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The Larger Foraminifera of the Scotland District of Barbados

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ABSTRACT

From a critical review of the published literature on the subject combined with the renewed study of the type sample of the Murphys beds, the conclusion is reached that the Upper Scotland Formation of Barbados is of lower Middle Eocene age, but that its fauna is heavily contaminated with reworked material from the Paleocene.

Ranikothalia, "*Discocyclina*" (*Neodiscocyclina*) *grimsdalei* and associated species, and *Actinosiphon* do not continue into the Middle Eocene: they have a normal restricted vertical range in the Paleocene and Lower Eocene and their presence in the Upper Scotland beds is due to secondary deposition.

Some of the "Discocycliniformes" are discussed in detail.

Introduction

The geology and paleontology of the small island of Barbados in the West Indies have been the subject of a couple of conscientious detailed studies and one would expect that by now the character of the foraminiferal fauna and its significance for the stratigraphy of the Carribbean region would be clear and reliable.

Unfortunately, this is far from being the case. Through a number of causes the results have turned out to be confused and even downright misleading.

The following pages may contribute to clear up the errors that have sneaked in and to come to a better understanding of the data we have in our hands.

I. Recapitulation of the published data

1. The stratigraphical section

For the field geology of Barbados we refer to the paper by Dr. ALFRED SENN (1940), who through the long years of his residence in the island and by his untiring efforts came to know this restricted area as few others.

The islands is for the greater part covered by Pleistocene coral limestones, but in a large erosional window in its NE corner, the so-called Scotland District, the underlying Eocene and a little Oligocene-Miocene are extensively exposed.

SENN proposed for this area the following stratigraphical section:

- Bissex Hill marl (Upper Oligocene to Lower Miocene)
- Codrington College marl (Lower Oligocene?)
- Oceanic Formation, essentially a Radiolaria marl (Upper Eocene)
- Joes River mudflows (linked to early Upper Eocene orogeny)

- Upper Scotland Formation (Middle Eocene), subdivided into:
  Mount All beds
  Chalky Mount beds
  Murphys beds
- Lower Scotland Formation (Lower Eocene), subdivided into:
  Morgan Lewis beds
  Walkers beds
- Nummulite limestone (Paleocene), not exposed in situ but found only in the form of erratic blocks in the Joes River mudflows.

SENNS' detailed lithological description of this section includes the preliminary determinations of some of the Larger Foraminifera. With their help, the Joes River limestone blocks which contain *Lithothamiumn*, *Discocyclina s.s.*, *Nummulites* and *Operculina* were correlated with the "*Pellatispirella* limestone" (Paleocene) on the Soldado Rock off Trinidad (KUGLER 1938). Also the Middle Eocene age of the Upper Scotland Formation with its locally rich fauna was based on the foraminifera: *Discocyclina s.s.*, *Asterocyclina*, *Nummulites*, *Operculina* and *Amphistegina* cf. *lopeztrigoi* (loc. cit., p. 1558–1560). The Lower Scotland Formation, in which only occasionally some small *Nummulites* or a fair amount of small *Discocyclinas* were found, was placed in the Lower Eocene for stratigraphical reasons.

2. Paleontology

With the intention of obtaining the best scientific results possible, SENN subsequently divided his paleontological collection between different specialists in the various fields: the corals went (eventually) to J.W. WELLS in Columbus, Ohio, the "orbitoids" to T.W. VAUGHAN in Washington D.C., the "Nummulites and Operculinas" to MARIE DE CIZANCOURT in Paris, and a very limited quantity of unsorted duplicate material was sent to the present writer in the Trinidad Leaseholds Laboratory at Pointe-à-Pierre, for comparison with local faunas of Trinidad (loc. cit., p. 1549, 1550 and 1558).

And that is where the trouble started! Though both VAUGHAN and DE CINZANCOURT were aware of the fact that they had incomplete material, they did not contact each other and they each presented to their readers a partial and therefore distorted picture of the fossil contents of the Barbadian beds.

