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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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Eofabiania cushmani (COLE and BERMÚDEZ)
Eoconuloides wellsi COLE and BERMÚDEZ
Proporocyclina sp. or *Pseudophragmina* sp.
Pseudophragmina sp.
Rotalia capdevilensis CUSHMAN and BERMÚDEZ.

The Capdevila assemblage of larger benthonic Foraminifera differs from that of the underlying Alkázar formation by the advent of *Eoconuloides wellsi* COLE and BERMÚDEZ, *Eofabiania cushmani* (COLE and BERMÚDEZ). *Dictyoconus cookei* MOBERG is represented by a single doubtful specimen. Also *Asterocyclina* seems to occur for the first time in the Capdevila beds. *Rotalia capdevilensis* CUSHMAN and BERMÚDEZ, a diagnostic form of lithologic Unit I, is here mentioned because of its similarity with *Globorotalia palmerae* CUSHMAN and BERMÚDEZ of lithologic Unit IV, with which it might be confounded. With the exception of a heterogeneous sample from the finca "La Coronela" at the highway to Rancho Boyeros (BERMÚDEZ station 1266), we were unable to find in our material *Boreloides cubensis* COLE and BERMÚDEZ and *Helicostegina gyralis* BARKER and GRIMSDALE, which both were mentioned by BERMÚDEZ (1952, p. 230) from his "Lucero member" of the Capdevila formation. These two interesting species, however, are quite common in Lower Eocene fore-reefal deposits of Oriente Province. According to our observations, "*Operculina*" *catenula* CUSHMAN and JARVIS, one of the most characteristic larger benthonic species of the Apolo and Alkázar formations, apparently does not extend into the Capdevila beds. This is in contrast with the findings of BECKMANN (1959, p. 417, fig. 2) who recorded "*Operculina*" *bermudezi* (="*Operculina*" *catenula*) throughout our Capdevila zones excepting the *Globorotalia palmerae* zone of Unit IV.

The sequence of planktonic Foraminifera recorded in the four lithologic units of the Capdevila formation shows the following Lower Eocene biostratigraphic zones from bottom to top:

a) *Globorotalia rex–Globorotalia formosa* zone
b) *Globorotalia broedermanni–Globorotalia pseudoscitula* zone
c) *Globorotalia palmerae* zone.

In terms of the discoasterid zonation, the Capdevila formation is part of the *Marthasterites tribrachiatus–Discoaster lodoensis* zone.

Universidad Formation

The Universidad formation was introduced by BERMÚDEZ (1937, p. 163) for massive beds of white to yellowish fine-grained, chalky limestones outcropping in the area from the Castillo del Príncipe to the campus of the University of Habana. As type locality he designated the outcrop in the northeastern corner of "Jardín de los Laureles" beneath the old library building of the University of Habana. This locality is represented by BERMÚDEZ station 257, today covered by University buildings and no longer accessible. Other typical outcrops of the Universidad formation listed by BERMÚDEZ (1950, p. 235) are the road cuts of the Avenida de los Presidentes, the Avenida de la Universidad and the Calle Zapata, all at Loma del Príncipe. The best exposures are the cuts on both sides of the Avenida de los Presidentes between the monument of J. M. Gómez and its intersection with the

Avenida de la Universidad. The cut on the western side of Avenida de los Presidentes is illustrated by the photograph, fig. 50. Foraminifera from various localities of the Universidad formation were compiled by BERMÚDEZ (1950, pp. 231–233), who mentioned the following planktonic species: *Globorotalia aragonensis* NUTTALL, *Globorotalia crassata* CUSHMAN, *Globorotalia spinulosa* CUSHMAN, *Globigerina topilensis* CUSHMAN, *Globigerina orbiformis* COLE, *Globigerina* cf. *apertura* CUSHMAN, *Globigerina* cf. *cretacea* D'ORBIGNY and *Nonion micrus* COLE. The road cut at Avenida de los Presidentes was previously described by R. H. PALMER (1934, pp. 132, 133, and fig. 2 on p. 133) as a characteristic locality of his Príncipe formation which at first was believed to be Upper Eocene. Subsequent faunal analysis by BERMÚDEZ, GRIMSDALE, KEIJZER, and Mrs. PALMER (BERMÚDEZ 1950, p. 233), however, established a late Lower Eocene age for this lithologic unit and demonstrated affinities with the foraminiferal faunas of the underlying Capdevila formation. BERMÚDEZ also substituted the name Príncipe formation by Universidad formation. The name Príncipe formation, on the other hand, was used by BERMÚDEZ (1937, p. 163) for Upper Eocene beds which were supposed to be overlying the Lower Eocene Universidad formation at Loma del Príncipe. In the stratigraphic chart of February 24, 1948 (BERMÚDEZ, 1950), the Príncipe formation is no longer listed and superseded by the Consuelo formation.

Príncipe formation is a better name than Universidad formation and although PALMER omitted to formally designate a type locality, the formation was unambiguously defined by his reference to the road cut at Loma del Príncipe. In our opinion, the name Príncipe formation was well chosen by PALMER and it would have been given preference over Universidad formation if it would have been retained by BERMÚDEZ in its original meaning (1950, p. 234). However, as in the case of the Capdevila formation, we will continue to use Universidad formation as a stratigraphic nomen conservandum. For the chalky upper member of the Universidad formation, the name Príncipe will be retained, because these beds are typically exposed at Loma del Príncipe. The here proposed nomenclatorial procedure seems to agree best with PALMER's original intention and description of his Príncipe formation in which the silicified lower beds of the Universidad formation are not included.

The silicified lower member of the Universidad formation is here named Toledo member. It was interpreted by BERMÚDEZ (1950, p. 236) as a silicified time equivalent of the Universidad formation. We have discussed a similar incorrect application of the term member in the chapter on the Capdevila formation. The Zapata formation or Toledo formation of BRODERMANN (1940, p. 8) is synonymous with the Toledo member as defined in this paper.

The Universidad formation is well developed along the northern rim-rock. As witnessed by many outcrops in Pinar del Río, Matanzas, Las Villas, Camagüey and Oriente provinces, the Universidad formation was laid down apparently uniformly over most of Cuba. We did not find any Universidad beds along the southern rim-rock of the area investigated except in a large quarry about 1.5 km west-southwest of Santa María del Rosario, coordinates 359.00 N and 369.80 E. The important outcrops of Toledo beds at the west entrance to Jaruco, about 45 km east-southeast of the Bahía de la Habana, and Toledo and Alkázar pebbles in

conglomeratic Rosario marls of post-Cojímar age outcropping southeast of San Francisco de Paula, coordinates 359.04 N and 368.06 E, demonstrate that at least Toledo beds existed also in this area and that they were partially removed in pre-Rosario time.

Toledo member

The Toledo member is a siliceous facies of the lower Universidad formation. The silicification varies locally, and it can affect a more or less thick portion of the lower Universidad formation. At Avenida de los Presidentes, where the member is transgressive on Capdevila clastics, the Toledo beds are poorly silicified and only about 4 m thick. At the corner of Calle Zapata and Calle C, Vedado, a few meters of typical, siliceous Toledo beds have been observed. In the quarry east of Río Almendares, Nuevo Vedado, where the bottom of the member is not exposed, we measured about 21 m of Toledo member. The average thickness of the Toledo member appears to be 10 to 12 m as on the east side of the road cut at Autopista del Mediodía, where the contacts with both the underlying Capdevila formation and the overlying Príncipe member are transitional.

The base of the Toledo beds is arbitrarily defined at the top of the highest clastic bed of Capdevila lithology. The character of the contact of the Universidad formation with the Capdevila formation changes locally. As mentioned above, it is transitional at the Autopista del Mediodía, disconformable or unconformable at Tejar Consuelo, and distinctly unconformable at Avenida de los Presidentes. The contact between Toledo and Príncipe members is throughout the area transitional, the top of the Toledo member being chosen arbitrarily where the highest silicified bed occurs.

Description of the type locality of the Toledo member

The type locality of the Toledo member is in the quarry of Tejar Toledo, west of the road from Marianao to Central Toledo, about 1.3 km south of the Carretera Central, coordinates 354.00 E and 360.00 N (index map, fig. 43). In this quarry crop out 10 to 15 m of whitish to slightly grayish or greenish more or less shaley and powdery limestone or chalk interbedded with flint nodule-bearing beds and silicified white to yellowish limestones, which are occasionally completely silicified into amber chert. Most of the joints are black due to accumulation of manganese oxide. The average thickness of the individual silicified bed is about 20 to 40 cm. Small asphalt pebbles have been found irregularly dispersed in the chalky limestones above BR station 368 and below BR station 370. At the type locality, top and bottom of the Toledo member are not exposed.

The relative stratigraphic position of the Toledo type samples is indicated in the columnar section, fig. 44. They are listed here from bottom to top:

BR station 369
Lithology: Chalk, soft, powdery, white, with asphalt pebbles.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI

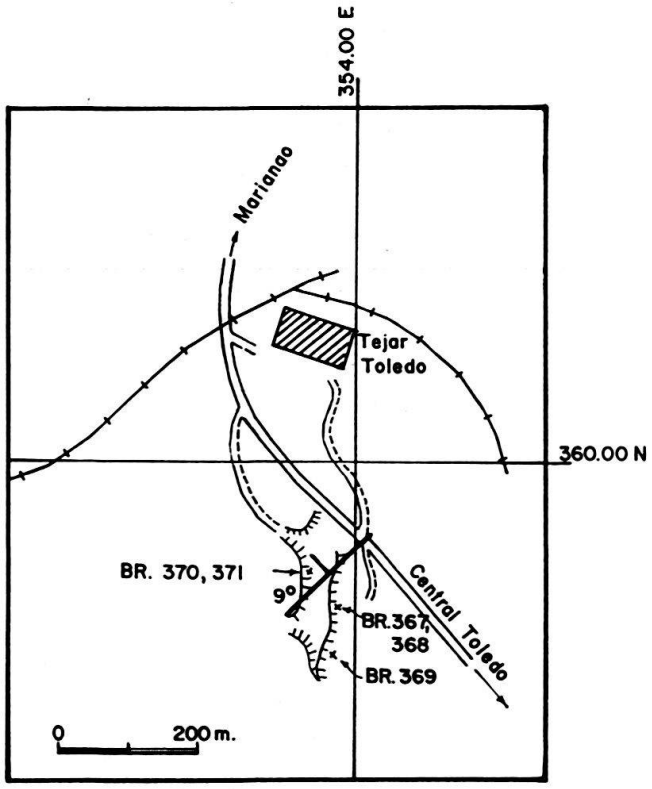


Fig. 43. Index map of Tejar Toledo.

Globigerina bolivariana PETTERS
Globigerina boweri BOLLI
Globigerina prolata BOLLI
Globigerina soldadoensis BRÖNNIMANN group
Globigerina aff. *turgida* FINLAY
Globorotalia convexa SUBBOTINA group
Globorotalia aff. *planoconica* SUBBOTINA
Globorotalia aff. *pseudoscitula* GLAESSNER
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Eocene spumellarias and nassellarias.

BR station 367
Lithology: Chalk, soft, powdery, white, with asphalt pebbles.

Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA group
Globorotalia aff. *planoconica* SUBBOTINA
Globigerina boweri BOLLI
Globigerina soldadoensis BRÖNNIMANN
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Eocene nassellarias and spumellarias.

