

The Boca de Serpiente formation

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Fernando and in the *Asterocyclina* marl (Bed 9a) of Soldado Rock. In its lack of *Helicosteginopsis*, Bed 10 corresponds with Bed 4. This correlation is further discussed below, in the chapter on the “Geological History of the Rock”.

The planktonic foraminifera do not offer much support to these detailed correlations. On their evidence J. B. Saunders states that he “would place Bed 10 in the *Globorotalia cerroazulensis* Zone (= *G. cocoaensis* Zone) rather than lower in the Upper Eocene, but it is not the topmost Eocene”. On the other hand, also many samples of Beds 7 and 9, and the *Asterocyclina* marl are assigned to this zone, in some cases rather to the lower than to the upper part of it.

C. THE BOCA DE SERPIENTE FORMATION

Author of name: MAURY (1929, p. 180)

Original description: idem

Bed 11

a) Bibliographic history

MAURY (1912, p. 28–31) described the highest of Veatch’s fossiliferous horizons on Soldado Rock (his Bed 8) as an indurated rock noticeable from being stained deep red with hematite, and greenish and purplish with other forms of iron, and gave a list of 28 species of mollusks and one brachiopod, most of them new (see under “Paleontology”, p. 418). Mainly on the abundant presence of *Ostrea thirsae* GABB, this fauna was correlated with the “Lignitic” fauna of the Gulf Coast of the United States; G. D. Harris considered this Soldado horizon to be the equivalent of the Nanafalia Formation (Wilcox) of Alabama.

KUGLER (1923, p. 258) failed to locate MAURY’s “Bed 8” during his short visit to the Rock, but assumed it to form part of his “Limestone Complex C”, which included the yellowish and red, nodular, in part sugary deposit forming the highest top of Soldado, and which rests on the well-bedded orbitoidal Bed B-4a; their contact is shown in Fig. 3. Since this Bed B-4a was recognized as being of Priabonian age, the “Complex C” was assigned a possible Oligocene age on the assumption that it would later prove to carry an *Isolepidina*–*Eulepidina* assemblage such as was known from Trinidad (an assumption that was not confirmed).

MAURY (1925c, p. 160) stated: “The age of Bed 6, characterized by foraminifera, is now thought to be Upper (Jacksonian) Eocene, and that of Bed 8 either uppermost Eocene or, less likely, basal Oligocene. Its fauna is not very decisive”.

LIDDLE (1928, p. 227) wrote: “Though there is no discordance of dip between the Eocene and Oligocene on Isla Soldado, an angular brecciated conglomerate indicates that considerable erosion has occurred between these two periods”. On p. 231 a translation of KUGLER’s description of the upper “Limestone Complex C” is given, whereby “knaurig” was erroneously translated as “lenticular conglomerate” instead of “nodular”. LIDDLE’s reproduction of Kugler’s photo of the contact between the “Orbitoidal Marlstone B” and the “Limestone Complex C” is of much better quality than that in the original paper. Also LIDDLE assumed that the fossiliferous Bed 8 of VEATCH and MAURY has to be included in the upper limestone formation, but his conception of MAURY’s faunas is rather confused.

MAURY (1929, p. 180) stressed the marked difference between the fauna of her Bed 2 (Soldado Formation) and that of Bed 8. For Bed 8 she established the term “Boca de Serpiente Formation” and the age was given as “Uppermost Eocene, equivalent to the European Ludian”. No type locality was specified.

MAURY (1935, p. 192) repeated her age determination of Bed 8 as Ludian, and compared its fauna to a horizon East of El Carmen in Northern Colombia (later described by CLARKE & DURHAM in 1946).

