Husillo formation

Objekttyp: **Chapter**

Zeitschrift: **Eclogae Geologicae Helvetiae**

Band (Jahr): **56 (1963)**

Heft 1

PDF erstellt am: **26.09.2024**

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

underlying the Tarará formation. Clearly, his name has priority over BERMÚDEZ' Jaruco formation. From the stratigraphic table on p. 145 it is evident, however, that the type locality of BRODERMANN's Jaruco formation is most probably the same as that of the Jaruco formation of BERMÚDEZ. We are therefore referring in the following to the more informative type locality report of BERMÚDEZ (1950, p. 270), who described the Jaruco formation as "una marga blanca amarillenta con mucha arena calcarea y gruesas capas de conglomerados costeros". The type locality, represented by Bermúdez station 614, is reported to be situated in the cut of the Central Hershey railroad near the town of Jaruco where ". . . las margas tienen la tendencia a consolidarse, formando una caliza grosera". We visited the type area and did not find any outcrops along the railroad of Central Hershey. The only outcrops were in the cuts of the railroad of the Ferrocarriles Unidos de la Habana close to the intersection with the railroad of Central Hershey where neither marls nor conglomerates were seen, the lithology being hard, whitish limestones with miogypsinas. BR station 886, described below, is from this locality.
Lithology: Limestone, fragmental, hard, in places vacuolar, white.
Texture: Microcrystalline groundmass, vacuolar, with densely packed fragments of mainly coralline algae, echinoderms, mollusks, and corals and encrusting Foraminifera. Common miogypsinas and amphisteginas. Rare planktonic Foraminifera. Texture similar to that of the hard fragmental Husillo limestones.

Assemblage:
- *Miogypsina* spp. (common)
- *Lepidocyclina* sp. (fragment only)
- *Amphistegina* cf. *angulata* CUSHMAN (common)
- *Archaias* cf. *operculiniformis* HENSON
- *Acervulina inhaerens* SCHULTZE
- *Gypsina globulus* REUSS
- *Sporadotrema* sp.
- *Globigerina* spp.

The top of the *Miogypsina*-bearing limestones and the contact with the underlying Toledo member of the Universidad formation are covered. The latter crops out in a small quarry north of the road from Campo Florido to Jaruco, just at the west entrance to Jaruco. The Universidad beds, documented by BR station 884, are of late Lower Eocene age, *Globorotalia bullbrooki–Globorotalia aragonensis* zone.

BR station 884
Lithology: Limestone, silicified, hard, white to pale greenish yellow.
Texture: Cryptocrystalline, silicified groundmass with abundant planktonic microfossils.

Assemblage:
- *Globigerina senni* (BECKMANN)
- *Globorotalia* sp. (truncate forms)
- *Chiloguembelina* sp.
- Radiolaria
- Coccoliths
- *Tremalithus eopelagicus* BRAMLETTE and RIEDEL
- *Discoaster aster* BRAMLETTE and RIEDEL (rare)
- *Discoaster barbadiensis* TAN (common)

Braarudosphaera discula BRAMLETTE and RIEDEL (common)
Thoracosphaera spp. (globular and ellipsoid bodies) (common).
Meyenella-like bodies (as described by RIEDEL, 1953) (rare)

Washed residue with

Globorotalia aragonensis NUTTALL
Globorotalia bullbrooki BOLLI
Globigerina senni (BECKMANN)
Catapsydrax unicavus BOLLI, LOEBLICH, and TAPPAN
Radiolaria.

The Jaruco formation is poorly defined lithologically and geographically. For this reason we prefer not to use Jaruco formation in the Habana area, and to introduce the Husillo formation for the mainly shallow-water beds between the deeper water Consuelo and Cojímar formations.

Description of the type locality of the Husillo formation

The type locality of the Husillo formation is situated in the Cantera Husillo 1.5 km east of the Colegio de Belén, Marianao, a western suburb of La Habana. The approximate coordinates of the type locality are 363.20 N and 356.00 E (index map, fig. 67). The low hill of about 60 m height called Loma del Husillo, a few hundred meters east of the type locality, is formed by Universidad beds which are also exposed in the easternmost part of the Husillo quarry. BR stations 845, 846, 940, 941, and 942, previously described under Universidad formation, are from the Príncipe member of this quarry. In the central part of the quarry, these beds are overlain unconformably by typical Oligocene Consuelo chalks which show strongly contorted bedding, evidence of submarine slumping. In the western part of the quarry the Consuelo beds are overlain unconformably by a series of beds, about 20 m thick, here designated the type section of the Husillo formation (columnar section, fig. 68 and photograph, fig. 69). The type Husillo consists of fine- to medium-grained, generally not well cemented reefal detritus of dominantly whitish color with a few intercalations of more shaley and chalky beds, and of pene-contemporaneous conglomerates and of bioherms. BR station 852 is from the basal bed of the formation which is a chalky calcirudite formed by reefal derived, loosely cemented material. This bed also contains angular boulders, BR station 855, and rounded isolated bioherms, BR station 854, built mostly by corals, coralline algae and benthonic Foraminifera, in particular encrusting forms and miogypsinas (photograph, fig. 70). The thickness of this bed is variable because of its transgressive character and its mode of deposition. On the average we measured about 2 m. On this basal bed follows a thin whitish to yellowish chalk represented by BR station 853. Then follow about 9 m of hard grayish reefal derived limestones, BR station 847, and white, chalky calcarenites, BR station 848, which in their top portion exhibit indications of cross-bedding, reminiscent of that observed in the dunes of the Pleistocene Santa Fé formation. This bed is overlain by 7 to 8 m of softer, more shaley and granular, whitish to yellowish gray chalks and chalky limestones where BR stations 944, 945, and 946 are located. It includes close to its base a 1 m thick, hard, reefal derived, yellowish gray calcirudaceous limestone, BR station 943. Just below BR station 945, about 1.5 m from the top of this section, occurs a distinct irregular limonitic intercalation which, in view of the micro-paleontological information and of the identical lithology above and below it, must be interpreted as an intraformational break probably caused by a brief period of

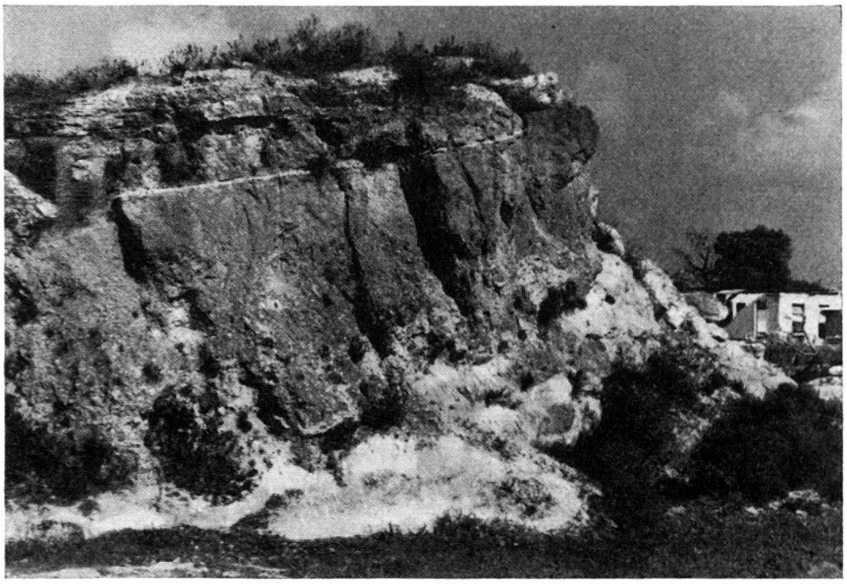

Fig. 69. Type section of the Husillo formation, eastern part of Cantera Husillo.

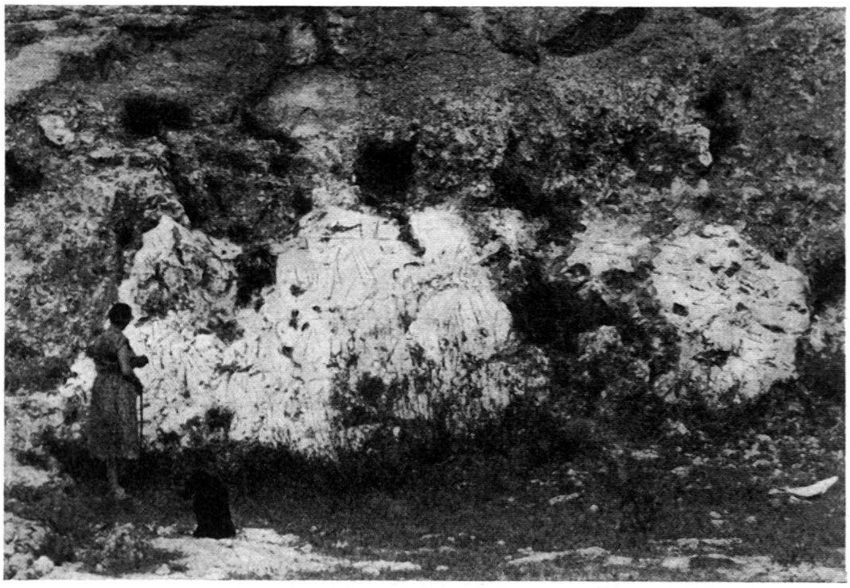

Fig. 70. Bioherms in the basal bed of the Husillo formation, cliff eastern part of Cantera Husillo.

emergence. It was noticed that the lithology of the chalky portion is similar to that of the type Cojímar, and close to that of BR station 1013A at Punta Brava, and to that of the Cacahual lithology outcropping east of the road from Santiago de las Vegas to Cacahual. On top of this chalky section there is again a 1 m thick reefal derived, calcirudaceous white limestone, where BR station 947 is located. The contact with the Cojímar formation forming the final cliff toward Marianao, is not exposed. However, it is believed that the dip-slope to the west-southwest of the top Husillo limestone bed represents actually an important lithologic boundary. From field evidence it is not clear whether the contact with the overlying Cojímar formation is disconformable or transitional. There is virtually no time gap, the Husillo beds being here in the *Globigerinatella insueta* zone and the Cojímar beds in the *Globorotalia fohsi* zone, and for paleontological reasons a pronounced unconformity is unlikely to exist.