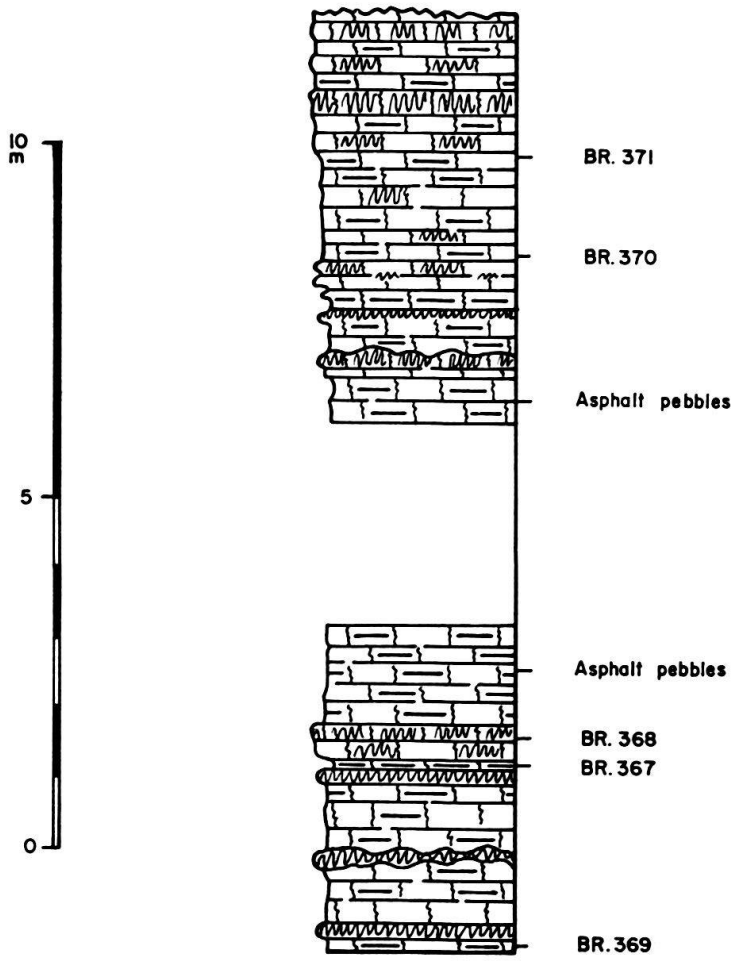


Fig. 44. Columnar section of the Toledo member of the Universidad formation, Tejar Toledo.

BR station 368

Lithology: Limestone, silicified, slightly calcareous, with asphalt pebbles, white to pale greenish yellow (coccolithite-radiolarite).

Texture: Silicified cryptocrystalline groundmass with abundant planktonic microfossils.

Assemblage:

Globorotalia bullbrooki BOLLI group
Globigerina spp.
Radiolaria (abundant)
Coccoliths, mainly placoliths (abundant)
Thoracosphaera sp.
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL)
Marthasterites sp.
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster barbadiensis TAN
a) Typical forms
b) Small forms of 8 to 9 μ diameter with 6 to 7 diamond-shaped and pointed arms
Discoaster geometricus BRÖNNIMANN and STRADNER

Discoaster cf. *woodringi* BRAMLETTE and RIEDEL, small form with 6 blunt arms of 7 μ diameter
Braarudosphaera bigelowi (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL.

BR station 370
Lithology: Chalk, soft powdery, white to yellowish white, with asphalt pebbles.
Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA group
Globorotalia aff. *planoconica* SUBBOTINA
Globigerina soldadoensis BRÖNNIMANN group
Globigerina bowerí BOLLI
Globigerina senni (BECKMANN)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Eocene nassellarias and spumellarias.

BR station 371
Lithology: Chalk, powdery, white to very pale yellow.
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils.
Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp.
Coccoliths, mainly placoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Thoracosphaera spp. (globular to ellipsoid bodies)
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster cf. *aster* BRAMLETTE and RIEDEL, small forms of about 12 μ diameter with 6 short rays with blunt to slightly pointed tips, intermediate between *D. aster* and *D. woodringi*.
Discoaster barbadiensis TAN (common)
Discoaster cf. *molengraaffi* TAN
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL)
Braarudosphaera bigelowi (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL (abundant) Diameter from about 5 to 15 μ
Nannotetraster swasticoides (MARTINI)

Other outcrops of the Toledo member

The silicified beds of the Toledo member are known from numerous good outcrops in the Habana area. The most important ones are described below.

Autopista del Mediodía

The Toledo member is well exposed along a road cut at the Autopista del Mediodía just north of its intersection with the secondary road to Arroyo Arenas, coordinates 357.90 N and 348.48 E (index map, fig. 45). It forms a prominent scarp at the base of which the mentioned secondary road leads from the Autopista

del Mediodía to Arroyo Arenas. The church of Arroyo Arenas is located on this scarp cut there by the Carretera Central. The excellent exposure at the church was recently covered with a coat of concrete. At the road cut at the Autopista del Mediodía, the Toledo member is in transitional contact with the underlying

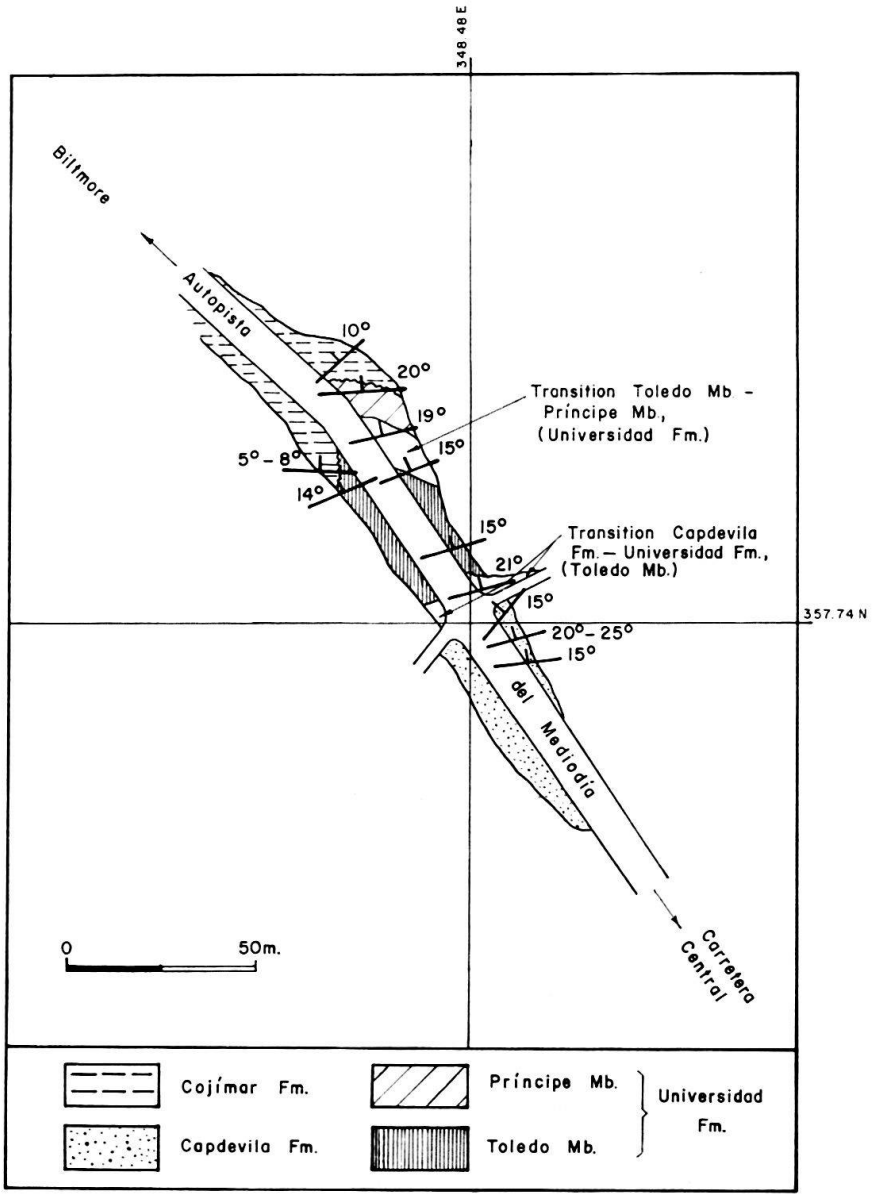


Fig. 45. Index map of the road cut at Autopista del Mediodía.

Globorotalia palmerae-bearing beds of the Capdevila formation (columnar section, fig. 46). The lower boundary of the Toledo beds is arbitrarily determined by the highest graywacke sands and silts of the Capdevila formation. BR station 415, on the western side of the road cut, is from the about 4 m thick transitional zone between the Toledo and the Capdevila beds as illustrated by the cross section, fig. 48. BR stations 416 to 418 are from the siliceous shales and chalks and interbedded siliceous limestones of the Toledo member proper. The samples are described below in stratigraphic order from bottom to top:

BR station 415
Lithology: Chalk, soft, white to grayish yellow.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia cf. *aspensis* (COLOM)
Globorotalia palmerae CUSHMAN and BERMÚDEZ
Globorotalia convexa SUBBOTINA group
Globorotalia broedermanni CUSHMAN and BERMÚDEZ
Globorotalia planoconica SUBBOTINA
Globorotalia imitata SUBBOTINA
Globorotalia pseudoscitula GLAESSNER
Globorotalia cf. *pseudomayeri* BOLLI
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN
Globigerina bolivariana PETTERS
Globigerina soldadoensis BRÖNNIMANN group
Pseudohastigerina micra (COLE)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Catapsydrax echinatus BOLLI
Eocene spumellarias and nassellarias.

BR station 416
Lithology: Chalk, soft, white to grayish yellow, and limestone, silicified, hard, conchoidal fracturing, white to grayish yellow.
Texture: Cryptocrystalline, silicified groundmass with abundant Radiolaria.
Assemblage: Radiolaria
Coccoliths, mainly placoliths
Discoaster lodoensis BRAMLETTE and RIEDEL (common)
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster geometricus BRÖNNIMANN and STRADNER
Discoaster sp., close to *D. barbadiensis* TAN, but without central knob
Discoaster barbadiensis TAN
Braarudosphaera discula BRAMLETTE and RIEDEL
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) (rare)
Thoracosphaera sp.
Globigerina spp. (minute forms)
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia imitata SUBBOTINA
Globorotalia palmerae CUSHMAN and BERMÚDEZ
Globorotalia pseudoscitula GLAESSNER
Globorotalia broedermanni CUSHMAN and BERMÚDEZ
Globorotalia convexa SUBBOTINA
Globigerina soldadoensis BRÖNNIMANN group

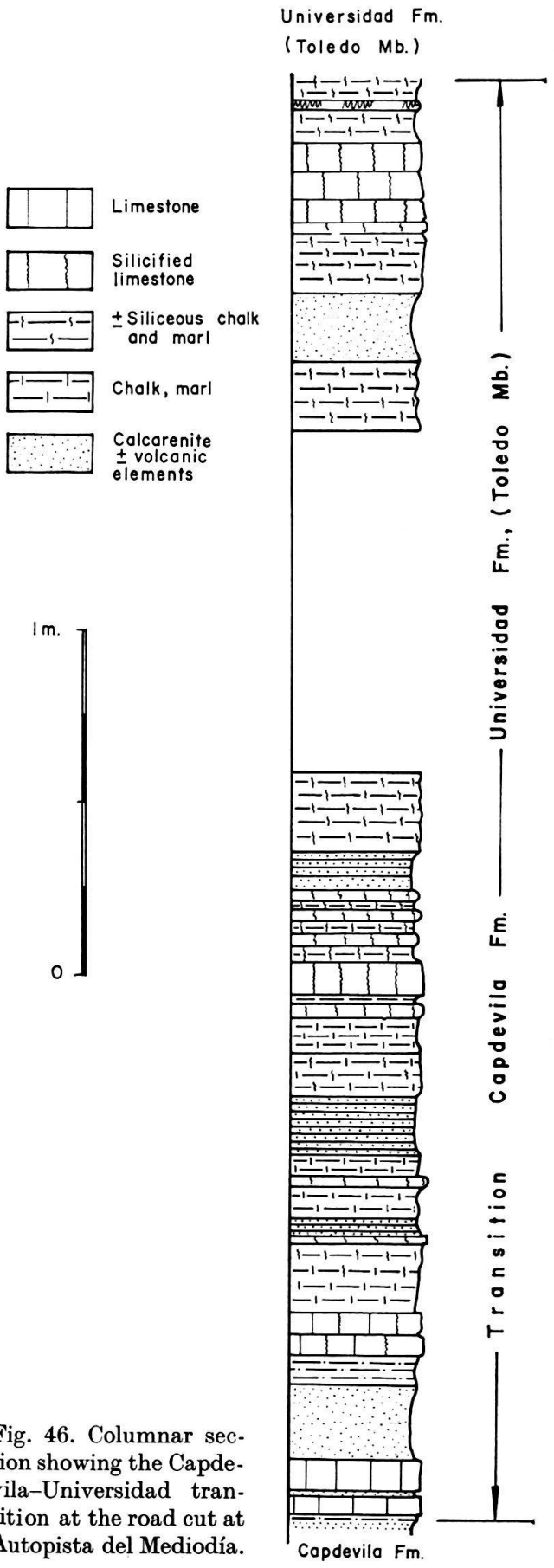


Fig. 46. Columnar section showing the Capdevila–Universidad transition at the road cut at Autopista del Mediodía.

