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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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cyclina barkeri VAUGHAN and COLE, *Discocyclina anconensis* BARKER, and usually other discocyclinas, pseudophragminas and proporocyclinas. This association is closely related with that from the younger Alkázar formation. The planktonic Foraminifera of the Apolo formation, on the other hand, are different from those of the Alkázar beds. The diagnostic planktonic form of the type samples is *Globorotalia angulata* (WHITE). *Globorotalia velascoensis* (CUSHMAN) and the keeled forms of the *Globorotalia pseudomenardii* BOLLI group are absent.

It follows that the Apolo formation falls in the Lower Eocene *Globorotalia angulata* zone, which underlies the *Globorotalia velascoensis–Globorotalia pseudomenardii* zone and overlies the Danian *Globigerina daubjergensis–Globorotalia compressa* zone.

Alkázar Formation

The Alkázar formation is a new lithologic unit of Lower Eocene age overlying the Apolo formation and underlying the Capdevila formation. The name is derived from Reparto Alkázar (correct spelling Alcázar), situated on the western side of the road from Arroyo Apolo to Arroyo Naranjo, about 1.5 km northeast of Arroyo Naranjo. The average coordinates of the outcrop area are 358.45 N and 360.10 E.

Before describing the outcrops of the Alkázar formation, we will briefly review the status of the old Tertiary Madruga, Luyano and Lucero beds. BERMÚDEZ (1950, p. 222) suggested that the Madruga Chalk introduced by LEWIS (1932, p. 539) may be the same as the Luyano Marl of DEGOLYER (1918, p. 141). Madruga Chalk and Luyano Marl, however, were both vaguely defined by their authors, and although they may mean the same it would be difficult to prove that they are identical with or equivalents of the Alkázar formation. Most probably, the Alkázar formation is only a part of, and therefore included in DeGolyer's and Lewis' lithologic units. Based on Lewis' description we can assume that the Madruga Chalk contains any whitish chalky and marly beds between the late Upper Cretaceous Vía Blanca formation, which is an approximate equivalent of Lewis' Havana shales, and the Capdevila formation, which is the same as his El Cano formation. BERMÚDEZ (1950, p. 219) re-defined the Madruga formation and selected as type locality the road cut under the bridge over the Carretera Central near San Antonio, Madruga, Habana Province, about 60 km east-southeast of La Habana. There are exposed brownish to yellowish graywacke silts and sandstones wthr large pebbles, sometimes up to 30 cm in diameter, mostly derived from Uppie Cretaceous limestones but also from volcanic rocks and from tuffaceous sandstones. The relationship of these beds to other formations is not known. R. H. PALMER's locality 1214, the type locality of the Maastrichtian index fossil *Vaughanina cubensis* D. K. PALMER, apparently is from the Madruga formation exposed in the cut of the railroad to Central Hershey, 1 km west of Central San Antonio. R. H. PALMER (1948, p. 72) found at this locality "abundant Foraminifera and one *Lanieria* in a conglomerate boulder and matrix". BRÖNNIMANN (1952, p. 93) resampled PALMER's station 1214 and found Lower Eocene planktonics associated with Upper Cretaceous larger Foraminifera. Although the Madruga formation in the sense of BERMÚDEZ may be a valid lithologic unit in the Madruga area, we propose to suppress it in the Habana area for the following reasons: 1) Lewis did