The stratigraphic position of the type samples is given in the columnar section, fig. 68. They are from bottom to top:

BR station 852 (basal bed of the formation)
Lithology: Calcirudite, chalky, loosely cemented, white.
Texture: Cryptocrystalline to microcrystalline groundmass, vacuolar, with fragments of Corallinaceae and Dasycladaceae (*Halimeda* sp.), corals, echinoderms and bryozoas. Also common benthonic and rare planktonic Foraminifera.

Assemblage:
- *Miogypsina* sp. (fragments)
- *Lepidocyclina* sp. (spatulate equatorial chambers)
- *Operculinoides* sp.
- *Amphistegina* cf. *angulata* Cushman (common)
- *Quinqueloculina* spp.
- *Gypsina globulus* Reuss
- *Planorbulina mediterranensis* d'Orbigny
- *Planorbulinella larvata* (Parker and Jones)
- *Archaias* cf. *operculiniformis* Henson
- *Meandropsina* sp.
- *Sporadotrema cylindricum* (Parker)
- *Acervulina inhaerens* Schultze
- *Globigerina* spp.

Washed residue with
- *Globigerinatella insueta* Cushman and Stainforth (rare)
- *Globoquadrina altispira* (Cushman and Jarvis) group
- *Globoquadrina dehiscens* (Chapman, Parr, and Collins)
- *Globoquadrina venezuelana* (Hedberg) group
- *Globigerinoides subquadratus* Brönnimann
- *Globorotalia fohsi barisanensis* LeRoy
- *Globorotalia mayeri* Cushman and Ellisor.

BR station 854 (Bioherm)
Lithology: Limestone, fragmental, hard, dense, white.
Texture: Cryptocrystalline to microcrystalline groundmass with fragments of corals, algae, echinoderms and encrusting Foraminifera. Rare planktonic Foraminifera. Also fecal pellets without internal structures.

Assemblage:
- *Amphistegina* cf. *angulata* Cushman
- *Planorbulinella larvata* (Parker and Jones)
- *Acervulina inhaerens* Schultze
- *Archaias* cf. *operculiniformis* Henson
- *Dendritina* sp.

Gypsina globulus REUSS
Gypsina vesicularis (PARKER and JONES) *discus* GOËS
Globigerina spp.

BR station 855 (Pebble)
Lithology: Limestone, fragmental, hard, white.
Texture: Cryptocrystalline dense groundmass with fragments of echinoderms, mollusks, algae and larger benthonic Foraminifera.
Assemblage: *Miogypsina* sp.
Lepidocyclina sp. (fragment)
Archaias cf. *operculiniformis* HENSON
Gypsina globulus REUSS
Heterostegina cf. *antillea* CUSHMAN (fragment)
Amphistegina cf. *angulata* CUSHMAN
Acervulina inhaerens SCHULTZE
Globigerina spp.

BR station 853
Lithology: Chalk, marly, powdery, whitish to yellowish.
Washed residue with
Globigerinatella insueta CUSHMAN and STAINFORTH (rare)
Globorotalia mayeri CUSHMAN and ELLISOR
Globoquadrina altispira (CUSHMAN and JARVIS) group
Globoquadrina dehiscens (CHAPMAN, PARR, and COLLINS)
Globoquadrina venezuelana (HEDBERG) group.

BR station 847
Lithology: Limestone, fragmental, hard, pinkish gray to yellowish gray.
Texture: Cryptocrystalline to microcrystalline groundmass with fragments of algae, echinoderms and mollusks.
Assemblage: *Amphistegina* cf. *angulata* CUSHMAN
Acervulina sp.
Globigerina spp.

BR station 848
Lithology: Calcarenite, somewhat chalky, white.
Texture: Cryptocrystalline groundmass, in part vacuolar, with fragments of algae, echinoderms, mollusks, bryozoas and larger benthonic Foraminifera. Also structureless fecal pellets.
Assemblage: *Miogypsina* sp.
Heterostegina antillea CUSHMAN
Amphistegina cf. *angulata* CUSHMAN
Acervulina inhaerens SCHULTZE
Sporadotrema sp.
Carpenteria proteiformis GOËS
Gypsina globulus REUSS
Archaias cf. *operculiniformis* HENSON
Meandropsina sp. (small forms)
Globigerina spp.

Washed residue with

Globorotalia mayeri Cushman and Ellisor
Globorotalia fohsi barisanensis LeRoy
Globigerinoides bisphericus Todd
Globigerinoides trilobus (Reuss) group
Globoquadrina altispira (Cushman and Jarvis) group
Globoquadrina dehiscens (Chapman, Parr, and Collins)
Globoquadrina venezuelana (Hedberg) group
Chiloguembelina cubensis (D. K. Palmer)
Globorotalia cf. *spinuloinflata* (Bandy) } reworked
Globigerapsis index (Finlay) } reworked

BR station 943

Lithology: Calcirudite, hard, vacuolar, yellowish gray.
Texture: Clear calcite groundmass with pseudoölitic and fragmental components derived mainly from Corallinaceae and Dasycladaceae (*Halimeda* sp.), echinoderms, mollusks and benthonic Foraminifera. Also rounded fragments of limestones with globigerinids. Diameter of average components from about 300 to 1200 μ.

Assemblage:

Amphistegina cf. *angulata* Cushman
Heterostegina antillea Cushman
Sporadotrema cylindricum (Carter)
Planorbulinella larvata (Parker and Jones)
Acervulina inhaerens Schultze
Archaias cf. *operculiniformis* Henson (common)
Dendritina sp.
Meandropsina sp.
Peneroplis sp.
Miliolids
Gypsina globulus Reuss
Globigerina spp.

BR station 944

Lithology: Chalk, powdery, granular, indurated, whitish to yellowish.

Washed residue with

Globigerinoides bisphericus Todd
Globigerinoides trilobus (Reuss) group
Globigerina foliata Bolli
"*Globigerina*" *juvenilis* Bolli
Globoquadrina altispira (Cushman and Jarvis) group
Sphaeroïdinella grimsdalei (Keijzer)
Globorotalia fohsi barisanensis LeRoy
Globorotalia mayeri Cushman and Ellisor
Globorotalia cf. *scitula* (Brady).

BR station 945

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

Washed residue with

Globigerinoides bisphericus TODD
Globigerinoides sacculifer (BRADY)
Globigerinoides subquadratus BRÖNNIMANN
Globigerinoides trilobus (REUSS) group
"*Globigerina*" *juvenilis* BOLLI
Globoquadrina altispira (CUSHMAN and JARVIS) group
Globorotalia fohsi barisanensis LEROY
Globorotalia mayeri CUSHMAN and ELLISOR
Cassigerinella chipolensis (CUSHMAN and PONTON).

W. A. VAN DEN BOLD (letter 21. 3. 1963) identified from this station and from BR station 944 the following ostracodes:

Aurila deformis (REUSS)
Bairdia sp.
Jugosocythereis ? *vicksburgensis* (HOWE)
Loxoconcha cubensis V. D. BOLD
Perissocytheridea sp.
Quadracythere antillea (V. D. BOLD)
This assemblage is regarded by VAN DEN BOLD as about "Güines" in age.

BR station 946

Lithology: Limestone, chalky, granular, grayish yellow.

Texture: Cryptocrystalline to microcrystalline groundmass with abundant planktonic Foraminifera. As a rule the minute microfossils are destroyed through recrystallization.

Assemblage:
Globorotalia fohsi barisanensis LEROY
Globigerinoides sp.
Globoquadrina sp.
Coccoliths (rare)
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Discoaster cf. *woodringi* BRAMLETTE and RIEDEL (rare)
Braarudosphaera discula BRAMLETTE and RIEDEL (rare)
Braarudosphaera bigelowi (GRAN and BRAARUD) (rare)
Thoracosphaera sp. (globular bodies)
Gypsina globulus REUSS.

Washed residue with

Miogypsina sp.
Amphistegina cf. *angulata* CUSHMAN
Globigerinatella insueta CUSHMAN and STAINFORTH (rare)
Globoquadrina altispira (CUSHMAN and JARVIS) group
Globigerinoides trilobus (REUSS) group.

BR station 947

Lithology: Calcirudite, hard, white.

Texture: Fragmental to pseudoölitic, unsorted. Components angular to rounded fragments of algae, mainly Corallinacea, bryozoas and echinoderms. Also larger benthonic Foraminifera. Diameter of average components from about 100 to 2500 μ. Also rounded fragments of limestones. Matrix clear calcite or cryptocrystalline. Aspect of texture and faunal composition very similar to that of the Pleistocene calcarenites.