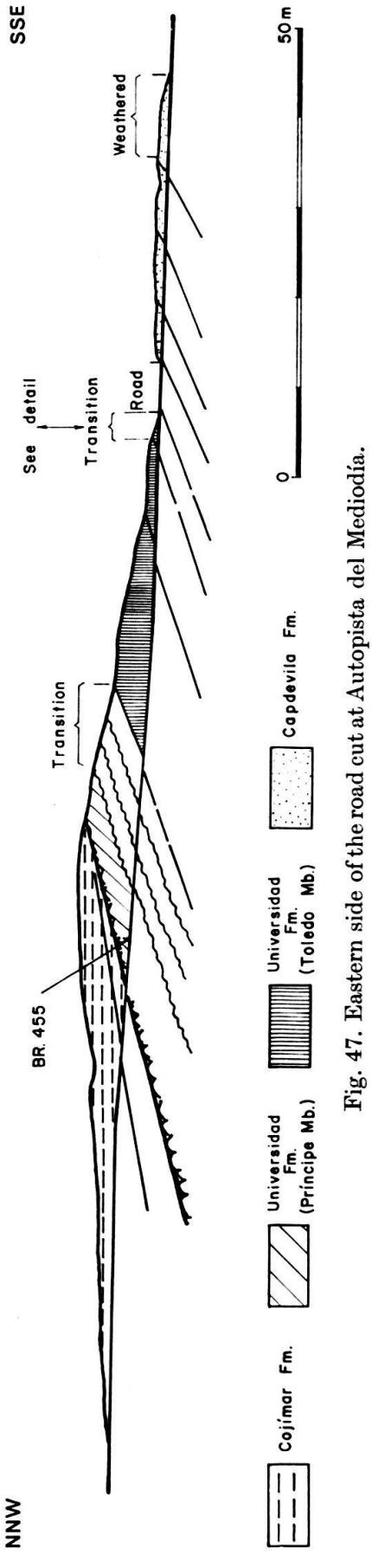
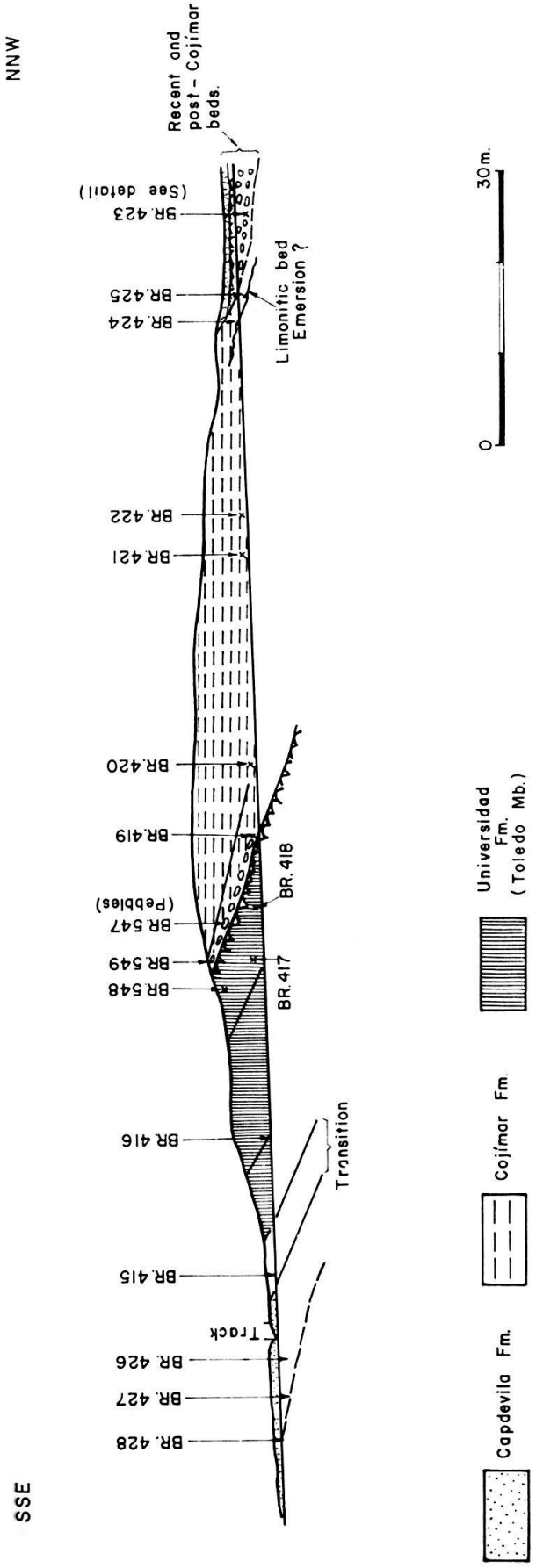


Fig. 47. Eastern side of the road cut at Autopista del Mediodía.

Globigerina bolivariana PETTERS
Globigerina cf. *boweri* BOLLI
Globigerina collactea (FINLAY)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina micra (COLE).

BR station 417
Lithology: Chalk, soft, white, and limestone, silicified white to yellowish.
Texture: As BR station 416.
Assemblage: Radiolaria
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Discoaster lodoensis BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Discoaster sp. close to *D. barbadiensis* but without central knob
Thoracosphaera sp.
Globigerinas with coarsely perforate thick walls.
Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia palmerae CUSHMAN and BERMÚDEZ
Globorotalia pseudoscitula GLAESSNER
Globorotalia convexa SUBBOTINA
Globorotalia imitata SUBBOTINA
Globigerina soldadoensis BRÖNNIMANN group
Globigerina collactea (FINLAY)
Globigerina yeguaensis WEINZIERL and APPLIN
Pseudohastigerina micra (COLE)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Eocene spumellarias and nassellarias.

BR station 418
Lithology: Shale, silicified, irregularly laminated, grayish yellow to moderate yellow with asphalt pebbles (coccolithite-radiolarite).
Texture: As BR stations 416 and 417.
Assemblage: Radiolaria (abundant)
Coccoliths (abundant), mainly placoliths
Discoaster lodoensis BRAMLETTE and RIEDEL (abundant)
a) typical forms
b) forms with stellate central knob
Discoaster barbadiensis TAN
Discoaster cf. *aster* BRAMLETTE and RIEDEL
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster geometricus BRÖNNIMANN and STRADNER
Discoaster currens STRADNER
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) (rare)
Thoracosphaera sp.
Globigerinas with thick and coarsely perforate walls.



About 20 m of Universidad formation are exposed on the east side of the road cut at the Autopista del Mediodía (cross section, fig. 47). The lower 12 m, approximately, are Toledo member and the upper 8 m are the lower part of the transitionally overlying Príncipe member. The Príncipe member is here overlain by transgressive and slightly unconformable Cojímar formation of *Globorotalia fohsi* age. The details of this contact will be described later under Príncipe member. On the west side of the road cut, the transgressive Cojímar formation cuts deeper and overlies the Toledo member as shown in the cross section of the road cut, fig. 48. The unconformity is characterized by bore holes in Toledo limestones filled with Cojímar material and by the occurrence of siliceous pebbles of the Toledo member at the base of the Cojímar formation. BR station 549 is from the bed with bore holes, and BR station 547 from the base of the Cojímar formation. On the eastern side, the about 5 m thick transitional zone between the Toledo and Príncipe members shows the progressive disappearance of the siliceous limestones. There, the Toledo member is composed of thin beds of cream to tan and grayish silicified limestones, marls, chalky limestones and more or less silicified chalky limestones. Small, irregularly distributed asphalt pebbles have been encountered throughout

Fig. 48. Western side of the road cut at Autopista del Mediodía.

the Universidad formation and in the basal beds of the Cojímar formation where they are probably reworked from the Universidad formation. The stratigraphic positions of the samples from the Toledo–Cojímar contact on the western side of this road cut are indicated in the cross section, fig. 48. They are listed from bottom to top.

BR station 548 (Universidad formation, Toledo member)
Lithology: Chalk, soft, powdery, whitish to very pale orange.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globigerina soldadoensis BRÖNNIMANN group
Globigerina senni (BECKMANN)
Globigerina aff. *prolata* BOLLI.

BR station 549

This sample is from the zone with bore holes below the unconformity surface. Material from bore hole fillings has been washed (a) and hard limestone from the Toledo beds in which the bore holes are sunk has been sectioned (b).

(a) Washed residue of very pale orange to grayish orange Cojímar chalk from bore hole fillings with

Globorotalia fohsi fohsi CUSHMAN and ELLISOR
Globorotalia fohsi lobata BERMÚDEZ
Globorotalia mayeri CUSHMAN and ELLISOR
Sphaeroidinella grimsdalei (KEIJZER)
Globoquadrina dehiscens (CHAPMAN, PARR, and COLLINS)
Globorotalia bullbrooki BOLLI (reworked from Toledo member)

(b) Thin section from very pale orange to grayish orange Toledo limestone (coccolithite-radiolarite).

Assemblage:
Globorotalia bullbrooki BOLLI
Globigerina spp.
Pseudohastigerina micra (COLE)
Radiolaria
Coccoliths (rock-forming)
Discoaster barbadiensis TAN (typical and minute forms)
Discoaster aster BRAMLETTE and RIEDEL
Discoaster lodoensis BRAMLETTE and RIEDEL.

BR station 547

This is a siliceous pebble from the conglomerate at the base of the Cojímar chalks which yields mixed Toledo and Cojímar faunas.
Lithology: Cryptocrystalline groundmass with planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp. with thick and coarsely perforate walls
Coccoliths (rock-forming), mainly placoliths
Discoaster aster BRAMLETTE and RIEDEL

Discoaster sp. close to *D. barbadiensis* TAN, but without central knob
Discoaster barbadiensis
Discoaster cf. *molengraaffi* TAN
Braarudosphaera discula BRAMLETTE and RIEDEL (abundant)
Micrantholithus sp. (not as strongly incised as *M.* cf. *vesper* DEFLANDRE illustrated by BRAMLETTE and RIEDEL, 1958, pl. 38, fig. 8)
Nannotetraster swasticoides (MARTINI)
Thoracosphaera sp.

BR station 546 (Cojímar)
Lithology: Chalk, soft, very pale yellowish orange.
Assemblage: *Globorotalia fohsi fohsi* CUSHMAN and ELLISOR
Globorotalia mayeri CUSHMAN and ELLISOR
Orbulina suturalis BRÖNNIMANN
Sphaeroidinella grimsdalei (KEIJZER).

Tejar Consuelo

Tejar Consuelo is located about 400 m southwest of the intersection of Avenida 26 and Calzada de Puentes Grandes, Cerro. The coordinates of the southern building of the brick factory are 364.50 N and 356.58 E (location map, fig. 59). For details on the geology of the quarry at Tejar Consuelo see the description under Consuelo formation. The Toledo member forms the lower portion of the southwestern cliff of the quarry, where it is overlain transitionally by the Príncipe member of the Universidad formation. Toledo beds are not exposed at the northeastern cliff of the quarry, but they occur either disconformably or slightly unconformably on the Capdevila beds in the eastern part of the quarry where Calle Santa María reaches the quarry area. The individual Toledo beds are here much thicker than in the quarry at Tejar Toledo. They consist of about 7 to 8 m of whitish to grayish greenish chalky and marly limestones with thin interbeds of silicified limestone and of siliceous nodules. Asphalt pebbles occur throughout the Universidad formation but mainly in the Príncipe beds. The Oligocene Consuelo formation overlies at Tejar Consuelo the Príncipe member with a slight but distinct angular unconformity (photographs, figs. 56, 57 and columnar sections, fig. 60). The Toledo member is here less silicified than at the type locality at Tejar Toledo.

The relative stratigraphic position of the Toledo samples is indicated in the columnar section, fig. 60. They are listed from bottom to top:

BR station 359
Lithology: Chalk, soft, powdery, pale to dark yellowish orange, with asphalt pebbles.

Washed residue with
Globorotalia spinuloinflata (BANDY)
Globigerina senni (BECKMANN).

