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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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Vía Blanca formation can be explained either by non-deposition due to emersion, or by erosion due to submarine currents, or by lack of any sedimentation, or by erosion prior to the deposition of the Vía Blanca formation. The first possibility is regarded as improbable because no evidence for subaerial weathering of the pre-Vía Blanca beds was found, and the last explanation is likewise improbable because there are no components of post-Turonian to pre-Campanian age in the conglomerates of the Via Blanca formation. Non-deposition due to submarine currents is probably the correct explanation. It was previously noted that sediments of Emscherian age were found only at a few scattered outcrops and that the post-Turonian to pre-Campanian sedimentary gap is encountered almost throughout Cuba.

Vía Blanca Formation

Underlying the Peñalver formation and probably transgressive on pre-Campanian strata there is a series of Upper Cretaceous mainly clastic sediments, here called Vía Blanca formation, which shows striking lithologic similarities with the younger clastic formations of the Habana group. The name is derived from the Vía Blanca, the north coast highway connecting Habana with Varadero, which opens up good exposures of the formation along road cuts immediately east of the Bahía de la Habana. The Vía Blanca formation has a wide geographic distribution as it is also known in the area of Bahía Honda about 90 km west of Habana. The Vía Blanca beds are very strongly folded and cut by numerous minor faults and except for a few road cuts poorly exposed. There is no place in the Habana area where a continuous undisturbed section of over 50 m can be measured, and the here described isolated outcrops do not afford more than a tentative grouping of lithologies. The thickness of the formation is estimated at about 500 m. The Vía Blanca formation extends in age from the Campanian *Globotruncana linneiana* zone to the *Rugotruncana gansseri* zone of the Lower Maastrichtian.

The present notes are preliminary and restricted to the description and age evaluation of the different lithologic units here assigned to the Vía Blanca formation. Future work will show whether or not the Vía Blanca formation could be differentiated into two or more lithologic units of formation rank.

The discontinuity of the outcrops and the complicated structure of the beds do not allow the designation of a type section representing all the different lithologies here included in the Vía Blanca formation. For this reason we will describe several discrete outcrops, none of which alone would suffice to define the Vía Blanca formation. However, together they furnish a relatively good understanding of the Vía Blanca lithologies.

Outcrop pattern

The best exposures are along the Vía Blanca highway north and northeast of the town of Guanabacoa, and along the recently constructed road which is the continuation to the southeast of the Avenida Monumental, connecting the Vía Blanca highway and the Carretera Central near Cuatro Caminos. Other fair to good outcrops are in the areas east of Casa Blanca, and southeast of Habana between Santa María del Rosario, El Calvario and the Bahía de la Habana. West

of the road from Habana to Calabazar, Vía Blanca beds were observed in a very few outcrops only, such as the greenish and yellowish gray tuffs, brownish tuffaceous Radiolaria-bearing graywacke sandstones, grayish yellow marls and green and brown bentonitic non-calcareous shales at the Plaza de la República, just at the foot of the Martí monument, coordinates 366.56 N and 357.86 E. BR stations 1008 to 1010 are from these beds which are typical of the lower part of the Vía Blanca formation. The fauna from station 1009 is of Campanian age. The texture of the tuff of BR station 1008 is very similar to that outcropping at the foot of Loma Urría described under Baughman stations 1789, coordinates 369.75 N and 366.40 E, and 1488, coordinates 369.64 N and 366.83 E. The geographic location of the latter two samples which are also of Campanian age, is explained in the geological map of the Casa Blanca–Cojímar area (plate III).

BR station 1008
Lithology: Tuff, porous, yellowish gray.
Texture: Glass shards and brownish igneous grains in argillaceous groundmass.
Washed residue with Radiolaria.

BR station 1009 (Campanian)
Lithology: Marl, grayish yellow.
Washed residue with

Globotruncana fornicata PLUMMER
Globotruncana stuarti (DE LAPPARENT)
"Globigerinella" messinae messinae BRÖNNIMANN
Pseudoguembelina striata (EHRENBERG)
Heterohelix sp. or *Pseudoguembelina* sp.

BR station 1010
Lithology: Shale, non-calcareous, grayish yellow to light brown.
Washed residue with Radiolaria.

Near the Martí monument, coordinates 366.13 N and 357.98 E, occurs also the westernmost extension within the Habana area of the late Maastrichtian Peñalver formation which forms the ridge on which the Palacio de Justicia is situated. Two samples from these late Maastrichtian calcarenites and calcilutites are described below.

BR station 1011 (Peñalver formation)
Lithology: Calcarenite, fine-grained, whitish.
Texture: Fragmental, poorly sorted. Components are angular to rounded fragments of sedimentary rocks, mollusks, echinoderms and benthonic Foraminifera. Rare igneous grains. Diameter of average components ranges from about 50 to 360 μ. Groundmass microcrystalline calcite.
Assemblage: *Sulcoperculina* sp. (strongly trochoid forms)
Vaughanina cubensis D. K. PALMER
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN)
Cuneolina bermúdezi D. K. PALMER
Globotruncana arca (CUSHMAN)
Globotruncana stuarti (DE LAPPARENT).

BR station 1012 (Peñalver formation)
Lithology: Calcilutite, coarse-grained, whitish.
Texture: As BR station 1011, but finer fragmental. Diameter of average components ranges from about 20 to 100 μ.
Assemblage: *Calcisphaerula innominata* BONET
Pithonella ovalis (KAUFMANN)
(These enigmatic forms are here virtually rock-forming).