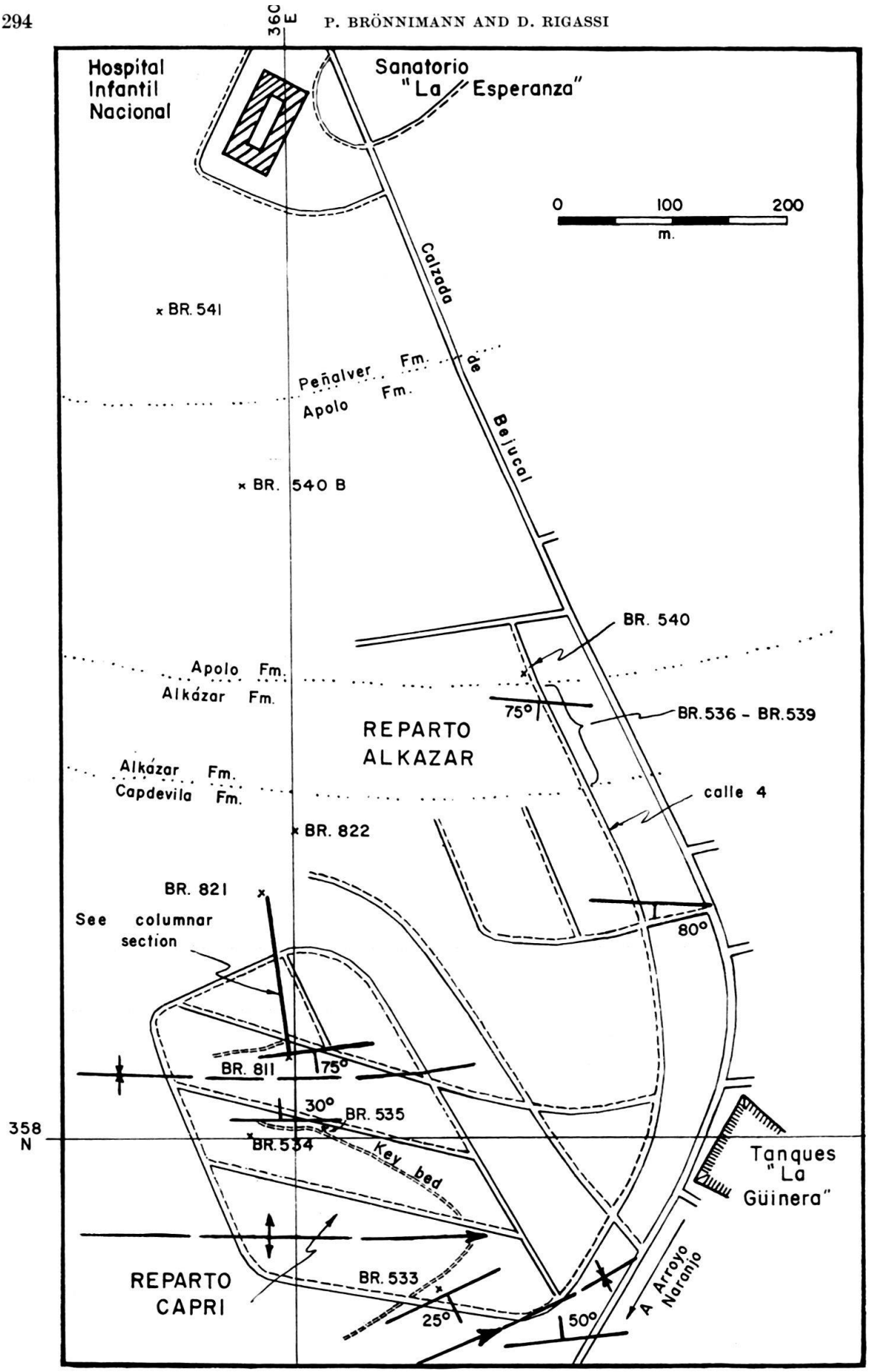

Fig. 27. Index map of the type locality of the Alkázar formation.

not explicitely define a type locality of his Madruga Chalk nor did he record its faunal content, 2) the lithology of BERMÚDEZ' type locality differs from the lithology reported by Lewis for his Madruga Chalk, and 3) in the Habana area proper, the lowermost Eocene does not contain any beds similar to those described by BERMÚDEZ from the type locality of his Madruga formation.

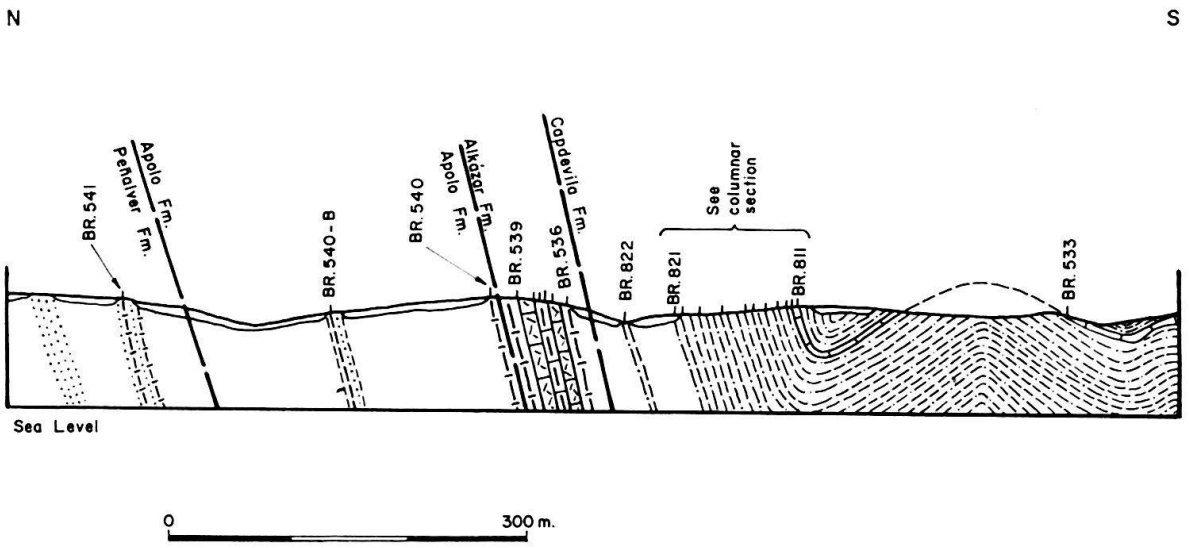

Fig. 28. Cross section type locality of the Alkázar formation.

To judge from lithology and microfauna, the Lucero formation of BRODERMANN (1943, p. 121) is most probably the same as or part of the Alkázar formation. Although the name Lucero was preoccupied by the Lucero beds of DEGOLYER (1918, p. 142), BRODERMANN used it again for a formation of ". . . arenisca fina rica en *Vaughanina cubensis* PALMER, intercalada entre arcilla grisacea con buena fauna microscopica en la que predominan *Globorotalia velascoensis* (CUSHMAN) y *G. membranacea* (EHRENBERG) [= *G. pseudomenardii* BOLLI]. . . . La fauna fina de la arcilla gris contiene abundante radiolaria. . . ." He regarded the Lucero formation as the upper beds of the Cretaceous or perhaps as Paleocene.

Relationship of Alkázar and Apolo formations

In the best-exposed Lower Eocene sections, the Alkázar formation always overlies transitionally the Apolo formation. At their type localities, the two formations appear to be lithologically well-defined units. As remarked previously under Apolo formation there are, however, indications that on a more regional scale Alkázar and Apolo formations could be regarded as a single formation rather than two different formations. In the Jaruco area, about 1.5 km west of Jaruco on the road to Campo Florido, for instance, there are at least 2 zones of Alkázar lithologies interbedded in the upper part of a series of Apolo-type beds. We also observed that in many Alkázar outcrops thin, reddish and brownish graywacke silts and sands of Apolo aspect are interbedded in the Alkázar formation, and that in Apolo outcrops occasionally occur thin intercalations of white chalks and fragmental Alkázar-type limestones.