Assemblage: *Amphistegina* cf. *angulata* Cushman
Archaias cf. *operculiniformis* Henson
Meandropsina sp.
Acervulina inhaerens Schultze
Gypsina globulus Reuss
Sporadotrema sp.

Other outcrops of the Husillo formation

Tejar Consuelo and vicinity

On top of the western cliff of Tejar Consuelo, a hard, cavernous reefal limestone with miogypsinas of maximum 7 m thickness fills the erosional channels in the highest beds of the Consuelo formation. This limestone is separated from the light colored Consuelo chalks by a red, limonitic layer suggesting emergence prior to its deposition. BR stations 773 and 774 are random samples from the *Miogypsina* limestone. Reference is made to the index map of Tejar Consuelo, fig. 59, and to the columnar sections, fig. 60.

BR stations 773 and 774

These samples are very similar lithologically and faunally and therefore described together.

Lithologies: Limestone, hard, vacuolar, fragmental, whitish to grayish yellow.

Textures: Cryptocrystalline groundmass with fragments of Corallinaceae and Dasycladaceae (*Halimeda* sp.), echinoderms, corals, bryozoas and encrusting Foraminifera. Common miogypsinas and amphisteginas.

Assemblages: *Miogypsina* spp.
Acervulina inhaerens Schultze
Gypsina globulus Reuss
Sporadotrema cylindricum (Carter)
Amphistegina cf. *angulata* Cushman
Meandropsina sp.
Archaias cf. *operculiniformis* Henson
Globigerina spp.

West-southwest of Tejar Consuelo along Calle San Antonio, Reparto Bosque de La Habana, coordinates 365.13 N and 356.32 E, the same fragmental limestone, represented by BR station 843, can be seen with the same relationship toward the Consuelo beds documented by BR station 844.

BR station 843 (Husillo formation)

Lithology: Limestone, coralligen, hard, grayish yellow.

Texture: Cross section of coral. Cavities filled with cryptocrystalline minutely fragmental groundmass.

Assemblage: *Amphistegina* cf. *angulata* CUSHMAN
Acervulina inhaerens SCHULTZE

BR station 844 (Consuelo formation)
Lithology: Chalk, granular, powdery, very pale orange.
Washed residue with
Globigerina ampliapertura BOLLI
Globigerina rohri BOLLI group
Chiloguembelina cubensis (D. K. PALMER)

Cantera de Vento

In the easternmost of the 3 quarries called Cantera de Vento, coordinates 356.09 N and 356.30 E, about 2.5 km south of Capdevila on the western side of the highway to Rancho Boyeros, a few decimeters of fragmental Husillo beds with miogypsinas overlie in the northern part of the quarry unconformably Lower Eocene Capdevila graywacke silts and shales. BR station 583 is from the *Miogypsina* limestone which is separated from the Capdevila beds by a thin calcite crust. In the western and southern part of this quarry occur about 10 m of hard

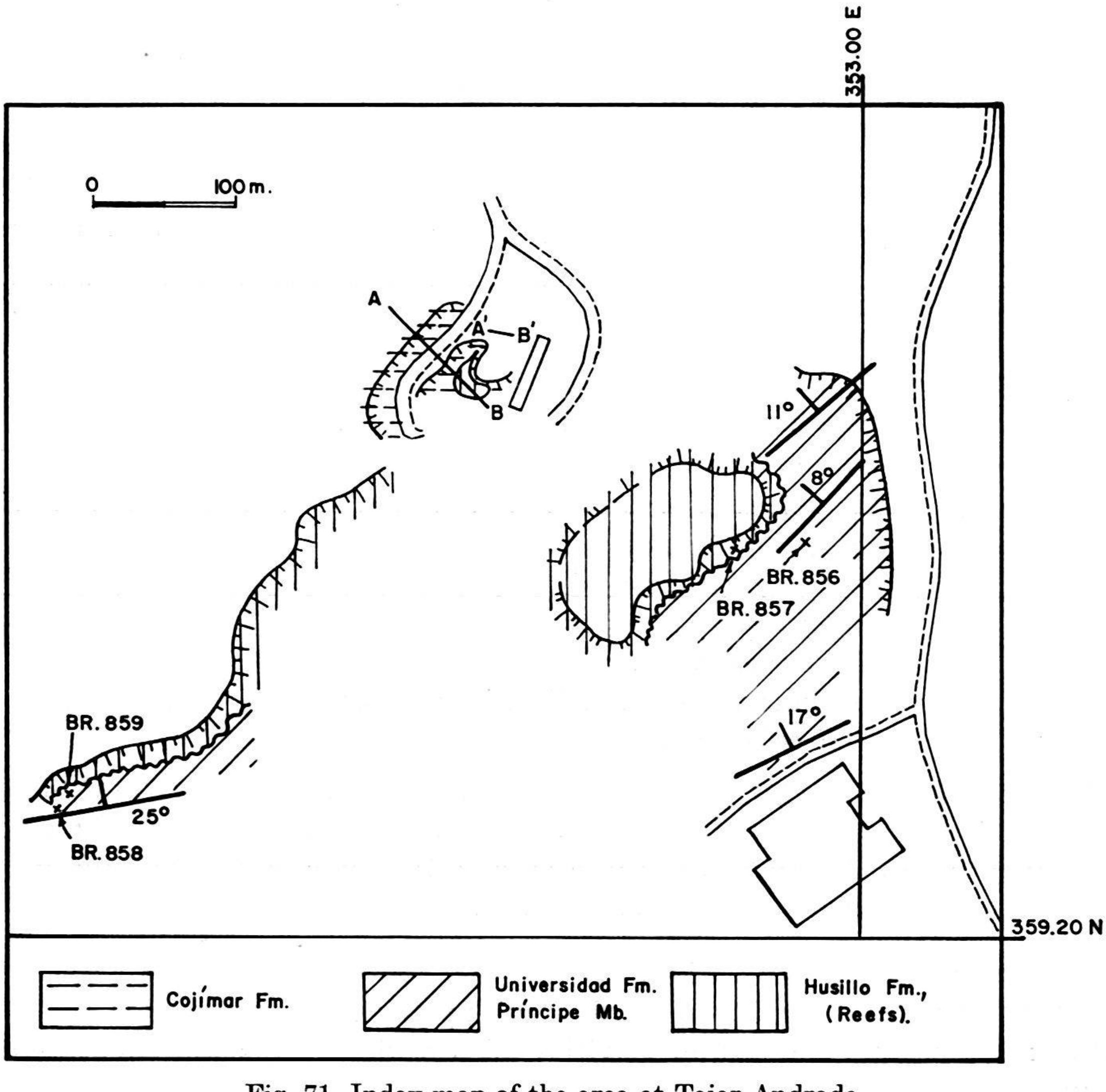

Fig. 71. Index map of the area at Tejar Andrade.

massive Husillo and Capdevila beds cut by a minor east striking fault. BR stations 584 and 606 are from the hard massive limestone which is lithologically and texturally similar to that found in the Pogolotti Quarry, Marianao area.

BR stations 583 and 606

Lithologies and faunas from these stations are practically identical and therefore reported together.

Lithologies: Calcirudite, not well-cemented, with large yellowish orange "clay" inclusions, yellowish gray to grayish yellow (583), calcirudite, well-cemented, grayish orange (606).

Textures: Microcrystalline groundmass with abundant miogypsinas, lepidocyclinas and other larger benthonic Foraminifera, fragments of echinoderms, algae and mollusks. Some planktonic Foraminifera. Also angular fragments of limestones.

Assemblages:
- *Miogypsina* spp.
- *Miogypsinoides* sp.?
- *Lepidocyclina* sp. with spatulate equatorial chambers
- *Lepidocyclina* (*Lepidocyclina*) sp.
- *Amphistegina* cf. *angulata* CUSHMAN
- *Sporadotrema cylindricum* (CARTER)
- *Operculinoides* sp.
- *Acervulina inhaerens* SCHULTZE
- *Carpenteria* sp.
- *Gypsina globulus* REUSS
- *Archaias* cf. *operculiniformis* HENSON
- *Globigerina* spp.

BR station 584

Lithology: Limestone, fragmental, hard, whitish to very pale orange.

Texture: Cryptocrystalline to microcrystalline groundmass with fragments of algae, bryozoas, echinoderms and mollusks. Some benthonic and planktonic Foraminifera.

Assemblage:
- *Miogypsina* sp.
- *Amphistegina* cf. *angulata* CUSHMAN
- *Operculinoides* sp.
- *Lepidocyclina* sp. with spatulate equatorial chambers
- *Acervulina inhaerens* SCHULTZE
- *Gypsina globulus* REUSS
- *Planorbulinella larvata* (PARKER and JONES)
- *Globigerina* spp.

Tejar Andrade

In Tejar Andrade, perfectly preserved bioherms of the Husillo formation are overlain, apparently disconformably, by the deeper water Cojímar chalks of the *Globorotalia fohsi* zone. The location of the following random samples from these bioherms is shown in the location map, fig. 72 and in the cross sections, fig. 73.

BR station 857

Lithology: Limestone, hard, fragmental, vacuolar, white.

Texture: Cryptocrystalline groundmass, vacuolar in places, with fragments of

Corallinacea and Dasycladaceae (*Halimeda* sp.), encrusting Foraminifera, echinoderms, bryozoas, and mollusks. Common amphisteginas.

