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Artikel: Contribution to the geology and paleontology of the area of the city La Habana, Cuba, and its Surroundings
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Coccoliths, with large specimens of *Tremalithus eopelagicus* BRAMLETTE and RIEDEL
Thoracosphaera spp. (globular and ellipsoid bodies).

Discoasterids, coccoliths and *Thoracosphaera* occur in all the thin sections studied, but their number often appeared reduced through recrystallization. Radiolaria are virtually absent in the Punta Brava beds.

The following diagnostic Universidad discoasterids do not extend into or perhaps occur only rarely in the Punta Brava formation:

Discoaster lodoensis BRAMLETTE and RIEDEL
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL)
Marthasterites sp.

The extinction of *D. lodoensis* and of *M. tribrachiatus*, the two most characteristic Universidad forms, creates a distinct faunal break between the Universidad and the Punta Brava beds. The latter are here referred to the *Discoaster barbadiensis* zone.

The planktonic Foraminifera of the Punta Brava formation are diagnostic for Upper Eocene, but not for the late Upper Eocene *Globorotalia cerroazulensis* zone, as represented at Jabaco. A lithologic gap, indicated in the field by an irregular, limonitic disconformity separates the Punta Brava formation and the *Globigerina ciperoensis–Globorotalia opima* zone of the Oligocene Consuelo formation. At Tejar Consuelo the Consuelo formation extends from the *Globigerina ampliapertura* zone into the *Globigerina ciperoensis–Globorotalia opima* zone. Based on the absence of *Globorotalia cerroazulensis* and on the occurrence of highly evolved representatives of *Globorotalia centralis* and *Globigerapsis semiinvoluta*, the Punta Brava beds are here placed at the top of the early Upper Eocene *Globigerapsis semiinvoluta* zone.

Consuelo Formation

Chalky beds of the older part of the Marianao group assigned by R. H. PALMER and later by BERMÚDEZ to formations of Upper Eocene age, turned out later to be either older or younger than Upper Eocene. The Consuelo formation proposed by BERMÚDEZ (1950) is a case in point, and a review appears indicated to explain the present nomenclatorial usage and age assignment of the beds erroneously regarded at one time or another as Upper Eocene.

PALMER (1934, p. 125, table I, pp. 132 and 133) included in his supposedly Upper Eocene Príncipe formation, or "upper phase of the Eocene", the soft whitish sediments above the Capdevila formation or "lower phase of the Eocene", and below the Oligo–Miocene overlap. In 1937, BERMÚDEZ (pp. 153–169) sampled the typical exposures of the Príncipe formation along the road cuts across Loma del Príncipe and on the campus of the University of Habana, and found certain but not all of the faunas to be Lower Eocene (index map, fig. 49). Based on this he believed to deal with an older lithologic unit different from PALMER's Príncipe formation which he called Universidad formation. But in fact BERMÚDEZ did not find a new formation. What he showed was simply that part of PALMER's Príncipe formation is of Lower Eocene age. PALMER in his paper of 1945 (table I on p. 6)

accepted BERMÚDEZ' Universidad formation. Later, BERMÚDEZ (1950, p. 258) restudied the outcrops at Loma del Príncipe and found them all to be Lower Eocene, i.e. belonging to the Universidad formation. At this point of the investigation, the nomenclatorially correct procedure would have been to re-define the age range and the type locality of PALMER's Príncipe formation and to drop the synonymous Universidad formation, which was proposed much later than Príncipe formation. This was, however, not done and as we explained in the introduction to the Universidad formation, reluctantly and only for reasons of tradition we accepted the name Universidad formation but used Príncipe to name its upper non-silicified member.

For apparently Upper Eocene beds, which BERMÚDEZ (1950, p. 258) found in the quarry at Tejar Consuelo, he chose the new name Consuelo formation. They are separated at Tejar Consuelo from the lithologically very similar underlying Lower Eocene Universidad beds by a distinct unconformity as shown by the photographs, figs. 56, 57 and 61. In the paper of 1950, BERMÚDEZ dropped the name Príncipe formation, and Consuelo formation instead of Príncipe formation was then used by this author for rocks of the Habana area believed to be of Upper Eocene age. For the beds unconformably overlying at Tejar Consuelo the Universidad formation, we will continue to use BERMÚDEZ' name Consuelo formation. But it will be necessary to define the type of this formation lithologically and geographically more accurately and to change its age assignment from Upper Eocene to Oligocene.

But before describing the type locality of the Consuelo formation, we will briefly comment on two formations most probably identical with the Consuelo formation, i.e. the Guatao formation of BRODERMANN (1943, p. 127) and the Tinguaro formation of R. H. PALMER (1945, p. 17). Although the Consuelo formation was later proposed than both Guatao and Tinguaro formations, it is considered advisable to drop the latter in favor of Consuelo formation.

Remarks on the Guatao formation

The type locality of the Guatao formation is a water well in the garden of the Finca Nuestra Señora de Lourdes of the Colegio de la Salle, Guatao, about 1.5 km due south of Punta Brava, on the Carretera Central, a locality referred to previously under Punta Brava formation. The lithology is described by BRODERMANN (1943, p. 127) as a "marga amarillenta" with a mixed assemblage of Upper Eocene and Lower Oligocene Foraminifera. This description also fits that of the slumped basal beds of the Consuelo formation at the southeastern cliff of the quarry at Tejar Consuelo. We were unable to study the lithology and the fauna from the Guatao type locality, because the samples referred to by BRODERMANN and by BERMÚDEZ could not be located in the collections of the Comisión del Mapa Geologico de Cuba. However, through the courtesy of Ing. J. BRODERMANN we received a microfauna from a surface exposure assigned by this author to the Guatao formation. It is from an outcrop south of the Habana area, on the Autopista del Mediodía, 4.9 km south of its intersection with the Carretera Central and 1.2 km north of the crossing with the road to El Chico. The fauna appears to be from a yellowish chalk. The more important planktonic Foraminifera are:

Globigerina ciperoensis angulisuturalis BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina ciperoensis ciperoensis BOLLI (abundant)
Globoquadrina venezuelana (HEDBERG) group
Globigerina euapertura JENKINS
Globigerina rohri BOLLI group
Globorotalia opima opima BOLLI
Globorotaloides suteri BOLLI
Chiloguembelina cubensis (D. K. PALMER)
Pseudohastigerina micra (COLE) } (reworked)
Globorotalia lehneri CUSHMAN and JARVIS }

This heterogeneous microfauna is from the *Globigerina ciperoensis–Globorotalia opima* zone. At the type locality of the Consuelo formation, the younger Consuelo beds extend into this zone and there is not much doubt that the above described sample comes from a bed of the Consuelo formation. A good outcrop of the Guatao formation within the Habana area, mentioned by BRODERMANN, occurs in the Bosque de la Habana, just north of Tejar Consuelo, but was not investigated by us. As the type locality of the Guatao formation is not readily accessible, and as the type samples are not available it is recommended to drop this name.

Remarks on the Tinguaro formation

R. H. PALMER (1945, p. 17) mentioned outcrops of marls on the lands of the Tinguaro sugar mill, west of Colón, Province of Matanzas, about 150 km east-southeast of La Habana as good exposures of his Tinguaro formation. He correlated the "soft, buff marl" from a shallow water well at Finca Adelina, approximately 9.5 km east of Colón and 0.5 km north of the Carretera Central, with the Tinguaro formation. The rich foraminiferal fauna from Finca Adelina was analyzed by D. K. PALMER and P. BERMÚDEZ (1936), and without using the name Tinguaro formation these authors reported (1936, p. 233) that similar assemblages were found at Central Tinguaro, 16 km to the west of Finca Adelina, at Central Alava, 5 km to the north, and at Finca Aguedita, 7 km to the southeast. Although the fauna is dominated by planktonic Foraminifera, PALMER and BERMÚDEZ recorded only three globigerinas, viz. *Globigerina* cf. *G. bulloides* D'ORBIGNY, *Globigerina conglobata* BRADY, var., and *Globigerina* cf. *G. inflata* D'ORBIGNY. Also mentioned are *Guembelina cubensis* D. K. PALMER and *Sphaeroidina bulloides* D'ORBIGNY. The planktonics from this material, which was also referred to by BERMÚDEZ (1950, pp. 268–270), need to be revised and brought up to date nomenclatorially. A rich and well-preserved microfauna from the Finca Adelina locality received from the late D. W. GRAVELL (station 5609) contains:

Globoquadrina venezuelana (HEDBERG) group (abundant)
Globigerina bradyi WIESNER (rare)
Globigerina ciperoensis angulisuturalis BOLLI (rare)
Globigerina ciperoensis angustiumbilicata BOLLI (rare)
Globigerina ciperoensis ciperoensis BOLLI (abundant)
Globigerina euapertura JENKINS (common)

Globigerina parva BOLLI (rare)
Globigerina rohri BOLLI group (common)
Globigerina cf. *trilocularis* D'ORBIGNY (common)
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ) (one specimen)
Globorotalia opima nana BOLLI (rare)
Globorotalia opima opima BOLLI (common)
Cassigerinella chipolensis (CUSHMAN and PONTON) (one specimen)
Pseudohastigerina micra (COLE) (one specimen)
Chiloguembelina cubensis (D. K. PALMER) (rare)
Globoquadrina altispira altispira (CUSHMAN and JARVIS) (common)
Globoquadrina altispira globosa BOLLI (one specimen).