The restricted areal distribution of the Vía Blanca and Peñalver formations to the west of the Habana area is due to the axial plunge of the structural units of the core of the Habana uplift to the west. The details of the structure of this area will be discussed in the chapter on the tectonics of the Habana area. As mentioned before, both the Vía Blanca and the Peñalver formations are again known farther to the west in the area of Bahía Honda.

Description of lithologic types

The lithologies of the Vía Blanca formation will be described in the following order, first the conglomerates, then the Bacuranao "limestone" intercalation of Campanian age, and finally 2 sets of samples from the typical flysch series. The one is from the Lower Maastrichtian *Rugotruncana gansseri* zone, collected along a road cut of the continuation of the Vía Monumental, and the other of Campanian to Maastrichtian age from the area east of Casa Blanca. Some notes will be added on igneous rocks.

The lithologies distinguished in the Vía Blanca beds are stratigraphically grouped as follows:

Lower Maastrichtian	Shales, Graywackes, Calcilutites, Vía Tunel and Schoolhouse Conglomerates
Campanian	Shales, Graywackes, Bacuranao "limestone", Tuffs, Flows, Bahía and Río Piedras Conglomerates.

Conglomerates of the Vía Blanca formation

The dominant lithologies of the Vía Blanca formation are well-bedded graywacke silts and shales in part bentonitic and usually graded-bedded coarser graywacke sandstones. The base of some of the coarser graywacke layers contains sometimes pebbles of igneous rocks of up to 2 cm in diameter. They also carry frequent "clay" pebbles. There occur further thin beds of very fine-grained clastic white limestone. These beds of an overall brownish occasionally somewhat greenish color are typically exposed along road cuts of the Vía Blanca highway and of the continuation of the Avenida Monumental. Conspicuous lithologic units within these dominant lithologies of the Vía Blanca formation are conglomerates composed either of mainly limestone elements or of mainly igneous elements. Of these conglomerates we have examined the following:

Bahía conglomerate Vía Tunel conglomerate	Both north of the Regla-Guanabacoa serpentinite mass.
Schoolhouse conglomerate Río Piedras conglomerate	Both south of the Regla-Guanabacoa serpentinite mass.

As based on a study of elements and matrix, the Campanian Bahía conglomerate seems to be the oldest conglomerate of the Vía Blanca formation. It is resting on pre-Vía Blanca beds and therefore interpreted as being a basal conglomerate, possibly of local significance, of the Vía Blanca formation. It is probably the oldest part of the Vía Blanca formation. Also of Campanian age, and apparently correlative with the Bahía conglomerate is the Río Piedras conglomerate, south of the Regla-Guanabacoa serpentinites, of which the stratigraphic position is not clearly known. The other two conglomerates, the Vía Tunel and the Schoolhouse conglomerates, are both of Maastrichtian age. These younger conglomerates may possibly cut down on older beds of the Vía Blanca formation or perhaps even on pre-Vía Blanca beds and the serpentinites. This question however can only then be answered when the areal distribution and stratigraphic position of the conglomerates are better known. It was noticed that the conglomerates contain apart from older elements usually also penecontemporaneous pebbles.

Bahía conglomerate

West of Guanabacoa, in the region of coordinates 367.00 N and 365.50 E, on the northern flank of the Regla-Guanabacoa serpentinite mass, there is a well-developed conglomerate, here called Bahía conglomerate, with Campanian and older Upper Cretaceous elements embedded in graywackes of medium to coarse grain size. The name is derived from the Reparto Residencial Bahía, just northwest of the town of Guanabacoa. The matrix samples, as represented by BR station 1353, are usually barren. Rarely they contain a poor Radiolaria assemblage as in Sisson station 236. The components can reach up to 1 m in diameter, but generally they are only 4 to 6 cm in diameter. Most of the elements are from andesitic and diabasic igneous rocks. Some of these were examined by H. H. Hess, Princeton, whose observations are included in the following descriptions of BR station 1351 (components 4, 6, 9, and 10) and Sisson stations 229, 231, and 235.

There occur also components of limestones, graywacke sandstones and siltstones, and radiolarites and some elements of apparently serpentinized peridotite and gabbro. Associated with the conglomeratic beds are thin-bedded reddish to brownish bentonitic shales and grayish whitish tuffs. Similar rocks crop out on the southern flank of this serpentinite uplift in the area of Habana Nueva, about 1 km south-southwest of the above described exposure. At coordinates 366.80 N and 365.34 E, just east of the plant of the Concretera Nacional, the Bahía conglomerate seems to be resting unconformably on the pre-Vía Blanca beds, which in their upper part show graywackes with slumping features reminiscent of those observed at the contact between Peñalver and Vía Blanca formations at the type locality of the Peñalver formation.

Samples from the grayish greenish radiolarites and siliceous shales of BR station 866 and Sisson stations 319 and 320, embedded in the slumped graywackes underlying the Bahía conglomerate, are described under pre-Vía Blanca beds. The age of these radiolarites is Turonian based on the occurrence of *Rotalipora* sp. affin to *Rotalipora turonica* (Brotzen), *Praeglobotruncana* cf. *delrioensis* (Plummer), and of *Globotruncana* sp. affin to *Globotruncana coronata* Bolli.

The following descriptions refer to components of the Bahía conglomerate.

BR station 867 (Probably Cenomanian to Turonian)
Lithology: Limestone, dense, yellowish gray.
Texture: Recrystallized microcrystalline calcite groundmass with glass shards, dark brown and green igneous grains and planktonic microfossils.
Assemblage: "*Globigerina*" sp. (thin-walled and finely spinose forms)
"*Globigerinella*" cf. *escheri* (KAUFMANN)
Heterohelix sp.
Radiolaria.

