *Hexagonocyclina*. Systematically, as well as from a standpoint of nomenclature, *Hexagonocyclina* thus remains a valid genus.

Subsequent records of *Discocyclina cristensis* are not quite convincing, but it is probable that most of them will turn out to refer to *Hexagonocyclina*. Vaughan's figure of a specimen form Chalma (Veracruz, Mexico; 1945, pl. 25:1) suggests the presence of at least one well-developed large auxiliar chamber straddling the division between proto- and deuteroconch and two of the four nepiontic spirals. Specimens from Yucatán (Butterlin & Bonet 1960) leave no doubt as to their hexagonoycline nepiont.

Sachs (1957) does not pay any attention to the early development of his *Discocyclina cristensis* from Cuba, but his material also looks more like *Hexagonocyclina* than a true *Discocyclina*.

De Cizancourt's *Discocyclina cristensis* from Venezuela (1951) is probably an entirely different species; the horizontal section shows predominantly rectangular median chambers, very broad in the central part and quite unlike those of *Discocyclina cristensis* or *Hexagonocyclina* as determined elsewhere.

The material of *Hexagonocyclina cristensis* from all the different localities should be carefully compared with *Hexagonocyclina inflata* and *meandrica* to check the validity of these three forms as separate species.

The systematic place of *Hexagonocyclina* within the Discocycliniformes is still open. Judging by its megalospheric nepiont, it is not directly related to the Discocyclinidae and might rather belong to the Orbitoclypeidae (Caudri 1972a). But it seems to be different from the rest of those in the position of the annular stolon. In *Hexagonocyclina meandrica*, wherever the radial walls show signs of not being fully developed, it is always the distal end that is missing or tapering out, which would suggest a distal and not a proximal stolon. The microspheric nepiont is as yet unknown.

The wide distribution of the Hexagonocyclinas throughout the Caribbean Region is already established beyond doubt (Barbados, Trinidad, Venezuela, Mexico, Cuba).

Hexagonocyclina belongs to the *Ranikothalia* fauna of Paleocene to early Early Eocene age (Cole's *Operculina catenula* fauna). De Cizancourt's record of its occurrence in the upper part of the Early Eocene in Venezuela, above her nummulites cordelées (*Ranikothalia*) is doubtful. Specimens found in younger deposits, like the Late Eocene of Trinidad, where they are quite frequent, are considered reworked.

Hexagonocyclina meandrica Caudri
Pl. 4:3; pl. 6:11; Pl. 12:9–10

1944 *Hexagonocyclina meandrica*, Caudri, p. 363, pl. 2:7, 9.
1975 *Hexagonocyclina meandrica*, Caudri, p. 543, pl. 3:1, 12; pl. 9:8–12; pl. 10:1, 3–5.

Hexagonocyclina meandrica is distinguished from *H. inflata* by the shape of the test and the pattern of the lateral chambers. Even in small specimens of *H. meandrica*, and in the inner layers of larger ones, the lateral chambers are already elongate in shape and look very different from the regular reticulate surface pattern of *H. inflata*.

Occurrence: Lizard Springs (Mky. 102b III type locality of the Lizard Springs Formation, Paleocene), Soldado Rock (K. 2950, K. 2951, Rz. 255, Paleocene, slump).

Hexagonocyclina inflata CAUDRI
Pl. 6:9; Pl. 12:3–5

1944	*Hexagonocyclina* sp., undescribed small robust lenticular species from Trinidad and Soldado Rock, Caudri, p. 365.
1948	*Bontourina inflata*, Caudri, p. 477, pl. 73:6; pl. 74:5.
1975	*Hexagonocyclina inflata*, Caudri, p. 544, pl. 3:2–4, 11, 13; pl. 9:2–7; pl. 10:2.

Occurrence: Point Bontour (Paleocene limestone blocks, St. 48), reworked in the San Fernando Formation (St. 49, 61a, 63, 67, 68, 68a, 75, 77, 84?; Cd. 18), San Fernando Hospital site (Rz. 127a, block), Soldado Rock (in redeposited Paleocene fauna of Bed 3, K. 2950, in Paleocene block, Rz. 248, and reworked in Late Eocene, K. 1321?, 2951b, 3690; Rz. 250?).

Genus *Neodiscocyclina* CAUDRI

Neodiscocyclina grimsdalei (VAUGHAN & COLE)
Pl. 12:7

1941	*Discocyclina (Discocyclina) grimsdalei*, Vaughan & Cole, p. 9, 24–25, 58, pl. 18:8–9; pl. 19:1–3; pl. 21:3.
1975	*Neodiscocyclina grimsdalei*, Caudri, p. 552, pl. 3:8; pl. 15; pl. 23:2.

The species has been extensively described and figured by Vaughan & Cole (1941), Vaughan (1945) and Caudri (1975).

Occurrence: Soldado Rock (Bed 3, K. 2950 rare, K. 2951 abundant), Lizard Springs (Mky. 102b III, one specimen in situ, Paleocene), Biche, Calyx well 50 (one doubtful specimen reworked in Middle Eocene), Dunmore Hill vicinity (reworked in Middle Eocene), Point Bontour (in Paleocene blocks abundant, as detached reworked specimens in Late Eocene), San Fernando area (various other Late Eocene localities, reworked).

Neodiscocyclina aguerreverei (CAUDRI)
Pl. 12:6

1944	*Discocyclina aguerreverei*, Caudri, p. 361, 378–379, 398, pl. 2:8, 11; pl. 3:13; pl. 4:17.
1975	*Neodiscocyclina aguerreverei*, Caudri, p. 553.

The species was described in 1944 as practically indistinguishable from *N. grimsdalei*. The main difference lies in its nucleoconch, which is nephrolepidine instead of showing the loose, floating protoconch in a circular second chamber, as is typical of the latter. It also seemed different in having two enlarged semi-crescent periembryonic chambers which symmetrically cover the protoconch.

Occurrence: Soldado Rock (Bed 3, re-deposited Paleocene, reworked in Late Eocene), Lizard Springs (Mky. 102b III, Paleocene, one doubtful specimen), Point Bontour (St. 48, Paleocene limestone block, common, reworked in Late Eocene at St. 67, St. 89, Cd. 18, several specimens), Dunmore Hill vicinity (N.E. corner of the type outcrop of the Dunmore Hill marl, and at nearby Hindustan Village (reworked in the Middle Eocene).

?*Neodiscocyclina mestieri* (VAUGHAN)

1945 *Discocyclina (Discocyclina) mestieri*, Vaughan, p. 18–19, 37, 65, 104, 112, pl. 12:1–6.
1975 ?*Neodiscocyclina mestieri*, Caudri, p. 554.

The species is probably closely related to *Neodiscocyclina grimsdalei* as it has the same kind of embryonic apparatus and shows the same degree of thickening of the annular walls of the equatorial chambers. For these reasons, *Discocyclina mestieri* is tentatively placed in the Neodiscocyclinas along with *N. grimsdalei*, though nothing is known about the microspheric form. The main difference between the two species lies in the lateral chambers: in *N. grimsdalei* the test shows a definitive depression in the center (or is at least flattened), whereas *Discocyclina mestieri* is a thick lenticular form without a hint of a depression and develops a great number of lateral layers over the center.

Occurrence: Hermitage Quarry (boulder in Plaisance conglomerate), ?Point Bontour (boulder), ?Marac Well 1 (core 7452–7458 feet), Soldado Rock (*Ranikothalia* limestone and reworked in Late Eocene).

Neodiscocyclina fonslacertensis (VAUGHAN)

Pl. 12:2; Pl. 30:5, 7

1941 *Discocyclina (Discocyclina) crassa*, Vaughan & Cole, p. 59, pl. 20:4–7.
1945 *Discocyclina (Discocyclina) fonslacertensis*, Vaughan, p. 72, 107, 112, pl. 24:3–6; pl. 26:3.
1975 *Neodiscocyclina fonslacertensis*, Caudri, p. 554, pl. 3:10; pl. 16.

Occurrence: Lizard Springs (type locality of Lizard Springs Formation, Ravine Ampelu, Mky. 102b III, in situ), Lizard Springs area (floats T.3, Z. 93b, M. 12, reworked in the Late Eocene), Charuma (A.E.G. 3635, reworked in Middle Eocene, one specimen), Soldado Rock (common A-forms and rare B-forms, reworked in Late Eocene).

Neodiscocyclina bullbrooki (VAUGHAN & COLE)

Pl. 13:9

1941 *Discocyclina (Discocyclina) bullbrooki*, Vaughan & Cole, p. 59, pl. 21:4–5; pl. 22:1–2.
1975 *Neodiscocyclina bullbrooki*, Caudri, p. 555, pl. 17; pl. 19:2, 5; pl. 23:3.

Only three A-forms and one B-form were so far found in Trinidad. The species is characterized by its very thin walled, in part hexagonal equatorial chambers arranged in wavy circles or irregular polygons, the B-forms with a very large trochoid initial spiral, the A-form with a thin walled embryonic apparatus of the nephrolepidine type (for illustrations see Caudri 1975).

Occurrence: Dunmore Hill type locality (A-form), Dunmore Hill marl at Hindustan Village (B-form), Point Bontour (Late Eocene, St. 67, 77, A-forms).

Neodiscocyclina anconensis (BARKER)

Pl. 12:8, 13, 17

1932 *Discocyclina anconensis*, Barker 1932b, p. 303–304, pl. 21:1, 4; textfig. 1.
1975 *Neodiscocyclina anconensis*, Caudri, p. 557–559, pl. 18:2–3.

Occurrence: Biche, Calyx Well 50A (Core 232–233 feet, Charuma silts, early Middle Eocene).

Neodiscocyclina barkeri (VAUGHAN & COLE)
Pl. 12:11, 16

1941 *Discocyclina (Discocyclina) barkeri*, Vaughan & Cole, p. 9, 24–25, 57, pl. 18:4, 6–7 (not 5); pl. 21:1–2.
1975 *Neodiscocyclina barkeri*, Caudri, p. 555, pl. 3:7, 9; pl. 14:1–4, 6–10; pl. 23:1.

The species has been extensively described and illustrated by Vaughan & Cole (1941) and by Vaughan (1945). Caudri (1975) stressed the shape of the main auxiliary chambers as one of the most important characteristics of the species, and drew attention to the tendency towards a polygonal arrangement of the median chambers.

Occurrence: Soldado Rock (Bed 3, redeposited Paleocene, Bed 4, isolated specimens in Late Eocene), Dunmore Hill vicinity (type locality of Dunmore Hill marl, Ha. 2119, Moruga Road junction, R.C.M. 2907, reworked in Middle Eocene), Point Bontour (reworked in several Late Eocene samples).

Neodiscocyclina caudriae (VAUGHAN)
Pl. 12:14–15

1945 *Discocyclina (Discocyclina) caudriae*, Vaughan, p. 70, pl. 23:1–4.
1975 *Neodiscocyclina caudriae*, Caudri, p. 552, pl. 14:5.

Occurrence: Lizard Springs (Mky. 102b III, Paleocene), Ramdat marl (K 4006, Early Eocene, probably reworked), ?Soldado Rock (Bed 3, K. 2950, 2951 redeposited Paleocene; Bed 4, 2951b heavily pillared variety of *Neodiscocyclina barkeri*? reworked in Late Eocene), Dunmore Hill type locality (Ha. 211 reworked in Middle Eocene).

Genus *Stenocyclina* CAUDRI

This genus was introduced by Caudri (1972a) for those Pseudophragminas that differ from all others by the exceptionally narrow rings of equatorial chambers. Vaughan (1945) distinguished them as the group of *Pseudophragmina advena*, and tentatively kept them in the subgenus *Proporocyclina*.

One doubtful sepcimen of *Stenocyclina* and a fragment were found in the type material of the Lizard Springs Formation (Mky. 102b III, Paleocene) and two tiny fragments (probably of the same species) in the Dunmore Hill marl at its type locality (Ha. 215, Middle Eocene, Pl. 12:12), either in situ or reworked. A hardly recognizable form turned up in Bed 11 of Soldado Rock (E.L. 1440, Early to Middle Eocene).

The stratigraphic range of *Stenocyclina* is not yet clear. Its main distribution seems to be in the Middle Eocene, but it also goes into the Late Eocene. The lower limit lies in the Early Eocene or even in the Paleocene.

The Trinidad material is too scanty for a specific determination. The specimen from Dunmore Hill is smooth, without pillars or granulations, the lateral chambers covering the median layer are meandric.

Genus *Pseudophragmina* DOUVILLÉ

Pseudophragmina bainbridgensis (VAUGHAN)
Pl. 27:17

1945 *Pseudophragmina (Pseudophragmina) bainbridgensis*, Vaughan, p. 86, pl. 33:1–4; pl. 34:1–3.
1974 *Pseudophragmina bainbridgensis*, Frost & Langenheim, p. 116, pl. 28:1–3.

Only one isolated specimen was found in Trinidad (Point Bontour, St. 46). In contrast with Vaughan's material which contained only megalospheric forms, this one is microspheric. Its nepionic development is of the simple spiral type, which places the genus in the family of the Orbitoclypeidae.

Genus *Asterocyclina* GÜMBEL

Stellate Discocycliniformes have been described under a number of different names. Vaughan (1924b) traced the classification back to Schlotheim, who in 1822 described a stellate microfossil as *Asteriacites patellaris*, and who as early as 1813 mentioned such forms under the name of *Asteriatites*. Both names have been rejected in 1926 by Hodson, because originally they did not refer to foraminifera. Also invalid is Schafhäutl's generic name *Asterodiscus* of 1863, which was applied to the right class of organisms but proved to be a homonym of *Asterodiscus* Ehrenberg 1839 (= *Planorbulina* d'Orbigny 1826).

In 1866 Guppy described the abundant stellate microfossils from the Trinidad Eocene under the name of *Cisseis asteriscus*. In spite of the fact that his types were lost (Nuttall 1928; Hodson 1926), there is no doubt about the identity of the form in question and at the time the genus seemed to be valid. Helen Hodson designated new cotypes and also made a thorough study of the material from Guppy's original Point Bontour locality.

The extreme variability in shape of the specimens within the Point Bontour population caused her to believe that only one of them, the usually four-rayed stellate form, represented the typical *Cisseis asterisca*; the others she described as different species. Vaughan & Cole (1941) came to the conclusion that all these varieties belonged to one and the same species (see also Caudri 1975, pl. 4). An additional description, of material from other localities in the San Fernando area, was given by Nuttall (1928), together with a comparison of *Asterocyclina asterisca* (Guppy) with *Asterodiscus asteriscus* (Kaufmann), a homonym, and *Cisseis georgiana*.

Vaughan (1928) found out that the name *Cisseis* was preoccupied and had to be replaced by *Asterocyclina*, proposed by Gümbel (1870). The genotype is *Asterocyclina stella* (d'Archiac).

In the Caribbean region, *Asterocyclina* occurs regularly from the Gulf States to the northern part of South America. Its most northerly occurrence is in California; its southern limits coastal Ecuador (Stainforth 1948) and Peru (Vaughan 1945). This is roughly the same distribution as for *Neodiscocyclina*. *Asterocyclina* first appeared in the Early Eocene (Jamica, Robinson 1968) or already in the Late Paleocene of Cuba (Beckmann 1968).

Most probably, the phylogenetic lineage of the American Asterocyclinas has sprung from some Paleocene form of *Neodiscocyclina barkeri*, which often shows a marked tendency towards a polygonal equatorial pattern. The development of *Asterocyclina* from

Neodiscocyclina may also have taken place at several levels. In the Middle Eocene Socorro Formation of Ecuador occurs a transitional form between the two genera: *Actinocyclina* cf. *asterisca* (Barker 1932b). A similar form was recorded from the Late Eocene of Cuba (M.G. Rutten 1935a). A very primitive *Asterocyclina (A. habanensis)*, which resembles the long-extinct *Neodiscocyclina barkeri*, even in the characteristic pair of wedge-shaped auxiliar chambers, occurs in the Cuban Middle Eocene (Cole & Bermudez 1932).

Asterocyclina asterisca (GUPPY)

Pl. 6:3–8; Pl. 13:2–4; Pl. 30:8

1866 *Cisseis asteriscus*, Guppy, p. 584, pl. 25:19a–b (in Hodson 1926, 11–12).
1926 *Cisseis asteriscus*, Nuttall, p. 105–107, pl. 8:8–9, testfig. 11.
1941 *Discocyclina (Asterocyclina) asterisca*, Vaughan & Cole, p. 20, 27, 60, pl. 23.
1975 *Asterocyclina asterisca*, Caudri, p. 560, pl. 4:1–12, 14–16; pl. 21:1, 3–5, 9–10; pl. 22:2, 5–6; pl. 23:4–5.

Together with *Lepidocyclina pustulosa* and *Operculinoides* sp. sp., *Asterocyclina asterisca* is one of the predominant components of the Late Eocene fauna in Trinidad. In a number of samples whole populations are found, including all shapes and ranging from minute embryos to fully grown forms of 8 mm and more; the fine residue is often flooded with specimens of less than 1 mm. The best material for a special study comes from Soldado Rock (K. 1316, 1500, 2854, 2855), from one restricted bed or pocket in the Vistabella Quarry (Cd. 218) and from the Navette area (R.M. 1337). In most other places, especially in the poorer faunas, *A. asterisca* does not attain its maximum size.

As a rule, the number of rays in *A. asterisca* is four or five. Occasionally, 6-rayed specimens are found (Point Bontour, Vistabella, Soldado Rock) and isolated specimens may have only three, or even two rays (Vistabella, Mount Moriah). In some samples 4-rayed forms are predominant, in others they are outnumbered by 5-rayed ones.

The Middle Eocene predecessor *Asterocyclina preasterisca* of Margarita Island has invariably four rays and also the calcareous sandstone member on the top of Mount Moriah, the oldest Late Eocene deposit, carries practically nothing but 4-rayed specimens.

In Douvillé's material from Point Bontour (coll. Tobler) most of the specimens have 5 rays, but in Hodson's material from the same locality 5-rayed specimens are rare. In the Vistabella Quarry 4-rayed forms predominate in most samples.

The Late Eocene Vistabella marl in the Vistabella section carries abundant *Asterocyclina asterisca*: More 4-rayed in St. 147, equal numbers in St. 45, 151, 5-rayed ones predominant in St. 148. In the overlying uppermost Late Eocene Marabella marl (St. 155, E.L. 1431c, 1434, 1435; F.S. 4622) there are only few and small Asterocyclinas, nearly all 4-rayed.

A remarkable feature of *Asterocyclina asterisca* is that the microspheric form is considerably smaller than the megalospheric one.

In the Vistabella Quarry, B-forms were observed in samples K. 2664a, 2664b, 25231 (Texaco cat. No. 48196), Cd. 15 and C.J. 28-12-29 (Texaco cat. No. 863). At Vistabella Estate (St. 147) the number of rays varies from four to six.

Asterocyclina asterisca is one of the most constantly present components of the Late Eocene fauna of Trinidad, but its abundance and individual development vary greatly from place to place, or even from sample to sample in the same locality. The species seems to have been extremely sensitive to differences in environment. In most cases, the forms remained small and unspectacular but, given optimal conditions, they were able to grow very large and develop their astonishing array of different shapes. Such assemblages occur, for instance, in Bed 9a of Soldado Rock (K. 1316, 2854 and others), at Point Bontour, in certain beds of the Vistabella Quarry and in the Navette area (R.M. 1337, bottom of pit). No explanation can be given for this explosive local development, though it is no doubt governed by environmental factors. In the Morne Roche Quarry the Asterocyclinas are particularly concentrated in the less gritty spots of the reef which also carry an abundance of algae, but the depositional circumstances in this locality seem to have been rather abnormal and mechanical segregation of the various kinds of foraminifera may certainly have come into play.

Asterocyclina asterisca is a typical Late Eocene fossil. It is present, often in floods, in the Late Eocene of Trinidad and Soldado Rock, and also in the basal beds of the Late Eocene on Mount Moriah. It continues, less numerously, into the uppermost part of the Eocene at Vistabella, the Marabella marl.

Occurrence: Late Eocene: Calcareous sandstone member, Vistabella marl and Marabella marl, Point Bontour, Hospital Hill (type locality of Hospital Hill marl), San Fernando Railway Station, Mount Moriah, Vistabella Quarry, Vistabella (Schlumberger office section), Vistabella (Calyx wells 57 and 59), Vistabella Estate (Vistabella and Marabella marls), Tarouba Estate, Morne Roche Quarry, Brighton and Vessigny wells (near Pitch Lake), Penal-Rock Road, Cortez Trace, Moruga, Erin Point, Lizard Springs area, Navette area (R.M. 1337), Charuma, Soldado Rock (Beds 4, 7, 9, 10). Middle Eocene: Hindustan-Monkey Town Road junction, type locality of the Dunmore Hill marl (R.M. 2932, very rare).

Asterocyclina rutteni VAUGHAN
Pl. 13:8

1945 *Discocyclina (Asterocyclina) rutteni*, Vaughan p. 82, pl. 30:1–5.

The specimen illustrated in fig. 8 on pl. 13, was found among the routine sections of *Asterocyclina asterisca*. Its periembryonic chambers show more affinity to Vaughan's *Asterocyclina rutteni* from the Late Eocene of Cuba (1945, pl. 30:4).

Asterocyclina vaughani (CUSHMAN)
Pl. 7:1; Pl. 13:10; Pl. 28:1

1917 *Orthophragmina vaughani*, Cushman, p. 118, pl. 43:4–5.
1941 *Discocyclina (Asterocyclina) vaughani*, Vaughan & Cole, p. 20, 27, 61, pl. 20:10.
1975 *Asterocyclina vaughani*, Caudri 1975, p. 563.

The species is characterized by its flat webbed test with 4–6 inflated radii and more or less clearly developed secondary swellings in between them. It was described by Cushman from the Ocala limestone in Georgia as a rare species, and so it is also in the Caribbean Region. Gorter & van der Vlerk found one or two specimens in material from Falcón, Venezuela, and also in Trinidad and Soldado Rock only very few isolated specimens can be referred to it.

Of the few Trinidad specimens the best one comes from Point Bontour (Pl. 13:10). It was found amongst Douvillé's type material of *Asterodiscus (Asterocyclina) asteriscus* collected by A. Tobler (Douvillé 1915). It has a diameter of 7.5 mm and shows the typical secondary swellings very clearly. A second, less pronounced form was found also at Point Bontour (St. 63).

Another very good specimen, with rounded ridges and secondary swellings, comes from Vistabella St. 148. A specimen from the Vistabella Calyx well 59 (used for a horizontal section) was flat and square, with distinct secondary bulges on its outline between the four main points.

Occurrence: Point Bontour (coll. A. Tobler, unnumbered sample, Texaco cat. No. 13572; St. 634), Vistabella (St. 148; Calyx 59, 390–400 feet).

Asterocyclina soldadensis CAUDRI
Pl. 6:14; Pl. 13:1, 5–7

1975 *Asterocyclina soldadensis*, Caudri, p. 563, pl. 4:13; pl. 21:2, 6–8; pl. 22:1, 3–4.

This form is readily distinguished from *Asterocyclina asterisca* in all its varieties by its blunt shape and the much coarser structure of its chambers. Maximal diameter 6.5 mm in the San Fernando area and on Soldado Rock, up to 8 mm in the Navette area. *Asterocyclina soldadensis* has not been found with certainty outside Trinidad, though judging from the general aspect of the horizontal section, part of Cole's material of *A. mariannensis* from Panama may refer to *A. soldadensis*. *A. soldadensis* is locally common in the Soldado section; it is scarce but consistently present in the San Fernando area, and is particularly abundant and well developed in the Navette area (R.M. 1337). Occasionally, it occurs in the uppermost Middle Eocene (one small, pillarless, but typical sepecimen in the limestone of Farallon Rock); but essentially the species is a marker for the Late Eocene (Vistabella marl).

Occurrence: Soldado Rock (Bed 7 and 9; Upper Eocene), Farallon Rock (S.L. 99, uppermost Middle Eocene), Point Bontour (Late Eocene), Vistabella Quarry (Late Eocene Vistabella marl), Vistabella Estate (Schlumberger office section, Late Eocene Vistabella marl), Vistabella (Calyx 59, Late Eocene Vistabella marl), Navette area (R.M. 1337, pit, middle and lower part, in lower part megalospheric form abundant, microspheric form scarce).

Asterocyclina cf. *barbadensis* VAUGHAN

1945 *Discocyclina (Asterocyclina) barbadensis*, Vaughan, p. 42, pl. 15:1–3.

A single specimen from the latest Middle Eocene Farallon Rock (Texaco Cat. no. 28401) is tentatively referred to this species, but it may also correspond with *Asterocyclina monticellensis* from the Punto Mosquito Formation, Margarita Island (Caudri 1975).

It is a very small, thin-walled, 5-rayed specimen, characterized by solid radial ridges on the surface, which shows particularly clearly in tangential section. In texture, it is more or less intermediate betweeen the very fine *A. asterisca* and the much coarser *A. soldadensis* in the Trinidad fauna.

Genus *Actinosiphon* VAUGHAN

Actinosiphon barbadensis (VAUGHAN)

Pl. 12:1

1944 *Lepidorbitoides* cf. *planasi*, Caudri, p. 16–17, pl. 1:3; pl. 2:10; pl. 3:14.
1945 *Lepidocyclina (Polylepidina) barbadensis*, Vaughan, p. 49–50, pl. 19:6–9 (not fig. 5).
1975 *Actinosiphon barbadensis*, Caudri, p. 542, pl. 9:1.

In Trinidad, *Actinosphon barbadensis* was not found in situ. Isolated reworked specimens occur in the Late Eocene of Soldado Rock, the San Fernando area, the Middle Eocene of Dunmore Hill and the Calyx wells in Biche.

Occurrence: Soldado Rock (K. 2951b, one rather doubtful microspheric specimen reworked in Late Eocene), Point Bontour (St. 63, reworked in Late Eocene), Dunmore Hill vicinity (type locality of Dunmore Hill marl, Ha. 215, Cd. 205, reworked in Middle Eocene), S.E. of Moruga Road junction (R.C.M. 2907, reworked in Middle Eocene), Biche, Calyx 50 and 50A (Charuma silts, early Middle Eocene, reworked habitus).

Genus *Lepidocyclina* GÜMBEL

Lepidocyclina s. l. has its roots in the Middle Eocene of the Western Hemisphere, from where it spread eastwards and soon gained worldwide distribution. In America it died out in Early Miocene and survived in the East until Early Pliocene.

From the beginning there has been a great diversification of species in *Lepidocyclina*. Efforts to place all these forms into rigid subgenera according to the shape of their nucleoconch *Polylepidina*, *Isolepidina* = *Lepidocyclina* s. s., *Pliolepidina*, *Nephrolepidina*, *Eulepidina*, etc. have failed. The best way to recognise true relationships is by comparing the chambers of the median layer, the shape and arrangements of which depends in first place on the framework of the stolons by which they are connected.

The first to use stolons in systematics were van de Geyn & van der Vlerk (1935), who created a new genus, *Orbitoina* (with subgenera *Polyorbitoina*, *Isorbitoina* and *Pliorbitoina*), for those Eocene forms which have only four stolons between chambers (as against six in the Oligo-Miocene forms). This is an oversimplification of the real state of affairs and moreover the names that are proposed are not in accordance with the International Rules of Zoological Nomenclature (Schenck & Frizzell 1936; Brönnimann 1946). But the principle is sound. The idea was followed up by Tan Sin Hok (1936a,b).

In 1959 the same criterion was taken up by Grimsdale in a more elaborate study. Grimsdale came to the conclusion that the genus was diphyletic, descending on one hand along a line (his Lineage Y) which is characterized by a system of crossed stolons (four in the proximal part of the test and six in the distal part where an annular stolon is added), and on the other hand along a second line (Lineage X) which has only four uncrossed, stolons all the way through. The stolon system of the Lineage X needs extensive study. Its principal Oligocene representative, *Lepidocyclina yurnagunensis* (Grimsdale 1959) has both annular and radial stolons in addition to the diagonal system (Vaughan & Cole 1941, pl. 38:6–7). According to Grimsdale, the Lineage Y can be traced back via *Polylepi-*

dina, Eulinderina and *Helicolepidinoides to Tremastegina*. This sequence was illustrated by Barker & Grimsdale in 1936.

The origin of Lineage X is not as clear. In each lineage the forms are grouped according to specific resemblances. No subgenera are recognized, although the author thought of re-introducing *Polylepidina* (his group of *Lepidocyclina antillea*) as a special group slightly more different from the rest. The terms polylepidine, isolepidine, nephrolepidine, pliolepidine, eulepidine, etc. are used only in the specific descriptions to indicate the shape of the nucleoconch in individual cases.

Grimsdale's paper was only an «interim review». Much detailed work lies ahead, for instance on the stolon system of the Polylepidinas. These forms are generally of the four-stolon type (Vaughan & Cole 1941) but little is known about the nature of these stolons, whether they are crossed or uncrossed. Perhaps both types are represented in them. They show some complications within the group; no straight line of descent of one species to another can be followed. *Polylepidina nitida* from the uppermost Middle Eocene of Trinidad, for instance, is as regards its nepionic stage nearly as primitive as the oldest form *Polylepidina antillea*, but in contrast with that species its lateral tissue is very advanced. Moreover, there is a difference between the species in the nepionic development of the microspheric form.

Our arrangement of the species on the following pages does not follow Grimsdale to the letter. We do not include the Paleocene form *Actinosiphon* in the Lepidocyclinidae like he does, and because of its helicolepidinoid development in the B-form, we have tentatively put *Lepidocyclina vichayalensis* in the Polylepidinas instead of in the most primitive group of the Lineage X. All Polylepidinas are described as one group, but instead of continuing with the Lineage Y, they are followed by the rather obvious phylogenetic series of *Lepidocyclina peruviana, pustulosa, subglobosa, yurnaguensis, vaughani* and *tempanii* (Lineage X) because it starts in the Middle Eocene along with the Polylepidinas. The first species of Lineage Y to be described is *Lepidocyclina sanfernandensis* (not mentioned by Grimsdale) with its mature form *depressata*, which starts in the Late Eocene (Marabella marl) but continues in the Oligocene. After that the typically Oligocene group of *Lepidocyclina undosa* and the other Oligocene and Miocene species of the Lineage Y are discussed.

Apart from *Polylepidina nitida* and *Lepidocyclina spatiosa* and *L. nuda*, no important forms have been added to the list given by Vaughan & Cole in 1941. On the contrary, some of the names they mention are omitted in the new list. Their *L. aurarensis* has been placed in the synonymy of *L. pustulosa*, the sp. aff. *ocalana* var. *pseudocarinata* is most probably our *L. spatiosa*, and *mortoni*? remains indeterminable. *L. sanluisensis* did not turn up in our material and neither did *L. macdonaldi* which was reported from the Penal-Rock Road.

Several of the specific names afterwards scrapped by Cole (1952, 1957, 1961) have been revived in the following pages. According to Cole, a drastic reduction of the number of species is justified by the fact that many of the so-called specific characteristics are extremely variable and that everywhere the species are linked by transitional forms. From a biological standpoint and within a given assemblage this attitude may be correct, but to paleontologic work it can be a disservice because it may cause the permanent loss of previous observations, especially when such gradual differences prove to be of stratigraphic significance, for instance in the case of *Lepidocyclina sanfernandensis* versus

Lepidocyclina chaperi. Careful evaluation of the overall appearance of such forms is sometimes of more importance than the scrupulous comparison of minute details and measurements.

Further studies should be made along the lines suggested by Grimsdale and by Tan Sin Hok. Some of the ample material from Trinidad (Mount Moriah, Vistabella Quarry, Cipero coast, Morne Diablo Quarry) might serve as a starting point.

Subgenus *Polylepidina* VAUGHAN

The interesting group of the Polylepidinas, considered by Vaughan as a subgenus of *Lepidocyclina*, has never been firmly outlined and the diagnoses of the species are vague. The differences between *Polylepidina* and *Lepidocyclina* are not even clear in the exhaustive study on the subject by Tan Sin Hok (1939).

Vaughan (1924b, 807–812, textfig. 5–6, pl. 30–32) based his new subgenus on the three Mexican species *chiapasensis, adkinsi* and *proteiformis. P. chiapasensis* was designated the subgenotype, chiefly because they seemed to have a greater number of chaotically arranged embryonic chambers than the rest of the Lepidocyclinas (the «mulberry mass» type of embryo according to Vaughan 1929e). In reality, however, there is a normal bilocular nucleoconch, followed by one or two auxiliary chambers, often very different in size, and one to four corresponding periembryonal spirals. The primary auxiliary chamber and one or two chambers of the primary spiral (the one which embraces the protoconch) may be as large or even larger than the embryonic chambers, which may create the impression of a multilocular nucleoconch. Vaughan presents photographs of all three of the original species, of which at least *adkinsi* and *proteiformis* clearly show the bilocular nucleoconch; the section of *chiapasensis* is not exactly in the equatorial plane and is less convincing.

Apart from the peculiar spiral nepiont, Vaughan's second criterion for the subgenus lies in the equatorial chambers, which are described as being similar to those of *Lepidorbitoides* or *Orbitoides*: arcuate outer walls, pointed or truncate inner ends, a greater tangential than radial diameter, and a pronounced tendency to appear in radial rows. Vaughan also stresses the rapid increase in height of the median layer towards the periphery in *chiapasensis* and *adkinsi*, this in contrast to *proteiformis*, which shows little increase.

In 1928 Galloway, who raised the Polylepidinas to generic rank, added *Lepidocyclina antillea* Cushman from St. Bartholomew to the genus.

Polylepidina antillea is generally speaking uniserial, it has one auxiliary chamber and one long spiral one, surrounding the protoconch and often continuing around part of the deuteroconch as well (Cole 1938, pl. 10:3; 1960, pl. 10:1; pl. 12:8; pl. 13:1–2, 5; Caudri 1974, pl. 8:7). However, from a comparative study of material from St. Bartholomew and from Jamaica, Eva (1980) observed that various nepionic types are represented in this species. From St. Bartholomew he had specimens with only one spiral, but even more were biserial ones, mostly with one auxiliary chamber with two spirals. Whereas amongst the material from Jamaica there was not one uniserial specimen but nearly all were biserial and some had a second auxiliary chamber and were triserial or quadriserial. But even the last-mentioned form was asymmetric because the primary auxiliary chamber and its main spiral are predominant over the weakly developed other elements.

Other species which vary from uniserial to biserial are *Polylepidina gardnerae* Cole from the Claiborne Formation in Texas and from Florida (Tan 1939) and *Polylepidina chiapasensis* from Vera Cruz (Barker & Grimsdale 1936). *Polylepidina nitida*, however, is nearly exclusively uniserial.

Apart from the asymmetrical Polylepidinas mentioned above, there are also symmetrical forms. The best example of these is *Polylepidina proteiformis* from the late Middle Eocene of Mexico, which has two equally big auxiliary chambers and four short subequal periembryonic spirals, closed off by symmetric chambers where they meet (Vaughan 1929e).

Superficially, this looks the same as the nepiont of the Late Eocene species *Lepidocyclina subglobosa*. It would be an error, though, to see in the latter an offspring of *Polylepidina proteiformis*. The shape of the median chambers and the development of the lateral tissue in *Lepidocyclina subglobosa* are too different to consider a close relationship between the two.

It is rather difficult to decide which species of *Lepidocyclina* are to be considered as *Polylepidina* and which are not. Several of the species listed by Barker & Grimsdale (1936) do not belong to *Polylepidina* at all. Apart from *cardenasensis, vanslobbeni* and *variabilis*, which were already eleminated by Vaughan, the forms described by Hodson from the Late Eocene of Venezuela should also be dropped: *Polylepidina churuguaritana, mirandana* and *zuliana* and *Lepidocyclina maracaibensis*. They belong to the group of *Lepidocyclina pustulosa tobleri*. Vaughan's *Polylepidina kinlossensis* from Jamaica, considered by Barker & Grimsdale as a variety of *Polylepidina chiapasensis*, is insufficiently diagnosed; it may even represent more than one species.

On the other hand the present author is inclined to consider *Eulinderina semiradiata* Barker & Grimsdale (1936) as the most primitive of the Polylepidinas because of its efforts to develop slit-like lateral chambers, and we tentatively place *Lepidocyclina ariana* Cole & Ponton from the Lisbon Formation of Florida in the genus *Polylepidina*. This form was included by Grimsdale (1959) in the group of *Lepidocyclina macdonaldi*, but in its equatorial pattern it is much closer to the Polylepidinas, especially *Polylepidina proteiformis* than to *Lepidocyclina macdonaldi* (compare Cole & Ponton 1934, pl. 2:4–5; Cole 1944, pl. 16:11–13; Caudri 1974, pl. 11:1–2, 13; pl. 14:4 with Vaughan & Cole 1941, pl. 31:2). *Polylepidina ariana* probably includes *Lepidocyclina claibornensis* Gravell & Hanna, found in Mississippi, 55 feet above the zone of *Polylepidina gardnerae* (Cole 1944).

Also the still problematic species *Lepidocyclina vichayalensis* L. Rutten seems to belong to the Polylepidinas. Apart from the American species, *Polylepidina* is also reported from the Eastern Hemisphere, but apart from the record of *Lepidocyclina* sp. from the base of the Middle Eocene of Senegal (van Raadshooven 1951) these appear to be suspect (Butterlin 1987).

Polylepidina antillea, nitida, chiapasensis gardnerae and *semiradiata* are a-symmetric, having in principal one predominant auxiliary chamber with one nepionic spiral, whereas others, like *adkinsi, discoidalis, vichayalensis, proteiformis* and *ariana*, have a symmetric nepiont with two subequal auxiliary chambers, each with two periembryonic spirals which, together with a symmetric chamber at their meeting point, enclose the entire nucleoconch. The systematic place of *Polylepidina* is not quite clear yet. Vaughan called it a subgenus of *Lepidocyclina* though there does not seem to be a direct connection with that genus. Cole followed that line and so did van de Geyn & van der Vlerk, although under the different name *Polyorbitoina*. This name is a synonym of *Polylepidina*, in spite of the different subgenotype chosen for the group: *Orbitoina (Polyorbitoina) proteiformis*. Moreover, the type figure presented with it does not depict *Polylepidina proteiformis*, but is a reproduction of one of Cole's type figures of *Lepidocyclina (Polylepidina) gardnerae*.

Galloway (1928), Barker & Grimsdale (1936) and Eva (1980) separated *Polylepidina* as an independant genus, developing side by side with the most primitive Lepidocyclinas (*Lepidocyclina pustulata* s. l. and *peruviana*), with which we agree. Barker & Grimsdale's phylogenetic line, which shows the gradual transition from the spirally wound *Amphistegina (Eoconuloides) lopeztrigoi* via *Helicostegina* and *Eulinderina* to *Polylepidina chiapasensis* and *Polylepidina proteiformis* does not represent the ancestry of *Lepidocyclina* but of *Polylepidina,* culminating in *Polylepidina proteiformis*. Eva widens the gap between the two genera by placing *Polylepidina* in a different subfamily of the Lepidocyclinidae, the Helicolepidininae. This conclusion is probably correct. Eva states that the difference between the subfamilies of the Lepidocyclininae and the Helicolepidininae lies in the fact that the deuteroconch in the former has many apertures giving rise to ad-auxiliary chambers, which in their turn lead to the cyclic growth of the median chambers, whereas in the latter the wall of the deuteroconch has only one or two apertures where it joins the protoconch, opening into the auxiliary chambers, and the nepionic tissue surrounding the nucleoconch is formed by a number of spirals, often of a very reduced nature of one or two chambers only.

In spite of Tan's very detailed study of the Polylepidinas (1939), the differences between the species, in part based on the periembryonic ring only and on insufficient material remain vague. It is possible that various species in the list above will prove to be synonyms. In 1944 Cole put *Lepidocyclina chiapasensis* and *gardnerae* in synonymy with *Lepidocyclina antillea*, thus eliminating the subgenotype designated by Vaughan. This was accepted by Grimsdale (1959) but needs further confirmation. Maybe the genus will have to be subdivided: Barker & Grimsdale's transition from *Polylepidina semiradiata* via *chiapasensis* and *discoidalis* to *proteiformis* seems quite logical, but it is impossible to find a place in this sequence for *Polylepidina nitida*, with its long primitive uniserial spiral and its lateral tissue which is far more developed than in *Polylepidina proteiformis*. If we may trust our scanty information, there also exist differences in the initial part of the microspherical forms. Some species begin with a simple spiral, e.g. *Polylepidina antillea* (Vaughan 1929e, fig. 7; Cole 1960c, pl. 12:8), *semiradiata* (Barker & Grimsdale 1936, pl. 35:2), *discoidalis* (ibid., pl. 36:6) and *birmanica* (Rao 1942), while others develop from a helicolepidinoid center, e.g. *Polylepidina vichayalensis* (Pl. 14:12), *P. zeijlmansi* (Tan 1936d, pl. 1:10).

As a group, *Polylepidina* is often considered as an indication of the Middle Eocene (Grimsdale 1959; Cole & Applin 1964), but one cannot fully rely on that. *Polylepidina vichayalensis*, for instance, is known to occur in abundance in the Middle Eocene of Eastern Mexico (Grimsdale 1959), but its type level is the Late Eocene Verdun Formation in Peru. Barring massiv reworking at the Peruvian locality, as suggested by Grimsdale, this would mean that the species crosses the boundary between the Middle and Late Eocene. In Trinidad one encounters *Polylepidina vichayalensis* in the Late Eocene where there is no indication of reworking from the Middle Eocene. Also for *Polylepidina nitida* a Middle Eocene age cannot be guaranteed, as it was also found in the lowest level of the Late Eocene Mount Moriah calcareous sandstone.

Lepidocyclina (Polylepidina) nitida CAUDRI, n. sp.
Pl. 2:12–13; Pl. 14:3–8; Pl. 30:3

1948 *Polylepidina* aff. *chiapasensis*, Caudri, pl. 73:8.

Exterior: Test lenticular, sharp-edged; maximal diameter 2.2 mm, thickness up to 0.7 mm (exceptionally 0.9 mm), ratio fairly constant; pillars numerous, not very heavy, evenly distributed over the central part; peripheral area pillarless, often showing radial rows of lateral chambers separated by radial ribs.

Horizontal section: Mostly megalospheric, rarely microspheric; in the A-forms nucleoconch 145–232 μ (usually 175–200 μ), consisting of a round protoconch and a subequal deuteroconch, generally thin-walled but outer spiral wall sometimes thickened, in which case the deuteroconch may be asymmetric; one large auxiliar chamber followed by a single spiral of 3 to 6 (mostly 4) conspicuously large nepionic chambers; median chambers arranged in radial rows which at first do not divide, so that with the increase of the circumference of the test, the chambers attain an extraordinary width (up to 150 μ); transition from the initial spiral to the normal equatorial pattern via several secondary spirals, depending on the individual; later, the rows split and the chambers are reduced to normal proportions (75–90 μ by 60 μ); microspheric form with the same radial pattern; initial spiral composed of about 15 chambers; nepionic development helicolepidine.

Vertical section: Equatorial layer sometimes faintly conical; height of equatorial layer only slowly increasing towards the edge; curved chamber walls; lateral chambers thin-walled and spacious, arranged in 5–7 continuous layers rather than vertical tiers; roofs variable in thickness but never heavy as in *Polylepidina antillea*.

Holotype: Pl. 2:12 (C 35930).