KUGLER (1938, p. 219–221) distinguished the upper “Limestone Complex C” of his previous paper as Bed 11 of his new detailed subdivision of the Soldado section. This bed starts with a zone

of glauconitic sand mixed with an autoclastic breccia of orbitoidal limestone of the same appearance as that forming the main mass of the summit. Further North, there are steeply dipping layers of dense limestone and thick beds, pockets and dykes of glauconite with green and copper red tinges. "It is in these glauconitic masses that are found the remains of those fossils described by MAURY as belonging to her Bed 8 and named by her the Boca de Serpiente Formation." From these glauconites RUTSCH determined six mollusks and one brachiopod (see p. 418). The material is deposited in the Natural History Museum in Basel.

Lithologically, Bed 11 seemed almost indistinguishable from the underlying orbitoidal Bed 10 (previously called: Bed B). KUGLER remarked that, if orbitoids in both beds should turn out to be the same, he would not hesitate to include Bed 11 in the San Fernando Formation, and to abandon the term "Boca de Serpiente Formation" altogether. (Note: VAUGHAN & COLE's work in 1941 proved the faunas to be different).

RUTSCH (1939a, p. 238) referred to the *Tubulostium* in his first fossil list (KUGLER 1938) as "*Tubulostium* aff. *leptosoma clymenoides*", as he was not sure it was completely identical to that species as found in the Vistabella Quarry in Trinidad. Correlation with the Trinidad Upper Eocene (Jacksonian) seemed probable but not certain. On the other hand, the presence of *Tubulostium* excludes an Oligocene age of Bed 11.

RUTSCH (1939b, p. 517) wrote: "Re-examination of the mollusks has shown that in all probability the Boca de Serpiente Formation may be correlated with the fauna from the Vistabella Quarry on Mount Moriah in Trinidad, and that it is definitely younger than Wilcox, and older than Vicksburg. Its age is probably Jacksonian (Upper Eocene)."

VAUGHAN & COLE (1941, p. 27) found that the Larger Foraminifera fauna of the basal glauconitic limestone of Bed 11 (K.3878) consisted exclusively of two new species: *Discocyclina* (*Discocyclina*) *bullbrookii* and *Pseudophragmina* (*Proporocyclina*) *tobleri*. As the horizon at which they occur lies above the typical Jacksonian of KUGLER's section (Beds 9 and 10), a certain stratigraphical importance was attached to this combination, but the age is still given as Upper Eocene. On p. 41 of their paper, they made the unfortunate mistake of stating that "*Operculinoides soldadensis* is an abundant species in the lower part of bed no. 11, at several places in bed no. 10, etc.", which is an obvious error. What they meant is: "the lower part of Bed 10, several placed in Bed 9" (compare loc. cit., p. 18-19). Bed 11 has yielded only one specimen of *Operculinoides* of this type (see below).

RENZ (1942, p. 541) included the Boca de Serpiente Formation in the San Fernando Formation.

CAUDRI (1944, p. 385, 386) pointed out that the exclusive *Proporocyclina tobleri* - *Discocyclina bullbrookii* fauna of Bed 11 (K.3878) had nothing in common with either the Paleocene or the typical Upper Eocene of Soldado Rock, and that the general character of these fossils seemed older, not younger, than that of comparable species in the underlying Jacksonian. She suggested that the fossil material in Bed 11 was of high Paleocene to basal Middle Eocene origin, redeposited in a barren post-Jacksonian sediment. On p. 386 is stated that, according to H. H. Renz, the benthonic fauna of Smaller Foraminifera in this sample has many species in common with the Paleocene fauna described by CUSHMAN & RENZ in 1942.

VAUGHAN (1945, p. 94, 106, 108, 112, 115) placed both species of Larger Foraminifera in the Upper Eocene.

LIDDLE (1946, p. 352-357) extended the term "Boca de Serpiente Formation" to include all the Upper Eocene sediments on Soldado Rock, and correlated them with a number of Upper Eocene formations in Trinidad and Venezuela.

CAUDRI (1948, p. 478) added *Amphistegina* sp. div. to the typical foraminiferal assemblage of Bed 11 and repeated the suggestion that the fauna was reworked.