BR station 868 (Campanian)
Lithology: Calcarenite, fine-grained, with igneous influence, very pale orange.
Texture: Microcrystalline calcite groundmass with angular to rounded fragments of mainly sedimentary rocks, mollusks, echinoderms, algae, and Foraminifera. Also dark brown and green igneous grains. Diameter of average components ranges from about 30 to 250 μ.
Assemblage: *Pseudorbitoides* cf. *rutteni* BRÖNNIMANN
Pseudorbitoides israelskyi VAUGHAN and COLE
Pseudorbitoides sp. (with single set of radial plates)
Sulcoperculina sp.
Globotruncana sp.
Heterohelix sp. or *Pseudoguembelina* sp.

BR station 1315A
Lithology: Limestone, fragmental, pale yellowish brown.
Texture: Microcrystalline clear calcite groundmass, with rounded to subangular fragments of sedimentary and igneous rocks, mollusks, echinoderms and algae.
Assemblage: *Quinqueloculina* sp.

BR station 1351

The numbers in parentheses refer to different components.

(1) Lithology: Limestone, dense, hard, pale yellowish brown.
Texture: Recrystallized microcrystalline groundmass with limonitic specks and remains of unidentifiable planktonic microfossils.

(2) Lithology: Limestone, somewhat fragmental, with slight igneous influence, grayish yellow.
Texture: Recrystallized calcite groundmass with dark brown and green angular igneous grains and planktonic microfossils.
Assemblage: Radiolaria
"*Globigerinids*"
Heterohelix sp.

(3) Lithology: Feldspathic lava with marked flow texture. Plagioclase microphenocrysts and plagioclase microlites in a partly glassy groundmass. Also microlites of a ferromagnesian mineral possibly hypersthene but probably amphibole (near parallel extinction slightly pleochroic colorless to green). Magnetite altered to limonite.

(4) Lithology: Lava similar to (3) but more glass, stronger flow structure and smaller phenocrysts.

(5) Lithology: Limestone, dense, yellowish gray.
Texture: Recrystallized calcite groundmass with glass shards and dark brown and green igneous grains and planktonic microfossils.
Assemblage: *Heterohelix* sp.
"*Globigerina*" sp.
Radiolaria.

(6) Lithology: Lava. Glassy rock with pronounced flow banding, plagioclase phenocrysts which are strongly zoned and microphenocrysts of magnetite.

(7) Lithology: Limestone, finely fragmental, slight igneous influence, yellowish gray.
Texture: Recrystallized calcite groundmass with angular brown and green igneous grains and some organic components.
Assemblage: *Robulus* sp.
Heterohelix sp.

(8) Lithology: Limestone, dense, hard, grayish yellow (Cenomanian to Turonian).
Texture: As (1) and discrete angular igneous grains.
Assemblage: *Heterohelix* sp.
"*Globigerina*" sp. (thin-walled and finely spinose forms)
"*Globigerinella*" *escheri* (KAUFMANN) group.

(9) Lithology: Lava. Plagioclase rich. Equidimensional plagioclase phenocrysts and microphenocrysts in a glassy groundmass. A few grains of nearly colorless ferromagnesian minerals (pale green) which have nearly parallel extinction (15°) and large negative optical angle (85°). Needle-like in shape. This is an amphibole. Cross sections of needles also indicate this.

(10) Lithology: Flow breccia or agglomerate. Fragments of glassy lavas and plagioclase crystals veined by quartz and fibrous minerals, possibly zeolites also red brown limonite (?) in veins. Lavas have a few serpentine pseudomorphs after hypersthene or olivine.

(11) Lithology: Limestone, algal, moderate yellowish brown.
Texture: Cryptocrystalline to microcrystalline groundmass with algae, encrusting Foraminifera, and discrete angular mollusk fragments. Also some igneous grains.
Assemblage: *Girvanella*-like forms
Nubecularia sp.
"*Globigerinia*" sp.
Acervulina sp.

BR station 1352
Lithology: Graywacke siltstone, friable, non-calcareous, moderate yellowish brown.
Washed residue with Radiolaria.

Sisson station 229
Lithology: Lava. Largely glass with clear plagioclase microlites and minute iron oxyde specks. A few small plagioclase phenocrysts indices of refraction considerably higher than the balsam used for mounting slide. Marked flow structures.

Sisson station 231
Lithology:

(1) Glomeroporphyritic clusters of plagioclase phenocrysts, cores apparently replaced by calcite. Similar to (3) but less biotite and its place taken by brown hornblende. Obviously a variant of (3).

(2) Fragments of lava in a calcite matrix. Fragments mostly same rock as (1) and (3).

(3) Quartzdacite lava or very shallow intrusive with calcite fracture fillings. Plagioclase and biotite phenocrysts in a groundmass of glass plagioclase microlites and irregular equidimensional quartz grains.

Sisson station 235
Lithology: Calcareous vitric tuff. Colorless glass shards in matrix probably calcite.

The following descriptions are from *matrix samples of the Bahía conglomerate:*

BR station 1353
Lithology: Graywacke sandstone, calcareous, pale yellowish brown. Barren.

Sisson station 236
Lithology: Graywacke sandstone, non-calcareous, light brown.
Washed residue with a few Radiolaria.