BR station 358
Lithology: Chalk, hard, powdery, pale yellowish orange with asphalt pebbles.
Washed residue with

Globorotalia bullbrooki BOLLI
Globorotalia aff. *planoconica* SUBBOTINA
Globorotalia convexa SUBBOTINA
Globigerina soldadoensis BRÖNNIMANN group
Globigerina cf. *turgida* FINLAY
Globigerina cf. *senni* (BECKMANN)
Pseudohastigerina micra (COLE)
Eocene spumellarias and nassellarias.

BR station 357
Lithology: Limestone, silicified, hard, slightly calcareous, finely laminated, with minute asphalt pebbles, very pale orange to grayish orange (coccolithite-radiolarite).
Texture: Silicified cryptocrystalline groundmass with abundant planktonic microfossils, in particular well-preserved coccoliths and discoasterids.
Assemblage:

Globorotalia bullbrooki BOLLI group
Globigerina spp. with thick and coarsely perforate walls
Chiloguembelina sp.
Pseudohastigerina micra (COLE)
Coccoliths, mainly placoliths (rock-forming)
Discoaster lodoensis BRAMLETTE and RIEDEL up to 35 μ maximum diameter (abundant)
Discoaster woodringi BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN (common)
Discoaster aster BRAMLETTE and RIEDEL (common)
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster binodosus MARTINI
Zygolithus dubius DEFLANDRE
Heliorthus fallax BRÖNNIMANN and STRADNER
Braarudosphaera discula BRAMLETTE and RIEDEL
Thoracosphaera spp.
Radiolaria (abundant).

Quarry east of Río Almendares, Nuevo Vedado

The entrance to this quarry is at the intersection of Avenida Antonio Soto with Calle 38 of Reparto Nuevo Vedado, coordinates 365.22 N and 356.08 E. About 29 m of Universidad formation are outcropping below the Vedado (?) formation, which is deposited on a very irregular channeled unconformity surface. Possibly there is Urría formation between the Vedado (?) formation and the Toledo member of the Universidad formation represented by 21 m of whitish to greenish gray, more or less shaley and chalky limestone with thin layers and nodules of silicified limestone. Asphalt pebbles are very conspicuous. The silicified beds are rather thin compared with those of the outcrops at Tejar Consuelo and separated by thicker chalky beds. The bottom of the member is not exposed. BR stations 680 and 680 A

are lithologically and faunally very similar random samples from the base of the Toledo member outcropping in this quarry:

BR stations 680 and 680A
Lithologies: Chalk, powdery, white to grayish yellow.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia aff. *convexa* SUBBOTINA
Globigerina senni (BECKMANN)
Globigerina boweri BOLLI
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina micra (COLE)
Eocene spumellarias and nassellarias.

Avenida de los Presidentes

The two members of the Universidad formation are cut by Avenida de los Presidentes between the monument of J. M. Gómez and the intersection with Avenida de la Universidad, coordinates 367.41 N and 358.26 E (index map, fig. 49). The total thickness of the Universidad formation is about 20 m. The Toledo member consists of only 4 to 5 m of white to yellowish chalky limestones with irregular beds and nodules of more or less silicified fractured limestones. As shown by the columnar section, fig. 51, the Toledo member is here considerably less silicified than in the quarry at Tejar Toledo. It overlies unconformably the brownish, thin and irregularly bedded gypsum-bearing graywacke sands, silts and shales of the basal unit of the Capdevila formation. The lowermost beds of the Toledo member, represented by BR station 1005, are somewhat brownish and shaley which is probably caused by reworking of Capdevila lithologies. Southwest of the Castillo del Príncipe at the corner of Calle C and Calle Zapata, just at the entrance to the Hospital de Nuestra Señora de las Mercedes, the silicified Toledo member is exposed in a low cliff where BR station 687 has been collected.

The stratigraphic position of the following samples is shown in the index map, fig. 49 and in the columnar section, fig. 51. They are from bottom to top:

BR station 1005 (Universidad formation, Toledo member, base)
Lithology: Shale, calcareous, moderate yellowish brown, associated with leached silicified limestone, pale yellowish brown to very pale orange.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM)
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA
Globorotalia palmerae CUSHMAN and BERMÚDEZ
Globorotalia pseudoscitula GLAESSNER
Globigerina aff. *collactea* (FINLAY)
Globigerina aff. *prolata* BOLLI
Pseudohastigerina micra (COLE).

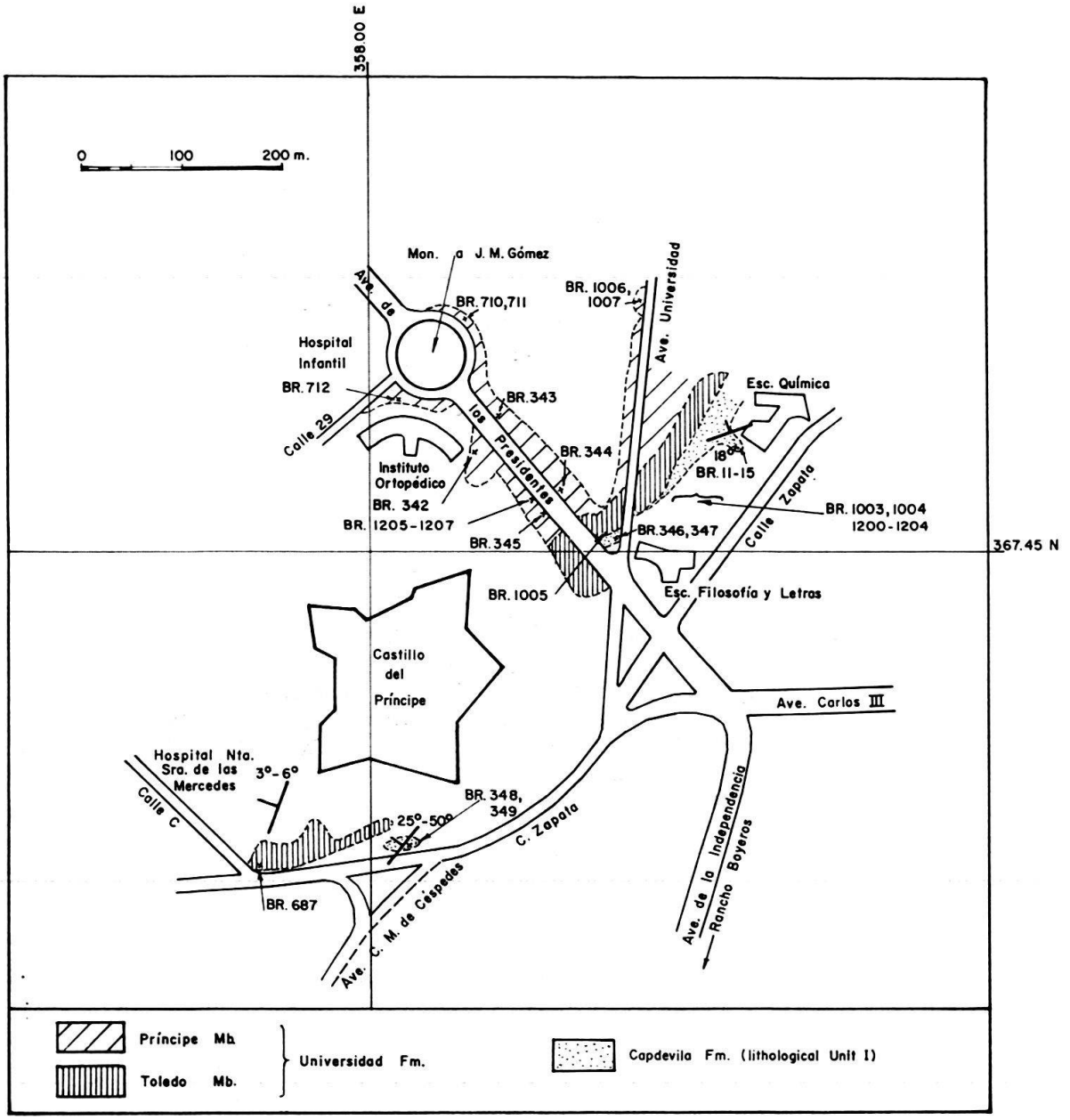


Fig. 49. Index map of the area at Castillo del Príncipe.

The outcrop at the corner of Calle C and Calle Zapata is documented by BR station 687:

Lithology: Limestone, silicified, hard, with asphalt pebbles, very pale orange (coccolithite).

Texture: Microcrystalline, silicified groundmass with abundant planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp. with thick and coarsely perforate walls
Pseudohastigerina micra (COLE)
Coccoliths, mainly placoliths (rock-forming)
Discoaster sp. close to *D. barbadiensis* TAN but without central knob

Discoaster barbadiensis TAN (abundant)
Discoaster cf. *lodoensis* BRAMLETTE and RIEDEL (small forms with short thin needle-like radii)
Discoaster lodoensis BRAMLETTE and RIEDEL (corroded specimens are common)
Thoracosphaera spp.

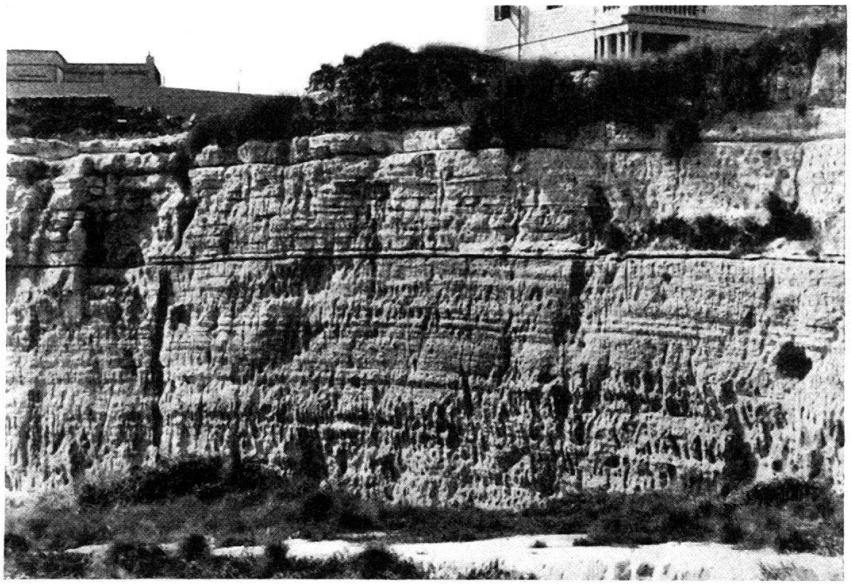


Fig. 50. View of the western side of the road cut at Avenida de los Presidentes just below the Instituto Ortopédico, showing the Príncipe member of the Universidad formation.

Príncipe member

The contact between Príncipe and Toledo members is transitional throughout the area studied. The true top of the Príncipe member is not known because it is everywhere unconformably overlain by younger rocks. The younger beds of the Príncipe member are of Middle Eocene age with *Hantkenina mexicana* CUSHMAN, *Hantkenina dumblei* WEINZIERL and APPLIN, *Globorotalia spinulosa* CUSHMAN, *Globorotalia lehneri* CUSHMAN and JARVIS, *Globorotalia aragonensis* NUTTALL, *Truncorotaloides rohri* BRÖNNIMANN and BERMÚDEZ, *Truncorotaloides topilensis* (CUSHMAN), *Globigerapsis index* (FINLAY), *Globigerina bowerí* BOLLI and the first representatives of *Globorotalia centralis* CUSHMAN and BERMÚDEZ. Some of these forms are characteristic of the early Middle Eocene *Hantkenina mexicana–Globorotalia aragonensis* zone, which overlies the *Globorotalia aragonensis–Globorotalia bullbrooki* zone of late Lower Eocene age and others of the late Middle Eocene *Hantkenina dumblei–Globigerinatheka barri* zone or common to both zones.

The unconformable upper boundary of the Universidad formation points toward post-Príncipe movements. In the quarry east of Punta Brava, the Universidad formation has been completely eroded before Upper Eocene time, allowing the transgression of the Upper Eocene Punta Brava formation on the Lower Eocene Capdevila formation. In other places, the Basal Oligocene Consuelo formation (Tejar Consuelo and Husillo quarry), or the Husillo formation (Tejar Andrade), or

the Cojímar formation (co-type locality Cojímar formation, Tejar Andrade), or the Rosario formation (quarry 1.5 km west-southwest of Santa María del Rosario) overlie unconformably the Príncipe beds.