Assemblage: *Amphistegina* cf. *angulata* CUSHMAN
Meandropsina sp.
Acervulina inhaerens SCHULTZE.

BR stations 859 and 862

These samples are lithologically and faunally very similar and here described together.

Lithologies: Limestone, hard, fragmental, with abundant Dasycladaceae, somewhat vacuolar, white to yellowish gray.

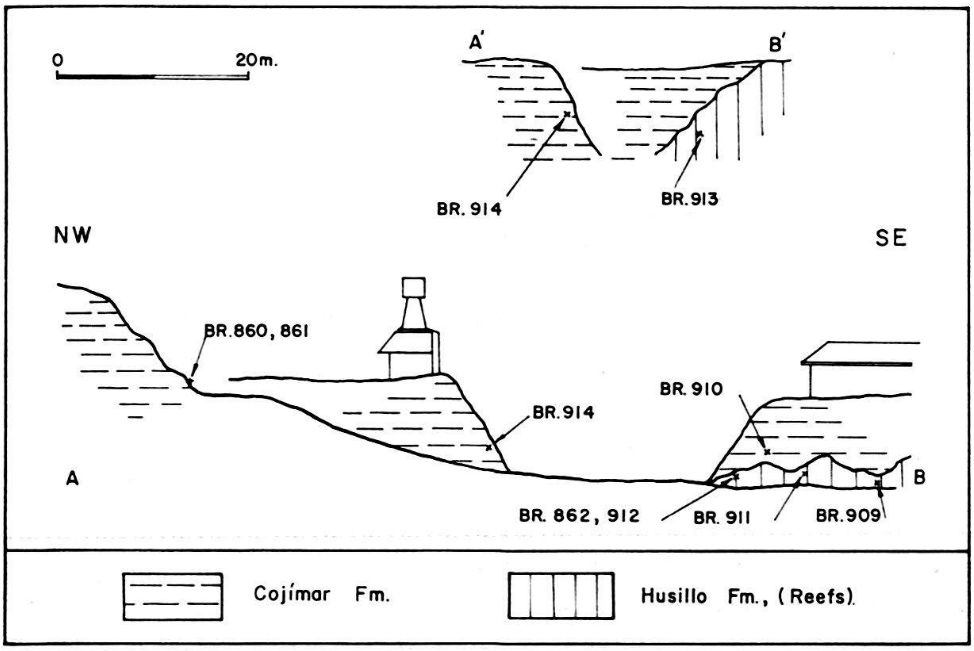

Fig. 72. Cross sections at Tejar Andrade.

Textures: Cryptocrystalline groundmass, recrystallized in places, with fragments of Corallinaceae, Dasycladaceae (*Halimeda* sp.), corals, encrusting Foraminifera, echinoderms, mollusks. Common amphisteginas and some globigerinas.

Assemblages: *Amphistegina* cf. *angulata* CUSHMAN
Archaias cf. *operculiniformis* HENSON
Meandropsina sp.
Sporadotrema sp.
Acervulina inhaerens SCHULTZE
Gypsina globulus REUSS
Globigerina spp.

BR station 909 A

Lithology: Limestone, hard, fragmental, white to yellowish gray.

Texture: Cryptocrystalline to microcrystalline groundmass, in places vacuolar, with fragments of Corallinaceae, Dasycladaceae, bryozoas, echinoderms, encrusting Foraminifera, corals and mollusks. Common heterosteginas and some globigerinas.

Assemblage: *Amphistegina* cf. *angulata* CUSHMAN
Heterostegina antillea CUSHMAN
Sporadotrema sp.
Planorbulina mediterranea D'ORBIGNY
Acervulina inhaerens SCHULTZE
Gypsina globulus REUSS
Archaias cf. *operculiniformis* HENSON
Meandropsina sp.
Globigerina spp.

BR station 911
Lithology: Limestone, chalky, fragmental, white to grayish yellow.
Texture: As BR station 909A.
Assemblage: *Heterostegina antillea* CUSHMAN
Amphistegina cf. *angulata* CUSHMAN
Meandropsina sp.
Archaias cf. *operculiniformis* HENSON
Peneroplis sp.
Acervulina inhaerens SCHULTZE
Sporadotrema sp.
Globigerinoides cf. *bisphericus* TODD
Globigerina spp.

BR station 913
Lithology: Limestone, hard, fragmental, whitish.
Texture: As BR stations 909A and 913.
Assemblage: *Amphistegina* cf. *angulata* CUSHMAN
Acervulina inhaerens SCHULTZE
Planorbulinella larvata (PARKER and JONES)
Gypsina globulus REUSS
Archaias cf. *operculiniformis* HENSON
Sporadotrema sp.

Pogolotti Quarry

About 10 m of rather flat-lying Husillo limestones are exposed in the Pogolotti quarry, Marianao, coordinates 361.45 N and 355.54 E. Random samples from the hard, whitish biohermal, in part fragmental to conglomeratic limestones are BR stations 976 and 977. The conglomeratic limestone contains large pebbles of Cacahual-type chalky limestone as described under BR station 978.

BR stations 976 and 977
The samples from these stations are very similar and therefore described together.
Lithologies: Limestone, algal, finely fragmental, white to yellowish gray (976), very light gray (977).
Textures: Microcrystalline groundmass of clear calcite with abundant fragments of Corallinaceae, Dasycladaceae (*Halimeda* sp.), echinoderms, bryozoas, mollusks and encrusting Foraminifera.

Assemblages:
Miogypsina sp.
Heterostegina antillea CUSHMAN
Amphistegina cf. *angulata* CUSHMAN
Sporadotrema sp.
Acervulina inhaerens SCHULTZE
Gypsina globulus REUSS
Archaias cf. *operculiniformis* HENSON
Meandropsina sp.
Globigerina spp.

BR station 978 (Pebbles of Cacahual-type limestone embedded in the reefal detrital limestone of BR stations 976 and 977).
Lithology: Limestone, hard, grayish orange to dark yellowish orange (pebbles), and limestone, hard, medium light gray (matrix).
Texture of pebbles: Cryptocrystalline groundmass with abundant planktonic Foraminifera.

Assemblage of pebbles:
Chiloguembelina cubensis (D. K. PALMER)
Globoquadrina dehiscens (CHAPMAN, PARR, and COLLINS)
Globorotalia cf. *praemenardii* CUSHMAN and STAINFORTH
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL? (large specimen)
Braarudosphaera bigelowi (GRAN and BRAARUD)
Discoaster cf. *aster* BRAMLETTE and RIEDEL
Discoaster deflanderi BRAMLETTE and RIEDEL
Discoaster woodringi BRAMLETTE and RIEDEL
Transitional forms between *D. woodringi* BRAMLETTE and RIEDEL and *D. deflandrei* BRAMLETTE and RIEDEL
Thoracosphaera sp. (globular bodies).

Quarry north of Cacahual

Described below are random samples collected in the large abandoned quarry north of Cacahual on the eastern side of the road from Santiago de las Vegas to Cacahual, about 800 m south of Santiago de las Vegas. About 10 to 15 m of fine-grained limestones here generally referred to as Cacahual limestones, are exposed. The *Discoaster* assemblage of these samples is identical with that reported above from the pebbles in the detrital limestone collected in the large quarry near Pogolotti.

BR stations 64–66, 933, 934

These random samples are lithologically and faunally virtually identical and here summarized in order to avoid repetition.
Lithologies: Limestone, chalky, granular through accumulation of tests of planktonic Foraminifera, friable, grayish orange.
Textures: Cryptocrystalline to microcrystalline groundmass with abundant planktonic microfossils.

Assemblages: *Globigerina* spp.
Globigerinoides spp.
Coccoliths
Tremalithus eopelagicus BRAMLETTE and RIEDEL ?
Discoaster aster BRAMLETTE and RIEDEL (common)
Discoaster barbadiensis TAN (rare)
Discoaster deflandrei BRAMLETTE and RIEDEL (common)
Discoaster woodringi BRAMLETTE and RIEDEL (common)
Braarudosphaera bigelowi (GRAN and BRAARUD) (rare)
Transitional forms between *D. woodringi* BRAMLETTE and RIEDEL and *D. deflandrei* BRAMLETTE and RIEDEL (common)
Thoracosphaera spp. (common).

Washed residue with
Globigerinatella insueta CUSHMAN and STAINFORTH (rare)
Porticulasphaera transitoria (BLOW)
Globoquadrina altispira (CUSHMAN and JARVIS) group
Globoquadrina dehiscens (CHAPMAN, PARR, and COLLINS)
Globigerinoides bisphericus TODD
Globigerinoides subquadratus BRÖNNIMANN
Globigerinoides trilobus (REUSS)
"*Globigerina*" *juvenilis* BOLLI
Globigerina rohri BOLLI group
Globigerina cf. *triloculari*s D'ORBIGNY
Globorotalia fohsi barisanensis LEROY
Globorotalia mayeri CUSHMAN and ELLISOR.

Cantera Cuyuji

Cantera Cuyuji is situated about 600 m east-northeast of the Cantera de Vento, approximate coordinates 356.40 N and 356.80 E. The relation of the Husillo limestones toward the Capdevila clastics is the same as in the Cantera de Vento. The main cliff of the quarry is broken by a number of minor east–west striking faults. The Husillo limestone, here about 15 m thick, is folded into a gentle anticline of the same east–west strike. The lithology is a porous, fragmental, whitish limestone. In places the beds follow the irregular surfaces of perfectly preserved harder and cavernous coral bioherms. Attitude and lithology of the beds and bioherms give the Husillo formation an irregular aspect which was also noticed at the type section at Tejar Husillo. BR station 607 is from the bottom of the quarry, BR station 608 is from its northern cliff.