Type locality: Farallon Rock, unnumbered sample collected by Stainforth, Renz & Rutsch in 1939.

Type level: Uppermost Middle Eocene.

Occurrence: Farallon Rock (especially abundant in type sample and in S.L. 99, only megalospheric specimens observed); top of Mount Moriah (A.G.H. 5550, rare but also B-form, ?A.G.H. 5584, M. 12924); Point Bontour (reworked, St. 67, 68, 68a; St. 71, rare but also B-form, Grimsdale 4); ?Vistabella Quarry (reworked); ?Charuma (Late Eocene block A.E.G. 1580A, reworked).

Polylepidina nitida resembles *P. antillea* Cushman in the radial arrangement of its median chambers, but in vertical section it shows a much better development of the lateral tissue.

The megalospheric form is characterized by a short uniserial spiral of very large periembryonic chambers and radially arranged neanic chambers, the early ones of which are exaggeratedly wide. The microspheric generation has a spiral of around 15 chambers possibly followed by a helicolepidinoid nepiont. The vertical section shows very well developed spacious lateral chambers. The equatorial layer increases only slowly in height towards the periphery.

It is remarkable that the many specimens from Farallon that were sectioned all proved to be megalospheric. The very rare microspheric forms that were found, in combination with megalospheric ones, at Point Bontour and on Mount Moriah, do not differ externally from the latter and they also show the same pattern of the equatorial chambers in horizontal section. One specimen from Point Bontour had an embryonic spiral of 15 chambers forming 1.75 coil. The helicolepidine development of the nepiont is reminiscent of *Lepidocyclina vichayalensis*, but the latter has a shorter embryonic spiral.

In the megalospheric generation, the transition from the initial spiral to the neanic radial growth pattern shows a lot of individual variation. In most cases, however, each chamber of the primary spiral apart fom the auxiliary chamber gives rise to a short secondary spiral which swings backwards over the first. One of these secondary spirals, as a rule the one originating from the first or from the second nepionic chamber, is better developed, encircles the auxiliar chamber and part of the deuteroconch and meets the end of the primary spiral in a symmetric chamber. A similar development which suggests, also in the A-form, a close relationship between *Polylepidina* and *Helicolepidina*, has also been observed in *Polylepidina chiapasensis* (Barker & Grimsdale 1936, pl. 35:8) and *P. gardnerae* (Cole 1938, pl. 9:2, 4?, 5; pl. 10:4).

In terms of nepionic acceleration, *Polylepidina nitida* seems to be midway between *Lepidocyclina antillea* with its slightly longer initial spiral in both generations (Cole 1938, pl. 10:3; 1960c, 61–62, pl. 12–13) and *L. gardnerae* which sometimes tends to develop a reduced biserial nepoint (Cole 1929, pl. 2:2; 1938, pl. 9:3; Tan 1939, 61–62, pl. 2:5). For that reason, it could be placed at the same level als *L. chiapasensis* as presented by Barker & Grimsdale (1936). We know, however, that the stratigraphic level of the species is the very highest Middle Eocene, way above the level of *L. chiapasensis*.

In other respects its place remains equally uncertain. The thickening of the outer wall of the nucleoconch and of the nepionic spiral is a primitive feature reminiscent of *Eulinderina*. Primitive are also the outward curvature of the walls of the aequatorial chambers and the arrangement of the lateral chambers in helicolepidinoid layers, but their roofs are never as heavy as in *Lepidocyclina antillea* or *L. gardnerae*. Not primitive are, however, the spaciousness of those lateral chambers and the thinness of the aequatorial layer, in which the species approaches *Lepidocyclina proteiformis*.

All these contradictory data do not encourage simply phylogenetic speculations, but suggest the existence of several parallel lines of descent within the group of the Polylepidinas. The radial arrangement of the equatorial chambers suggests the presence of a distal stolon as in *Lepidocyclina vichayalensis*, but such a stolon was not actually observed in our material of *L. nitida*.

The stratigraphic range of the species is still a puzzle. There is no doubt that it is in situ in the Farallon limestone where it occurs in great numbers and in very good preservation. But, as in the case of the other peculiar Farallon forms (*Operculina bontourensis* and *Helicolepidinoides intermedius*), it is doubtful the scattered specimens found at Point Bontour and on Mount Moriah are also autochthonous or just reworked. It may be interesting that at Point Bontour occurred a few heavily pillared specimens with a granulated flange and also some with an abnormally flat test, varieties that were not spotted on Farallon Rock, which might have something to do with a difference of environment. In this context one wants to spotlight also the curious fact that only in this Late Eocene material, where *Lepidocyclina nitida* is scarce, does one come across the microspheric form. If reworked, it seems that those specimens must at least have come from a different locality than where the limestone block of Farallon Rock has originated. But it may also be that the species did cross over into the Late Eocene.

Lepidocyclina (Polylepidina) vichayalensis L. RUTTEN

Pl. 14:9, 11–12

1928 *Lepidocyclina (?Polylepidina) vichayalanesis*, L. Rutten, pl. 15:24f–k, n–p; pl. 2:25–26.
1935 *Actinosiphon vichayalensis*, M.G. Rutten 1935b, 546–547, fig. 1–2.
1948 *Lepidocyclina vichayalensis*, Stainforth, 134.

The specific determination of the Trinidad specimens of this curious species was based on the resemblance in horizontal section to M.G. Rutten's figures of the Type material from Peru (1935). It was confirmed in 1949 by T.F. Grimsdale, who was familiar with the species from Mexico, where it forms entire populations, together with *Lepidocyclina peruviana* (Grimsdale 1959).

In Trinidad, *Polylepidina vichayalensis* has been found chiefly in the Mount Moriah calcareous grit at the base of the San Fernando Formation and in the lower part of the Vistabella marls in Charuma. In both places microspheric and megalospheric specimens exist sporadically; the species occurs also in the Vistabella marl at Point Bontour, in the Vistabella Quarry and in the lower part of Calyx well 59 on Vistabella Estate.

Occurrence: Top of Mount Moriah (base Late Eocene: A.G.H. 5550 frequent, A.G.H. 5583, A.G.H. 5584, also B-form); Charuma (Late Eocene: A.E.G. 1580A, 1580B, common, also a few B-forms, 1580C, 2740); Point Bontour (Late Eocene: St. 63); Vistabella Quarry (Late Eocene: Cd. 12–14); Vistabella Calyx well 59, 440–450 feet (Late Eocene).

Lepidocyclina (Polylepidina) proteiformis VAUGHAN

Pl. 14:10

1924 *Lepidocyclina (Polylepidina) proteiformis*, Vaughan 1924b,810, textfig. 6; pl. 32:1–7.

The Lepidocyclinas of Grimsdale's (1959) Lineage X

The Trinidad species that belong to this lineage are *Lepidocyclina peruviana, pustulosa* and its varieties, *spatiosa, yurnagunensis-subglobosa, vaughani* and *tempanii.*

Lepidocyclina peruviana CUSHMAN

Pl. 6:12; Pl. 15:4, 6

1922 *Lepidocyclina (Nephrolepidina) peruviana*, Cushman, 138, pl. 24:1.
1975 *Lepidocyclina peruviana*, Caudri, 573, pl. 5:4; pl. 25:7–14; pl. 26:1–4, 8.

In Trinidad, the species occurs everywhere together with the Lepidocyclinas of the *pustulosa*-group. It is particularly common on Soldado Rock, in the transgressive beds on the top of Mount Moriah and in Charuma. Specimens may attain a diameter of 3 mm, but they are often very small. In several samples these small specimens form the main component of the finer fractions of the residue.

Lepidocyclina peruviana nana CAUDRI

1975 *Lepidocyclina peruviana* var. *nana*, Caudri, 574, pl. 26:5.

Of the very small specimens of *L. peruviana* which can be so overwhelmingly numerous in the Late Eocene assemblages of Trinidad and Soldado Rock, most turn out to be immature forms consisting of the nepionic stage only, surrounded by a few neanic median chambers.

However, there are amongst them also a fair number of true miniature forms, which are fully developed tests of the same general aspect as *L. peruviana* but on a much smaller scale.

Lepidocyclina pustulosa (H. DOUVILLÉ)

Pl. 6:10; Pl. 15:1, 5, 8

1917 *Isolepidina pustulosa*, H. Douvillé, 843, textfig. 1–4.
1928 *Lepidocyclina trinitatis* and *Pliolepidina tobleri*, Nuttall, 103, 105, fig. 10.
1941 *Lepidocyclina (Pliolepidina) pustulosa* s. s., forma *trinitatis* and forma *tobleri*, Vaughan & Cole, 20, 27, 64–67, pl. 24–30 (with extensive synonym list).
1975 *Lepidocyclina pustulosa*, Caudri, 374, pl. 5:1, 3, 5–6; pl. 26:6–7, 9, 12–14; pl. 27; pl. 28:1, 3–4; pl. 29:5.

The Trinidad material of *Lepidocyclina pustulosa* has been extensively described and figured by Vaughan & Cole (1941). They studied large suites of specimens and came to the conclusion that, though the extreme variants may be very different indeed, it is impossible to divide the series into separate species. They, therefore, united Douvillé's *Isolepidina pustulosa* and *I. trinitatis*, including also his *Pliolepidina tobleri* (the teratological form) under one species name: *Lepidocyclina pustulosa*. In contrast to Vaughan & Cole's views the present author prefers to maintain *I. trinitatis* and *I. tobleri* as subspecies of *Lepidocyclina pustulosa*.

The B-forms of *Lepidocyclina pustulosa* from the San Fernando area (Vistabella Quarry) are in their early development very different from those in the Navette area. The first type shows a short spiral of rounded chambers, followed by an area in which the chambers are arranged in radial rows, very similar to *L. peruviana*. The latter type has a smaller and more tightly wound spiral and lacks the zone of radially arranged chambers. The difference is so striking that we must conclude that the form determined as *L. pustulosa* represents more than one species. On Soldado Rock the two types occur together in the same sample.

The Trinidad material of *Lepidocyclina pustulosa* is excellently suited for an extensive study as some of the faunas can be considered as real autochthonous populations. The best material comes from Soldado Rock (K. 903, 1316, 1499, 1500, 2854, 2855, 3677, 10716, etc.; see Kugler & Caudri 1975; Caudri 1975), from the Vistabella Quarry and from the Navette area.

Lepidocyclina pustulosa trinitatis (H. DOUVILLÉ)
Pl. 15:3, 9

1924 *Isolepidina trinitatis*, H. Douvillé, 34, pl. 1:4; textfig. 7–12.
1975 *Lepidocyclina pustulosa trinitatis*, Caudri, 575, pl. 1:17–18; pl. 5:3, 5–6; pl. 26:14; pl. 27:1, 9–11; pl. 29:7.

The best populations to study this form are from Soldado Rock (K. 2854, 3677, 10716). The specimens from K. 10716 often show the same peculiar little solid squares at the intersection of the walls of the median chambers that are such a constant chracteristic of *Lepidocyclina yurnagunensis*. The same was also noticed in a few specimens from Point Bontour (St. 63).

Lepidocyclina pustulosa tobleri (H. DOUVILLÉ)
Pl. 15:7, 12

1917 *Pliolepidina tobleri* H. Douvillé, 844, textfig. 5–6.
1975 *Lepidocyclina pustulosa tobleri*, Caudri, 575, pl. 27:4–7.

The systematic place of the subspecies is still problematic. Brönnimann (1946) considers it as a valid species and Grimsdale (1959) not only recognizes it as a separate species but distinguishes it as a group of *Lepidocyclina* by itself. Cole's final conclusion (1963) is followed here: The form is left within the species *pustulosa*, as many transitional forms between the isolepidine type of nucleoconch and the forma *tobleri* are found in the lower(?) bed of the Vistabella Quarry and several specimens have a double nucleoconch or are completely abnormal.

Occurrence: Point Bontour (Vistabella marl, type locality of the subspecies); Morne Roche (basal beds of Late Eocene); Vistabella marl (frequent), Charuma (frequent), Navette area (abundant), San Fernando Railway Station (Marabella marl, Cd. 208); Lizard Springs area (Late Eocene blocks, Z. 456a).

In Trinidad, *Lepidocyclina pustulosa* continues into the uppermost Late Eocene Marabella marl, where it is associated with *Lepidocyclina subglobosa, yurnagunensis* and *sanfernandensis* and *Helicocyclina paucispira*, but does not go beyond.

Lepidocyclina pustulosa compacta CAUDRI
Pl. 15:2

1974 *Lepidocyclina pustulosa*, small-chambered variety, Caudri, 312, pl. 12:1.
1975 *Lepidocyclina pustulosa* forma *compacta*, Caudri, 575, pl., 26:12.

This mostly small form is scattered throughout the San Fernando Formation, from the basal deposits (Mount Moriah calcareous sandstone) up to the uppermost Eocene beds at the San Fernando Railway Station (Marabella marl). It is nowhere common. Some very small microspheric forms with the same characteristics were also found.

Lepidocyclina spatiosa CAUDRI
Pl. 7:4, 9; Pl. 16:1–4

1941 *Lepidocyclina (Lepidocyclina)* sp. aff. *ocalana* var. *pseudocarinata*, Vaughan & Cole, 68, pl. 31:10–11.
1974 *Lepidocyclina «spatiosa»*, Caudri, 312, pl. 12:2.
1975 *Lepidocyclina spatiosa*, Caudri, 576, pl. 1:21; pl. 28:2; pl. 29:1–2.

Lepidocyclina spatiosa is closely related to *L. pustulosa*. On the other hand, it resembles *L. supera* which, in Trinidad, has been found in the Cipero section. Topotype material of *L. supera* at our disposal shows this species to have likewise meandrine lateral chambers on the surface and very small median chambers along the unbroken undamaged edge of adult forms. But it has a smaller and more compact nucleoconch, without large periembryonic chambers around it, and the equatorial chambers are not rhomboid or ogival but spatulate to rounded-hexagonal (Pl. 28:4). *L. supera* is an Oligocene species.
Occurrence: Soldado Rock (K. 1316, 1499, 2854); Navette area (R.M. 1337, pit, middle and lower part); Point Bontour (G.F. 4123, very small St. 63?).

Group of *Lepidocyclina yurnagunensis*

Lepidocyclina yurnagunensis (CUSHMAN)
Pl. 3:6; Pl. 7:2, 5; Pl. 17:1–3, 7–8, 10–15; Pl. 30:4

1919 *Lepidocyclina canellei* var. *yurnagunensis*, Cushman, 57, pl. 12:7–8; textfig. 6.
1941 *Lepidocyclina (Lepidocyclina) yurnagunensis*, Vaughan & Cole, 22, 28, 64, 70, 72, pl. 33:1–7.
1975 *Lepidocyclina* cf. *yurnagunensis*, Caudri, 577.

Lepidocyclina yurnagunensis is one of the most easily recognizable species amongst the American Lepidocyclinas. It is a relatively small delicately built form, characterized by thin-walled lozenge-shaped median chambers arranged in a fan-like pattern, which generally show a minute square of solid shell material at the intersection of their walls. In vertical section it shows spacious thin-walled rectangular lateral chambers. The nucleoconch consists of two thick-walled chambers of near equal size, and its periembryonic ring is composed of large broad irregularly shaped chambers, as in *L. pustulosa*.

In Trinidad, *L. yurnagunensis* occurs in great quantities in various Oligocene localities, in first place in the basal Oligocene at Point Bontour, in the Early Oligocene of the Cipero section and in the hard rocks of the Mejias Quarry. The Cipero material is exceptionally well preserved. It is a mixture of countless juvenile and adult specimens of all sizes and shapes, and represents a natural population in all its variations. Nearly all of the specimens are megalospheric, but there are also a few microspheric forms, which distinguish themselves somewhat in general shape but not in size.

Part of the microspheric specimens has a close-wound initial spiral with a thick outer wall, like those of *Lepidocyclina pustulosa* from the Navette area. Others, however, have a spiral of rounded more spacious thick-walled chambers, sometimes forming a well-defined initial shell before going on with the regular rhomboid median chambers.

The stratigraphic range of the species in Trinidad is uppermost Eocene to Middle Oligocene.
Occurrence: Cipero section; Flat Rock rongue (Early Oligocene); Mejias Quarry (Middle Oligocene); Vistabella reservoir (E.L. 1207, uppermost Eocene); Vistabella Calyx

well 57 (Oligocene and uppermost Eocene); Vistabella Estate (uppermost Eocene Marabella marl, E.L. 1209); Point Bontour (basal Oligocene and uppermost Eocene); Coora-Quinam Road (Oligocene, block, Vaughan & Cole (1941) mention the species also from Erin, erratic blocks in mudflows); Chagonary Point; Penal-Rock Road; old Guayaguayare Road; Lizard Springs area; Tamana-Biche Road. The B-form was found in the Cipero section, at Point Bontour (Cd. 1211) and at the Vistabella reservoir (E.L. 1207).

Lepidocyclina yurnagunensis var. *inflata* CAUDRI, n. var.
Pl. 3:6

Holotype: Pl. 3:6 (C 35972).
Type locality: Cipero coast, Grimsdale 2.
Type level: Early Oligocene.

The megalospheric new variety is as a rule a very small form. An exceptionally large specimen (3.5 mm) which was left intact, is suspected to be a B-form. The central pillar can be as much as 1.1 mm in diameter and is surrounded by rather large lateral chambers; towards the edge they become very small. In horizontal section the variety is indistinguishable from typical *Lepidocyclina yurnagunensis*.

Lepidocyclina subglobosa NUTTALL
Pl. 7:6–7; Pl. 17:4–6, 9

1928	*Lepidocyclina subglobosa*, Nuttall, 104, pl. 8:3, 5–7.
1941	*Lepidocyclina* (?*Pliolepidinaa*) *subglobosa*, Vaughan & Cole, 65, 67, pl. 31:8–9.
1975	*Lepidocyclina subglobosa*, Caudri, 576, pl. 26:10–11.

The species was first described from wells on the Tarouba and Palmira Estates North of San Fernando (Marabella marl).

Small specimens of *Lepidocyclina yurnagunensis* with large irregular periembryonic chambers occur together with *L. subglobosa* already in the uppermost beds of the Eocene Marabella marl at Point Bontour and in Vistabella Calyx well 57 and surface samples. *L. subglobosa* is represented in large quantities in the finer fractions of the washed samples from the basal Oligocene at Point Bontour and from the Early Oligocene Flat Rock tongue of the Cipero section. This small form has up to now been overlooked amongst the floods of the more conspicuous larger specimens of *L. yurnagunensis*.

In Trinidad *Lepidocyclina subglobosa* ranges from uppermost Eocene to Early Oligocene.

Occurrence: Tarouba-Palmyra Estates (Marabella marl); Vistabella Calyx 57 and 59 (surface sample E.L. 1207, 1435); San Fernando Railway Station; Point Bontour (Basal Oligocene); Cipero section (Early Oligocene); Mejias Quarry (Oligocene); Coora-Quinam Road.

Lepidocyclina vaughani CUSHMAN

1918 (1919) *Lepidocyclina vaughani*, Cushman, 93, pl. 37:4; pl. 38.

In Trinidad, the species occurs in considerable numbers in the limestone of Kapur Quarry (Lz. 3465), associated with abundant Lepidocyclinas of the *undosa-favosa-gigas*-group. It also is present in several erratic blocks of Oligocene limestone in the South of the Island.

Towards the end of the Middle Oligocene, *L. vaughani* and *tempanii* take over from *L. yurnagunensis*, which appears in the uppermost Eocene and has, in Trinidad, its main development in the Early Oligocene and the early part of the Middle Oligocene.

Occurrence: Kapur Quarry (especially Lz. 3465); Erin, Tapara Point (Cole 1968, Locality 11); Penal-Rock Road (K. 409a = Cole 1968, locality 12).

Lepidocyclina tempanii VAUGHAN & COLE
Pl. 7:3; Pl. 17:16–17

1924 *Nephrolepidina tournoueri*, H. Douvillé, 47–48, textfig. 44–45 (not *Lepidocyclina tournoueri* P. Lemoine & R. Douvillé 1904).

1941 *Lepidocyclina (Nephrolepidina) tempanii*, Vaughan & Cole, 12, 75, pl. 39:5–9.

Because of its spacious delicate build, especially clear in the vertical section, this small species belongs to the same group as *Lepidocyclina yurnagunensis*, but it has a nephrolepidine embryonic apparatus and elongated hexagonal equatorial chambers, which do not show the fan-like pattern of the other members of the group.

Occurrence: Kapur Quarry, Logeon area, Guayaguayare (Lz. 3464, 3465, 3473, 3475, abundant); Charuma (A.E.G. 4567, abundant); Vaughan & Cole report the species from several other localities, all near or along the South coast: Erin Bay, Erin Point, Tapara Point, Chagonary Point, Penal-Rock Road, Marac River and along the old Rio Claro-Guayaguayare Road.

The Lepidocyclinas belonging to Grimsdale's (1959) Lineage Y are *Lepidocyclina sanfernandensis*, the group of *L. undosa, L. supera, L. forresti* and the group of *L. canellei.*

Lepidocyclina sanfernandensis VAUGHAN & COLE
Pl. 16:5–7

1941 *Lepidocyclina* (Nephrolepidina) *sanfernandensis*, Vaughan & Cole, 27, 73, cotypes: pl. 42:5a, 6; pl. 43:1–2; paratypes: pl. 42:1a–d, 2a–b, 3a–b, 4, 5b–c; pl. 43:3; pl. 44:1.

The species was described by Vaughan & Cole from a locality northwest of San Fernando (K. 3762), from a bed designated as «slightly younger than typical Vistabella» or «above the Mount Moriah Formation but in association with some Mount Moriah species».

L. sanfernandensis was subsequently found in several samples from the San Fernando area. Like *L. yurnagunensis, L. subglobosa* and *Helicocyclina paucispira*, it does not appear before the uppermost beds of the Eocene San Fernando Formation (Marabella marl), and, also like the other Lepidocyclinas mentioned above seems to continue into the Oligocene. In the Eocene *L. sanfernandensis* stands out against the bulk of *L. pustulosa* by its flatness and delicate build. It is often broken up into fragments.

Our material comes from the Vistabella reservoir (E.L. 1207). In contrast with the type locality, where the majority of the specimens are microspheric, most of ours are megalospheric: even one of the larger pieces, of 8 mm diameter, proved to be an A-form.

Occurrence: Northeast of San Fernando (K. 3762, type locality, uppermost Eocene, Marabella marl); Vistabella reservoir (E.L. 1207; uppermost Eocene, Marabella marl); Point Bontour (St. 84, 85; basal Oligocene, specimens weathered and probably reworked from the Eocene).

Lepidocyclina sanfernandensis var. *depressata* CAUDRI n. var.
Pl. 3:1–2, 7; Pl. 30:9

Exterior: Apart from the central depression the form is externally similar to *Lepidocyclina favosa*. Like that species, it is pillarless and covered with a network of thick-walled lateral chambers that, however, are somewhat smaller than in favosa.

Horizontal section: Embryonic apparatus eulepidine with a tendency towards the nephrolepidine type; outer wall rather thin. Median layer flat or slightly undulated, consisting of irregular rounded-hexagonal median chambers, indistinguishable from those of *L. sanfernandensis*.

Vertical section: Median chambers irregular, with convex vertical walls. Lateral chambers in tiers, with thick-straight walls but lenticular cavities; number of lateral layers very variable; central depression clearly derived from the peculiar curvature of these layers (not caused by erosion). The lateral tissue seems to cover the median layer to the edge (vertical section very different from the thin-walled *L. favosa*).

Holotype:Pl. 3:1 (C 35998).

Type locality:Cipero coast, C.S. 11.

Type level:Early Oligocene.

Occurrence:Cipero coast (C.S. 11); Point Bontour (Cd. 211).

In a few Oligocene localities occurs a very conspicuous robust *Lepidocyclina* which stands out by its peculiar shape. It is fairly large up to 7 oder 8 mm, and has a highly inflated body with a pronounced central depression and a thin flange. Such forms are here placed in the new variety *depressata* of *L. sanfernandensis*. Smaller and flatter specimens of the new variety cannot be distinguished from the typical Late Eocene *L. sanfernandensis*. It is therefore considered to be the typical, fully developed form of that species, but is kept apart for the following reasons: The new variety has so far only been found in the Oligocene. It however may be that, like *L. yurnagunensis*, the variety first occurred already in the latest part of the Late Eocene but did not reach its full development until the Oligocene in which case it may also be of stratigraphic value.

Group of *Lepidocyclina undosa*

As is the case with the group of *Lepidocyclina pustulosa*, we also have in *Lepidocyclina undosa* a group which consists of a series of species that resemble each other to such an extent that no sharp lines can be drawn between them. They are: *Lepidocyclina undosa, favosa, gigas*, its variety *duncanensis,* and *L. nuda.*

It is easy to separate the large sellaeform specimens of *L. undosa* from a typical *subglobosa* flanged *L. favosa* but, through the forms described by Vaughan as *L. undosa* var. *tumida*, they are intricately linked together and a firm specific determination of the many non-typical and intermediate cases becomes impossible. Moreover, because all these forms generally occur together, a rigid separation is of little consequence.

Nevertheless, we follow Cole (1952), though *Lepidocyclina undosa, favosa* and the microspheric form *gigas* most probably belong together, the three names should be continued, as a fusion would do more to obscure the picture of a given fauna than to clarify it.

Lepidocyclina undosa CUSHMAN
Pl. 20:1; Pl. 21:1

1919 *Lepidocyclina undosa*, Cushman, 65, pl. 2:1a.
1941 *Lepidocyclina (Eulepidina) undosa*, Vaughan & Cole, 75, pl. 34:5; pl. 41:1–3.

The best saddle-shaped forms occur in the Kapur Quarry; the specimens from the Cipero section are as a rule small and of non-typical habitus.

Occurrence: Vaughan & Cole recorded the species from the Cipero coast, Erin Point, Tapara Point, Penal-Rock Road, Mejias Quarry, old Rio Claro-Guayaguayare Road and the Lizard Springs area; added here is the Kapur Quarry.

Lepidocyclina favosa CUSHMAN
Pl. 20:2–3; Pl. 21:2

1919 *Lepidocyclina favosa*, Cushman, 66, pl. 3:1, 2b; pl. 15:4.
1941 *Lepidocyclina (Eulepidina) favosa*, Vaughan & Cole, 75, pl. 40:1–4.

Lepidocyclina favosa is characterized by the even curvature of the body surface and by the peculiar thick-walled lateral chambers on the surface, features which grade into *L. undosa*.

Occurrence: Kapur Quarry, Logeon, Guayaguayare area; Vaughan & Cole recorded the species from the Cipero coast, Erin Bay, Mapapire River and along Kapur Ridge.

Lepidocyclina gigas CUSHMAN
Pl. 21:3; Pl. 23:1

1919 *Lepidocyclina gigas*, Cushman, 64, pl. 1:3–5; pl. 5:4.
1941 *Lepidocyclina gigas*, Vaughan & Cole, 76.

The limestone of the Kapur Quarry contains the typical huge form of *Lepidocyclina gigas*. The specimens could not be detached without damage, and the diameter could not be measured exactly, but it is far in excess of 50 mm. The inflated central body occupies about 10–12 mm and has a thickness of 9–10 mm. The flange is flat or slightly undulated.

L. gigas is considered to be the microspheric generation of *L. undosa* as well as of *L. favosa*, both also present in the megalospheric form in this material.

Occurrence: Kapur Quarry Logeon, Guayaguayare area; Vaughan & Cole recorded it from Penal-Rock Road, Mejias Quarry, Marac River, Erin Point, and upper reaches Navette River (Lizard Springs area).

Lepidocyclina gigas CUSHMAN *duncanensis* COLE

1928 *Lepidocyclina gigas* var., Vaughan, 295.
1934 *Lepidocyclina gigas* var., *duncanensis*, Cole, 27, pl. 3:16; pl. 4:1.
1941 *Lepidocyclina gigas* var. *duncanensis*, Vaughan & Cole, 70.

Vaughan & Cole do not mention *L. gigas* from the Cipero coast where very large specimens occur in the Oligocene Flat Rock tongue that are here placed in this subspecies.

They are somewhat smaller and a good deal thinner than the typical *L. gigas* as known from Kapur Quarry and other places in southern Trinidad.

The state of preservation of the Cipero material is not favourable for a specific study. The specimens are broken up into tiny fragments, to the extent that they crumble away beyond recognition the moment the sample which contains them is soaked in water. For that reason they are bound to be overlooked in the washed residue, but on the weathered surface of the rock they are very conspicuous and look exactly like Cole's figure of one of his Florida specimens (pl. 4:1).
Occurrence: Cipero coast.

Lepidocyclina nuda CAUDRI, n. sp.
Pl. 28:5–7

Exterior: Diameter up to 6 mm. Test lenticular, rather flat, slightly depressed in the center, with gently sloping flanks; no distinct flange but very thin towards the edge. Large meandric lateral chambers and small pillars developed all over the central part of the test. Peripheral parts of the shell devoid of lateral tissue, showing the very large median chambers on the surface.
Horizontal section: Nucleoconch very large, thin-walled, nephrolepidine or eulepidine. Median chambers very large, elongated-spatulate; sometimes the chambers in the center are smaller, more or less like *Lepidocyclina undosa*, but in other specimens the large spatulate chambers are present right from the beginning.
Vertical section: unknown.
Holotype: Pl. 28:6 (C 36061).
Type locality: Flat Rock tongue, Cipero coast (Grimsdale 2).
Type level: Early Oligocene.

Lepidocyclina nuda resembles in its shape *L. supera* from the same sample and in the meandric lateral chambers, but it differs by the very large naked median chambers which are clearly visible on the peripheral part of the test. The new species is based on eight adult specimens and three loose embryos composed of the nucleoconch and the first 2–3 rings of median chambers only.

Lepidocyclina supera (CONRAD)
Pl. 28:2, 4

1865 *Orbitolites supera*, Conrad, Catalogue of Eocene Annulata, Foraminifera, Echinodermata and Cirripedia of the United States, Philadelphia Aca. Nat. Sci., Proc., 74.
1941 *Lepidocyclina (Lepidocyclina) supera*, Vaughan & Cole, 70, pl. 33:5–8; pl. 34:2–4.

The species is very rare in Trinidad. Vaughan & Cole (1941) recorded its presence only in one sample from the Cipero section.

The Trinidad form is characterized by the meandric lateral chambers on the surface and the small but rather conspicuous pillars.

Occurrence: Cipero coast (Grimsdale 2, K. 251); Vistabella, Calyx well 57, 730–740 feet (basal Oligocene, one specimen).

Lepidocyclina cf. *supera* (CONRAD), large variety
Pl. 3:3, 5

A single specimen stood out for its exceptional appearance among the other Lepidocyclinas of the Cipero coast material (Grimsdale 2). In the following it is tentatively described as a variety of *Lepidocyclina supera.*

Exterior: Diameter about 3 mm (damaged edge). Flat lenticular with a distinct narrow flange; entire test covered with close-set equally sized rounded beads of about 100 μ on the central body and somewhat smaller on the flange. Lateral chambers obscured by the pillars but, where visible, small, irregular, partly meandric.

Horizontal section: Median plane strongly undulated. Nucleoconch of the *Lepdocyclina* s. s. type, with a straight dividing wall; 550 μ in diameter. Median chambers rounded-hexagonal, thick-walled.

Vertical section: Unknown, but the broken edge shows long, very low lateral chambers with straight horizontal walls.

Lepidocyclina forresti VAUGHAN
Pl. 7:11; Pl. 19:2–5; Pl. 22:3; Pl. 23:2; Pl. 29:1

1927 *Lepidocyclina (Lepidocyclina) forresti*, Vaughan 1927a, 1, pl. 1:1–4; pl. 2:1–6.
1941 *Lepidocyclina (Lepidocyclina) forresti*, Vaughan & Cole, 70, pl. 35:1–3.

Vaughan & Cole (1941) identified the prominent large Lepidocyclinas in a sample from the Morne Diablo Quarry limestone (K. 2864) as *Lepidocyclina forresti*, an isolepidine species with a pronounced circular arrangement of the median chambers.

Among our extensive material from this locality, sample K.S. 70 showed the most complete array of forms of this species. There were countless megalospheric and microspheric specimens, in all varieties from pillarless to fairly heavily pillared, with and without a central knob, and a large number of juvenile forms consisting of a central knob and a thin flange or just of the small central body alone. These juvenile specimens are composed of little more than the nucleoconch with the very first rings of equatorial chambers, covered by one or two layers of lateral tissue. Intermediate forms abound and there was no reason to separate these forms from one another. Also, in the horizontal and vertical sections there is no difference between the pillarless and the pillared individuals.

The large B-forms of *Lepidocyclina forresti* in the Morne Diablo Quarry are not all of the same type in their initial development. Some have a simple embryonic spiral, others show a peculiar helicolepidinoid nepiont (Pl. 22:3).

Occurrence: Morne Diablo Quarry.

Group of *Lepidocyclina canellei*

Because it is difficult to draw the line between the Lepidocyclinas of this group (*canellei, pancanaalis, parvula, waylandvaughani, asterocolumnata, asterodisca, miraflorensis, giraudi* and *antiguensis*), Cole thought in 1961 that they might be different variations of one and the same species, to which the name of *Lepidocyclina canellei* should be applied. He came to the conclusion that in the American post-Eocene there are only two species of *Lepidocyclina* sensu stricto: *L. canellei* and *L. mantelli*. This generalization goes in our opinion too far. For instance, Cole's megalospheric specimens of *L. giraudi* from the Morne Diablo Quarry (1957b, pl. 4:3; pl. 5:1–2; pl. 6:2) and his microspheric *L. parvula* from Panama (1952, pl. 15:8) cannot be identified with *canellei*, and also several vertical sections of *L. waylandvaughani* (Vaughan 1933; Cole 1952, 1957b) are too different from those of typical *L. canellei* to be united with it.

Lepidocyclina canellei LEMOINE & R. DOUVILLÉ
Pl. 18:1–2; Pl. 29:4; Pl. 30:1

1904 *Lepidocyclina canellei*, Lemoine & R. Douvillé, Soc. Géol. France, Mém., vol. 12, 20, pl. 1:1; pl. 3:5.
1941 *Lepidocyclina (Lepidocyclina) canellei*, Vaughan & Cole, 70–71, pl. 35:6–7; pl. 41:4–5.

The large form of *Lepidocyclina canellei* is by no means common in Trinidad. Even in the Morne Diablo Quarry, where the canellei-group is well developed, this large form is rare in comparison with *L. pancanalis*, and is not typical either as far as the external features are concerned. The Morne Diablo specimens resemble the original pillarless type in their flat lenticular shape (sometimes with a definite flange), but nearly all of them show fine granulations on the surface (Pl. 29:4). Such granulated specimens occur also in the Cipero material. The pattern of the median layer is often fairly irregular due to growth disturbances and regeneration (Pl. 30:1).
Occurrence: Morne Diablo Quarry and Charuma, doubtful in the Mejias Quarry and the Cipero section.

Lepidocyclina pancanalis VAUGHAN & COLE
Pl. 7:8; Pl. 18:3–4

1932 *Lepidocyclina (Lepidocyclina) pancanalis*, Vaughan & Cole, 510, fig. 1–9.
1933 *Lepidocyclina (Lepidocyclina) pancanalis*, Vaughan 1933a, 15, pl. 6:6.
1941 *Lepidocyclina (Lepidocyclina) pancanalis*, Vaughan & Cole, 71, pl. 35:8–9.

Occurrence: Morne Diablo Quarry; Cunapo River (common); Baccus River, Guaico-Tamana Road, Charuma, Cascas River (K.R. 17725, specimens are dwarfed, at most 1.0 mm diameter); Vaughan & Cole report this species also from Erin Bay and Penal-Rock Road.

Lepidocyclina parvula CUSHMAN
Pl. 18:5–7; Pl. 29:2

1919 *Lepidocyclina parvula*, Cushman 1919a, 58, pl. 3:4–7.
1941 *Lepidocyclina (Lepidocyclina) parvula*, Vaughan & Cole, 20, 28, 71, pl. 36:1–5.

This species includes the centrally inflated heavily pillared representatives of the *canellei*-group. It is in this form that the group is chiefly represented in the Cipero section, but it is equally well developed in the Morne Diablo Quarry and elsewhere.

Sometimes the pillars are very large and arranged in a ring, but in the megalospheric specimens from Trinidad they are not fused to form radial ridges. Typical *L. parvula* var. *crassicosta* is absent in our material.

In the Morne Diablo material there is also a peculiar subglobose or biconical flanged form which, because of the general pattern of its lateral tissue, must likewise be considered as a form of *L. parvula*.

Occurrence: Morne Diablo Quarry, Cipero section, Mejias Quarry, Baccus and Cunapo rivers (Tamana area). Vaughan & Cole list it also from Erin Bay, Erin Point, Tapara Point, Penal-Rock Road, Marac River and Lizard Springs area. Microspheric forms occur in the Morne Diablo Quarry.

Lepidocyclina giraudi R. DOUVILLÉ
Pl. 7:10; Pl. 18:8; Pl. 19:1; Pl. 22:4

1907	*Lepidocyclina giraudi*, R. Douvillé, Bull. Soc. Géol. France, sér. 4, vol. 7, 305–311, pl. 10:9–10, 15–16.
1941	*Lepidocyclina (Lepidocyclina) giraudi*, Vaughan & Cole, 71, pl. 36:6–7; pl. 37.

Only the typical form with radial costae on the surface was listed under the name of *Lepidocyclina giraudi*; microspheric specimens with more or less heavy individual pillars but without costae were included in *L. parvula*-B on the fossil lists.

Occurrence: Morne Diablo Quarry, Chagonary Point.

Lepidocyclina waylandvaughani COLE

1928	*Lepidocyclina (Lepidocyclina) waylandvaughani*, Cole, 221, pl. 35:1–10.
1941	*Lepidocyclina (Lepidocyclina) waylandvaughani*, Vaughan & Cole, 70, l. 35:4–5.

This species is characterized by its small inflated central body, surrounded by a wide thin flange, and one or more rings of heavy pillars in the center. Cole now includes it in *Lepidocyclina canellei*, but this is accepted with some reservation as the lateral tissue, as seen in vertical section, seems less spacious.

The sepcimen from the Cipero section yielded three typically developed A-forms and one B-form. In these, the central body is well set off against the flat flange. The pillars are arranged in strikingly regular circles, especially in the B-form; they are heavy in the center but turn to fine granulations on the flange. The lateral chambers are small and polygonal.

In the same sample there were also three specimens with a much flatter central body which grades into the flange and in which the distribution of the pillars is less regular. The pillars in this form are small but prominent; no granulations on the flange. The lateral chambers are meandric rather the polygonal. These specimens correspond with the form figured by Cole from the Panama Canal Zone (1952).

Occurrence: Erin Point (Vaughan & Cole 1941, one specimen); Cipero section (four typical specimens).

Lepidocyclina asterocolumnata CAUDRI, n. sp.
Pl. 2:14

Exterior: Diameter 3.5 mm (edge broken off), thickness 1.2 mm. Inflated central body, gradually sloping down and surrounded by a thin flat flange, here 0.3–0.5 mm wide but possibly much wider in undamaged condition; lateral tissue continued on flange. The new species is characterized by the peculiar pattern of pillars and lateral chambers in its center. About 20 large composite pillars surrounded by large rounded lateral chambers (100 μ) with extremely thin but finely granulated walls; the pillars consist of a small star-shaped central granule, mostly forming an asterisk of 100–150 μ in combination with the radiating walls of the chambers which are thickened to tiny rods or rows of elongated granules.

The sloping flanks are covered with coarse granulations which obscure the here much smaller lateral chambers; on the flange the chambers are clearly visible and are separated by minute granules arranged in regular circles; the median chamber layer is rather high at the edge and not subdivided.

Holotype: Pl. 2:14 (C 36060).
Type locality: Cipero coast, Grimsdale 2.
Type level: Early Oligocene.

Variations in the external ornamentation of the test of larger foraminifera are not usually considered an important systematic feature. An exception is here made for the new species *Lepidocyclina asterocolumnata* which is characterized by the development of very peculiar stellate pillars.

The new species appears at first sight closely related to *L. waylandvaughani* Cole, it is based on a single isolated specimen of which no sections were made.

Lepidocyclina asterodisca NUTTALL
(see illustrations in: Vaughan & Cole, 1941)

1932 *Lepidocyclina (Lepidocyclina) asterodisca*, Nuttall, 34, pl. 7:5, 8; pl. 9:10.
1941 *Lepidocyclina (Lepidocyclina) asterodisca*, Vaughan & Cole, 73, pl. 39:1–7.

In this species, characterized by the polygonal arrangement of the equatorial chambers, the diameter, the number of rays and the shape of the test (webbed or star-shaped) are variable. In horizontal section the form shows very regular hexagonal chambers which are not even elongated in the radii.

Occurrence: Mejias Quarry and two localities on the Penal-Rock Road; one small, badly preserved four-rayed specimen from Penal-Rock Road.

Genus *Eoconuloides* COLE & BERMUDEZ

Eoconuloides cf. *lopeztrigoi* (D. PALMER)
Pl. 27:1

1948 *Amphistegina* sp. (heavily pillared, belonging to the group of *Amphistegina lopeztrigoi*?), Caudri, 479.

The only Trinidad specimen which can tentatively be referred to this species is one obviously reworked glauconitic specimen in the Late Eocene of Point Bontour (St. 89).

It is the specimen mentioned by Brönnimann as *Tremastegina senni*? from the Mount Moriah boulder bed (1950). It has well developed counter-septal hooks.

Eoconuloides senni (CUSHMAN)
Pl. 8:18

1945 *Amphistegina senni*, Cushman (in Vaughan 1945, 49, pl. 19:1–4).

The Trinidad specimens of *Eoconuloides senni* are very small, much smaller than the types from Barbados. They are poorly preserved and do not lend themselves to photography either of the external appearance or of the thin sections.

In Charuma, the species occurs in great numbers to form a typical *Amphistegina* fauna comparable to that of the type locality in Barbados.

The age of the fauna is early Middle Eocene, as indicated by the presence of *Neodiscocyclina anconensis* in Calyx well 50A, Biche, at a depth of 232 to 233 feet. This assemblage can be directly compared with the fauna in Barbados. Both in Biche and in Charuma the assemblage contains reworked Paleocene foraminifera, the same as in Barbados.

Occurrence: Biche, Calyx well 50, at 44–54 feet, Charuma silt (early Middle Eocene); Calyx well 50A, at 101–102, 194–199, 232–233 feet; Charuma silt (early Middle Eocene); Charuma silt (A.E.G. 3635, 3635A, 3635B, early Middle Eocene); T.P.D. Esmeralda well 1, SE of Mayo, at 2630–2650 feet.

Eoconuloides senni var. *conicus* CAUDRI, n. var.
Pl. 2:11

Holotype: Pl. 2:11 (C 36032).
Type locality: Charuma, A.E.G. 3635B.
Type level: Early Middle Eocene.

A variety of *Eoconuloides senni* (Cushman) in which the dorsal side is high conical with a central pillar, while the ventral side is completely flat. Although it is linked with the normal form by a whole range of transitional specimens, it is set apart as a variety.

Eoconuloides wellsi COLE & BERMUDEZ

1944 *Eoconuloides wellsi*, Cole & Bermudez, 11, pl. 1:4–10.

This is an exceedingly high conical species with thick walls and a smooth surface, conspicuously different from *Eoconuloides senni*. Two or three specimens of this form were found at Biche, in Calyx well 50A at 232–233 feet, together with *E. senni*.