Description of the type locality of the Alkázar formation

The type section of the Alkázar formation are the outcrops on the secondary road, Calle 4 of Reparto Alkázar, running about 50 m west of and parallel with the road from Arroyo Apolo to Arroyo Naranjo (index map, fig. 27). At this locality, about 25 m of Alkázar formation were exposed during the summer of 1958, but neither bottom nor top could be directly observed (cross section, fig. 28). The relatively hard Alkázar beds form a minor ridge between the relatively softer Capdevila and Apolo formations. The latter occurs in a shallow depression to the north and contains in BR stations 540 and 540B a Lower Eocene fauna with *Globorotalia angulata* (WHITE) and reworked Upper Cretaceous Foraminifera. The Alkázar formation underlies the Capdevila formation which is well exposed to the south of the type section; the contact however was covered. When the type locality was again visited in December 1958, it was found to be completely built over by a settlement and only isolated outcrops and floats of Alkázar chalks and calcarenites were seen.

The Alkázar formation consists of whitish, greenish and grayish, rarely light brown shales and chalks with interbeds of mostly whitish to yellowish gray, well-cemented, hard, fragmental limestones, calcarenites and calcirudites with angular "clay" inclusions. The chalks and shales differ from the whitish chalky calcilutites of the upper part of the Peñalver formation by the absence or scarcity of exotic igneous fragments. The components of the hard calcarenites and the clastic limestones are predominantly fragments of calcareous algae and other organic detritus and Foraminifera.

The relative stratigraphic position of the Alkázar type samples is given in the cross section, fig. 28. They are from bottom to top:

BR station 539

Lithology: Shale, slightly calcareous, hard, conchoidal fracturing, whitish to very pale orange and yellowish gray (coccolithite).

Texture: Argillaceous to cryptocrystalline groundmass with minute fragments.

Assemblage:
- *Coccolithus grandis* BRAMLETTE and RIEDEL and other coccoliths, mainly placoliths (rock-forming)
- *Discoaster multiradiatus* BRAMLETTE and RIEDEL (common)
  - a) typical form of about 11 to 16 μ diameter, with central knob and with about 20 radii
  - b) very small form of about 5 to 7 μ diameter with central knob and with 14 to 15 distally bluntly pointed radii
- *Discoaster* cf. *barbadiensis* TAN
- *Discoaster bebalaini* TAN
- *Discoaster hilli* TAN
- *Discoaster ornatus* STRADNER
- *Thoracosphaera* spp. (very small globular and ellipsoid bodies).

BR station 538A

Lithology: Calcarenite, fine-grained, hard, yellowish gray.

Texture: Fragmental to pseudoölitic, unsorted, similar to BR station 537, but somewhat coarser. Diameter of average components ranging from about 50 to

650 μ. Rare rounded to subangular, brown to brown green igneous grains. Abundant fragments of Corallinaceae and Foraminifera.

Assemblage:
Globorotalia pseudomenardii BOLLI group
Globorotalia spp. (truncate forms)
Chiloguembelina sp.
"*Amphistegina*" *lopeztrigoi* D. K. PALMER
"*Operculina*" *catenula* CUSHMAN and JARVIS
Discocyclina barkeri VAUGHAN and COLE
Pseudophragmina sp. or *Proporocyclina* sp.
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE
Discoaster hilli TAN (rare)
Vaughanina cubensis D. K. PALMER (reworked).

BR station 538
Lithology: Shale, hard, slightly calcareous, pale grayish to pale greenish yellow (coccolithite–radiolarite).

Texture: Argillaceous to cryptocrystalline groundmass with abundant Radiolaria and diatoms (*Triceratium* sp.).

Assemblage:
Coccolithus grandis BRAMLETTE and RIEDEL
Coccoliths, mainly placoliths (rock-forming)
Discoaster bebalaini TAN
Discoaster hilli TAN
Discoaster cf. *ornatus* STRADNER
Discoaster multiradiatus BRAMLETTE and RIEDEL (typical and minute forms)
Marthasterites cf. *tribrachiatus* (BRAMLETTE and RIEDEL) (Maximum diameter from tip to tip of radii about 11 μ. Lengths of radii from 5 to 7 μ. Thickness of radii 1.5 to 2 μ)
Marthasterites bramlettei BRÖNNIMANN and STRADNER (Diameter about 12.5 μ)
Marthasterites riedeli BRÖNNIMANN and STRADNER
Nannoturbella moriformis BRÖNNIMANN and STRADNER
Thoracosphaera spp. (minute globular and ellipsoid bodies).

BR station 537
Lithology: Calcarenite, fine-grained, hard, very pale orange to grayish orange pink.

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components ranging from about 35 to 350 μ. Angular to subrounded fragments derived from shells, algae, and limestones. Also dark brown and green igneous fragments. Abundant planktonic microfossils and some fragments of discocyclinas. Groundmass microcrystalline.

Assemblage:
Globorotalia pseudomenardii BOLLI group
Globorotalia spp. (truncate forms)
Globigerinas with spinose tests
Chiloguembelina sp.

Discocyclina spp. (fragments with ± square equatorial chambers as seen in horizontal section)
"*Amphistegina*" *lopeztrigoi* D. K. PALMER
Coccoliths (rare)
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE
Vaughanina cubensis D. K. PALMER (reworked).

BR station 536
Lithology: Chalk, whitish to yellowish gray (coccolithite).
Texture: Cryptocrystalline to argillaceous groundmass with abundant coccoliths and discoasterids. Also Radiolaria.