Description of the type locality of the Príncipe member

The type locality of the Príncipe member is situated along the road cut at Avenida de los Presidentes between the monument of J. M. Gómez and the intersection with Avenida de la Universidad, coordinates 367.41 N and 358.26 E (index map, fig. 49). The road cut is illustrated by the photograph, fig. 50. The Príncipe member is about 16 m thick and formed by massive, white to yellowish and orange fine-grained chalks and chalky limestones (columnar section, fig. 51). The chalk is generally hard and locally shows, evidenced by darker and lighter colors, crossbedding probably caused by submarine currents. There are a few thin and softer shaley breaks. BR station 712 is from the less massive top beds of the Príncipe member on the west-northwest side of the road cut close to the Instituto Ortopédico of the University of Habana. They bear tubular organisms and small pebbles probably of intraformational origin. Asphalt pebbles have been noticed throughout the Príncipe beds. The contact with the underlying poorly silicified Toledo beds is transitional.

At the base of the western cliff of the road cut, about 100 m northeast of the intersection of Avenida de los Presidentes and Avenida de la Universidad, occurs an irregularly contoured recrystallized silicified limestone body of nodular appearance, which is embedded in Príncipe chalks. Recrystallization apparently was caused by waters which raised along a minor fault. The irregular top of this mass could be taken for an unconformity. Oil impregnation, probably also fault

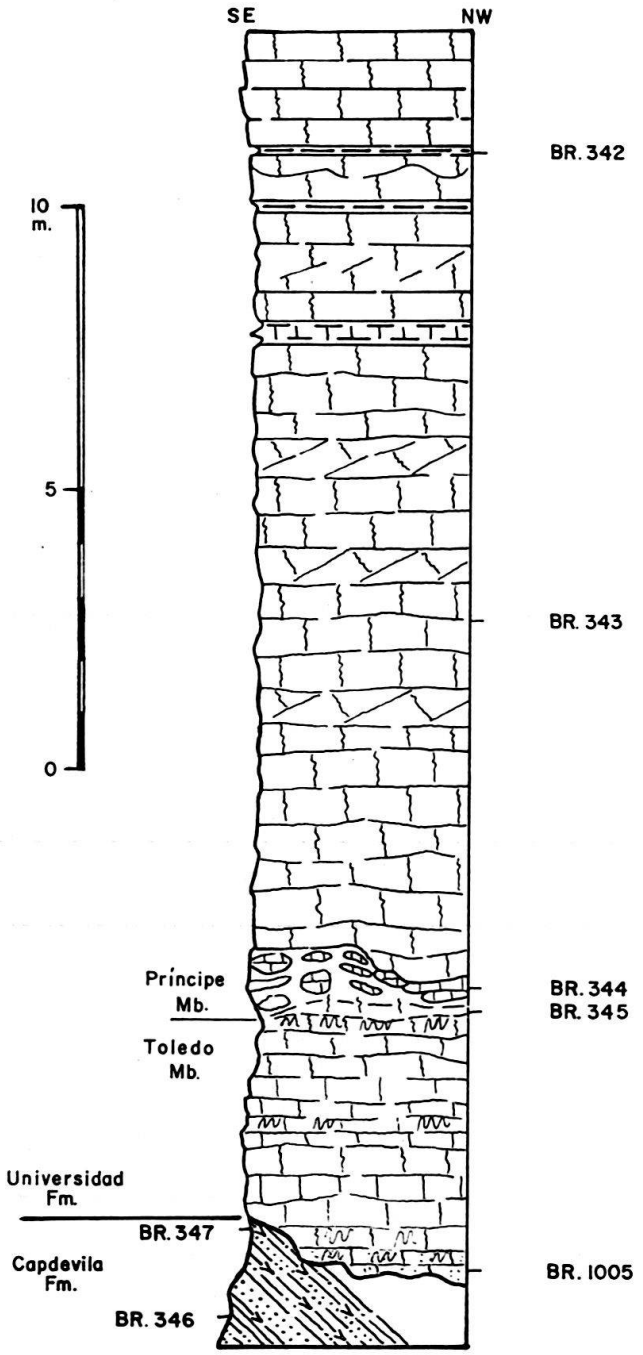


Fig. 51. Columnar section of Capdevila beds and Universidad formation, Avenida de los Presidentes.

controlled, was noticed in the chalk immediately overlying the silicified mass. Another secondary alteration was seen at the top of the Príncipe beds just beneath the buildings of the Hospital Calixto García at Avenida de la Universidad, where the overlying Miocene limestones have been changed by surface waters into a hard recrystallized, cavernous mass. Bore holes made by lithophagic organisms were noticed and thin sections from BR stations 1006 and 1007 exhibit numerous *Palaxius habanensis* BRÖNNIMANN and NORTON, a crab coprolite with 2 groups of 5 comma-shaped canals (BRÖNNIMANN and NORTON, 1961).

The relative stratigraphic position of the Príncipe type samples is shown in the index map and in the columnar section (figs. 49, 51). They are listed below from bottom to top:

BR station 1207
Lithology: Limestone, hard, light yellowish gray.
Texture: Microcrystalline groundmass with abundant planktonic Foraminifera. Asphalt inclusions.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina senni (BECKMANN)
Globigerina spp. with thick and coarsely perforate walls
Coccoliths, *Thoracosphaera* spp. } rare

BR station 1205
Lithology: Shale, calcareous, pale yellowish brown to light olive gray.
Washed residue with
Globorotalia aspensis (COLOM)
Globorotalia spinuloinflata (BANDY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Globigerina boweri BOLLI
Globigerina senni (BECKMANN)
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina micra (COLE).

BR station 1206
Lithology: Chalk, soft, powdery, pale yellowish orange, with asphalt pebbles.
Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM)
Globorotalia convexa SUBBOTINA
Globorotalia spinuloinflata (BANDY)
Truncorotaloides aff. *topilensis* (CUSHMAN)
Globigerapsis index (FINLAY)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Globigerina aff. *collactea* (FINLAY)
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group

Globigerina turgida FINLAY
Globigerina cf. *yeguaensis* WEINZIERL and APPLIN
"Globigerinoides" higginsi BOLLI.

BR 345 (Universidad formation, Príncipe member, base)
Lithology: Chalk, soft, powdery, grayish orange to dark yellowish orange.
Washed residue with
Globorotalia aspensis (COLOM)
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globigerina prolata BOLLI
Globigerina soldadoensis BRÖNNIMANN group
Globigerina aff. *turgida* FINLAY
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN.

BR station 344
Lithology: Limestone, silicified, hard, with asphalt pebbles, very pale orange.
Texture: Microcrystalline groundmass with abundant planktonic microfossils.
Assemblage: *Globorotalia* spp. (truncate forms)
Globigerina with thick and coarsely perforate walls
Pseudohastigerina micra (COLE)
Coccoliths
Discoaster barbadiensis TAN
Thoracosphaera sp.

BR station 343
Lithology: Chalk, soft, white to light grayish yellow with algal pebbles.
Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia cf. *spinulosa* CUSHMAN
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN
Globigerina sp.
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina sp. close to *P. micra* (COLE), but with compressed test.

BR station 342
Lithology: Chalk, soft, white.
Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM) group
Globorotalia bullbrooki BOLLI
Globigerina boweri BOLLI
Globigerina senni (BECKMANN)
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN.

BR station 710 and 711
Lithology: Chalk, soft, powdery, white to yellowish, with asphalt pebbles.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia aff. *spinuloinflata* (BANDY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Globigerina bowerí BOLLI
Globigerina yeguaensis WEINZIERL and APPLIN.

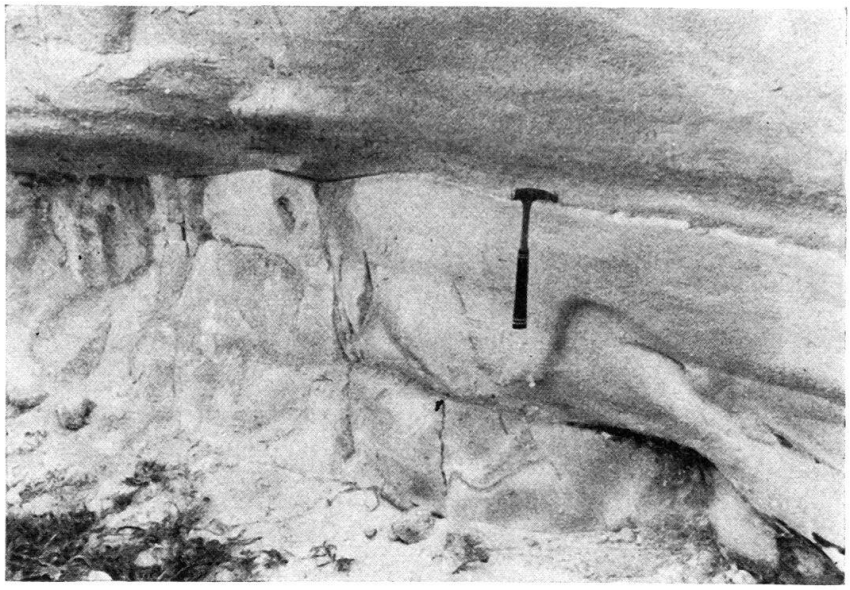


Fig. 52. Intraformational unconformity in the Universidad formation, quarry east of Río Almendares.

BR station 712
Lithology: Chalk, soft, powdery, white.
Washed residue with

Hantkenina dumblei WEINZIERL and APPLIN
Hantkenina mexicana CUSHMAN
Globorotalia aragonensis NUTTALL
Globorotalia cf. *bullbrooki* BOLLI
Globorotalia spinulosa CUSHMAN
Truncorotaloides topilensis (CUSHMAN)
Globigerina bowerí BOLLI
Globigerina aff. *linaperta* FINLAY
Globigerina yeguaensis WEINZIERL and APPLIN
"*Globigerinoides*" *higginsi* BOLLI.

BR stations 1006 and 1007 are two random samples from the recrystallized chalk at Hospital Calixto García, just at the Eocene–Miocene unconformity:
Lithology: Limestone, hard, vacuolar, yellowish to yellowish gray.

Texture: Cryptocrystalline, dense, in places recrystallized clear calcite, with abundant planktonic microfossils and some benthonic Foraminifera and *Palaxius habanensis* BRÖNNIMANN and NORTON (crab coprolites) in fillings of bore holes.

Assemblage:
Globorotalia cf. *lehneri* CUSHMAN and JARVIS
Globorotalia spp. (truncate forms)
Truncorotaloides topilensis (CUSHMAN)
Globigerina senni (BECKMANN)
Coccoliths
Discoaster barbadiensis TAN
Braarudosphaera discula BRAMLETTE and RIEDEL.

Other outcrops of the Príncipe member

Autopista del Mediodía

In the description of the Toledo member we have mentioned that the contact between the Príncipe and the Toledo members on the eastern side of the road cut is transitional (index map, fig. 45, and columnar section, fig. 46). The massive, more or less chalky, whitish and yellowish limestones of the Príncipe formation show at this locality a gradual increase of limonitic material toward the top. Several irregular limonitic surfaces are suggestive of intraformational disconformities. The top beds are recrystallized, strongly limonitic and the unconformity surface is characterized by bore holes filled with material of the transgressively overlying *Globorotalia fohsi*-bearing Cojímar formation. On the western side of the road cut, the Príncipe member had been eroded in pre-Cojímar time and is found only in the form of limonitic limestone pebbles at the base of the Cojímar formation (cross section, fig. 48). Asphalt pebbles occur throughout the Príncipe beds.

The only sample investigated from the eastern side of the road cut is just from the uppermost bed of the Príncipe member:

BR station 455
Lithology: Limestone, hard, with asphalt pebbles, very pale orange.
Texture: Cryptocrystalline to microcrystalline groundmass with limonitic specks and abundant planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp. with thick and coarsely perforate walls
Pseudohastigerina micra (COLE)
Coccoliths, mainly placoliths (abundant)
Braarudosphaera cf. *bigelowi* (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL (abundant)
Discoaster sp. close to *D. barbadiensis* TAN, but without central knob
Discoaster barbadiensis TAN
Discoaster cf. *molengraaffi* TAN
Discoaster cf. *lodoensis* BRAMLETTE and RIEDEL
a) forms close to the typical ones
b) forms with slightly indentated radii
Thoracosphaera sp.