This assemblage is composed of the forms generally recorded in Cuba from the *Globigerina ciperoensis–Globorotalia opima* Zone, and of two representatives of the genus *Globoquadrina* FINLAY, i.e. *Globoquadrina altispira altispira* (CUSHMAN and JARVIS) and *Globoquadrina altispira globosa* BOLLI (one typical specimen). According to the stratigraphic distribution established for the Tertiary planktonics in Trinidad, B.W.I., *Globoquadrina* occurs for the first time in the *Catapsydrax dissimilis* Zone with *Globoquadrina altispira globosa*. *Globoquadrina altispira altispira* evolved from *Globoquadrina venezuelana* (HEDBERG) which seems to be a typical "Durchläufer", by developing a higher spiral and stronger apertural flaps, but in other respects, especially in the number of chambers of the final whorl, it is very close to *Globoquadrina venezuelana*. The delicate apertural flaps being the diagnostic feature, it is very much a matter of preservation whether a primitive form of the *venezuelana–altispira* group can be recognized as a *Globoquadrina*. *Globigerina euapertura* JENKINS is not related with *Globoquadrina venezuelana* as assumed by JENKINS (1960), but with *Globigerina ampliapertura* BOLLI. *Globigerina rohri* BOLLI most probably is a *Globoquadrina*.

The association of primitive globoquadrinas with *Globigerina ciperoensis ciperoensis* BOLLI and *Globorotalia opima opima* BOLLI indicates that the advent of *Globoquadrina* FINLAY takes place in Cuba already in the *Globigerina ciperoensis–Globorotalia opima* zone.

W. A. VAN DEN BOLD (letter March 21, 1963) identified from GRAVELL station 5609 the below listed ostracodes regarded as about Vicksburg in age:

Krithe hiwanneensis HOWE and LEA
Brachycythere russelli HOWE and LAW
Costa maquayensis VAN DEN BOLD
Ambocythere reticulata VAN DEN BOLD
Pterygocythereis ivani (HOWE)
Trachyleberidea cubensis mammidentata (VAN DEN BOLD)

The beds of the Finca Adelina water well would then fall in the *Globigerina ciperoensis–Globorotalia opima* zone, which is represented by the youngest beds of the Consuelo type section at Tejar Consuelo, and by the conglomeratic *Lepidocyclina*-bearing basal Husillo (?) beds at Punta Brava.

R. H. PALMER (1945, p. 17) regarded the Tinguaro formation in part as the deeper water equivalent of the zone of larger lepidocyclinas with *Lepidocyclina*

undosa CUSHMAN and *Lepidocyclina favosa* CUSHMAN that occurs directly above the Eocene in many widely separated localities in Cuba and which we tentatively put at the base of the Husillo formation.

From supposedly shallow-water developments of the Tinguaro formation, BERMÚDEZ (1950) reported, without giving localities, the following larger Foraminifera:

Lepidocyclina dilatata MICHELOTTI
Lepidocyclina formosa SCHLUMBERGER
Lepidocyclina fragilis CUSHMAN
Lepidocyclina parvula CUSHMAN
Lepidocyclina piedraensis VAUGHAN
Lepidocyclina yurnagunensis CUSHMAN
Lepidocyclina yurnagunensis CUSHMAN var. *morganopsis* VAUGHAN
Operculinoides vicksburgensis VAUGHAN and COLE.

The type area of the Tinguaro formation near Central Tinguaro, Matanzas Province, was visited by us in the summer of 1958 and again by DUCLOZ in 1959. East of the Central we observed poorly outcropping chalk reminiscent of the Consuelo lithologies. The yellowish, indurated and powdery chalk of Ducloz station 699 as described below is representative of this lithology. At Central Tinguaro proper there are no outcrops, the terrain being under heavy soil cover. The following samples collected in March 1959 by DUCLOZ and kindly put at our disposal are from the outcrops east of Central Tinguaro. Their geographic locations are given in the index map, fig. 58. Of particular significance are the Consuelo-like chalk from Ducloz station 699 which yields a rich homogeneous microfauna of the *Globigerina ciperoensis–Globorotalia opima* zone, and the occurrence of abundant specimens of *Heterostegina israelskyi* GRAVELL and HANNA in the overlying limestones of Ducloz station 703 about 2.8 km southwest of Ducloz station 699. This species was not found in the Husillo samples of the Habana area, where certain beds carry abundant *Heterostegina antillea* CUSHMAN, and possibly suggests a horizon stratigraphically different from the *Miogypsina* spp.–*Heterostegina antillea* horizon of the Husillo formation. Ducloz stations 700 to 702, 704 and 705, are from whitish and yellowish calcarenites and limestones with benthonic Foraminifera reminiscent of the Husillo and Cojímar lithologies. These beds are all younger than the chalk outcropping at Ducloz station 699. Miogypsinas are absent and only a single fragment of a *Lepidocyclina* sp. was encountered in a thin section from Ducloz station 702.

Ducloz station 699
Lithology: Chalk, indurated, powdery, whitish to pale yellowish orange.
Washed residue with

Globigerina ciperoensis angulisuturalis BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina ciperoensis ciperoensis BOLLI (abundant)
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina cf. *trilocularis* D'ORBIGNY

Globoquadrina venezuelana (HEDBERG) group
Globorotalia opima nana BOLLI
Globorotalia opima opima BOLLI (common)
Globorotaloides suteri BOLLI.

Ducloz station 700
Lithology: Calcarenite, fine-grained, whitish to grayish yellow.
Texture: Fragmental to pseudoölitic, somewhat vacuolar, in part recrystallized groundmass. Components are fragments of algae, mollusks and echinoderms. Common benthonic Foraminifera and ostracodes. Diameter of average component from about 30 to 150 μ. Texture and generic composition of the microfauna are very similar to that of the Pleistocene calcarenites.

Assemblage: *Archaias* cf. *operculiniformis* HENSON
Acervulina inhaerens SCHULTZE
Amphistegina sp.
Meandropsina sp.
Peneroplis sp.
Miliolids.

Ducloz station 701
Lithology: Limestone, hard, yellowish orange.
Texture: Completely recrystallized groundmass. Microfossils destroyed.

Ducloz station 702
Lithology: Limestone, calcarenaceous, hard, whitish.
Texture: As Ducloz station 700.

Assemblage: *Sporadotrema cylindricum* (CARTER)
Meandropsina sp.
Gypsina sp.
Archaias cf. *operculiniformis* HENSON
Amphistegina sp.
Lepidocyclina sp. (only fragment).

Ducloz station 703
Lithology: Limestone, granular, grayish yellow, with abundant oriented larger Foraminifera.
Texture: Microcrystalline groundmass with abundant heterosteginas.

Assemblage: *Heterostegina israelskyi* GRAVELL and HANNA (rock-forming).

Ducloz station 704
Lithology: Limestone, granular, laminated, grayish yellow.
Texture: Microcrystalline groundmass with abundant densely packed planktonic microfossils. Minute forms destroyed through recrystallization.

Assemblage: *Globigerina* spp.

