Principal Characteristics of Cuban Neogene Stratigraphy

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Abstract
The Neogene (Miocene and Pliocene) rocks of Cuba occupy large areas of the island. Those which overlie the deformed Cretaceous eugeosyncline are described in this paper. Because most of Cuba is underlain by eugeosynclinal rocks, only a small part of the Neogene rocks is not described.

I divide the Cuban Neogene rocks geographically into five lithofacies complexes. In all of the complexes, the strata are principally Miocene. Lithofacies complex I (Pinar del Río Province) is a carbonate, sandstone-shale, and conglomerate sequence deposited in shallow neritic water. Lithofacies complex II (mainly Habana and Matanzas Provinces) is separated from complex I on the west and complex IV on the east by major north-trending faults. The rocks are largely marl, shale, and limestone of deep-water deposition and local neritic sandstone and limestone. Lithofacies complex III (southern Isle of Pines) is a carbonate sequence of shallow neritic deposition. Lithofacies complex IV (Las Villas, Camagüey, and western Oriente) consists mainly of carbonate and terrigenous-clastic rocks of shallow neritic deposition. Lithofacies complex V (rest of Oriente Province) comprises a varied group of conglomerate, sandstone, shale, marl, limestone, and dolomite beds deposited in diverse environments.

Tectonically, the Cuban Neogene rocks are divisible into (1) transgressive cover rocks (thin deposits, mainly carbonates, and generally flat lying); (2) transgressive-regressive strata of subsiding, deep basins (up to 1,000-1,500 m thick, varied lithologic types, and dips as great as 40°); and (3) transgressive deposits of shallow neritic basins (up to 600 m of carbonate and terrigenous-clastic rocks, dips gentle, but locally as great as 20°).

The overall Cuban Neogene history indicates gradual shallowing of the sea from earliest Miocene through Pliocene time, and emergence of the island.

INTRODUCTION
The Neogene (Miocene-Pliocene) has been one of the least studied rock groups in Cuba, largely because its economic importance is very limited with regard to metallic mineral exploration; the principal economic use has been for construction materials and ornaments. Nevertheless, the Cuban Neogene is very important hydrologically, because the principal aquifers of potable water are in karst regions of the Neogene. Therefore, after the Instituto Nacional de Recursos Hidrálicos (INRH=National Institute of Hydrologic Resources) was established, detailed studies were made of the principal hydrogeologic basins. The many new data discovered as a result of the studies permit new descriptions, and modifications of the information previously available on the Neogene strata.

This paper is not a summary of previously published results, but a presentation of INRH investigations in which I participated, either directly or indirectly, both in the field and in paleontologic studies in the laboratory.

Although they are less complete, many excellent works of a regional nature in the literature contribute to and complement the ideas expressed herein. Among them are contributions by Palmer and Bermúdez (1936), Brodermann (1945), Bermúdez (1950, 1961, 1967), Bermúdez and Hofstetter (1959), Brönnmann and Rigassi (1963), Furrazola et al. (1964), Iturralde (1966, 1967a, 1968, and unpub. ms.), and Torre (1966).
of the island. A Late Jurassic-Cretaceous mio-
geoysynclinal facies occupies the north coastal
region from northern Matanzas Province to
northwestern Oriente Province (Fig. 2), and an
age-equivalent eugeosynclinal sequence of vol-
canic rocks, graywacke, etc. underlies the rest
of the island. Some metamorphic rocks are
present on the Isle of Pines and in the Sierra de
Trinidad, along the south coast of Cuba, as
well as in southeastern Oriente Province. Fur-
razola et al. (1964) and Khudoley (1967) in-
terpreted most of the metamorphic rocks to be
Early and Middle Jurassic. In northern Pinar
del Rio Province, dated Early to Middle Juras-
sic strata are present. The evaporite diapirs of
the north coast also contain Jurassic sediments
(Ducloz, 1960; Meyerhoff and Hatten, 1968).

The orthoeyosynclinal sequence was de-
formed strongly during Late Cretaceous and
early Tertiary times. Middle Eocene and youn-
erg sediments gradually buried the relief that
had been developed on the eugeosynclinal rocks.
The Neogene of Cuba is part of the younger,
post-orthoeyosynclinal sequence.

This paper concerns only the Neogene strata
overlying the eugeosynclinal section (Fig. 2).
Equivalent strata overlying the mioeyosynclinal
facies of the Cretaceous are not included, ex-
cetp those in the northern part of the Morón
basin (Fig. 2). However, because much of
Cuba is underlain by the eugeosynclinal facies,
most Cuban Neogene rocks are described. The
only Neogene strata not described are those in
the present offshore shelf areas, where lack of
lithologic control makes descriptions impossi-
ble.

The Neogene is divided into lithofacies com-
plexes which are based on the distinctive sedi-
mentary rock suites and faunas present in dif-
ferent areas. Grouping the lithofacies associa-
tions into distinct complexes by region facil-
itates description and study. The boundaries be-
tween the complexes may be related in places
to deep regional faults, and elsewhere to facies
changes only (Fig. 2).

The following five principal lithofacies com-
plexes are recognized above the area of the for-
er eugeosyncline from west to east.

**Lithofacies complex I**—Limited to Pinar del Río
Province. The eastern boundary is the steep fault
that extends from Mariel Bay to Carraguao Point (Fig. 2).

**Lithofacies complex II**—Extends from the Mariel-
Carraguao fault to a fault joining Cárdenas and Cochinos
Bays (Isle of Pines excluded).

**Lithofacies complex III**—Developed on the south
side of the Isle of Pines.

**Lithofacies complex IV**—Bounded on the west by

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**Fig. 1.**—Foraminiferal zonation of Neogene rocks
of Cuba. Neogene as used herein includes Aquitanian
stage.

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lithofacies complex II, and on the east by a line ex-
tending from Gibara to the Gulf of Guacanayabo.