Genus *Helicolepidinoides* TAN

Helicolepidinoides intermedius CAUDRI, n. sp.
Pl. 2:3–8; Pl. 27:9, 13–15

1951	*Helicostegina soldadensis*, de Cizancourt, pl. 5:14–15.
1960	*Helicostegina polygyralis* pro parte, Cole 1960c, 59, pl. 11:12.

Exterior: Diameter 1.2–1.3 mm; test often more or less oval in shape, with a blunt edge; heavy pillars in center and radial rows of fine granulations on the flanks; near the periphery the septal lines are often visible, as is also the network of secondary chamberlets in transparent specimens.

Horizontal section: Megalospheric and microspheric forms; innermost chamberlets elongate, slanting and imbricated as in *Helicolepidina polygyralis*; megalospheric nucleoconch followed by 2 to 5 undivided chambers.

Vertical section: Thick solid roofs separated only by the undivided lumen of the alar prolongations of the inner chamberlets; no lateral chambers developed.

Holotype: Pl. 2:7 (C 36038).

Type locality: Point Bontour, St. 68 (reworked material).

Type level: Late Middle Eocene (Farallon Rock).

Occurrence: Farallon Rock off Point Bontour (late Middle Eocene, S.L. 99, Stainforth, Renz & Rutsch coll. 1933; A-form abundant, B-form frequent); Top of Mount Moriah (calcareous sandstone member of the Late Eocene, A.G.H. 5550, 5584, M. 12282, 12283a, scarce); Point Bontour (Late Eocene, St. 63, both A- and B-forms, scarce, rare at St. 49, 61a, 68, 68a, 71, 86, Cd. 211); Vistabella Quarry (Late Eocene, coll. Lehner 1933 cat. No. 20001, scarce, also B-forms, Cd. 215 rare, C.J. 28-12-29 very rare, unnumbered sample coll. H.G. Kugler); Charuma (lower part of Late Eocene, A.E.G. 1580A scarce, A.E.G. 2740 rare); Point Fortin West (well F.W. No. 181, 8687–8707 feet, Late Eocene).

The new species occurs in abundance in the hard limestone of Farallon Rock (Middle Eocene). However, detached specimens from the Late Eocene of Point Bontour lend themselves better for description and diagnosis and were chosen as the type material, in spite of the fact that they are reworked. Morphologically, *Helicolepidinoides intermedius* can be placed between the Helicosteginas of Barker & Grimsdale, 1936, and *Helicolepidina polygyralis* Barker (1934).

At first sight, it resembles *Helicostegina dimorpha* Barker & Grimsdale, but it has only very few undivided chambers in the center and the spiral continues right through the edge, enclosing all the secondary chamberlets. There is no trace of an annular flange. On the other hand, the species can hardly be distinguished from *Helicolepidina polygyralis* though it is somewhat closer coiled, but lacks the lateral chambers which are typical of the latter species. Therefore, this form has to be assigned to the genus *Helicolepidinoides*. For comparison are presented here illustrations of typical *Helicolepidina polygyralis* (Pl. 2:9–10).

Helicolepidinoides intermedius is abundant in the late Middle Eocene of the Farallon Rock off Point Bontour and rare to sporadic in the Late Eocene of Trinidad, including the Marabella marl. Because of this distribution, the horizon of the Farallon limestone (not found in situ) is considered as the type level. The Farallon material seems to represent an entire population of specimens ranging from very small to the normal adult size.

It may even be that the species is restricted to the late Middle Eocene, though the basal beds of the Late Eocene should perhaps be included. The specimens in the Late Eocene and younger beds are probably all reworked; they are often more recrystallized than the rest of the fauna in which they are found.

The Farallon specimens are weathered, broken and covered with detritus. As in the case of *Operculina bontourensis*, which belongs to the same Farallon fauna, one has to turn to Point Bontour for type material, where it is reworked.

Helicolepidinoides intermedius is a conspicuous form, easily distinguished from the somewhat similar *Helicosteginopsis soldadensis* which abounds in the accompanying Late Eocene fauna. It is larger (1.2–1.3 mm), often more or less oval in shape with a blunt edge and with heavier pillars in the center. On the flanks there are radial rows of fine granulations and near the periphery the wavy septal filaments are often visible through the smooth wall. Exceptionally transparent specimens (Point Bontour) may even show the entire pattern of secondary chamberlets along the edge.

The damaged material from Farallon is very instructive as to the internal structure of the test. Often the septal filaments of the various coils are beautifully exposed. In the inner coils they are more or less regular with a strong backwards slant. Later, they assume a complicated pattern of meandric anastomosing walls, at first still with the tendency to curve backwards but finally developing into a network of irregular elongated chambers. These are not true lateral chambers, though, as they form only one layer between the consecutive roofs, it is easy to imagine how this pattern can be converted into that of *Helicolepidina polygyralis*.

Real pillars are developed in the center only. The granulations showing on the flanks are the heads of internal supports between the roofs of the alar prolongations. Pillars and granulations are always placed on the filaments, not between them.

In horizontal section the species shows the same elongated slanting and imbricated spiral chamberlets as *Helicolepidina polygyralis*, very different from those of *Helicosteginopsis soldadensis*, where they tend to be rounded like a string of pearls. The nepionic development is slightly more primitive than in *Helicolepidina polygyralis*, whereas in the latter, the formation of secondary chamberlets starts from the beginning, with the first spiral chamber after the auxiliar chamber. There are as a rule 2 to 5 undivided spiral chambers in *Helicolepidinoides intermedius*.

The foregoing description would suggest that *Helicolepidinoides intermedius* is the ancestral form of *Helicolepidina polygyralis*, but there is no stratigraphic support for such a theory. On the contrary, if one considers the type locality of *Helicolepidina polygyralis* (the Socorro Formation of Northwest Ecuador) and the Colombian locality, from where comes the material illustrated here, as Middle Eocene, the latter may even precede the more primitive *Helicolepidinoides*. But there is no doubt that they are very closely related, and in random sections in hard rock it is difficult to distinguish one from the other. *Helicolepidinoides intermedius* may occur in a *Helicolepidina* limestone from northern Colombia (collection J. Butterlin, Paris).

Also the *Helicostegina soldadensis* reported by de Cizancourt (1951, pl. 5:14–15) from the late Middle Eocene El Cumbe limestone of western Venezuela seems to belong to *Helicolepidinoides intermedius*. Apart from these somewhat doubtful occurrences, *H. intermedius* has so far not been recorded from outside Trinidad including Farallon Rock. It is however absent in the Late Eocene of Soldado Rock.

Genus *Helicolepidina* TOBLER

Helicolepidina spiralis TOBLER

Pl. 4:1–2; Pl. 6:13; Pl. 15:10–11; Pl. 30:6

1922	*Lepidocyclina (Helicolepidina) spiralis*, TOBLER 1922a, 343.
1928	*Helicolepidina spiralis*, Nuttall, 105.
1941	*Helicolepidina spiralis*, Vaughan & Cole, 76, pl. 45:1.
1975	*Helicolepidina spiralis*, Caudri, 572, pl. 25:2–6.

Helicolepidina spiralis was described by Tobler (1922a) from a limestone intercalation in the Upper Pauji shales, East of Lake Maracaibo, Venezuela, in combination with material from Point Bontour near San Fernando, Trinidad.

In Trinidad, the only Middle Eocene record of the typical form is from the type locality of the Dunmore Hill marl. The specimens from Farallon Rock belong to the form described below as *Helicolepidina* cf. *nortoni*, which is a nearly spiral-less variety. *Helicolepidina* cf. *spiralis* is generally present and often abundant in the Late Eocene (Vistabella marl). It also occurs at localities which are considered the base of the Late Eocene (top of Mount Moriah, calcareous sandstone member of the San Fernando Formation). In the uppermost part of the Late Eocene (Marabella marl, transitional beds to the Oligocene) its presence is somewhat erratic. It is conspicuously absent in Calyx well 57 at Vistabella, but occurs in considerable numbers in the equivalent bed at the San Fernando Railway Station (Cd. 208).

Occurrence: Dunmore Hill marl, type locality (late Middle Eocene); top of Mount Moriah (calcareous sandstone member of the San Fernando Formation, base Late Eocene); Morne Roche Quarry (base Late Eocene); Charuma (blocks, Late Eocene); Navette area (pit, R.M. 1337, Late Eocene); Hospital Hill marl, type locality (Late Eocene); Point Bontour (Late Eocene); Vistabella Quarry (Late Eocene); Vistabella Calyx well 59, bottom part (Vistabella marl, Late Eocene); Vistabella, Schlumberger office section, bottom part (Vistabella marl, Late Eocene); Tarouba Estate, test well A (Marabella marl, uppermost Late Eocene); San Fernando Railway Station (Marabella marl, uppermost Late Eocene); Soldado Rock, Bed 4 (A- and B-forms), Bed 7, Bed 9 (common to abundant, A- and B-forms), Bed 10 (common to abundant, A- and B-forms, also rare tricarinate forms in K. 1500), Bed 9a (both A- and B-forms common).

Helicolepidina cf. *nortoni* VAUGHAN

Pl. 14:1–2

1922	*Lepidocyclina (Helicolepidina) spiralis*, pars, Tobler 1922b.

In typical *Helicolepidina spiralis* the main spiral of the test begins soon after the nepionic spirals and surrounding chambers are formed, and continues right through to the edge. Specimens where this main spiral does not start right away and has an indefinitive beginning and no firm development were distinguished by Vaughan as *Helicolepidina nortoni*.

Some rather rare forms occur in Trinidad where the spiral is indefinite or not at all developed. Rather arbitrarily they were determined as *Helicolepidina* cf. *nortoni*, but they may just as well be considered as a variety of *Helicolepidina spiralis*.

Occurrence: All localities are Late Eocene except Farallon Rock. Point Bontour (St. 63); Vistabella, Schlumberger office section (St. 148); Vistabella Quarry (C.J. 28-12-29, Texaco cat. No. 863); Vistabella Calyx well 59, 500–510 feet (Vistabella marl), Top of Mount Moriah (A.G.H. 5550, M. 12924, calcareous sandstone); Charuma (A.E.G. 1580A, 1580B?, 1580C?); Farallon Rock (S.L. 99, Middle Eocene); Soldado Rock, Bd 10, K. 10716.

Family Amphisteginidae

Genus *Amphistegina* d'ORBIGNY

In Trinidad, *Amphistegina* of the type of *A. lessonii* s. l. occur in great numbers in some of the younger Tertiary beds, also flat forms covered with small pustules arranged in radial rows (*A.* cf. *radiata*) are frequent; none of these have been studied in detail.

More attention was paid to the Eocene species and their relationship to *Helicosteginopsis* and *Helicocyclina*.

Amphistegina undecima CAUDRI

1975 *Amphistegina undecima*, Caudri, 564, pl. 1:8–9; pl. 5:11–12; pl. 19:6; pl. 20:1–5, 7; pl. 23:6–16, 20–21.

In Trinidad, the species occurs in the Paleocene limestone of the Marac Quarry and reworked in the type sample of the Dunmore Hill member of the Navet Formation, Rz. 476.

Amphistegina grimsdalei CAUDRI

Pl. 8:15–16; Pl. 27:5–6

1941 *Amphistegina* sp. indet., Vaughan & Cole, 77, pl. 45:3.
1975 *Amphistegina grimsdalei*, Caudri, 566, pl. 5:8–9, 13–14; pl. 24:1–3 (fig. 2 = HT).

In Trinidad, *Amphistegina grimsdalei* ranges throughout the Late Eocene from the basal beds of Mount Moriah through the Marabella marl.

Amphistegina pregrimsdalei CAUDRI

Pl. 8:14

1974 *Amphistegina pregrimsdalei*, Caudri, 303, pl. 1:6–7, 10–11; pl. 2:14–17; pl. 5:6, 8–9, 12; pl. 6:1–4.
1975 *Amphistegina* sp. cf. *pregrimsdalei*, Caudri, 566, pl. 24:4–7.

The common *Amphistegina* from Farallon Rock probably belong to this species.

Amphistegina farallonensis CAUDRI, n. sp.
Pl. 2:1–2

Exterior: Diameter up to 1.4 mm. Test flat-lenticular often with a concentration of numerous pillars in the central area, sometimes with a larger knob in the center. Septal filaments, and along the edge also the septa, clearly marked in well preserved specimens. No ramification of the filaments.

Horizontal section: Closely wound spiral; thick spiral wall. Chambers very long and curved from the beginning. No septal or counter-septal hooks developed.

Vertical section: Extremely thick-walled, with hardly any space left for the alar prolongations between the walls.

Holotype: Pl. 2:1 (C 35945).

Type locality: Farallon Rock, S.L. 99.

Type level: Late Middle Eocene.

Occurrence: Farallon Rock.

The species resembles *Amphistegina grimsdalei* in many respects, externally as well as in horizontal section, but is larger, the septal filaments are straighter and the septa are much more apparent on the outside. The curvature of the chambers is considerable, but never as exaggerated as in the outer coils of *A. grimsdalei*. In vertical section the two forms are entirely different.

Genus *Helicosteginopsis* CAUDRI

Helicosteginopsis soldadensis (GRIMSDALE)
Pl. 8:17; Pl. 27:2, 7, 11–12, 16; Pl. 28:3; Pl. 30:2

1941 *Helicostegina soldadensis*, Grimsdale, 86, pl. 46:1–7.
1975 *Helicosteginopsis soldadensis*, Caudri, 570, pl. 5:7, 10, 15–16; pl. 24:8–15, 19?, 20.

Helicosteginopsis soldadensis is one of the most characteristic forms in the Late Eocene Vistabella Quarry and Marabella marls of Trinidad and on Soldado Rock.

The megalospheric form of *H. soldadensis* is by far the most abundant; microspheric specimens are sporadic in comparison, and it is an exception when they occur in considerable quantity in any particular sample.

Occurrence: Point Bontour; Vistabella Quarry (Cd. 12 abundant, also B-form; Cd. 13–16, also wide-flanged variety; Cd. 17, 206, abundant, no B-forms; Cd. 218–220, abundant; Cd. 221, K. 2664b, K. coll. 25-2-31, cat. No. 48196, also B-form; C.J. coll. 28-12-29; Lehner coll. 31933, cat. No. 20001); Vistabella Estate (St. 45, also B-form; St. 145, 147, 148, 151 also B-form; St. 155; Calyx well 57, 900–1010 feet; Calyx well 59, 50–6780 feet, also wide-flanged variety); San Fernando Railway Station (also B-form); Hospital Hill marl type locality (Rz. 75); T.P.D. well Marabella 1; Boussignac (Rz. 383, also B-form); Brighton and Vessigny wells AB No. 1, AV No. 4 and 32 (also wide-flanged variety); Cush River W of Biche (Rz. 383, also B-form). Navette area (R.M. 1337, pit, lower and middle part, numerous B-forms); Lizard Springs area (Z. 456a, Z. 459a, also B-form); Charuma (Eocene, A.E.G. 1549A, 1580B, 1580C, 2740 also B-form).

Genus *Helicocyclina* TAN

Helicocyclina paucispira (BARKER & GRIMSDALE)
Pl. 8:19; Pl. 27:3–4, 8, 10

1936 *Helicolepidina paucispira*, Barker & Grimsdale, 243, pl. 31:11–12; pl. 33:4–6; pl. 36:1, 3; pl. 38:4.
1941 *Helicolepidina paucispira*, Vaughan & Cole, 76, pl. 45:2.
1975 *Helicocyclina paucispira*, Caudri, 571, pl. 24:18, 22–23; pl. 25:1

g*Helicocyclina paucispira* is a short ranged species and in general is considered as a marker for the uppermost Eocene, typical in association with *Lepidocyclina subgibbosa, yurnagunensis* and *sanfernandensis*. *Helicocyclina paucispira* has evolved from *Helicosteginopsis soldadensis* towards the close of the Eocene. In Trinidad, the geographical occurrence of the *Helicocyclina paucispira* Zone is restricted to the San Fernando area. The species is found in the Eocene of the San Fernando Railway Station and a certain Eocene level in the section of Point Bontour, but it is also typical of the Marabella marl in Vistabella.

Occurrence: Point Bontour (St. 79, Cd. 211; probably reworked in St. 80, 85, Basal Oligocene); Vistabella Estate (St. 155; E.L. 1435, common); Vistabella Reservoir (E.L. 1207); Vistabella Calyx well 57 (900–910 feet, 1000–1010 feet); Vistabella Calyx well 59 (40–50 feet, 260–290 feet, 300-310 feet, 340–350 feet); San Fernando Railway Station (also B-form, Cd. 208 and Cole's samples 1963, loc. 7a; 1969, loc 6).

Family Miogypsinidae

Genus *Miogypsina* SACCO

Miogypsina (Miogypsinoides) complanata SCHLUMBERGER
Pl. 24:1

1900 *Miogypsina complanata*, Schlumberger, Bull. Soc. géol. France, sér. 3, tome 28, 330, pl. 2:13-16; pl. 3:18–21.
1941 *Miogypsina (Miogypsinoides) complanata* Schlumberger, Vaughan & Cole, 79–79.

Occurrence: Boussillac well 1 at 3790 feet; Mejias Quarry (sample Terpstra 143); N of Brasso-Tamana Road, W of Tumpuna River (A.E.G. 6616 auger hole, 18–30 feet).

Miogypsina (Miogypsina) gunteri COLE
Pl. 8:1; Pl. 24:2–4

1938 *Miogypsina (Miogypsina) gunteri*, Cole, 13, 42, pl. 6:10–12, 14; pl. 8:1–9.
1941 *Miogypsina (Miogypsina) gunteri*, Vaughan & Cole, 79, pl. 45:8.

Occurrence: Mejias Quarry, Kapur Quarry, Penal-Rock Road at 14 miles (K. 409a), Penal-Rock Road at 14 1/2 miles (K. 432).

Miogypsina (Miogypsina) hawkinsi HODSON
Pl. 8:5; Pl. 24:6, 7?

1926 *Miogypsina hawkinsi*, Hodson, 28, pl. 7:9; pl. 8:1–2.
1941 *Miogypsina (Miogypsina) hawkinsi*, Vaughan & Cole, 79, pl. 45:9.

Occurrence: Oligocene: Penal-Rock Road, at 14$1/2$ and 15$1/4$ miles (K. 431, J.A.B. 43), Marac River (K. 482 = K. 911), Erin (J.A.B. 22), Tapara Point, Cunapo River (J.A.B. 148, 150, 157). Miocene: Morne Diablo Quarry (J.A.B. 34, K.S. 21, 69, 70, 77, M. 13600B), Calyx well 42, drilled in the quarry at 130–133 and 170–173 feet.

Miogypsina (Miogypsina) bramletti GRAVELL

Pl. 8:4; Pl. 24:5, 8–11

1933 *Miogypsina bramletti*, Gravell, 32, pl. 6:5–10.

Occurrence: Morne Diablo Quarry (Early Miocene, throughout section).

Miogypsina (Miolepidocyclina) staufferi KOCH

Pl. 8:2; Pl. 25:1–8

1926 *Miogypsina staufferi*, Koch, 751–753, pl. 28:1–3.

Occurrence: Morne Diablo Quarry (Early Miocene, throughout section).

Family Planorbulinidae

Genus *Planorbulinella* CUSHMAN

Planorbulinella trinitatensis (NUTTALL)

Pl. 8:8–10; Pl. 10:15–17

1928 *Planorbulina larvata* Parker & Jones var. *trinitatensis*, Nuttall, 65, 97, Table I (No. 27, pl. VII:1–2.
1941 *Planorbulinella trinitatensis*, Vaughan & Cole, 24, 29, 80.

Occurrence: Tarouba Estate; Ste. Croix Quarry (Early Miocene); Morne Diablo Quarry (Early Miocene); Miocene limestones in Central Range (Biche Quarry, along Guaico-Tamana Road, Tamana-Carmichael Road, Mayo Quarry, Guaracara limestone); Hibernia Estate (Late Miocene).

Family Soritidae

Genus *Sorites* EHRENBERG

Sorites sp.

Pl. 8:11–12; Pl. 29:5–6

1935 *Sorites* sp., Senn, 82–83.
1941 *Amphisorus* sp. cf. *A. duplex* (Carpenter, Vaughan & Cole, 29, 80, pl. 45:10–12.

This species, which sometimes occurs in rock-building quantities in the more silty horizons of the Miocene reefs, is not an *Amphisorus*, but a *Sorites*. Although it shows a double row of apertures on its edge, the layer of chambers is single throughout. In Trinidad it does not appear until the last Miogypsinas are extinct.
Occurrence: Ste. Croix, Biche, Gasparillo quarries.

Annotations to Figure 7

The ranges of *Polylepidina nitida*, *Helicolepidinoides intermedius* and *Operculina bontourensis* are not yet completely known. All three are autochthonous in the uppermost Middle Eocene of Farallon Rock, but in the Late Eocene (and even the Oligocene) of Point Bontour, at Vistabella and especially in Charuma where the preservation of the specimens looks suspect, they are considered reworked. However, about their occurrence in the basal part of the Late Eocene, the Mount Moriah calcareous sandstone, one can not be so sure. Here, in contrast with the rich Farallon fauna where only megalospheric specimens were found, *Polylepidina nitida* is also represented by its microspheric form, which might suggest an independent development at this level. The Farallon fauna (*Polylepidina* and *Helicolepidinoides*) has, therefore, been marked on the charts with reservations as in situ on Mount Moriah.

What would weigh in favour of their being reworked in the entire Late Eocene is the observation that none of these forms occur on Soldado Rock, in particular not in Bed 10 which is the equivalent of the Mount Moriah sandstone.

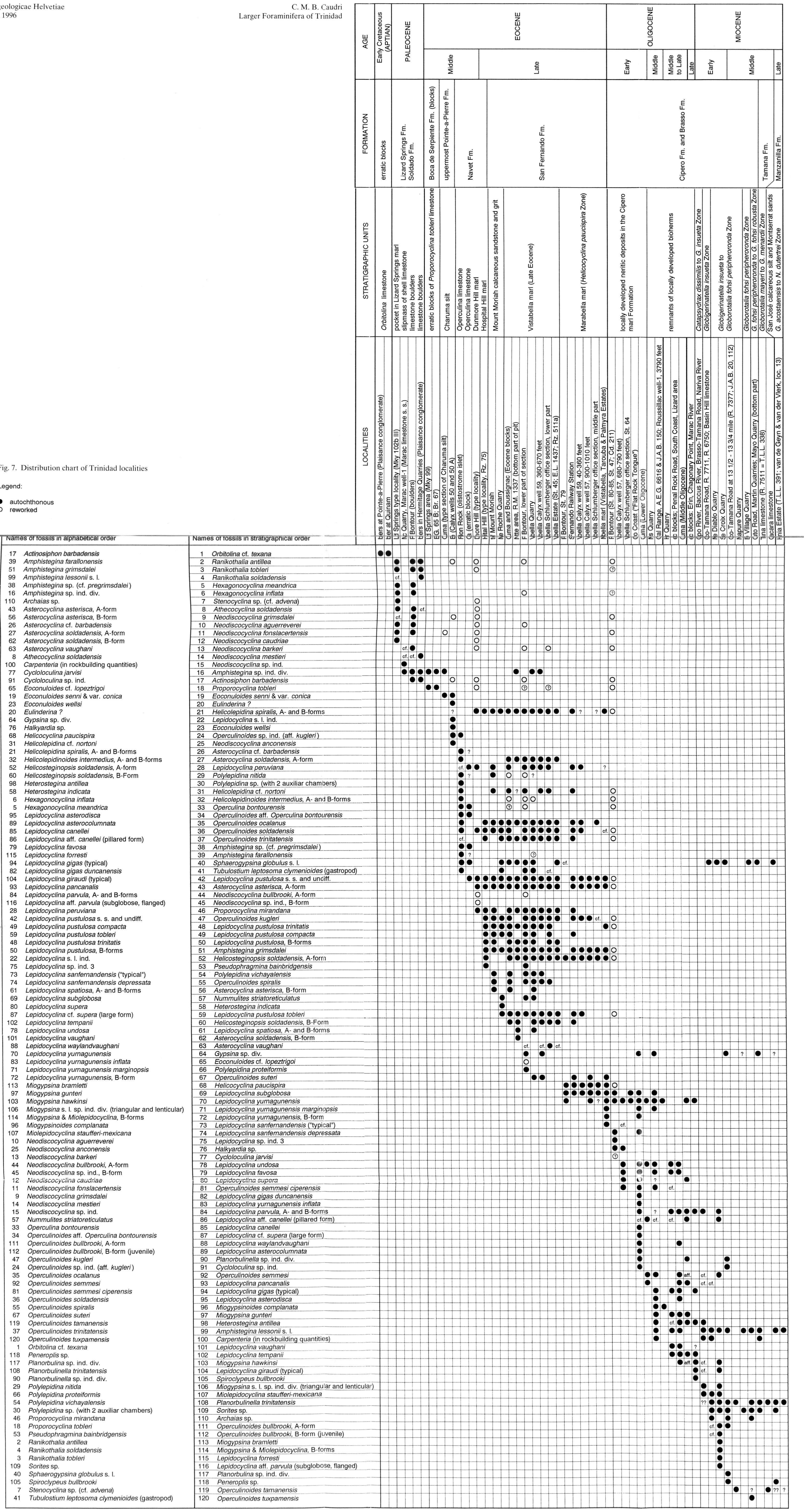
Lepidocyclina vaughani is very closely related to *Lepidocyclina yurnagunensis* but has more elongated diamond-shaped median chambers and a nephrolepidine nucleoconch. It forms a transition between the latter species and *Lepidocyclina* (*Nephrolepidina*) *tempanii*, in which the median chambers are elongated hexagonal instead of diamond-shaped. Short-chambered *L. yurnagunensis*, after a hesitating start in the Marabella marl, is typical of the lower levels of the Oligocene (Cipero coast, Mejias Quarry, etc.); in the higher levels (Kapur Quarry) *Lepidocyclina vaughani* and *L. tampanii* make their appearance, at first still accompanied by typical *L. yurnagunensis*, but the exact top of the latter remains vague as we had only hard limestone to work with, which does not lend itself to such detailed studies.

The Paleocene-Eocene part of the distribution chart for Trinidad is in complete harmony with that given for Soldado Rock (Kugler & Caudri 1975). In general character the assemblages of Trinidad are far more similar to what, up to now, is known of the South American mainland and Barbados than to the faunas of Florida and the other Gulf States and of the Greater Antilles. There is a great difference between our two charts and that given by Beckmann (1958) for Cuba and by Robinson (1968) for Jamaica. Not only do the latter contain a number of genera which for environmental or geographical reasons are absent in Trinidad, but of several genera they do have in common, the stratigraphic range is different, e.g. *Asterocyclina* which over there has its roots as low as the Paleocene or Early Eocene, and *Pliolepidina* in the Middle to Late Eocene. The last mentioned subgenus has, however, to be taken in the sense of Cole; in other words, as *Lepidocyclina pustulosa* s. l. and *Lepidocyclina peruviana*, and is not necessarily the *Pliolepidina* s.s. *tobleri* which in Trinidad and Soldado Rock is indicative of the Jacksonian and post-Jacksonian Late Eocene.

Fig. 7. Distribution chart of Trinidad localities

Legend:

● autochthonous
○ reworked



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Index for taxonomic descriptions and illustrations

REFERENCES

ANDREIEFF, P. 1983: Extension stratigraphique des grands foraminifères néogènes de la région caraibe: *Paraspiroclypeus chawneri* (Palmer) et *Operculinoides cojimarensis* (Palmer). Bull. Soc. géol. France 25, 885–889.

ARNI, P. 1966: Contribution to the history of growth of the choroperculinoides shell. Eclogae geol. Helv. 59, 339–346.

BAGG, R.M. 1912: see C.J. Maury 1912.

BANNINK, D.D. 1948: Een monografie van het genus *Operculina* d'Orbigny 1826. Ph.D. thesis, Univ. Leyden, 1–159.

BARKER, R.W. 1932a: Three species of larger foraminifera from S.W. Ecuador. Geol. Mag. 69, 277–281.

— 1932b: Larger foraminifera from the Eocene Santa Elena Peninsula, Ecuador. Geol. Mag. 69, 302–310.

— 1934: Some notes on the genus *Helicolepidina* Tobler. Paleont. 8, 344–351.

— 1938: On *Camerina petri* M.G. Rutten and *Nummulites striatoreticulata* L. Rutten. Geol. Mag. 75, 49–51.

— 1939: Species of the foraminiferal family Camerinidae in the Tertiary and Cretaceous of Mexico. Proc. U.S. natl. Mus. 86, 305–330.

BARKER, R.W. & BLOW, W.H. 1976: Biostratigraphy of some Tertiary formations in the Tampico-Misantla Embayment, Mexico. J. foram. Res. 6, 39–58.

BARKER, R.W. & GRIMSDALE, T.F. 1936: A contribution to the phylogeny of the orbitoidal foraminifera with descriptions of new forms from the Eocene of Mexico. J. Paleont. 10, 231–247.

— 1937: Studies of Mexican fossil foraminifera. Ann. Mag. nat. Hist. ser. 10, 19, 161–178.

BECKMANN, J.P. 1958: Correlation of pelagic and reefal faunas from the Eocene and Paleocene of Cuba. Eclogae geol. Helv. 51, 416–422.

— 1960: Distribution of benthonic foraminifera at the Cretaceous-Tertiary boundary of Trinidad. Int. geol. Congr. Rep. 21st Sess., Norden (Copenhagen) 1960, 57–69.

BERMUDEZ, J.P. 1950: Contribución al estudio del Cenozoico cubano. Mem. Soc. Cubano Hist. nat., Habana 19, 203–375.

BLONDEAU, A. 1977: Les relations entre l'Amérique et l'Euro-Afrique à partir de l'étude des Ranikothalia et des Nummulites. Mem. segundo Congr. Latinamer. Geol. (Caracas 1973) 3, 1451–1460.

BOLD, W.A. van den 1960: Eocene and Oligocene Ostracods of Trinidad. Micropaleontology 6, 145–196.

BOLLI, H.M. 1950: The direction of coiling in the evolution of some Globorotaliidae. Contr. Cushman Found. foram. Res. 1, 82–89.

— 1957a: The genera *Globigerina* and *Globorotalia* in the Paleocene – Lower Eocene Lizard Springs Formation of Trinidad, B.W.I. Bull. U.S. natl. Mus. 215, 61–81.

— 1957b: Planktonic foraminifera from the Navet and San Fernando Formations of Trinidad, B.W.I. Bull. U.S. natl. Mus. 215, 155–172.

— 1957c: Planktonic foraminifera from the Oligo-Miocene Cipero and Lengua Formations of Trinidad, B.W.I. Bull. U.S. natl. Mus. 215, 97–123.

— 1966: Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera. Bol. inform. Asoc. venez. Geol. Min. Petr. 9, 3–32.

BRÖNNIMANN, P. 1942: Eine *Proporocyclina* aus dem Eozän von Venezuela. Schweiz. Paleont. Abh. 63, 1–17.

— 1946: Zur Neudefinition von *Pliolepidina*. Eclogae geol. Helv. 39, 373–379.

— 1950: *Tremastegina*, ein neues Genus der Familie Asterigerinidae d'Orbigny. Eclogae geol. Helv. 43, 255–265.

BRÖNNIMANN, P. & RIGASSI, D. 1963: Contribution to the geology of the area of the City of Habana, Cuba, and its surroundings. Eclogae geol. Helv. 56, 193–481.

BUTTERLIN, J. 1956: La constitution géologique et la structure des Antilles. Edit. Paris, Centr. Nat. Res. Sci. 433.

— 1968: Données fournies par les macro-foraminifères pour l'établissement des limites de l'Oligocène dans la région des Caraïbes. Trans. 4th Carib. Geol. Conf., Trinidad & Tobago 1965. 183–188.

— 1970: Foraminíferos y edad de la Formación Punta Mosquito (Grupo Punta Carnero) de la isla de Margarita. Bol. inform. Asoc. venez. Geol. Min. Petr. 13, 273–315.

— 1971: Contribution à la connaissance du Paléogène marin du Nord-ouest de la Colombie, basée sur les macroforaminifères, Eclogae geol. Helv. 64, 13–17.

— 1976: Biostratigraphie de divèrses localités du Crétacé supérieur et du Tertiaire de la région des Caraïbes, basée sur les macroforaminifères. 3rd Congr. Latinamer. Geol., Acapulco 1976 (preliminary copy).

— 1977: Problèmes concernant la répartition stratigraphique et les relations phylétiques de macroforaminifères du Paléocène de la région des Caraïbes. Mem. segundo Congr. Latinamer. Geol., Caracas 1973. 3, 1367–1379.

— 1987: Origine et évolution des Lepidocyclines de la région des Caraïbes. Comparaisons et relation avec les lépidocyclines des autres régions du Monde. Rev. Micropaleont. 29, 203–219.

BUTTERLIN, J. & BONET, F. 1960a: Répartition stratigraphique de *Operculina catenula* Cushman & Jarvis dans le bassin des Caraïbes. Somm. séances Soc. Géol. France 1960. 1, 14.

— 1960b: Microfauna del Eoceno inferior de la Peninsula de Yucatán. Univ. Nac. Aut., Mexico, Pal. Mexicana. 7, 1–18.

CAUDRI, C.M. BRAMINE 1934: Tertiary deposits of Soemba. Ph.D. thesis, Leyden Univ., 1–224.

— 1944: The larger foraminifera from San Juan de los Morros, State of Guárico, Venezuela. Bull. amer. Paleont. 28/114, 355–404.

— 1948: Note on the stratigraphic distribution of *Lepidorbitoides*. J. Paleont. 22, 473–481.

— 1961: Some remarks on the ferrugenous interval in the Eocene section of Humocaro Bajo, Lara (Venezuela). Bol. inform. Asoc. venez. Geol. Min. Petr. 4, 285–287.

— 1972a: Systematics of the American Discocyclinas. Eclogae. geol. Helv. 65, 211–219.

— 1972b: The larger foraminifera of the Scotland District of Barbados. Eclogae geol. Helv. 65, 221–234.

— 1974: The Larger Foraminifera of Punta Mosquito, Margarita Island, Venezuela. Verh. natf. Ges. Basel 84, 293–318.

— 1975: Geology and Paleontology of Soldado Rock, Trinidad (West Indies), Part 2: The larger foraminifera. Eclogae geol. Helv. 68, 533–589.

CIZANCOURT, MARIE DE 1948: Nummulites de l'île de la Barbade. Mém. Soc. géol. France, nouv. sér. 27, Mém. 57, 1–40.

— 1951: Grands foraminifères du Paléocène, de l'Eocene inférieur et de l'Eocène moyen du Vénézuéla. Mém. Soc. géol. France, nouv. sér. 30, Mém. 64, 1–68.

CIZANCOURT, MARIE DE & CUVILLIER, J. 1954: Les Nummulites cordelées du Sénégal occidental. C.R.S. Soc. géol. France 7, 131–134.

COLE, W.W. 1929: Three new Claiborne fossils. Bull. amer. Paleont. 15/56, 55–66.

— 1934: Oligocene Orbitoids from near Cuncan Church, Washington county, Florida. J. Paleont. 8, 21–28.

— 1938: Stratigraphy and micropaleontology of two deep wells in Florida. Bull. Florida State geol. Surv. 16, 7–73.

— 1944: Stratigraphic and micropaleontologic studies of wells in Florida, No. 3. Bull. Florida State geol. Surv. 26, 1–168.

— 1945: Stratigraphic and paleontologic studies of wells in Florida, No. 4. Bull. Florida State geol. Surv. 28, 11–160.

— 1949: Upper Eocene larger foraminifera from the Panama Canal zone. J. Paleont. 23, 267–275.

— 1952: Eocene and Oligocene larger foraminifera from the Panama Canal zone and vicinity. Prof. Pap. U.S. geol. Surv. 244, 1–41.

— 1953: Criteria for the recognition of certain assumed Camerinid genera. Bull. amer. Paleont. 35/137, 27–46.

— 1956: Jamaican larger foraminifera. Bull. amer. Paleont. 36/158, 214–233.

— 1957a: Late Oligocene larger foraminifera from Barro Colorado Island, Panama Canal zone. Bull. amer. Paleont. 37/163, 312–338.

— 1957b: Variation in American Oligocene species of *Lepidocyclina*. Bull. amer. Paleont. 38/166, 31–51.

— 1958a: Names of and variation in certain American larger foraminifera, No. 1. Bull. amer. Paleont. 38/170, 179–213.

— 1958b: Larger foraminifera from Carriacou, British West Indies. Bull. amer. paleont. 38/171, 219–233.

— 1958c: Names of and variation in certain American larger foraminifera, particularly the Camerinids, No. 2. Bull. amer. Paleont. 38/173, 261–284.

— 1958d: Names of and variation in certain American larger foraminifera, particularly the Discocyclinids, No. 3. Bull. amer. Paleont. 38/176, 411–429.

— 1959a: Faunal associations and the stratigraphic position of certain American Paleocene and Eocene larger foraminifera. Bull. amer. Paleont. 39/182, 377–393.

— 1959b: *Asterocyclina* from a Pacific seamount, Teamotu Islands. Contr. Cushman Found. foram. Res. 10, 10–14.

— 1960a: Variability in embryonic chambers of *Lepidocyclina*. Micropaleontology 6, 133–144.

— 1960b: The genus *Camerina*. Bull. amer. Paleont. 41/190, 189–205.

— 1960c: Revision of *Helicostegina, Helicolepidina* and *Lepidocyclina (Polylepidina)*. Contr. Cushman Found. foram. Res. 11, 57–63.

— 1961a: Some nomenclatural and stratigraphical problems involving larger foraminifera. Contr. Cushman Found. foram. Res. 12, 136–147.

— 1961b: An analysis of certain taxonomic problems in the larger foraminifera. Bull. amer. Paleont. 43/197, 372–407.

— 1962a: Embryonic chambers and the subgenera of *Lepidocyclina*. Bull. amer. paleont. 44/200, 29–60.

— 1962b: Periembryonic chambers in *Helicolepidina*. Contr. Cushman Found. foram. Res. 13, 145–152.

— 1963: Illustrations of conflicting interpretations of the biology and classification of certain larger foraminifera. Bull. amer. Paleont. 46/205, 5–63.

— 1964a: Family Discocyclinidae Galloway 1928: in Treatise of Invertebrate paleont., edit. R.C. Moore. Geol. Soc. amer. and Univ. Kansas Press, Part C, 2, 712–717.

— 1964b: American Mid-Tertiary Miogypsinid foraminifera, classification and zonation. Contr. Cushman Found. foram. Res. 15, 138–153.

— 1966: Additional comments on the foraminiferal genus *Camerina*. Bull. amer. paleont. 50/228, 229–263.

— 1968: More on variation in the genus *Lepidocyclina*. Bull. amer. Paleont. 54/243, 295–325.

— 1969a: Names of and variation in certain American larger foraminifera, particularly the Eocene Pseudophragminids, No. 4. Bull. amer. Paleont. 56/248, 4–55.

— 1969b: Internal structure, stratigraphic range and phylogenetic relationships of certain American Eocene foraminifera. Contr. Cushman Found. foram. Res. 20, 77–86.

COLE, W.S. & APPLIN, E.R. 1961: Stratigraphic and geographic distribution of larger foraminifera occurring in a well in Coffee County, Georgia. Contr. Cushman Found. foram. Res. 12, 127–135.

— 1964: Problems of the geographic and stratigraphic distribution of American Middle Eocene larger foraminifera. Bull. amer. Paleont. 47/212, 3–48.

COLE, W.S. & BERMUDEZ, P.J. 1944: New foraminiferal genera from the Cuban Middle Eocene. Bull. amer. Paleont. 28/113, 3–20.

— 1947: Eocene Discocyclinidae and other foraminifera from Cuba. Bull. amer. Paleont. 31/125, 191–224.

COLE, W.S. & GRAVELL, D.W. 1952: Middle Eocene foraminifera from Peñon Seep, Matanzas Province, Cuba. J. Paleont. 26, 708–727.

COLE, W.S. & HERRICK, S.M. 1953: Two species of larger foraminifera from Paleocene beds in Georgia. Bull. amer. Paleont. 35/148, 49–62.

CUSHMAN, J.A. 1917: Orbitoid foraminifera of the genus *Orthophragmina* from Georgia and Florida. Prof. Pap. U.S. geol. Surv. 108-G, 115–124.

— 1918: The larger foraminifera of the Panama Canal Zone. Bull. U.S. natl. Mus. 103, 89–102.

— 1919: Fossil foraminifera from the West Indies. Carnegie Inst., Washington D.C. 291, 21–71.

— 1920: The American species of *Orthophragmina* and *Lepidocyclina*. Prof. Pap. U.S. geol. Surv. 125-D, 39–108.

— 1921: American species of *Operculina* and *Heterostegina* and their faunal relation, and a new species of *Orthophragmina* from Louisiana. Prof. Pap. U.S. geol. Surv. 128-E, 125–142.

— 1922: Foraminifera from the Eocene deposits of Peru. In: Bosworth, T.O., Geology of the Tertiary and Quaternary periods in the northwest part of Peru, Macmillan London 1922, 136–139.

CUSHMAN, J.A. & JARVIS, P.W. 1928: Cretaceous foraminifera from Trinidad. Contr. Cushman Lab. foram. Res. 4, 85–103.

— 1929: New foraminifera from Trinidad. Contr. Cushman Lab. foram. Res. 5, 6–17.

— 1932: Upper Cretaceous foraminifera from Trinidad. Proc. U.S. natl. Mus. 80, 1–60.

CUSHMAN, J.A. & RENZ, H.H. 1946: The foraminiferal fauna of the Lizard Springs Formation of Trinidad, B.W.I., Cushman Lab. foram. Res., Spec. Paper 18, 1–48.

— 1947: The foraminiferal fauna of the Sainte Croix Formation, Trinidad, B.W.I. Cushman Lab. foram. Res., Spec. publ. 22, 1–46.

— 1948: Eocene foraminifera of the Navet and Hospital Hill formations of Trinidad, B.W.I. Cushman Lab. foram. Res., Spec. publ. 24, 1–42.

CUSHMAN, J.A. & STAINFORTH, R.M. 1945: The foraminifera of the Cipero marl formation of Trinidad, B.W.I. Cushman Lab foram. Res., Spec. publ. 14, 3–75.

DAVIES, L.M. 1927: The Ranikoth beds at Thal (northwest frontier provinces of India). Quart. J. geol. Soc. London 83, 260–290.

— 1949: *Ranikothalia* in East and West Indies. Geol. Mag. 86, 113–116.

DOUVILLÉ, H. 1915: Les orbitoïdes de l'île de la Trinité. C.R. Acad. France 161, 87–93.

— 1917: Les orbitoïdes de l'île de la Trinité. C.R. Acad. France 164, 841–847.

— 1924: Révision des Lépidocyclines. Mém. Soc. géol. France, nouv. sér. 1, 1–49.

DROOGER, W.W. 1951: Notes on some representatives of *Miogypsinella*. Proc. (K.) nederl. Acad. Wetensch., ser. B, 54, 357–365.

— 1952: Study of American Miogypsinidae. Ph.D. thesis, Utrecht Univ., 1–80.

— 1960: Some early rotalid foraminifera. Proc. (K.) nederl. Acad. Wetensch., ser. B, 63, 287–334.