Vía Tunel conglomerate

Overturned, steeply northward dipping and about east-southeast striking conglomeratic beds of the late Vía Blanca formation crop out approximately 2.5 km east-northeast of the town of Casa Blanca situated opposite the old part of Habana on the northern coast of the Bahía de la Habana. The approximate coordinates of the best outcrops of this conglomerate, here called Vía Tunel conglomerate from the Reparto Vía Tunel south of Loma Urría, are 369.34 N and 365.35 E (plate III). The matrix of the conglomerate consists mainly of thin-bedded brownish shales, graded-bedded brownish graywacke sands and silts and hard fragmental limestones. The components are mainly fragments and casts of rudists and fragmental limestones. Igneous elements are scarce. The age of the conglomerate is Maastrichtian, but not late Maastrichtian as shown by the absence of *Omphalocyclus macroporus* (LAMARCK). Of particular significance is the common occurrence in some of the fragmental limestone components of *Historbitoides kozaryi* BRÖNNIMANN, a pseudorbitoid which was also found in elements of the Schoolhouse conglomerate outcropping along a road cut of the continuation of the Avenida Monumental, near coordinates 364.84 N and 371.41 E. *H. kozaryi* BRÖNNIMANN is usually accompanied by *Sulcoperculina angulata* BROWN and BRÖNNIMANN. The two conglomerates probably form a single unit, although the igneous elements are much more common in the Schoolhouse conglomerate than in the Vía Tunel conglomerate.

The following samples are from *components of the Vía Tunel conglomerate.* The youngest of these elements is of Lower Maastrichtian age, i.e. penecontemporaneous with the matrix of the conglomerate.

BR station 1374

The numbers in parentheses refer to different elements of the conglomerate.

(1, 2, 5, 6, 10, 11) Lithologies: Limestone, fragmental, grayish orange, usually filling of cavities of rudists (Lower Maastrichtian).
Textures: Fragmental, poorly sorted. Cryptocrystalline argillaceous and vacuolar groundmass usually with abundant densely packed angular fragments of mollusks, algae, echinoderms and encrusting Foraminifera. Diameters of average components from about 50 to 600 μ. Embedded in this fragmental matrix are larger fragments of mollusks and echinoderms of up to 3000 μ maximum diameter.
Assemblage: *Historbitoides kozaryi* BRÖNNIMANN
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN)
Acervulina cenomaniana (SEGUENZA).

(4, 13) Lithologies: Limestone, fragmental, grayish orange (Lower Maastrichtian).
Textures: Fragmental, poorly sorted. Cryptocrystalline argillaceous, in places microcrystalline recrystallized calcite groundmass with densely packed angular fragments of mollusks, echinoderms, algae and benthonic Foraminifera. Diameter of average components from about 60 to 600 μ. Rare larger fragments up to a maximum diameter of about 1000 μ.
Assemblages: *Historbitoides kozaryi* BRÖNNIMANN
Sulcoperculina angulata BROWN and BRÖNNIMANN
Sulcoperculina spp.
Calcisphaerula innominata BONET.

(12) Lithology: Chalk, indurated, dense, white (Campanian).
Texture: Microcrystalline groundmass with planktonic microfossils.
Assemblage: *Heterohelix* sp. or *Pseudoguembelina* sp. (strongly striate forms)
Globotruncana lapparenti BROTZEN group
"*Globigerina*" sp.
Globotruncana stuarti (DE LAPPARENT)
Globotruncana calcarata CUSHMAN.

Baughman station 1762

(1) Lithology: Limestone, fragmental, with igneous influence, grayish orange (Lower Maastrichtian).
Texture: Recrystallized clear calcite groundmass with generally rolled fragments of limestones, mollusks, echinoderms, algae, and benthonic Foraminifera. Abundant pseudorbitoids, many of them coated with dark argillaceous material. Also some rounded igneous grains. Diameters of average components range from about 300 to 1000 μ.
Assemblage: *Orbitoides palmeri* GRAVELL
Historbitoides kozaryi BRÖNNIMANN
Pseudorbitoides cf. *rutteni* BRÖNNIMANN (?reworked)
Sulcoperculina spp.
Globotruncana lapparenti BROTZEN group
Calcisphaerula innominata BONET.

(2) Lithology: Limestone, fragmental, dark yellowish orange (Lower Maastrichtian).
Texture: Fragmental. Groundmass microcrystalline calcite, vacuolar. Components mainly planktonic microfossils, fragments of benthonic Foraminifera, algae, echinoderms and mollusks. Some angular brownish igneous grains. Diameter of average components ranges from about 100 to 350 μ.
Assemblage: *Vaughanina cubensis* D. K. PALMER
Pseudorbitoides sp. (with single set of radial plates)
Orbitoides palmeri GRAVELL (fragment)
Sulcoperculina sp.
Heterohelix sp. or *Pseudoguembelina* sp.
Globotruncana lapparenti BROTZEN group
Globotruncana stuarti (DE LAPPARENT)
Globotruncana linneiana (D'ORBIGNY)
Rugoglobigerina rugosa (PLUMMER)
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN)

(3) Lithology: Limestone, fragmental, very pale orange (Lower Maastrichtian).
Texture: Fragmental, poorly sorted. Mainly elongate mollusk fragments, and subangular to rounded fragments of sedimentary rocks, echinoderms and algae. Diameters of average components vary from about 60 to 1200 μ. Groundmass microcrystalline calcite.
Assemblages: *Vaughanina* cf. *cubensis* D. K. PALMER
Sulcoperculina spp.
Calcisphaerula innominata BONET.

(4) Lithology: Limestone, finely fragmental, pale yellowish brown (Campanian or Lower Maastrichtian).
Texture: Fragmental. Microcrystalline calcite groundmass with angular to rounded igneous grains. Large discrete mollusk and echinoderm fragments and common sulcoperculinas. Some planktonic microfossils.
Assemblage: *Sulcoperculina* cf. *dickersoni* (D. K. PALMER)
Sulcoperculina sp.
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN)
Globotruncana lapparenti BROTZEN group.