Ducloz station 705
Lithology: Limestone, hard, whitish.
Texture: Fragmental to pseudoölitic, recrystallized groundmass. Components

fragments of mollusks, echinoderms, algae and benthonic Foraminifera. Large discrete inclusions of dense, light brown barren argillaceous material.

Assemblage: Miliolids
Peneroplis sp.
Sorites sp.
Meandropsina sp.
Amphistegina sp.
Archaias sp.

In our opinion there is no question that the Tinguaro formation, as represented by Ducloz station 699 and by the Finca Adelina beds, is a time equivalent of the Consuelo formation. Moreover Tinguaro formation has priority over Consuelo formation. However, R. H. PALMER did not define a type locality and the isolated outcrops near Central Tinguaro do not afford a clear understanding of the lithologic sequence which, as shown by the above listed samples, is referable to different formations. Further, it is impossible to determine the thickness of the Tinguaro formation and its attitude toward adjoining units. For these reasons it is suggested to discard the name Tinguaro formation at least for the Habana area and to use in its stead Consuelo formation.

Description of the type locality of the Consuelo formation

The type locality of the Consuelo formation is in the quarry at Tejar Consuelo situated in the Reparto Cerro, La Ciénaga, on the northern side of the Calzada de Puentes Grandes about 400 m west-southwest of its intersection with Avenida 26, and about 1 km east of Río Almendares (BERMÚDEZ, 1950, p. 260). The coordinates of the southern building of the brick factory are 364.50 N and 356.58 E (index map, fig. 59).

The geology of the quarry is rather complicated and its significance as a central and easily accessible outcrop area where Capdevila, Universidad, Consuelo and Husillo formations are exposed warrants a more detailed description of the geological situation. In the smaller eastern part of the quarry, brownish beds of the Capdevila formation are in transitional contact with the Toledo member of the Universidad formation. This outcrop has been previously described under Capdevila formation (pp. 340 to 342, of this paper). In 1958 and 1959 the main part of the quarry, southeast of the factory buildings was flanked by two steep cliffs. The northeastern cliff, directly under the factory buildings, trends in northwestern direction and shows a continuous exposure over a distance of about 200 m and with a height ranging from 6 to 10 m. Along the southeastern base of this cliff grayish yellow chalky limestones with asphalt pebbles of the Príncipe member of the Universidad formation are exposed. As shown in the index map, fig. 59, BR stations 703 and 708 are from the basal part of the cliff. They have been described in the chapter on the Universidad formation. The Príncipe chalks are unconformably overlain by the likewise chalky, whitish to grayish yellow Consuelo formation. The lithologic similarity between the Consuelo formation and the Príncipe member of the Universidad formation is reflected by the fact that the brick factory uses indiscriminately material from both the Universidad and the Consuelo formation in the manufacture of the bricks. Slight lithologic differences

between the Príncipe member and the Consuelo formation are 1) the Universidad formation contains abundant asphalt pebbles which are virtually absent in the Consuelo formation, and 2) the Universidad formation is more regularly and thinner bedded than the Consuelo formation. These differences are rather tenuous, and in an isolated outcrop the two formations can be distinguished by their faunal contents only. The higher southwestern cliff is about 350 m long and up to 16 m high. The base of its eastern part is formed by both Toledo and Príncipe member of the Universidad formation on which transgress the type Consuelo beds as defined in this paper. On top of the central part of this cliff occur unconformably overlying the Consuelo formation a few meters of *Miogypsina*-bearing white to yellowish, hard, cavernous and limonitic weathering reefal Husillo limestones. BR stations 773 and 774, which will be described in the chapter on the Husillo formation, are from this limestone. At the northwestern half of the larger cliff the maximum thickness of the Consuelo formation is about 19 m. At other places only about 8 m of Consuelo formation are preserved between the Universidad formation and the transgressive Husillo formation (columnar sections, fig. 60).

The Consuelo formation is a series of whitish to grayish yellow, massive chalky limestones, with a few thin layers of greenish grayish soft calcareous shale. In places there occur very thin limonitic layers.

At the southwestern cliff, the type Consuelo formation rests unconformably on the Universidad formation (index map and columnar sections, figs. 59, 60, and photographs of cliff and contact, figs. 56, 57, 61). This angular unconformity, already mentioned by Bermúdez (1950, p. 258), is here clearly recognizable, but in an isolated outcrop the contact could appear to be almost transitional. In such cases the only evidences of an unconformity would be the abrupt change in faunas and the occurrence of numerous limonitic spots in the basal beds of the Consuelo formation. Such an accumulation of limonitic spots could be regarded as the expression of an emergence.

At the lower northeastern cliff of the quarry matters are more complicated. There the basal beds of the Consuelo formation are formed by a 2 to 5 m thick zone of hard whitish chalk, which is lighter in color than both the underlying Príncipe member and the overlying typical Consuelo formation. This peculiar Consuelo chalk is characterized by very irregular and contorted bedding apparently caused by submarine slumping (photograph of contact, fig. 61). Dispersed throughout this zone are small pebbles up to fist-size derived from the underlying Universidad formation. The unconformable character of the contact between Consuelo and Universidad formations is here demonstrated not alone by the fact that the underlying Universidad beds are truncated, but also by the occurrence in the Universidad beds of bore holes made by lithophagic organisms. Moreover, the unconformity surface shows irregular channel-like depressions filled by the slumped, hard, whitish, pebble-bearing Consuelo chalk. Faunal analysis of the samples from BR stations 361, 769, 770, 772, 704 to 707, shows that the slumped material is derived from Lower, Middle and Upper Eocene beds, with Late Middle and Upper Eocene planktonics predominant. The occurrence of Upper Eocene planktonic Foraminifera suggests that strata of this age and of deep-water origin were once deposited in the Habana area but removed in pre-Consuelo erosional periods. The slumped

material is interpreted to represent the filling, at the time of the Consuelo transgression, of channels scoured by post-Universidad erosion. These channels are reminiscent of those at the south flank of Loma de Urría in which the dolomitic Urría beds are deposited. Simultaneous reworking of Universidad material took place and pebbles were formed, which then were dispersed throughout the slumped zone. The typical Consuelo beds of the *Globigerina ampliapertura* zone (BR station 702B) overlying this whitish zone, do not exhibit evidence of slumping. From this can be inferred that the sedimentation gradually became quiet. However, heterogeneous faunas from BR stations 702 and 702A of these depositionally more quiet beds are proof that reworking of older material continued for some time. The contact between the slumped beds and the regularly bedded Consuelo chalks is transitional. The age of the slumped zone is either Upper Eocene or Oligocene. The age cannot be definitely established because *Globigerina ampliapertura*, the youngest diagnostic form occurring in these beds, is not restricted to the Oligocene but occurs according to LOEBLICH et al. (1958) already in the Upper Eocene, *Globorotalia cerroazulensis* zone. However, more for lithologic and general geological considerations than for faunistic reasons, we are placing tentatively the slumped beds in the *Globigerina ampliapertura* zone of the basal Consuelo formation. Similar heterogeneous assemblages were found by us only in the Oligocene *Globigerina ciperoensis–Globorotalia opima* zone of the Consuelo formation outcropping at Punta Brava, and in a sample of the same age referred by BRODERMANN to his Guatao fauna.

Southwestern cliff

The southwestern cliff as described above is herewith designated the type locality of the Consuelo formation. As shown in the columnar sections, fig. 60, the type samples are from BR stations 360 and 363 to 366. BERMÚDEZ (1950, pp. 259 and 260) mentioned as type locality of the Consuelo formation the "parte superior" or "capas superiores" of the quarry at Tejar Consuelo. In view of the rather complicated geology of this quarry this designation is not adequate to locate Bermúdez' type station 36, in which this author recorded the following planktonic species:

Globigerina apertura CUSHMAN [=*Globigerina ampliapertura* BOLLI]
Globorotalia cerroazulensis (COLE)
Gümbelina cubensis D. K. PALMER [=*Chiloguembelina cubensis* (D. K. PALMER)]
Gümbelina goodwini CUSHMAN and JARVIS [=*Chiloguembelina martini* (PIJPERS)]
Hantkenina alabamensis CUSHMAN
Hantkenina brevispina CUSHMAN
Hantkenina longispina CUSHMAN
Nonion micrus COLE [=*Pseudohastigerina micra* (COLE)]

This may be a homogeneous fauna of Upper Eocene age, or a basal Consuelo assemblage with reworked Upper Eocene forms. It is probably from the slumped basal Consuelo beds of the southeastern cliff. The microfauna listed by BERMÚDEZ

as another typical Consuelo fauna from his station 18, Cantera Kohly, Bosque de la Habana, about 1 km northwest of Tejar Consuelo, is clearly heterogeneous. It contains the above listed Upper Eocene planktonics and the Middle Eocene *Globigerina mexicana* CUSHMAN [=*Porticulasphaera mexicana* (CUSHMAN)]. We were unable to find this sample in the collections of the Comisión del Mapa Geologico de Cuba. It is probably also from the slumped basal Consuelo beds.