**Lithofacies complex V**.—Occupies the region south-
east of complex IV.

This subdivision of the areas of Neogene de-
position is purely informal and is used only to
simplify the treatment in the text.

**Stratigraphy**

In the descriptions of the five lithofacies
complexes, formation names are used only if
they are easily recognized. Where there is
doubt I propose a new name or do not refer to
specific "formations." The stratigraphic extent
of certain formations has been modified; hence
the sections presented differ somewhat from
those of previous workers. To make correla-
tions as precise as possible, the lithologic units
described herein have been referred to known
formations. Thus the nomenclature has been
kept relatively simple.

**Lithofacies Complex I**

Lithofacies complex I (Fig. 2) occupies
most of Pinar del Río Province south of the
Sierra del Rosario and Sierra de los Organos,
Fig. 2.- Index map of Cuba showing principal geologic features, geographic localities, and Neogene lithofacies complexes discussed in text. Salt-dome localities from Ducloz (1960) and Meyerhoff and Hatten (1968).
and west of the steep fault between Mariel Bay and Carraguao Point. Movement along the fault raised the region occupied by this lithofacies complex. As a result, the sediments were deposited exclusively in a neritic environment.

According to the structure of this region, this complex must be divided into two subcomplexes: (1) the Palacios basin, and (2) the San Diego de los Baños tectonic unit (Khudoley, 1967).

Subcomplex 1.—This is a deeply subsided basin where early to middle Miocene sediments were deposited; the thickness is more than 1,000 m.

The sequence consists of a basal terrigenous-clastic unit and an upper calcareous unit. The basal part is polymictic conglomerate, with poorly sorted clasts ranging from very small to 0.5 m in diameter. The matrix either is calcareous cement or consists of smaller grains of gravel size. The biocoenosis is predominantly algae, mollusks, miliolids, *Archaia angulatus*, *Miogypsina* sp., *Heterostegina* sp., and *Lepidocyclina* sp., which correlate the unit with the *Lepidocyclina-Heterostegina-Miogypsina* zone of the early Miocene (Fig. 1). The thickness is varied and the maximum is 200 m. The strata generally are folded gently. The sequence probably correlates with the Guines Formation and the Arabos Member of that formation, contrary to Bermúdez’s (1950) opinion. Bermúdez proposed the name “Paso Real Formation” for these rocks (Fig. 3; Iturralde, 1967a).

Subcomplex 2.—This subcomplex is predominantly carbonate. The sediments attain a thickness of 800 m and, depending on the ages present, correspond to the Soritiidae-Miliolidae-Amphisteginidae zone of the lower to middle Miocene. Aquitanian strata are absent. The area where this subcomplex is present coincides with an upfaulted block (Furrazola et al., 1964, their Fig. 88). The sequence is composed of organogenic and dolomitized limestone with beds of fine-grained sandstone and shale. The fauna is homogeneous throughout, and contains *Archaia angulatus*, *Peneroplis proteus*, *P. planatus*, *Cyclorhicans ventosa*, *miliolids*, *Amphistegina* sp. and, in the brackish-water beds, also *Elphidium sagrai*, *Ammonia beccarii parkinsoniana*, and ostracods.

The northern fringe of the Neogene strata, which occupies a narrow zone around Mariel, consists of organogenic and organogenic-detrital limestones of early Miocene age (Iturralde, 1967b).

As indicated by the fauna and lithologic character of lithofacies complex I, the sediments originally were deposited in water no deeper than 100 m. Most of the deposits were laid down near the coast. Ultimately, an influx of fresh water modified the conditions of deposition, and sand and clay of the upper terrigenous-clastic unit were deposited. Deposition ended with the upper marine carbonate sequence.
Lithofacies Complex II

Lithofacies complex II (Fig. 2) represents a peculiar set of environmental and depositional conditions, because it was deposited in a deep basin bounded by steep faults. The basin had the characteristics of a graben. For convenience, the sequence is described by ages, from oldest to youngest (Fig. 4).

**Early Miocene.**—The early Miocene sediments were deposited predominantly in a marine pelagic environment, although along the margins of the pre-Neogene structures of the orthogeosyncline, the sediments were deposited in shallower neritic water. The pelagic strata have been referred to the Jaruco and Cojimar Formations, whereas the neritic facies has been referred to the Husillo (= Colon) and Guines Formations. The pelagic sequence extends from the base of the Catapsidrax dissimilis zone to the top of the Globorotalia fohsi lobata zone, and the neritic sequence includes the Lepidocyclina-Heterostegina-Miogypsina, Miogypsina-Soritiidae, and Soritiidae-Miliolidae-Amphistegiidae zones (Fig. 1).

The Jaruco and Cojimar strata consist of calcareous to shaly organogenic marl, argillaceous limestone, calcareous sandstone, and shale, generally in beds 20-50 cm thick. The biocoenosis of the two formations consists of planktonic and small benthonic foraminifers, together with mollusks, ostracods, and echinoderms in the part corresponding to the Cojimar. In the part corresponding to the Jaruco, planktonic and small benthonic foraminifers predominate.


The thickness of the strata is varied, but averages about 200 m. The dip generally does not exceed 20–25°, but the range can be from 0 to 40°. The biocoenosis indicates deposition in water of normal salinity, ranging in depth from 100 m to more than 300 m.

The rocks which are equivalent to the Guines and Husillo (= Colón) Formations are adjacent to and on ancient topographic highs of orthogeosynclinal rocks. The strata consist of argillaceous organogenic limestone, organogenic-detrital limestone, dolomite, and sandstone. The thickness ranges from 50 to 100 m, and the dip does not exceed 30°. Though generally massive, beds in places are 30–40 cm thick.

The biocoenosis of these strata of Aquitanian-Burdigalian age is characteristic of shallow normal-marine water, and consists of large benthonic foraminifers, corals, mollusks, echinoderms, and other forms. Among those identified are Lepidocyclina undosa, L. favosa, Heterostegina antillea, Nuimulites dius, Miogypsina antillea, Amphistegina angulata, and A. rotundata.