EAMES, F.E., BANNER, F.T., BLOW, W.H. & CLARKE, W.J. 1962: Fundamentals of Mid-Tertiary stratigraphical correlation. Cambridge Univ. Press, 1–59.

EAMES, F.E. & CLARKE, W.J. 1967: A Paleocene *Heterostegina*. Palaeontology 10, 314–316.

EAMES, F.E., CLARKE, W.J., BANNER, F.T., SMOUT, A.H. & BLOW, W.H. 1968: Some larger foraminifera from the Tertiary of Central America. Palaeontology 11, 283–305.

FROST, S.H. & LANGENHEIM JR., R.L. 1974: Cenozoic reef biofacies, Tertiary larger foraminifera and scleractinian corals from Chiapas, Mexico. Northern Illinois Univ. Press, DeKalb, Illinois, 3–388.

GALLOWAY, J.J. 1928: Notes on the genus *Polylepidina* and a new species. J. Paleont. 1, 299–303.

GEYN, W.A.E. VAN DE & VLERK, I.M. VAN DER 1935: A monograph on the Orbitoididae occurring in the Tertiary of America (compiled in connection with the examination of a collection of larger foraminifera from Trinidad). Leidse geol. Meded. 7, 221–272.

GILL, W.D. 1953: Facies and fauna in the Bhadzar Beds of the Punjab Salt Range, Pakistan. J. Paleont. 27, 824–844.

GLAESSNER, M.F. 1943: Problems of stratigraphic correlation in the Indo-Pacific Region. Proc. Roy. Soc. Victoria 55, 41.

GORTER, NETTIE E. & VLERK, I.M. VAN DER 1932: Larger foraminifera from Falcón (Venezuela). Leidse geol. Meded. 4, 94–122.

GRAVELL, D.W. 1933: Tertiary larger foraminifera of Venezuela. Smithson. misc. Collect. 89/11, 1–44.

GRAVELL, D.W. & HANNA, M.A. 1937: The *Lepidocyclina texana* horizon in the *Heterostegina* zone, Upper Oligocene, of Texas and Louisiana. J. Paleont. 11, 517–529.

— 1938: Subsurface Tertiary zones of correlation through Mississippi, Alabama and Florida. Bull. amer. Assoc. Petroleum Geol. 22, 984–1013.

— 1940: New larger foraminifera from the Claiborne of Mississippi. J. Paleont. 14, 412–416.

GRIMSDALE, T.F. 1941: New species of *Helicostegina* from Soldado Rock. Appendix in VAUGHAN & COLE 1941, 86.

— 1952: Cretaceous and Tertiary foraminifera from the Middle East. Bull. brit. Mus. nat. Hist. 1/8, 223–247.

— 1959: Evolution in the American Lepidocyclinidae. Proc. (K.) nederl. Akad. Wetensch., ser. B, 62, 8–33.

GRIMSDALE, T.F. & Vlerk, I.M. van der 1959: A review of some subgeneric nomenclature among the Lepidocyclinae. Proc. (K.) nederl. Akad. Wetensch., ser. B, 62, 1–7.

GUPPY, R.J.L. 1863: On the occurrence of foraminifera in the Tertiary beds at San Fernando, Trinidad. Trans. Sci. Assoc. Trinidad 1863–66, 1, 11–12.

— 1866: On the relations of the Tertiary formations of the West Indies. Quart. J. geol. Soc. London 22, 570–590.

— 1892: The Tertiary microzoic formations of Trinidad. Quart. J. geol. Soc. London 48, 519–541.

HANZAWA, S. 1937: Notes on some interesting Cretaceous and Tertiary foraminifera from the West Indies. J. Paleont. 11, 110–117.

— 1940: Micropaleontological studies of drill cores from a deep well in Kita-Daito-Zima (North Borodino Island). Jubilee Publ. in Commem. of Prof. H. Yabe's 60th Birthday, 755–802.

— 1962: Upper Cretaceous and Tertiary three-layered larger foraminifera and their allied forms. Micropaleontology 8, 129–186.

HANZAWA, S. & ASANO, K. 1942: Note on some Lepidocyclines from Palmalt, Tamismolon, Vera Cruz, Mexico. J. Geol. & Geogr. Soc. Japan 18, 119–126.

HARRIS, G.D. 1926: Notes on the paleontology. In: Waring, G.A., The geology of the Island of Trinidad, B.W.I. Johns Hopkins Univ., Studies in Geol. 7, 87–112.

HODSON, HELEN 1926: Foraminifera from Venezuela and Trinidad. Bull. amer. Paleont. 12/47, 1–46.

HOFKER SR., J. 1927: The foraminifera of the Siboga Expedition. Siboga Expedition, Monogr. 4/1, 1–78.

— 1932: Une analyse du foraminifère fossil *Orthophragmina advena*. Ann. Protistologie, Paris, 3, 209–215.

— 1933: Foraminifera of the Malay Archipelago. Papers from Dr. Th. Mortensens' Pacific Exp. 1914–1916 62, 71–167.

— 1968: Tertiary foraminifera of Coastal Ecuador. Paleontographica 130, 1–59.

HOTTINGER, L. 1962: Les genres *Operculina* et *Heterostegina* et leur utilité stratigraphique. Extrait du colloque sur le paléogène (Bordeaux, Sept. 1962).

— 1973: Selected Paleogene larger foraminifera. In: Atlas of Paleobiogeogr., 1973, edit. A. Hallam, Elsevier, Amsterdam, 443–452.

HUNTER, V.F. 1974: The Mid-Tertiary stratigraphic unit of the Southern Caribbean Area. Verh. natf. Ges. Basel 84, 172–190.

HUTCHISON, A.G. & TERPSTRA, G.R.J. 1939: A note upon the Biche Quarry limestone, Trinidad. Bull. amer. Assoc. Petroleum Geol. 23, 1242.

JENKINS, D.G. 1964: Panama and Trinidad Oligocene rocks. J. Paleont. 38, 606.

KUGLER, H.G. 1936: Summary digest of the geology of Trinidad. Bull. amer. Assoc. Petroleum Geol. 20, 1439–1453.

— 1953: Jurassic to Recent sedimentary environments in Trinidad. Bull. Assoc. suisse Géol. Ing. Pétrole 20/59, 27–60.

— 1956: Lexique stratigraphique de Trinidad, Amérique Latine. Centre natl. Rech. Sci., Paris, 41–116.

KUGLER, H.G. & CAUDRI, C.M. BRAMINE 1975: Geology and Paleontology of Soldado Rock, Trinidad, West Indies, Part 1: Geology and Biostratigraphy. Eclogae geol. Helv. 68, 365–430.

LIDDLE, R.A. 1928: The geology of Venezuela and Trinidad. edit. P.J. MacGowan, Forth Worth, 1–890.

MAURY, C.J. 1912: A contribution to the paleontology of Trinidad. J. Acad. Nat. Sc. Philadelphia 15, 23–112, including R.M. Bagg's annotations.

— 1925: A further contribution to the paleontology of Trinidad (Miocene fossils). Bull. amer. Paleont. 10/42, 153–402.

NAGAPPA, Y. 1959: Foraminiferal biostratgraphy of the Upper Cretaceous-Eocene succession in the India-Pakistan-Burma region. Micropaleontology 5, 145–192.

NUTTALL, W.L.F. 1926: The zonal distribution of the larger foraminifera in the Eocene of Western India. Geol. Mag. 68, 495–504.

— 1928: Tertiary foraminifera from the Naparima Region, Trinidad, British West Indies. Quart. J. geol. Soc. London 84, 57–115.

— 1930: Eocene foraminifera from Mexico. J. Paleont. 4, 271–293.

— 1932: Lower Oligocene foraminifera from Mexico. J. Paleont. 6, 3–35.

— 1933: Two species of *Miogypsina* from the Oligocene of Mexico. J. Paleont. 7, 175–177.

PALMER, DOROTHY K. 1934: Some large fossil foraminifera from Cuba. Mem. Soc. Cubana Hist. natl. 8, 235–264.

PEIRSON, III, A.L., SALVADOR, A. & STAINFORTH, R.M. 1966: The Guárico Formation of North-Central Venezuela. Bol. inform. Asoc. venez. Geol. Min. Petr. 9, 183–224.

RAADSHOOVEN, B. VAN 1951: On some Paleocene and Eocene larger foraminifera of Western Venezuela. Proc. 3rd World Petroleum Congr., sect. 1, 476–489.

RAHAGHI, A. 1978: Paleocene biostratigraphy of parts of Iran. Nat. Iranian Oil Co., Geol. Lab., Publ. 7, 1–82.

RENZ, H.H. 1942: Stratigraphy of northern South America, Trinidad and Barbados. Proc. 8th amer. Sci. Congr. geol. sci., Washington, 4, 513–571.

ROBINSON, E. 1968a: Stratigraphic ranges of some larger foraminifera in Jamaica. Transact. 4th Carib. Geol. Conf., Port of Spain, Trinidad 1965, 189–194.

— 1968b: Zonation by larger foraminifera of the Cretaceous and Lower Tertiary. Unpublished paper read at the 5th Carib. Geol. Conf., St. Thomas, Virgin Islands 1968. Preprint Univ. of Puerto Rico, 1968 (Abstr. only in the Transact. of the conf., 1971).

ROBINSON, E. & JUNG, P. 1972: Stratigraphy and age of marine rocks, Carriacou, West Indies. Bull. amer. Assoc. Petroleum Geol. 56, 114–127.

RUTSCH, R. 1939: Die Gattung *Tubulostium* im Eocaen der Antillen. Eclogae geol. Helv. 32, 231–244.

— 1943: Die Paläocän Mollusken der Inseln Trinidad und Soldado Rock (B.W.I.). Eclogae geol. Helv. 36, 139–192.

RUTTEN, L. 1928: On Tertiary rocks and foraminifera from Northwestern Peru. Proc. (K.) nederl. Akad. Wetensch. 31, 931–946.

RUTTEN, M.G. 1935a: Larger foraminifera of Northern Santa Clara Province, Cuba. J. Paleont. 9, 527–545.

— 1935b: A note on *Actinosiphon vichayalensis* (Rutten). J. Paleont. 9, 546–547.

SACHS, K.N. 1957: Restudy of some Cuban larger foraminifera. Contr. Cushman Found. foram. Res. 8, 106–120.

— 1959: Puerto Rico Upper Oligocene larger foraminifera. Bull. amer. Paleont. 39/183, 399–416.

SALVADOR, A. 1950: Stratigraphy of the Chejendé region, Venezuela. Ph.D. thesis Stanford Univ.

SAMANTA, B.K. 1963: A new species of *Discocyclina* from the Garo Hills, Assam. Univ. Calcutta, Dept. Geol. Sci. & Cult. 29, 39–40.

SCHENCK, H.G. 1929: *Discocyclina* in California. Trans. San Diego Soc. Nat. Hist. 5, 211–240.

SCHENCK, H.G. & FRIZZELL, D.L. 1936: Subgeneric nomenclature in foraminifera. Amer. J. Sci. 31, 464–466.

SEIGLIE, G.A. 1965: Cuadro preliminiar sobre la distribución estratigráfica de los foraminíferos grandes de Cuba. Lagena, Inst. oceanogr., Univ. Oriente, Venezuela, 7, 23–30.

SENN, A. 1935: Die stratigraphische Verbreitung der tertiären Orbitoiden, mit spezieller Berücksichtigung ihres Vorkommens in Nord-Venezuela und Nord-Marokko. Eclogae geol. Helv. 28, 15–113, 369–373.

SILVESTRI, A. 1924: Fauna paleogenica di Vasciano presso Todi. Bol. Soc. geol. ital. 42, 7–29.

— 1939: Foraminiferi dell'Eoceno della Somalia. Paleontografica ital. 32, suppl. 3, suppl. 4, 93.

STAINFORTH, R.M. 1948a: Description, correlation and paleoecology of the Tertiary Cipero marl Formation, Trinidad, B.W.I. Bull. amer. Assoc. Petroleum Geol. 32, 1292–1330.

— 1948b: Applied micropaleontology in coastal Ecuador. J. Paleont. 22, 113–151.

— 1955: Ages of Tertiary formations in Northwest Peru. Bull. amer. Assoc. Petroleum Geol. 39, 2068–2077.

STRATIGRAPHICAL LEXICON OF VENEZUELA (ENGLISH EDITION) 1956;. Min. Minas e Hidrocarb. Bol. Geol. Special publ. 1, 664.

SUTER, H.H. 1954: The general and economic geology of Trinidad (originally published in 1951–1952, reproduced and amended in 1954). Colon. geol. & min. Resour. 2/3, 177–217; 2/4, 271–307; 3/1, 3–51.

— 1960: The general and economic geology of Trinidad, second edition, with revisionary appendix by G.E. Higgins. Overseas geol. Surv. Min. Resour. Div., 1–134, appendix 135–143.

TAN SIN HOK 1936a: Zur Kenntnis der Miogypsiniden. De Ing. in nederl.-Indië 4, Mijnb. en Geol., De Mijning. 3, 45–61.

— 1936b: Beitrag zur Kenntnis der Lepidocycliniden. Proc. (K.) nederl. Akad. Wetensch. 39, 990–999.

— 1936c: Zur Kenntnis der Lepidocycliniden. Natkd. Tijdschr. nederl.-Indië 96, 235–280.

— 1936d: *Lepidocyclina zeijlmansi* nov. spec., eine polylepidine Orbitoidide von Zentral-Borneo, nebst Bemerkungen über die verschiedenen Einteilungsweisen der Lepidocyclinen. De Ing. in nederl.-Indië, Mijnb. en Geol., De Mijning. 3, 7–14.

— 1939: On *Polylepidina, Orbitocyclina* and *Lepidorbitoides*. De Ing. in nederl.-Indië, Mijnb. en Geol., De Mijning. 6, 53–84.

THALMANN, H.E. 1932: Das Vorkommen der Gattung *Miogypsina* Sacco 1893 in Ost-Mexiko. Eclogae geol. Helv. 25, 282–286.

— 1935: Liste der Foraminiferen von der Typus-Lokalität der miozänen Tuxpan-Stufe, Ciudad de Tuxpan, Veracruz, Mexiko. Eclogae geol. Helv. 28, 602–605.

TOBLER, A. 1922a: Die Jackson-Stufe (Priabonien) in Venezuela and Trinidad. Eclogae geol. Helv. 17, 342–346.

— 1922b: *Helicolepidina*, ein neues Subgenus von *Lepidocyclina*. Eclogae geol. Helv. 17, 380–384.

TODD, J.U. & BARKER, W.R. 1932: Tertiary Orbitoids from Northwest Peru. Geol. Mag. 69, 529–543.

VAUGHAN, T.W. 1924: American and European Tertiary larger foraminifera. Bull. geol. Soc. Amer. 35, 785–822.

— 1926: Species of *Lepidocyclina* and *Carpenteria* from the Cayman Islands. Quart. J. geol. Soc. London 82, 388–400.

— 1927a: Larger Foraminifera of the genus *Lepidocyclina* related to *Lepidocyclina mantelli*. Proc. U.S. natl. Mus. 71, 1–5.

— 1927b: Notes on the types of *Lepidocyclina mantelli* (Morton) Gümbel and on topotypes of *Nummulites floridanus* Conrad. Proc. Acad. Sc. Philadelphia 79, 299–303.

— 1928a: New species of *Operculina* and *Discocyclina* from the Ocala limestone. Ann. Florida State geol. 19, 155–165.

— 1928b: Species of large arenaceous and orbitoidal foraminifera from the Tertiary deposits of Jamaica. J. Paleont. 1, 277–298.

— 1929a: Description of new species of foraminifera of the genus *Discocyclina* from the Eocene of Mexico. Proc. U.S. natl. Mus. 76, 1–18.

— 1929b: *Actinosiphon semmesi*, a new genus and species of *orbitoidal* foraminifera, and *Pseudorbitoides trechmanni* H. Douvillé. J. Paleont. 3, 163–169.

— 1929c: Species of *Orbitocyclina*, a genus of American orbitoidal foraminifera from the Upper Cretaceous of Mexico and Louisiana. J. Paleont. 3, 170–175.

— 1929d: Studies of orbitoidal foraminifera: the subgenus *Polylepidina* of *Lepidocyclina*, and *Orbitocyclina*, a new genus. Proc. Nat. Acad. of Sci. 15, 288–295.

— 1933a: Studies of American species of foraminifera of the genus *Lepidocyclina*. Smithson. misc. Coll. 89, 1–53.

— 1933b: Report on species of corals and larger foraminifera collected in Cuba by O.E. MEINZER. J. Washington Acad. Sci. 23, 252–355.

— 1936: *Helicolepidina nortoni*, a new species of foraminifera from a deep well in St. Landry Parish, Louisiana. J. Paleont. 10, 248–252.

— 1937: The Tertiary larger foraminifera of Southwest Ecuador. In: Sheppard, G., The Geology of Southwestern Ecuador, edit. Thomas Murby & Co. London, 150–175.

— 1945: American Paleocene and Eocene larger foraminifera: Part 1: Paleocene and Eocene larger foraminifera from Barbados; Part 2: Catalogue of American Discocyclinidas. Mem. geol. Soc. Amer. 9, 1–175.

VAUGHAN, T.W. & COLE, W.S. 1936: New Tertiary foraminifera of the genus *Operculina* and *Operculinoides* from North America and the West Indies. Proc. U.S. natl. Mus. 83, 487–496.

— 1941: Preliminary report on the Cretaceous and Tertiary larger foraminifera of Trinidad, British West Indies (with an appendix on new species of *Helicostegina* from Soldado Rock by THOMAS F. GRIMSDALE). Geol. Soc. Amer. Spec. paper 30, 1–137.

VLERK, I.M. VAN DER 1955: Correlation of the Tertiary of the Far East and Europe. Micropaleontology 1, 72–75.

VOORTHUYSEN, J.H. VAN 1969: Holocene and Paleocene foraminifera of the boring Alliance-28 in Surinam (Dutch Guiana). Geol. en Mijnb. 48, 135–161.

WALL, G.P. & SAWKINS, J.G. 1860: Report on the geology of Trinidad. Mem. geol. Survey, Part 1: West Indian Survey, 211.

WARING, G.A. 1926: The geology of the Island of Trinidad, B.W.I. Johns Hopkins Univ., Studies in Geol. 7, 1–181.

WONG, T.E. 1976: Tertiary Stratigraphy and Micropaleontology of the Guiana Basin. Meded. geol. Mijnb. Dienst, Suriname 25, 13–107.

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Plate 1

Fig. 1	*Operculina bontourensis* Caudri, n. sp., holotype Point Bontour, St. 63, C 36023, × 10.	p. 1185
Fig. 2	*Operculina bontourensis* Caudri, n. sp. Farallon Rock, C 36024, × 10.	p. 1185
Fig. 3–4	*Operculina bontourensis* Caudri n. sp. Point Bontour, St. 63, C 36025, × 17.	p. 1185
Fig. 5	*Operculinoides suteri* Caudri, n. sp., holotype Calyx 59, 390–400 feet, C 35961, × 17.	p. 1189
Fig. 6–8	*Operculinoides suteri* Caudri, n. sp. San Fernando Railway Station, C 36026–36028 (Fig. 6–8), × 17.	p. 1189
Fig. 9	*Heterostegina indicata* Caudri, n. sp. Morne Roche Quarry, K.S. 167, C 35964, × 17	p. 1193
Fig. 10	*Heterostegina indicata* Caudri, n. sp., holotype Morne Roche Quarry, K.S. 167, C 35965, × 17.	p. 1193

Plate 1

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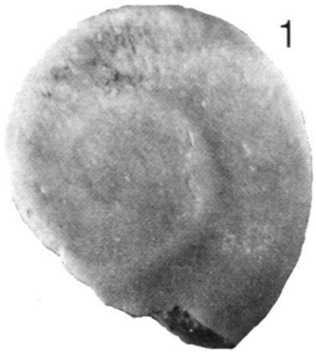

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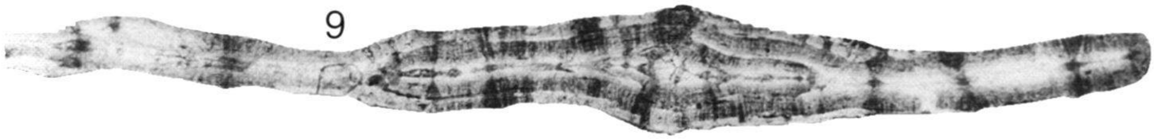

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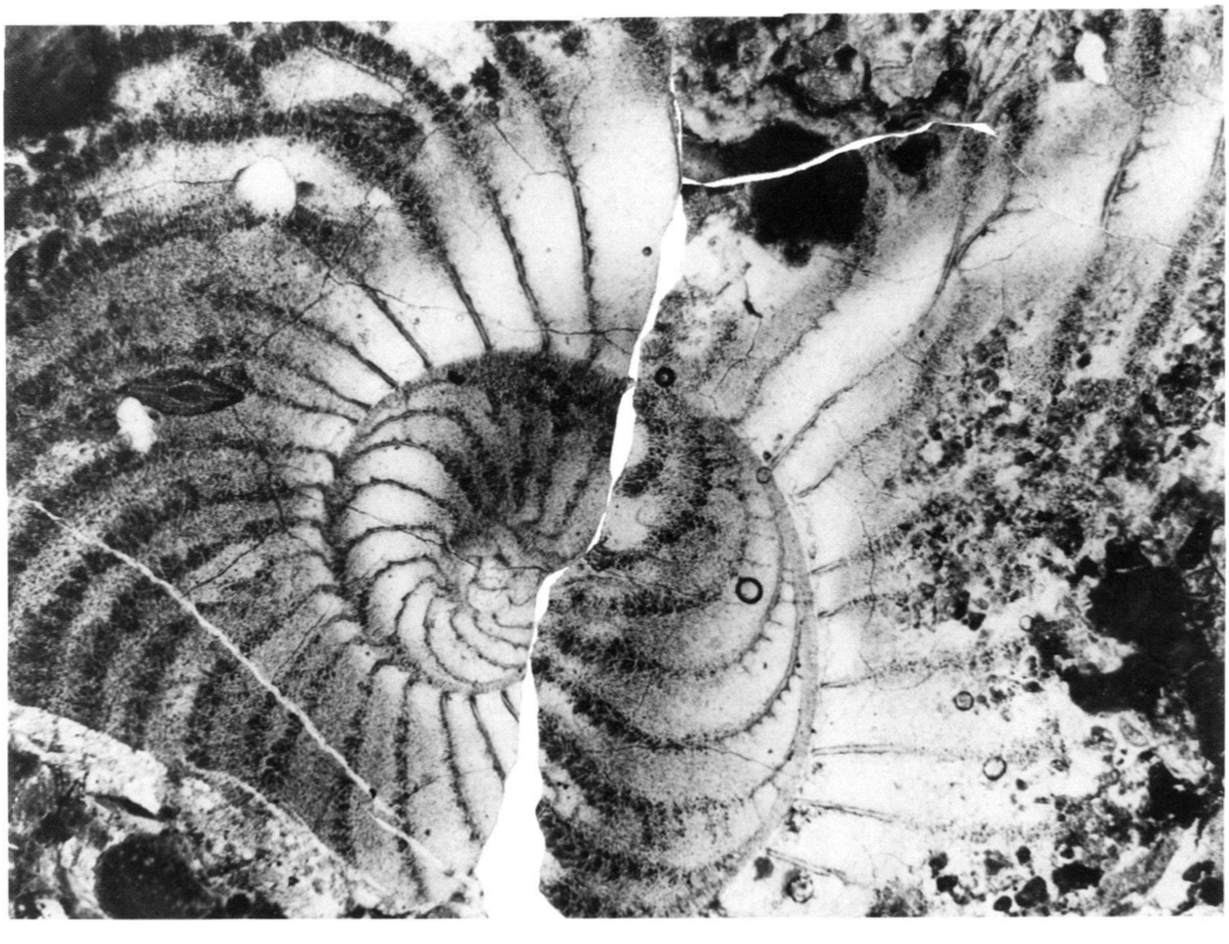
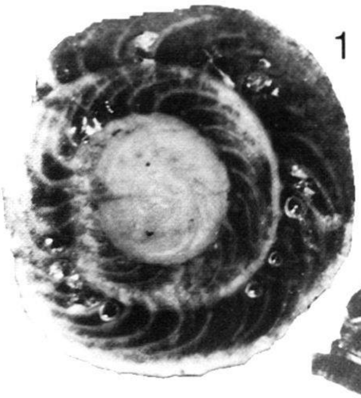


Plate 2

Fig. 1	*Amphistegina farallonensis* Caudri, n. sp., holotype Farallon Rock, S.L. 99, C 35945, × 30.	p. 1235
Fig. 2	*Amphistegina farallonensis* Caudri, n. sp. Farallon Rock, S.L. 99, C 35946, × 30.	p. 1235
Fig. 3	*Helicolepidinoides intermedius* Caudri, n. sp. Point Bontour, St. 68, C 36075, × 30.	p. 1231
Fig. 4	*Helicolepidinoides intermedius* Caudri, n. sp., B-form Vistabella Quarry, coll. Lehner 1933, C 36073, × 30.	p. 1231
Fig. 5	*Helicolepidinoides intermedius* Caudri, n. sp. broken specimen showing the alar prolongations (no lateral chambers), Farallon Rock, coll. Stainforth, Renz & Rutsch 1939, C 36072, × 30.	p. 1231
Fig. 6	*Helicolepidinoides intermedius* Caudri, n. sp. axial section, Farallon Rock, same locality, C 36037, × 30.	p. 1231
Fig. 7	*Helicolepidinoides intermedius* Caudri n. sp. A-form, holotype, Point Bontour, St. 68, C 36038, × 30.	p. 1231
Fig. 8	*Helicolepidinoides intermedius* Caudri, n. sp. tangential section, Point Bontour, St. 68, C 36074, × 30.	p. 1231
Fig. 9–10	*Helicolepidina polygyralis* Barker N.W. Colombia, Province of Bolivar, v.S. 795 Middle Eocene (introduced for comparison with *Helicolepidinoides intermedius*), C 36035 (Fig. 9), C 36036 (Fig. 10), × 30.	
Fig. 11	*Eoconuloides senni* var. *conicus* Caudri, n. var., holotype Charuma, A.E.G. 3635B, C 36032, × 30.	p. 1230
Fig. 12	*Lepidocyclina (Polylepidina) nitida* Caudri, n. sp., holotype Farallon Rock, coll. Stainforth, Renz & Rutsch 1939, C 35930, × 30.	p. 1215
Fig. 13	*Lepidocyclina* (*Polylepidina*) *nitida* Caudri, n. sp. with slightly conical equatorial layer, Farallon Rock, S.L. 99, C 36034, × 30.	p. 1215
Fig. 14	*Lepidocyclina asterocolumnata* Caudri, n. sp., holotype Cipero coast, Grimsdale 2, C 36060, × 17.	p. 1229

Plate 2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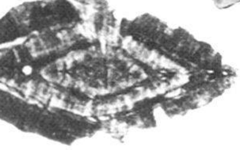
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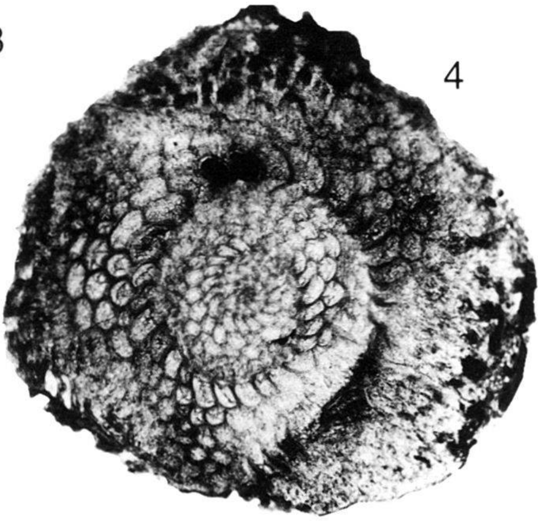
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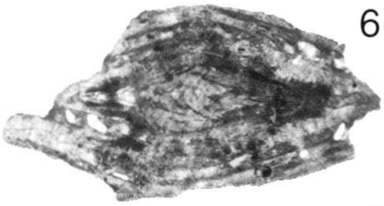
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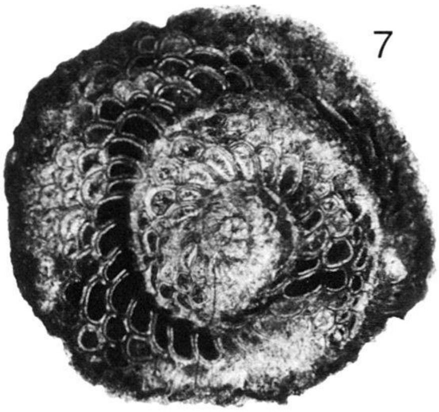
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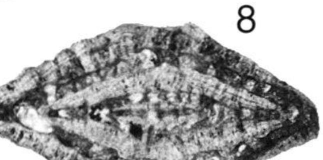
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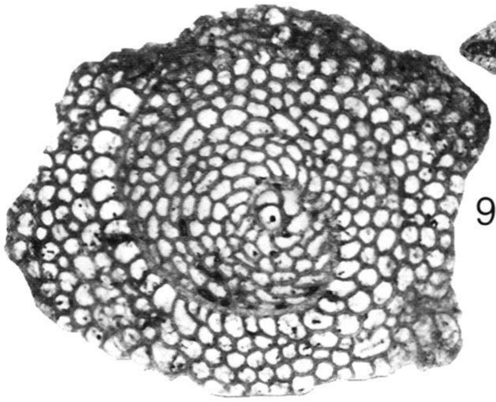
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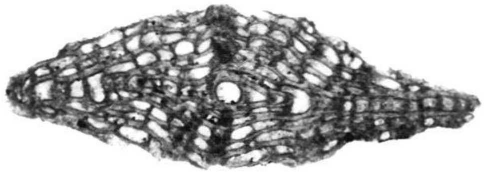
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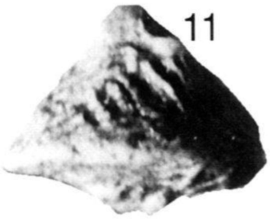
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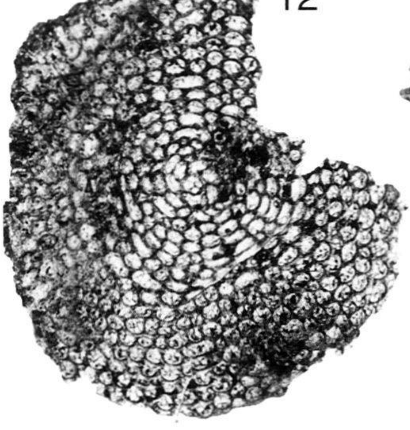
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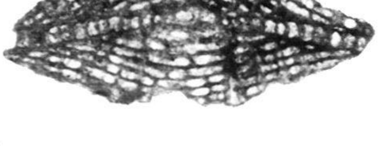
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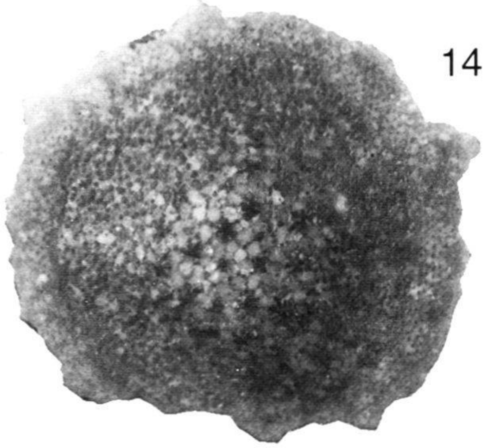
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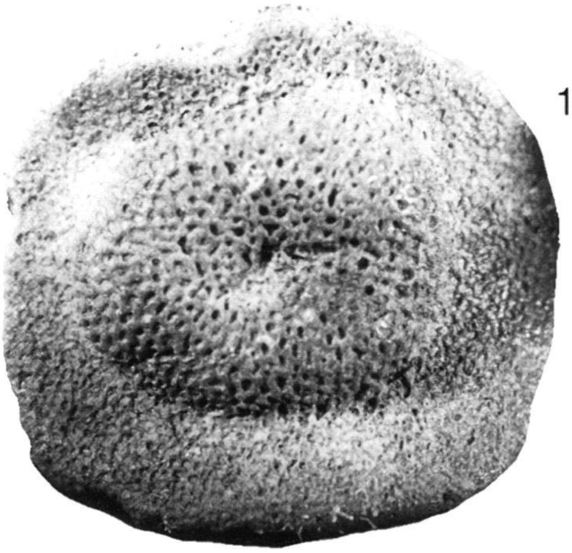
Plate 3

Fig. 1	*Lepidocyclina sanfernandensis* var. *depressata* Caudri, n. var. holotype, Cipero coast, C.S. 11, C 35998, × 8.	p. 1223
Fig. 2	*Lepidocyclina sanfernandensis* var. *depressata* Caudri, n. var. Cipero coast, C.S. 11, C 35999, × 17.	p. 1223
Fig. 3	*Lepidocyclina* cf. *supera* (Conrad), large variety ground down to equatorial layer (see Fig. 5), Cipero coast, Grimsdale 2, C 36062, × 17.	p. 1226
Fig. 4	*Operculinoides ocalanus* var. *decoratus* Caudri, n. var. holotype, Point Bontour, St. 68, C 36030, × 17.	p. 1187
Fig. 5	*Lepidocyclina* cf. *supera* (Conrad), large variety (see Fig. 3), Cipero coast, Grimsdale 2, C 36062, × 17.	p. 1226
Fig. 6	*Lepidocyclina yurnagunensis* var. *inflata* Caudri, n. var. holotype, Cipero coast, Grimsdale 2, C 35972, × 17.	p. 1221
Fig. 7	*Lepidocyclina sanfernandensis* var. *depressata* Caudri, n. var. Cipero coast, C.S. 11, C 36076, × 17.	p. 1223

Plate 3



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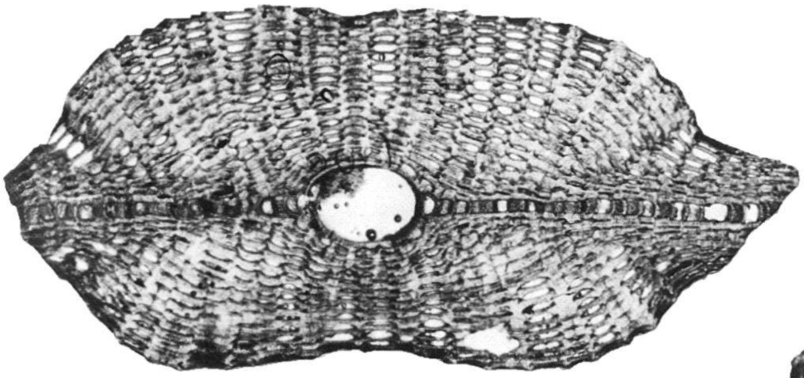

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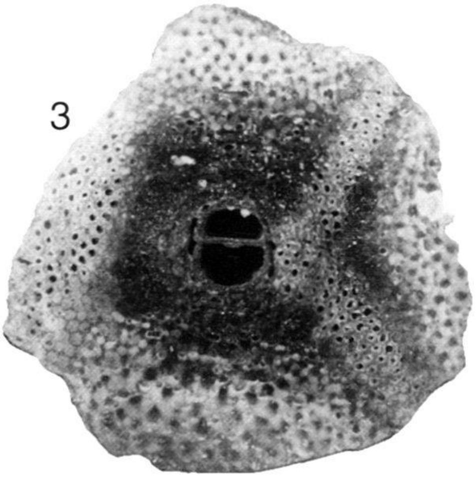

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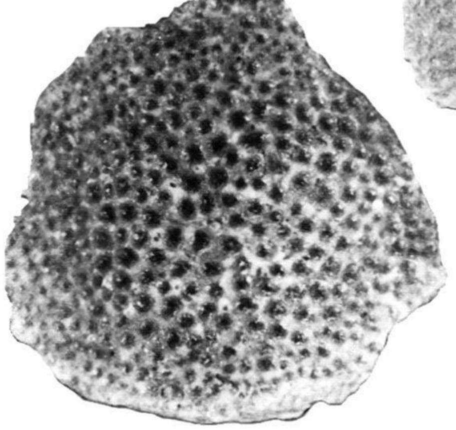

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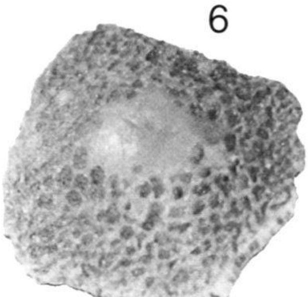

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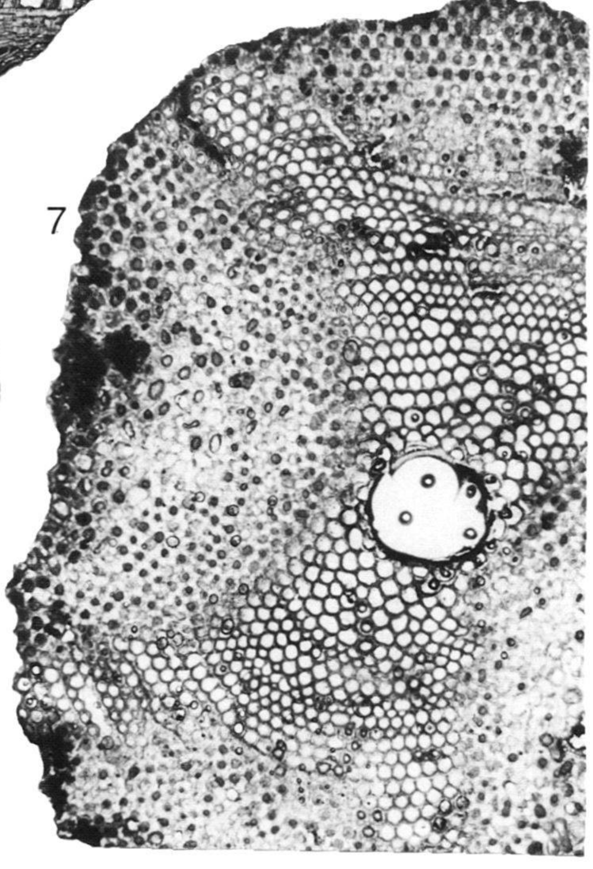

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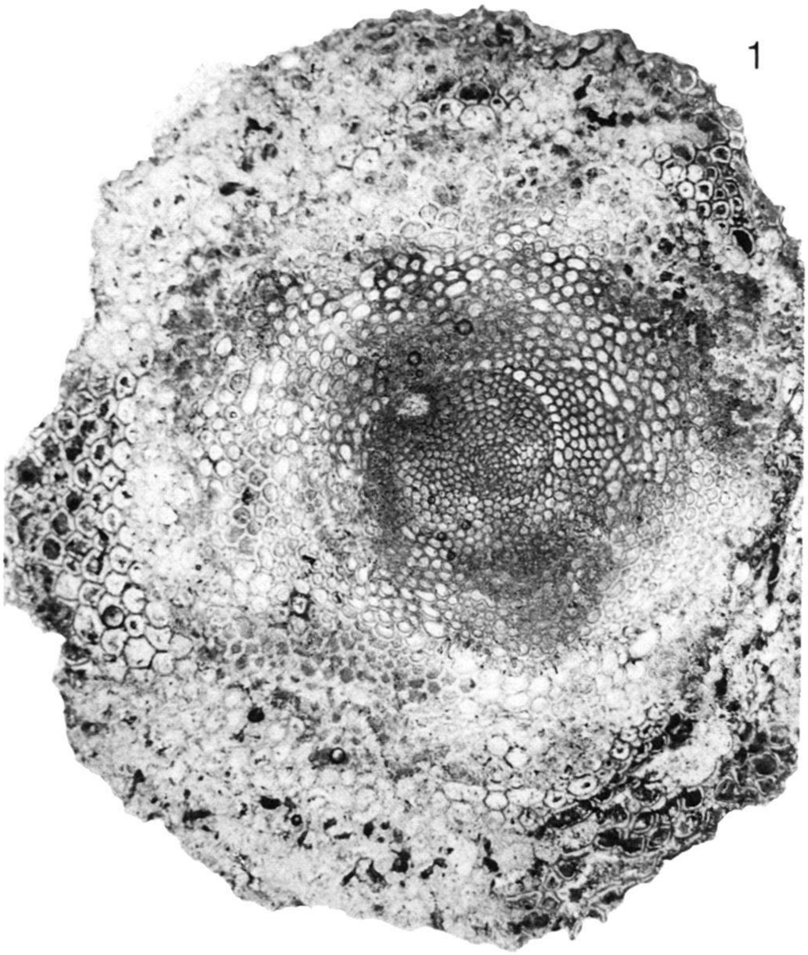
Plate 4

Fig. 1	*Helicolepidina spiralis* Tobler, B-form section exactly through the spiral of the nepiont (same specimen as Pl. 15:11), Point Bontour, St. 63, C 35925, × 17.	p. 1233
Fig. 2	*Helicolepidina spiralis* Tobler, B-form section through the trochoid level of the nepiont (compare with Pl. 15:11), Soldado Rock, K. 3677, C 31172, × 50.	p. 1233
Fig. 3	*Hexagonocyclina meandrica* Caudri Soldado Rock, K. 2951, C 31148, × 50.	p. 1202

Plate 4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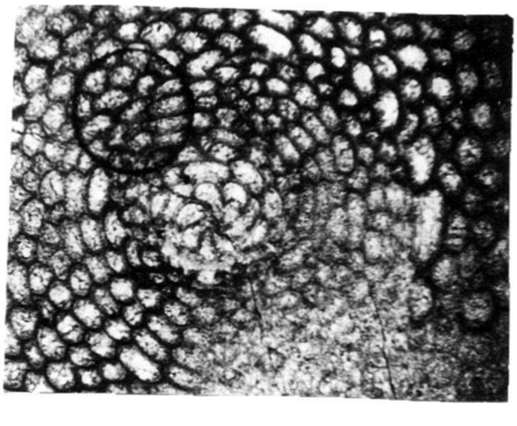
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Plate 5

Fig. 1	*Ranikothalia antillea* (Hanzawa) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 2	*Ranikothalia antillea* (Hanzawa) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 3	*Ranikothalia tobleri* (Vaughan & Cole) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 4	*Ranikothalia soldadensis* (Vaughan & Cole) juvenile specimen, Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1185
Fig. 5	*Operculinoides ocalanus* (Cushman) Vistabella area, St. 45, C 31249, × 17.	p. 1187
Fig. 6	*Operculinoides soldadensis* Vaughan & Cole Soldado Rock, K. 3692, C 31180, × 17.	p. 1187
Fig. 7	*Operculina bontourensis* var. *ornata* Caudri, n. var., holotype Point Bontour, St. 63, C 36045, × 17.	p. 1187
Fig. 8	*Operculinoides spiralis* Caudri Point Bontour, St. 46, C 31251, × 17.	p. 1189
Fig. 9	*Operculinoides kugleri* Vaughan & Cole Point Bontour, St. 63, C 36039, × 17.	p. 1188
Fig. 10	*Operculinoides semmesi ciperensis* Vaughan & Cole Cipero Coast, Cd. 26, C 35954, × 17.	p. 1191
Fig. 11	*Operculinoides trinitatensis* (Nuttall) Soldado Rock, K. 2855, C 31131, × 17.	p. 1188
Fig. 12	*Operculinoides bullbrooki* Vaughan & Cole juvenile form (or *cojimarensis*), Morne Diablo Quarry, K.S. 122, C 35952, × 17.	p. 1191
Fig. 13	*Nummulites striatoreticulatus* (Rutten) small specimen, Point Bontour, St. 63, C 36041, × 17.	p. 1192
Fig. 14	*Operculinoides semmesi* Vaughan & Cole Morne Diablo Quarry, K.S. 122, C 35955, × 17.	p. 1190
Fig. 15	*Operculinoides bullbrooki* Vaughan & Cole Morne Diablo Quarry, E.L. 1178, C 36054, × 17.	p. 1191