BR station 607
Lithology: Limestone, chalky, fragmental, whitish to very pale orange.
Texture: Cryptocrystalline to microcrystalline vacuolar groundmass with abundant miogypsinas and other benthonic and some planktonic Foraminifera and with fragments of algae, bryozoas, echinoderms and mollusks.

Assemblage: *Miogypsina* spp.
Sporadotrema cylindricum (CARTER)

Acervulina inhaerens SCHULTZE
Gypsina globulus REUSS
Amphistegina cf. *angulata* CUSHMAN
Archaias cf. *operculiniformis* HENSON
Globigerina spp.

BR station 608
Lithology: Limestone, chalky, powdery, fragmental, finely vacuolar, whitish.
Texture: Cryptocrystalline to microcrystalline in part vacuolar groundmass with abundant fragments of algae, mollusks, corals, echinoderms and bryozoas. Common miogypsinas and other benthonic Foraminifera. Some globigerinas.
Assemblage: *Miogypsina* spp.
Lepidocyclina sp. with spatulate equatorial chambers
Lepidocyclina (*Lepidocyclina*) sp.
Operculinoides sp.
Amphistegina cf. *angulata* CUSHMAN
Gypsina globulus REUSS
Acervulina inhaerens SCHULTZE
Archaias cf. *operculiniformis* HENSON
Sporadotrema sp.
Planorbulinella larvata (PARKER and JONES)
Globigerina spp.

Outcrop on the road from Barreras to the Vía Blanca, south of Playa Tarará

An outcrop of massive *Miogypsina* limestones outside of the Habana area proper, here referred to as the Husillo formation, can be seen in a small abandoned quarry on the northwestern side of the road from Barreras to the Vía Blanca, just southwest of the Reparto Alturas de Boca Ciega, coordinates 370.28 N and 376.99 E. The orbitoidal Husillo limestones of BR station 889 described under Urría beds, rest unconformably on Urría dolomite or Lower Eocene beds. The actual thickness of the Husillo formation is not known and its relationship to younger formations was not studied in detail. BERMÚDEZ (1950, p. 271) mentioned *Miogypsina*-bearing marls about 2 km south of Playa Tarará at his stations 594 to 597 and assigned them to the Jaruco formation. The outcrop referred to by BERMÚDEZ is very likely the same as the one described here.

On the west of the road immediately north of the abandoned quarry described above, coordinates 370.37 N and 376.89 E, a white friable chalk is interbedded in harder Husillo limestones. The fauna from this chalk, Sisson station 31, contains apart from miogypsinas and *Almaena alavensis* (D. K. PALMER), a well preserved planktonic assemblage with

Globigerina rohri BOLLI (group)
Globoquadrina altispira (CUSHMAN and JARVIS)
Globoquadrina dehiscens (CHAPMAN, PARR, and COLLINS)
Globoquadrina venezuelana (HEDBERG)
Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ) (common)

which refers it to the *Catapsydrax dissimilis* zone.

Quarry East of Punta Brava

The location of this quarry has been explained in the chapter on the Upper Eocene Punta Brava formation. Unconformably on the whitish to yellowish Consuelo beds there were exposed in the early summer of 1958 about 5 m of yellowish to orange conglomeratic chalky marls and chalky limestones. Details of the contact between the truncated Consuelo formation and the younger beds as it was observed at that time are illustrated in fig. 66. The conglomeratic beds carry abundant discoid and sellate lepidocyclinas, pelecypods, echinoderms, corals. Microfaunas from 2 horizons within the conglomeratic beds, represented by BR stations 376 and 383, were previously described in the explanations to the columnar section of the Punta Brava formation (fig. 65). The top of these beds was not exposed when the stratigraphic succession was first studied. In the course of the late summer of 1958, the Punta Brava quarry was completely filled up. South of the southeastern part of the former quarry new excavations exposed about 5 to 10 m of yellowish orange and yellowish gray chalks and fragmental limestones overlying the conglomeratic beds with lepidocyclinas. The thickness is estimated because the gentle dip cannot be exactly determined. The top of these limestones is formed by a fragmental limestone with scattered pebbles similar to those collected from the underlying *Lepidocyclina* horizon of the *Globigerina ciperoensis–Globorotalia opima* zone. With the exception of these pebbles, the fragmental limestone is lithologically virtually identical with the fragmental Husillo limestones of the Husillo–Pogolotti–Andrade outcrops of the Marianao area. The relationship with the conglomeratic and fragmental limestones of the Pogolotti quarry is striking. The lower and thicker part of these upper beds, however, is a finely granular yellowish to dark orange, chalky limestone with abundant planktonic microfossils. It is lithologically identical with the Cacahual limestone and contains *Globigerinoides bisphericus* TODD, *Globigerinoides subquadratus* BRÖNNIMANN and *Globigerinatella insueta* CUSHMAN and STAINFORTH. The fact that no lithologic break can be seen between the *Lepidocyclina*-bearing conglomeratic beds of the *Globigerina ciperoensis–Globorotalia opima* zone and the younger chalks of Cacahual type of the *Globigerinatella insueta* zone suggests that the conglomerates and the chalks are probably separated by a disconformity rather than by a significant unconformity.

BR station 1014 (conglomeratic beds with lepidocyclinas)

See also descriptions of BR stations 383 and 376.

Lithology: Chalk, friable, powdery, pale to dark yellowish orange.

Washed residue with

Catapsydrax dissimilis (CUSHMAN and BERMÚDEZ)
Globigerina euapertura JENKINS
Globigerina ciperoensis angulisuturalis BOLLI
Globigerina ciperoensis angustiumbilicata BOLLI (abundant)
Globigerina ciperoensis ciperoensis BOLLI (abundant)
Globigerina rohri BOLLI (group)
Globigerina cf. *trilocularis* D'ORBIGNY
Globoquadrina venezuelana (HEDBERG)
Globorotalia opima nana BOLLI

Globorotalia opima opima Bolli
Globorotaloides suteri Bolli
Chiloguembelina cubensis (D. K. Palmer)
Pseudohastigerina micra (Cole).

W. S. Cole (letter, Feb. 23, 1959) identified from this sample
Operculinoides dius (Cole and Ponton)
Lepidocyclina (Lepidocyclina) giraudi R. Douvillé
Lepidocyclina (Lepidocyclina) wayland-vaughani Cole
Lepidocyclina (Lepidocyclina) yurnagunensis Cushman
Lepidocyclina (Eulepidina) undosa Cushman.

Cole places this assemblage in the *Lepidocyclina (Lepidocyclina)–Lepidocyclina (Eulepidina)* zone, which he proposed as the lower zone of the Oligocene, and correlates it approximately with the Suwannee limestone of Florida. He does not regard it as forming the basal part of his lower zone. This opinion is supported by the planktonic Foraminifera diagnostic of the *Globigerina ciperoensis–Globorotalia opima* zone, which overlies the basal Oligocene *Globigerina ampliapertura* zone.
BR station 1013A (Cacahual lithology)
Lithology: Limestone, hard, granular, pale yellow orange.
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils and rare fragments of lepidocyclinas and algae.

Assemblage:
Globigerina spp. (abundant)
Chiloguembelina cubensis (D. K. Palmer)
Lepidocyclina sp.
Coccoliths
Tremalithus eopelagicus Bramlette and Riedel (large specimens)
Discoaster woodringi Bramlette and Riedel
Braarudosphaera bigelowi (Gran and Braarud)
Thoracosphaera sp.

BR station 1013 (Husillo-type fragmental and conglomeratic limestones and Cacahual-type chalk, limestone)
Lithologies: Chalk, indurated, yellowish to yellowish gray (1), calcarenite to calcirudite, hard, pale yellowish orange (2) and (3), calcirudite, conglomeratic, yellowish gray (4).

(1) Texture: as BR station 1013A.
Assemblage: As BR station 1013A.
(2), (3) and (4) Textures: Microcrystalline groundmass with fragments of algae, mollusks, echinoderms, bryozoas, and benthonic Foraminifera, and larger rounded inclusions of cryptocrystalline material. Lepidocyclinas and large rotalias are common. Diameter of average components from about 150 to 1500 μ.

Assemblages:
Pararotalia mexicana mecatepecensis (Nuttall)
Lepidocyclina spp.
Amphistegina cf. *angulata* Cushman
Operculinoides sp.
Globigerina spp.

Gypsina globulus REUSS
Carpenteria sp.
Sporadotrema sp.
Planorbulina mediterranensis D'ORBIGNY
Discoaster deflandrei BRAMLETTE and RIEDEL } in reworked
Thoracosphaera sp. } component

Whether the conglomeratic *Lepidocyclina* beds of BR stations 376, 377, 383 and 1014 are a local transgressive facies of the basal Husillo formation or whether they are a new lithologic unit between the deep-water Consuelo formation and the generally shallow-water Husillo formation sensu stricto, cannot be answered from the isolated outcrop at Punta Brava alone. Although we tentatively and for convenience sake assigned the *Lepidocyclina* beds to the Husillo formation, we prefer to leave this problem open. In our opinion it can only be resolved by further field studies south and west of Punta Brava. BRODERMANN (1943, stratigraphic table, p. 145) distinguished in his stratigraphic succession beds with large lepidocyclinas underlying those described from the water well near Finca Adelina and overlying his Guatao formation. From the localities mentioned by BRODERMANN it appears that the beds with large lepidocyclinas represent a stratigraphic horizon which can be followed over a wide area. At Punta Brava they are separated from the Consuelo formation by a distinct unconformity and for this reason they are not regarded as a shallow-water facies of the Consuelo formation [=Tinguaro formation of Bermúdez and Palmer] although both belong to the *Globigerina ciperoensis–Globorotalia opima* zone.