**Middle Miocene.**—Rocks of this age are widely distributed in the zone of lithofacies complex II and are found in numerous outcrops. They generally are correlated with the Guines Formation and the Arabos Member of that formation. The oldest strata extend into the upper part of the early Miocene (G. fohsi robusta zone of Bolli, 1957). The fauna shows that most of the unit is equivalent to the upper part of the Soritiidae-Miliolidae-Amphistegiidae zone. In places, the middle Miocene is separated from the lower Miocene by a slight
discordance caused by syndepositional movements. Where slight discordances are present, they are disconformities characterized by an abrupt lithofacies change. In other places the contact is gradational. There is no proof of a hiatus between the early and middle Miocene beds. In a very few localities, some strata of probable middle Miocene age overlap the lower Miocene and are on pre-Miocene rocks.

The lithofacies are extremely variable both laterally and vertically, although dolomite is found on both the east and west. Dolomite predominates in the upper part of the western section, whereas it predominates in the lower part of the eastern section. The dolomite seems to be of secondary origin, and the fact that dolomite is present both on the east and the west does not hinder a reconstruction of the various facies.

The Güines Formation, properly defined and excluding the Arabos Member, consists of organogenic-detrital, relict-organogenic, coralline, biothermal, shaly, recrystallized, and dolomitized limestone beds, calcareous sandstone, dolomite, and calcareous marl. The Arabos Member consists of calcareous shale, marl, and sandstone which form lenses of varied thickness within the carbonate rocks. The various lenses of the Arabos Member seem unlikely to be of the same age, because they represent responses to changing depositional conditions in different localities.

The middle Miocene rocks range in thickness from 100 to 400 m, but locally may be thicker or thinner. The general dip range is from 0 to 10°, and the beds are folded gently within the outcrop area.

On the Zapata Peninsula, southern Matanzas Province, the El Maiz test well was drilled to a total depth of 610 m (Fig. 5). Below 440-450 m, the well penetrated a section of limestone, shaly limestone, and calcareous shale bearing a fauna which corresponds to that of the lower part of Banner and Blow's (1965, 1967) zone No. 16. This sequence indicates a very marked lateral facies change between rocks of this area and the equivalent rocks on the north. The rocks found in the El Maiz well do not belong to the Güines Formation. I have named this section the "El Maiz Formation," of middle to late Miocene age (Iturralde, unpub. ms.). The biocoenosis corresponding to the middle Miocene consists of mollusks, algae, and planktonic and small benthonic foraminifers. Significant species include Globorotalia merotumida, G. pseudomiocenica, Globigerina eggeri, Orbulina universa, "Sphaeroidinella" seminulina.
Globigerinoides trilobus, G. ruber, and Globorugquadrina altispira. These particular species were found in a core at a depth of 526-539 m. There is no question but that the sequence represents a lateral facies change of the Giiines. Geographically, the El Maiz facies is present in the Zapata Peninsula west of Cochinos Bay (Bay of Pigs).

**Late Miocene.**—Late Miocene strata are restricted in lithofacies complex II to the Zapata Peninsula, and to a 1-2-km-wide northern coastal fringe zone between the cities of Matanzas and Cárdenas, Matanzas Province (Fig. 4). They have been studied in the El Maiz well (Fig. 5) on the Zapata Peninsula, but the only data from the north coast of Matanzas Province are field observations. I include the late Miocene in the El Maiz Formation of the Zapata Peninsula, but use the informal term “Gypsina beds” for the north coast outcrops (Iturralde, unpub. ms.).

On the Zapata Peninsula, the upper Miocene rocks consist of shaly limestone and calcareous shale. The fauna, composed almost wholly of planktonic and small benthonic foraminifers (Table 1), permit correlation with zones Nos. 16, 17, and 18 of Banner and Blow (1965, 1967). The total thickness on the Zapata Peninsula is about 280 m, and the water depth at the time of deposition was 150-200 m.

Rocks of equivalent age along the north coast of Matanzas do not appear to be thicker than 100 m. They are composed of calcarenite beds which grade laterally into sandy marl and limestone. The biocoenosis consists of mollusks, ostracods, foraminifers, echinoderms, brachiopods, and other marine forms. The only sample containing an age-diagnostic fauna was reported by Bermúdez (1967). I collected two samples which contain unidentifiable planktonic foraminifers and the following ostracods, identified by W. A. van den Bold: *Paracypris* sp., *Bairdia longiseta*, *B. antillea*, *B. spp.*, *Quadacythere producta*, *Mutilus confragosus*, *Xestoleberis* sp., *Paracytheroma* sp., *Cytixerella* sp., *Loxoconcha dorsotuberculata*. The samples were collected below the Homicultura Hospital, Matanzas City, in outcrops which Bermúdez (1967) assigned to the upper Miocene.

Along the Rio Canimar, the strata dip 6°; in other areas they dip as much as 10° or more. The strata were deposited in a marine environment, possibly near the coast, and the waters became muddy as a result of the influx of terrigenous materials from nearby rivers.