KUGLER (1956b, p. 44) reported that it had been decided at the Meeting of Geologists in Trinidad to include Bed 11 in the San Fernando Formation, and that the term "Boca de Serpiente Formation" had become obsolete.

DE RIVERO (1956a, p. 79-83) gave an extensive detailed account of the bibliography of the Boca de Serpiente Formation, which on p. 83 she closed with the remark: "The question of whether the name Boca de Serpiente is to be retained or not and, if so, what rank is to be assigned to it, is

more properly a question for our Trinidadian colleagues. Since Soldado Rock is so isolated we would be in favor of using formational names limited to the island (even though the correlation with Trinidad may be indisputable). For this reason we would favour using 'Boca de Serpiente' according to LIDDLE's 1946 usage, even though it includes more than MAURY's original definition. MAURY's (1929) 'Boca de Serpiente', in our opinion having been defined by purely paleontologic criteria, really is more properly considered as a fauni-zone. It may be that Bed 11 represents a zone high in the Jacksonian, which might eventually merit distinction as a substage. In view of the fact that the name 'Boca de Serpiente' may be useful in the terminology of the Upper Eocene, we hope that Dr. Kugler will not insist (on his) tentative suggestion of (the term) 'Serpiente Formation' for Bed 3 of the Soldado section (which he now believes to be Wilcox, Lower Eocene, and would separate from the Soldado Formation)."

COLE (1959, p. 380) reported the find of *Discocyclina* (*Discocyclina*) *anconensis* BARKER, in association with *Pseudophragmina* (*Proporocyclina*) *tobleri*, in a second foraminifer sample from Bed 11 (E.L.1440, near the North shore). He came to the conclusion that, seemingly, *Discocyclina bullbrooki* (of which at K.3878 only microspheric forms had been found) was the B-form of *Discocyclina anconensis*. As this species occurs all through the Upper Scotland Formation of Barbados (Middle Eocene), he provisionally also assigned a Middle Eocene age to the fauna in Bed 11, for which he proposed the name of "*Pseudophragmina* (*Proporocyclina*) *tobleri* Zone". The stratigraphical aspects of Bed 11 were left out of the discussion.

COLE (1962*b*, p. 148) repeated VAUGHAN & COLE's erroneous statement that the lower part of Bed 11 carries *Operculinoides soldadensis* in abundance.

COLE (1969*a*, p. 10–13, 48) discussed certain features of *Proporocyclina tobleri* from K.3878 and assigned a Lower Eocene age to the material (p. 48).

CAUDRI (1972*a*, p. 216) changed the generic name of *Discocyclina bullbrooki* to *Neodiscocyclina*.

JUNG (1972, private correspondence) stated that the Boca de Serpiente mollusk fauna is not diagnostic enough for an age determination. The fauna is not rich, there are relatively few species and the fossils are not well preserved. Conclusions obtained from the foraminifera would be more reliable than those based on the mollusk remains.

CAUDRI in the paleontological section (Part 2) of the present study draws attention to the presence of a small megalospheric *Neodiscocyclina*, associated with *Neodiscocyclina bullbrooki* and *Proporocyclina tobleri* at K.3878 and elsewhere, which is a far more likely companion for *Discocyclina bullbrooki* than COLE's form from E.L.1440. Also, the author does not agree with COLE's specific identification as *Discocyclina anconensis*, but considers the form in question as a new species (*Neodiscocyclina mauryae*). The "*Proporocyclina tobleri* Zone" should not be correlated with the San Eduardo Limestone of Ecuador (type locality of *Discocyclina anconensis*), or the Upper Scotland Formation of Barbados, but is probably slightly older (see further under "age of Bed 11"). The relationship between the fauna and the matrix in which it is embedded, Bed 11 as such, is extensively discussed on p. 415 and 419 (present paper). Apart from the already mentioned new *Neodiscocyclina*, also two new species of *Amphistegina* are described from the *Proporocyclina tobleri* assemblage (*A. undecima* and *A. pauciseptata*).