Tejar Consuelo

The Príncipe member is at Tejar Consuelo in transitional contact with the silicified Toledo member (index map, fig. 59). It consists of about 15 m of more or less well-bedded, whitish to yellowish chalks and marls. Numerous asphalt pebbles are irregularly dispersed throughout the Príncipe beds. There are local accumulations of chalk pebbles of intraformational origin, particularly in the eastern cliff of the quarry. The Príncipe member is cut unconformably by the lithologically very similar transgressive Oligocene Consuelo chalks of the *Globigerina ampliapertura* zone (photographs, fig. 56, 57, and columnar sections, fig. 60). In its basal beds the latter show slumping phenomena. The unconformity between Universidad and Consuelo formations is evidenced by different dips, but features suggestive of emergence such as bore holes or limonitic crusts do not occur in the cliff. On the eastern side of the quarry, however, a good contact with bore holes and Universidad pebbles can be observed on top of the Príncipe beds. Here, the unconformity surface is very irregular and channeled as in the quarry east of Río Almendares. BR station 708 is from intraformational pebbles of the Príncipe beds, and BR station 703 from the top of the Príncipe beds.

The stratigraphic position of the following samples from the western cliff of the quarry can be seen in the columnar sections (fig. 60). They are here listed from bottom to top:

BR station 356
Lithology: Limestone (radiolarite-coccolithite), hard, with asphalt pebbles, laminated, pale greenish yellow (1) and chalk, hard, whitish yellow (2).
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils (1).
Assemblages: *Globorotalia* spp. (truncate forms)
Globigerina spp. with thick and coarsely perforate walls
Coccoliths, mainly placoliths (rock-forming)
Radiolaria (abundant)
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN (abundant)
a) typical forms
b) minute forms of about 6μ diameter with large central knob of 2 to 2.5 μ diameter. In these specimens, the radii appear to be better separated than in *D. barbadiensis.*
Discoaster lodoensis BRAMLETTE and RIEDEL (common)
Discoaster colleti PARÉJAS
Discoaster hilli TAN
Discoaster gemmeus STRADNER
Discoaster geometricus BRÖNNIMANN and STRADNER
Nannotetraster swasticoides (MARTINI)
Marthasterites sp.
Thoracosphaera spp.
Washed residue (2) with
Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM) group

Globorotalia bullbrooki BOLLI
Globigerina cf. *senni* (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Eocene spumellarias and nassellarias.

BR station 353A
Lithology: Chalk, powdery, grayish yellow, with asphalt pebbles.
Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM)
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA
Globorotalia spinuloinflata (BANDY)
Globigerina cf. *prolata* BOLLI
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group (abundant)
Globigerina cf. *turgida* FINLAY
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Pseudohastigerina micra (COLE).

BR stations 354 and 355
Lithology: Chalk, nodular, fairly hard, whitish to grayish yellow (354), and chalk, powdery, whitish yellow (355).
Washed residues with

Globorotalia aragonensis NUTTALL
Globorotalia aspensis (COLOM)
Globorotalia bullbrooki BOLLI
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Globigerina aff. *yeguaensis* WEINZIERL and APPLIN
Catapsydrax cf. *unicavus* BOLLI, LOEBLICH, and TAPPAN.

The following samples are from the Príncipe member of the northeastern cliff of the quarry. Their stratigraphic position is shown in the index map of the Consuelo area, fig. 59:

BR station 708 (intraformational pebbles or concretions in the Príncipe beds)
Pebble 1
Lithology: Chalk, indurated, grayish yellow, with asphalt inclusions.
Texture: Microcrystalline, with asphalt inclusions and recrystallized remains of planktonic microfossils. Recrystallization destroyed discoasterids, coccoliths, etc.

Pebble 2
Lithology: Chalk, indurated, blotchy, grayish yellow, with asphalt inclusions.
Texture: As pebble 1.

Pebble 3
Lithology: Chalk, indurated, whitish to grayish yellow, with limonitic film.
Texture: As pebbles 1 and 2.

Assemblage: *Thoracosphaera* sp.
Discoaster barbadiensis TAN.

BR station 703
Lithology: Chalk, indurated, powdery, grayish yellow, with abundant asphalt fragments.

Washed residue with
Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA.
Globorotalia spinuloinflata (BANDY)
Globigerina senni (BECKMANN)
Globigerina soldadoensis BRÖNNIMANN group
Globigerina turgida FINLAY
Globigerina yeguaensis WEINZIERL and APPLIN
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN

Quarry east of Río Almendares

The location of this quarry is described under Toledo member. The Príncipe member is here a rather massive whitish yellow chalk with some thin marly layers. The preserved thickness below the transgressive coralligen Vedado (?) formation is about 4 to 10 m. Asphalt pebbles are abundant. A low-angle intraformational unconformity has been observed within the Príncipe member at the northwest side of the quarry as shown by the photograph, fig. 52. The unconformity surface on top of the Príncipe member is very irregularly channeled. We were not able to obtain samples from the somewhat darker top beds underlying the Vedado (?) formation nor from the latter. Although the darker beds are believed to be Universidad formation, a faunistic study is needed to exclude the possibility of their being part of the Consuelo formation.

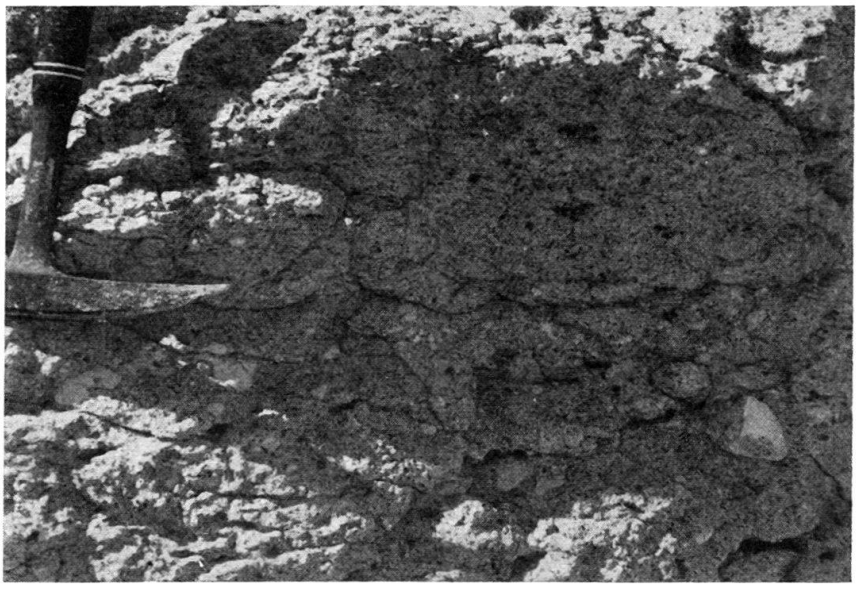


Fig. 53. Toledo beds with asphalt pebbles at the road cut of the Vía Blanca just east of Playa Jibacoa.

Fig. 54. Toledo beds with asphalt veins at the road cut of the Vía Blanca just east of Playa Jibacoa.

Many excellent outcrops of Universidad beds occur along the rim-rock of the Marianao area. Of these only two will be mentioned, i.e. Cantera Husillo and Tejar Andrade.

Cantera Husillo

The Príncipe member of the Universidad formation is well exposed in the southeastern part of Cantera Husillo, Marianao, which is described in detail under Husillo formation (index map, fig. 67). The beds dip 6° toward W 10° N. The following Príncipe samples have been collected in this quarry:

BR stations 845 and 846

BR station 846 is about 3 m stratigraphically below station 845, which comes from a bed showing slumping features. The samples from these stations are lithologically and faunally very similar and are described together to avoid repetition.
Lithologies: Chalk, indurated, whitish to very pale orange (845), chalk, whitish with asphalt inclusions (846).
Textures: Cryptocrystalline to microcrystalline groundmass with planktonic microfossils.

Assemblages:
Globorotalia spp. (truncate forms)
Globigerina senni (Beckmann)
Coccoliths spp., mainly placoliths
Tremalithus eopelagicus Bramlette and Riedel (large specimens)
Braarudosphaera discula Bramlette and Riedel (common to abundant)
Discoaster aster Bramlette and Riedel
Discoaster barbadiensis Tan
Discoaster cf. *lodoensis* Bramlette and Riedel

Discoaster cf. *woodringi* BRAMLETTE and RIEDEL
Micrantolithus cf. *vesper* DEFLANDRE
Thoracosphaera spp. (globular and ellipsoid bodies).

Fig. 55. Typical thin-bedded siliceous Toledo beds at the road cut of the Vía Blanca just east of Playa Jibacoa.

Washed residue with

Globorotalia cf. *aragonensis* NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia cf. *spinuloinflata* (BANDY)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Truncorotaloides topilensis (CUSHMAN)
Globorotalia convexa SUBBOTINA
Globigerinatheka barri BRÖNNIMANN
Globigerina boweri BOLLI
Globigerina senni (BECKMANN)
Globigerina yeguaensis WEINZIERL and APPLIN
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Chiloguembelina martini (PIJPERS).

Tejar Andrade

Tejar Andrade is situated east of La Lisa, a suburb of Marianao, about 500 m southwest of the Autodromo of Marianao. Coordinates of the factory building are 359.20 N and 353.00 E. In the northeastern part of Tejar Andrade, Husillo bioherms and chalky limestones rest unconformably on Príncipe beds. The Toledo member is represented by BR station 856 and the Príncipe member by BR station 858. The location of these two samples can be seen in the sketch, fig. 72.

BR station 856 (Universidad formation, Toledo member)
Lithology: Limestone, laminated, siliceous, white to grayish yellow.

Texture: Cryptocrystalline silicified groundmass with abundant planktonic microfossils and asphalt inclusions.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp.
Radiolaria (common)
Coccoliths, mainly placoliths
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Discoaster woodringi BRAMLETTE and RIEDEL
Braarudosphaera bigelowi (GRAN and BRAARUD) (up to 23 μ diameter)
Braarudosphaera discula BRAMLETTE and RIEDEL
Marthasterites sp.
Thoracosphaera sp.

BR station 858 (Universidad formation, Príncipe member)
Lithology: Chalk, hard, powdery, white.
Texture: Microcrystalline to cryptocrystalline with abundant planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate forms)
Globigerina spp.
Chiloguembelina spp.
Coccoliths, mainly placoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)
Braarudosphaera bigelowi (GRAN and BRAARUD) (common)
Braarudosphaera discula BRAMLETTE and RIEDEL (common)
Braarudosphaera undata STRADNER
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Discoaster lodoensis BRAMLETTE and RIEDEL
Discoaster woodringi BRAMLETTE and RIEDEL
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster cf. *molengraaffi* TAN
Marthasterites sp.
Thoracosphaera sp.

BR station 858 (Universidad formation, Príncipe member)
Lithology: Chalk, hard, powdery, white.
Texture: Microcrystalline to cryptocrystalline with abundant planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate form)
Globigerina spp.
Chiloguembelina spp.
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL (large specimens)

Braarudosphaera bigelowi (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL
Discoaster aster BRAMLETTE and RIEDEL
Discoaster barbadiensis TAN
Discoaster lodoensis BRAMLETTE and RIEDEL
Discoaster woodringi BRAMLETTE and RIEDEL
Marthasterites sp.