**Pliocene.**—Rocks of Pliocene age have been identified from planktonic foraminifers along the northern coast of Matanzas Province. The strata identified are late Pliocene. Pliocene rocks in the south are found only on the Zapata Peninsula. They contain a benthonic

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**Table 1. Microfauna Identified from Banner and Blow's (1965, 1967) Zones 16-18, El Maiz Borehole, Zapata Peninsula.**

<table>
<thead>
<tr>
<th>EL MAIZ BOREHOLE</th>
<th>ZAPATA PENINSULA, LAS VILLAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ZONES OF BANNER AND BLOW (1965, 1967)</strong></td>
<td><strong>NO. 16</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA MEROTUMIDA</strong></td>
<td><strong>174-184</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA PLESIOTUMIDA</strong></td>
<td><strong>216-228</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA PSEUDOMIOCENICA</strong></td>
<td><strong>246-257</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA MULTICAMERATA</strong></td>
<td><strong>283-295</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA SR A</strong></td>
<td><strong>307</strong></td>
</tr>
<tr>
<td><strong>GLOBOROTALIA SP B</strong></td>
<td><strong>329</strong></td>
</tr>
<tr>
<td><strong>GLOBIDERINA EGGERI (W. DUERTREI)</strong></td>
<td><strong>351</strong></td>
</tr>
<tr>
<td><strong>HASTIGERINA PELAGICA</strong></td>
<td><strong>373</strong></td>
</tr>
<tr>
<td><strong>ORBULINA UNIVERSA</strong></td>
<td><strong>395</strong></td>
</tr>
<tr>
<td><strong>SPHAEROIDINELLA SEMINULINA</strong></td>
<td><strong>417</strong></td>
</tr>
<tr>
<td><strong>SPHAEROIDINELLA SEMINULINA ROCKI</strong></td>
<td><strong>439</strong></td>
</tr>
<tr>
<td><strong>SPHAEROIDINELLA DEHISCENS</strong></td>
<td><strong>461</strong></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES RUBER</strong></td>
<td><strong>483</strong></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES TRILOBUS</strong></td>
<td><strong>505</strong></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES IMMATURES</strong></td>
<td><strong>527</strong></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES OBLIPUS</strong></td>
<td><strong>549</strong></td>
</tr>
<tr>
<td><strong>GLOBIGERINOIDES CONGLOBATUS</strong></td>
<td><strong>571</strong></td>
</tr>
<tr>
<td><strong>GLOBOGUARDINA ALTISPIRA</strong></td>
<td><strong>593</strong></td>
</tr>
<tr>
<td><strong>GLOBOGUARDINA CF. VENEZUELANA</strong></td>
<td><strong>615</strong></td>
</tr>
<tr>
<td><strong>SPHAEROIDINELLOIDES SUBDEHISCENS</strong></td>
<td><strong>637</strong></td>
</tr>
</tbody>
</table>

* Location shown on Figure 2.
fauna which is not diagnostic, and the exact age cannot be ascertained.

In the northern part of the province, the sequence occupies part of a narrow coastal belt between Matanzas City and Cárdenas. It extends into the Río San Agustín basin to near Ceiba Mocha. The Pliocene consists of organogenic, argillaceous, and sandy limestone, sandy marl, shale, sand, gravel, and conglomerate. These lithologic types were penetrated in test well No. 28, drilled at the confluence of the Ríos Cañas and San Agustín
Manuel A. Iturralde-Vinent

The thickness in the well is 80 m. The fauna includes Globorotalia tosaensis, G. hirsuta, G. acostaensis humerosa, and Globigerinoides ruber pyramidalis.

A very well-exposed section of Pliocene crops out at the Abra ("gateway") of the Rio Yumuri (Fig. 7). The beds dip 6° S 30°E. The section is composed of 80 m of polymictic conglomerate and sandstone, calcarenite, and biothermal limestone, in medium to thin beds. The section appears to be partly deltaic. The biocoenosis includes mollusks, foraminifers, bryozoans, corals, ostracods, phanerogam leaves, and other fossils. The deposits appear to have formed at a river mouth where marine and estuarine conditions alternated.

Bermúdez (1967) described from the Rio Canimar a typical fauna of Pliocene age. The sequence there consists of calcarenite and limestone beds which dip 6° seaward. The term Canimar Formation is used for the Pliocene in that area, and the facies in the Abra of the Rio Yumuri and in the Río San Agustin basin are referred to the El Abra Member of the Canimar Formation.

The Pliocene of Zapata Peninsula consists of possibly 150 m of organogenic limestone which was penetrated in the El Maiz well (Fig. 5). I have termed this Pliocene unit the "Peninsula Formation" (Iturralde, unpub. ms.).

Lithofacies Complex III

Lithofacies complex III (Fig. 2) has been described by Kuman and Gavián (1965), and is not described in detail here. The data in the INRH files are incomplete, and come from a few boreholes drilled by INRH in the southern part of the Isle of Pines. The rocks consist of 400 m, or less, of organogenic and organogenic-detrital limestone, with a fauna similar to that of the Guines Formation.

Lithofacies Complex IV

This is the most extensive of the lithofacies complexes (Fig. 2) and is the most uniform in thickness and lithologic character. The area which it covers is bounded on the west by lithofacies complex II and on the east by a line joining Gibara Bay on the north coast with the Gulf of Guacanayabo on the south coast. The complex can be divided conveniently into three subcomplexes: (1) the western region (Matanzas Province), (2) the southern part of the Sierra de Guamuahaya (Trinidad), and (3) the eastern region, including the Morón basin.

The complex consists predominantly of a carbonate and terrestrial-clastic facies deposited in a shallow neritic environment (Fig. 8). The rocks are mainly of early and middle Miocene ages, and in very few places are thicker than 500 m. They have been referred to the Colón and Guines Formations.

Subcomplex 1. - The lower part of the section in the western region consists of calcareous organogenic marl, somewhat argillaceous organogenic-detrital limestone, and thin lenses of sandstone. The fauna includes mollusks, ostracods, bryozoans, and large benthonic foraminifers which are correlated with the Lepidocyclina-Heterostegina-Miogypsina zone of the early Miocene. The most typical species of the assemblage are Lepidocyclina undosa, L. favosa, L. yarmagunensis, Miogypsina antillae, Heterostegina antillae, and Nummulites dias. Dip is no greater than 15°, and the thickness does not exceed 100 m. The unit is correlated with the Colón (= Husillo) Formation. The depth of water in which the sediments were deposited was not greater than 150 m. Generally, salinity was normal, and the water was slightly muddy.