Vaughan (1945, p. 18–20) leaves out all the "nummulites" from the fauna of the Upper Scotland Formation which he claims to be "the type Middle Eocene Larger Foraminifera fauna of America"; DE CIZANCOURT does mention the "orbitoids" in SENN's sample list and even cites VAUGHAN'S determinations (1948, p. 13–19), but she completely omits them in her conclusions and in the "distribution table of the faunas" on p. 31–33. CAUDRI's observations went into private company reports in 1941; after permission for publication was obtained, she only offered a preliminary list of fossils in connection with a different subject, without further comments (1948, p. 477–478).

II. Synthesis and additional new data

For a complete picture of the Larger Foraminifera fauna of the Scotland beds we have to combine all three lists; in addition, I recently had the opportunity to re-study the material in my own private collection.

In the following discussion I have modernized the names used in the forementioned publications to bring them in line with the other literature on the subject (CAUDRI 1944, 1972; DE CIZANCOURT 1951). Thus VAUGHAN'S *Discocyclina s.s.* is in most cases changed to *Neodiscocyclina*; *Asterocyclina*, *Proporocyclina* and *Athecocyclina* are recognized as genera in their own right, unrelated to *Discocyclina* and *Pseudophragmina* of which they were considered as mere subgenera. *Amphistegina senni* has been assigned to the genus *Eoconuloides* COLE and BERMUDEZ 1944. DE CIZANCOURT (1948) lists ten different species of Camerinidae from the Joes River blocks and the Scotland Formation, including *Operculina catenula* and *Operculina bermudezi*. I do not intend at the moment to go into all the details of these specific determinations, but all of them clearly belong to what she calls the group of "Nummulites cordelées", which is the same as CAUDRI'S genus *Ranikothalia* 1944, and all of them seem to fall within the limits of the widely divergent varieties of one species, to which I think the name of *Ranikothalia catenula* (CUSHMAN and JARVIS) should be applied and which in Trinidad includes the forms *antillea* (HANZAWA), *tobleri* (VAUGHAN and COLE) and *soldadensis* (VAUGHAN and COLE).

As regards my own material, I had at my disposal only seven samples: one of the Joes River limestone (collected by SENN, unnumbered), four from the Murphys beds (S. 34b, incomplete; S. 34c, and a duplicate sample collected by myself from the same locality under the personal guidance of Dr. SENN; S. 62), a couple of isolated "*Discocyclinas*" collected from the middle Chalky Mount beds at Spa by a Mr. ROSE, a Barbadian friend of Dr. SENN's, and one poor sample from the Mount All beds (S. 711). Only one of these localities (but fortunately the most important one) yielded a good fauna: S. 34c, the type locality of the Murphys beds.

Though scanty, my material from that locality has the great advantage that it has not been tampered with. It may well be the only complete material in existence. Eventually, it will find its place in the Natural History Museum in Basel, Switzerland, which is also in the possession of DE CIZANCOURT'S types. VAUGHAN'S type material is in the National Museum in Washington D.C., but a set of co-types, identified by him, is also in Basel.

a) Upper Scotland Formation

Murphys beds

SENN'S description of the outcrop of the Murphys beds at their type locality S. 34c runs like this:

"Bluish-grey barren silt with nests of gritty silt containing mostly angular or poorly rounded quartz pebbles up to 4 mm in diameter, glauconite common, and with *Discocyclina*, *Operculina*, *Amphistegina*, small *Nummulites*, echinoid spines and fish teeth."

The sample collected by myself was taken from such a grit nest. Its particular lithology can be described like this: coarse argillaceous non calcareous grit composed of angular unsorted grains of clear and milky quartz, with abundant well preserved

Larger Foraminifera, Echinoids and small, extremely delicate and finely ornamented Gastropods.

The complete fauna of the two samples from S. 34c together is as follows:

Ranikothalia antillea (HANZAWA), common; outer chambers in most cases filled with glauconite

Ranikothalia tobleri (VAUGHAN and COLE), scarce

Neodiscocyclina anconensis (BARKER), common; mostly very well preserved, with air-filled chambers

Neodiscocyclina barkeri (VAUGHAN and COLE), scarce

Neodiscocyclina grimsdalei (VAUGHAN and COLE), scarce

Neodiscocyclina aguerreverei (CAUDRI), one specimen

Neodiscocyclina fonslacertensis (VAUGHAN), one specimen

Neodiscocyclina cf. *bullbrooki* (VAUGHAN and COLE), B-form, one specimen

Neodiscocyclina cf. *bullbrooki* (VAUGHAN and COLE), A-form, scarce

"*Discocyclina*" sp. indet. a (see description on p. 232), one specimen

"*Discocyclina*" sp. indet. b (see description on p. 232), scarce

Asterocyclina cf. *asterisca* (GUPPY), one very small subglobular heavily pillared split specimen showing the typical periembryonic ring, and one similar but indeterminable specimen (horizontal section)

? *Proporocyclina schomburgki* VAUGHAN, one specimen (compare VAUGHAN's paratype from the same locality!)