Assemblage:
Radiolaria
Coccoliths, mainly placoliths (rock-forming)
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Discoaster bebalaini TAN
Discoaster hilli TAN
Discoaster multiradiatus BRAMLETTE and RIEDEL (typical and minute forms)
Marthasterites contortus (STRADNER)
Marthasterites cf. *tribrachiatus* (BRAMLETTE and RIEDEL) (Very thick three-armed forms with truncate and indentated tips. Maximum diameter from tip to tip from about 10 to 20 μ. Diameter of radii from 3.75 to 5 μ. Peripheral indentation about 2.5 μ deep. This form differs from those here referred to *M. tribrachiatus* and may represent a new species)
Thoracosphaera spp. (minute globular and ellipsoid bodies)

Washed residue with Eocene spumellarias and nassellarias.

Other outcrops of the Alkázar formation

We examined many outcrops of Alkázar formation, but rarely we could see the contacts with other formations.

Alta Habana

At Alta Habana, a locality described previously under Apolo formation, the entire Alkázar formation is exposed (index map and columnar sections, figs. 25 and 26). It is a 20 m thick sequence of alternating, well-bedded, whitish to greenish chalks and whitish chalky limestones, which are practically identical with those described from the type locality. In the upper 7 m there are a few thin intercalations of whitish to greenish and reddish shales which were not found at the type locality. The boundaries toward the Capdevila and Apolo formations are transitional. This would suggest that the irregular Capdevila–Alkázar contact as observed at the type locality of the Apolo formation near Arroyo Apolo is disconformable rather than unconformable.

The following stations are from this section. They are here arranged from bottom to top:

BR station 801

Lithology: Shale, somewhat calcareous, indurated, white (coccolithite–radiolarite).

Texture: Cryptocrystalline to argillaceous groundmass with rock-forming coccoliths and Radiolaria.

Assemblage:
- Coccoliths (rock-forming)
- *Discoaster* cf. *barbadiensis* TAN
- *Discoaster hilli* TAN
- *Discoaster multiradiatus* BRAMLETTE and RIEDEL (typical and minute forms (common))
- *Discoaster ornatus* STRADNER
- *Marthasterites bramlettei* BRÖNNIMANN and STRADNER
- *Nannoturbella moriformis* BRÖNNIMANN and STRADNER
- *Thoracosphaera* spp. (globular and ellipsoid bodies of 19 to 25 μ diameter)
- Radiolaria (common).

BR station 800

Lithology: Shale, chalky, calcareous, somewhat indurated, white to pale greenish yellow (coccolithite–radiolarite).

Texture: Cryptocrystalline to argillaceous groundmass with rock-forming coccoliths and with abundant planktonic Foraminifera and with Radiolaria.

Assemblage:
- *Globorotalia pseudomenardii* BOLLI group (small and high-spired forms)
- *Globorotalia* spp. (truncate forms)
- Globigerinas with spinose tests
- Coccoliths, mainly placoliths (rock-forming)
- *Discoaster bebalaini* TAN
- *Discoaster hilli* TAN (common)
- *Discoaster multiradiatus* BRAMLETTE and RIEDEL (typical and minute forms)
- *Discoaster ornatus* STRADNER
- *Marthasterites contortus* (STRADNER)
- *Marthasterites* cf. *tribrachiatus* (BRAMLETTE and RIEDEL)
- *Nannoturbella moriformis* BRÖNNIMANN and STRADNER
- *Thoracosphaera* spp. (very small globular to ellipsoid bodies)
- Radiolaria.

BR station 799

Lithology: Shale, practically non-calcareous, indurated, white to pale greenish yellow (coccolithite–radiolarite).

Texture: Cryptocrystalline to argillaceous groundmass with rock-forming coccoliths and Radiolaria, diatoms (*Triceratium* sp.), rare planktonic Foraminifera and sponge spicules.

Assemblage:
- *Globorotalia* spp. (truncate forms)
- *Globigerina* spp. with spinose walls
- Radiolaria (abundant)
- Coccoliths (abundant)

Coccolithus grandis BRAMLETTE and RIEDEL (abundant)
Discoaster multiradiatus BRAMLETTE and RIEDEL
Marthasterites contortus (STRADNER)
Marthasterites cf. *tribrachiatus* (BRAMLETTE and RIEDEL)
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) var. *robustus* (STRADNER)
Braarudosphaera bigelowi (GRAN and BRAARUD)
Thoracosphaera sp. (minute ellipsoid and globular bodies)
Nannoconus steinmanni KAMPTNER (reworked).

Cerro

Alkázar beds are poorly exposed in a small and isolated road cut at Avenida de la Independencia, 300 m northeast of its intersection with the Calzada del Cerro, between Calle Talleres and Calle Santa Ana, Reparto Ensanche del Vedado, coordinates 365.20 N and 357.49 E. This outcrop was previously described by BERMÚDEZ (1950, p. 221) as his station 530 and referred to the Madruga Chalk. It consists of steeply dipping, soft whitish chalky limestones, olive grayish siliceous shales and harder layers of indurated yellowish gray calcarenites and fragmental limestones. The contacts with other formations are not exposed.

The following are descriptions of random samples from this locality:

BR station 331
Lithology: Shale, non-calcareous, indurated, in part silicified, whitish to pale yellowish gray (coccolithite–radiolarite), and chalk, marly, whitish.
Texture: Cryptocrystalline to argillaceous with abundant minute angular fragments derived from organic material and dark igneous rocks. Planktonic microfossils, especially coccoliths and Radiolaria, diatoms (*Triceratium* sp.), and sponge spicules.