Underlying these beds in places is a conglomerate unit about 20 m thick. It is polymictic conglomerate with a calcareous matrix in the upper part and a clay or sandy matrix in the lower. Clasts range in diameter from 1 mm to 3 cm or more, and are angular to subrounded. No fossils have been found, but the age is assumed to be early Miocene.
Above this sequence the Güines Formation was deposited. Its lithologic character and fauna are the same as lithofacies complex II. The Arabos Member is well developed, reaching a thickness of 100 m (Iturralde, 1966). Silicified sandstone in the Arabos is scarce in this area. The total thickness of the Güines, except in very few places, does not exceed 300 m and is more commonly 100–150 m. The strata are gently folded; maximum dips are 10–15°.

Subcomplex 2.—In subcomplex 2, south of the Sierra de Trinidad along the south coast, basal conglomerate is present, as in Pinar del Río Province. As would be expected, the conglomerate differs in composition from that of Pinar del Río—in content, type of cement, and thickness—although the conglomerates are of similar genetic origin. Microfaunal and field evidence indicates a late Oligocene to early Miocene age (Lepidocyclina-Heterostegina-Miogypsina zone). The basal conglomerate underlies the Güines Formation.

I propose the name Banao Formation for the conglomerate unit below the Güines Formation. The fauna consists of Lepidocyclina yurnagunensis morganopsis, L. duclozi, L. undosa, L. favosa, L. wayland-vaughani, Gypsina sp., Miogypsina sp., miliolids, algae, corals, and other forms. The type section at Loma Maria Teresa, near the Rio Higuanojo (Fig. 9; Lambert coordinates N–636, E–217.6), unconformably overlies severely deformed schist. From top to base the following section is present.

**Description**

<table>
<thead>
<tr>
<th>Thickness (M)</th>
<th>Guines Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Limestone, organogenic-detrital, compact, recrystallized, equivalent to basal Güines</td>
<td>35</td>
</tr>
<tr>
<td>Total Güines, this locality</td>
<td>35</td>
</tr>
</tbody>
</table>

**Banao Formation (conglomerate unit)**

| 9. Limestone, organogenic-detrital | 10 |
| 8. Conglomerate, polymictic, calcite cement containing clasts ranging in diameter from a few millimeters to 20–30 cm; clasts are both angular and rounded | 10 |
| 7. Sandstone | 4 |
| 6. Conglomerate as above | 10 |
| 5. Limestone, compact, organogenic-detrital | 0.3 |
| 4. Conglomerate, polymictic | 3 |
| 3. Limestone, sandy, compact | 3 |
| 2. Conglomerate, compact; interbedded with limestone, compact, beige; intergradational | 3 |
| 1. Marl, light-brown, sandy, with clasts of underlying schist | 2 |
| Total conglomerate unit | 45.3 |

**Angular unconformity**

Schist | 45.3 |

The strata at the type locality dip 25° east-northeast. The basal Güines and Banao Formations in this locality are Miocene, and are part of the Lepidocyclina-Heterostegina-Miogypsina zone. The biocoenosis is composed of large foraminifers characteristic of the zone, but mixed with reworked faunas from older rocks.

The conglomerate crops out at other places along the highway between Banao and Trinidad, where it dips 10–12° east-northeast. Although the thickness was not measured along the highway, it is estimated to be 80 m. In the section between Banao and Trinidad, the conglomerate directly overlies the schist or late Eocene marl, and lenticular beds of late Oligocene marl are included in the upper part of the conglomerate.
A lower section of marl and shale (Arabos Member) and an upper section of limestone of the Gúînes Formation proper. In a borehole drilled at Vertientes, southern Camagüey Province (Fig. 10), the lower beds of this sequence include siltstone, shale, and marl, with a fauna typical of the Arabos Member. The upper part contains limestone characteristic of the Gúînes Formation. In age the sequence is equivalent to the Soritiidae-Miliolidae-Amphisteginidae zone of the early and middle Miocene, as is shown by the presence of Procythereis cf. deformis and, higher in the section, of Globorotalia menardii.

A more complete section is north of Victoria de las Tunas, western Oriente Province (Fig. 11). The lower part consists of calcareous shale, marl, shaly limestone, thin lenses of gypsum, lignite, and beds with plant remains. The marl and argillaceous limestone are more abundant above, whereas shale is more common below. Pyrite and pyritized materials are common in the samples. The biocoenosis consists predominantly of small foraminifers and ostracods typical of waters of less-than-normal salinity. However, in places, fragmented remains of mollusks, echinoderms, and other forms are present. In many zones one or two species of Foraminifera may dominate the fauna.

In the Victoria de las Tunas section, the most common forms are Ammonia beccarii s.l., A. beccarii parkinsoniana, Elphidium lens, E. chipolensis, Discorbis cercadensis, D. cf. floridensis, Nonion sp., Peneroplis sp., Archaias sp., Gypsina sp., Amphistegina angulata, Clavulina tricarinata, Valvulammina sp., Hastigerina? sp., Globigerina concinna angustiumbilicata, miliolids, and ostracods. W. A. van den Bold identified the following ostracods from three samples in the lower part of the sequence: Bairdia willisensis, B. condylus, B. antillea, B. spp., Triebellina crumena, Haplocytheridea stephensoni, H. cubensis, H. subovata, H. cf. pinguis, Cushmanidea howei, Aurila gelerita, A. amygdala, Procythereis cf. deformis, Quadracythere antillea, Jugoscytherie vicksburgensis, Loxoconcha antillea, L. sp., Paracytheridea tschoppi, Cytherura cf. sella, Xestoleberis dactylotypa, X. sp., Macrocypris cf. decorus, Actinocythere bahamen sis, Munseyella sp., Paracypris sp., Cythereella sp., and Perissocytheridea sp.

Boreholes have drilled to 130 m, but have not penetrated the complete section. The age may be considered to be early Miocene, though index fossils are lacking and the rocks may be
of middle Miocene age at the top. In my opinion, the section is equivalent to the Arabos Member of the Güines Formation; its lithologic character, fauna, and apparent mode of origin support this interpretation.