Proporocyclina perpusilla (CUSHMAN), one heavily pillared specimen[1])

Actinosiphon barbadensis (VAUGHAN), fairly frequent (also one microspheric specimen)

Orbitolinoides senni VAUGHAN, two specimens

Lepidocyclina cf. *pustulosa* DOUVILLÉ s.l. (or Polylepidina?), one specimen

Lepidocyclina sp. indet., very thinwalled, probably closely related to *L. pustulosa forma trinitatis* (DOUVILLÉ) VAUGHAN and COLE, one specimen

Eoconuloides senni (CUSHMAN), abundant

Amphistegina sp. indet. div., some reminescent of the Middle Eocene of Farallon Rock off Trinidad, others of the *Proporocyclina tobleri* assemblage in bed 11 of Soldado Rock, few

Sphaerogypsina globulus s.l., scarce

Smaller Foraminifera, mostly of a whitish colour, all of them scarce:

Cyclammina sp.

Arenobulimina sp.

Sigmoidella sp.

Nodosaria s.l., sp. div.

Marginulina sp.

Robulus s.l. sp. div.

Flabellina sp.

Frondicularia sp. div.; also one very large dark-brown specimen

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[1]) CAUDRI (1948, p. 478) mentions this specimen as *Proporocyclina perpusilla*? or *P. tobleri*?. In combination with *Neodiscocyclina* cf. *bullbrooki*, the possible presence of *P. tobleri* could be interesting, but both determinations are very precarious (see below, p. 230–231).

Siphogenerina sp. div.
Cancris ? sp.
Eponides sp. div.
Gyroidina sp.
Anomalina sp.
Cibicides sp.
Ostracods, scarce
Bryozoa, scarce
Crab claws, scarce
Gastropods (small, probably chiefly juvenile, very delicate and well-preserved), few
Echinoids, frequent
Corals, scarce

For the Murphys beds as a whole, we have to complete this list with the following forms mentioned by VAUGHAN and DE CIZANCOURT but not noticed in this particular sample[2]):

Ranikothalia, nine of the ten varieties distinguished by DE CIZANCOURT, including the form R. *soldadensis* (VAUGHAN and COLE)
"*Discocyclina*" (*Neodiscocyclina* ?) *harrisoni* VAUGHAN, mentioned from sample S. 34b

Chalky Mount and Mount All beds

My material from the other members of the Upper Scotland Formation did not contribute much to our knowledge of their fauna. The fossils collected by Mr. ROSE at Spa (Chalky Mount beds) turned out to be B-forms of *Neodiscocyclina anconensis* (five specimens) and a beautiful specimen of "*Discocyclina*" *harrisoni*, and the sample S. 711 (Mount All beds) yielded N. *anconensis*, A forms. For the rest, I refer to the published lists:

Chalky Mount beds

Ranikothalia, all the different varieties recognized by DE CIZANCOURT
Neodiscocyclina anconensis (BARKER)
"*Discocyclina*" (*Neodiscocyclina* ?) *harrisoni* VAUGHAN
"*Discocyclina*" (*Neodiscocyclina* ?) *turnerensis* VAUGHAN
Neodiscocyclina grimsdalei (VAUGHAN and COLE)
Asterocyclina franksi VAUGHAN
Proporocyclina perpusilla (CUSHMAN)
Proporocyclina schomburgki VAUGHAN
Pseudophragmina ? sp. (or *Proporocyclina* ?: no section available)
"*Athecocyclina*" (*Stenocyclina* CAUDRI) *jukesbrownei* VAUGHAN (see annotation on p. 233)
Orbitolinoides senni VAUGHAN
Lepidocyclina (*Pliolepidina*) sp. cf. *pustulosa* DOUVILLÉ
Eoconuloides senni (CUSHMAN)

[2]) CAUDRI's record of *Asterocyclina barbadensis* VAUGHAN from the Murphys beds is an error: the species has up to now not been found outside the Mount All beds (CAUDRI 1948, p. 478).