(5) Lithology: Limestone, fragmental, pale yellowish brown (Campanian or Lower Maastrichtian).
Texture: Fragmental. Microcrystalline calcite groundmass with small angular organic fragments. Diameters of average components range from about 25 to 150 μ. Embedded are isolated large mollusk and echinoderm fragments and sulcoperculinas. No igneous grains.
Assemblage: *Sulcoperculina* sp.
Sulcoperculina cf. *dickersoni* (D. K. PALMER)
Globotruncana lapparenti BROTZEN group
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

(6) Lithology: Limestone, dense, grayish orange (Campanian or Lower Maastrichtian).
Texture: Coral. Cavities filled with microcrystalline groundmass.
Assemblage: *Sulcoperculina* sp.
Globotruncana lapparenti BROTZEN group
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

(10) Lithology: Limestone, dense, very pale orange.
Texture: Microcrystalline calcite groundmass with specks of dark brown material. Barren.

(11) Lithology: Limestone, fragmental, grayish orange (filling of rudist cavity) (Lower Maastrichtian).
Texture: Fragmental, poorly sorted. Microcrystalline calcite groundmass with angular to subrounded fragments of sedimentary rocks, algae, mollusks, encrusting Foraminifera and echinoderms. Some larger Foraminifera. Diameters of average components from about 100 to 1500 μ. No igneous grains.
Assemblage: *Vaughanina cubensis* D. K. PALMER
Orbitoides cf. *palmeri* GRAVELL (small forms)
Sulcoperculina spp.
Placopsilina ex gr. *cenomana* D'ORBIGNY-*longa* TAPPAN.

(12) Lithology: Limestone, fragmental, grayish orange (filling of rudist cavity) (Lower Maastrichtian).
Texture: Fragmental, poorly sorted. Components angular to subrounded fragments of sedimentary rocks, mollusks, echinoderms, algae and benthonic Foraminifera. Diameters of average components range from about 50 to 700 μ. Groundmass microcrystalline calcite. Limonitic stains.
Assemblage: *Vaughanina cubensis* D. K. PALMER
Orbitoides palmeri GRAVELL
Sulcoperculina spp.
Calcisphaerula innominata BONET.

Baughman station 1769 (Lower Maastrichtian)
Lithology: Limestone, fragmental, vacuolar, grayish red.
Texture: Fragmental, poorly sorted. Angular fragments of mollusks, echinoderms, algae and benthonic Foraminifera in calcite groundmass. Interstices and vacuoles filled with black substance. Diameter of average components ranges from about 60 to 1000 μ.
Assemblage: *Vaughanina cubensis* D. K. PALMER
Orbitoides palmeri GRAVELL
Sulcoperculina spp.

Baughman station 1779
The numbers in parentheses refer to different components of the conglomerate.
(1) Lithology: Limestone, fragmental, very pale yellowish brown (Lower Maastrichtian).
Texture: Fragmental, poorly sorted. Microcrystalline calcite groundmass with angular to rounded fragments of mollusks, echinoderms, algae, sedimentary

rocks and benthonic Foraminifera. Diameter of average components ranges from about 90 to 1000 μ.

Assemblage: *Vaughanina cubensis* D. K. PALMER
Orbitoides palmeri GRAVELL
Sulcoperculina spp.
Placopsilina ex gr. *cenomana* D'ORBIGNY-*longa* TAPPAN
Calcisphaerula innominata BONET.

(2) Lithology: Limestone, fragmental, calcarenaceous with some igneous influence, dark yellowish orange (Campanian).
Texture: Fragmental, poorly sorted. As (1) but vacuolar, and some igneous grains.
Assemblage: *Sulcoperculina* spp.
Pseudorbitoides sp. (with single set of radial plates).

(3) Lithology: Calcarenite to calcirudite, with large discrete clay inclusions, light gray to yellowish gray.
Texture: Fragmental, unsorted. Same suite of components as in (1) and (2), but diameters of average fragments range from about 100 to 3000 μ.
Assemblage: *Pseudorbitoides* sp. (with single set of radial plates)
Historbitoides kozaryi BRÖNNIMANN
Sulcoperculina spp.

The following stations are from the Lower Maastrichtian *matrix of the Vía Tunel conglomerate.*

BR station 1375
Lithology: Shale, calcareous, pale yellowish brown.
Washed residue with

Globotruncana stuarti (DE LAPPARENT)
Globotruncana cf. *arca* (CUSHMAN)
Rugotruncana cf. *ellisi* BRÖNNIMANN and BROWN
Pseudoguembelina striata (EHRENBERG).

Baughman station 1761
Lithology: Graywacke siltstone, friable, marly, pale yellowish orange.
Washed residue with

Globotruncana arca (CUSHMAN)
Globotruncana contusa (CUSHMAN)
Globotruncana stuarti (DE LAPPARENT)
Planoglobulina glabrata (CUSHMAN)
Pseudotextularia elegans (RZEHAK)
Pseudoguembelina striata (EHRENBERG)
Pseudoguembelina excolata (CUSHMAN)
Sulcoperculina spp.

The following samples are from conglomerates of the Vía Blanca formation outcropping along the continuation of the Avenida Monumental from the Vía Blanca to the Carretera Central.