Plate 5

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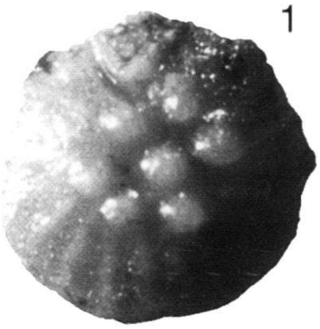

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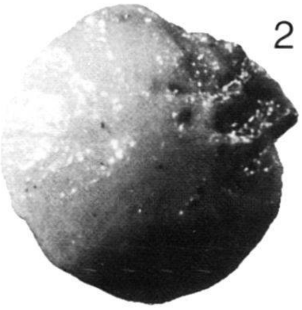

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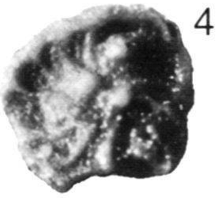

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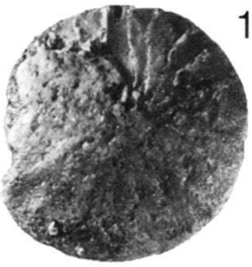

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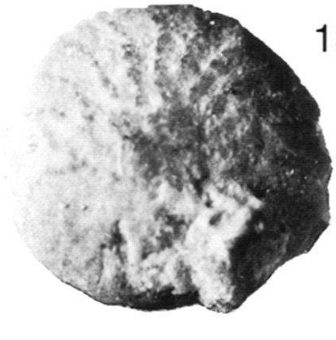

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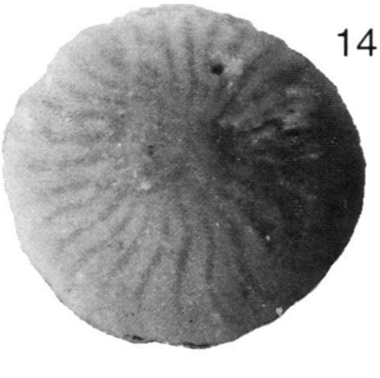

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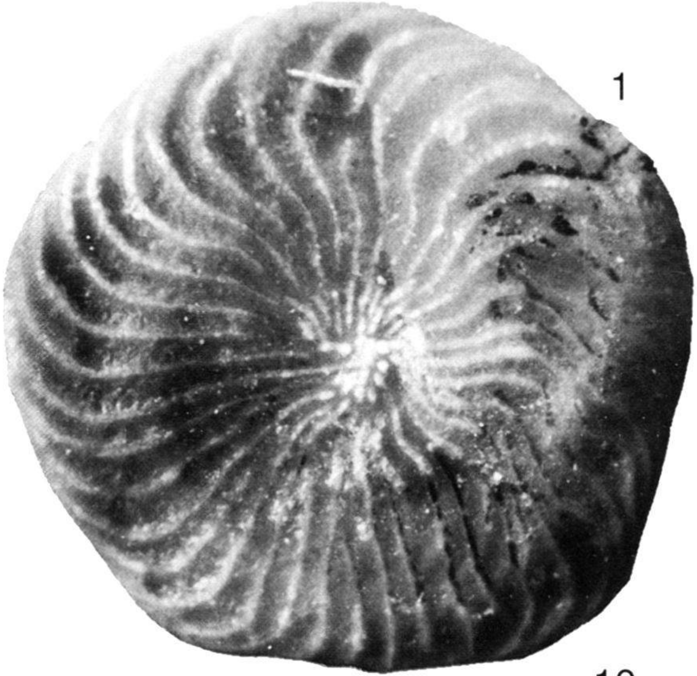
Plate 6

Fig. 1	*Operculinoides tuxpamensis* (Thalmann) Cole (no central plug), Biche Quarry, C 35958, × 17.	p. 1192
Fig. 2	*Operculinoides tamanensis* Vaughan & Cole (topohyle) Tamana-Carmichael Road, K.R. 7541, C 36046, × 17	p. 1192
Fig. 3–7	*Asterocyclina asterisca* (Guppy), A-forms Soldado Rock, Bed 9a, C 31124 (Fig. 3), C 31123 (Fig. 4), C 31064 (Fig. 5), C 31063 (Fig. 6), C 31065 (Fig. 7), × 9.	p. 1207
Fig. 8	*Asterocyclina asterisca* (Guppy), B-form Soldado Rock, Bed 9a, C 31129, × 9.	p. 1207
Fig. 9	*Hexagonocyclina inflata* Caudri, holotype Point Bontour, St. 63, × 17.	p. 1203
Fig. 10	*Lepidocyclina pustulosa* (H. Douvillé) s. l. common eroded form (after Vaughan & Cole 1941), Soldado Rock, K. 2854, U.S.N.M. Washington, × 17.	p. 1218
Fig. 11	*Hexagonocyclina meandrica* Caudri Soldado Rock, Bed 3, K. 2950, C 31132, × 17.	p. 1202
Fig. 12	*Lepidocyclina peruviana* Cushman Soldado Rock, K. 1500, C 31077, × 17.	p. 1217
Fig. 13	*Helicolepidina spiralis* Tobler with radiating rows of lateral chambers near edge, Point Bontour, St. 63, C 36052, × 17.	p. 1233
Fig. 14	*Asterocyclina soldadensis* Caudri Navette area, R.M. 1337, C 35947, × 17.	p. 1209

Plate 6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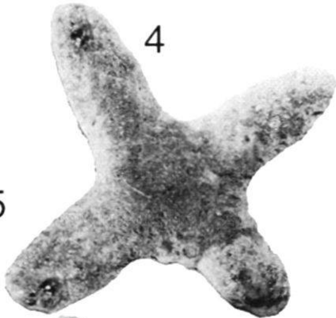
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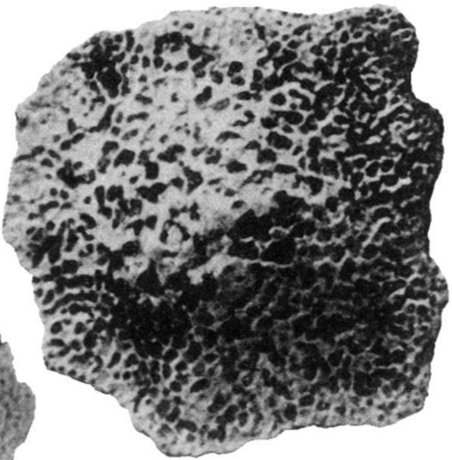
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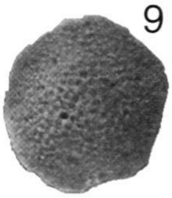
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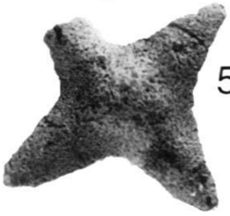
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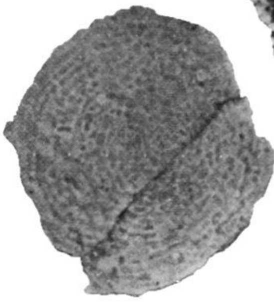
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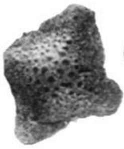
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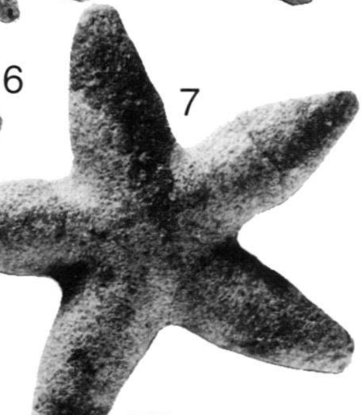
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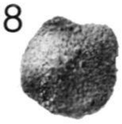
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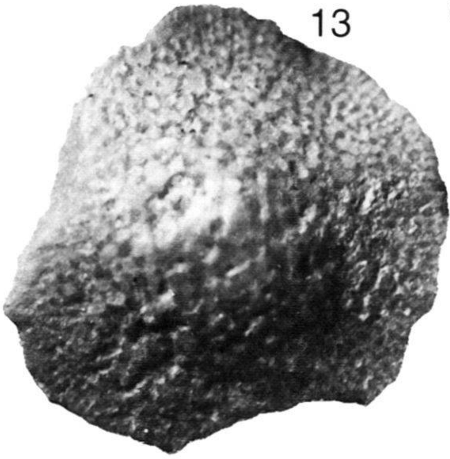
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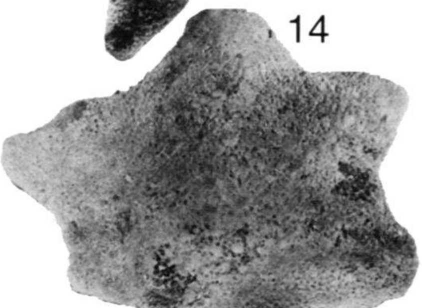
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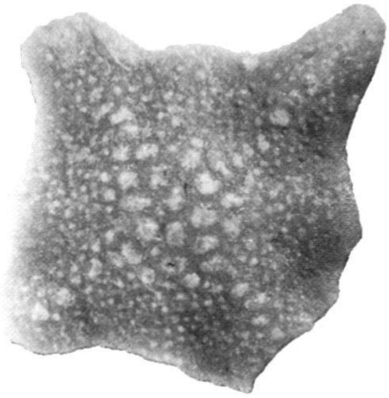
Plate 7

Fig. 1	*Asterocyclina (Miogypsina) vaughani* (Cushman) Vistabella, Schlumberger office section, St. 148, C 35951, × 17.	p. 1208
Fig. 2	*Lepidocyclina yurnagunensis* Cushman Common A-form, Cipero Coast, Grimsdale 2, C 35966, × 17.	p. 1220
Fig. 3	*Lepidocyclina tempanii* Vaughan & Cole Charuma, A.E.G. 4567, C 35975, × 17.	p. 1222
Fig. 4	*Lepidocyclina spatiosa* Caudri, B-form Navette area, R.M. 1337, C 36069, × 9.	p. 1220
Fig. 5	*Lepidocyclina yurnagunensis* Cushman, B-form Vistabella, E.L. 1207, C 35969, × 17.	p. 1220
Fig. 6	*Lepidocyclina subglobosa* Nuttall intact specimen, Vistabella, E.L. 1435, C 35973, × 17.	p. 1221
Fig. 7	*Lepidocyclina subglobosa* Nuttall common eroded form, Point Bontour, St. 79, C 36022, × 17.	p. 1221
Fig. 8	*Lepidocyclina pancanalis* Vaughan & Cole Charuma, A.E.G. 1820, C 35993, × 17.	p. 1227
Fig. 9	*Lepidocyclina spatiosa* Caudri, A-form Navette area, R.M. 1337, C 31259, × 9.	p. 1220
Fig. 10	*Lepidocyclina giraudi* R. Douvillé Morne Diablo Quarry, K. coll. 12-1-41 (photographed specimen lost, replaced by one from K.S. 21), C 36021, × 9.	p. 1228
Fig. 11	*Lepidocyclina forresti* Vaughan pillarless variety, Morne Diablo Quarry, K.S. 70, C 36003, × 9.	p. 1226

Plate 7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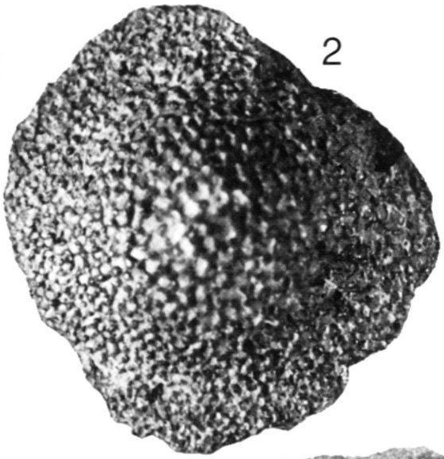
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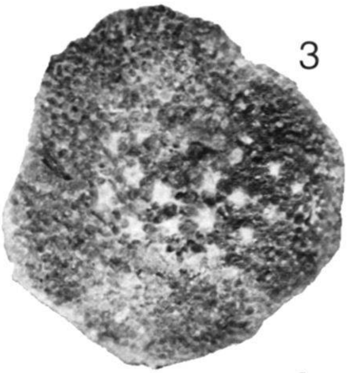
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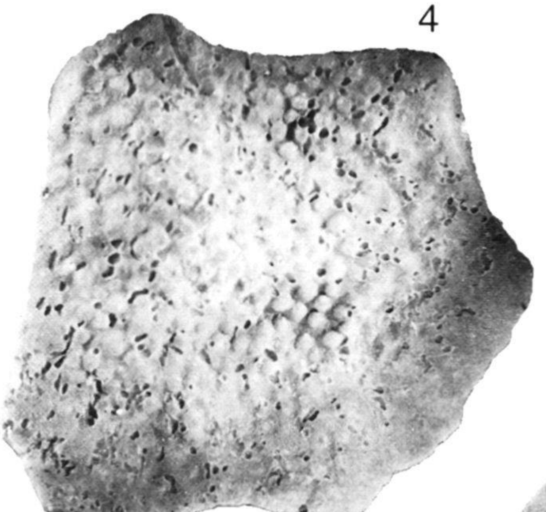
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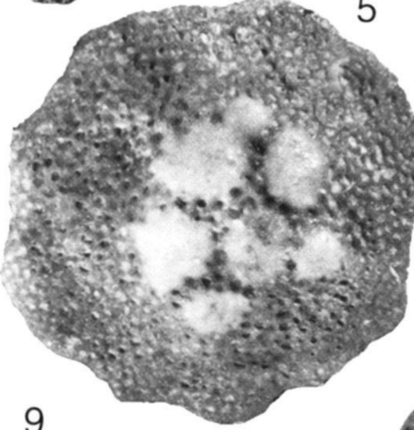
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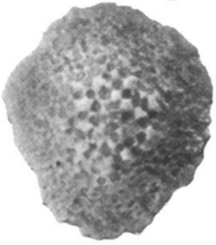
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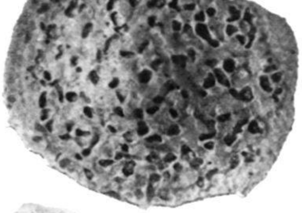
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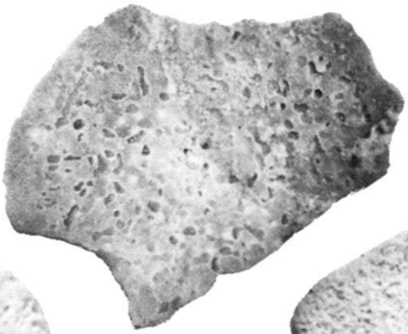
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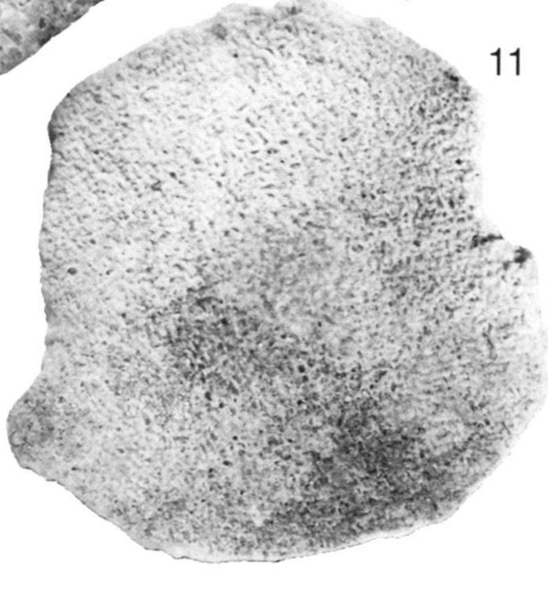
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Plate 8

Fig. 1	*Miogypsina* (*Miogypsina*) *gunteri* Cole Kapur Quarry, Lz. 3473, C 35916, × 17.	p. 1236
Fig. 2	*Miogypsina* (*Miolepidocyclina*) *staufferi* Koch A-form, Morne Diablo Quarry, K. 2668, C 35918, × 17.	p. 1237
Fig. 3	*Miogypsina* sp., B-form (with colony of Bryozoa attached to the surface) Morne Diablo Quarry, K.S. 70, C 35922, × 17.	
Fig. 4	*Miogypsina* (*Miogypsina*) *bramletti* Gravell Morne Diablo Quarry, K.S. 19b, C 36019, × 17.	p. 1237
Fig. 5	*Miogypsina* (*Miogypsina*) *hawkinsi* Hodson Morne Diablo Quarry, K. coll. 12-1-41, C 35917, × 17.	p. 1236
Fig. 6	*Heterostegina antillea* Cushman Moruga River District, BB. 5958, C 36015, × 17.	
Fig. 7	*Spiroclypeus bullbrooki* Vaughan & Cole Marac River, K. 482, C 36049, × 14.	p. 1193
Fig. 8	*Planorbulinella trinitatensis* (Nuttall) Morne Diablo Quarry, K.S. 70, C 36055, × 17.	p. 1237
Fig. 9–10	*Planorbulinella trinitatensis* (Nuttall) both sides of same specimen, Biche Quarry, C 36051, × 17.	p. 1237
Fig. 11	*Sorites* sp. edge, Sainte Croix Quarry, C 36043, × 60.	p. 1237
Fig. 12	*Sorites* sp. eroded surface, Sainte Croix Quarry, C 36043, × 60.	p. 1237
Fig. 13	*Cycloloculina jarvisi* Cushman Soldado Rock, K. 3692 (same specimen as Pl. 29:3), C 31049, × 17.,	
Fig. 14	*Amphistegina pregrimsdalei* Caudri Farallon Rock, C 35944, × 30.	p. 1234
Fig. 15	*Amphistegina grimsdalei* Caudri, common form Soldado Rock, K. 3677, C 31173, × 30.	p. 1234
Fig. 16	*Amphistegina grimsdalei* Caudri flat flaring form, Soldado Rock, K. 3677, C 31089, × 30.	p. 1234
Fig. 17	*Helicosteginopsis soldadensis* (Grimsdale) Soldado Rock, K. 2651, C 31090, × 30.	p. 1235
Fig. 18	*Eoconuloides senni* (Cushman) Calyx 50A, 194–199 feet, C 36012, × 30.	p. 1230
Fig. 19	*Helicocyclina paucispira* (Barker & Grimsdale) Vistabella Estate, E.L. 1435, C 35940, × 30.	p. 1236

Plate 8

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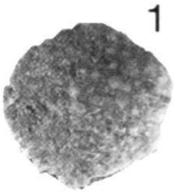

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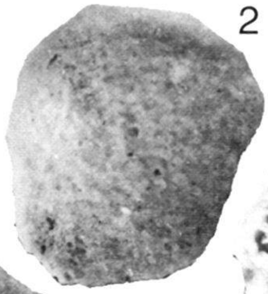

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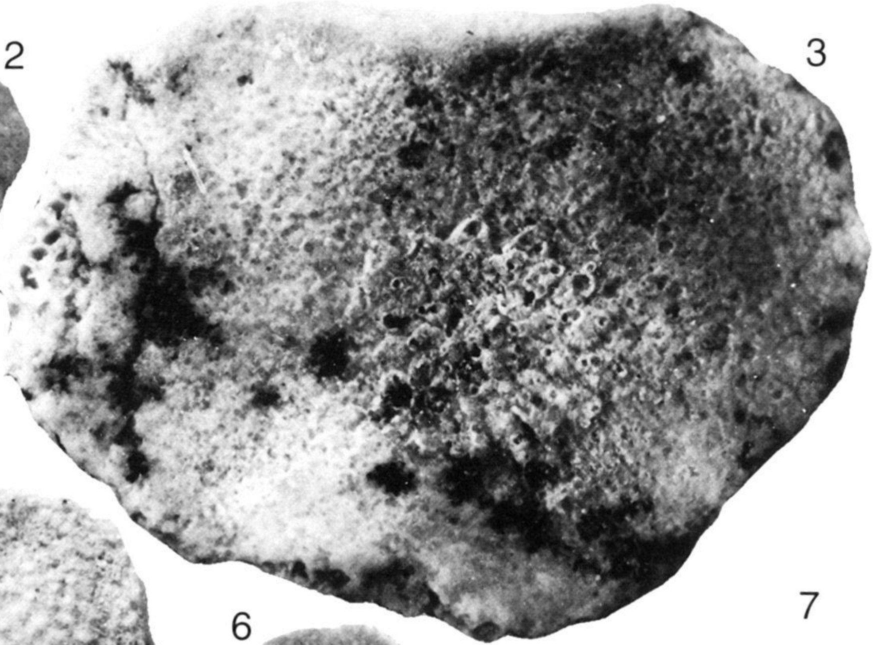

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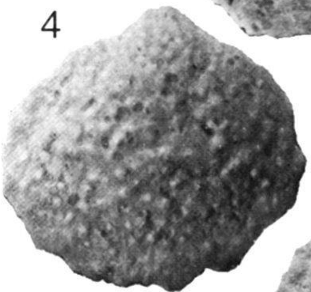

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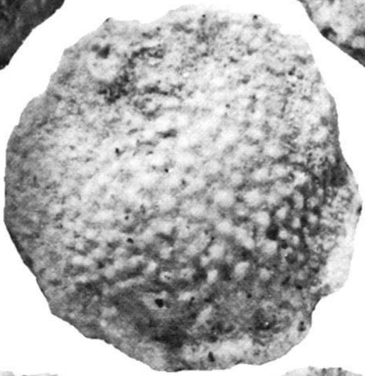

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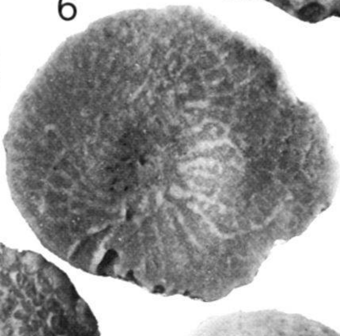

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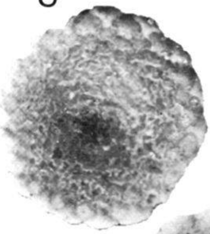

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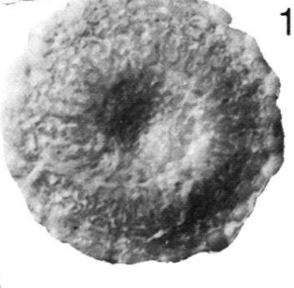

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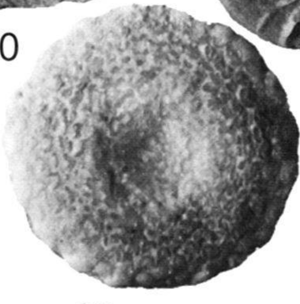

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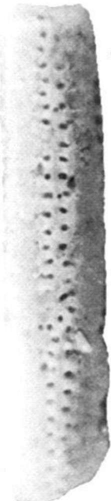

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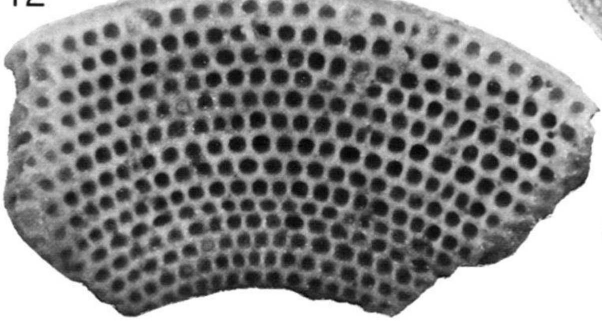

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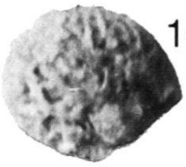

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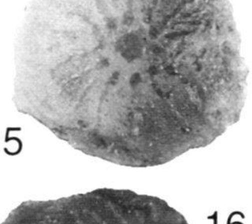

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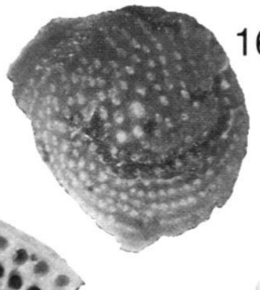

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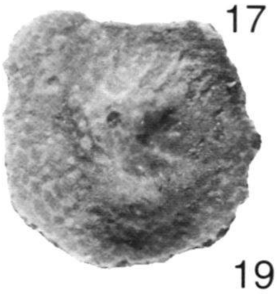

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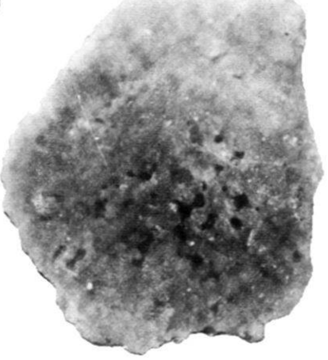
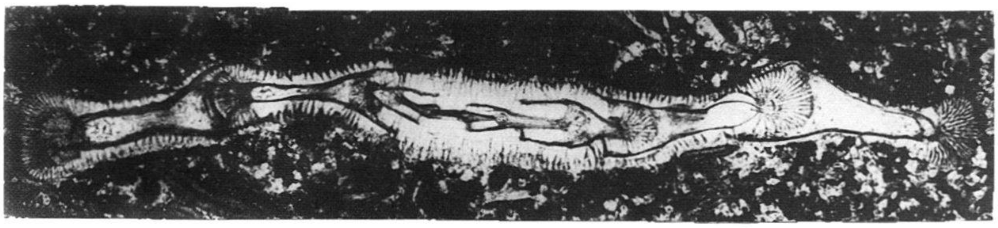


Plate 9

Fig. 1	*Ranikothalia soldadensis* (Vaughan & Cole) vertical section in rock matrix, Soldado Rock, Rz. 248, C 31227, × 9.	p. 1185
Fig. 2	*Ranikothalia tobleri* (Vaughan & Cole), B-form Dunmore Hill, R.M.C. 2907 (reworked), Collection Shell in the Hague, × 17.	p. 1183
Fig. 3	*Operculina bontourensis* Caudri, n. sp. Point Bontour, St. 63 (reworked), C 36078, × 17.	p. 1185
Fig. 4	*Ranikothalia tobleri* (Vaughan & Cole), A-form canal system showing, boulder in Stollmeyer Quarry, Grimsdale 43, × 17.	p. 1183
Fig. 5	*Ranikothalia tobleri* (Vaughan & Cole) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 6	*Ranikothalia antillea* (Hanzawa) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 7	*Ranikothalia antillea* (Hanzawa) Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1183
Fig. 8	*Ranikothalia antillea* (Hanzawa) (reworked), Point Bontour, Cd. 18, × 17.	p. 1183
Fig. 9	*Ranikothalia antillea* (Hanzawa) (reworked), Point Bontour, St. 85, × 17.	p. 1183
Fig. 10	*Operculina bontourensis* Caudri, n. sp. (reworked), Point Bontour, St. 63, × 17.	p. 1185
Fig. 11	*Operculinoides ocalanus* (Cushman) Hanzawa Vistabella area, St. 45, C 31250, × 17.	p. 1187
Fig. 12	*Operculinoides ocalanus* (Cushman) Hanzawa Soldado Rock, J.S. 1950, C 31246, × 17.	p. 1187
Fig. 13	*Operculinoides ocalanus* (Cushman) Hanzawa Point Bontour, St. 63, C 36033, × 17.	p. 1187
Fig. 14	*Operculinoides soldadensis* Vaughan & Cole Soldado Rock, K. 3692, C 31179, × 17.	p. 1187
Fig. 15	*Operculinoides soldadensis* Vaughan & Cole Soldado Rock, J.S. 1950, C 31244, × 17.	p. 1187
Fig. 16	*Operculinoides trinitatensis* (Nuttall) granulated form, Soldado Rock, K. 2855, C 31126, × 17.	p. 1188
Fig. 17	*Operculinoides trinitatensis* (Nuttall) smooth form, Point Bontour, St. 63, C 31253, × 17.	p. 1188
Fig. 18	*Operculinoides spiralis* Caudri, holotype Soldado Rock, K. 2651, C 31092, × 17.	p. 1189

Plate 9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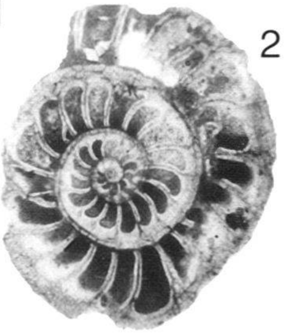
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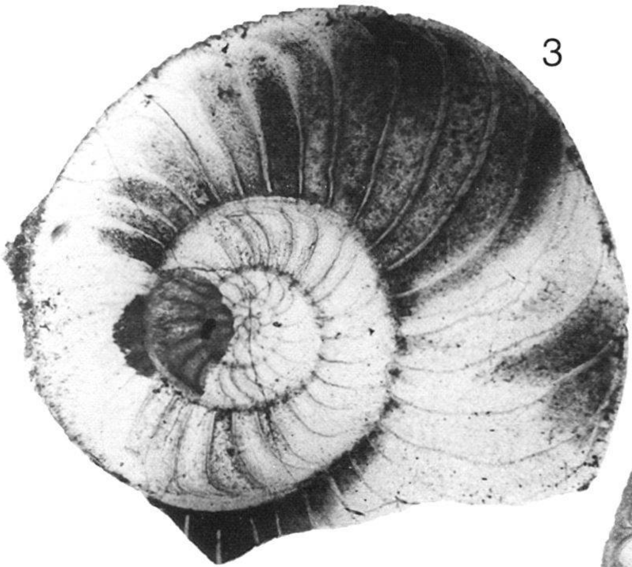
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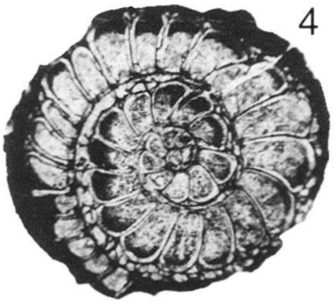
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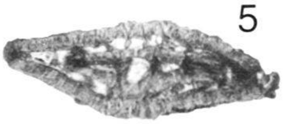
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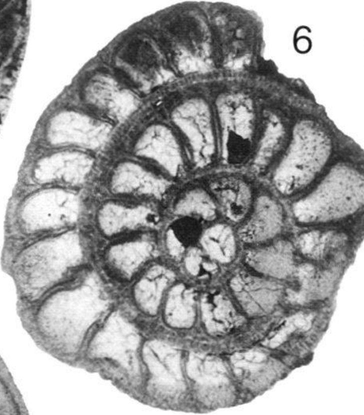
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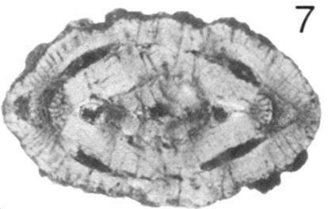
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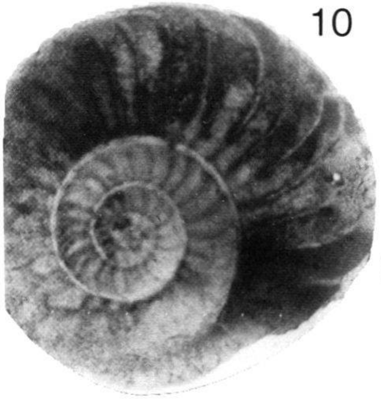
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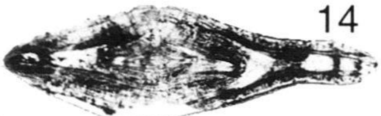
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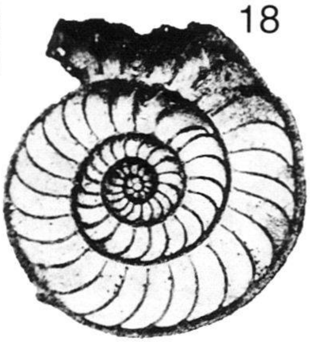
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Plate 10

Fig. 1	*Operculinoides kugleri* Vaughan & Cole Point Bontour, St. 63, C 36040, × 17.	p. 1188
Fig. 2	*Nummulites striatoreticulatus* (Rutten) Point Bontour, St. 63, C 35962, × 17.	p. 1192
Fig. 3	*Operculinoides kugleri* Vaughan & Cole Point Bontour, St. 63, C 36085, × 17.	p. 1188
Fig. 4	Random section through the *Operculina*-limestone on the Coora-Quinam Road, including one of the rare Lepidocyclinas, C 36071, × 9.	
Fig. 5–6	*Operculinoides semmesi* Vaughan & Cole Morne Diablo Quarry, K. 2667, C 35957 (Fig. 5), C 36086 (Fig. 6), × 17.	p. 1190
Fig. 7–9	*Operculinoides semmesi ciperensis* Vaughan & Cole Cipero Coast, Cd. 26, C 35956 (Fig. 7), C 36129 (Fig. 8), C 36130 (Fig. 9), × 17.	p. 1190
Fig. 10–12	*Operculinoides cojimarensis* (Palmer), B-form Morne Diablo Quarry, K.S. 122, C 36031 (Fig. 10), C 36087 (Fig. 11), C 36088 (Fig. 12), × 17.	p. 1191
Fig. 13–14	*Operculinoides bullbrooki* Vaughan & Cole Morne Diablo Quarry, E.L. 1178, C 35953 (Fig. 13), C 36126 (Fig. 14), × 17.	p. 1191
Fig. 15–17	*Planorbulinella trinitatensis* (Nuttall) Biche Quarry, C 36057 (Fig. 15), C 36056 (Fig. 16), C 36127 (Fig. 17), × 17.	p. 1237
Fig. 18	*Orbitolina*-limestone Quinam, Hg. 769, C 36070, × 9.	
Fig. 19	*Operculinoides suteri* Caudri, n. sp. exceptionally large specimen, San Fernando Railway Station, Cd. 208, C 36029, × 17.	p. 1189

Plate 10


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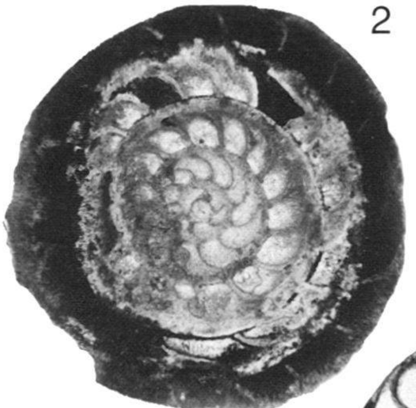
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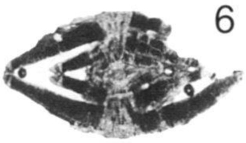
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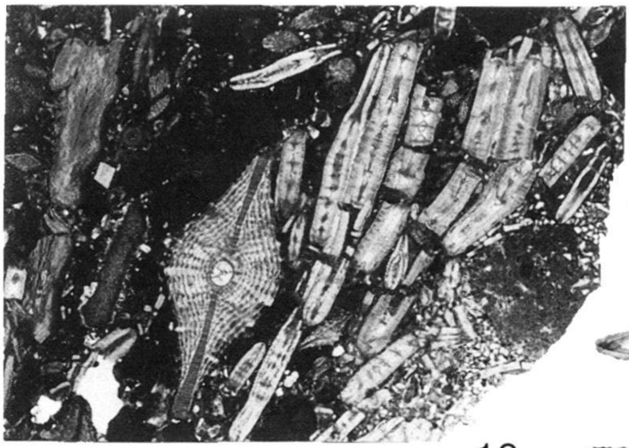
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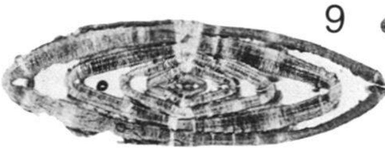
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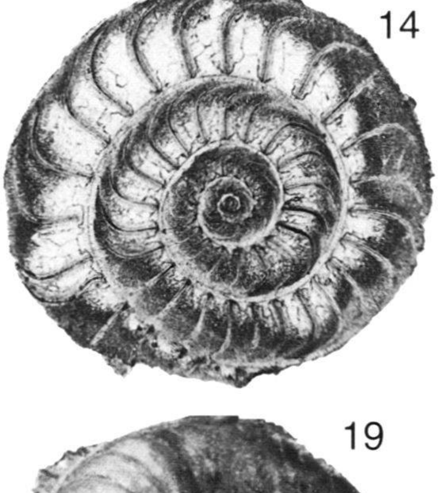
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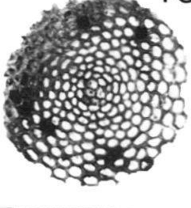
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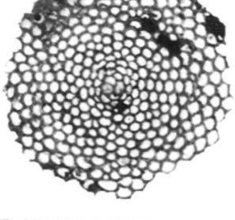
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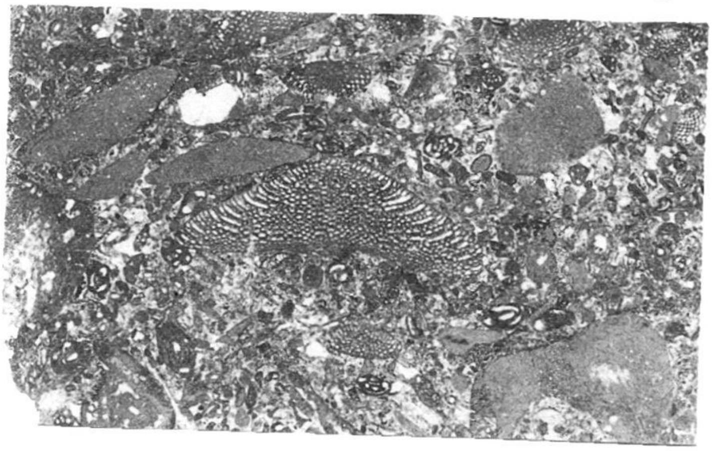
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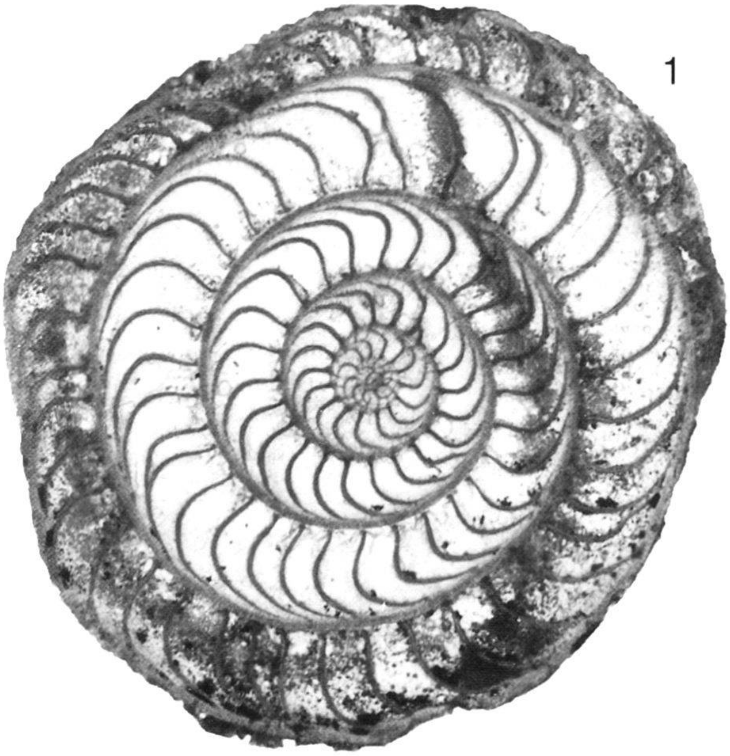
Plate 11

Fig. 1	*Operculinoides tuxpamensis* (Thalmann) Cole Biche Quarry, C 36058, × 17.	p. 1192
Fig. 2	*Operculinoides tamanensis* Vaughan & Cole, topohyle Central Range, Tamana-Carmichael Road, K.R. 7541, C 36047, × 17.	p. 1192
Fig. 3–4	*Operculinoides tuxpamensis* (Thalmann) Cole without central plug, Biche Quarry, C 35959 (Fig. 3), C 36059 (Fig. 4), × 17.	p. 1192
Fig. 5–6	*Operculinoides tamanensis* Vaughan & Cole topohyle, with central plug, Tamana-Carmichael Road, K.R. 7541, C 36048 (Fig. 5), C 36090 (Fig. 6), × 17.	p. 1192
Fig. 7	*Operculinoides tamanensis* Vaughan & Cole topohyle, with heterosteginoid subdivisions, Tamana-Carmichael Road, K.R. 7541, C 36089, × 17.	p. 1192
Fig. 8	*Heterostegina antillea* Cushman Charuma, A.E.G. 5183A, C 35963, × 17.	