Assemblage:
Radiolaria (abundant)
Coccoliths, mainly placoliths (abundant)
Marthasterites cf. *tribrachiatus* (BRAMLETTE and RIEDEL)
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) var. *robustus* (STRADNER)
Discoaster brouweri TAN (one specimen) (Six-armed specimen of about 25 μ maximum diameter from tip to tip of opposite radii. Radii very slender, about 2.5 μ thick, only very slightly tapering toward the tips. Central portion of test shows spiral arrangement of radii. No central knob.)
Discoaster multiradiatus BRAMLETTE and RIEDEL (typical and minute forms)
Braarudosphaera cf. *discula* BRAMLETTE and RIEDEL
Thoracosphaera spp. (minute ellipsoid and globular bodies)
Nannoconus steinmanni KAMPTNER
Nannoconus bermudezi BRÖNNIMANN
Nannoconus truitti BRÖNNIMANN
Nannoconus colomi (DE LAPPARENT)
} reworked

Washed residue with

Globorotalia cf. *aequa* CUSHMAN and RENZ
Globorotalia velascoensis (CUSHMAN)
Globigerina velascoensis CUSHMAN
Globorotalia pseudomenardii BOLLI (identical to the forms illustrated by SUBBOTINA, pl. 16, figs. 12-13, 1953)
Globorotalia aff. *elongata* GLAESSNER
Globigerina cf. *pseudobulloides* PLUMMER (large specimen)
Globigerina triangularis WHITE
Discocyclina sp. (very small and strongly pitted forms)
Radiolaria.

BR station 1197
Lithology: Calcarenite, whitish to yellowish gray (1–4). Shale, non-calcareous, silicified, yellowish gray to pale olive (5).

Thin sections 1–4

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components ranges from about 150 to 700 μ. Components are mainly fragments of coralline algae, mollusks and echinoderms, and larger Foraminifera. Very rare dark brown and green igneous grains. Matrix microcrystalline calcite.

Assemblage:
"Operculina" catenula CUSHMAN and JARVIS
"Amphistegina" lopeztrigoi D. K. PALMER
Discocyclina barkeri VAUGHAN and COLE
Pseudophragmina sp. or *Proporocyclina* sp.
Pseudophragmina sp.
Globigerinas with spinose tests
Globorotalia spp. (truncate forms)
Coccoliths
Lithoporella melobesioides FOSLIE
Cosinella sp. } reworked
Vaughanina cubensis D. K. PALMER }

Thin section 5

Texture: Cryptocrystalline to argillaceous, silicified groundmass with abundant Radiolaria and sponge spicules.

Assemblage:
Radiolaria
Coccoliths.

BERMÚDEZ (1950, p. 221) mentioned the following planktonic Foraminifera from this outcrop: *Globigerina triloculinoides* PLUMMER, *Globorotalia albeari* CUSHMAN and BERMÚDEZ, *Globorotalia membranacea* (EHRENBERG) [= *Globorotalia pseudomenardii* BOLLI] and *Globorotalia* cf. *velascoensis* (CUSHMAN).

Arroyo Apolo

The field relationship between Alkázar and Capdevila formations can be seen along the southern flank of the east–west striking ridge formed by the late Maastrichtian Peñalver formation about 500 to 600 m north of Arroyo Apolo. The con-

tact at the corner of Avenida Lourdes and Avenida María Auxiliadora, Reparto Vibora Park, Arroyo Apolo, coordinates 361.55 N and 361.40 E is irregular (index map, fig. 23). But there appears to be not an unconformity but only a local disconformity between the two formations, because 250 m to the east of this outcrop the top Alkázar formation and the base Capdevila formation are perfectly conformable (cross section of the Apolo formation, fig. 24). The contact with the underlying Apolo formation was not exposed at this locality and we believe that it is transitional for reasons explained in the description of the Apolo formation.

BR stations 1188 and 596 are from the bottom, 1187 from the middle and 597 from the top of the Alkázar formation. BR stations 1186 and 598 are from the basal beds of the overlying Capdevila formation. BR station 1188 is from the first whitish calcarenaceous bed at the transition from Apolo to Alkázar formation, indicating the base of the Alkázar formation.

BR station 1188 (basal bed of Alkázar formation)
Lithology: Calcarenite, hard, with rare igneous grains, whitish to yellowish gray (1), and shale, calcareous, pale yellowish brown (2).

Thin section (1)

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components ranges from about 100 to 700 μ. Components are mainly fragments of coralline algae, mollusks, echinoderms and larger Foraminifera. Planktonic microfossils are common. Rare dark brown and green rounded igneous grains. Matrix microcrystalline calcite.

Assemblage:
"Operculina" catenula CUSHMAN and JARVIS
"Amphistegina" lopeztrigoi D. K. PALMER
Discocyclina barkeri VAUGHAN and COLE
Pseudophragmina sp. or *Proporocyclina* sp.
Proporocyclina sp.
Globorotalia spp. (truncate forms)
Globigerinas with spinose tests
Globorotalia pseudomenardii BOLLI group
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE

Washed residue (2) with
Globorotalia aequa CUSHMAN and RENZ
Globorotalia velascoensis (CUSHMAN)
Globorotalia wilcoxensis CUSHMAN and PONTON
Globorotalia pseudomenardii BOLLI group
Globigerina linaperta FINLAY
Globigerina primitiva FINLAY
Globigerina soldadoensis BRÖNNIMANN group
Globigerina triangularis WHITE
Discocyclina sp. (small and strongly pitted form)
Eocene spumellarias and nassellarias.

BR station 596

Lithology: Calcarenite, yellowish gray to very light gray, with many dark igneous grains.