b) Type section of Bed 11

From the highest top of the islet down to the Northern shore (D-3, C-2, C-1).

c) Stratigraphic relationship

Bottom: the bottom of Bed 11, observed at K.3693(D-3), is formed by a 30 cm thick breccia of angular blocks of orbitoid limestone embedded in dark green glauconite (weathering to hematite) with abundant oysters, which rests on the thin-bedded, yellow and brown, glauconitic orbitoidal marl of Bed 10 (K.3692(C-3)).

Top: the irregular masses of limestone and glauconite of Bed 11 are in obvious contrast with the lightbrown petroliferous sandstone of Bed 12 which emerges across

the narrow channel just off the North shore of the Rock. The actual contact is eroded and remains below the low tide water level.

d) Thickness and dip

About 17 meters: steep dip from the summit down to the North shore.

e) Lithology

Bed 11 is built up of three different kinds of rock. Firstly, a mollusk-bearing highly glauconitic marlstone or marly limestone (MAURY's "Boca de Serpiente Formation" s.s.). Secondly, a glauconitic orbitoidal limestone, which occurs in the form of banks and autoclastic breccia and blocks around the triangulation signal and which (following COLE 1959) we shall call the "*Proporocyclina tobleri* limestone". Both these units are embedded in masses of glauconite which penetrates everywhere and fills up the gaps. Finally there is a dense barren limestone which dominates the acute scarp descending from the top to the North shore.

Apart from the dense limestones, no definite bedding was observed and there is no question of a consistent stratification. The whole is a tumbled mass of semi-autochthonous and erratic blocks, often internally cracked, filled in with large-grained glauconite and infiltrated by hematite and other consolidating substances.

The base of the bed, in the Southern part of the exposure, consists of a prominent autoclastic breccia of *Proporocyclina tobleri* limestone and more or less consolidated "greensand" which contains oysters and some echinoids (cf. *Linthia*, K.3693). The limestone itself has relatively little glauconite, and only locally carries any appreciable amount of molluscan material. Banks and blocks of the same limestone, together with other, erratic, limestone blocks form the summit of Soldado Rock (triangulation station). The erratic blocks are mostly of Paleocene age: *Ranikothalia* limestone (K.3694, K.10710), *Neodiscocyclina grimsdalei* limestone (K.10710, K.10717), *Dasyclad* algae limestone (K.10711). In some places the *Proporocyclina tobleri* limestone takes the form of a microbreccia of thin orbitoids (*Proporocyclina*), fossil fragments and abundant Globigerinidae, Miliolidae and Textulariidae in a clear recrystallized matrix (K.10712, C-3).

Towards the North, the deposit assumes the lithological aspect which corresponds more particularly to MAURY's original "Boca de Serpiente Formation". In this area recur thick layers, pockets and vertical dykes of glauconite penetrating between, and mingling with, the highly fossiliferous, slightly marly limestones. The glauconitic masses of this part of Bed 11 have yielded most of the mollusk remains which were studied by R. F. Rutsch and by P. Jung, and also MAURY's "Boca de Serpiente fauna" must have come from here.

Also in this Northern area there are erratic blocks, of the same nature as around the summit: *Athecocyclina* limestone (K.10720), *Discocyclina grimsdalei* limestone (K.10724), *Dasyclad* algae limestone (K. 10724, J.S.1949, J.S. 1954).