Plate 11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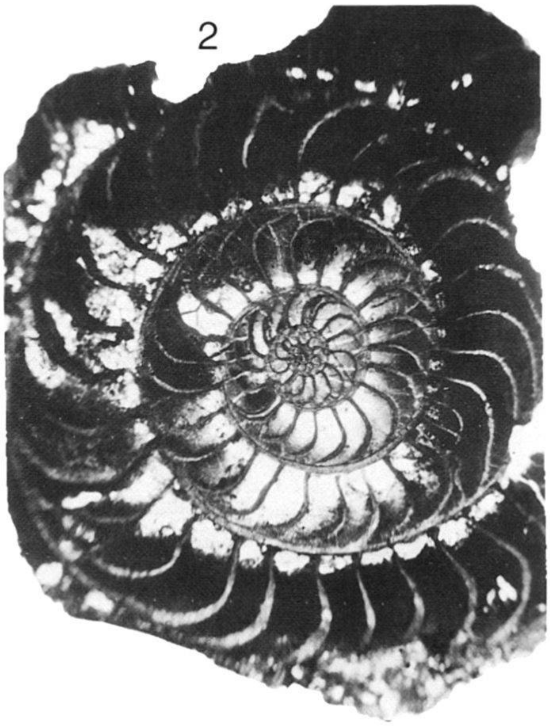
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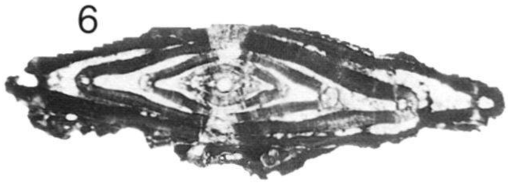
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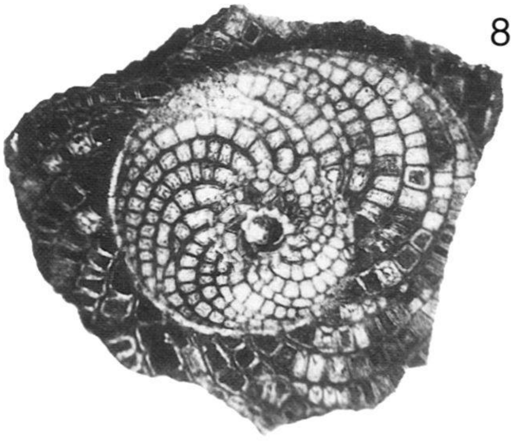
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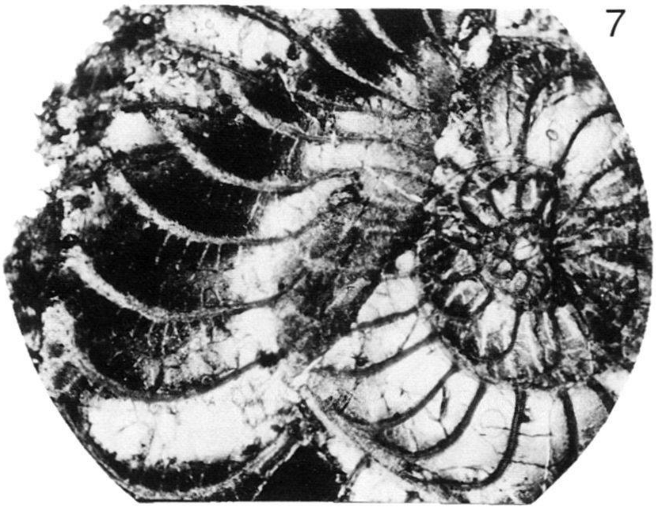
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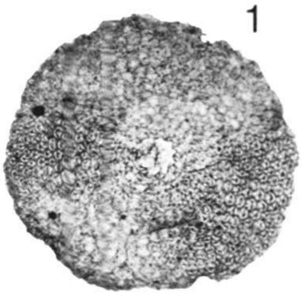
Plate 12

Fig. 1	*Actinosiphon barbadensis* (Vaughan) Point Bontour, St. 63 (reworked), C 31255, × 34.	p. 1210
Fig. 2	*Neodiscocyclina fonslacertensis* (Vaughan) Lizard Springs, Mky 102b III, U.S.N.M., Washington, × 34.	p. 1204
Fig. 3	*Hexagonocyclina inflata* Caudri Point Bontour, St. 67 (reworked), C 31256, × 34.	p. 1203
Fig. 4	*Hexagonocyclina inflata* Caudri, holotype Point Bontour, Cd. 18 (reworked), after Caudri 1948, Pl. 74:5, × 34.	p. 1203
Fig. 5	*Hexagonocyclina inflata* Caudri Point Bontour, Cd. 18 (reworked), after Caudri 1948, Pl. 73:6, × 34.	p. 1203
Fig. 6	*Neodiscocyclina aguerreverei* (Caudri) Point Bontour, Cd. 18 (reworked), C 36009, × 34.	p. 1203
Fig. 7	*Neodiscocyclina grimsdalei* (Vaughan & Cole) Soldado Rock, K. 2950, U.S.N.M., Washington, × 34.	p. 1203
Fig. 8	*Neodiscocyclina anconensis* (Barker) Biche Calyx 50A, 232–233 feet, C 36008, × 34.	p. 1204
Fig. 9	*Hexagonocyclina meandrica* Caudri Lizard Springs, Mky 102b III, U.S.N.M., Washington, ¥ 34.	p. 1202
Fig. 10	*Hexagonocyclina meandrica* Caudri Soldado Rock, K. 2950, C 31134, × 34.	p. 1202
Fig. 11	*Neodiscocyclina barkeri* (Vaughan & Cole) Soldado Rock, K. 2951, C 31146, × 34.	p. 1205
Fig. 12	*Stenocyclina* sp. (fragment) Dunmore Hill, Ha. 215, C 36068 (different fragment), × 34.	
Fig. 13	*Neodiscocyclina anconensis* (Barker) Biche Calyx 50A, 232–233 feet, C 36091, ¥× 34.	p. 1204
Fig. 14–15	*Neodiscocyclina caudriae* (Vaughan) Lizard Springs, Mky 102b III, U.S.N.M., Washington, × 36.	p. 1205
Fig. 16	*Neodiscocyclina barkeri* (Vaughan & Cole) with polygonal equatorial arrangement, Soldado Rock, K. 2951, C 31137, × 34.	p. 1205
Fig. 17	*Neodiscocyclina anconensis* (Barker) Biche Calyx 50A, 232–233 feet, C 36092, × 34.	p. 1204

Plate 12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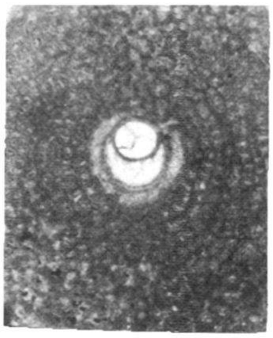
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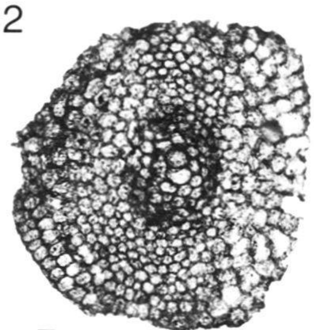
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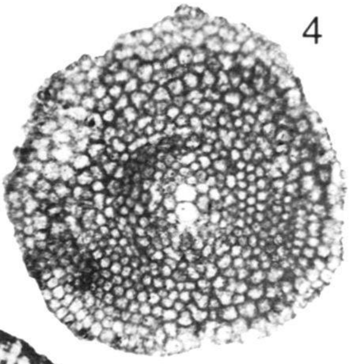
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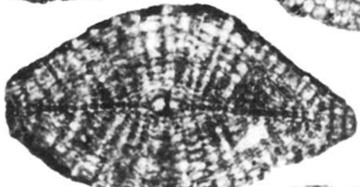
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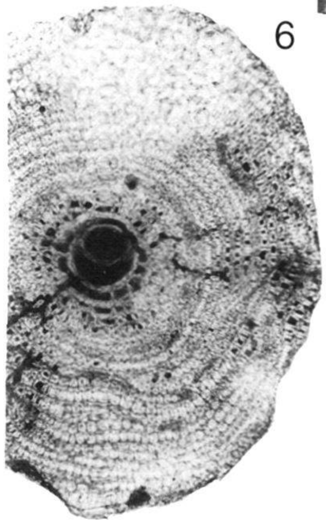
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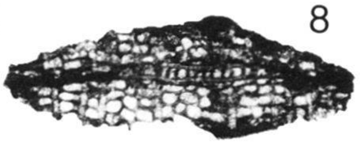
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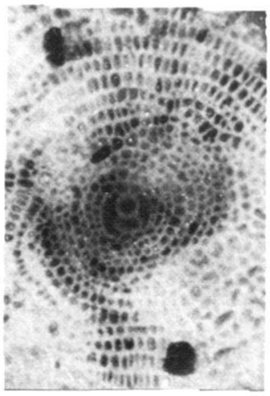
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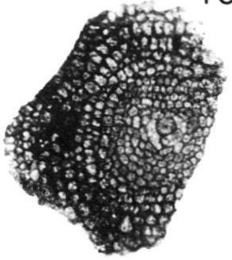
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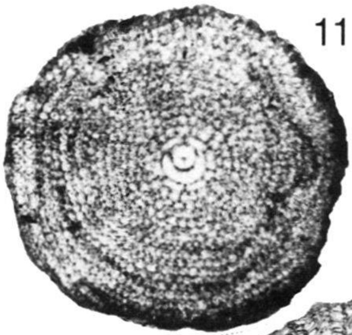
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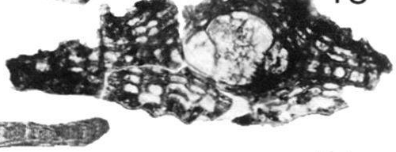
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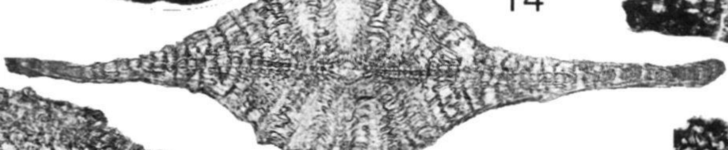
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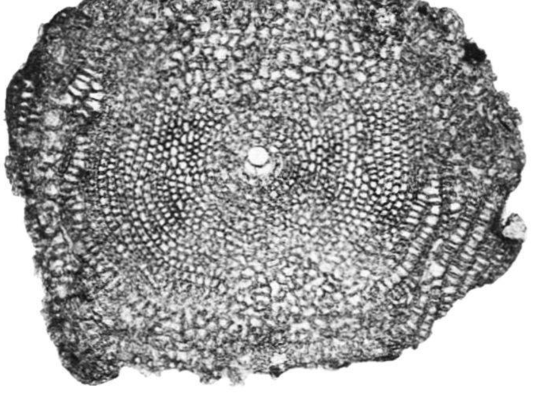
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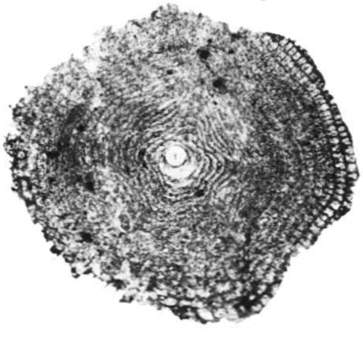
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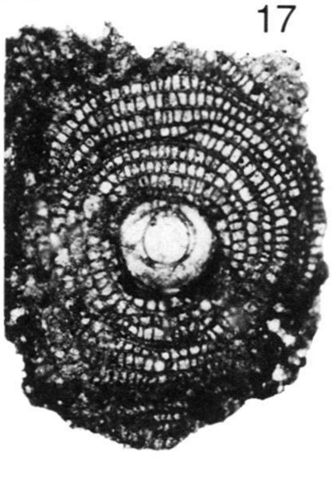
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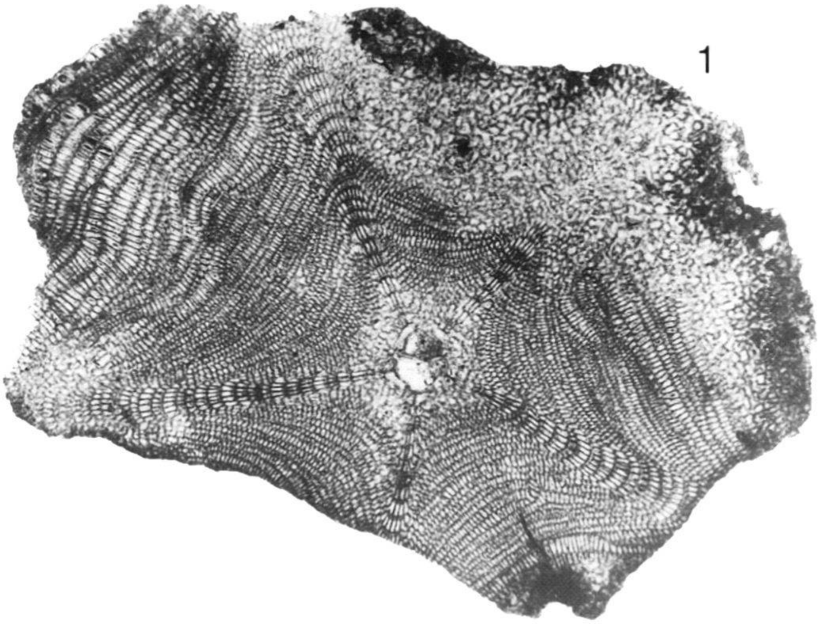
Plate 13

Fig. 1	*Asterocyclina soldadensis* Caudri Navette area, R.M. 1337, C 35949, × 9.	p. 1209
Fig. 2	*Asterocyclina asterisca* (Guppy), typical nepiont Soldado Rock, K. 2854, same specimen as Fig. 4, probably in Shell's collection in the Hague, × 68.	p. 1207
Fig. 3	*Asterocyclina asterisca* (Guppy) Soldado Rock, K. 2854, C 31120, × 17.	p. 1207
Fig. 4	*Asterocyclina asterisca* (Guppy) see Fig. 2, Soldado Rock, K. 2854, probably in Shell's collection in the Hague, × 17.	p. 1207
Fig. 5–6	*Asterocyclina soldadensis* Caudri Soldado Rock, K. 2651, C 31095 (Fig. 5), C 31096 (Fig. 6), × 17.	p. 1209
Fig. 7	*Asterocyclina soldadensis* Caudri embryonic and periembryonic chambers, Soldado Rock, K. 2651, C 31094, × 34.	p. 1209
Fig. 8	*Asterocyclina rutteni* Vaughan Point Bontour, St. 46, C 36063, × 34.	p. 1208
Fig. 9	*Neodiscocyclina bullbrooki* (Vaughan & Cole), A-form Point Bontour, St. 67 (reworked), C 36010, × 34.	p. 1204
Fig. 10	*Asterocyclina vaughani* (Cushman) (type material) Point Bontour, C 35950, × 9.	p. 1208

Plate 13

1



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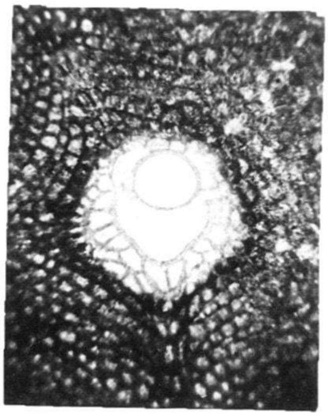

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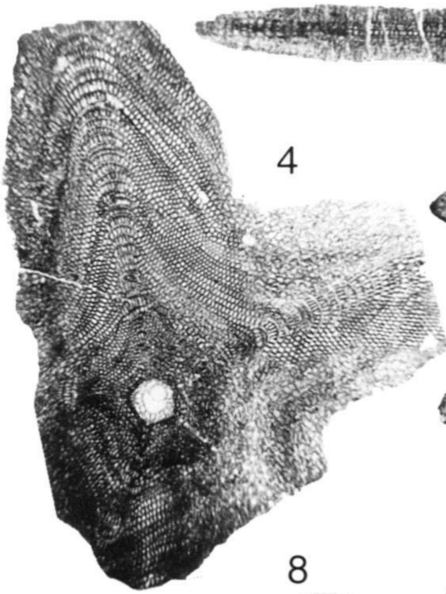

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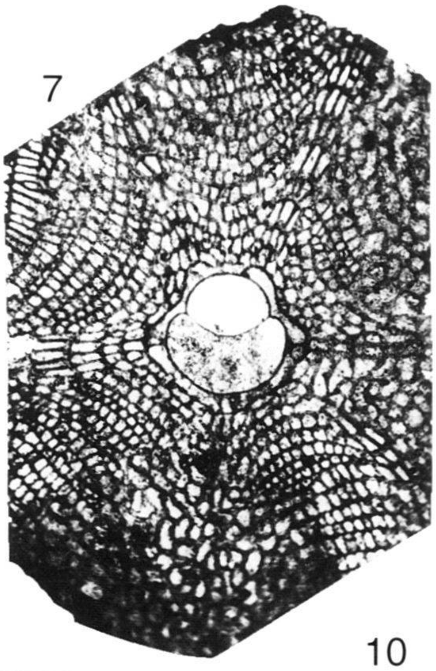

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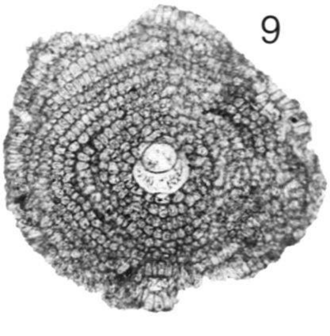

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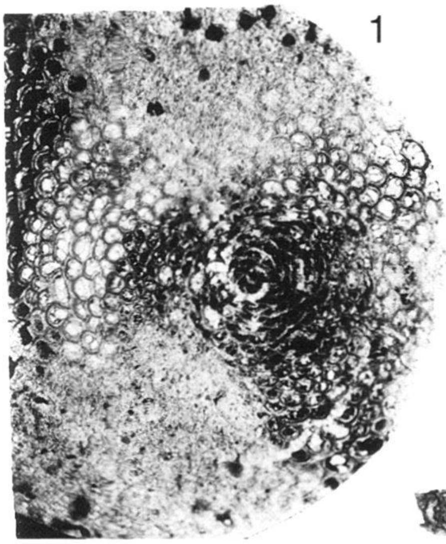
Plate 14

Fig. 1	*Helicolepidina* cf. *nortoni* Vaughan, B-form Charuma, A.E.G. 1580A, C 35929, × 30.	p. 1233
Fig. 2	*Helicolepidina* cf. *nortoni* Vaughan, A-form Vistabella Calyx 59, 500–510 feet, C 35928, × 30.	p. 1233
Fig. 3, 6–8	*Lepidocyclina* (*Polylepidina*) *nitida* Caudri, n. sp. horizontal sections, Farallon Rock, coll. Stainforth, Renz & Rutsch 1939, C 36080 (Fig. 3), C 36081–36083 (Fig. 6–8), × 30.	p. 1215
Fig. 4–5	*Lepidocyclina* (*Polylepidina*) *nitida* Caudri, n. sp. vertical sections, Farallon Rock, same locality, C 35931 (Fig. 4), C 36084 (Fig. 5), × 30.	p. 1215
Fig. 9	*Lepidocyclina* (*Polylepidina*)? *vichayalensis* L. Rutten Point Bontour, St. 63, C 35932, × 30.	p. 1217
Fig. 10	*Lepidocyclina* (?*Polylepidina*) *proteiformis* Vaughan Point Bontour, St. 63, C 35935, × 30.	p. 1217
Fig. 11	*Lepidocyclina* (*Polylepidina*) *vichayalensis* L. Rutten A-form, Mount Moriah near Dr. Krogh's house (note stolon system), M. 12923, C 35934, × 30.	p. 1217
Fig. 12	*Lepidocyclina* (*Polylepidina*) *vichayalensis* L. Rutten B-form, Charuma, A.E.G. 1580A, C 35933, × 30.	p. 1217

Plate 14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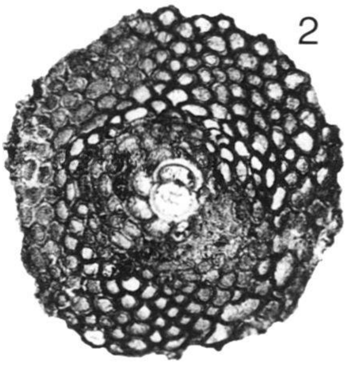
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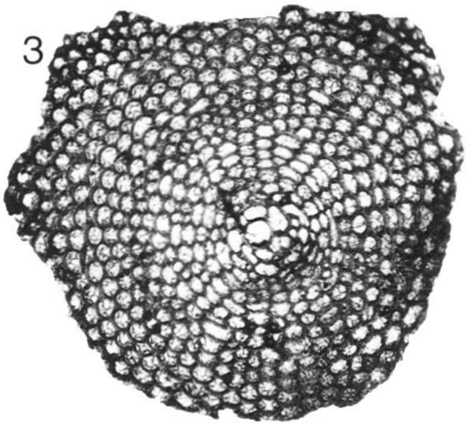
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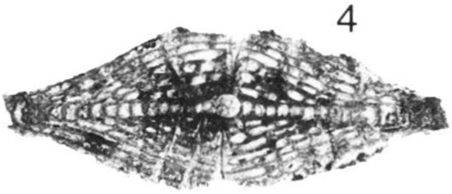
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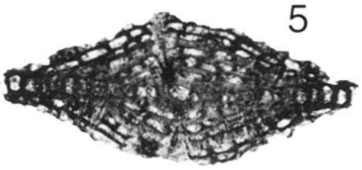
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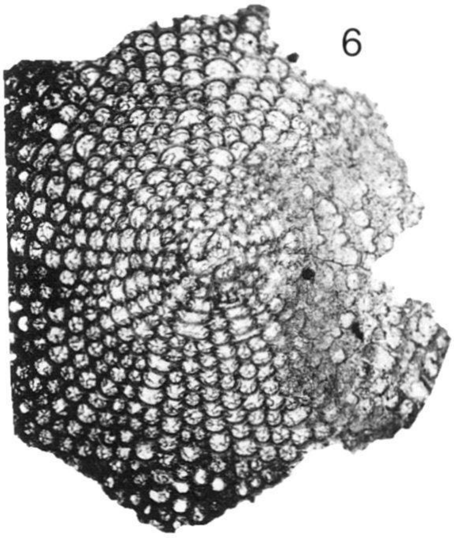
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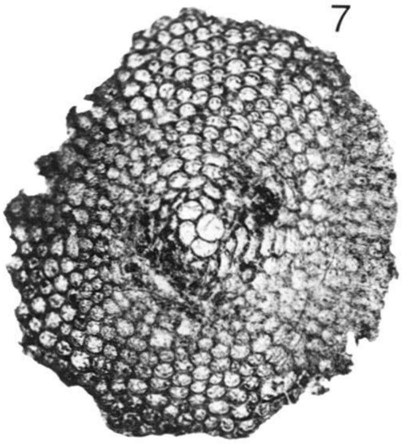
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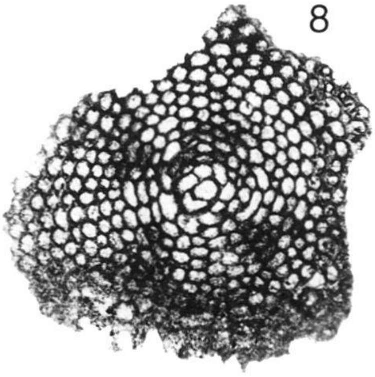
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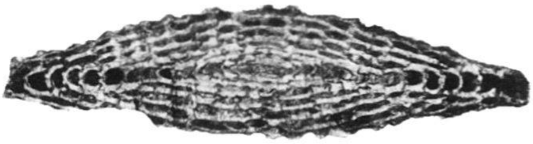
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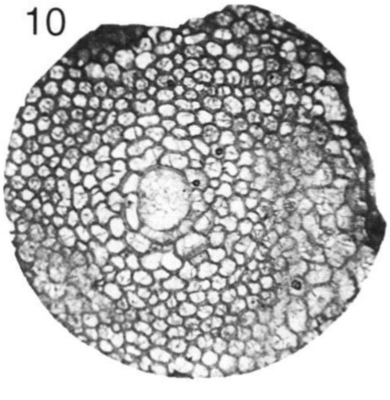
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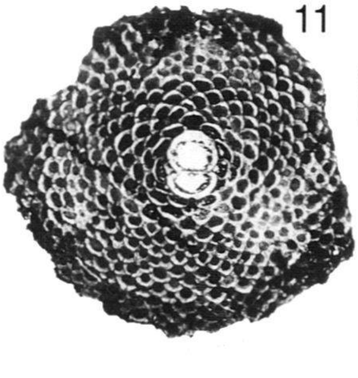
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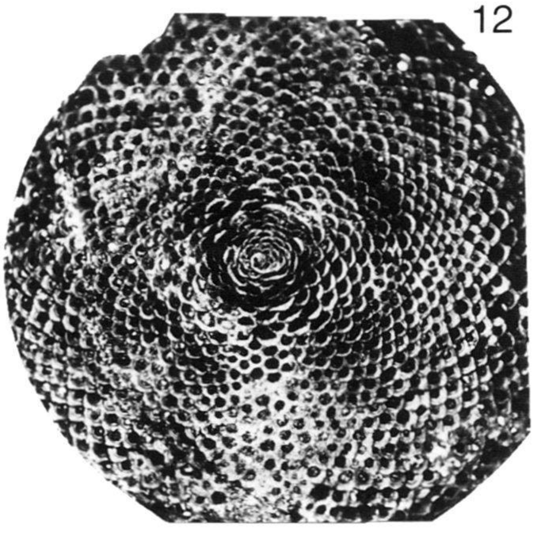
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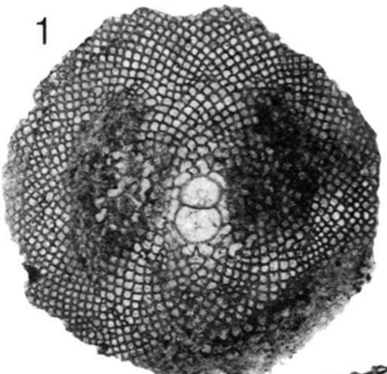
Plate 15

Fig. 1	*Lepidocyclina pustulosa* (H. Douvillé), s. s. Soldado Rock, J.S. 1950, C 31245, × 17.	p. 1218
Fig. 2	*Lepidocyclina pustulosa compacta* Caudri holotype, Point Bontour, St. 63, C 31252, × 17.	p. 1219
Fig. 3	*Lepidocyclina pustulosa trinitatis* (H. Douvillé) Soldado Rock, K. 2854, C 31113, × 17.	p. 1219
Fig. 4	*Lepidocyclina peruviana* Cushman with split equatorial layer, Soldado Rock, K. 1500, C 31079, × 17.	p. 1217
Fig. 5	*Lepidocyclina pustulosa* (H. Douvillé) with small chambers in the periphery, Cush River, coll. Lehner, × 17.	p. 1218
Fig. 6	*Lepidocyclina peruviana* Cushman Soldado Rock, K. 2951B, C 31152, × 17.	p. 1217
Fig. 7	*Lepidocyclina pustulosa tobleri* (H. Douvillé) with double completely abnormal embryonic apparatus, Vistabella Quarry, C 36002, × 17.	p. 1219
Fig. 8	*Lepidocyclina pustulosa* (H. Douvillé), s. s. Soldado Rock, Rz. 251, C 31230, × 17.	p. 1218
Fig. 9	*Lepidocyclina pustulosa trinitatis* (H. Douvillé) Soldado Rock, K. 2854, C 31111, × 17.	p. 1219
Fig. 10	*Helicolepidina spiralis* Tobler vertical section, Point Bontour, St. 63, C 35926, × 17.	p. 1233
Fig. 11	*Helicolepidina spiralis* Tobler section through the initial spiral (same specimen as Pl. 4:1, compare with Pl. 4:2), Point Bontour, St. 63, C 35925, × 50.	p. 1233
Fig. 12	*Lepidocyclina pustulosa tobleri* (H. Douvillé) specimen with regular embryonic chambers, Vistabella Quarry, C 36093, × 17.	p. 1219

Plate 15



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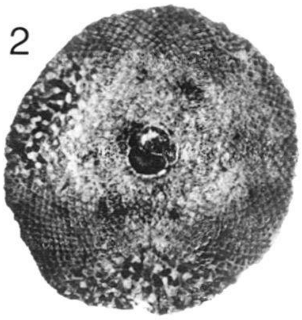

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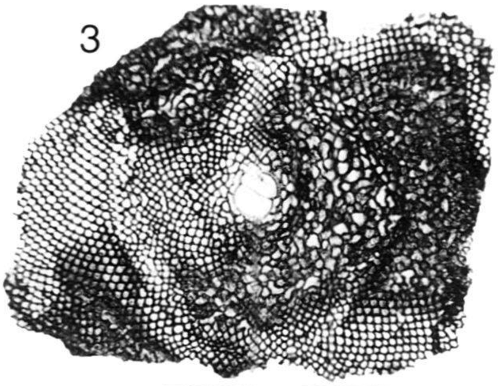

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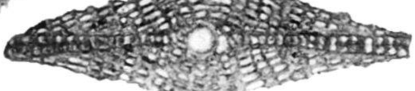

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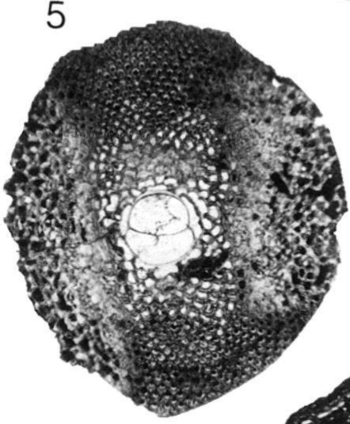

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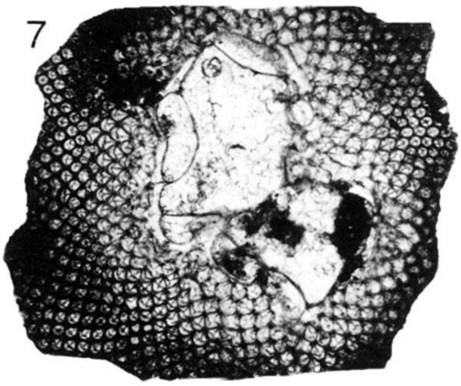

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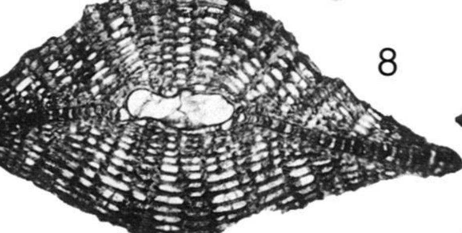

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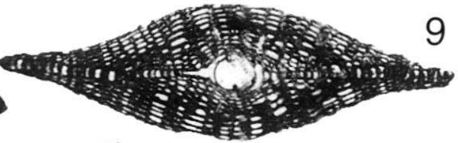

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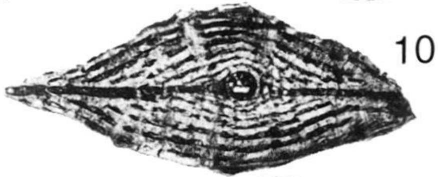

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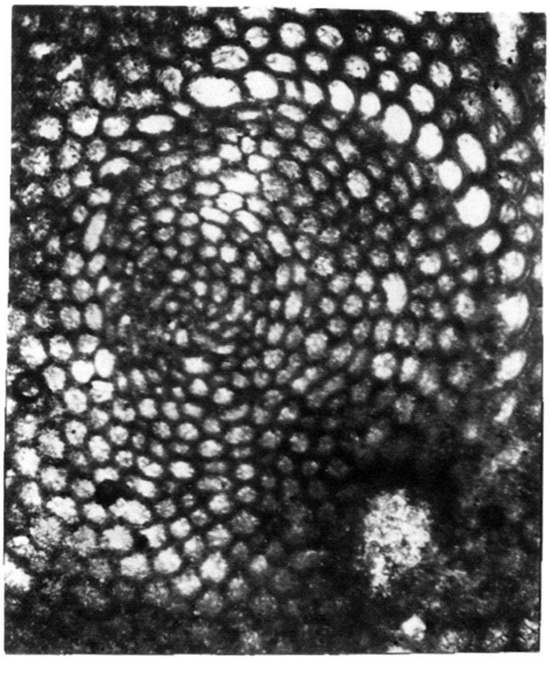

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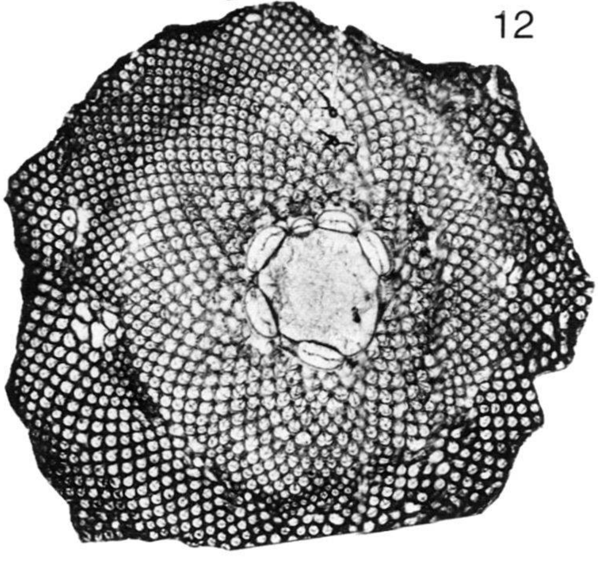

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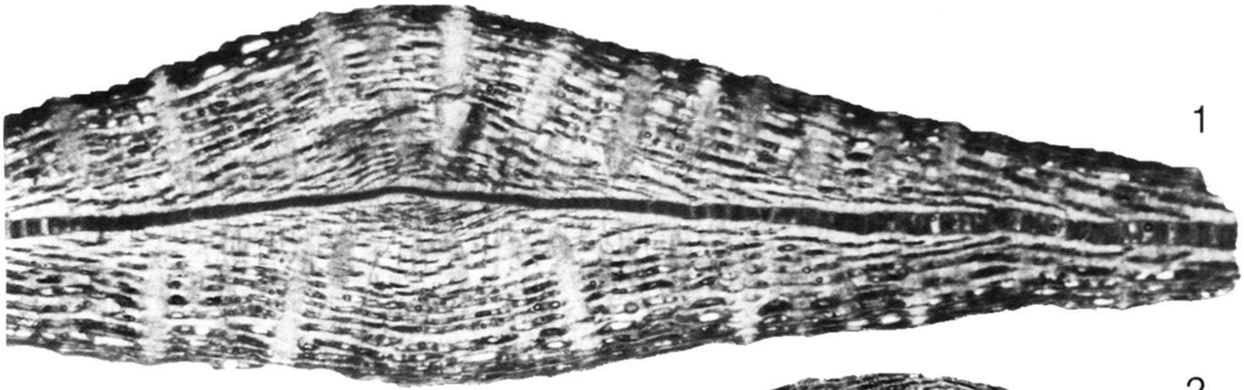
Plate 16

Fig. 1–4	*Lepidocyclina spatiosa* Caudri, A- and B-forms Navette area, R.M. 1337, C 35987 (Fig. 1), C 35988 (Fig. 2), C 35989 (Fig. 3), C 35990 (Fig. 4), × 17.	p. 1220
Fig. 5–7	*Lepidocyclina sanfernandensis* Vaughan & Cole typical form (underdeveloped form, compare with the forma depressata Pl. 3:1–2, 7), Vistabella Reservoir, E.L. 1207, C 35980 (Fig. 5), C 36128 (Fig. 6), C 35981 (Fig. 7), × 17.	p. 1222

Plate 16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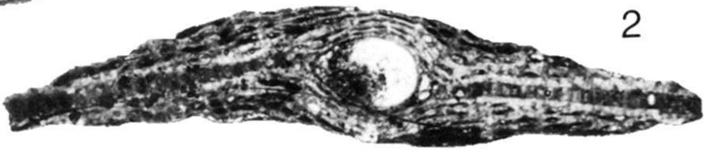
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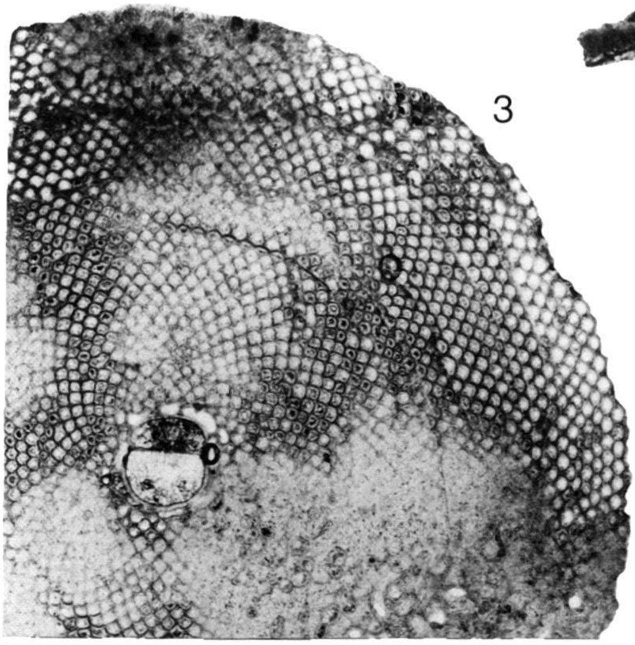
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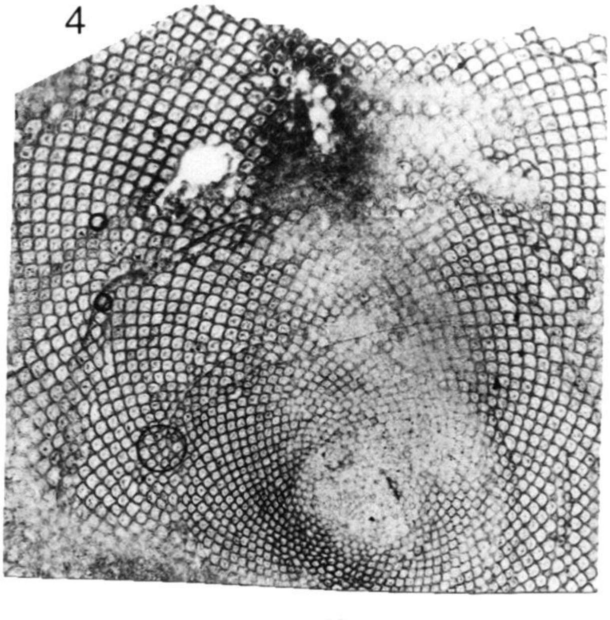
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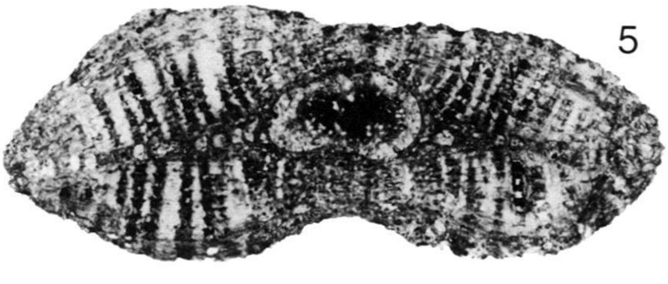
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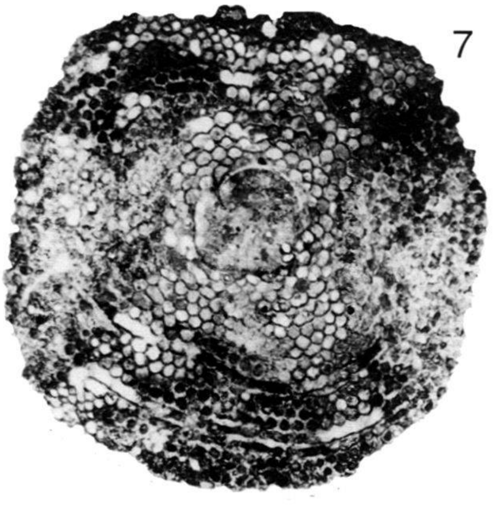
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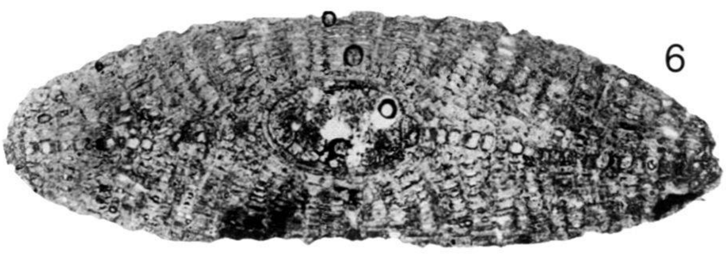
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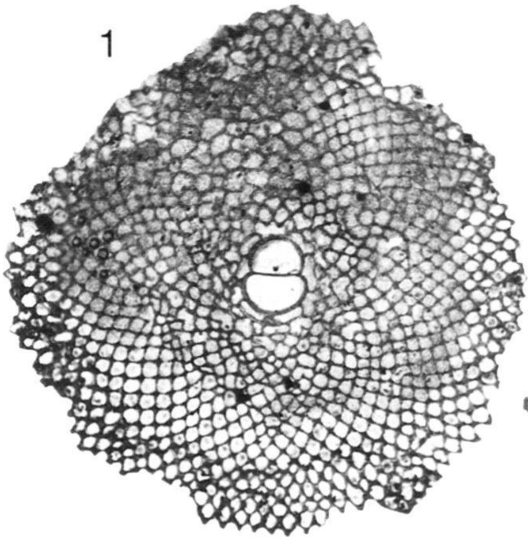
Plate 17

Fig. 1–2	*Lepidocyclina yurnagunensis* (Cushman) Cipero Coast, C.S. 11, × 34 and × 17.	p. 1220
Fig. 3, 7	*Lepidocyclina yurnagunensis* (Cushman) Cipero Coast, C.S. 11, × 17 (Fig. 3), × 34 (Fig. 7).	p. 1220
Fig. 4, 6	*Lepidocyclina subglobosa* Nuttall Vistabella, Calyx 59, 380–390 feet, × 17 (Fig. 4), × 34 (Fig. 6).	p. 1221
Fig. 5, 9	*Lepidocyclina subglobosa* Nuttall Vistabella, E.L. 1435, C 35974, × 17 and × 34 (same specimen).	p. 1221
Fig. 8	*Lepidocyclina yurnagunensis* (Cushman) Cipero Coast, Grimsdale 2, C 35970, × 17.	p. 1220
Fig. 10	*Lepidocyclina yurnagunensis marginopsis* Vaughan Cipero Coast, C.S. 11, C 35968, × 17.	
Fig. 11	*Lepidocyclina yurnagunensis crassimargo* Vaughan Cipero Coast, Grimsdale 2, C 36094, × 17.	
Fig. 12	*Lepidocyclina yurnagunensis* (Cushman) Cipero Coast, Grimsdale 2, × 17.	p. 1220
Fig. 13–15	*Lepidocyclina yurnagunensis* (Cushman), B-form Cipero Coast, Cd. 26, C 35971 (Fig. 13), C 36095–36096 (Fig. 14–15), × 17.	p. 1220
Fig. 16–17	*Lepidocyclina tempanii* Vaughan & Cole Charuma, A.E.G. 4567, C 35976–35977 (Fig. 16–17), × 17.	p. 1222

Plate 17

1



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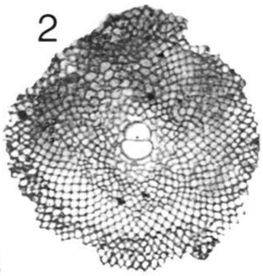

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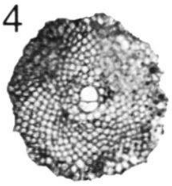

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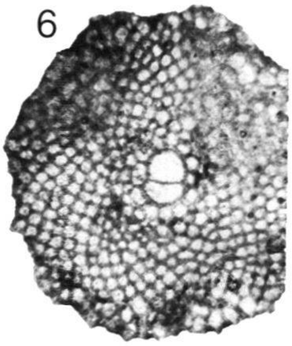

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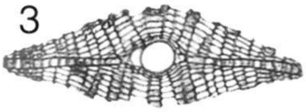

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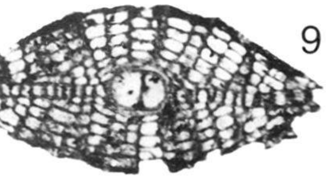

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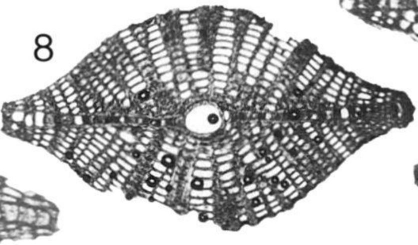

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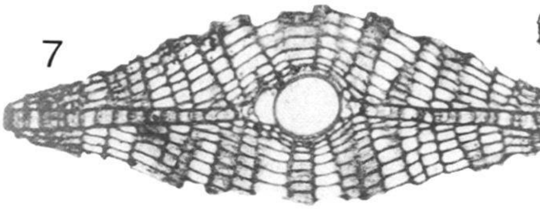

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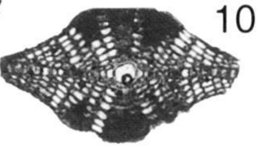

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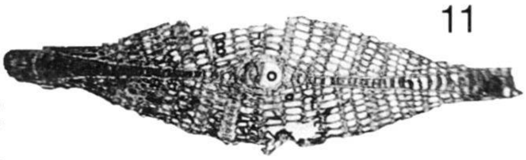