The type samples described below are listed from bottom to top. BR stations 360 and 364 to 366 are from the *Globigerina ampliapertura* zone and the stratigraphically youngest sample, BR station 363, is from the *Globigerina ciperoensis–Globorotalia opima* zone. Most of the assemblages contain reworked Lower to Middle (?Upper) Eocene species. The ostracodes from BR stations 360, 363 to 366 have been identified generically by W. A. VAN DEN BOLD (letter March 21, 1963).

BR station 360
Lithology: Chalk, powdery, light grayish yellow.
Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ) (one specimen)
Globigerina ampliapertura BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina parva BOLLI (abundant)
Globigerina rohri BOLLI group (common)
Globigerina cf. *trilocularis* D'ORBIGNY
Globoquadrina venezuelana (HEDBERG) group
Pseudohastigerina micra (COLE)
Chiloguembelina cubensis (D. K. PALMER) (abundant)
Globorotalia centralis CUSHMAN and BERMÚDEZ } reworked
Globorotalia sp. (truncate form). }

Macrocypris sp.
Bairdia sp.
Krithe sp.
Pseudocythere sp.

BR station 366
Lithology: Chalk, fairly indurated, powdery, grayish yellow.
Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globorotalia opima nana BOLLI
Globigerina ampliapertura BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI (common)
Globigerina euapertura JENKINS
Globigerina parva BOLLI (abundant)
Globigerina rohri BOLLI group
Globoquadrina venezuelana (HEDBERG) group
Globorotaloides suteri BOLLI
Chiloguembelina cubensis (D. K. PALMER) (abundant)
Cassigerinella chipolensis (CUSHMAN and PONTON)

Pseudohastigerina micra (COLE)
Globigerina soldadoensis BRÖNNIMANN group } reworked
Globigerina linaperta (FINLAY)

Macrocypris sp.
Bairdia sp.
Argilloecia sp.

BR station 365
Lithology: Chalk, powdery, grayish yellow.
Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globorotalia opima nana BOLLI
Globigerina ampliapertura BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina parva BOLLI (abundant)
Globigerina rohri BOLLI group
Globoquadrina venezuelana (HEDBERG) group
Chiloguembelina cubensis (D. K. PALMER) (abundant)
Cassigerinella chipolensis (CUSHMAN and PONTON)

Cytherella sp.
Bairdia sp.
Bythocypris sp.
Krithe sp.

BR station 364
Lithology: Chalk, fairly indurated, powdery, light yellowish to grayish yellow.
Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina ampliapertura BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina euapertura JENKINS
Globigerina parva BOLLI (abundant)
Globigerina rohri BOLLI group
Globigerina cf. *trilocularis* D'ORBIGNY
Globoquadrina venezuelana (HEDBERG) group
Chiloguembelina cubensis (D. K. PALMER) (abundant)
Globorotalia spinuloinflata (BANDY) (reworked).

Bairdia sp.
Bradleya sp.
Macrocypris sp.
"*Krausella*" sp.
Krithe sp.

BR station 363
Lithology: Chalk, powdery, white to grayish yellow, with limonitic streaks and concretions.

Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina ampliapertura BOLLI (rare)
Globigerina ciperoensis angulisuturalia BOLLI
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina ciperoensis ciperoensis BOLLI
Globigerina euapertura JENKINS
Globigerina parva BOLLI (abundant)
Globigerina rohri BOLLI group
Globoquadrina venezuelana (HEDBERG) group
Globorotalia opima nana BOLLI
Globorotalia opima opima BOLLI group (common) (first large and well-developed specimen)
Globorotaloides suteri BOLLI
Chiloguembelina cubensis (D. K. PALMER) (abundant).

Bradleya aff. *dictyon* (BRADY)
Bairdia sp.
Bythocypris sp.
Cytherella sp.

Northeastern cliff

The slumped beds, here about 3.9 m thick, were closely and carefully sampled in order to establish beyond doubt the heterogeneous composition of the faunas. The relative positions of the samples are shown in the index map of the Consuelo quarry, fig. 59. BR stations 361 and 362 are random samples from the slumped beds. BR station 704 is from the base of the slumped zone, 705 is 1.2 m stratigraphically above 704, and 706 is 1.5 m stratigraphically above 705. BR station 706 is still within the slumped beds which at this level are without pebbles.

BR station 361
Lithology: Chalk, indurated, grayish yellow, with asphalt inclusions.
Washed residue heterogeneous with

Hantkenina alabamensis CUSHMAN
Hantkenina cf. *dumblei* WEINZIERL and APPLIN
Hantkenina longispina CUSHMAN
Hantkenina suprasuturalis BRÖNNIMANN
Globigerina ampliapertura BOLLI
Globigerina boweri BOLLI
Globigerina parva BOLLI
Globigerina prolata BOLLI
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Globigerina cf. *yeguaensis* WEINZIERL and APPLIN
Globorotalia cerroazulensis (COLE)
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globigerapsis kugleri BOLLI

Globorotalia aequa CUSHMAN and RENZ
Globorotalia aragonensis NUTTALL
Globorotalia cf. *aspensis* (COLOM)
Globorotalia lehneri CUSHMAN and JARVIS
Globorotalia spinuloinflata (BANDY)
Pseudohastigerina micra (COLE)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Globigerinatheka barri BRÖNNIMANN
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ).

BR station 362
Lithology: Chalk, indurated, powdery, whitish to pale greenish yellow.
Texture: Cryptocrystalline to microcrystalline groundmass with planktonic microfossils (a) and with irregular shaped inclusions of the same texture of up to about 3000 μ diameter (b).

Assemblage: a) Groundmass

Globigerina spp.
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Braarudosphaera bigelowi (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Thoracosphaera spp.

b) Inclusions

Globigerina spp.
Coccoliths.

Washed residue heterogeneous with

Hantkenina alabamensis CUSHMAN
Hantkenina suprasuturalis BRÖNNIMANN
Cribohantkenina bermudezi (THALMANN)
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globigerapsis index (FINLAY)
Globigerapsis semiinvoluta (KEIJZER)
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina ampliapertura BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Pseudohastigerina micra (COLE)
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Truncorotaloides cf. *topilensis* (CUSHMAN)
Porticulasphaera mexicana (CUSHMAN)
Chiloguembelina martini (PIJPERS)
Globigerinatheka barri BRÖNNIMANN.

BR station 704

This sample is from the base of the slumped zone.

Lithology: Chalk, indurated, whitish to grayish yellow.

Washed residue heterogeneous with

Globorotalia cf. *aequa* CUSHMAN and RENZ
Globorotalia cf. *aspensis* (COLOM)
Globorotalia cf. *bullbrooki* BOLLI
Globorotalia spinulosa CUSHMAN
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globigerinatheka barri BRÖNNIMANN
Globigerapsis index (FINLAY)
Globigerapsis kugleri BOLLI
Globigerapsis semiinvoluta (KEIJZER)
Globigerina ampliapertura BOLLI
Globigerina senni (BECKMANN)
Globigerina cf. *yeguaensis* WEINZIERL and APPLIN
Pseudohastigerina micra (COLE)
Chiloguembelina martini (PIJPERS)

BR station 705

Lithology: Chalk, indurated, powdery, whitish to grayish yellow, with limonitic inclusions.

Washed residue heterogeneous with

Hantkenina longispina CUSHMAN
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globorotalia lehneri CUSHMAN and JARVIS
Globigerina ampliapertura BOLLI
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerinatheka barri BRÖNNIMANN
Globigerapsis index (FINLAY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ.