The age of the transgressive Husillo beds seems to change from area to area. At the Husillo type locality, they form part of the *Globigerinatella insueta* zone, BR station 852, and near the quarry north of Barreras on the road to Tarará, a planktonic microfauna diagnostic of the *Catapsydrax dissimilis* zone occurs in chalks interbedded in typical Husillo limestones with *Miogypsina* and *Heterostegina antillea*, Sisson station 31. In the Punta Brava area, the transgressive beds with large *Lepidocyclina* carry the planktonics of the *Globigerina ciperoensis–Globorotalia opima* zone. The Husillo formation thus would range from the *Globigerina ciperoensis–Globorotalia opima* zone to the *Globigerinatella insueta* zone. The *Globorotalia kugleri* zone which is within this interval, was not found in the Habana area. This may be explained by the transgressive nature, in the rim-rock area, of the Husillo beds. Southward of the mainly shallow-water reefal complex Husillo beds may be replaced by deeper water deposits of the Cacahual-type and it is expected that in this facies the complete planktonic zonal sequence will be present. This facies change is clearly indicated by the occurrence of a thin Cacahual-type layer between reefal limestones in the Husillo quarry and by the thicker Cacahual-type limestones southward at Punta Brava.

Environment and age

The type section of the Husillo formation is composed of the following principal lithologies:

a) Calcarenites and calcirudites.

Loosely or firmly cemented with calcite, porous. Groundmass in thin section generally vacuolar, cryptocrystalline to microcrystalline, occasionally of clear calcite, with more or less densely packed transported fragments of rocks of types (b), (c) and (d) and comminuted fragments of mollusks, corals, echinoderms, bryozoas, encrusting and other benthonic Foraminifera, and of algae, mainly Corallinaceae and Dasycladaceae (*Halimeda* sp.). Orbitoidal and planktonic Foraminifera usually occur in the groundmass between the above listed components but rarely in great numbers. Structureless fecal pellets were occasionally noticed. Environment: Reefal complex.

b) Fragmental limestones.
Dense, cryptocrystalline to microcrystalline groundmass which contains in form of discrete inclusions essentially the same suite of components as the rocks described under (a). Environment: Reefal complex.

c) Chalky limestones.
Cryptocrystalline to microcrystalline groundmass containing abundant planktonic microfossils. Environment: Relatively deep water.

d) Chalks.
Generally friable, powdery, with abundant planktonic microfossils. Environment: Relatively deep water.

Isolated, in places interconnected, irregularly rounded bioherms with large corals characterize the basal transgressive bed of the type section of the Husillo formation, demonstrating that this bed is from the reefal area sensu stricto. We do not know whether there was a continuous fringing reef landwards of these isolated or semi-isolated bioherms or whether they are representative of the open-shoal type of reef as defined by HENSON (1950, p. 23). The bioherms are buried by or associated with comminuted organic material derived from reefs by wave action and later consolidated into a porous, loosely or firmly cemented calcareous sand. Comminuted reefal derived material and occasional fragments of older limestones form the younger detrital beds of the type section. Bioherms, however, were not found in these younger beds, which for reasons explained below were probably deposited in the fore-reefal area.

The lithologies described under (a) and (b) were laid down in the area of the reef complex in the sense of Henson. The environmental types of the reef complex can best be determined by groups of fossils with living representatives of which the ecology is known. Orbitoidal Foraminifera such as lepidocyclinas and miogypsinas therefore can only be indirectly considered for paleoecologic conclusions. On the other hand, the environmental significance of peneroplids, amphisteginids, heterosteginas, *Operculinoides* and certain Dasycladaceae, all forms which occur throughout the Husillo samples, will be examined below in some detail.

It is significant that miliolids, frequent in the back-reef areas, are scarce in the Husillo type samples. Whole tests and fragments of peneroplids, represented by *Archaias* cf. *operculiniformis* HENSON, *Meandropsina* n. sp. (small form), *Peneroplis* sp., *Dendritina* sp. and *Sorites* cf. *orbiculus* (FORSKÅL) occur in most samples but are generally scarce. A noteworthy exception is BR station 943, which is from a hard porous calcirudite with a clear calcite groundmass where *Archaias* cf. *operculiniformis* HENSON is common. The peneroplids are one of the biostratigraphically more important groups of the post-Husillo strata, in particular of the relatively shallow-water Güines to Recent beds. According to NORTON (1930), MYERS (1942, 1943), and HENSON (1950, pp. 22–24), living peneroplids prefer clear, shallow water of temperatures ranging from 18.9°C to 31.4°C. They are particularly abundant down to 5 fathoms depth, rarely occur below 60 fathoms, and apparently do not flourish on mud bottoms. HENSON noted further that most peneroplids are rare in the actual reef rocks, and where the latter form a distinct fringing reef, the back-reef "Miliolid–Peneroplid biofacies" may be quite sharply limited from the fore-reef "Nummulitic–Orbitoid biofacies". In areas of patchy bioherms, however, this boundary may not be as clearly developed and the peneroplids and miliolids are often scattered through the surrounding calcareous sands derived from reef erosion. Reviewing the environments in which fossil peneroplids occur, HENSON finds that they are not necessarily restricted to the back-reef areas but also inhabit the reef limestones proper and may extend into the fore-reef areas, but doubts if they actually lived there. According to MOORE (1947, pp. 732 and 734), Peneroplidae, i.e. *Peneroplis pertusus, Sorites, Archaias,* occur in the Florida Keys mainly in the back-reef environment and also, but rarely, in the shallow fore-reef area down to a depth of 102 feet. Peneroplidae and Amphisteginidae, the latter with *Amphistegina* cf. *angulata* CUSHMAN also very frequent in our material, are the dominant Foraminifera in the sediments of the reefal area, and reach their peak abundance on the outer reef patches, that is in the shallow fore-reef area. The great abundance of peneroplids in the shallow-water Florida Bay, where no live forms were found, is interpreted by MOORE as accumulations through sorting or as accumulations from previous geologic time when the environment was such that peneroplids could live in this area. The ecologic results of MOORE are particularly significant because they refer to an area close to Cuba, and as the environments of fossil peneroplids are according to HENSON (1950, p. 21) closely analogous to those favored by Recent species, it may be inferred that the environments of the biohermal and reefal detrital beds of the Husillo formation were probably very similar to those of the Recent reefal and shallow fore-reefal areas along the east coast of Florida, but perhaps with stronger fore-reef influence as indicated by the occasionally abundant lepidocyclinas, miogypsinas, *Heterostegina antillea* CUSHMAN, *Operculinoides* and by the consistent but never dominant occurrence of planktonic microfossils.

Heterostegina, another important genus represented in the Husillo beds, is flourishing in temperatures from about 22°C to 27°C and in depths down to perhaps 40 fathoms (NORTON, 1930, p. 347). COLE (1958, p. 750) found *Heterostegina suborbicularis* D'ORBIGNY in the vicinity of Bikini and the Philippine islands at an average depth of 25 to 52 fathoms. This author (1958, p. 751) comes to the conclusion that "The sediments which contain *Heterostegina, Lepidocyclina,* and similar genera probably accumulated at shallower depth [than 70 fathoms]". The best estimate for depth of accumulation of such sediments would be around 25–40 fathoms. This depth interval partly lies within the deeper fore-reef area of the northern Florida Keys.

Operculinoides, a genus recently put by COLE (1959) into synonymy with *Operculina*, occurs virtually throughout the Husillo samples, but is never abundant.

It also occurs with *Operculinoides cojimarensis* (D. K. PALMER) in the Cojímar beds. *Operculina* was found in the vicinity of the Philippine Islands and Bikini from 10 to 1105 fathoms (CUSHMAN, 1921) and from 10 to 410 fathoms (CUSHMAN, TODD, and POST, 1954). The average depth at which *Operculina* was frequent or common is 25 fathoms (Bikini) and 70 fathoms (Philippines). *Operculina* is common in slightly greater average depth than *Heterostegina* and the peneroplids.

Restricted environments are also represented but appear to be the exception for the Husillo formation. A singular oölitic limestone with crab coprolites encountered in the large quarry 1.5 km west-southwest of Santa María del Rosario, is here regarded as deposited under lagoonal bank-type conditions. The fragments of calcareous algae, in particular of *Halimeda* LAMOUROUX, 1812, a tropical Dasycladacea, known from 0 to 80 m depth, which is abundant, occasionally rock-forming in some of the detrital Husillo beds from Tejar Andrade, the Husillo quarry and the quarry near Pogolotti, is suggestive of lagoonal and reefal environments or nearness to these environments. Green algae such as *Caulerpa* and *Halimeda* are according to WELLS (1957, pp. 618 and 623), common on the undersides of overhangs of coral colonies growing in the coral–algal zone, limiting the reefal flat from the seaward slope, and on lagoon reef structures, and TAYLOR (1957, p. 701) reported chiefly *Caulerpa* and *Halimeda* from the deeper water of the lagoons of 4 atolls of the Marshall Islands. TAYLOR described the surface sediment of the lagoon floors to be formed mainly by the segments of *Halimeda*. Abundant segments of *Halimeda opuntia* LAMOUROUX were seen by BRÖNNIMANN in the back-reef area of Boocoo reef, Tobago, British West Indies (BRÖNNIMANN, 1949, p. 182).