Mount All beds

Ranikothalia catenula (CUSHMAN and JARVIS), A-form
Neodiscocyclina anconensis (BARKER)
"*Discocyclina*" (*Neodiscocyclina* ?) *harrisoni* VAUGHAN
Neodiscocyclina grimsdalei (VAUGHAN and COLE)
Asterocyclina barbadensis VAUGHAN
Proporocyclina perpusilla (CUSHMAN)
Eoconuloides senni (CUSHMAN)

b) Lower Scotland Formation

As to the Lower Scotland Formation, our information remains very incomplete.

The only data we have on the upper part, the Morgan Lewis beds, consist of VAUGHAN's determination of *Neodiscocyclina grimsdalei* in sample S. 411 and that of *Nummulites convexa* nov. by DE CIZANCOURT at S. 162. The latter is a small tightly coiled form which I myself would include in *Ranikothalia antillea*.

From the lower member, the Walkers beds, SENN reports the local occurrence of "common *Discocyclinas* and very small *Nummulites*". This refers chiefly to sample S. 587 (see VAUGHAN 1945, p. 16). Under the guidance of Dr. SENN, the present writer collected some duplicate material at this same important locality. A preliminary list of its fauna was given by me in 1948 (p. 477), partly with an erroneous nomenclature, which is here corrected.

Morgan Lewis beds

Ranikothalia antillea (HANZAWA)
Neodiscocyclina grimsdalei (VAUGHAN and COLE)

Walkers beds

Ranikothalia antillea (HANZAWA)
Neodiscocyclina cf. *bullbrooki* ? (VAUGHAN and COLE)
Athecocyclina sp. indet.
Actinosiphon barbadensis (VAUGHAN)
Actinosiphon ? sp. div., with arcuate and with rhomboid equatorial chambers
? *Eoconuloides* cf. *lopeztrigoi* (PALMER)
Cyclammina sp.
Robulus sp. div.
Ostracods
Fish teeth

c) Joes River limestone blocks

Of the hard limestone blocks from the Joes River mudflows all three students had essentially the same material and the results from all sides converge. This fauna contains:

Ranikothalia antillea (HANZAWA)
Ranikothalia soldadensis (VAUGHAN and COLE)

Ranikothalia indet., cf. *tobleri* (VAUGHAN and COLE)
Neodiscocyclina barkeri (VAUGHAN and COLE)
Neodiscocyclina grimsdalei (VAUGHAN and COLE)
Neodiscocyclina aguerreverei (CAUDRI)
"*Discocyclina*" (*Neodiscocyclina* ?) *mestieri* VAUGHAN
Hexagonocyclina cf. *meandrica* CAUDRI
Athecocyclina soldadensis VAUGHAN and COLE *var. calebardensis* VAUGHAN
Actinosiphon barbadensis (VAUGHAN)

III. Age determination

1. *The Joes River limestone blocks (remnant formation)*

The fauna of the limestone blocks in the Joes River mudflows does not present any difficulties. SENN's correlation with KUGLER's "*Pellatispirella* limestone" (which now, more correctly, is called the *Ranikothalia* limestone) at the type locality of the Caribbean Paleocene on Soldado Rock, is in all respects confirmed.

The sandy and gritty limestone which furnished these blocks represents a characteristic stratigraphical unit in the Barbadian section, but in the absence of an outcrop and geographical type locality no formational name can be allotted to it.

The greatest number of blocks was found in the uppermost part of the Mount All River and on the southern slopes of the Mount All Ridge. SENN (loc. cit., p. 1574–1576) came to the conclusion that the mudflows have originated from two distinctly different vents: one in the manjak mines on the Springvale Estate, giving rise to the flows south of the Murphys anticline, and another one, linked to the manjak vein of Groves, for those on the north flank. As the Paleocene blocks have all been found north of the anticline, whereas they seem to be absent on the south side, our best chance to find something of this Paleocene limestone in the subsurface section appears to be in the vicinity of Groves.