Above these beds is 80 m of organogenic-detrital limestone, in places dolomitized and locally argillaceous, of middle Miocene age.

The Morón basin in northwestern Camagüey Province (Fig. 2) contains a Neogene sequence which also can be included within subcomplex 3. The basin was named by Meyerhoff and Hatten (1968), who described its strata under the heading of Unit 1 (p. 342). However, I obtained most of the information given herein from G. Z. Martashvili (personal commun.).

The lower part of the Morón basin section corresponds to the Arabos Member of the Güines Formation. It consists of bluish, calcareous shale with fine flakes of gypsum, and intercalated beds 50-60 cm thick of gypsum and calcite. These strata grade upward into compact, calcareous marl with fine-grained, noncalcareous sandstone beds in the lower part and limestone and dolomite beds in the upper part. The total thickness of the shale-marl complex is approximately 170 m.

Conformably overlying the shale-marl sequence is compact, massive-bedded, finely crystalline, dolomitized limestone with a few beds of dolomite and intercalations of marl. Toward the northern part of the basin, the limestone complex is thicker than 300 m. The unit corresponds to the Güines Formation (sensu stricto). A cross section of the Morón basin is presented on Figure 12. Meyerhoff and Hatten (1968) noted that the total thickness of the Neogene ranges from 225 to 540 m in the basin.

The Neogene section in the basin lies with erosional unconformity on Paleogene, Cretaceous, and igneous rocks. It is almost horizontal, though some gentle folding is apparent: the broad, gentle folds generally trend northwest-southeast, and dips are toward the southwest or northeast. The age of the strata is early and middle Miocene, although the basal part of the Aquitanian has not been identified.

Locally the Morón basin sequence overlies...
with slight angular unconformity a section of
calcareous marl that is similar lithologically
and faunistically to the Colón Formation, but
neither Miogypsina nor Soritiidae is present.
The absence of this fauna leads me to believe
that the calcareous marl below the Arabos
Member is Oligocene. If so, it is not equivalent
to the Colón; and if the Colón is absent in the
Morón basin, the basin belongs in subcomplex 3.
If future studies show that the calcareous
marl complex is early Miocene, the Morón
basin section should be assigned to subcom-
plex 1.

Lithofacies Complex V

Lithofacies complex V, limited to Oriente
Province, is characterized by marked, abrupt
lateral and vertical lithofacies changes. The
western limit is the eastern border of litho-
facies complex IV. Because of its great vari-
ability, it is neither possible nor reasonable
to characterize this complex as a whole. In-
stead, it is best to consider separately the three
subcomplexes into which it may be divided.
According to the facies and tectonic charac-
teristics, the three subcomplexes are (1) Cauto
basin, (2) Nipe basin, and (3) Guantánamo
basin and the surrounding area.

Subcomplex 1.—Subcomplex 1 occupies the
Cauto basin (Fig. 2), which contains a very
thick section of Tertiary and older rocks.
INRH studies began there only recently and
data are sparse. Several wells along the north-
ern margin of the basin penetrated lower
Miocene rocks (Lepidocyclina-Heterostegina-
Miogypsina zone). The fauna consists of
Amphistegina angulata, A. rotundata, Num-
mullites dius, Lepidocyclina sp., Miogyp-
sina antillea, Peneroplis sp., Archaias sp., Procy-
thereis cf. deformis, miliolids, and other
forms. The strata are limestone, argillaceous
limestone, shale, and marl; the thickness is
unknown.

Other wells in the same region penetrated
limestone and calcareous shale of the Miogyp-
sina-Soritiidae zone containing Miogypsina sp.,
Archaias sp., Amphistegina angulata, A. rotun-
data, ostracods, and other species. Above this
sequence are marl and shale with Elphidium
sp., E. chipolensis, Clavulina tricolorata, Am-
monia beccarii parkinsoniana, Discorbis sp.,
Procythereis cf. deformis, Bairdia sp., miliolids,
and other fossils.

Because of the scanty data from the subcom-
plex, samples were utilized from two wells (Fig.
2) drilled during the late 1950s by United
States petroleum companies. Data were fur-
nished through the courtesy of Gustavo
Furrazola-Bermúdez. The Lavanderas No. 1
(just offshore in the Gulf of Guacanayabo)
and Manzanillo No. 1 (near the town of that
name) boreholes penetrated total thicknesses of
1,100 and 700 m, respectively, of the Neogene.
Lavanderas No. 1 found a section of shale and
limestone, at the base of which is a shale inter-
calation containing a pelagic microfauna. In
Manzanillo No. 1, lower Miocene calcareous
marl, shale, dolomitized limestone, sandy lime-
stone, sandstone, and conglomerate were pene-
trated. The fauna includes specimens of Orbulina
sp., Globigerina spp., Globorotalia menardii,
G. praemenardii, Miogypsina sp., Heterostegina
sp., Nummulites sp., and Lepidocyclina sp.
Above the lower Miocene is 100 m of organo-
genic limestone containing algae, gastropods,
echinoderms, ostracods, miliolids, Amphisorus
sp., Archaias sp., Amphistegina sp., Gypsina
sp., Elphidium sp., and other forms. The strata
are referred tentatively to the middle Miocene.

Subcomplex 2.—Subcomplex 2 occupies the
Nipe basin (Fig. 2) and the closely adjacent
area. Like the Cauto basin, it is deep, and is
characterized by a thick section of pelagic sedi-
mentary rocks from the base of the Miocene to
the late middle or late Miocene. The section is
better understood if described from base to top,
by age.