BR station 706

Lithology: Chalk, indurated, powdery, whitish to grayish yellow.

Washed residue heterogeneous with

Hantkenina alabamensis CUSHMAN
Hantkenina suprasuturalis BRÖNNIMANN
Globorotalia cerroazulensis (COLE)
Globorotalia lehneri CUSHMAN and JARVIS
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina ampliapertura BOLLI
Truncorotaloides topilensis (CUSHMAN)
Pseudohastigerina micra (COLE)
Chiloguembelina cubensis (D. K. PALMER).

BR station 707

The following descriptions refer to two indurated chalk pebbles from the basal layer of the slumped bed.

Lithology: Chalk, indurated, whitish to grayish yellow, with asphalt inclusions, (1) and (2).

Pebble 1
Texture: Cryptocrystalline to microcrystalline groundmass with planktonic microfossils. Asphalt inclusions and limonitic stains.
Assemblage: *Globorotalia* spp. (truncate forms)
Globigerina senni (BECKMANN)
Globigerina spp.
Coccoliths
Braarudosphaera bigelowi (GRAN and BRAARUD) (common)
Discoaster barbadiensis TAN
Thoracosphaera spp. (globular and ellipsoid bodies).

Pebble 2
Texture: As Pebble 1.
Assemblage: *Globorotalia centralis* CUSHMAN and BERMÚDEZ
Globigerina spp.
Pseudohastigerina micra (COLE)
Coccoliths
Discoaster barbadiensis TAN (abundant)
Braarudosphaera discula BRAMLETTE and RIEDEL
Braarudosphaera bigelowi (GRAN and BRAARUD)
Thoracosphaera spp. (globular and ellipsoid bodies).

The following three samples are from additional BR stations located in the slumped bed. They are arranged in stratigraphic sequence from bottom to top. BR stations 769 and 770 are from the pebbly basal layer and 772 is just from below the environmentally more quiet beds on top of the slumped zone.

BR station 769
Lithology: Chalk, indurated, whitish, with reworked asphalt inclusions.
Washed residue heterogeneous with
Hantkenina alabamensis CUSHMAN
Hantkenina suprasuturalis BRÖNNIMANN
Cribohantkenina bermudezi (THALMANN)
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia spinuloinflata (BANDY)
Globorotalia cerroazulensis (COLE)
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globigerina ampliapertura BOLLI
Globigerina parva BOLLI
Globigerina senni (BECKMANN)
Truncorotaloides topilensis (CUSHMAN)
Pseudohastigerina micra (COLE).

BR station 770
Lithology: Chalk, indurated, powdery, grayish yellow. With abundant asphalt fragments.

Washed residue heterogeneous with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina cf. *ampliapertura* BOLLI
Globigerina parva BOLLI
Globigerapsis index (FINLAY)
Globorotalia centralis CUSHMAN and BERMÚDEZ
Pseudohastigerina micra (COLE)
Globigerinatheka barri BRÖNNIMANN
Globorotalia sp. (truncate form).

BR station 772
Lithology: Chalk, indurated, powdery, finely laminated, whitish to grayish yellow.
Washed residue heterogeneous with

Hantkenina cf. *alabamensis* CUSHMAN
Globigerina ampliapertura BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina senni (BECKMANN)
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina micra (COLE)
Globorotalia spinuloinflata (BANDY)
Chiloguembelina cubensis (D. K. PALMER).

The following samples are from the typical, undisturbed Consuelo beds transitionally overlying the slumped zone. They still show reworking with the exception of the fauna from BR station 702B.

BR station 702
Lithology: Chalk, indurated, powdery, grayish yellow, with reworked asphalt fragments.
Washed residue heterogeneous with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globoquadrina venezuelana (HEDBERG) group
Globigerina ampliapertura BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina cf. *ciperoensis ciperoensis* BOLLI
Chiloguembelina cubensis (D. K. PALMER)
Globorotaloides suteri BOLLI
Pseudohastigerina micra (COLE)
Globorotalia spinuloinflata (BANDY)
Globorotalia spinulosa CUSHMAN
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Globigerapsis index (FINLAY)

BR station 702A
Lithology: Chalk, indurated, powdery, grayish yellow, with abundant reworked asphalt fragments.

Washed residue heterogeneous with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Pseudohastigerina micra (COLE)
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina senni (BECKMANN) (reworked)
Globoquadrina venezuelana (HEDBERG) group
Globorotaloides suteri BOLLI
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globorotalia cerroazulensis (COLE)
Globorotalia rex MARTIN
Globorotalia spinulosa CUSHMAN
Globorotalia spinuloinflata (BANDY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Truncorotaloides topilensis (CUSHMAN)

BR station 702B

This is the first Consuelo sample, *Globigerina ampliapertura* zone, without reworked older Foraminifera.

Lithology: Chalk, indurated, powdery, grayish yellow, with reworked asphalt particles.

Washed residue with

Globigerina ampliapertura BOLLI (abundant)
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globoquadrina venezuelana (HEDBERG) group
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Chiloguembelina cubensis (D. K. PALMER).

Other outcrops of the Consuelo formation

Reparto Alturas del Vedado

About 300 m northwest of Tejar Consuelo and south of Reparto Alturas del Vedado, the Consuelo formation is exposed along the slope of Avenida Antonio Soto, approximate coordinates 365.22 N and 356.10 E. Lithologically, the Consuelo beds are similar to those of the nearby type locality, excepting the occurrence of numerous well-preserved echinid spines probably of *Rhabdocidaris sanchezi* LAMBERT, and of conspicuous, heavy, egg-shaped concretions, which H. H. HESS determined as barytes (letter dated June 2, 1958). Along this slope we observed limonitic layers.

The following samples are from bottom to top of the outcrop:

BR station 685

Lithology: Chalk, indurated, powdery, whitish to grayish yellow.

Washed residue with

Globigerina ampliapertura BOLLI
Globigerina rohri BOLLI group
Globoquadrina venezuelana (HEDBERG) group
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globorotalia cf. *opima nana* BOLLI
Chiloguembelina cubensis (D. K. PALMER).

BR stations 682 and 683

The samples from these stations are very similar faunally and lithologically and therefore reported together.

Lithologies: Chalk, indurated, powdery, whitish to grayish yellow.

Textures: Cryptocrystalline to microcrystalline groundmass with abundant planktonic microfossils.

Assemblages: *Globigerina* spp.
Chiloguembelina cubensis (D. K. Palmer)
Coccoliths, mainly placoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN (common)
Discoaster woodringi BRAMLETTE and RIEDEL (common)
Discoaster cf. *molengraaffi* TAN
Discoaster sp. indet.
Marthasterites sp.
Braarudosphaera bigelowi (GRAN and BRAARUD)
Microantholithus flos DEFLANDRE
Thoracosphaera sp.

Washed residue with

Globigerina ampliapertura BOLLI
Globigerina rohri BOLLI group
Globorotaloides suteri BOLLI
Chiloguembelina cubensis (D. K. PALMER).

Quarry east of Punta Brava

The location of this quarry has been described under Punta Brava formation (index map, fig. 64). In the summer of 1958, 4 to 5 m of whitish massive Consuelo chalks were exposed overlying the Upper Eocene Punta Brava beds. The lowermost bed of the Consuelo formation is a 5 to 10 cm thick shaley layer which rests on a limonitic and irregularly eroded solution surface on top of the early Upper Eocene Punta Brava formation. This suggests emergence, but no evidence of an angular unconformity between the Punta Brava and the Consuelo beds was seen because of the poor bedding near the contact between the two formations. The top of the Consuelo formation, on the other hand, is truncated by definitely transgressive and unconformable conglomeratic beds characterized by large discoid and sellate lepidocyclinas and here tentatively placed in the Husillo formation. The stratigraphic position of the Consuelo and Husillo samples, BR stations 376 to 378, and 383, from this outcrop is shown in the columnar section, fig. 65.