2. *The Scotland Formation*

Our attention goes in the first place to the Upper Scotland Formation and particularly to the Murphys beds of which we have the best fauna. Afterwards we shall turn to the age determination of the lower part of the formation (p. 231).

a) The Upper Scotland Formation

The age of the Murphys beds is characterized as Middle Eocene by the affinity of its corals to those of the Claiborne Formation of the Gulf States (WELLS 1945) and by the occurrence of *Neodiscocyclina anconensis* and *Eoconuloides senni* in its foraminiferal assemblage.

The same applies also to the other two members of the formation; there are no paleontological reasons to separate them from the Murphys beds. The presence of a costate species of *Asterocyclina* (*A. barbadensis*) adds another argument in favour of a Middle Eocene age.

VAUGHAN (p.21) says: "It is probable that the Upper Scotland Formation comprises much of the Middle Eocene, not merely its upper part", but we have to go

one step further: the combination of *Neodiscocyclina anconensis* (and "*Discocyclina*" *harrisoni*) and *Eoconuloides* pins it down to the lower part of the Middle Eocene. The Upper Scotland must be correlated with the San Eduardo limestone of Coastal Ecuador (STAINFORTH 1948), the Basal Talara shale of NW Peru (STAINFORTH 1955), the *Gaudryina* beds of the Navet Formation in Trinidad, the limestones of the Las Bermudez and El Dátil Formations of Margarita (DE RIVERO 1956), the Peñon Seep in western Cuba (COLE and GRAVELL 1952), Zone I of Lake City Formation in Florida (COLE and APPLIN 1964) and the lower part of the Guayabal Formation of Mexico (BARKER and GRIMSDALE 1936). Indications that also younger beds may be included in the formation, such as the first *Polylepidinas* (?) and primitive *Lepidocyclinas* of the *pustulosa*-group and an odd specimen of *Asterocyclina* cf. *asterisca*, are negligible. In other words, the Upper Scotland Formation is older than the zone of *Lepidocyclina antillea*.

However, the moment we look at the rest of the foraminifera we immediately run into complications, as this age determination is not in accordance with the vertical range of several of the accompanying species as we know them from elsewhere. As a rule, the other *Neodiscocyclinas*, the *Ranikothalias* and *Actinosiphon* are considered as markers for the Paleocene and the lower part of the Lower Eocene and, according to the Pointe-à-Pierre Laboratory, also the Smaller Foraminifera show a mixed character, some of them pointing to the Middle Eocene *Gaudryina* beds of Trinidad and others to the Paleocene at Lizard Springs and on Soldado Rock.

This contradiction has completely escaped VAUGHAN, who accepted the orbitoid fauna as homogenous and consequently assigned to *Neodiscocyclina grimsdalei* a vertical range which is entirely out of proportion. But DE CIZANCOURT's suspicion was roused by the striking resemblance of the *Ranikothalias* in the Middle Eocene with those of the Paleocene of the Joes River blocks and of other areas, as well as by the observation that in Barbados they did not show any sign of an evolutionary development throughout that whole long period of time.

In 1948 (p. 31) she writes:

"After studying only such a limited number of *Nummulites* I do not want to express a definite opinion on the age of the Scotland beds, especially because I should actually make them much older (than they are supposed to be) and for such a conclusion more decisive arguments would be needed."

"The data which I have at the moment at my disposal lead me to a comparison of the Nummulite fauna of the Scotland beds and the Joes River blocks with the forms from the Ranikot stage in India (viz. the forms belonging to the group of *N. nuttalli*, described by L. M. DAVIES[3]) and with certain forms from Trinidad (*N. catenula*), *Operculinoides bermudezi* from Cuba and *N. pellatispiroides* from Mexixo."

"The state of preservation of the Barbadian *Nummulites* shows that they were subjected to erosion, which may indicate that they were transported after fossilization. In other words, that they are re-deposited, in which case their stratigraphical value would be nil."

"A remarkable fact is that the selfsame species occur throughout the Scotland Formation at all different levels. Not one horizon is characterized by a special well defined species which could be considered as really in situ and as a true stratigraphical marker. To the contrary: the same species are, for instance, found in the Joes River blocks and in the middle Chalky Mount beds."