The detrital Matansa and Tagpochau limestones from Saipan, Tinian, and Rota referred by HANZAWA (1957, pp. 6, 32 and 33) to biohermal, lagoonal and fore-reefal detrital facies of coral reefs and to shallow submarine banks are lithologically and faunally comparable with our lithologic types (a) and (b). TODD, CLOUD, LOW, and SCHMIDT (1954, p. 677) suggested that the Tagpochau limestone was deposited in water of about 100 m depth. HANZAWA (1957, pp. 54, 55) listed from the Tagpochau limestone *Archaias angulatus* (FICHTEL and MOLL) ?, *Sorites martini* (VERBEEK) and *Marginopora vertebralis* BLAINVILLE. In the Mariana and younger limestones, usually elevated fringing reefs, HANZAWA recorded *Sorites marginalis* (LAMARCK) [=*Sorites orbiculus* (FORSKÅL)] and *Marginopora vertebralis* BLAINVILLE.

As witnessed by the cryptocrystalline to microcrystalline texture in thin sections and the abundant planktonic microfossils, the chalky limestones and chalks of the lithologic types (c) and (d) were deposited under deeper water conditions similar to those which prevailed during Consuelo or Universidad time. The relatively high ratio of planktonic to benthonic Foraminifera suggests a depth range of 500 to 1200 m for these deposits.

From the paleoecological point of view the most striking feature of the type beds of the Husillo formation is the rapid change in space and time from relatively shallow-water, reefal complex to relatively deeper water deposits. These facies changes and the occurrence of conglomeratic beds with angular limestone boulders derived from bioherms, of irregularly shaped isolated or nearly isolated bioherms, and of cross-bedded calcarenites give this formation a lithologically unstable and intricate aspect. It is to be expected that toward the uplift area, the Husillo formation is made up mainly of back-reefal or even littoral deposits, and that in basinal direction it assumes a deeper water character, as for instance in the Cacahual area. Husillo strata may show locally considerable reworking of older elements. This is explained by their transgressive character.

Although megafossils such as corals, mollusks and fragments of echinoderms were seen by the writers in the Husillo beds, apparently none have been described in the literature. It is possible, however, that some of the echinids reported by JACKSON (1922) and by VAUGHAN (1922, p. 112) from Cuban localities, and some of the forms of assumed Oligocene age mentioned by SÁNCHEZ ROIG (1949) may originate from the Husillo formation. Only two Middle Oligocene species, *Clypeaster parvus* MICHELIN and *Clypeaster lanceolatus* COTTEAU have been described by JACKSON (1922, p. 42) from Habana and its vicinity. SÁNCHEZ ROIG (1949, p. 71) refers *Clypeaster lanceolatus* COTTEAU to the Lower Miocene.

Larger benthonic Foraminifera are common. In the conglomeratic Husillo beds of the *Globigerina ciperoensis–Globorotalia opima* zone outcropping near Punta Brava occur *Operculinoides dius* (COLE and PONTON), *Lepidocyclina (Lepidocyclina) giraudi* R. DOUVILLÉ, *Lepidocyclina (Lepidocyclina) waylandvaughani* COLE, *Lepidocyclina (Lepidocyclina) yurnagunensis* CUSHMAN, *Lepidocyclina (Eulepidina) undosa* CUSHMAN, and *Pararotalia mexicana mecatepecensis* (NUTTALL). This assemblage is from COLE's *Lepidocyclina (Lepidocyclina)–Lepidocyclina (Eulepidina)* zone. In the Husillo strata of the *Catapsydrax dissimilis* zone, exposed at the abandoned quarry on the west side of the road from Barreras to Tarará, *Miogypsina bracuensis* VAUGHAN, *Lepidocyclina (Lepidocyclina)* sp., *Heterostegina antillea* CUSHMAN and *Operculinoides* cf. *dius* (COLE and PONTON) were recorded. This assemblage would fall into COLE's *Lepidocyclina (Lepidocyclina)–Miogypsina* zone, which overlies the *Lepidocyclina (Lepidocyclina)–Lepidocyclina (Eulepidina)* zone referred to above. In thin sections from the type Husillo beds, which are biostratigraphically part of the *Globigerinatella insueta* zone, random sections of the following larger Foraminifera were identified (miogypsinas by HANZAWA).

The stations are listed from bottom to top:

BR station 852	*Miogypsina* sp.
	Operculinoides sp.
	Lepidocyclina sp. (single fragment only).
BR station 855	*Miogypsina bracuensis* VAUGHAN ?
	Lepidocyclina sp. (single fragment only)
	Heterostegina cf. *antillea* CUSHMAN.
BR station 848	*Miogypsina* sp.
	Heterostegina antillea CUSHMAN.
BR station 943	*Heterostegina antillea* CUSHMAN.
BR station 946	*Miogypsina* sp.

Well preserved assemblages of larger Foraminifera were further encountered in thin sections from the following stations, outside of the Husillo type section:

BR station 583	*Miogypsina hawkinsi* HODSON ? or *Miogypsina bramlettei* ?
	Miogypsina hawkinsi HODSON ?

	Miogypsina antillea CUSHMAN
	Miogypsina bracuensis VAUGHAN
	Miogypsinoides ?
	Lepidocyclina (*Lepidocyclina*) sp.
	Operculinoides sp.
BR station 588	*Miogypsina hawkinsi* HODSON ?
	Lepidocyclina (*Lepidocyclina*) *sp.*
	Operculinoides sp.
BR station 606	*Miogypsina bracuensis* VAUGHAN or *Miogypsina antillea* CUSHMAN
	Miogypsina antillea CUSHMAN ?
	Lepidocyclina (*Lepidocyclina*) sp.
	Operculinoides sp.
BR station 607	*Miogypsina bracuensis* VAUGHAN ?
	Miogypsina antillea CUSHMAN ?
BR station 608	*Miogypsina hawkinsi* HODSON ?
	Miogypsina antillea CUSHMAN ?
	Miogypsina bracuensis VAUGHAN ?
	Lepidocyclina (*Lepidocyclina*) sp.
BR station 778	*Miogypsina* sp.
BR station 889	*Miogypsina bracuensis* VAUGHAN ?
	Heterostegina antillea CUSHMAN
	Operculinoides sp.

In terms of orbitoidal Foraminifera, the *Miogypsina* assemblages with rare fragments of lepidocyclinas may be from the upper part of COLE's *Lepidocyclina* (*Lepidocyclina*)–*Miogypsina* zone or from the *Miogypsina* zone considering the possibility of reworking of *Lepidocyclina* fragments, and the assemblages from BR stations 607, 778, 848, 889, 943, and 946 without *Lepidocyclina* may represent the *Miogypsina* zone. *Miogypsina* apparently became extinct at the end of the *Globigerinatella insueta* zone. A few miogypsinas were encountered in the Cojímar formation, but regarded as re-deposited from the Husillo beds, which in places are unconformably overlapped by Cojímar chalks and chalky limestones.

Heterostegina antillea CUSHMAN occurs in most *Miogypsina* assemblages, and the term *Heterostegina* zone, as applied in the Gulf Coast (AKERS and DROOGER, 1957) could also be used in Cuba to designate the interval from the *Lepidocyclina* (*Lepidocyclina*)–*Miogypsina* zone to the *Miogypsina* zone, or in terms of planktonic Foraminifera, the interval from the *Catapsydrax dissimilis* zone, or perhaps from the *Globorotalia kugleri* zone, to the *Globigerinatella insueta* zone. The range of *Heterostegina israelskyi* GRAVELL and HANNA, which was not encountered in the Husillo strata of the Habana area, but occurs in shallow-water deposits near Central Tinguaro, is not known. The term *Heterostegina* zone as used above therefore refers only to *Heterostegina antillea* CUSHMAN. SACHS (1959, pp. 405–406) arrived from a study of *H. antillea* CUSHMAN from Puerto Rico at the conclusion that *H. israelskyi* GRAVELL and HANNA is a junior synonym of *H. antillea*. From the Cuban material, we had the impression that the two forms can be distinguished in thin sections.

The minute planktonic microfossils are usually destroyed through recrystallization. In the chalky limestone from BR station 946 rare discoasters, thoracospheres and coccoliths were recorded. In the chalky limestones from Cacahual and in the pebbles of Cacahual-type limestone, embedded in the conglomeratic Husillo beds outcropping in Pogolotti quarry, rich discoaster and coccolith assemblages were encountered with the following dominant species

Braarudosphaera bigelowi (GRAN and BRAARUD) (rare)
Coccoliths (common)
Discoaster aster BRAMLETTE and RIEDEL (common)
Discoaster barbadiensis TAN (rare)
Discoaster deflandrei BRAMLETTE and RIEDEL (common)
Discoaster woodringi BRAMLETTE and RIEDEL (common)
Transitional forms between *D. woodringi* BRAMLETTE and RIEDEL and *D. deflandrei* BRAMLETTE and RIEDEL (common)
Thoracosphaera spp. (common).