Schoolhouse conglomerate

A well-developed conglomerate occurs on the continuation of the Avenida Monumental along a cut of about 170 m length near to a point of coordinates 364.84 N and 371.41 E (see photograph of detail, fig. 3). The name of this conglomerate is derived from the rural schoolhouse No. 4 which is situated above the

Fig. 3. Detail view of the Schoolhouse conglomerate. The dark components are igneous rocks, the light colored components usually limestones. Scale 1:32.

eastern flank of the road cut. The matrix of the practically vertical conglomeratic beds consists mainly of brownish medium-grained graywacke sandstones and non-calcareous brownish shales of Maastrichtian age. Some of the beds are bearing almost exclusively well-rounded pebbles of andesitic and diabasic igneous rocks. Other beds carry mostly rudist fragments and subangular to angular boulders of white limestones rich in rudist fragments. The youngest of these boulders are of Maastrichtian age. On the western side of the road cut we observed a large allochthonous whitish limestone block of a volume of several cubic meters.

The following samples are from *components of the Schoolhouse conglomerate:*

BR station 655

The numbers in parentheses refer to different pebbles.

(1) Lithology: Limestone, fragmental, light gray (Campanian).
Texture: Cryptocrystalline to clear calcite groundmass with some grains of brown and green igneous rocks and abundant poorly sorted angular to subangular calcareous components derived from limestones, mollusks, echinoderms and algae (Corallinaceae and Dasycladaceae). Also benthonic and rare planktonic Foraminifera. Diameter of average grains from 150 to 1200 μ.
Assemblage: *Sulcoperculina* spp. (including very large almost planispiral forms with deep sulcus related to *Sulcoperculina dickersoni* (D. K. PALMER))
Meandropsina rutteni D. K. PALMER

Pseudorbitoides cf. *israelskyi* VAUGHAN and COLE
Pseudorbitoides sp. (with single set of radial plates)
Spiroloculina sp.
Calcisphaerula innominata BONET
Radiolaria.

(2) Lithology: Graywacke sandstone, calcareous, pale yellowish brown (Campanian).

Texture: As in (1), but stronger igneous influence and grain size from 100 to 1200 μ. Groundmass clear calcite.

Assemblage: *Sulcoperculina* spp.
Orbitoides sp. (primitive form, usually as rolled and coated fragments)
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET
Spiroloculina sp. (as in (1)).

(3) Lithology: Limestone, fragmental (Lower Maastrichtian).

Texture: Clear calcite groundmass with usually somewhat rolled and coated poorly sorted fragments of limestones, mollusks, echinoderms, algae, and benthonic Foraminifera and with some igneous grains. Common orbitoidal Foraminifera. The diameter of average fragments ranges from about 100 to 1200 μ.

Assemblage: *Orbitoides* cf. *palmeri* GRAVELL
Sulcoperculina sp.
Calcisphaerula innominata BONET
Vaughanina cubensis D. K. PALMER
Spiroloculina sp. (as in (1)).

(4) Lithology: Limestone, fragmental, grayish yellow (Campanian or Lower Maastrichtian).

Texture: Fragmental, unsorted. Cryptocrystalline groundmass with angular organic fragments, mainly algae and mollusks, and rare planktonic Foraminifera.

Assemblage: *Acervulina cenomaniana* (SEGUENZA)
Pseudorbitoides sp. (fragments only)
Globotruncana lapparenti BROTZEN group
Rugoglobigerina rugosa (PLUMMER)
Pseudotextularia elegans (RZEHAK)
Heterohelix sp. or *Pseudoguembelina* sp.
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET.

(5) Lithology: Limestone, fragmental, pale yellowish brown (Lower Maastrichtian).

Texture: As in (4), but groundmass microcrystalline and components smaller, ranging in diameter from about 100 to 350 μ.

Assemblage: *Historbitoides kozaryi* BRÖNNIMANN (this species is common in the components from the Vía Tunel conglomerate east of Casa Blanca)
Sulcoperculina angulata BROWN and BRÖNNIMANN
Orbitoides palmeri GRAVELL
Vaughanina cubensis D. K. PALMER
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET.

(6) Lithology: Limestone, fragmental, with large mollusk fragments, yellowish gray (Lower Maastrichtian).
Texture: Finely fragmental groundmass with discrete large rudist fragments.
Assemblage: *Orbitoides palmeri* GRAVELL (small form)
Vaughanina cubensis D. K. PALMER
Sulcoperculina sp.

(7) Lithology: Graywacke siltstone, calcareous, dark yellowish brown.
Texture: Fragmental. Densely packed angular to rounded fragments mainly of sedimentary and of brown and green igneous rocks. The diameter of average grains varies from about 70 to 350 μ. The matrix is recrystallized clear calcite.
Assemblage: *Globotruncana stuarti* (DE LAPPARENT) group
Radiolaria.

(8) Lithology: Graywacke sandstone, yellowish gray (Maastrichtian).
Texture: As in (7), but poorly sorted, and diameter of average grains from about 300 to 2000 μ. Also some oölites.
Assemblage: *Vaughanina cubensis* D. K. PALMER
Calcisphaerula innominata BONET.

Sisson station 242
Lithology: Limestone, fragmental, grayish orange (1), and limestone fragmental, with igneous grains, pale brown (2) (Maastrichtian).

(1) Texture: Fragmental, poorly sorted. The components are mainly angular fragments of mollusks in particular rudists, echinoderms and algae. Some orbitoidal Foraminifera were noticed. Diameter of average fragments ranges from about 100 to 300 μ. The matrix is microcrystalline to cryptocrystalline calcite.
Assemblage: *Sulcoperculina* sp.
Vaughanina cubensis D. K. PALMER
Acervulina cf. *cenomaniana* (SEGUENZA)
Globotruncana lapparenti BROTZEN group
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

(2) Texture: Fragmental. The components are mainly small angular to rounded organic fragments and dark brown igneous grains. Diameter of average fragments ranges from about 20 to 100 μ. The matrix is microcrystalline. Embedded in the finely fragmental groundmass are isolated sulcoperculinas and larger mollusk and echinoderm fragments.