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[3]) The type species of the genus *Ranikothalia* CAUDRI, which was created for this group in 1944, is this same *Nummulites nuttalli* (NUTTALL) DAVIES from the Ranikot beds at Thal in Sind, a country now included in Western Pakistan, not India.

Summarizing, DE CIZANCOURT's conclusion is that the presence of the "Nummulites cordelées" in the Barbadian Middle Eocene is easier explained by reworking than by assigning such an abnormally long vertical range to them.

This view is supported by SENN's observations in the field (1940, p. 1555–1556). For the Chalky Mount beds he describes conglomeratic layers and lenses which contain irregular pieces of partly calcareous sandstones and grits with shell fragments, of *Lithothamnium* – *Amphistegina* – limestones and of sandy limestones full of small *Nummulites* and *Operculina*. The whole mass of the "lower grits" in this member carries mollusks and Larger Foraminifera. In the conglomerates the fossils are worn and rolled, but in the grits there are many delicate shells which are preserved with their finest sculpture intact, proving that at least the greater part of the fauna in them is autochthonous. But he warns that "the presence of the aforementioned pieces of nummulitic limestone makes it probable that one might also expect some reworked pieces amongst the isolated fossils".

This description equally applies to the gritty nests in the silt of the Murphys beds (for instance S. 34c), which contain a curious mixture of dense, worn and sometimes glauconite-filled foraminifera and beautifully preserved delicate Gastropods and specimens of *Neodiscocyclina anconensis* with open cavities. All of them in a matrix of coarse quartz grains that cannot possibly represent the quiet water conditions under which they were deposited.

All this points to the heterogeneous nature of the Scotland beds which are the product of neritic sedimentation, erosion, slump, bottom currents and wave action combined. SENN considers them as a genuine Flysch, linked with the initial stage of the orogeny which later, in pre-Oceanic times, lifted the entire area above sea level and caused the effusion of the Joes River mudflows (loc. cit., p. 1560, 1584, 1585).

In 1951, DE CIZANCOURT takes up the question of the stratigraphical value of the Barbadian *Nummulites* again, in connection with her study of those of Venezuela (loc. cit., p. 9):

"The (*Nummulites*) collected from the different levels of the Eocene of Barbados, where they occur in a reworked condition and are accompanied by *Discocyclina* s.l. of a younger age than Paleocene, did not allow me to reach any stratigraphical conclusions. In contrast with this, the 'Nummulites cordelées' of Venezuela, at least in those areas from which I had my samples, are restricted to a (definite) zone."

And further, on p. 44:

"We thus have (in Venezuela) all the elements of the Barbadian (Nummulite) fauna, but over there because they are re-deposited, they do not lend themselves to an age determination of the various beds. In Venezuela, however, we find them framed between the underlying Maestrichtian (*Vaughanina* beds) and the overlying top part of the section which consists of the upper part of the Lower Eocene (the La Paz limestone) and the Middle Eocene (the Cuicas and El Cumbe limestones)". Neither the Maestrichtion nor these overlying beds carry any Ranikothalias.

DE CIZANCOURT assigns to the "zone à *Nummulites cordelées*" a Paleocene to early Lower Eocene age.

As the Venezuelan section seems to be undisturbed and continuous, this is a valuable observation. Now, intercalated between this zone and the horizon of the lower Middle Eocene represented by the Upper Scotland Formation, there are in the Caribbean region at least two different faunas of Larger Foraminifera in which there

are no *Ranikothalias* and (in spite of DE CIZANCOURT's report to the contrary) no typical Paleocene "*Discocyclinas*": that of the above-mentioned La Paz limestone and the equivalent beds at San Francisco de Cara (upper Lower Eocene), and the enigmatic *Proporocyclina tobleri* fauna which was found (in a reworked state) in the uppermost bed of the Upper Eocene on Soldado Rock but which must have come from a horizon at the turn of the Lower to the Middle Eocene (CAUDRI 1944, p. 385). It would be illogical to assume that after such a long period of time the old *Ranikothalia* assemblage should suddenly have come to life again in Barbados. Everything considered, reworking is the best explanation for its presence in the Upper Scotland beds.