The planktonic microfauna from BR station 379 is heterogeneous with Lower and Upper Eocene forms re-deposited in a *Globigerina ciperoensis–Globorotalia opima* assemblage. It is reminiscent of the heterogeneous faunas reported from the slumped Consuelo beds of Tejar Consuelo and of BRODERMANN's Guatao fauna. The fauna of BR station 378 is homogeneous. The numerous large and in part sellate lepidocyclinas from BR stations 376 and 383 are long-ranging forms. According to W. STORRS COLE they may suggest correlation with the Meson formation of Mexico which at many horizons yields great quantities of *Lepidocyclina (Eulepidina) undosa* CUSHMAN. *Globigerina ciperoensis ciperoensis* BOLLI, *Globigerina ciperoensis angustiumbilicata* BOLLI, *Globigerina ciperoensis angulisuturalis* BOLLI, *Catapsydrax dissimilis* (CUSHMAN and BERMÚDEZ), *Globorotalia opima* BOLLI and *Globigerina euapertura* JENKINS, associated at Punta Brava with the large lepidocyclinas, are diagnostic of the *Globigerina ciperoensis–Globorotalia opima* zone. The planktonic Foraminifera encountered in a sample from the type locality of the Meson formation in a road cut at 24.8 km of the Tuxpan road, Tampico, Mexico, kindly donated by Mrs. Maria Luisa Robles Ramos, chief paleontologist of Petroleos Mexicanos, Mexico City, are essentially *Globigerina ciperoensis ciperoensis, Globigerina ciperoensis angustiumbilicata*, and *Globigerina* cf. *trilocularis*. The absence of *Globigerina ampliapertura* and of *Globorotalia opima* suggests that this fauna falls in the younger part of the *Globigerina ciperoensis–Globorotalia opima* zone. This is only very slightly younger than the age of our *Lepidocyclina*-bearing samples from the Punta Brava quarry as described in the following and in the chapter on the Husillo formation. Although the *Lepidocyclina* beds are younger than the underlying Consuelo chalks, the age difference is not measurable in terms of planktonic Foraminifera, which in both horizons are diagnostic of the *Globigerina ciperoensis–Globorotalia opima* zone. In the type locality of the Consuelo formation, the youngest Consuelo beds extend into this zone. It is possible that the rich planktonic assemblages of the *Lepidocyclina* beds are, at least in part, re-deposited. The faunas, however, appear homogeneous and reworking cannot be detected.

BR station 379 (Consuelo formation)
Lithology: Chalk, powdery, with reworked asphalt fragments, whitish yellow to grayish orange.
Washed residue heterogeneous with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina euapertura JENKINS
Globigerina ciperoensis angulisuturalis BOLLI
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina ciperoensis ciperoensis BOLLI
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Globoquadrina venezuelana (HEDBERG) group
Globorotaloides suteri BOLLI
Globorotaloides cf. *suteri* BOLLI (as illustrated in LOEBLICH et al., 1958, pl. 27, figs. 14 a–c)

Globorotalia brodermanni CUSHMAN and BERMÚDEZ
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globorotalia opima opima BOLLI
Cassigerinella chipolensis (CUSHMAN and PONTON)
Reworked Punta Brava and older hantkeninas, globigerinas, and truncate keeled globorotalias as listed below
Hantkenina alabamensis CUSHMAN
Hantkenina suprasuturalis BRÖNNIMANN
Globorotalia aequa CUSHMAN and RENZ
Globorotalia bullbrooki BOLLI
Globorotalia cf. *formosa* BOLLI
Globigerapsis index (FINLAY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Pseudohastigerina micra (COLE).

BR station 378 (Consuelo formation)
Lithology: Chalk, powdery, white (coccolithite).
Texture: Microcrystalline to cryptocrystalline with abundant planktonic microfossils.

Assemblage:
Chiloguembelina cubensis (D. K. PALMER)
Globigerina spp.
Discoaster deflandrei BRAMLETTE and RIEDEL (common)
Typical specimens as illustrated by BRAMLETTE and RIEDEL (1954, p. 399, figs. 1 a–c). Maximum diameter 10 to 12 μ.
Coccoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)
Thoracosphaera spp.

Washed residue with
Globigerina euapertura JENKINS
Globigerina ciperoensis angustiumbilicata BOLLI
Globigerina rohri BOLLI group
Globorotalia opima BOLLI group
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Pseudohastigerina micra (COLE).

BR station 383 (Husillo formation)
Lithology: Chalk, powdery, yellowish to pale yellowish orange, with lepidocyclinas (smaller specimens than in station 376) and *Operculinoides*.

Washed residue with
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globorotalia opima nana BOLLI (common)
Globorotalia opima opima BOLLI (common)
Globigerina euapertura JENKINS (common)
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina cf. *trilocularis* D'ORBIGNY

Globoquadrina venezuelana (HEDBERG) group
Globorotaloides suteri BOLLI
Chiloguembelina cubensis (D. K. PALMER)
W. STORRS COLE (letter, March 3, 1959) identified from this station
Lepidocyclina gigas CUSHMAN
Lepidocyclina (Lepidocyclina) giraudi R. DOUVILLÉ
Lepidocyclina (Eulepidina) undosa CUSHMAN
W. A. VAN DEN BOLD (letter March 26, 1963) listed the following ostracodes
Aurila deformis (REUSS) ?
Bairdia sp.
Cytherella sp.

BR station 376 (Husillo formation)
Lithology: Chalk, rather hard, whitish to grayish yellow, with large and sellate lepidocyclinas up to 4 cm diameter.
Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globorotalia opima nana BOLLI (abundant)
Globorotalia opima opima BOLLI (abundant)
Globorotaloides suteri BOLLI
Globigerina euapertura JENKINS (common)
Globigerina ciperoensis angulisuturalis BOLLI (common)
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina ciperoensis ciperoensis BOLLI (abundant)
Globigerina parva BOLLI
Globigerina rohri BOLLI group
Globigerina cf. *trilocularis* D'ORBIGNY
Globoquadrina venezuelana (HEDBERG) group
Chiloguembelina cubensis (D. K. PALMER)
Cassigerinella chipolensis (CUSHMAN and PONTON)
Porticulasphaera mexicana (CUSHMAN) (reworked)
W. STORRS COLE (letter March 3, 1959) identified from this station
Lepidocyclina gigas CUSHMAN
Lepidocyclina (Eulepidina) undosa CUSHMAN, and W. A. VAN DEN BOLD (letter March 21, 1963)
Aurila deformis (REUSS)
Jugosocythereis vicksburgensis (HOWE)
Krithe sp.
Bairdia sp.

BR station 377

Described below are thin sections (1–14) from pebbles of sedimentary origin collected in a heterogeneous basal conglomerate tentatively assigned to the Husillo formation overlying the Consuelo beds in the quarry east of Punta Brava. As

shown in the columnar section, fig. 65, BR station 383 is situated at the base of the interval from which the pebbles have been collected. Apart from sedimentary pebbles occur also usually well-rounded gabbro, basalt, serpentinite and granodiorite components (personal communication, J. P. BAUGHMAN). North and west of Guanajay this conglomerate can be found on serpentine and on Upper Cretaceous to Upper Eocene formations. The well-roundedness of the igneous elements may be suggestive of derivation from older Cretaceous igneous conglomerates. The here listed sedimentary pebbles are from the late Dogger and older Cayetano (?) formation, from Neocomian *Nannoconus* limestones and from Tertiary limestones.

Thin section 1 (Universidad formation)
Lithology: Limestone, hard, somewhat siliceous.
Texture: Cryptocrystalline groundmass with planktonic microfossils, whitish to grayish yellow.
Assemblage: *Globorotalia centralis* CUSHMAN and BERMÚDEZ
Globigerina senni (BECKMANN)
Truncorotaloides cf. *topilensis* (CUSHMAN)
Braarudosphaera bigelowi (GRAN and BRAARUD)
Thoracosphaera sp.
Radiolaria (common).

Thin section 2
Lithology: Limestone, grayish orange.
Texture: Mainly fragments of algae, echinoderms and mollusks embedded in clear calcite groundmass. Also benthonic Foraminifera.
Assemblage: *Amphistegina* sp.
Cibicides sp.
?*Eofabiania cushmani* (COLE and BERMÚDEZ)
Lithoporella melobesioides FOSLIE.