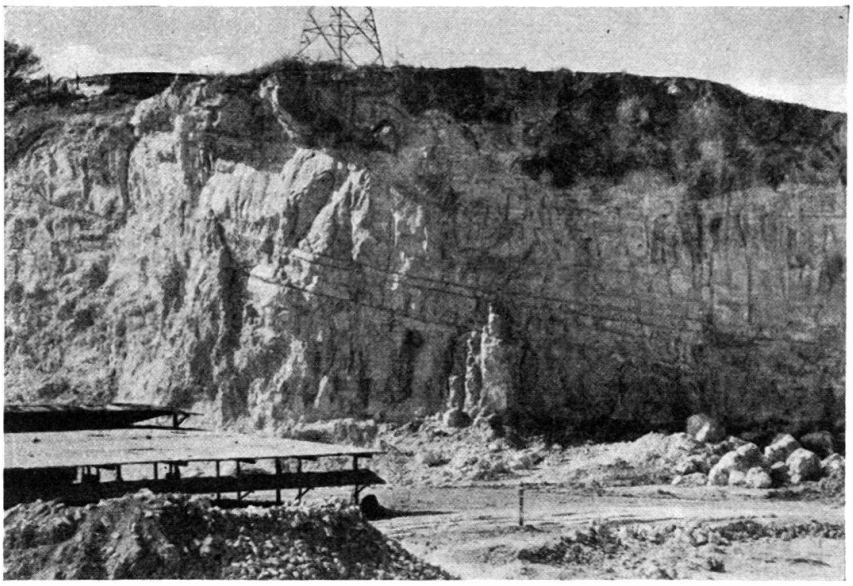


Fig. 56. General view of the southeastern cliff at Tejar Consuelo.

Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globorotalia convexa SUBBOTINA
Globigerina boweri BOLLI
Globigerina turgida FINLAY
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN.

As pointed out in the introduction to this chapter, there is only a single exposure of Universidad formation at the southern rim-rock, in a large quarry near Santa María del Rosario.

Santa María del Rosario

About 1.5 km west-southwest of Santa María del Rosario is a large quarry, coordinates 359.00 N and 369.80 E, in which the Príncipe member apparently transgresses on Alkázar formation. The contact is not exposed. The Príncipe beds consist of about 15 to 20 m of hard, massive white orange chalks on top of which there are a few intercalations of a fine-grained hard, yellowish limestone. Samples from the white chalk are BR stations 1115 and 1116, and the limestone is represented by BR stations 1117 and 1149. In the eastern part of the quarry, the Príncipe member is unconformably overlain by Husillo reefal limestones of the *Lepido-*

cyclina–Miogypsina zone, where BR station 1150 is located. In the southern part of the quarry, the Universidad formation is covered by gently dipping transgressive conglomeratic chalks and marls of the Rosario formation (BR stations 1112 and 1148).

Fig. 57. Detail of the angular unconformity between the Consuelo formation, above, and the Universidad formation, Príncipe member, below, southwestern cliff at Tejar Consuelo.

BR station 1115
Lithology: Chalk, hard, powdery, very pale orange.
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils.
Assemblage: *Globorotalia bullbrooki* BOLLI group
Globorotalia spp. (truncate forms)
Chiloguembelina martini (PIJPERS)
Truncorotaloides cf. *topilensis* (CUSHMAN)
Globigerina senni (BECKMANN)
Pseudohastigerina micra (COLE)
Discoaster barbadiensis TAN
Braarudosphaera discula BRAMLETTE and RIEDEL
Thoracosphaera spp.
Washed residue with
Globorotalia aff. *spinuloinflata* (BANDY)
Globigerina senni (BECKMANN).

BR station 1116
Lithology: Chalk, hard, powdery, white.
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils.
Assemblage: *Hantkenina* cf. *mexicana* CUSHMAN
Globorotalia lehneri CUSHMAN and JARVIS
Globorotalia spp. (truncate forms)
Globigerina senni (BECKMANN)

Coccoliths
Discoaster barbadiensis TAN
Braarudosphaera discula BRAMLETTE and RIEDEL
Thoracosphaera spp.

Washed residue with
Hantkenina dumblei WEINZIERL and APPLIN
Hantkenina mexicana CUSHMAN
Globorotalia centralis CUSHMAN and BERMÚDEZ
Globigerina senni (BECKMANN)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Globigerapsis index (FINLAY).

BR station 1117
Lithology: Limestone, very pale orange.
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils.

Assemblage:
Globorotalia spp. (truncate forms)
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Truncorotaloides topilensis (CUSHMAN)
Globigerina senni (BECKMANN)
Discoaster barbadiensis TAN
Braarudosphaera bigelowi (GRAN and BRAARUD)
Braarudosphaera discula BRAMLETTE and RIEDEL
Thoracosphaera spp.

BR station 1149
Lithology: Limestone, very pale orange.
Texture: Microcrystalline to cryptocrystalline groundmass with recrystallized planktonic Foraminifera.

Assemblage:
Globorotalia ex gr. *lehneri* CUSHMAN and JARVIS
Truncorotaloides rohri BRÖNNIMANN and BERMÚDEZ
Truncorotaloides topilensis (CUSHMAN)
Globigerina senni (BECKMANN)
Braarudosphaera discula BRAMLETTE and RIEDEL
Thoracosphaera spp.

BR station 1150 (Husillo formation)
Lithology: Limestone, hard, white to very pale orange.
Texture: Cryptocrystalline groundmass, in places recrystallized, with abundant organic detritus. Larger Foraminifera are common.

Assemblage:
Lepidocyclina spp. with spatulate equatorial chambers
Operculinoides sp.
Miogypsina sp.
Gypsina globulus (REUSS)
Amphistegina sp.

Associated with the white orbitoidal Husillo limestone as described above occurs a grayish orange pseudoölitic to oölitic shallow-water limestone composed of subcircular to elongate elements of a dense cryptocrystalline groundmass con-

taining larger angular, organic fragments, embedded in a recrystallized clear calcite groundmass. The pseudoölites appear to be crab coprolites. The oölites were originally pseudoölites around which one or more thin secondary layers were deposited. Composite pseudoölites were also noticed.

BR stations 1112 and 1148 (Rosario formation)

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

Lithology: Chalk, marly, conglomeratic, white (1112) and chalk, yellowish to pale yellowish orange (1148).

Washed residue with

Discorbis floridensis CUSHMAN
Elphidium poeyanum (D'ORBIGNY)
Elphidium puertoricense GALLOWAY and HEMINGWAY
Clavulina tricarinata D'ORBIGNY
Valvulina oviedoiana D'ORBIGNY
"*Streblus*" *beccarii* (LINNÉ)
Amphistegina angulata (CUSHMAN)
Globigerinoides trilobus (REUSS)
Globorotalia menardii (D'ORBIGNY)
Planorbulina cf. *dominicana* BERMÚDEZ
Meandropsina cf. *matleyi* (VAUGHAN)
Peneroplis proteus D'ORBIGNY
Archaias cf. *angulatus* (FICHTEL and MOLL)
Reworked miogypsinas and Universidad globigerinas.

H. S. PURI (letter February 9, 1959) identified the following ostracodes from these stations:

Actinocythereis exanthemata (ULRICH and BASSLER)
Bairdoppilata triangulata EDWARDS
Orionina vaughani (ULRICH and BASSLER)
Mutilus confragosa (EDWARDS)
Aurila conradi (HOWE and MCGUIRT)
Paracytheridea chipolensis PURI
Cytheropteron sp.
Loxoconcha sp.

and noted that *Bairdoppilata triangulata, Mutilus confragosa* and *Aurila conradi* are confined to the Choctawhatchee Miocene in Florida, and that *Orionina vaughani* and *Actinocythereis exanthemata* range from the Chipola Miocene to the Recent. *Paracytheridea chipolensis* is restricted to the Chipola, but as only a single specimen of this form was found Puri prefers not to put too much weight on this species, and regards the assemblage as probably of Choctawhatchee age.

Environment and age

The Universidad formation consists mainly of well-bedded, light colored chalks and limestones with generally cryptocrystalline to microcrystalline microtextures. Asphalt grains and pebbles are dispersed throughout the formation. Veins and

veinlets of asphalt cutting the thin-bedded Toledo member were observed at the bottom of the road cut at the Vía Blanca just east of Playa Jibacoa about 20 km east of the Bahía de la Habana. The asphalt fragments are syngenetic. The veins and veinlets, on the other hand, are post-Universidad. The asphalt was probably derived during and after Universidad time from large seepages formed on the structures of the pre-Universidad orogeny. Toledo beds from this outcrop with

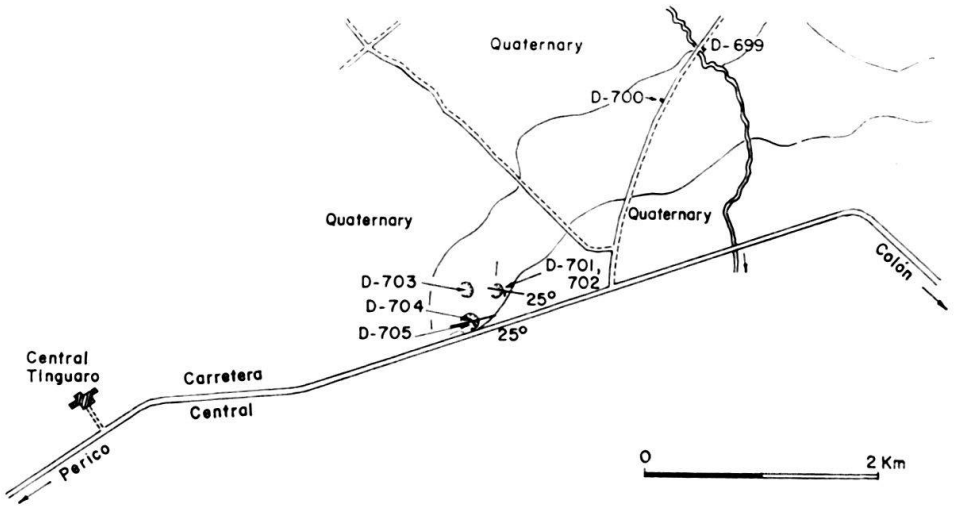


Fig. 58. Index map of the area near Central Tinguaro.

asphalt pebbles are illustrated by the photograph, fig. 53, and with asphalt veins by the photograph, fig. 54. The absence or scarcity of asphalt elements in the lithologically very similar Consuelo formation aids in distinguishing the Universidad from the overlying Consuelo beds. We noticed that asphalt pebbles are not restricted to the Universidad formation, but that they appear locally also in the Cojímar chalks. The fine-grained sediments and the large amount of planktonic microfossils, of which coccoliths, discoasterids and Radiolaria occur occasionally in rock-forming quantities, are good evidence for a basinal environment of the Universidad formation. This opinion, however, is not shared by all students of Cuban geology. SÁNCHEZ ROIG (1949) reported from the Lower and Middle Eocene of Tejar Consuelo rare specimens or only fragments of *Sanchezaster habanensis* LAMBERT, *Habanaster sanchezi* LAMBERT, *Histocidaris sanchezi* LAMBERT (fragments of test and spines), *Cidaris cubensis* LAMBERT (only spines), *Centrostephanus habanensis* LAMBERT (only spines), *Leiopedina cienaguensis* SÁNCHEZ ROIG, *Gauthieria sanchezi* LAMBERT, *Cyclaster jacksoni* LAMBERT and *Victoriaster lamberti* SÁNCHEZ ROIG, and from the Toledo member of Tejar Toledo *Goniocidaris habanensis* SÁNCHEZ ROIG (known only by its characteristic spines). The beds from which the echinids from the Consuelo quarry originate are not described and there is some doubt regarding their actual provenance. Possibly, some or all of them may come from the Consuelo chalks. BRODERMANN (1949, p. 309) inferred from the occurrence of echinids in the Lower to Middle Eocene Universidad formation that it was deposited in a shallow sea. But for the overall lithology and wide-spread distribution of the Universidad beds, the microfaunas, the microtextures, the occurrence

of manganese oxide films, we do not agree with BRODERMANN. The light tests of echinids were capable of floating after death, similar to those of cephalopods, and thus could be transported from their original shallow-water habitat into the open sea.