Thus, the Larger Foraminifera fauna of the Upper Scotland Formation falls apart into two different groups:

Autochthonous are:

Orbitolinoides senni VAUGHAN
Neodiscocyclina anconensis (BARKER)
"*Discocyclina*" (*Neodiscocyclina* ?) *harrisoni* VAUGHAN
? "*Discocyclina*" sp. indet. a
Asterocyclina barbadensis VAUGHAN
Asterocyclina franksi VAUGHAN
Asterocyclina cf. *asterisca* (GUPPY)
Asterocyclina sp. indet.
"*Athecocyclina*" (*Stenocyclina*) *jukes-brownei* (VAUGHAN)
Proporocyclina perpusilla (CUSHMAN)
Proporocyclina schomburgki VAUGHAN
Lepidocyclina cf. *pustulosa* DOUVILLÉ
Lepidocyclina cf. *pustulosa forma trinitatis* (DOUVILLÉ)
Lepidocyclina (*Polylepidina* ?) sp. indet.
Eoconuloides senni (CUSHMAN)
Amphistegina sp., resembling the form from Farallon Rock off Trinidad

Reworked from the Paleocene (original formation of the Joes River limestone blocks):

Ranikothalia catenula (CUSHMAN and JARVIS), in the varieties *antillea* (HANZAWA), *tobleri* (VAUGHAN and COLE), *soldadensis* (VAUGHAN and COLE) and others (see DE CIZANCOURT 1948)
Neodiscocyclina barkeri (VAUGHAN and COLE)
Neodiscocyclina grimsdalei (VAUGHAN and COLE)
Neodiscocyclina aguerreverei (CAUDRI)
Neodiscocyclina fonslacertensis (VAUGHAN)
"*Discocyclina*" (*Neodiscocyclina* ?) *turnerensis* VAUGHAN
"*Discocyclina*" sp. indet. b
Actinosiphon barbadensis (VAUGHAN)

Apart from these, there are the isolated specimens which I have hesitatingly determined as belonging to the *Proporocyclina tobleri* fauna: ? *Proporocyclina* cf. *tobleri*, *Neodiscocyclina* cf. *bullbrooki* and the new species of *Amphistegina* which, at their

type locality, is associated with these two. If the determination is correct, this would mean that also this younger zone has been involved in the process of reworking, but all this should be taken with a very critical mind.

Barbados does not stand alone as an example of reworking of Paleocene material into the Middle Eocene. At Biche, in eastern Trinidad, we also find badly preserved *Ranikothalia*, *Neodiscocyclina grimsdalei* and *Actinosiphon barbadensis* in combination with *Neodiscocyclina anconensis* and *Eoconuloides senni* (*Gaudryina* beds, Navet Formation). Also COLE and BERMUDEZ (1947, p. 3–6) mention reworked *Discocyclina barkeri* and *Discocyclina mestieri* (and *Vaughanina cubensis*!) from the Middle Eocene of the Habana Province in Cuba.

The record of large numbers of *Operculina catenula* in the upper part of the Lower Eocene (and the ? Middle Eocene) of Yucatan and in Haiti deserves special attention in this connection (see BUTTERLIN and BONET 1960).

b) The Lower Scotland Formation

The poor fauna of both the Morgan Lewis and the Walkers beds is insufficient for a definitite paleontological conclusion on the age of this formation, but it shows an undeniable affinity to that of the Paleocene and the Lower Eocene elsewhere.

The relative frequency and the variability of the *Actinosiphons* in the Walkers beds are vaguely reminescent of the Paleocene and lower Lower Eocene of Venezuela (DE CIZANCOURT 1951).

Of course, also here there is the possibility that all the "Paleocene" forms are reworked, but there are no definite indications for a younger age to counterbalance the "old" character of the fauna.

At the moment, a Lower Eocene age still seems the best guess.

IV. Paleontological annotations

"*Discocyclina*" (*Neodiscocyclina* ?) *harrisoni* VAUGHAN

1945 *Discocyclina harrisoni*, VAUGHAN, p. 35, Pl. 11, Fig. 1–5.
Discocyclina anconensis pars, VAUGHAN, p. 35, Pl. 10, Fig. 3.
1952 *Discocyclina marginata*, COLE and GRAVELL, p. 714, Pl. 93, Fig. 1–9; Pl. 94, Fig. 1–8; Pl. 95, Fig. 7–8.