1. The early Miocene strata are of two fa-
cies, a pelagic facies which fills the basin
proper and a neritic cover on the pre-Neogene
structures of the orthogeosyncline that sur-
round the basin. The upper, or neritic, se-
quence can be correlated with the Lepidocy-
clina-Heterostegina-Miogypsina and Miogyp-
sina-Soritiidae zones, and possibly with the lower
part of the Soritiidae-Miliolides-Amphistegi-
nae zone. The strata are organogenic, massive,
recrystallized limestone, about 50–70 m thick.
The most typical fossils include Neorotalia sp.,
Amphistegina angulata, Gypsina globulus,
Nummulites spp., Archaias angulatus, Globiger-
inoides diminuta, Miogypsina antillea, Lepido-
cyclina favosa, L. undosa, L. yurnagunensis,
Carpenteria sp., Heterostegina sp., miliolids,
algae, and corals. The rocks are widespread west
of the city of Banes.

Lavanderas No. 1, Cuban Stanolind Oil Co., TD
1,676 m, abandoned in March 1958; Manzanillo No. 1,
Cia. Petrolera Trans-Cuba, S.A., TD 2,089 m, aban-
doned in July 1956.
The pelagic facies consists of shaly marl with *Amphistegina angulata*, *Globigerinoides bisphaericus*, *G. ruber*, *Globoquadrina altispira*, *G. tripartita rohri*, and *G. venezuelana* of the *Globigerinoides altiaperturus—G. bisphaericus* zone. Also present are *Cataphydrax dissimilis*, *G. ruber*, *Globoquadrina altispira*, *G. dehiscens*, *G. venezuelana*, *G. tripartita rohri*, *G. venezuelana* of the *Nummulites cojimarensis*, *Paraspiroclypeus glomerosa circularis*, *Glohorotalia fohsi* cf. *s.l.* zone. A partial description was published by Bermúdez (1961) and Charlton de Rivero (1963) under the headings “La Cruz Formation” and “Punta Maisí Formation.”

**Tectonics**

Few general works have been published on the tectonics of the Cuban Neogene. The most useful are those by Furrazola *et al.* (1964) and Pushcharovskiy *et al.* (1967). Even those two groups of authors differed on the position of the boundary between the Oligocene and Miocene. Furrazola *et al.* included the Aquitanian stage within the Oligocene—a decision which greatly simplifies their descriptions of the Neogene. Pushcharovskiy *et al.* placed both the Oligocene and Miocene into a single tectonic cycle, but failed to indicate whether they place the Aquitanian in the Miocene or in the Oligocene. As a result, the descriptions of Neogene tectonics by those authors must be considered tentative. In general, they considered the Neogene rocks to be much simpler tectonically than they really are.

A new synthesis of the Neogene—including the Aquitanian—is presented here. The strata can be divided into three types according to tectonic style: (1) transgressive cover rocks, (2) transgressive-regressive strata of deep, subsiding basins, and (3) transgressive deposits of shallow neritic basins.

**Type 1. Transgressive Cover Rocks**

The transgressive cover rocks are composed of thin carbonate sequences of different ages: in some areas the age cannot be determined because of deep weathering. The strata cover transgressively the pre-Neogene structures of the orthogeo-syncline. Generally they are flat lying, though locally they may be somewhat folded; the degree of folding depends on the tectonic stability of the structures covered. The rocks are of neritic facies and are present in all parts of the island.

**Type 2. Transgressive-Regressive Strata of Deep, Subsiding Basins**

These sedimentary rocks include marl, limestone, and sandstone, in order of abundance, from base to top. The thicknesses are greater than those of the Neogene strata of other tectonic environments. Thicknesses up to 1,000–1,500 m are found in some localities. Within type 2 areas are lithofacies complex II and most of complex V (Nipe and Cauto basins).
Lithofacies complex II belongs to type 2 because it accumulated in a subsiding, graben-type basin between two steep faults. Uplift along the faults at the end of Oligocene time raised the areas where lithofacies complexes I, III, and IV were deposited. Evidence for the grabenlike subsidence of the area of lithofacies complex II is listed.

1. Oligocene strata of pelagic, deep-water deposition are present but do not crop out in lithofacies complex II; they are exposed mainly in complex IV.
2. The thickness of the Neogene of lithofacies complex II is about 1,000 to 1,500 m, but in lithofacies complex IV, subcomplex I, only 300 m.
3. The early Miocene strata of lithofacies complex II are of pelagic, deep-water deposition, whereas those of the surrounding areas were formed in shallow neritic water.
4. Late Miocene and Pliocene rocks are present in the graben area, but are absent on the surrounding blocks.
5. In the adjacent blocks of lithofacies complexes I and IV, the Oligocene is largely a pelagic, deep-water section and the entire Miocene is a shallow-water neritic sequence. Thus, at the Oligocene-Miocene boundary there is a pronounced facies discordance which has no counterpart in the area underlain by facies complex II, where Oligocene and early Miocene rocks are of the same deep-water facies.
6. Uplift of the blocks surrounding the area of lithofacies complex II is shown also by the presence of early Miocene basal conglomerate in the area of lithofacies complex I, in the section south of the Sierra de Trinidad (lithofacies complex IV), and in subcomplex I of lithofacies complex IV.
7. Sublatitudinal folds and fractures are present in the Neogene rocks along the boundary area between lithofacies complexes II and IV.

I conclude that the area of lithofacies complex II remained depressed as the rest of the island was elevated gradually from Paleogene through early Neogene time. However, by middle Miocene time, the graben had stabilized, as shown by the fact that the facies of the middle Miocene of complexes I, II, and IV are similar. Nevertheless, the block was somewhat de-pressed along its northern and southern margins, because late Miocene strata were deposited in those two areas. After Miocene time, the entire block rose above sea level until middle to late Pliocene time, when deposition again occurred on both the north and south sides of the block. This fact indicates that the Miocene was a time of regression, whereas the late Pliocene was an epoch of brief transgression.