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components varying from 70 to 700 μ. Fragments are from shells, algae, limestones, and dark brown and greenish igneous rocks. Foraminifera are common. Matrix microcrystalline.

Assemblage:
"Operculina" catenula CUSHMAN and JARVIS
"Amphistegina" lopeztrigoi D. K. PALMER
Discocyclina barkeri VAUGHAN and COLE
Pseudophragmina sp.
Globorotalia spp. (truncate forms)
Globigerinas with spinose tests
Globorotalia pseudomenardii BOLLI group
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE
Vaughanina cubensis D. K. PALMER (reworked).

BR station 1187

Lithology: Calcarenite, coarse-grained, hard, with igneous influence, very pale orange (1) and shale, chalky, calcareous, white to pale greenish yellow (coccolithite) (2).

Texture:

Thin section 1: Fragmental to pseudoölitic, unsorted. Diameter of average components from about 100 to 1500 μ. Components are from limestones, mollusks, echinoderms, coralline algae, larger Foraminifera, and dark igneous rocks. Matrix microcrystalline.

Thin section 2: Cryptocrystalline to argillaceous groundmass with rock-forming coccoliths and discoasterids and abundant planktonic Foraminifera.

Assemblage:

Thin section 1:
"Operculina" catenula CUSHMAN and JARVIS
Eoconuloides wellsi COLE
"Amphistegina" lopeztrigoi D. K. PALMER
Discocyclina cf. *barkeri* VAUGHAN and COLE
Proporocyclina sp.
Pseudophagmina sp. or *Proporocyclina* sp.
Globigerina spp. with spinose walls
Globorotalia spp. (truncate forms)
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE
Vaughanina cubensis D. K. PALMER (reworked).

Thin section 2
Coccoliths (abundant)
Discoaster multiradiatus BRAMLETTE and RIEDEL (abundant) (typical and minute forms)
Discoaster bebalaini TAN (common)
Discoaster hilli TAN

Thoracosphaera sp. (globular and ellipsoid bodies)
Globorotalia pseudomenardii BOLLI group
Globorotalia spp. (truncate forms)
Globigerinas with spinose walls.

Washed residue (1) with
Globorotalia aequa CUSHMAN and RENZ
Globorotalia cf. *velascoensis* (CUSHMAN)
Globigerina primitiva FINLAY
Eocene spumellarias.

BR station 597
Lithology: Limestone, shaley, whitish to yellowish gray.
Assemblage: *Globorotalia* cf. *aequa* CUSHMAN and RENZ
Globorotalia velascoensis (CUSHMAN)
Globigerina spp. (deformed specimens).

BR station 1186
Lithology: Calcarenite, fine-grained, friable, dark yellowish orange.
Washed residue with
Globorotalia aequa CUSHMAN and RENZ
Globorotalia cf. *broedermanni* CUSHMAN and BERMÚDEZ
Globigerina intermedia (SUBBOTINA)
Globigerina linaperta FINLAY
Globigerina soldadoensis BRÖNNIMANN group
Globigerina triangularis WHITE
Tertiary spumellarias.

BR station 598
Lithology: Shale, non-calcareous, pale yellowish brown.
Washed residue with Eocene spumellarias and nassellarias.

San Francisco de Paula

At coordinates 360.45 N and 368.30 E, about 1.4 km east to east-northeast from San Francisco de Paula, a village on the Carretera Central east of La Habana, typical Alkázar beds occur in a northward overturned tight anticline. On the northeastern flank of the anticline, the Alkázar formation is bordered by steeply south dipping overturned Capdevila beds. BR stations 484 to 487 are from graded-bedded, white to yellowish gray fragmental limestones and yellow gray shaley chalks. Some of the reworked limestone fragments contain planktonic assemblages derived from older or penecontemporaneous Lower Eocene beds.

BR station 484
Lithology: Chalk, shaley, soft, yellowish gray.
Assemblage: Tertiary spumellaria and nassellaria and sponge spicules.

BR station 485
Lithology: Shale, calcareous, indurated, yellowish gray (coccolithite).
Texture: Cryptocrystalline to argillaceous groundmass with minute planktonic microfossils.

Assemblage: Coccoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL
Braarudosphaera discula BRAMLETTE and RIEDEL
Discoaster multiradiatus BRAMLETTE and RIEDEL (abundant) (typical and minute forms)
Discoaster sp.
Thoracosphaera sp. (small globular and ellipsoid bodies).

BR station 486
Lithology: Calcarenite, with abundant igneous grains, of salt and pepper aspect, yellowish gray.

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components from about 100 to 550 μ. Components densely packed fragments of algae, different types of limestones and igneous rocks, shells and abundant Foraminifera. Matrix microcrystalline calcite.

Assemblage: "*Amphistegina*" *lopeztrigoi* D. K. PALMER
"*Operculina*" *catenula* CUSHMAN and JARVIS
Discocyclina spp.
Globorotalia pseudomenardii BOLLI group
Globorotalia spp. (truncate forms)
Globigerinas with spinose tests
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE.

BR station 487
Lithology: Calcarenite, coarse-grained, hard, rounded igneous grains, whitish to grayish yellow.

Texture: Fragmental to pseudoölitic with little recrystallized microcrystalline groundmass. Diameter of average elements from about 100 to 1500 μ. Components are fragments of algae, limestones of different origin, echinoderms, mollusks and igneous rocks. Larger Foraminifera are abundant.