The lithological nature of the Northern limestone is interesting enough to be described in more detail. It is a red-weathering, often rather friable, in part marly glauconitic limestone, locally full of shell remains (amongst them, common "*Terebratula*") and orbitoids. The fresh rock is grey and full of bright green glauconite pellets. Sometimes pieces and lumps of pale red silt are enclosed. A typical sample of



Fig. 7. Erosional bench cut into Bed 11 at NNW end of Rock (B-2) (photo H. G. Kugler 1946).

this deposit is J.S.1955(B-1): red and green speckled, glauconitic and hematitic limestone with large grains of glauconite, many orbitoids and apparently abundant mollusk remains which, however, are replaced by hematite so that they are no longer recognizable in the rock sections. The Larger Foraminifera, though recrystallized, have kept their structure and have remained determinable. Lumps of green (fecal?) pellets occur in this rock, and also some curious chitinous organisms filled with small foraminifera and detritus. All these heterogeneous elements are joined together by a trellis-like network of infiltrated hematite. There exists a certain orientation of the shell remains, but this was not observed in the position of the Larger Foraminifera.

The fauna is not evenly distributed through the deposit. In some spots, there is a concentration of the thin *Proporocyclina tobleri*, in others large robust lenticular *Neodiscocyclinas* predominate, and then again there are parts in which Larger Foraminifera and *Amphistegina* are rare. This would point to selection by currents. Also, in this Northern area Globigerinidae are locally abundant, but likewise in a hard recrystallized matrix (K.10719, B-2).

The fossils in J.S. 1955 are often rolled, cracked and broken, sometimes showing a calcite or detritus coating, or a dark outline, but in this case those things are not to be taken as a sign of reworking. Often a specimen, especially a *Proporocyclina*, is cracked and broken up into many fragments, each with its dark hematite lining, but all the fragments are still lying together with hardly any displacement (see Part 2, Paleontology, Pl. 20, Fig. 1, 5, 6, 7). Damage (by pressure?) and infiltration are post-depositional.

The limestones of Bed 11 are not real reef limestones: they carry a negligible amount of coral fragments, and algae are practically absent. They were fore-reef ridges of loose material, probably swept together by currents. Their depositional environment is characterized by the abundance of coarse glauconite as a near-shore mud along a steep rocky coast devoid of large estuaries, into which those banks of

contemporaneous limestone have slumped down. The nearby coast contributed very little: the curious chitinous organisms found in sample J.S. 1955 may be of terrestrial origin, but no reworked fossils were found in any of the samples. The erratic blocks seem to lie *on* the formation but not embedded in it.

f) Type samples

There is no doubt that the entire Bed 11 belongs to one formation for which we want to keep the name of "Boca de Serpiente Formation", extending the term over its full thickness and including the "Proporocyclina tobleri limestone", the mollusk banks and the dense barren limestones, wherever they prove to fit in.

Although no clear subdivision can be made in this bed, there are certain differences between the limestone in the South and that in the Northern part, the most important being that *Neodiscocyclina mauryae* n. sp. has been found thus far in the Northern beds only. As the facies is the same in both spots, the restriction in the range of this species seems to hint at a slight difference in age.

For the designation of one single type sample for Bed 11 we would have to choose between the mollusk-bearing glauconite masses in the North and the orbitoid breccia in the South, from which VAUGHAN & COLE (1941) and CAUDRI (present paper) described the peculiar Larger Foraminifera fauna, but neither sample would be representative of the whole. MAURY did not indicate a type locality for her Boca de Serpiente mollusk fauna, and the one chosen for RUTSCH's limited collection (K.1496, B-1) is not a very satisfactory proposal. VAUGHAN & COLE's type locality (K.3878, C-3), on the other hand, does not cover the mollusks. Instead of arbitrarily designating one particular locality, it seems better to choose a representative sample of each of the two types of rock:

1. K.3878(C-3), the type locality of the "Proporocyclina tobleri limestone", which lies near the base of the bed in the general line of the measured Soldado section;
2. J.S. 1955(B-1), the mollusk-orbitoid limestone typical of the matrix of the "Boca de Serpiente" mollusk fauna.

g) Paleontology

Microfossils

As representative of the microfauna of the Boca de Serpiente Formation we give the contents of the two samples mentioned above:

1. K.3878(C-3), friable yellowish-grey somewhat glauconitic marly limestone with a rich fauna. Larger Foraminifera strongly recrystallized so as to render them practically unrecognizable from the outside. Most of them with more or less well-developed pillars.