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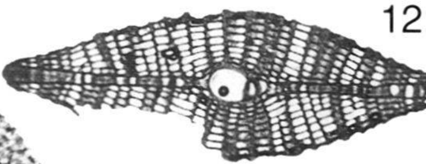

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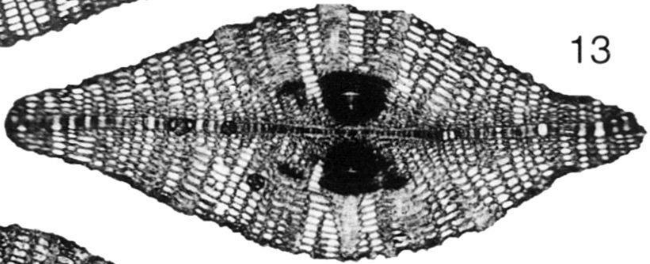

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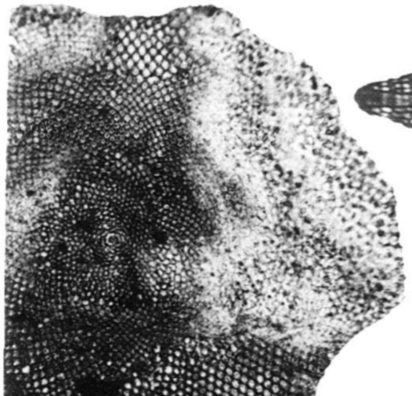

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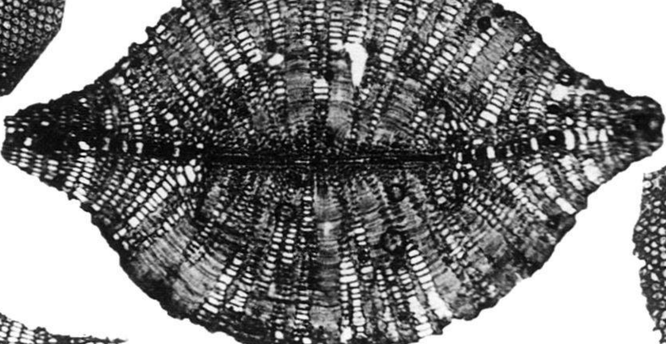

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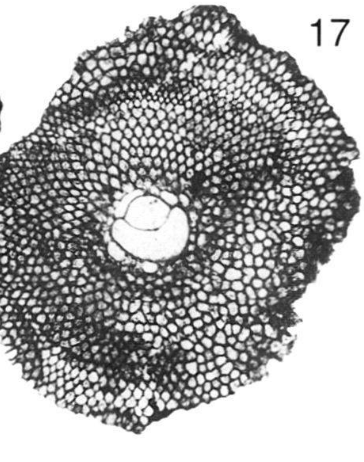
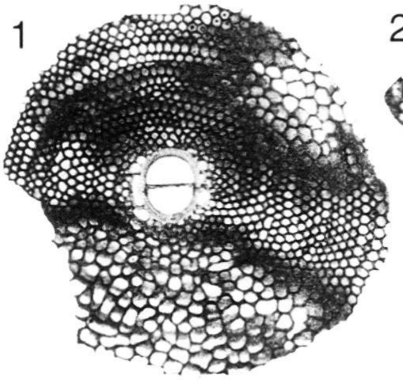


Plate 18

Fig. 1–2	*Lepidocyclina canellei* Lemoine & R. Douvillé Morne Diablo Quarry, K. 2667, C 35991 (Fig. 1), C 36097 (Fig. 2), × 17.	p. 1227
Fig. 3–4	*Lepidocyclina pancanalis* Vaughan & Cole Charuma, A.E.G. 1820, C 35994 (Fig. 3), C 36099 (Fig. 4), × 17.	p. 1227
Fig. 5	*Lepidocyclina parvula* Cushman, A-form Morne Diablo Quarry, K.S. 70, C 35996, × 17.	p. 1227
Fig. 6–7	*Lepidocyclina parvula* Cushman, B-forms Morne Diablo Quarry, K.S. 21, C 36100–36101 (Fig. 6–7), × 17.	p. 1227
Fig. 8	*Lepidocyclina giraudi* R. Douvillé Morne Diablo Quarry, K.S. 21, C 35995, × 17.	p. 1228

Plate 18

1



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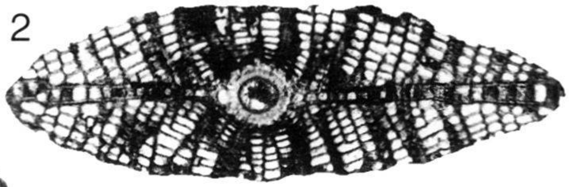

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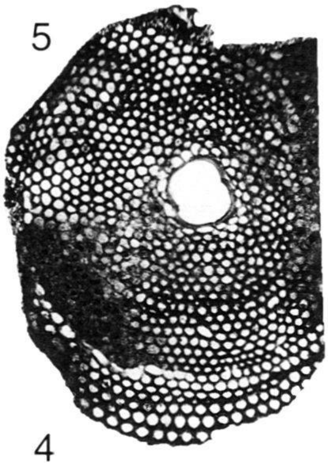

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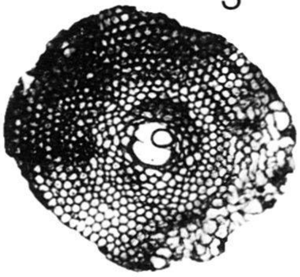

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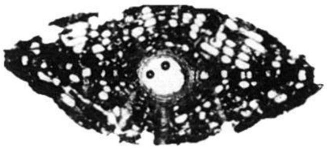

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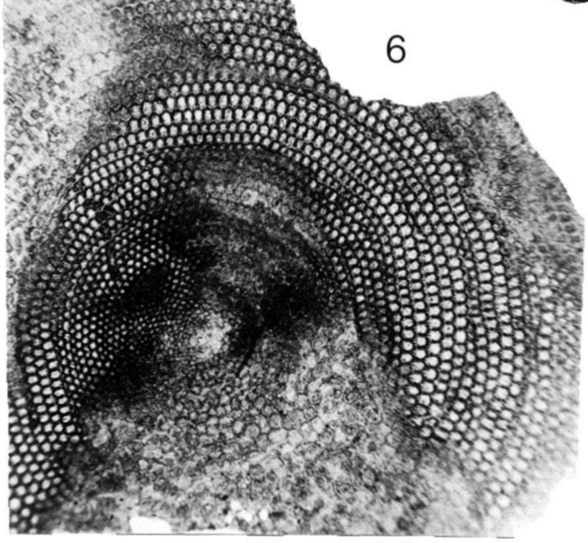

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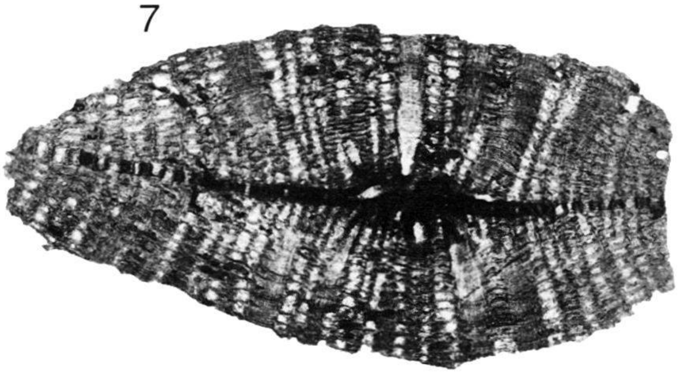

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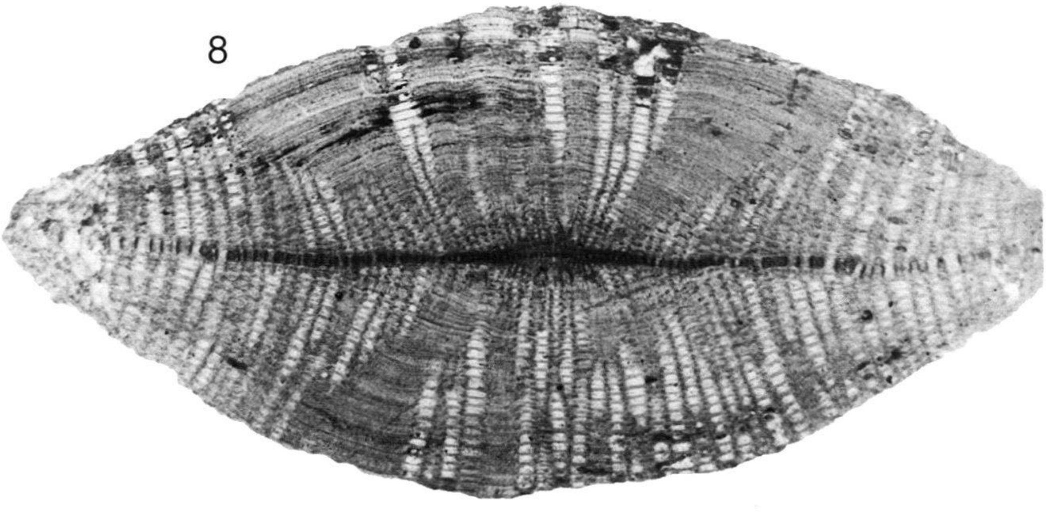
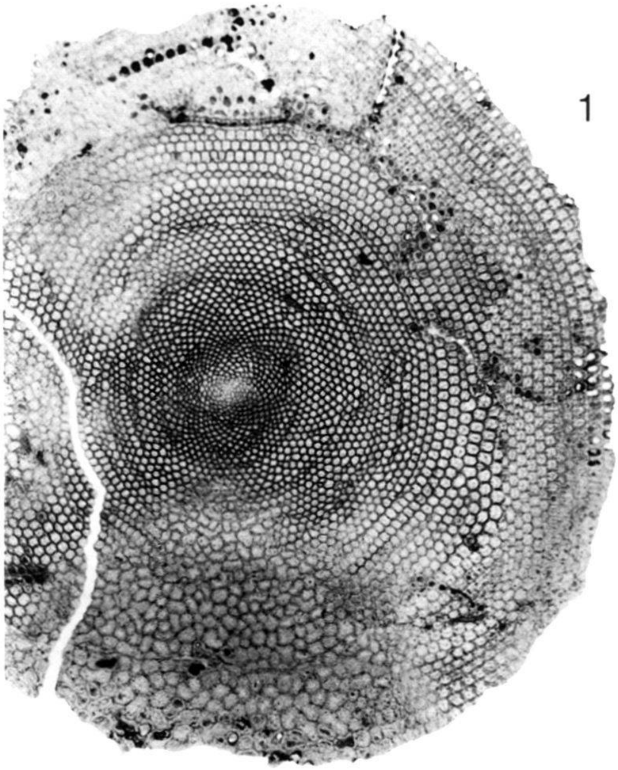


Plate 19

Fig. 1	*Lepidocyclina giraudi* R. Douvillé (same specimen as Pl. 22:4) Morne Diablo Quarry, K.S. 21, C 36102, × 17.	p. 1228
Fig. 2	*Lepidocyclina forresti* Vaughan, A-form Morne Diablo Quarry, K.S. 70, C 36004, × 17.	p. 1226
Fig. 3	*Lepidocyclina forresti* Vaughan, pillarless A-form Morne Diablo Quarry, K.S. 70, C 36103, × 17.	p. 1226
Fig. 4	*Lepidocyclina forresti* Vaughan, pillared A-form Morne Diablo Quarry, K.S. 70, C 36005, × 17.	p. 1226
Fig. 5	*Lepidocyclina forresti* Vaughan, pillarless B-form Morne Diablo Quarry, K.S. 70, C 36006, × 17.	p. 1226

Plate 19

1



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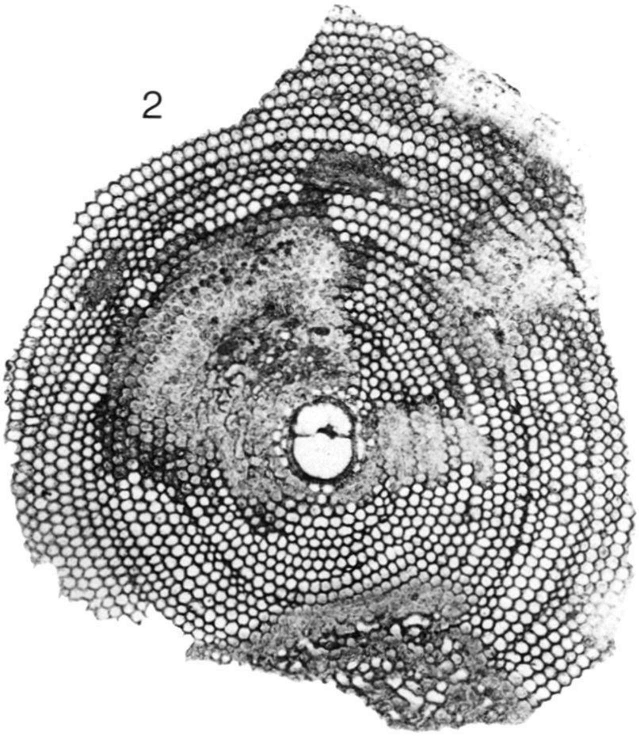

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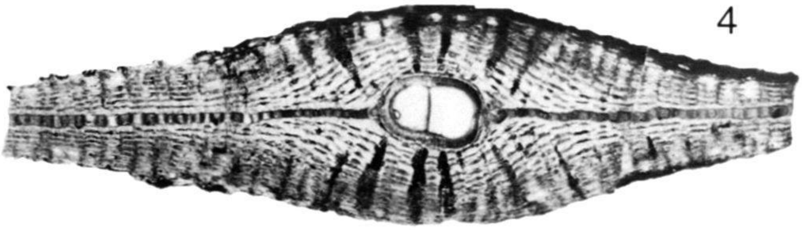

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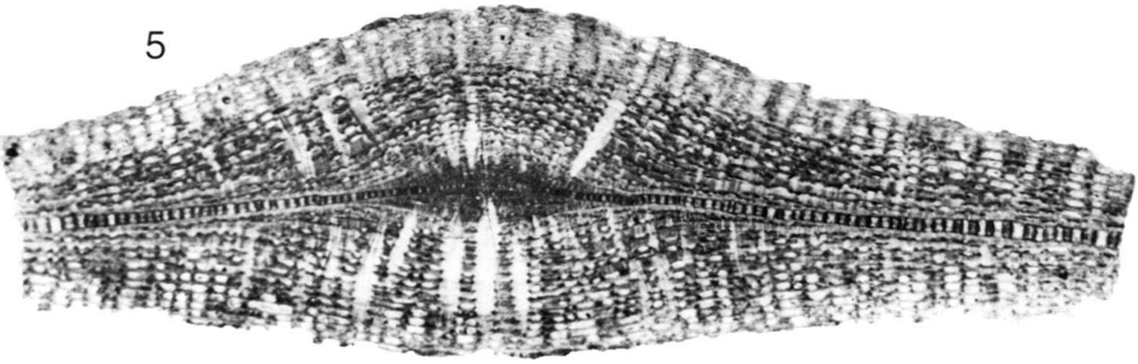
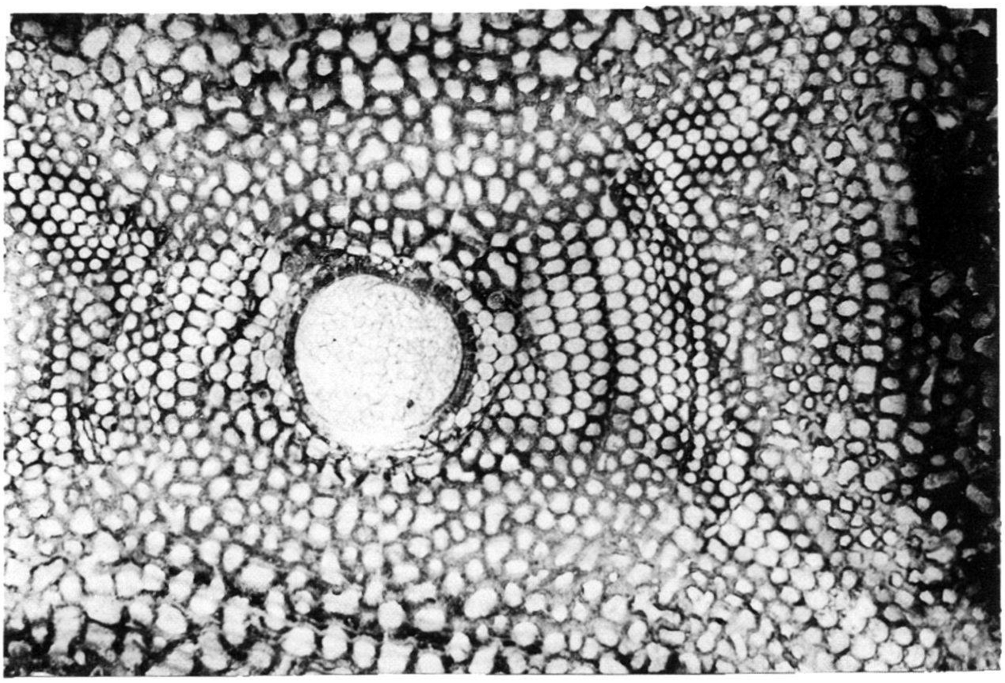


Plate 20

Fig. 1	*Lepidocyclina undosa* Cushman Kapur Quarry, Lz. 3465, C 35982, × 17.	p. 1224
Fig. 2	*Lepidocyclina favosa* Cushman Kapur Quarry, Lz. 3465, C 35984, × 17.	p. 1224
Fig. 3	*Lepidocyclina favosa* Cushman Kapur Quarry, Lz. 3465, C 35983, × 8.	p. 1224

Plate 20

1



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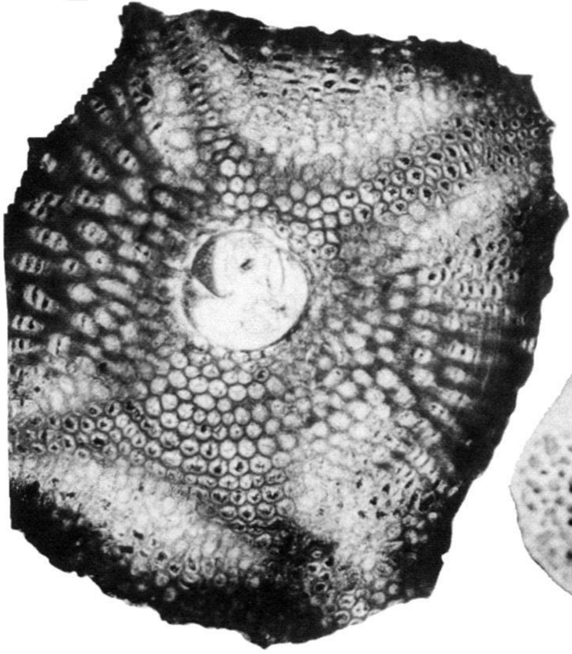

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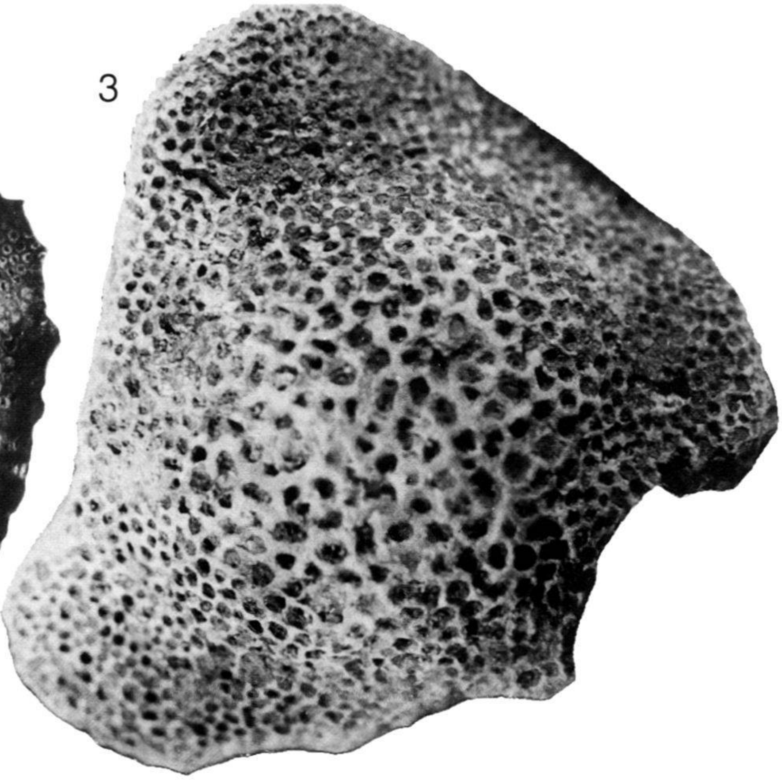
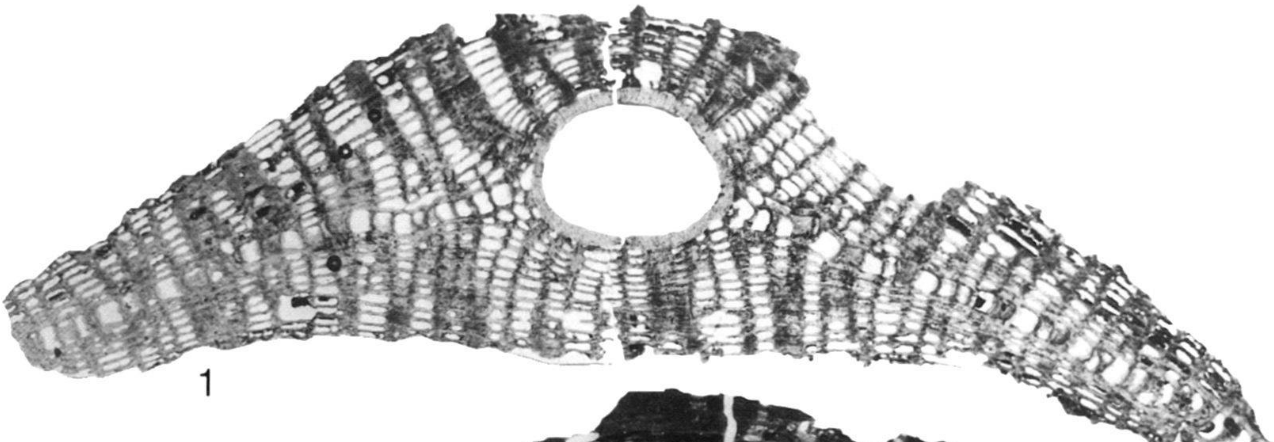


Plate 21

Fig. 1	*Lepidocyclina undosa* Cushman Kapur Quarry, Lz. 3465, C 36105, × 17.	p. 1224
Fig. 2	*Lepidocyclina favosa* Cushman Kapur Quarry, Lz. 3465, C 36106, × 17.	p. 1224
Fig. 3	*Lepidocyclina gigas* Cushman Kapur Quarry, Lz. 3465, C 35985, × 8.	p. 1224

Plate 21



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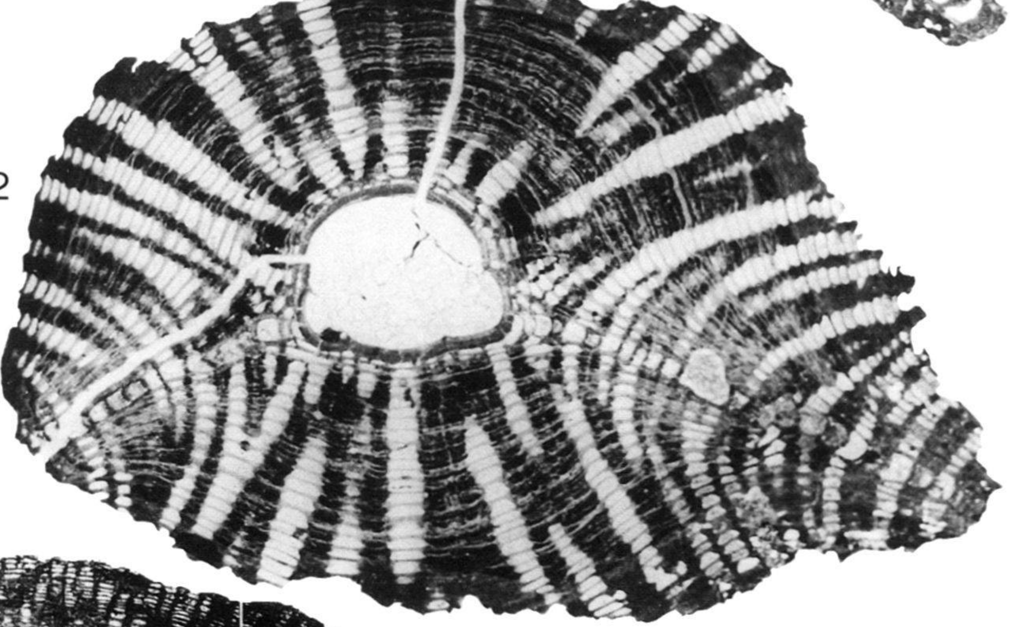

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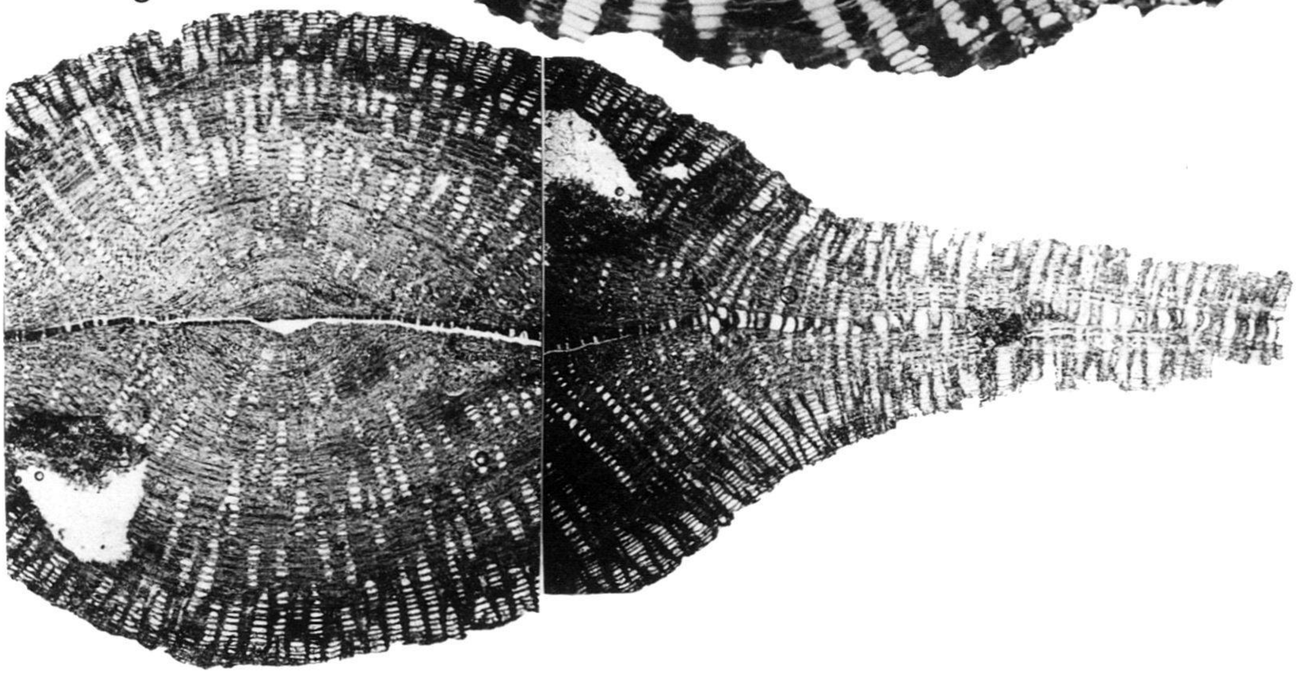
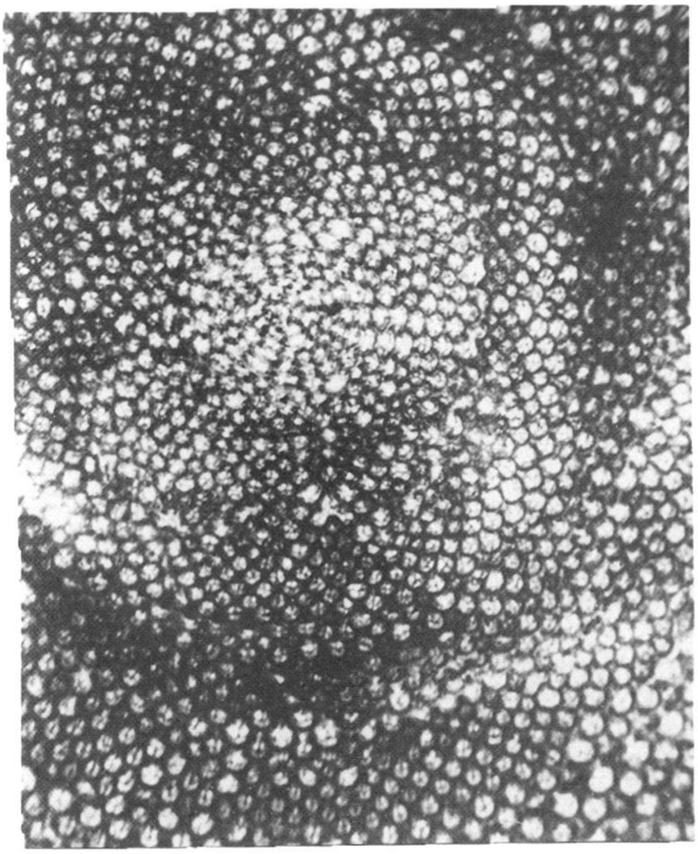


Plate 22

Fig. 1	*Lepidocyclina pustulosa* H. Douvillé, B-form initial chambers, Vistabella Quarry, C 36001, × 50.	p. 1218
Fig. 2	*Lepidocyclina pustulosa* H. Douvillé, B-form initial chambers, Navette area, R.M. 1337, C 36000, × 50.	p. 1218
Fig. 3	*Lepidocyclina forresti* Vaughan, B-form initial chambers (helicolepidinoid nepiont), Morne Diablo Quarry, K.S. 71, C 36007, × 50.	p. 1226
Fig. 4	*Lepidocyclina giraudi* R. Douvillé initial chambers, Morne Diable Quarry, K.S. 21 (same specimen as Pl. 19:1), C 36102, × 50.	p. 1228

Plate 22



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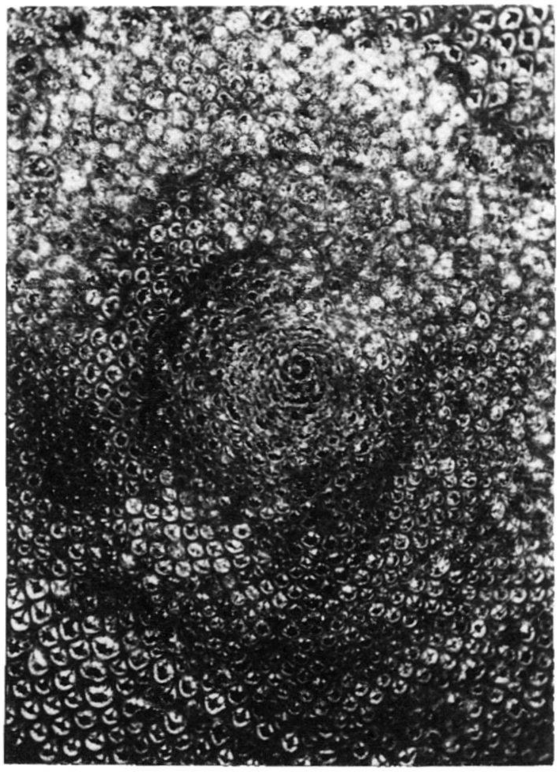

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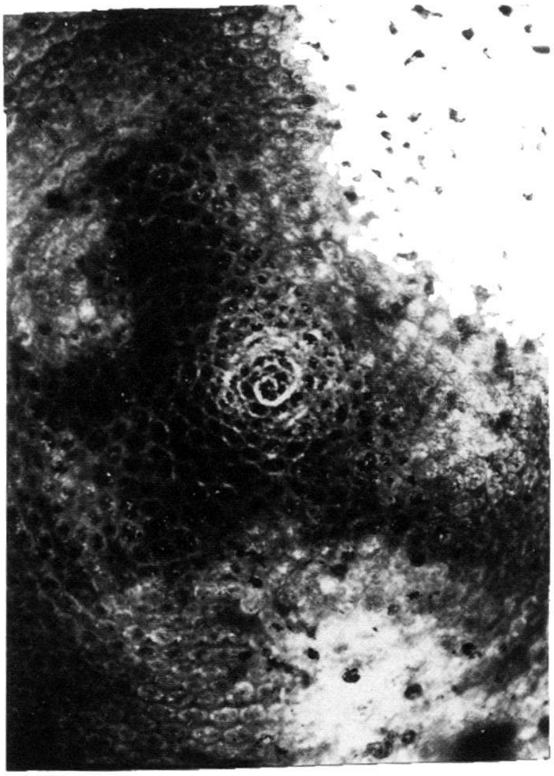

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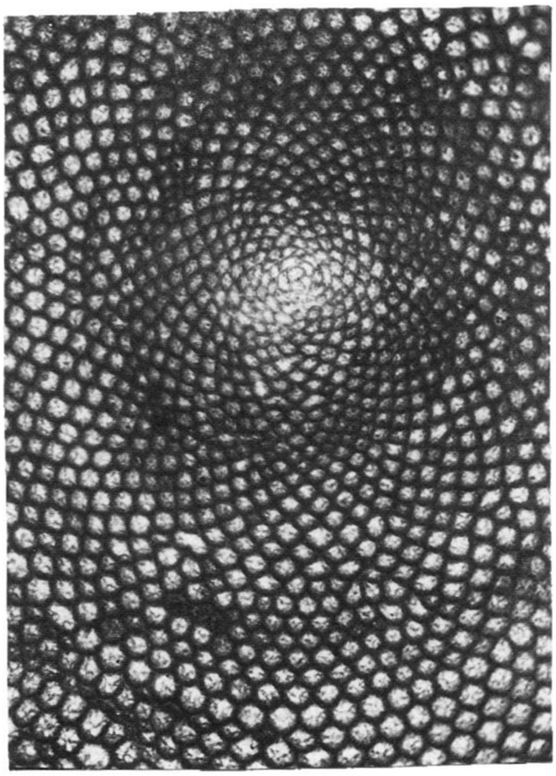

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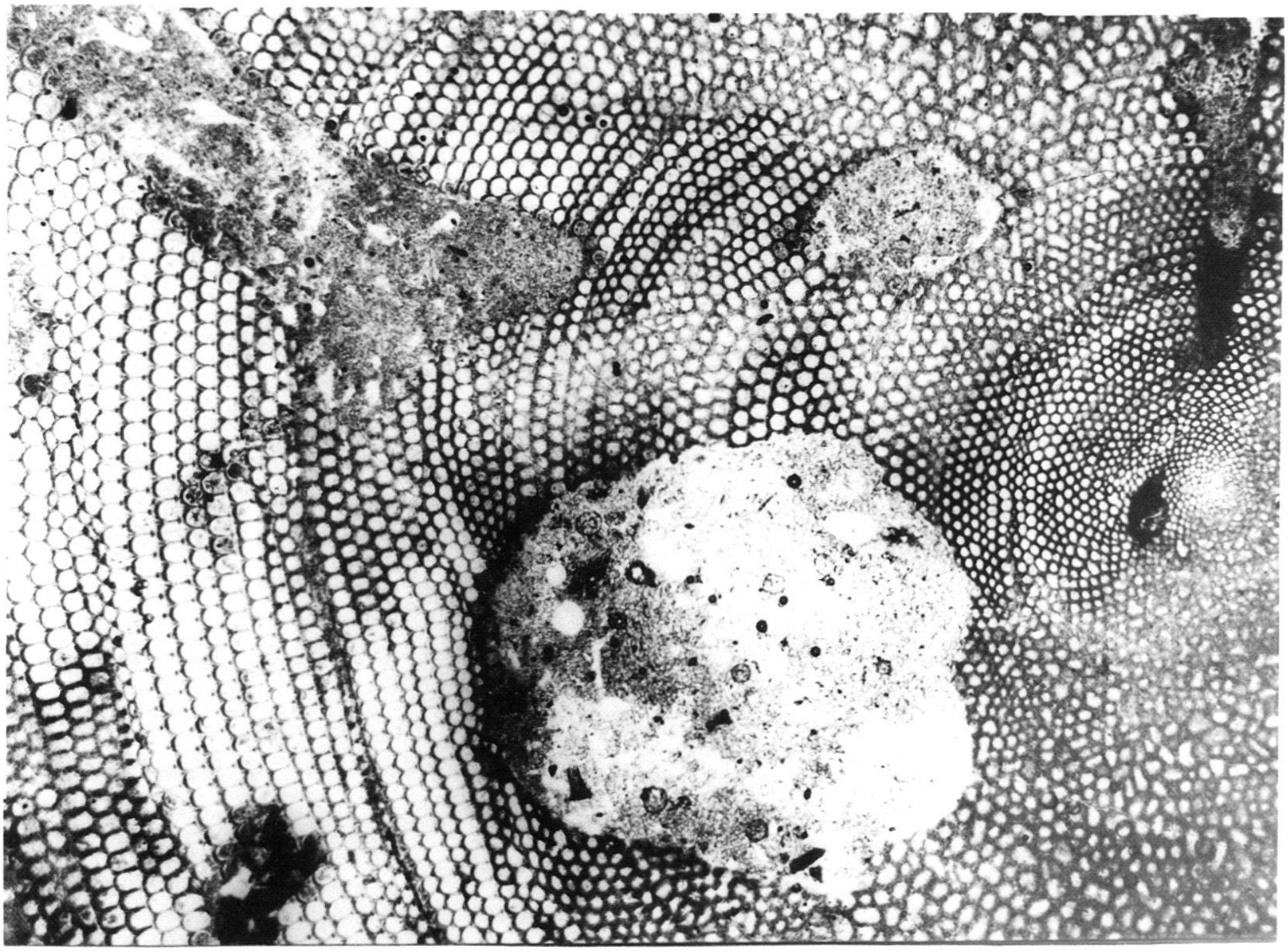
Plate 23

Fig. 1	*Lepidocyclina gigas* Cushman Kapur Quarry, Lz. 3465, C 35986, × 17.	p. 1224
Fig. 2	*Lepidocyclina forresti* Vaughan, B-form with normal lepidinoid nepiont and small pillars, Morne Diablo Quarry, K.S. 70, C 36104, × 17.	p. 1226

Plate 23



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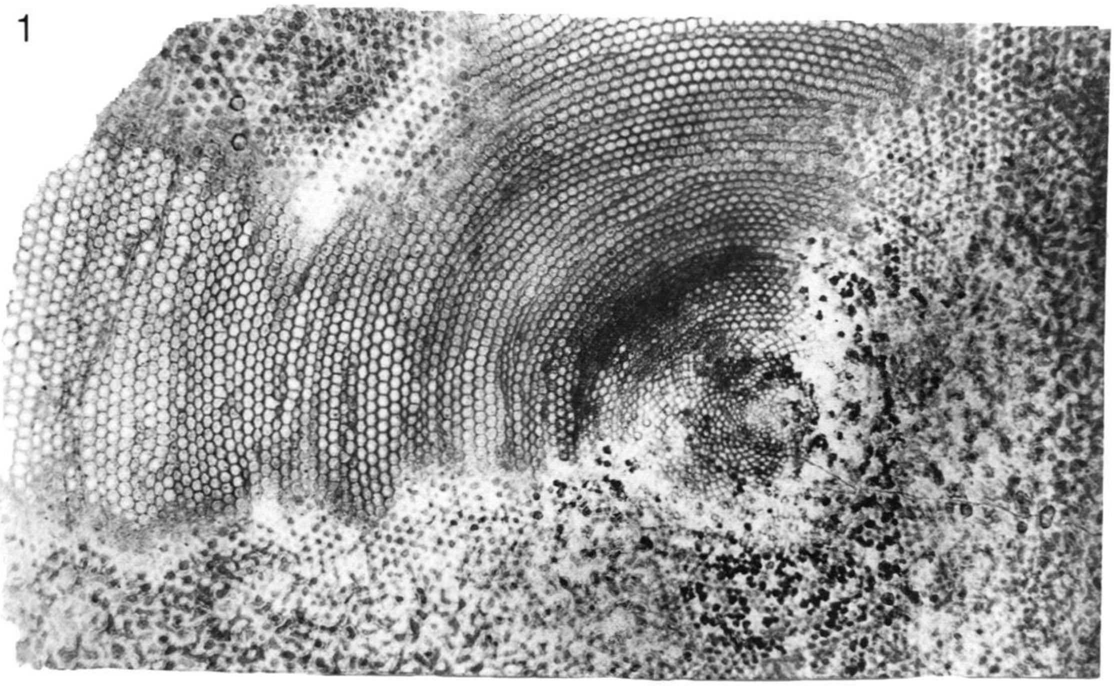

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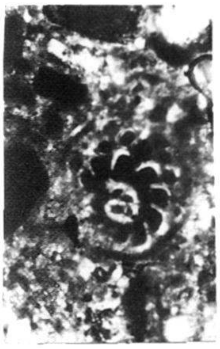
Plate 24

Fig. 1	*Miogypsina* (*Miogypsinoides*) *complanata* Schlumberger Mejias Quarry (in matrix), Terpstra 143, C 35912, × 30.	p. 1236
Fig. 2–4	*Miogypsina* (*Miogypsina*) *gunteri* Cole Kapur Quarry, Lz. 3473, C 35914 (Fig. 2), C 36107–36108 (Fig. 3–4), × 30.	p. 1236
Fig. 5	*Miogypsina* (*Miogypsina*) *bramletti* Gravell Morne Diablo Quarry, K.S. 19b, C 35911, × 30.	p. 1237
Fig. 6	*Miogypsina* (*Miogypsina*) *hawkinsi* Hodson Morne Diablo Quarry, coll. K. 12-1-41, C 35915, × 30.	p. 1236
Fig. 7	*Miogypsina* (*Miogypsina*) *hawkinsi* ? Morne Diablo Quarry, coll. K. 12-1-41, C 36113, × 30.	p. 1236
Fig. 8–11	*Miogypsina* (*Miogypsina*) *bramletti* Gravell Morne Diablo Quarry, K.S. 19b, C 36109–36112 (Fig. 8–11), × 30.	p. 1237