Estimates of the ratio of planktonic and benthonic microfossils suggest that the depth of the Universidad sea was from about 600 to 1200 m (GRIMSDALE and VAN MORKHOVEN, 1955). These depth figures agree in a general way with a depth estimate of 500 to 1500 m, probably 800 to 1000 m, for the ecologically related Eo-Oligocene Oceanic sea of Barbados by BECKMANN (1954), based on the assumed depth distribution of fossil benthonic Foraminifera as derived from that of related

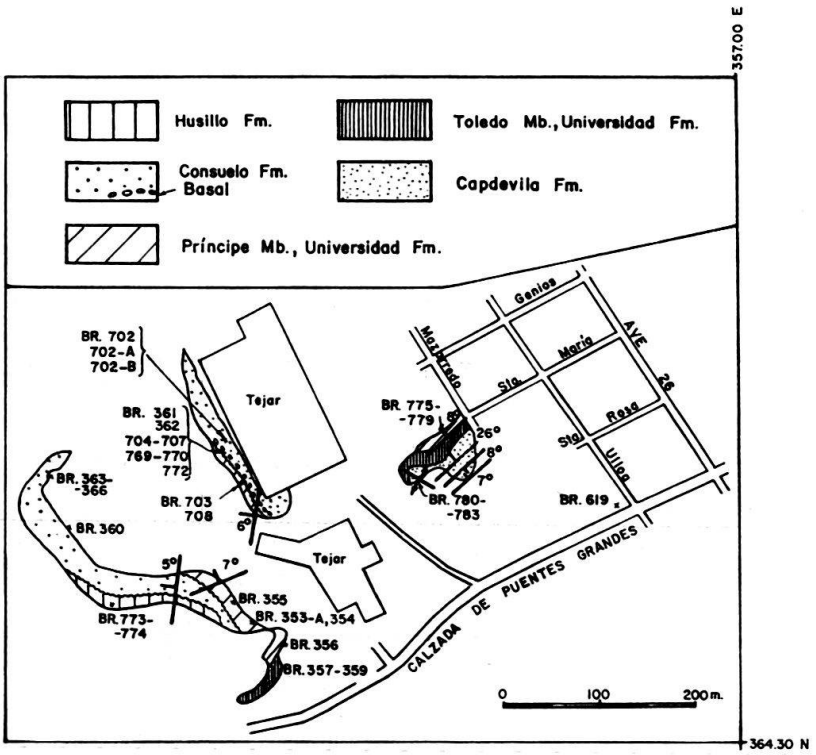


Fig. 59. Index map of Tejar Consuelo.

Recent forms. STAINFORTH (1945, 1948) suggested a depth of 400 to 500 m for the ecologically likewise related Oligo-Miocene Cipero sea of Trinidad, although the high percentage of planktonic specimens, more than 90 % according to STAINFORTH, would indicate a depth of about 1200 m, if we apply the results obtained from the depth distribution of Recent faunas of the Gulf of Mexico by GRIMSDALE and VAN MORKHOVEN (1955, p. 484).

Conspicuous sedimentary features of the Universidad formation are local intraformational unconformities, cross-bedding and slumping caused by currents and possibly by unstable bottom conditions (photograph, fig. 52). Frequently noticed were also structureless rounded pebbles from a few millimeters diameter to fist-size, composed of the same material in which they are embedded and which appear to be concretions formed contemporaneous with deposition.

Discoasters, coccoliths and associated nannofossils are common and conspicuous elements of the Universidad chalks and limestones. In silicified Toledo limestones they are often perfectly preserved. The following discoasterids were recorded:

Braarudosphaera bigelowi (GRAN and BRAARUD) (rare)
Braarudosphaera discula BRAMLETTE and RIEDEL (common to abundant)
Braarudosphaera undata STRADNER
Discoaster aecus BRÖNNIMANN and STRADNER
Discoaster aster BRAMLETTE and RIEDEL (rare)
Discoaster barbadiensis TAN (common)
Discoaster binodosus MARTINI
Discoaster colleti PARÉJAS
Discoaster currens STRADNER
Discoaster gemmeus STRADNER
Discoaster geometricus BRÖNNIMANN and STRADNER
Discoaster hilli TAN
Discoaster lodoensis BRAMLETTE and RIEDEL (common to abundant)
Discoaster cf. *molengraaffi* TAN
Discoaster woodringi BRAMLETTE and RIEDEL (rare)
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) (rare)
Marthasterites spp.
Nannotetraster swasticoides (MARTINI).

Associated nannofossils are:

Coccoliths, mainly placoliths, which occur in rock-forming quantities, with large specimens of *Tremalithus eopelagicus* BRAMLETTE and RIEDEL
Heliorthus fallax BRÖNNIMANN and STRADNER
Micrantholithus sp. (rare)
Thoracosphaera spp. (common to abundant)
Zygolithus dubius DEFLANDRE.

The Lower to Middle Eocene Universidad formation is subdivided into a lower part which belongs to the *Discoaster lodoensis-Marthasterites tribrachiatus* zone and an upper part assigned to the *Discoaster lodoensis* zone. The discoaster assemblages of the lower part which correspond to the *Globorotalia palmerae* and the *Globorotalia bullbrooki–Globorotalia aragonensis* zones are therefore identical to those of the Capdevila formation as far as the diagnostic forms are concerned.

As in the Alkázar and Capdevila formation, Radiolaria, i.e. spumellarias and nassellarias, are common in certain beds, in particular of the Toledo member.

Larger benthonic Foraminifera such as discocyclinas, asterocyclinas, *Dictyoconus* etc., and algal fragments are absent in the relatively deep-water sediments of the Universidad formation. In the thin sections and washed residues studied no reworked pre-Universidad in particular no Upper Cretaceous material was encountered.

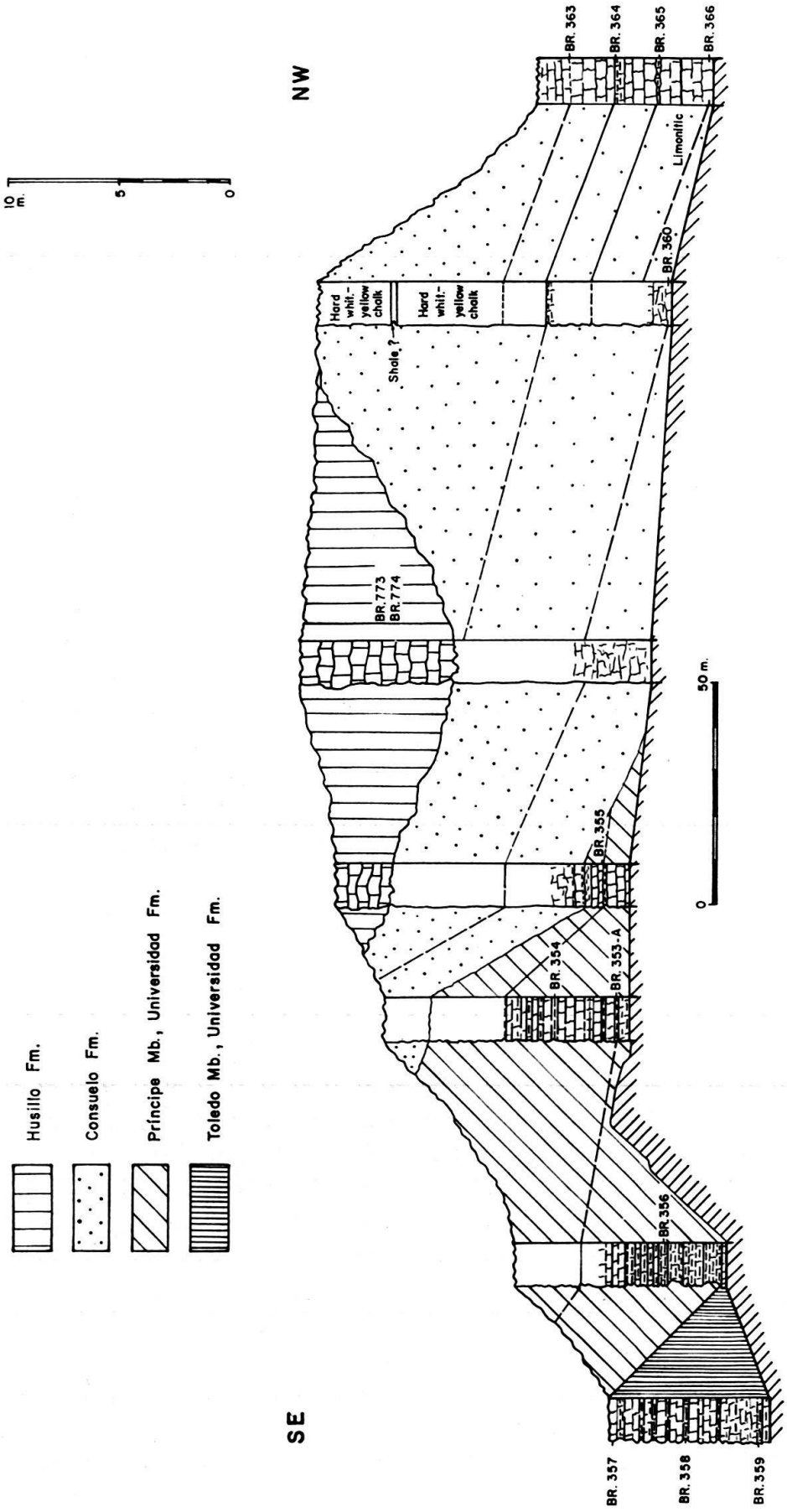


Fig. 60. Columnar section, southwestern cliff at Tejar Consuelo.

In terms of planktonic Foraminifera, the Universidad formation is zoned as follows:

d) *Hantkenina dumblei–Globigerinatheka barri* Zone	Príncipe Member	Universidad formation	Eocene: Middle
c) *Hantkenina mexicana–Globorotalia aragonensis* Zone			
b) *Globorotalia bullbrooki–Globorotalia aragonensis* Zone	Toledo Member		Eocene: Lower
a) *Globorotalia palmerae* Zone			

During the *Globorotalia palmerae* zone, the transition took place from the clastic flysch-type sedimentation of the Capdevila formation to the carbonate-type sedimentation of the Universidad formation. The *Globorotalia palmerae* zone therefore includes Capdevila and Universidad beds. It is of interest to note, that Bolli

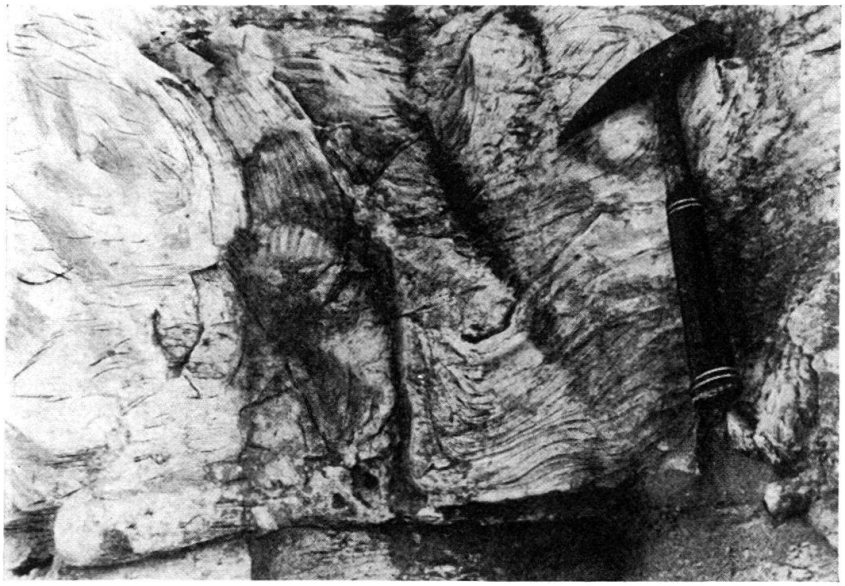


Fig. 61. Unconformity between Universidad formation, Príncipe member, below, and slumped and contorted Consuelo beds, above, Tejar Consuelo.

(1958, in Loeblich et al., p. 158) recognized in Trinidad a planktonic assemblage apparently intermediate between those of the *Globorotalia palmerae* and of the *Hantkenina aragonensis* [=*H. mexicana* Cushman] zones in which *Globorotalia palmerae* is no longer present and *Hantkenina mexicana* has not yet appeared. This intermediate assemblage is characteristic of our late Lower Eocene *Globorotalia bullbrooki–Globorotalia aragonensis* zone. The *Hantkenina dumblei–Globigerinatheka barri* zone is only locally preserved in the Habana area. It is representative of the 4 Middle Eocene zones proposed in Trinidad, B.W.I., between the *Hantkenina mexicana–Globorotalia aragonensis* zone and the Upper Eocene *Globigerapsis semiinvoluta* zone, which in our area appear to be of minor stratigraphic significance and, if present, probably only detectable by very close-spaced sampling. Forms diagnostic of this zone were found allochthonous in Consuelo beds.