Neodiscocyclina bullbrooki (VAUGHAN & COLE),
A-form (scarce)

Neodiscocyclina bullbrooki (VAUGHAN & COLE),
B-form (common)

Proporocyclina tobleri (VAUGHAN & COLE),
A-form (abundant)

Proporocyclina tobleri (VAUGHAN & COLE),
B-form (common)

Amphistegina undecima CAUDRI n. sp.
(abundant)

Amphistegina pauciseptata CAUDRI n. sp.
(scarce)

Smaller Foraminifera, benthonic forms only, determined by H. H. Renz (common): *Quinqueloculina* sp., *Robulus* sp., *Eponides elevata* (PLUMMER), *Gyroidina subangulata* PLUMMER, *Pulvinulinella obtusa* (BURROWS & HOLLAND), *Anomalina* sp., *Cibicides praecursorius* SCHWAGER, etc.

Ostracods (scarce), crab claws (scarce), pelecypods (scarce), gastropods (scarce), worms ? (scarce), echinoids (common), corals (scarce).

Of this same horizon we also had the samples K.3693(D-3), K.10709(D-3), K.10712(C-3) and Gr. 627 (a "greensand", C-3). The only additions they furnish to the above list would be that K.3693 carries a lot of oysters and that one of the echinoids was determined as *Linthia*, that K.10712 is rich in Smaller Foraminifera (also planktonics, e.g. Globigerinidae, but alas in a hard recrystallized matrix), and that some Globorotalias in K.10709 can be determined as Middle Eocene (J. B. Saunders, private information).

2. J.S. 1955(B-1), hard highly glauconitic and fossiliferous, red and green speckled marly limestone (consolidated "greensand"); see above. Larger Foraminifera:

<i>Neodiscocyclus mauryae</i> CAUDRI, A-form (abundant)	<i>Proporocyclus tobleri</i> (VAUGHAN & COLE), A- and B-forms (common)
<i>Neodiscocyclus bullbrooki</i> (VAUGHAN & COLE), A-form (probably common)	<i>Amphistegina</i> sp., in part clearly determinable as
<i>Neodiscocyclus mauryae</i> and <i>bullbrooki</i> , undifferentiated B-forms (abundant)	<i>Amphistegina undecima</i> (common)

Smaller Foraminifera: *Carpenteria* ?, Globigerinidae, *Globorotalia* ? (spinose forms), *Robulus* div. (rather frequent), "*Nodosaria*" s.l., Textulariidae.

Ostracods (very thick-walled forms) (frequent; in part perhaps brachiopods?, but walls seem imperforate).

Bryozoans (rare).

Mollusks (pelecypods and gastropods; probably common to abundant, but unrecognizable).

Echinoid spines and plates (common); among others a kind of large spine of very regular structure, in some cross sections resembling a *Sphaerogypsina*, but with a secondarily spinose surface as seen in other sections (Pl. 20, Fig. 2: see Part 2).

Corals (rare).

Fossils *incertae sedis*, shaped like an amphora with a chitinous(?) wall, filled with detritus (of non-marine origin?).

Algae (practically none: one small fragment observed only).

Of this kind of limestone we also had the sample K.1496(B-1) (mollusks; no microfauna studied), K.3696(B-2) (with "*Terebratula*"), K.10729(B-2) (abundant Globigerinidae in hard rock), K.10721(C-1), K.10722(C-1) and E.L.1440(C-1). K.10721, described as a "highly glauconitic disintegrating limestone belonging to the main glauconitic mass on top of orbitoidal limestone", contains, apart from the list given above, one small specimen of an *Operculinoides* of the type of *Operculinoides soldadensis* and one specimen of *Sphaerogypsina globulus* s.l. Both this sample and K.10722 have an abundance of *Amphistegina undecima*, A- and B-forms. E.L.1440 has frequent very small colonies of bryozoa, subglobular and lenticular kinds, and shows a wide range in the size of its mollusks, from microscopic to fairly large. It also carries very rare and small *Tubulostium*.