During the uplift at the end of the Miocene, the Miocene strata were folded throughout the island. Dips locally are as steep as 30–40° in the vicinity of rejuvenated pre-Neogene structures of the ortho-geosyncline. Much faulting and shearing occurred, particularly along the fault separating complexes II and IV, as well as along the flanks of some ortho-geosynclinal structures.

Folds in the Neogene strata have rather broad dimensions, although small-scale structures are common throughout the island. The large-scale folds are in the Neogene basins, whereas the small-scale structures are in the vicinity of the older rejuvenated pre-Neogene structures.

Furrazola et al. (1964) indicated that the Miocene strata are discordant on all older beds (they were referring to the base of the Burdigalian, and not to the base of the Aquitanian); that conclusion is incorrect (Iturralde, 1966). Furrazola et al. generally are correct, but not with regard to the graben area of lithofacies complex II. In the areas next to the pre-Neogene structures, Burdigalian rocks in places overlie early Eocene rocks. However, within the graben, farthest from the ancient structures of the blocks which bound lithofacies complex II, the basal Neogene and not the Burdigalian strata directly overlie the Oligocene with facies and lithologic conformity, thus, in the graben, the Burdigalian is concordant in all respects upon the Aquitanian.

The other principal unconformities are at the top of the middle Miocene, the top of the upper Miocene, and at the top of the Pliocene. Locally, unconformities of less importance are present, e.g., between Aquitanian and Burdigalian strata and between Burdigalian and Vindobonian strata.

Lithofacies complex I also is included in this type, but as a subtype in which the entire sequence is neritic. At the base, the sequence is transgressive, but grades upward into a less regressive type. The area was uplifted at the end of the Paleogene (at least the northern margin); after Burdigalian time, it subsided considerably during the remainder of early to middle Miocene time.

The Cauto and Nipe subcomplexes of lithofacies complex V also were deposited in a deep-basin structural environment. Pelagic beds characterize the lower part of the section and grade upward into shallow neritic beds. There are, however, certain differences in history between these subcomplexes and lithofacies complex II: (1) the presence of boundary graben faults has not been proved in the Cauto and Nipe basins, (2) in these two basins, sandy beds are absent at the top of the sequences, and (3) the presence of Pliocene has not been proved in either the Cauto or Nipe basin.
Type 3. Transgressive Deposits of Shallow Neritic Basins

Strata of type 3 are developed the most widely within the eugeosynclinal province. They include lithofacies complexes III, IV, and the Guantánamo basin of lithofacies complex V. The rocks consist of a carbonate and terrigenous-clastic sequence of neritic deposition. The strata commonly overlap pre-Oligocene rocks.

Generally sequences of type 3 areas show a mildly regressive character. There was a gradual shallowing of seawater during their deposition. Most type 3 areas were uplifted near the end of middle Miocene time and were never again covered by the sea.

The gradual uplift of type 3 areas produced milder tectonic effects than those which affected the Neogene of the type 2 areas. Broad, very gentle folding occurred in type 3 areas,

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Fig. 13.—Paleogeographic reconstruction of Cuba during Neogene. 1, carbonate rocks, neritic facies; 2, marly rocks, pelagic facies; 3, shale rocks, shallow-water brackish facies; 4, sandy terrigenous rocks; 5, basal conglomerate; 6, land areas; 7, faults.
and in only a very few places do dips exceed 15–20°. The steepest dips are adjacent to old structures within the eugeosynclinal section. The overall dip is toward the sea on all sides of the island. Furrazola et al. (1964) have described steeper dips (up to 80° in one place) in the strata of this structural type, but they are related to salt diapirism in northwestern Camagüey Province (Meyerhoff and Hatten, 1968). The salt diapirs are mainly in the area of the Cretaceous miogeosyncline, not in the eugeosynclinal part of Cuba.

Deep crustal faults are less common in the type 3 than in the type 2 areas. Where present, such faults generally are associated with pre-Neogene structures. The principal discordances within the Neogene section of this tectonic setting are at the base of the Neogene and at the top of the middle Miocene.

**Conclusions**

Generally, the Neogene tectonic cycle is structurally simple. It is characterized by atypical transgressive and regressive sequences, except in lithofacies complex II, where the overall succession shows a typical regressive character. The principal discordances are at the base of the Neogene (base of Aquitanian), except in the deep-basin area of lithofacies complex II and at the top of the middle Miocene. The development of active wrench faults during Neogene time has not been established. Consequently, block-type faulting seems to have predominated.

**PALEOEOGRAPHY**

Except for the paleogeographic maps of Furrazola et al. (1964) and Weyl (1966a, b), no paleogeographic reconstructions of the Cuban Neogene are available. The paleogeography is summarized in three steps in Figure 13.

Tectonic movements at the end of Paleogene time led to the development of the subatlitudinal faults bounding lithofacies complex II. Except for the area of that complex, all of the island was exposed. Shortly thereafter, at the beginning of early Miocene time, the sea transgressed much of Cuba.

Early Miocene rocks are characterized by sharp faciologic differentiation of the lithofacies complexes. Shallow-water beds are found in certain areas, and deep-water beds in others. During the middle Miocene, water depths across the island were about the same as during early Miocene, and deep pelagic basins disappeared except on the Zapata Peninsula and in the Nipe basin. Elsewhere, faciologic “homogenization” occurred and shallow-water deposition predominated. At the end of the middle Miocene time, all of the island emerged except the Zapata Peninsula, northernmost Matanzas Province, and parts of Oriente. Most of the folding of Miocene rocks occurred at that time, forming folds that parallel the axial trend of the island. During late Miocene time, complete emergence occurred.

Minor transgressions occurred in northern Matanzas, on the Zapata Peninsula, and possibly in parts of Oriente Province during late Pliocene time. The sea was shallow, and deposition was near-continental in some areas. Generally the Neogene terminated with complete emergence of Cuba, uplift of major mountain ranges, and activity on several deep crustal faults, such as those bounding Bartlett Trough.

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* Name incorrectly spelled Kurman in original publication.