Thin section 3
Lithology: Limestone, grayish orange.
Texture: Fragmental. Components mainly fragments of coralline algae, echinoderms and mollusks. Also many benthonic Foraminifera. Groundmass calcite.
Assemblage: *Pararotalia mexicana mecatepecensis* (NUTTALL)
Amphistegina sp.
Lepidocyclina sp. (fragments)
Lithoporella melobesioides FOSLIE.

Thin section 4 (Cayetano formation)
Lithology: Quartz sandstone, fine-grained, yellowish gray. Barren.

Thin sections 5, 9, 11 (*Nannoconus* limestones)
Lithology: Limestone, pale yellowish brown (5), light gray (9), (11).
Texture: Cryptocrystalline to microcrystalline groundmass, pseudoölitic in places, with abundant Radiolaria. Incipient dolomitization.
Assemblage: Radiolaria
Nannoconus globulus BRÖNNIMANN
Nannoconus kamptneri BRÖNNIMANN.

Thin sections 6, 7, 8
Lithology: Limestone, light gray.
Texture: Microcrystalline. Barren.

Thin section 10
Lithology: Limestone, pale yellowish brown.
Texture: Cryptocrystalline groundmass with incipient dolomitization. Barren.

Thin section 12
Lithology: Chert, dark gray, slightly calcareous.
Texture: Silicified; originally probably pseudoölitic, dolomitic groundmass. Barren.

Thin section 13
Lithology: Chalk, whitish to grayish yellow.
Texture: Microcrystalline groundmass with planktonic microfossils.

Assemblage:
Globigerina spp. (abundant)
Discoaster cf. *aster* BRAMLETTE and RIEDEL (common)
Discoaster barbadiensis TAN
Braarudosphaera bigelowi (GRAN and BRAARUD)
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)
Thoracosphaera spp.

Thin section 14
Lithology: Chalk, whitish to grayish yellow.
Texture: Microcrystalline groundmass with planktonic microfossils (coccolithite).

Assemblage:
Globigerina spp.
Chiloguembelina cubensis (D. K. PALMER)
Discoaster barbadiensis TAN
Discoaster deflandrei BRAMLETTE and RIEDEL (common)
Coccoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)
Thoracosphaera spp.

Cantera Husillo

The location of the Husillo quarry will be explained under Husillo formation (index map, fig. 67). In the southern part of the quarry, the Consuelo beds rest on the Príncipe member of the Universidad formation. BR stations 845 and 846 are from the *Hantkenina dumblei–Globigerinatheka barri* zone of the late Middle Eocene Príncipe chalks outcropping in the southeastern part of the quarry. These chalks exhibit submarine slumping. In its northwestern part, where the type section of the Husillo formation is exposed, the Consuelo beds form the bottom part of the cliff as illustrated by the photograph, fig. 69. The unweathered Consuelo chalks are grayish, as at BR station 849, and the overlying weathered Consuelo beds are grayish yellow and partly affected by submarine slumping as at BR stations 850 and 851. Both PALMER (1945, p. 17) and BERMÚDEZ (1950, p. 264), observed that also the Tinguaro beds outcropping in the Colón anticline of Matanzas Province, probably identical with the Oligocene Consuelo formation, are bluish

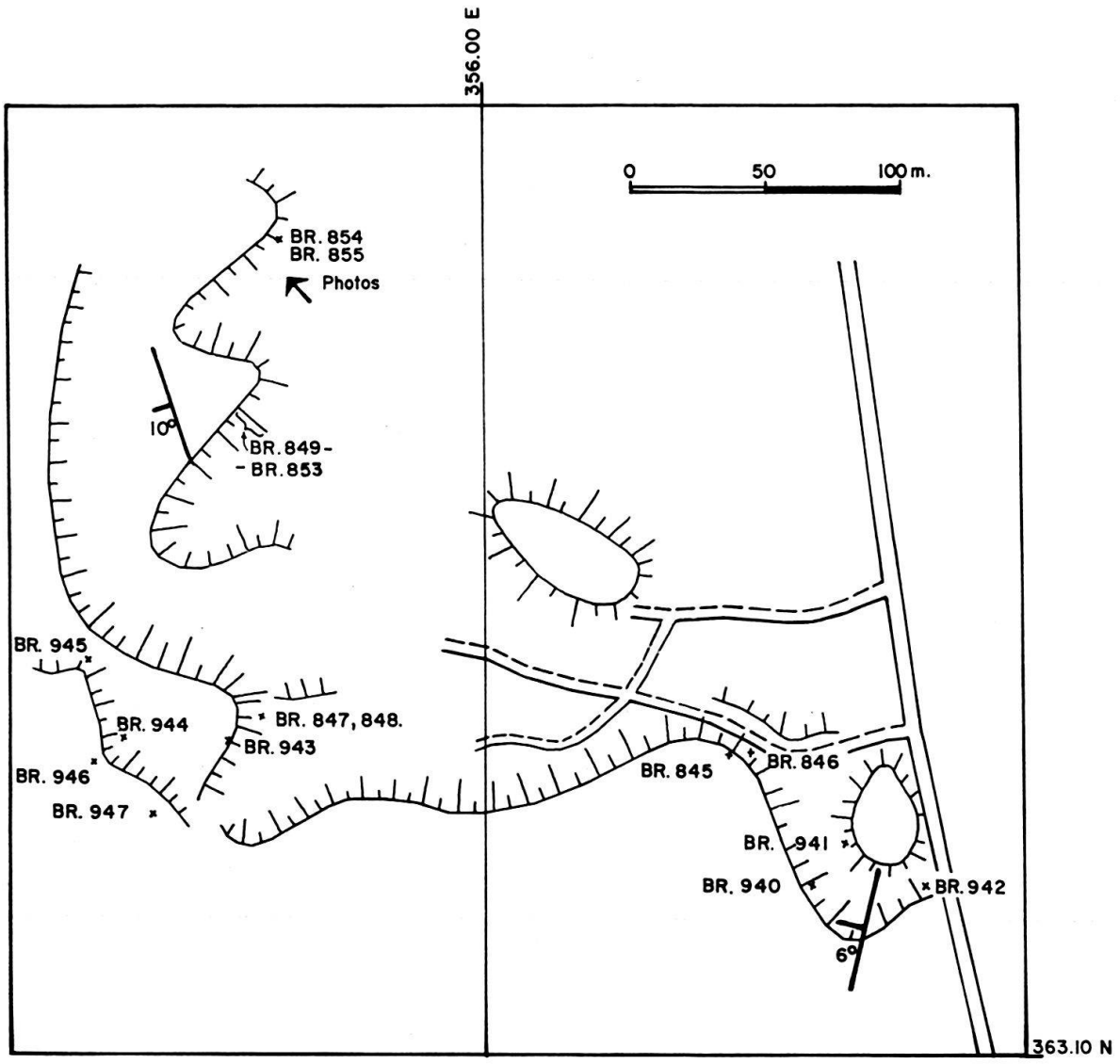

Fig. 67. Index map of Cantera Husillo.

gray unweathered and yellowish weathered. The stratigraphic positions of BR stations 849 to 851, listed below from bottom to top, are given in the columnar section, fig. 68:

BR stations 849 and 850 (Consuelo formation)

BR station 849 is from the unweathered Consuelo chalk immediately underlying the weathered grayish yellow Consuelo chalk of BR station 850. In order to avoid repetition the two samples are here reported together. They are both from the *Globigerina ampliapertura* zone.

Lithologies: Chalk, very light gray (849); chalk, powdery, grayish yellow, weathered (850).

Washed residues with

Globigerina ampliapertura Bolli
Globigerina parva Bolli (abundant)
Globigerina rohri Bolli group

Globorotalia opima nana BOLLI
Globorotaloides suteri BOLLI
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Chiloguembelina cubensis (D. K. PALMER).

BR station 851 (Consuelo formation)

This station is from a chalky bed exhibiting distinct intraformational slumping features. The planktonic microfauna is homogeneous and representative of the *Globigerina ampliapertura* zone.