Smaller Foraminifera: These are chiefly present in the hard recrystallized limestones where they are totally indeterminable. Locally, Textulariidae, Miliolidae and especially Globigerinidae are predominant. H. H. Renz thought the benthonic forms in K.3878 to be of Paleocene age. The only more or less determinable planktonic material comes from the marl K.10709(D-3) and was described by J. B. Saunders as: "poor preservation, mostly casts; shallow water forms and planktonics; Middle

Eocene Globorotalias. Possibly Upper and Middle Eocene" (private correspondence).

Mollusks

MAURY (1912, p. 30) determined from her "Bed 8", which has never been traced back again but must have lain in the Northern or North-western part of our present Bed 11, the following mollusk fauna:

<i>Ostrea golfotristensis</i> n. sp.	<i>Fusus bocarepertus</i> n. sp.
<i>Ostrea thirsae</i> GABB	<i>Fusus longiusculoides</i> n. sp.
<i>Spondylus</i> sp. indet.	<i>Fusus taeniensis</i> n. sp.
<i>Modiola alabamensis</i> ALDRICH	<i>Fusoficula juvenis</i> WHITE.
<i>Venericardia crucedemaionis</i> n. sp.	<i>Cassis (Phalium) guppyana</i> n. sp.
<i>Meretrix</i> cf. <i>nuttalliopsis</i> HEILPRIN	<i>Rimella fowleriana</i> n. sp.
<i>Meretrix subimpressa</i> var. <i>golfotristensis</i> n. var.	<i>Rimella knappiana</i> n. sp.
<i>Venerupis atlantica</i> n. sp.	<i>Cerithiopsis veatchiana</i> n. sp.
<i>Corbula (Cuneocorbula) subengonata</i> DALL	<i>Turritella mortoni</i> var.
<i>Corbula (Cuneocorbula) weaveri</i> n. sp.	<i>Solarium stephanophorum</i> n. sp.
<i>Cyclichna solivaga</i> n. sp.	<i>Natica</i> cf. <i>semilunata</i> LEA var.
<i>Pleurotoma guppyana</i> n. sp.	<i>Amauropsis smithiana</i> n. sp.
<i>Caricella</i> ? sp. indet.	<i>Liotia lillianae</i> n. sp.
<i>Volutilithes</i> sp. indet.	<i>Dentalium microstria</i> HEILPRIN

Her type specimens are kept in the Paleontological Research Institute at Ithaca, New York. Dr. Katherine V. W. Palmer, Director of the Institute, very kindly lent us some of the types for renewed study by P. Jung.

RUTSCH's list (1938, private report; see KUGLER 1938, p. 220) does not add much to that of MAURY, apart from modernization of some of the names and the find of *Tubulostium*. He identified:

<i>Ostrea</i> sp. indet.	<i>Terebellum</i> sp. aff. <i>procerum</i> MERIAN
<i>Tubulostium leptostoma clymenoides</i> (GUPPY)	<i>Pachycromium smithianum</i> (MAURY)
(one specimen)	<i>Callianassa</i> sp. indet. (det. VAN STRAELEN)
<i>Rimella (Ectinochilus) knappiana</i> MAURY	

The specimen of *Tubulostium*, re-determined by RUTSCH in 1939a as "*Tubulostium leptostoma* aff. *clymenoides*" has been lost and is no longer accessible for checking. More material of *Tubulostium* (rare, very small specimens) have later on been found in the washed residue of sample E.L.1440, but these still await further expert study.