Assemblage: *Sulcoperculina* sp.
Calcisphaerula innominata BONET (common)
Pithonella ovalis (KAUFMANN) (common).

Sisson station 243
Lithology: Limestone, coralligen and algal, yellowish gray (1), and limestone, fragmental, yellowish gray (2) (Lower Maastrichtian).

(1) Texture: Cryptocrystalline groundmass with corals, encrusting algae and Foraminifera.
Assemblage: *Placopsilina* ex gr. *cenomana* D'ORBIGNY-*longa* TAPPAN.

(2) Texture: As Sisson station 242, but finer grained.
Assemblage: *Historbitoides kozaryi* BRÖNNIMANN
Fragments of orbitoidal Foraminifera
Pithonella ovalis (KAUFMANN).
Calcisphaerula innominata BONET

Sisson station 244
Lithology: Calcarenite to calcirudite, conglomeratic appearance with large clay pebbles, yellow gray (Lower Maastrichtian).
Texture: Fragmental, unsorted. The components are fragments of limestones, igneous rocks, mollusks, echinoderms and algae. Common vaughaninas and sulcoperculinas. The diameter of average components is from about 150 to 2500 μ. The groundmass is microcrystalline, vacuolar.

Assemblage: *Vaughanina cubensis* D. K. PALMER (common)
Orbitoides palmeri GRAVELL
Ctenorbitoides cardwelli BRÖNNIMANN (rare) (?reworked)
Sulcoperculina spp.
Orbitocyclina sp.
Pseudorbitoides sp. (with single set of radial plates) (coated)
Spiroloculina sp. (in fragment)
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

Sisson station 245 (Lower Maastrichtian)
This is from a component embedded as a reworked fragment in the conglomeratic sample described under Sisson station 244.
Lithology: Chalk, friable, powdery, white.
Washed residue with
Globotruncana fornicata PLUMMER
Intermediate forms between *Globotruncana fornicata* PLUMMER and *Globotruncana contusa* CUSHMAN
Globotruncana linneiana (D'ORBIGNY)
Globotruncana stuarti (DE LAPPARENT)
Globotruncana marginata (REUSS)
Pseudotextularia elegans (RZEHAK)
Rugoglobigerina rugosa rugosa (PLUMMER) group
Planoglobulina glabrata (CUSHMAN)

Heterohelix globulosa (EHRENBERG)
Pseudoguembelina striata (EHRENBERG).

The following samples are from the *matrix of the Schoolhouse conglomerate.*

BR station 656
Lithology: Clay, non-calcareous, pale yellowish brown.
Washed residue with a cast of *Heterohelix* sp.

Sisson station 246
Lithology: Clay, non-calcareous, dark yellowish brown, with white calcite inclusions.
Washed residue with

Vaughanina cubensis D. K. PALMER
Sulcoperculina dickersoni (D. K. PALMER)
Sulcoperculina sp.
Cosinella sp.

Río Piedras conglomerate

Conglomeratic beds with igneous and limestone components occur also along cuts on both sides of the continuation of the Avenida Monumental about 220 m south of its intersection with the road to Santa María del Rosario, and about 3.15 km E 8° S of the church of Santa María del Rosario. The outcrops are just south of the Río Piedras quarry of the Atlas Company, from which the name of the conglomerate is derived. The matrix is a graywacke sandstone. The youngest components and the matrix are of Campanian age. Of interest is the occurrence of common Cenomanian to Turonian components. Some of the components from this conglomerate are described below:

BR station 1152
The numbers in parentheses refer to components of the conglomerate.

(1) Lithology: Limestone, fragmental, light gray.
Texture: Fragmental. Subangular to rounded fragments of mollusks, echinoderms and algae embedded in microcrystalline calcite matrix. Some angular dark brown and green igneous grains. Diameter of average components ranges from about 50 to 1500 μ.
Assemblage: *Placopsilina* ex gr. *cenomana* D'ORBIGNY–*longa* TAPPAN
Calcisphaerula innominata BONET.

(2) Lithology: Limestone, laminated, dense, yellowish gray (coccolithite).
Texture: Cryptocrystalline groundmass with abundant planktonic microfossils.
Assemblage: Coccoliths (rock-forming)
Radiolaria
"*Globigerina*" sp. (mainly very thin-walled smooth forms with deep umbilicus)
"*Globigerinella*" sp.

(3) Lithology: Limestone, fragmental, pale yellowish brown.

Texture: As (1), but diameter of average components ranges from about 70 to 600 μ. Matrix microcrystalline calcite.

Assemblage: *Pseudorbitoides* sp. (forms with a single set of radial plates)
Sulcoperculina sp.
Globotruncana lapparenti BROTZEN group
Heterohelix sp.

(4) Lithology: Calcilutite, dense, yellowish gray (coccolithite).
Texture: Argillaceous groundmass with minute angular organic derived fragments and angular igneous grains, ranging in size from about 2 to 20 μ. Manganese dendrites.

Assemblage: Coccoliths (rock-forming)
Radiolaria
"*Globigerina*" sp.

(5) Lithology: Graywacke sandstone, coarse-grained, non-calcareous, yellowish brown.
Texture: Cryptocrystalline to argillaceous groundmass with poorly sorted subangular to rounded igneous grains ranging in size from about 150 to 3500 μ.