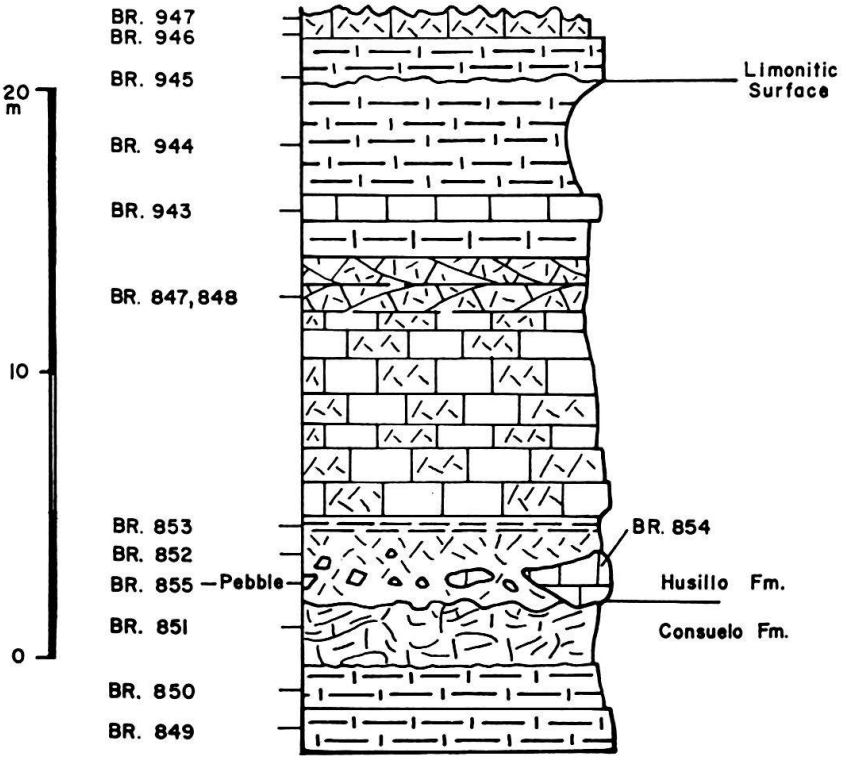

Fig. 68. Columnar section of the Husillo formation.

Lithology: Chalk, whitish to grayish yellow.
Texture: Cryptocrystalline to microcrystalline groundmass with abundant planktonic microfossils.

Assemblage:
Globigerina spp.
Chiloguembelina cubensis (PALMER)
Coccoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Discoaster woodringi BRAMLETTE and RIEDEL
Braarudosphaera bigelowi (GRAN and BRAARUD)
Thoracosphaera spp. (globular and ellipsoid bodies).

Washed residue with
Globigerina ampliapertura BOLLI (common)
Globigerina euapertura JENKINS

Globigerina parva BOLLI
Globigerina rohri BOLLI group
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globoquadrina venezuelana (HEDBERG) group
Chiloguembelina cubensis (D. K. PALMER).

Environment and age

The Consuelo formation is lithologically so close to the Príncipe member of the Universidad formation that in an isolated outcrop the two units can hardly be distinguished. Only the absence or scarcity of asphalt inclusions in the undisturbed Consuelo beds may aid to separate them from the Universidad chalks. Intraformational unconformities, disconformities and slumping suggesting unstable bottom conditions are features common to both the Consuelo and Universidad formations. The cryptocrystalline to microcrystalline textures as seen in thin sections and the abundance of planktonic microfossils of which the minute discoasterids and coccoliths may occur in rock-forming quantities, point toward a basinal environment of the Consuelo formation. Planktonic Foraminifera predominate, and although no counts were made, the estimated ratio between planktonic and benthonic species appears to be rather high, suggesting after GRIMSDALE and VAN MORKHOVEN (1955) a depth range of about 600 to 1200 m for the Consuelo sea. Detailed counts might narrow this depth interval down, but it is believed that the order of magnitude for the estimated depth range would remain unchanged. The depth range of the Consuelo sea is the same as that inferred for the ecologically related Universidad and Punta Brava seas of Cuba. The late Cojímar and the Husillo faunas, on the other hand, show a lower ratio between planktonic and benthonic species than the Consuelo faunas suggesting a sea considerably shallower than 600 m. D. K. PALMER and BERMÚDEZ (1936, pp. 223–239) arrived at a depth range of about 180 to 900 m for the foraminiferal fauna from the water well at Finca Adelina [=Tinguaro beds of R. H. PALMER] by comparing the depth distributions of the fossil species with those compiled by NORTON (1930) and by THORP (1931) for Recent species of the Caribbean area. The Finca Adelina fauna is dominated by abundant globigerinas. According to NORTON, in the Recent deposits of the Caribbean seas globigerinas are usually common to abundant below 900 m. The restrictive remark of PALMER and BERMÚDEZ (1936, p. 239) that probably the depth distribution of the Finca Adelina fauna tends toward the shallower limits of above range therefore does not seem to be justified. From the abundance of globigerinas it appears to be more probable that the actual depth range tends more toward 900 m than toward 180 m. This would essentially be in agreement with the depth estimate arrived at by us.

Megafossils and larger benthonic Foraminifera are not reported from the Consuelo chalks, although fragments of echinids were noticed in the outcrops of Avenida Antonio Soto, north of Tejar Consuelo. As mentioned earlier it may be possible that some or most of the echinids listed by SÁNCHEZ ROIG from the quarry at Tejar Consuelo originate from the Consuelo and not from the Universidad beds as stated by SÁNCHEZ ROIG (1949). The conglomeratic beds with the large discoid and sellate lepidocyclinas, interpreted by D. K. PALMER and also by

BERMÚDEZ as shallow-water equivalents of the Consuelo formation, are here regarded as a new lithologic unit tentatively assigned to the Husillo formation. Redeposited Lower to Upper Eocene planktonic Foraminifera are common in the slumped and disturbed basal Consuelo beds. Radiolaria appear to be absent.

The discoasterids and associated nannofossils of the type locality samples were not studied, but thin sections from the somewhat more indurated Consuelo chalks outcropping close to the type locality along Avenida Antonio Soto, about 300 m northwest of Tejar Consuelo, contain the following species:

Braarudosphaera bigelowi (GRAN and BRAARUD) (common)
Coccoliths (common), mainly placoliths, with large specimens of *Tremalithus eopelagicus* BRAMLETTE and RIEDEL
Discoaster aster BRAMLETTE and RIEDEL (rare to common)
Discoaster barbadiensis TAN (common)
Discoaster cf. *molengraaffi* TAN
Discoaster woodringi BRAMLETTE and RIEDEL (common)
Discoaster cf. *woodringi* BRAMLETTE and RIEDEL (common)
Discoaster sp. indet.
Marthasterites sp.
Micrantholithus flos DEFLANDRE
Thoracosphaera spp. (globular and ellipsoid bodies).

This assemblage is closely related with that of the Upper Eocene Punta Brava formation. *Discoaster woodringi* BRAMLETTE and RIEDEL, only rarely or doubtfully encountered in the Universidad and Punta Brava samples is one of the dominant discoasters of the Consuelo formation which is here assigned to the *Discoaster woodringi* zone of Oligocene age. Thoracosphaeras and coccoliths continue seemingly unchanged from the Eocene beds.

In terms of planktonic Foraminifera, the Consuelo formation extends from the *Globigerina ampliapertura* zone into the overlying *Globigerina ciperoensis–Globorotalia opima* zone.

Husillo formation

For rocks between the Lower Oligocene Tinguaro formation [=Consuelo formation] and the Upper Oligocene Cojímar formation, BERMÚDEZ (1950, p. 270) proposed the Jaruco formation. This Middle Oligocene formation was described to contain either abundant lepidocyclinas and miogypsinas or rich *Globigerina* faunas. In both ecologic types reportedly occurs as diagnostic species the compressed rotaliid *Kelyphistoma* [=*Almaena*] *alavensis* (D. K. PALMER). Mrs. PALMER ascribed in her manuscripts to the Jaruco formation a local stage sense, that is the Cuban Middle Oligocene (vide BERMÚDEZ). BRODERMANN's (1943, pp. 128 and 145) lithologic units Colon, or *Heterostegina* zone, Middle Oligocene, Jaruco and Tarará, both Upper Oligocene, were put by BERMÚDEZ (1950, p. 272) into synonymy with his Middle Oligocene Jaruco formation. BERMÚDEZ' Middle Oligocene Jaruco formation thus differs from the Jaruco formation of BRODERMANN, who already in 1943 (pp. 129, 130 and 145) introduced this name for an Upper Oligocene unit