"*Discocyclina*" *harrisoni* is a very robust form, coarser than *Neodiscocyclina anconensis* and clearly distinguished from it by its heavier annular walls and by its denser vertical section.

VAUGHAN mentions the species only from the Chalky Mount beds and the Murphys beds, but one of his illustrations of *N. anconensis* from the Mount All beds also refers to *N. harrisoni*.

There is little doubt that VAUGHAN'S *Discocyclina harrisoni* from Barbados is the same as the form from the lower Middle Eocene of the Peñon Seep in Cuba which Cole and Gravell determined as *D. marginata*, one of the few American "*Discocyclinas*" recognized by COLE in 1959 (p. 381) as valid species. But whether this Cuban form should really be determined as *marginata* is another question. The original *Disco-*

cyclina marginata (CUSHMAN) from St. Bartholomew was placed by VAUGHAN in 1945 in the genus *Proporocyclina*. Confusion of genera in this case is made easy by the peculiar tendency of the specimens from Cuba as well as from Barbados (observation made on the specimen from the Chalky Mount beds, coll. ROSE) to grow, in the peripheral region, very long and narrow median chambers in which the radial walls are often in alignment, instead of the strictly alternating chambers that are the rule in "*Discocyclina s. s.*" But VAUGHAN claims to have observed distal stolons in the holotype from St. Bartholomew, whereas COLE and GRAVELL'S Cuban specimens have a proximal stolon. This leaves some doubt as to the identity of the two forms, reason why I provisionally stick to the non-committal name of *harrisoni* for the fossils from Barbados.

Thus far nothing is known about the microspheric nepiont of the three forms mentioned above, so it has to be left undecided whether any of them belongs to the genus *Neodiscocyclina* or not.

Localities: S. 34b, Murphys beds; S. 61, base of the lower Chalky Mount beds; S. 43, S. 152, top of the lower Chalky Mount beds; unnumbered sample, coll. ROSE, middle Chalky Mount beds; S. 711, Mount All beds.

"*Discocyclina*" sp. indet. a

Exterior:

Diameter 3 mm (edges probably broken off).
Test thin, irregularly inflated in center, with small granulations all over the surface, best developed in the central part (specimen resembling a non-typical form of *Asterocyclina asterisca*).

Horizontal section:

Embryonic apparatus small (170 μ, including wall), formed by a globular protoconch and an only slightly larger reniform deuteroconch; periembryonic chambers probably forming a complete ring.

Equatorial chambers in very irregular annuli, generally 60–70 μ long, rectangular; annular and frequently also the radial walls thickened; radial walls often incomplete.

Vertical section: unknown.

Note: This form may be closely related to "*Discocyclina*" *harrisoni*, but differs from it in the shape of the nucleoconch.

Locality: S. 34c, Murphys beds (one specimen only).

"*Discocyclina*" sp. indet. b

Exterior:

Diameter about 2–2.3 mm; thickness 0.3 mm.
Test flat, without inflated center, ornamented all over the surface with circles of minute granulations.

Horizontal section:

Embryonic apparatus 150–200 μ (including wall), consisting of two chambers of practically equal size, surrounded by a nearly complete horseshoe-shaped ring of periembryonic chambers.

Equatorial chambers in irregular rings, 30–40 μ, but frequently not more than 15 μ long, often very broad. Thick annular walls; chamber lumina distally rounded. Radial walls thin, alternating, locally obliterated so as to form wobbly undivided rings, similar to *Athecocyclina* (partly due to secondary alteration?).

Vertical section:

Dense structure; very small fissiform lateral chambers and a low median layer: no parallel inner lateral layers on either side of the median layer.

Horizontal walls of median chambers not well developed; whole structure of the test faintly "nummulitic".

Locality: S. 34c, Murphys beds (scarce).

"*Athecocyclina*" *jukes-brownei* VAUGHAN

This species is not a true *Athecocyclina*, but a member of the group of *Proporocyclina advena*, *cloptoni*, etc., which is now distinguished as the genus *Stenocyclina* (see CAUDRI 1972).

Localities: S. 360, upper part of the middle Chalky Mount beds; S. 80, base of the middle Chalky Mount beds.

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