Plate 24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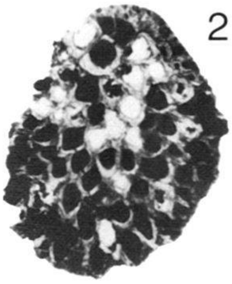
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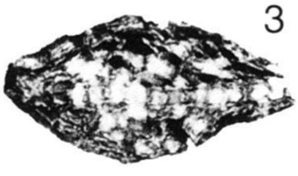
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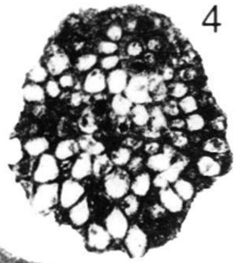
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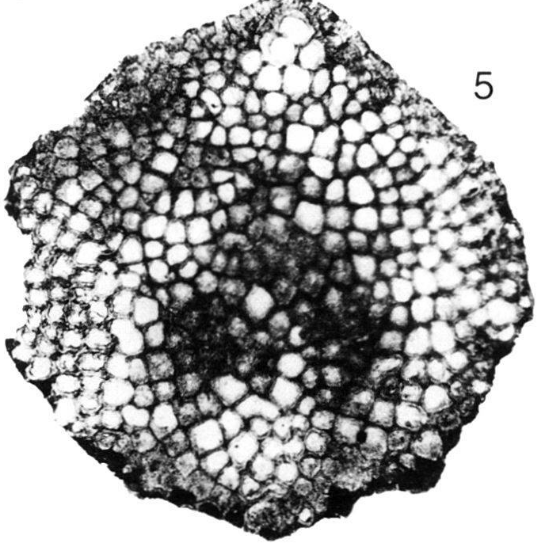
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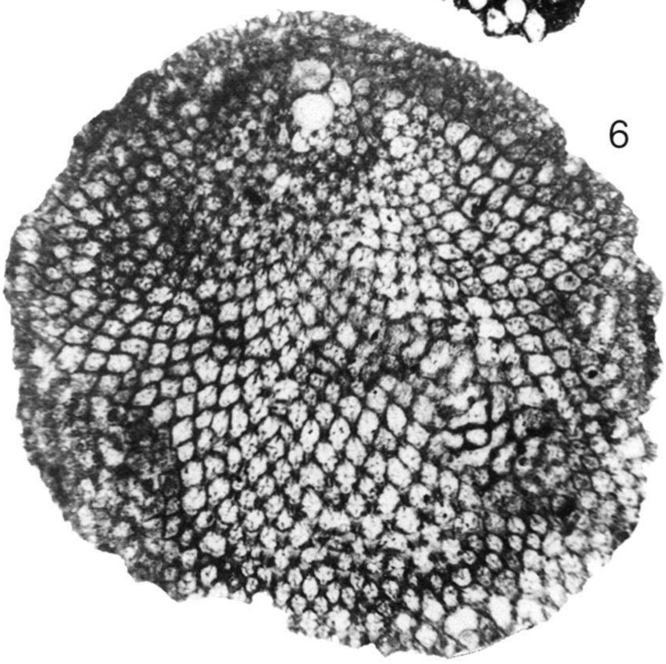
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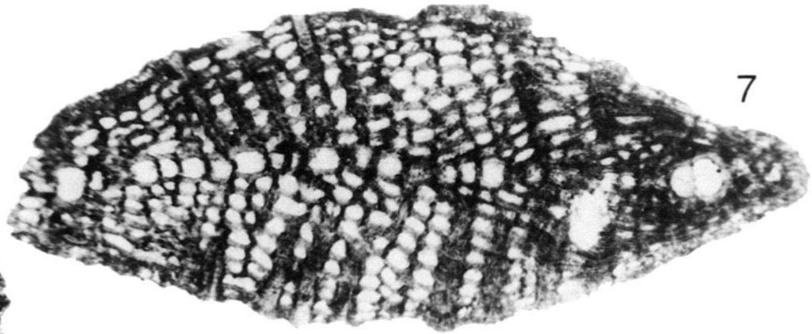
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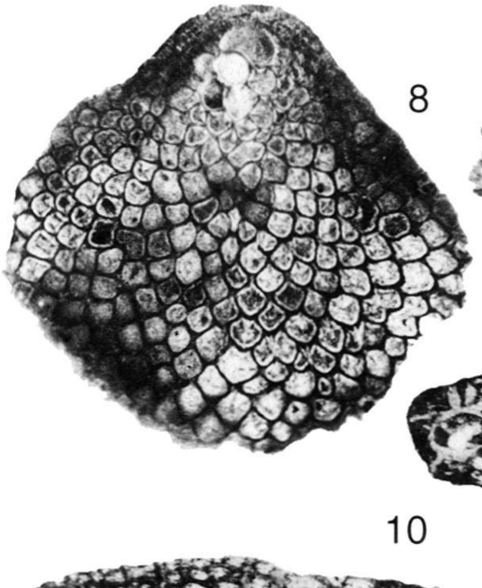
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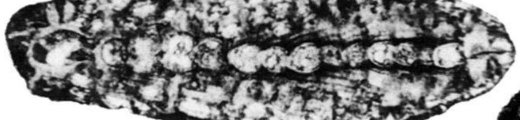
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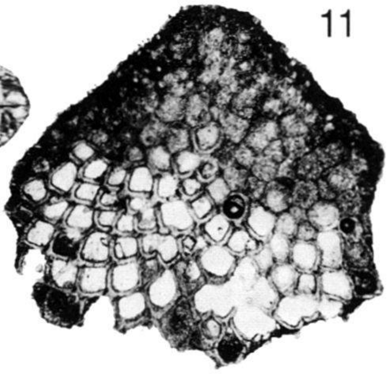
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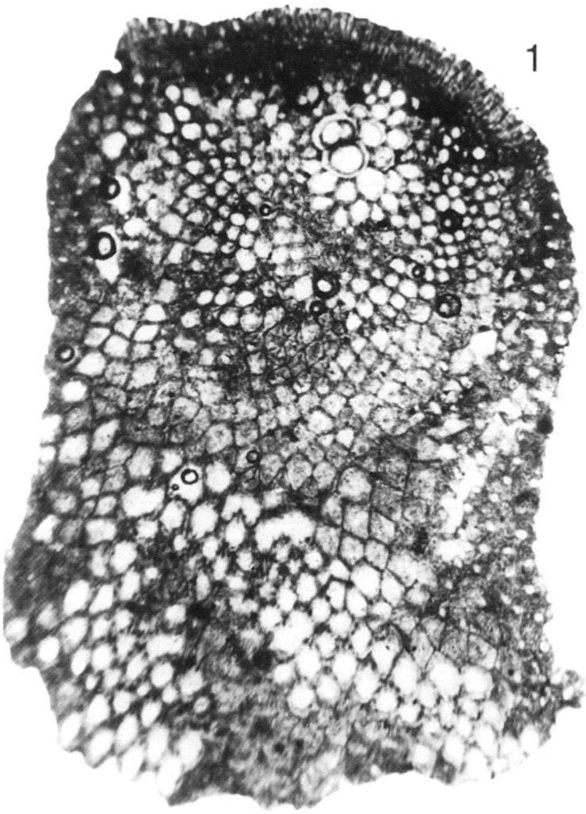
Plate 25

Fig. 1–8 *Miogypsina* (*Miolepidocyclina*) *staufferi* Koch p. 1237

Fig. 1, 4–5, 8: lenticular; 2–3, 6–7 conchoidal; Morne Diablo Quarry, K.S 70 (Fig. 1–7), K.S. 79 (Fig. 8), Fig. 35920 (Fig. 1), C 35919 (Fig. 2), C 36114 (Fig. 3), C 36117–36118 (Fig. 4–5), C 36115–36116 (Fig. 6–7), C 35921 (Fig. 8), × 30.

Plate 25



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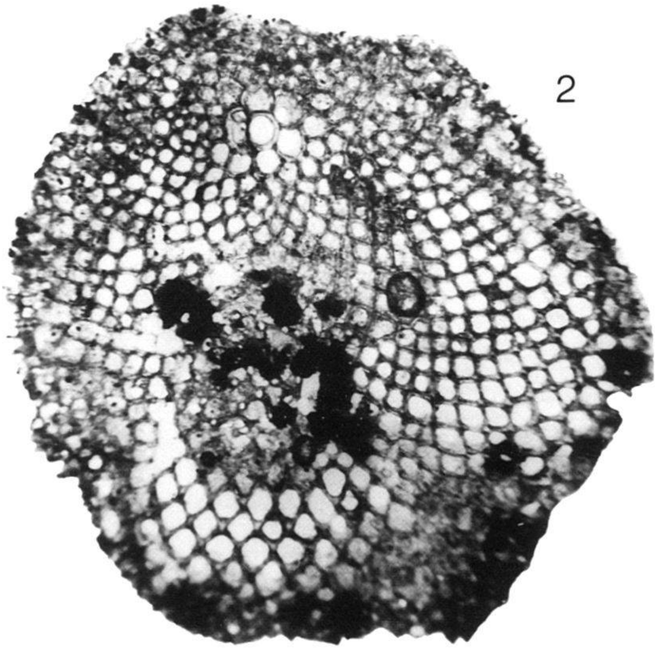

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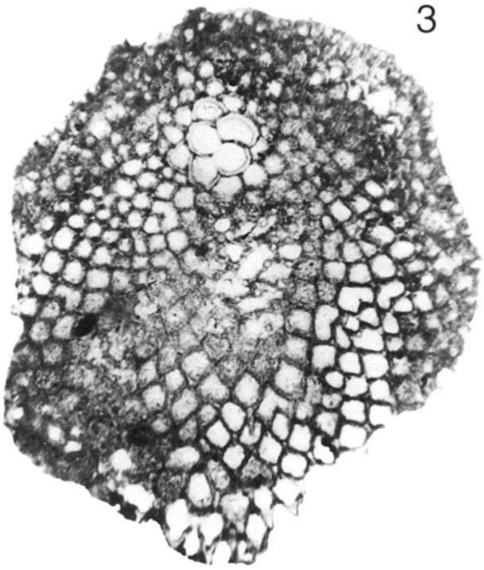

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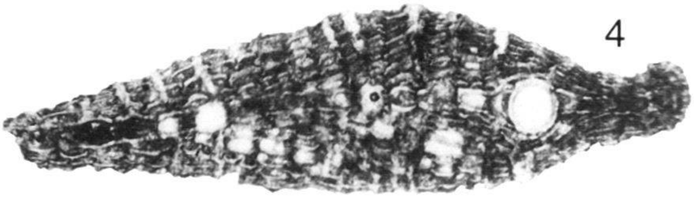

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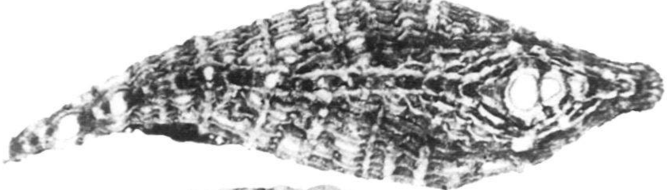

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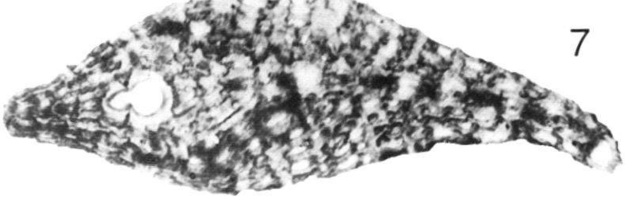

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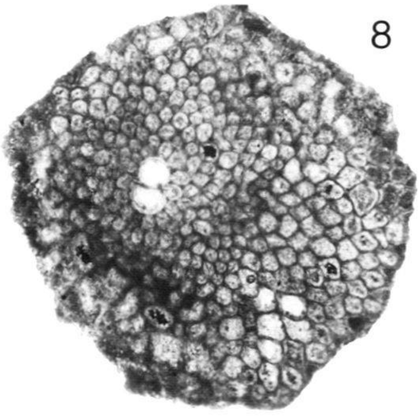

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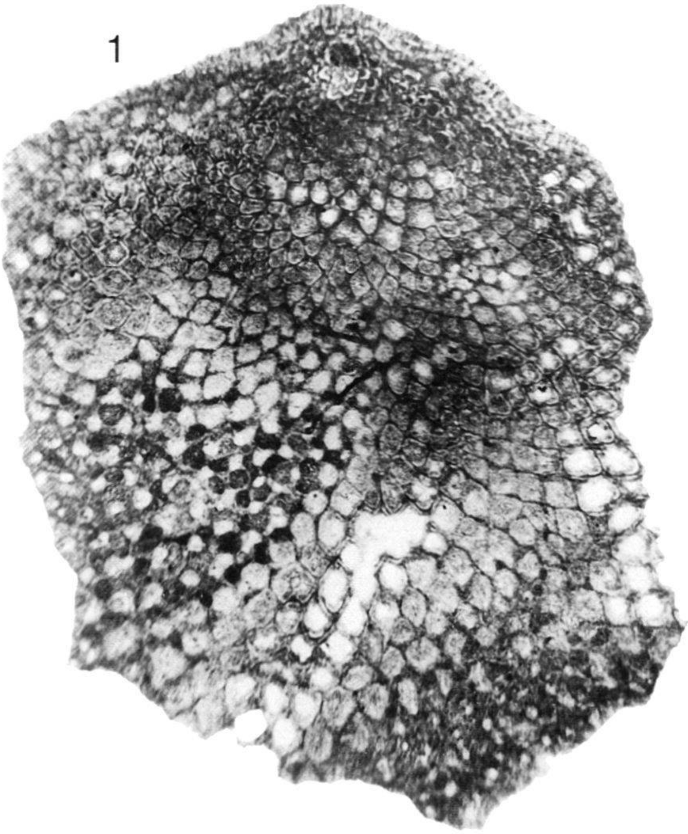
Plate 26

Fig. 1–2	*Miogypsina* sp., B-form same specimen, Morne Diablo Quarry, K.S. 70, C 35923, × 30 and × 50.
Fig. 3	*Miogypsina* sp., B-form Morne Diablo Quarry, K.S. 70, C 36119, × 50.
Fig. 4	*Miogypsina* sp., B-form Morne Diablo Quarry, M. 13600B, C 35924, × 50.

Plate 26

1



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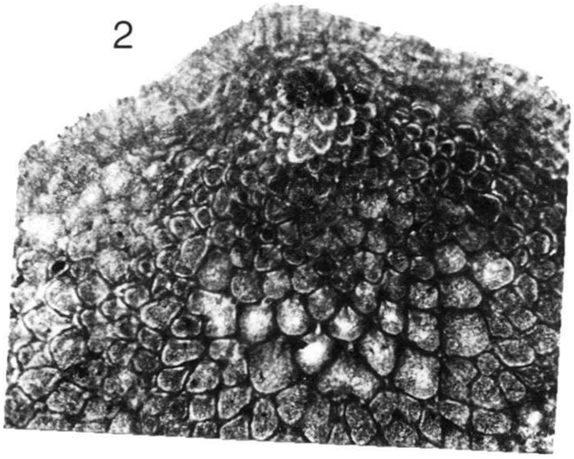

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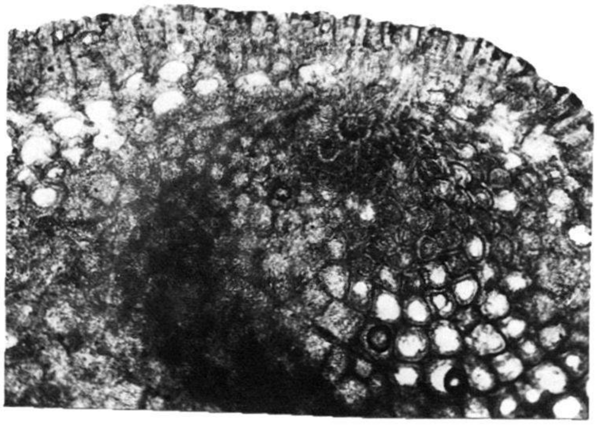

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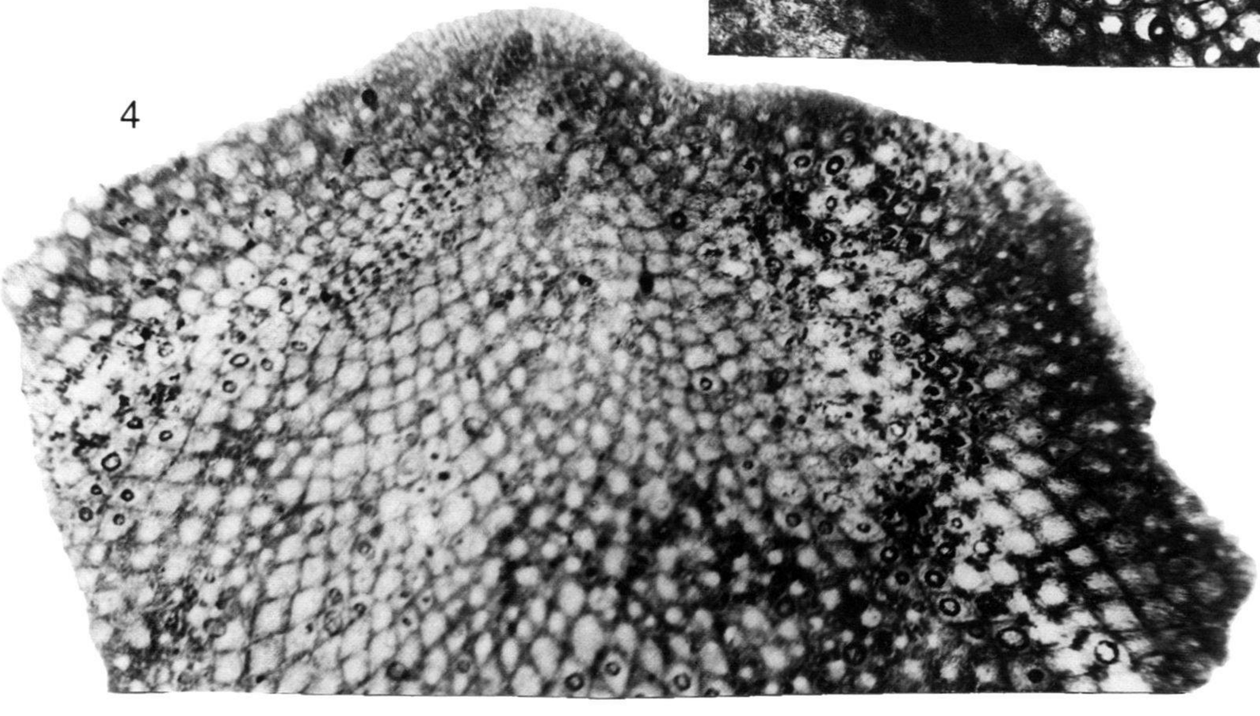
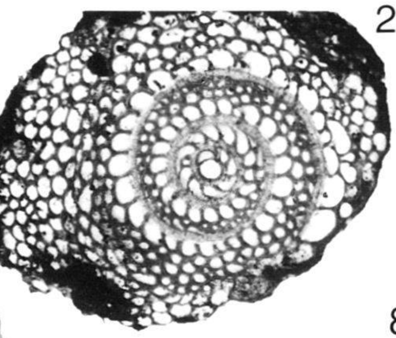


Plate 27

Fig. 1	*Eoconuloides* cf. *lopeztrigoi* (D. Palmer) (reworked specimen), Point Bontour, St. 89, C 36042, × 30.	p. 1229
Fig. 2	*Helicosteginopsis soldadensis* (Grimsdale) Soldado Rock, K. 2854, C 31099, × 30.	p. 1235
Fig. 3	*Helicocyclina paucispira* (Barker & Grimsdale) Point Bontour, St. 85, C 35942, × 30.	p. 1236
Fig. 4	*Helicocyclina paucispira* (Barker & Grimsdale) Vistabella Calyx 57, 1000–1010 feet, × 30.	p. 1236
Fig. 5	*Amphistegina grimsdalei* Caudri Soldado Rock, K. 2651, specimen in Shell's collection in the Hague, × 30.	p. 1234
Fig. 6	*Amphistegina grimsdalei* Caudri Soldado Rock, Grimsdale 33, specimen in Shell's collection in the Hague, × 30.	p. 1234
Fig. 7	*Helicosteginopsis soldadensis* (Grimsdale) Soldado Rock, K. 2651, C 31100, × 30.	p. 1235
Fig. 8	*Helicocyclina paucispira* (Barker & Grimsdale) Vistabella, E.L. 1435, C 35943, × 30.	p. 1236
Fig. 9	*Helicolepidinoides intermedius* Caudri, n. sp. Farallon Rock, coll. Stainforth, Renz & Rutsch, C 36079, × 30.	p. 1231
Fig. 10	*Helicocyclina paucispira* (Barker & Grimsdale) Vistabella, E.L. 1207, C 35941, × 30.	p. 1236
Fig. 11	*Helicosteginopsis soldadensis* (Grimsdale) B-form, Vistabella Quarry, Cd. 12, C 35938, × 30.	p. 1235
Fig. 12	*Helicosteginopsis soldadensis* (Grimsdale) B-form, Vistabella Quarry, coll. Lehner 1933, C 35937, × 30.	p. 1235
Fig. 13	*Helicolepidinoides intermedius* Caudri, n. sp. Point Fortin West, UBOT well, F.W. 181, 8687–8707 feet, specimen in Shell's collection in the Hague, × 30.	p. 1231
Fig. 14–15	*Helicolepidinoides intermedius* Caudri, n. sp. Farallon Rock, coll. Stainforth, Renz & Rutsch, C 36121–36122 (Fig. 14–15), × 30.	p. 1231
Fig. 16	*Helicosteginopsis soldadensis* (Grimsdale) B-form, vertical section, Navette area, R.M. 1337, C 35939, × 24.	p. 1235
Fig. 17	*Pseudophragmina bainbridgensis* (Vaughan) B-form, Point Bontour, St. 46, C 36011, × 34.	p. 1206

Plate 27


1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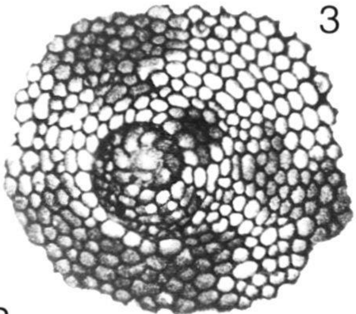
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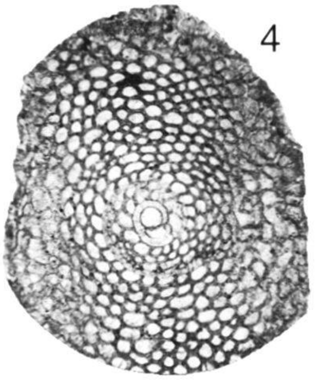
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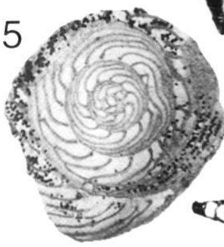
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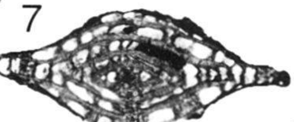
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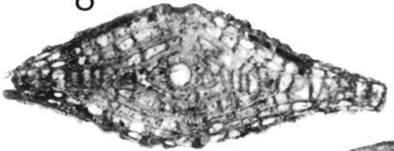
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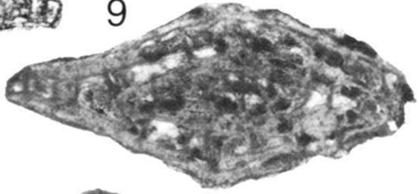
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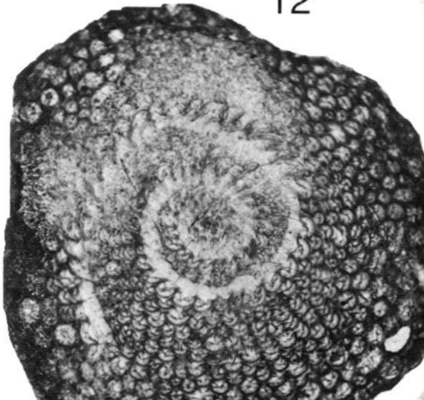
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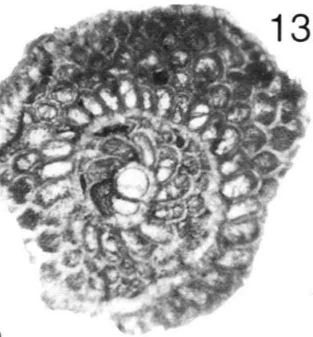
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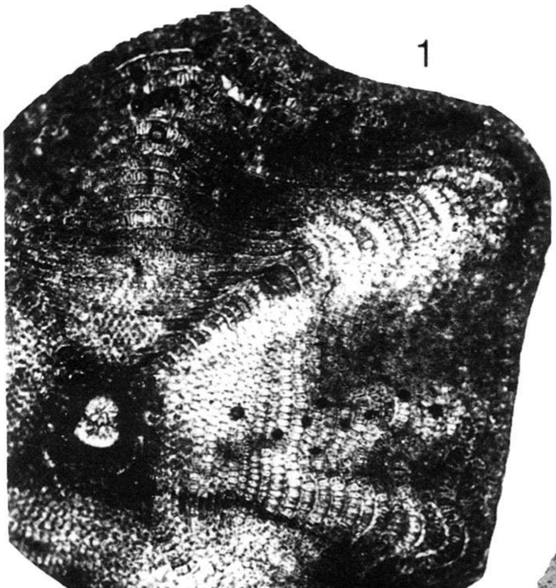
Plate 28

Fig. 1	*Asterocyclina vaughani* (Cushman) Vistabella, Calyx 59, 390–400 feet, C 36065, × 34.	p. 1208
Fig. 2	*Lepidocyclina supera* (Conrad) Cipero Coast, Grimsdale 2, C 35978, × 17.	p. 1225
Fig. 3	*Helicosteginopsis soldadensis* (Grimsdale), B-form Navette area, R.M. 1337, C 35936, × 30.	p. 1235
Fig. 4	*Lepidocyclina supera* (Conrad) Cipero Coast, Grimsdale 2, C 35979, × 17.	p. 1225
Fig. 5, 7	*Lepidocyclina nuda* Caudri, n. sp. Cipero Coast, Grimsdale 2, C 36123 (Fig. 5), C 36124 (Fig. 7), × 17.	p. 1225
Fig. 6	*Lepidocyclina nuda* Caudri, n. sp, holotype Cipero Coast, Grimsdale 2, C 36061, × 17.	p. 1225

Plate 28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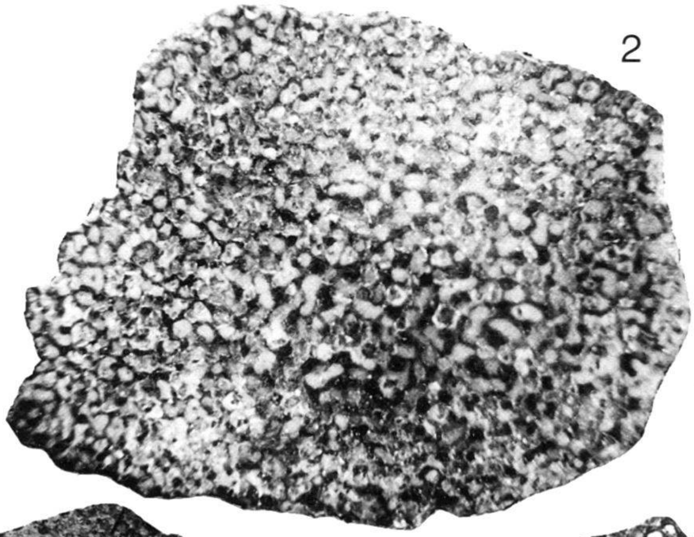
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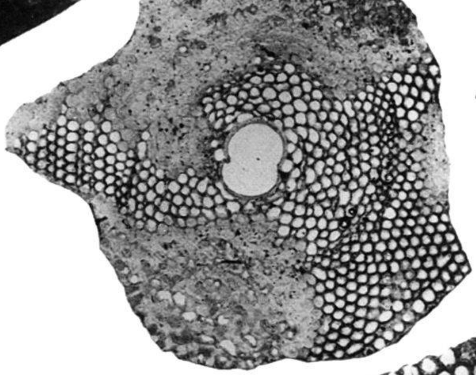
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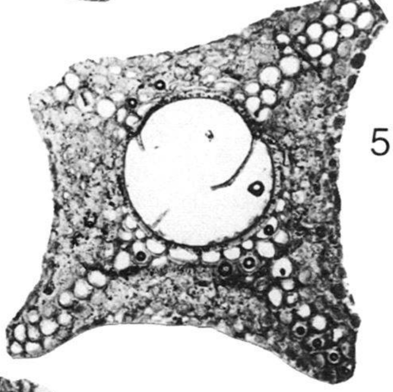
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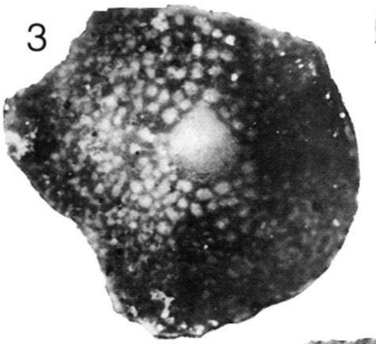
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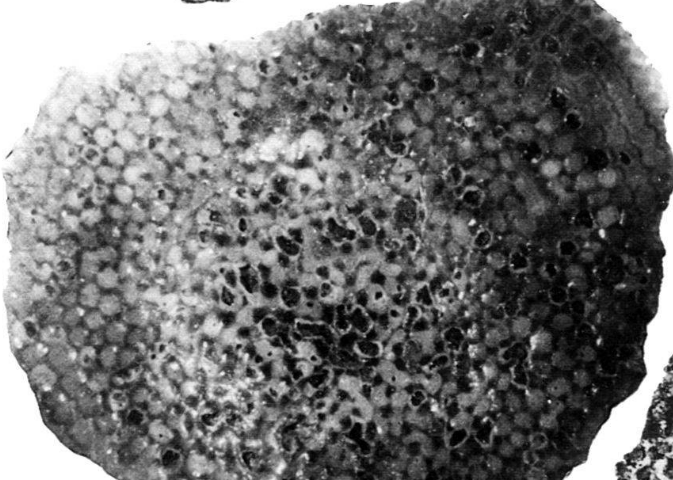
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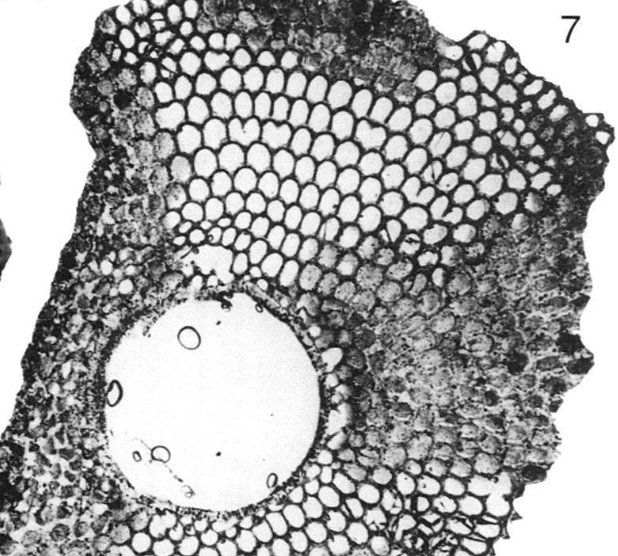
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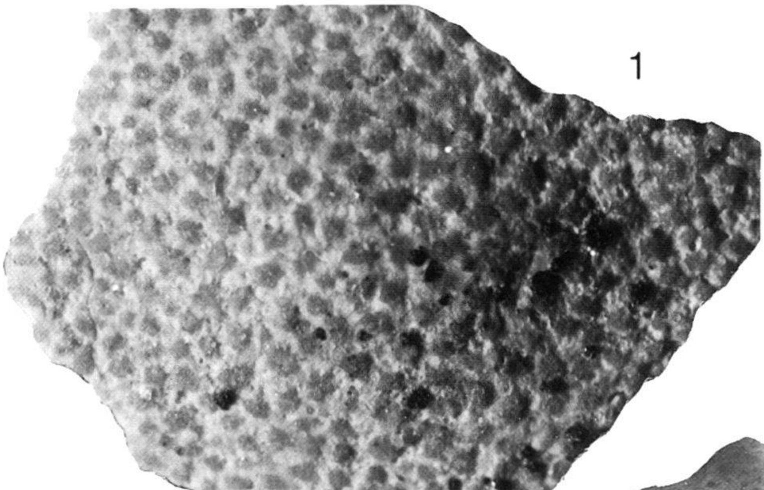
Plate 29

Fig. 1	*Lepidocyclina forresti* Vaughan pillared variety, Morne Diablo Quarry, K.S. 70, C 36053, × 17.	p. 1226
Fig. 2	*Lepidocyclina parvula* Cushman, A-form Morne Diablo Quarry, K.S. 70, C 35997, × 17.	p. 1227
Fig. 3	*Cycloloculina jarvisi* Cushman Soldado Rock, K. 3692, same specimen as Pl. 8:13, C 31049, × 60.	
Fig. 4	*Lepidocyclina canellei* Lemoine & R. Douvillé Morne Diablo Quarry, K. 2667, C 35992, × 17.	p. 1227
Fig. 5–6	*Sorites* sp. Gasparillo Quarry, C 36044 (Fig. 5), C 36125 (Fig. 6), × 17.	p. 1237

Plate 29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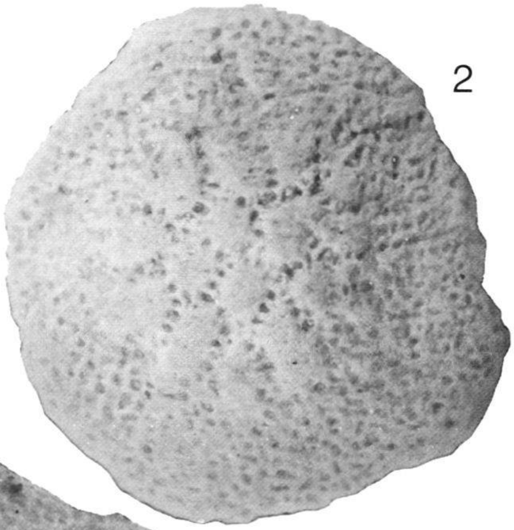
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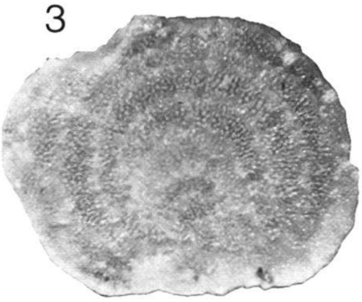
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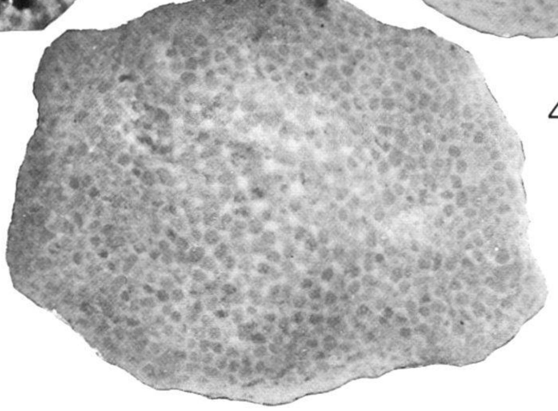
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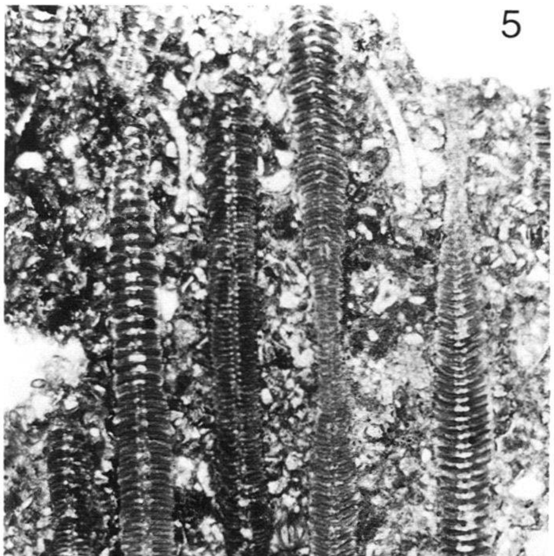
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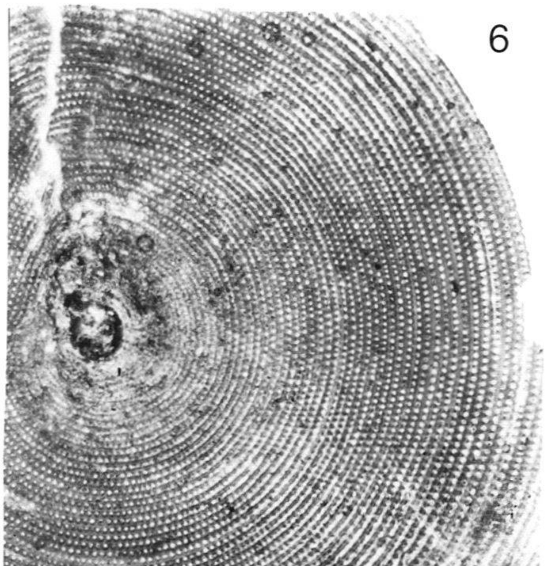
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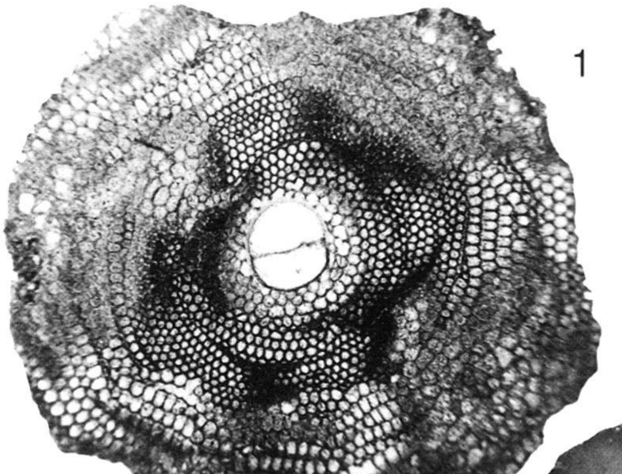
Plate 30

Fig. 1	*Lepidocyclina canellei* Lemoine & R. Douvillé regenerated specimen, Morne Diablo Quarry, K. 2667, C 36098, × 17.	p. 1227
Fig. 2	*Helicosteginopsis soldadensis* (Grimsdale), B-form Vistabella Quarry, Coll. Lehner 1933, C 36120, × 30.	p. 1235
Fig. 3	*Lepidocyclina (Polylepidina) nitida* Caudri, n. sp., B-form Point Bontour, St. 71, C 36067, × 30.	p. 1215
Fig. 4	*Lepidocyclina yurnagunensis* (Cushman), B-form Cipero Coast, Cd. 26, C 35967, × 17.	p. 1220
Fig. 5	*Neodiscocyclina fonslacertensis* (Vaughan & Cole) with clear undivided ring around the nucleoconch, Soldado Rock, K. 2951B, C 31154, × 34.	p. 1204
Fig. 6	*Helicolepidina spiralis* Tobler common form, Point Bontour, St. 63, C 35927, × 17.	p. 1233
Fig. 7	*Neodiscocyclina fonslacertensis* (Vaughan & Cole) flat form, Lizard Springs, Mky 102b III, U.S.N.M. Washington, × 17.	p. 1204
Fig. 8	*Asterocyclina asterisca* (Guppy) lenticular variety, Point Bontour, St. 63, × 17.	p. 1207
Fig. 9	*Lepidocyclina sanfernandensis depressata* Caudri, n. var. Cipero Coast, C.S. 11, coll. Naegeli, C 36077, × 17.	p. 1223

Plate 30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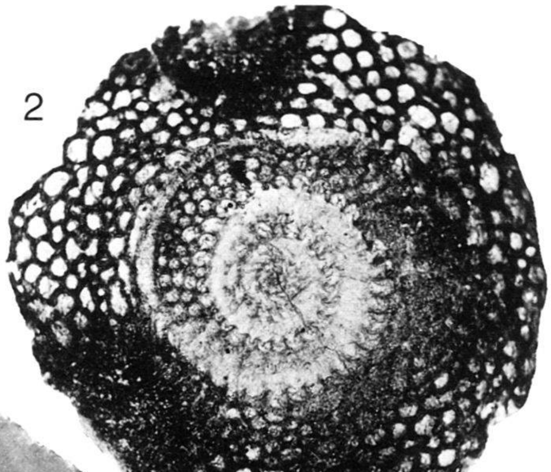
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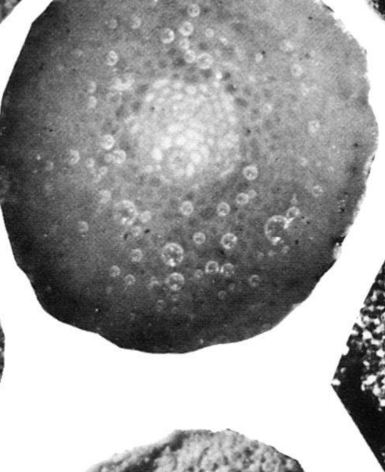
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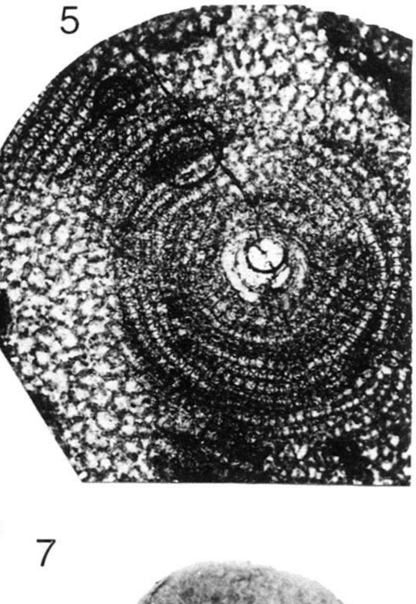
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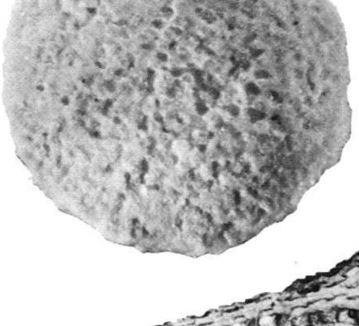
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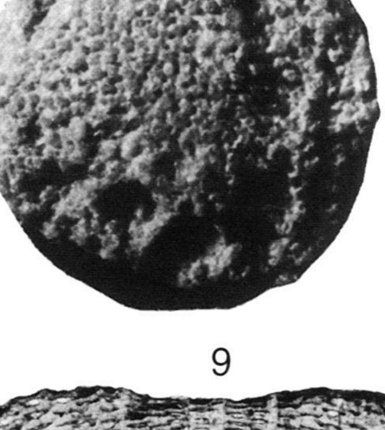
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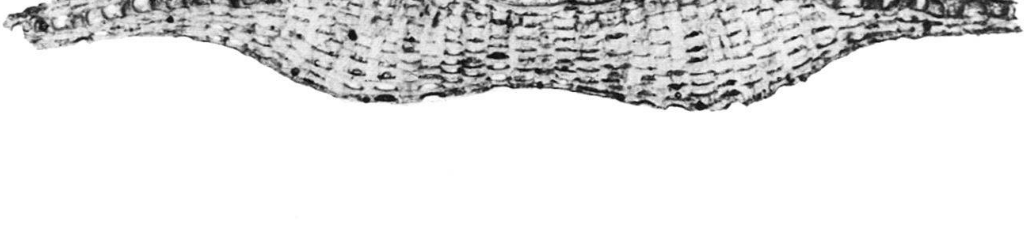
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