Assemblage: "*Amphistegina*" *lopeztrigoi* D. K. PALMER
"*Operculina*" *catenula* CUSHMAN and JARVIS
Discocyclina barkeri VAUGHAN and COLE
Discocyclina spp. (among these forms are small discocyclinas with hexagonal equatorial chambers)
Pseudophragmina sp. or *Proporocyclina* sp.
Fabularia sp.
Distichoplax biserialis (DIETRICH)
Lithoporella melobesioides FOSLIE.

A large allochthonous angular limestone fragment with planktonic microfauna contains apart from reworked *Vaughanina cubensis* D. K. PALMER and *Sulcoperculina* sp.

Globorotalia spp. (truncate forms)
Globorotalia pseudomenardii BOLLI group
Globigerinas with spinose tests.

Road from Guanabacoa to Cojímar

The type beds of the Cojímar formation overlie unconformably grayish yellow marly, nodular graywackes, siliceous shales and calcarenites of the Lower Eocene Alkázar formation (?) which in type of bedding and lithology display affinity to the Capdevila formation. The contact between Alkázar (?) and Cojímar beds is exposed at the bottom of the quarry, which opens up the basal portion of the Cojímar chalks, and immediately north of Avenida Río (index map of the Cojímar type locality, fig. 73). The unconformity between the Alkázar (?) and the Cojímar formations is illustrated by the photographs, figs. 29 and 30. The planktonic assemblage of BR station 1378, which is from a marly chalk just below the Cojímar beds at Avenida Río, contains *Globorotalia* cf. *rex* MARTIN, indicating a younger Lower Eocene age than that of the Alkázar beds west of the Bahía de La Habana.

The top beds of the Alkázar formation (?) are represented by the following samples here listed from bottom to top:

Outcrop in bottom of quarry

BR station 930

Lithology: Calcarenite, with rare igneous grains, yellowish gray.

Texture: Fragmental to pseudoölitic, unsorted. Diameter of average components from about 50 to 550 μ. Components are mainly rounded to subrounded fragments of coralline algae, mollusks, echinoderms and larger Foraminifera. Some rounded dark brown and green igneous grains. Planktonic Foraminifera are common. Matrix recrystallized calcite.

Assemblage:
- *"Amphistegina" lopeztrigoi* D. K. PALMER (common)
- *Pseudophragmina* sp. or *Proporocyclina* sp.
- *Discocyclina* sp.
- *Discocyclina* cf. *anconensis* BARKER
- *"Operculina" catenula* CUSHMAN and JARVIS
- *Globorotalia* spp. (truncate forms)
- Globigerinas with spinose tests
- *Lithoporella melobesioides* FOSLIE
- *Distichoplax biserialis* (DIETRICH)
- *Vaughanina cubensis* D. K. PALMER (reworked).

BR station 931

Lithology: Limestone, chalky, hard, white to grayish yellow (coccolithite).

Texture: Cryptocrystalline to argillaceous, with abundant Radiolaria, planktonic Foraminifera and nannoplankton.

Assemblage:
- Coccoliths, mainly placoliths (abundant)
- *Tremalithus eopelagicus* BRAMLETTE and RIEDEL
- Radiolaria (abundant)
- *Globorotalia* spp. (truncate forms)
- Globigerinas with spinose tests
- *Discoasters multiradiatus* BRAMLETTE and RIEDEL (typical and minute forms)
- *Discoaster bebalaini* TAN (rare)

Braarudosphaera cf. *discula* BRAMLETTE and RIEDEL (rare)
Thoracosphaera spp. (globular and ellipsoid bodies).

Outcrops north of Avenida Río immediately below contact with Cojímar beds

BR station 959

Lithology: Chalk, shaley, soft, grayish yellow.

Washed residue with Tertiary spumellarias and nassellarias mixed with Cojímar globigerinas (contaminated).

Road from the Vía Blanca to the Carretera Central (Continuation of Avenida Monumental)

About 4.5 km north of the intersection of the continuation of the Avenida Monumental with the Carretera Central, a section is exposed of about 20 m of brownish to whitish shales and chalks with interbedded conglomeratic layers. It is immediately south of a ridge of spillitic variolitic pillow lavas and possibly overlies them unconformably. Most of the pebbles are of sedimentary origin. Igneous components are andesites, serpentinites and tuffs, but no spillites have been found as yet. Although the color of the beds and the white chalks and fragmental limestones are very similar to other Alkázar beds, the conglomerates with mainly sedimentary pebbles are strongly reminiscent of the conglomeratic beds in the cut of the Carretera Central near Central San Antonio which have been redefined as type locality of the Madruga formation by BERMÚDEZ (1950). The exposure at the continuation of the Avenida Monumental and the Madruga outcrop are about in the same strike. The conglomeratic lenses are scattered throughout the Madruga formation, which is probably contemporaneous with the Apolo–Alkázar beds. The Avenida Monumental outcrop apparently is but a local facies of these early Eocene deposits which seem to be restricted to an area along the southern rim-rock of the Habana anticlinorium.

BR station 489

Lithology: Chalk, shaley, whitish to pale greenish yellow.

Washed residue with

Globorotalia velascoensis (CUSHMAN)
Globorotalia cf. *aequa* CUSHMAN and RENZ
Globorotalia pseudomenardii BOLLI
Globorotalia elongata GLAESSNER
Globigerina velascoensis CUSHMAN
Globigerina triangularis WHITE.

BR station 490

Lithology: Shale, indurated, somewhat calcareous, white to very pale orange (coccolithite).

Texture: Cryptocrystalline to argillaceous groundmass with abundant coccoliths, sponge spicules and some planktonic Foraminifera.