Brachiopods

In 1912 (p. 104), MAURY described and figured *Terebratula stantoni* n. sp., which she considered to be different from the *Terebratula lecta* GUPPY of the San Fernando Formation of Trinidad. RUTSCH (1938), who changes the name to *Liothyryna stantoni* (MAURY), remarked, however, that in his opinion the species was very similar to forms of *Liothyryna* described by GUPPY (1866) from "gypseous marls containing *Orbitoides mantelli* and *Nummulina*, exposed near the town of San Fernando".

h) Age of Bed 11: Late Early to Early Middle Eocene

The age of the Boca de Serpiente Formation remains one of the greatest puzzles in the Caribbean Region. In the field section of Soldado, this bed appears to overlie the Upper Eocene. However, the foraminiferal fauna does not reflect the evolutionary level generally reached in a Late Eocene assemblage. The above bibliographic list

shows clearly enough how the malacologists have been shifting their age determinations up and down between the Lower Eocene (Wilcox) and the Oligocene, and how in the end preference had to be given to the evidence of the foraminifera over that of the unsatisfactory mollusk remains. The Larger Foraminifera fauna proves to be a curiously restricted one:

Proporocyclina tobleri (VAUGHAN & COLE)
Neodiscocyclina bullbrooki (VAUGHAN & COLE)
Neodiscocyclina mauryae CAUDRI n. sp.

Amphistegina undecima CAUDRI n. sp.
Amphistegina pauciseptata CAUDRI n. sp.

Apart from reworked and slumped material, scattered in profusion throughout the beds of the saddle of Soldado Rock itself (especially Bed 10), this typical restricted fauna has been found elsewhere only once: in a limestone block in Southern Trinidad. Isolated specimens of *Proporocyclina tobleri* were spotted in the Middle Eocene Navet Formation of Trinidad, but we are not sure whether it is *in situ* there or reworked. Further, there are indications that a similar fauna may occur along the edges of the Caribbean Basin. *Proporocyclina tobleri* has been reported from Campeche (Mexico, Middle Eocene, but perhaps not in place; see BUTTERLIN 1968) and, more important, from the Walton County of Florida (subsurface Lower Eocene; see COLE & APPLIN 1964), but the assemblage is nowhere so well developed and characteristic as right here on Soldado Rock.

Because of the relatively primitive characteristics of both the *Proporocyclina* and *Neodiscocyclina*, CAUDRI attached a very late Early Eocene or a very early Middle Eocene age to this fauna (see Paleontological section of present paper). J. B. Saunders' badly preserved Globorotalias from K.10709 (p. 417) seem to advocate Middle Eocene rather than Lower.

The find of a small isolated specimen of "*Operculinoides soldadensis*" in K.10721 is no obstacle to this age determination. Though the species has originally been described from Bed 10 (K.3692, C-3) and also occurs in abundance in the Trinidad Upper Eocene, it has lately been found in great numbers also in the Upper Middle Eocene of Margarita Island (BUTTERLIN 1970; CAUDRI 1974). Moreover, because it is a fundamentally simple, non-specialized form, its roots may go deep into the section⁶). Its presence may, however, tip the scales in favour of a Middle rather than an Early Eocene age, as would also those Middle Eocene Globorotalias spotted in K.10709.

Our careful study of Bed 11 leads to the conclusion that CAUDRI's previous suggestion of wholesale reworking of the fauna into a barren deposit of Late Eocene age can be dismissed. Bed 11 is an undisturbed formation with a pure autochthonous fauna, and its age is as indicated by those fossils: very early Middle Eocene, or perhaps very late Early Eocene. How it came to lie in its present position, topographically overlying the Upper Eocene in the section, is discussed below, in the chapter on the "Geological History" of this complicated little chunk of rock.

⁶) As has already been mentioned above (p. 412), VAUGHAN & COLE's statement (1941, p. 41) that *Operculinoides soldadensis* is an abundant species in the lower part of Bed 11 is an obvious error.