These assemblages differ from those of the Consuelo formation only by the common occurrence of *Discoaster deflandrei* BRAMLETTE and RIEDEL. The *Globigerinatella insueta*-bearing beds of the Husillo formation are here referred to the *Discoaster deflandrei* zone. BRAMLETTE (in WOODRING, 1958, p. 21) identified the following discoasters and coccolithophores from the Caimito formation of Barro Colorado Island, Canal Zone, Woodring station 54n, which is from the *Globorotalia kugleri* zone:

Discoaster aff. *D. challengeri* BRAMLETTE and RIEDEL (few)
Discoaster deflandrei BRAMLETTE and RIEDEL (common)
Discoaster aff. *D. deflandrei* BRAMLETTE and RIEDEL (some characters intermediate between those of *D. deflandrei* and *D. woodringi*) (common)
Discoaster perplexus BRAMLETTE and RIEDEL (few)
Discoaster woodringi BRAMLETTE and RIEDEL (common)
Thoracosphaera imperforata KAMPTNER (few)
Sphenolithus abies DEFLANDRE (few)
Sphenolithus ? sp. (common)
Coccolithus sp. (common)
Coccolithus cf. *C. leptoporus* (MURRAY and BLACKMAN) (rare)
Coccolithus cf. *C. pelagicus* (WALLICH) (common)
Discolithus sp. (few)
Helicosphaera aff. *H. carteri* KAMPTNER (common)
Rhabdosphaera cf. *R. claviger* (MURRAY and BLACKMAN) (rare)
Unidentified coccoliths, including many having a diameter of 2 to 3 μ.

The discoasters common in this assemblage are the same as in the Cacahual chalky limestone of the *Globigerinatella insueta* zone. It therefore appears that the *Discoaster deflandrei* zone, as proposed above, covers the interval from the *Globo-*

rotalia kugleri to the *Globigerinatella insueta* zone. The larger Foraminifera from the Caimito zone, identified by COLE (in WOODRING, 1958, p. 24) are *Heterostegina antillea* CUSHMAN, *Heterostegina israelskyi* GRAVELL and HANNA, *Operculinoides panamensis* (CUSHMAN), *Lepidocyclina* (*Lepidocyclina*) *canellei* LEMOINE and R. DOUVILLÉ, *Lepidocyclina* (*Lepidocyclina*) *giraudi* R. DOUVILLÉ, *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* CUSHMAN, *Lepidocyclina morganopsis* VAUGHAN, *Lepidocyclina* (*Nephrolepidina*) *vaughani* CUSHMAN, *Miogypsina* (*Miogypsina*) *antillea* (CUSHMAN) and *Miogypsina* (*Miolepidocyclina*) *panamensis* (CUSHMAN). This assemblage would be referrable to COLE's *Lepidocyclina* (*Lepidocyclina*)–*Miogypsina* zone which according to the associated planktonic Foraminifera from Woodring station 54n would also include the *Globorotalia kugleri* zone. It is of interest, that *Heterostegina antillea* CUSHMAN and *Heterostegina israelskyi* GRAVELL and HANNA are associated in the assemblage from WOODRING station 54f, whereas in the Cuban material examined by us, the two forms do not seem to occur together.

The following table shows the tentative correlation between the zones established on discoasters and on planktonic Foraminifera and Cole's zones of orbitoidal Foraminifera, based on the Cuban and Panamanian associations. The *Operculinoides* zone is proposed for the assemblages of larger Foraminifera without miogypsinids overlying the *Miogypsina* zone. It probably can be extended to cover the interval from the *Globorotalia fohsi* zone to the end of the Miocene.

The Husillo formation extends from the *Globigerina ciperoensis–Globorotalia opima* zone, Oligocene, to the *Globigerinatella insueta* zone, Miocene; in terms of

<table>
<tr><th></th><th>Discoasters</th><th>Planktonic Foraminifera</th><th colspan="2">Larger Foraminifera</th><th>Formation</th></tr>
<tr><td rowspan="4">Miocene</td><td>————</td><td>Globorotalia fohsi zone</td><td colspan="2">Operculinoides zone</td><td>Cojímar format.</td></tr>
<tr><td rowspan="3">Discoaster deflandrei zone</td><td>Globigerinatella insueta zone</td><td>Miogypsina zone</td><td rowspan="3">Heterostegina antillea zone</td><td rowspan="4">Husillo formation</td></tr>
<tr><td>Catapsydrax dissimilis zone</td><td rowspan="2">Lepidocyclina (Lepidocyclina)–Miogypsina zone</td></tr>
<tr><td>Globorotalia kugleri zone</td></tr>
<tr><td rowspan="2">Oligocene</td><td rowspan="2">Discoaster woodringi zone</td><td>Globigerina ciperoensis–Globorotalia opima zone</td><td colspan="2" rowspan="2">Lepidocyclina (Lepidocyclina)–Lepidocyclina (Eulepidina) zone</td></tr>
<tr><td>Globigerina ampliapertura zone</td><td>Consuelo formation</td></tr>
</table>

larger Foraminifera from the *Lepidocyclina* (*Lepidocyclina*)–*Lepidocyclina* (*Eulepidina*) to the *Miogypsina* zone; and in terms of discoasters from the *Discoaster woodringi* to the *Discoaster deflandrei* zone.

Cojímar formation

The Cojímar formation is one of the best known lithostratigraphic units of the Habana area. It was proposed by R. H. PALMER (1934, p. 134) for a series of Oligocene (? Miocene) "soft white and tan marls" outcropping at different localities

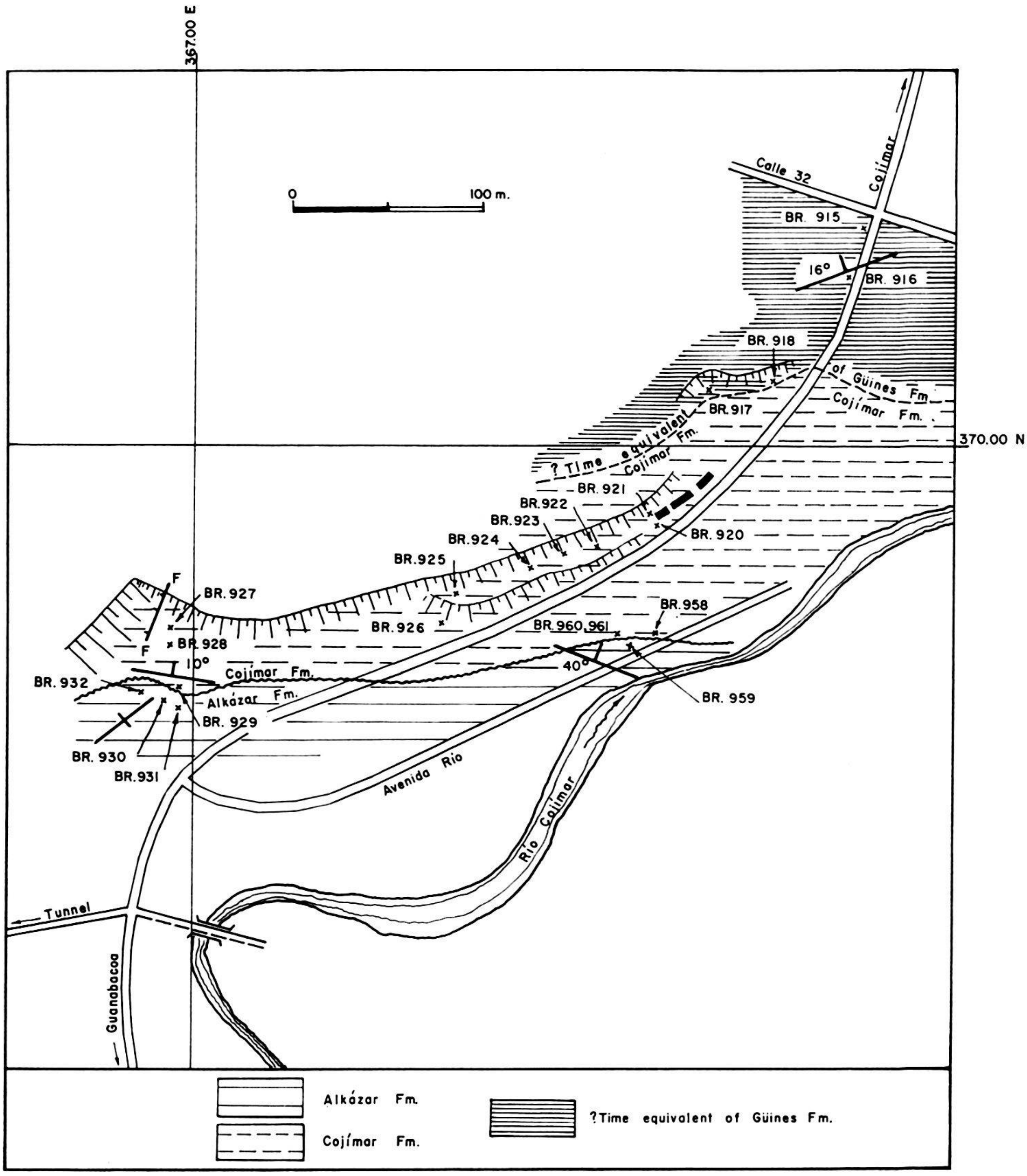

Fig. 73. Index map of the type locality of the Cojímar formation at the road from Guanabacoa to Cojímar.