Assemblage: Coccoliths, mainly placoliths (abundant)
Tremalithus eopelagicus BRAMLETTE and RIEDEL

Discoaster multiradiatus BRAMLETTE and RIEDEL (typical and minute forms)
Discoaster sp. indet.
Thoracosphaera spp. (globular and ellipsoidal bodies)
Radiolaria
Globorotalia spp. (truncate forms)
Globigerinas with spinose walls
Chiloguembelina spp.

Washed residue with

Globorotalia velascoensis (CUSHMAN)
Globigerina spp.
Tertiary spumellarias.

Environment and age

The rapid alternation of relatively thin layers of graded clastics derived from reefal complexes containing apart from benthonic also planktonic microfossils with shaley and chalky layers in which planktonic microfossils, in particular coccoliths and discoasterids, prevail, indicates that the depositional environment of the Alkázar formation is fore-reefal to basinal and that the sedimentation is of flysch-type. The clastics show relatively little igneous influence, and the overall light color of the Alkázar formation suggests that not much lateritic material, which gave the strong brownish color to the basal Apolo beds, was eroded during the deposition of the Alkázar beds. Reworked Upper Cretaceous microfossils are no longer as common as in the Apolo beds, although *Vaughanina cubensis* D. K. PALMER still occurs in most of the thin sections of the clastic limestones. Allochthonous representatives of the Lower Cretaceous *Nannoconus* KAMPTNER have occasionally been encountered in the very fine-grained rocks.

We were unable to isolate planktonic Foraminifera from the hard type samples of the Alkázar formation. Random cuts of planktonics in thin sections show that truncate keeled globorotalias close to *G. velascoensis* (CUSHMAN), globigerinas and globorotalias ex gr. *G. pseudomenardii* BOLLI are common. Important nannoplanktonic elements of the chalks and calcareous shales of the Alkázar type samples affording identification of species in thin sections, are the often rock-forming discoasterids and the coccoliths.

In the Habana area, discoasterids occur for the first time in a sample of the Apolo formation, BR station 595, where a specimen of *Braarudosphaera discula* BRAMLETTE and RIEDEL was recorded. None were observed in the Upper Cretaceous, and the advent of common discoasterids in the Alkázar beds is regarded as a biostratigraphically important event. Coccoliths, on the other hand, occur in both the Upper Cretaceous and the Tertiary of the Habana area. The following suite of discoasterids was recorded:

Braarudosphaera cf. *discula* BRAMLETTE and RIEDEL (rare)
Braarudosphaera bigelowi (GRAN and BRAARUD) (rare)
Discoaster cf. *barbadiensis* TAN (rare)
Discoaster bebalaini TAN (common)
Discoaster brouweri TAN (a single specimen)

Discoaster hilli TAN (common)
Discoaster multiradiatus BRAMLETTE and RIEDEL (common) (typical and minute forms)
Discoaster ornatus STRADNER
Discoaster sp. indet.
Marthasterites bramlettei BRÖNNIMANN and STRADNER
Marthasterites contortus (STRADNER)
Marthasterites riedeli BRÖNNIMANN and STRADNER
Marthasterites cf. *tribachiatus* (BRAMLETTE and RIEDEL)
Marthasterites tribrachiatus (BRAMLETTE and RIEDEL) var. *robustus* (STRADNER) (common)

Associated minute microfossils are coccoliths, which occur rock-forming, and of which *Coccolithus grandis* BRAMLETTE and RIEDEL and *Tremalithus eopelagicus* BRAMLETTE and RIEDEL could be identified. These two forms are conspicuous because of their relatively large size.

Other minute microfossils are:

Thoracosphaera spp.
Nannoturbella moriformis BRÖNNIMANN and STRADNER.

Outside of the type section, most of the listed discoasterids are associated with *Globorotalia velascoensis* (CUSHMAN), *Globorotalia aequa* CUSHMAN and RENZ, and *Globorotalia pseudomenardii* BOLLI group, to name only the most significant planktonic Foraminifera. *Globorotalia* cf. *rex* MARTIN was encountered in the Alkázar (?) beds unconformably underlying the Cojímar formation.

Radiolaria, i.e. spumellarias and nassellarias, are common in some of the non-calcareous shales and soft chalks. They are often well preserved and would deserve a more detailed investigation. Diatoms (*Triceratium* sp.) were also noticed.

The benthonic Alkázar assemblages are virtually identical with those reported from the Apolo formation. Characteristic benthonic Foraminifera are "*Operculina*" *catenula* CUSHMAN and JARVIS, "*Amphistegina*" *lopeztrigoi* D. K. PALMER, *Discocyclina barkeri* VAUGHAN and COLE, and *Discocyclina* cf. *anconensis* BARKER. Pseudophragminas and proporocyclinas are present throughout the formation. *Eoconuloides wellsi* COLE and BERMÚDEZ, a conical form related with "*Amphistegina*" *lopeztrigoi*, on the other hand, was encountered only in BR station 1194 from the top of the Alkázar beds in Reparto Veracruz. *Boreloides cubensis* COLE and BERMÚDEZ and *Helicostegina gyralis* BARKER and GRIMSDALE, both reported by BERMÚDEZ (1952, p. 230) from his "Lucero member" of the Capdevila formation where they are associated with *E. wellsi*, were not found in the Alkázar beds. According to BECKMANN (1959, p. 417), *B. cubensis* appears for the first time in the *Globorotalia rex* zone of his biostratigraphic subdivision, and the first helicosteginas are recorded only slightly later than *B. cubensis*.

Based on planktonic Foraminifera, the Alkázar beds are of *Globorotalia velascoensis–Globorotalia pseudomenardii* group age. In terms of a discoasterids zonation, the Alkázar formation would fall in the *Discoaster multiradiatus–Marthasterites bramlettei–Marthasterites contortus* zone.