Assemblage: Radiolaria
Heterohelix sp.
"*Globigerina*" sp. (as in (2))
Sulcoperculina sp. ?

(6) Lithology: Limestone, hard, dense, medium gray to gray (coccolithite).
Texture: Cryptocrystalline groundmass with subangular to angular igneous grains ranging in size from about 150 to 3500 μ.

Assemblage: Coccoliths (abundant)
Radiolaria
Heterohelix sp.
"*Globigerina*" sp. (thin-walled, smooth forms)
Schackoina cenomana (SCHACKO)
"*Globigerinella*" sp.

(7) Lithology: Limestone, fragmental, laminated, pale yellowish brown.
Texture: Fragmental, sorted, laminated. Components are subangular to rounded fragments of sedimentary and mainly dark green and brown igneous rocks, of mollusks, echinoderms, Foraminifera and algae. Diameter of average components in the fine-grained portion ranges from about 30 to 300 μ, in the coarse-grained portion from about 150 to 3500 μ. Groundmass clear calcite.

Assemblage: *Sulcoperculina* spp.
Pseudorbitoides sp. (with single set of vertical plates)
Heterohelix sp. or *Pseudoguembelina* sp.
"*Globigerina*" sp.
Calcisphaerula innominata BONET

(8) Lithology: Limestone, fragmental, pale yellowish brown.
Texture: Fragmental. Cryptocrystalline to microcrystalline groundmass with common angular to rounded mainly dark brown igneous grains, mollusks and echinoderm fragments. Abundant planktonic microfossils.

Assemblage: Radiolaria
Heterohelix sp. or *Pseudoguembelina* sp.
Globotruncana lapparenti BROTZEN group
"*Globigerina*" spp.

Sisson station 148
Lithology: Graywacke siltstone, non-calcareous, yellowish gray.
Washed residue with
"*Globigerina*" spp. (smooth thin-walled forms)
Radiolaria (common).

Sisson station 150
(1) Lithology: Calcilutite, pale yellowish brown (coccolithite).
Texture: Cryptocrystalline, brownish groundmass with minute angular organic derived fragments and abundant planktonic microfossils.
Assemblage: *Globotruncana* cf. *tricarinata* (QUEREAU)
Globotruncana linneiana (D'ORBIGNY)
Globotruncana cf. *fornicata* PLUMMER
Globotruncana stuarti (DE LAPPARENT)
Globotruncana lapparenti BROTZEN group
"*Globigerinella*" *messinae messinae* BRÖNNIMANN
"*Globigerinella*" *messinae carinata* BRÖNNIMANN
Rugoglobigerina rugosa (PLUMMER) group
Heterohelix sp. or *Pseudoguembelina* sp. (strongly striate forms),
Coccoliths (rock-forming).

(2, 3) Lithologies: Limestone, dense, light gray.
Textures: Cryptocrystalline calcite groundmass with abundant Radiolaria and planktonic Foraminifera.
Assemblage: "*Globigerina*" spp. (mainly thin-walled and finely spinose forms and forms in axial section affin to *Ticinella roberti* (GANDOLFI))
"*Globigerinella*" sp.
Schackoina cf. *jeanneti* REICHEL
Tubulospines of *Schackoina* sp.
Schackoina sp. (with spines and complanate coiling)
Radiolaria (abundant).

Sisson station 202
Lithology: Limestone, silty, pale yellowish to brown.
Texture: As Sisson station 150 (2).
Assemblage: "*Globigerina*" spp. (mainly thin-walled and in part finely spinose forms and forms in axial section affin to *Ticinella roberti* (GANDOLFI))
"*Globigerinella*" sp.
Hastigerinoides cf. *alexanderi* (CUSHMAN)
Tubulospines of *Schackoina* sp.
Radiolaria (abundant).

Sisson station 203
Lithology: Claystone, calcareous, pale brown.

Washed residue with

Globotruncana fornicata PLUMMER
Globotruncana linneiana (D'ORBIGNY)
Globotruncana cf. *marginata* (REUSS)
Globotruncana cf. *cretacea* (D'ORBIGNY)
Globotruncana stuarti (DE LAPPARENT)
Rugoglobigerina rugosa rugosa (PLUMMER)
Pseudoguembelina excolata (CUSHMAN)
Heterohelix globulosa (EHRENBERG)
Heterohelix pulchra (BROTZEN).
"*Globigerina*" spp.
"*Globigerinella*" *messinae messinae* BRÖNNIMANN

The following descriptions refer to *matrix samples from the Río Piedras conglomerate*:

Sisson station 149
Lithology: Graywacke sandstone, non-calcareous, yellowish brown. Barren.

Sisson station 201
Lithology: Graywacke siltstone, calcareous, moderate yellowish brown.
Washed residue with

Globotruncana fornicata PLUMMER
Globotruncana stuarti (DE LAPPARENT)
Globotruncana linneiana (D'ORBIGNY)
Globotruncana lapparenti BROTZEN group
Rugoglobigerina rugosa rugosa (PLUMMER)
Pseudotextularia elegans (RZEHAK)
?*Orbitocyclina minima* H. DOUVILLÉ (fragments).

Bacuranao "limestone"

Intercalations in the Vía Blanca graywackes and shales of graded-bedded calcareous clastics with numerous greenish pebble-sized "clay" inclusions in the lower beds are here called Bacuranao "limestone". The name is derived from the town of Bacuranao situated to the north of the main outcrops of the Bacuranao "limestone". The top of these intercalations is generally a very fine calcilutite composed mainly of coccoliths. The overall color is yellowish gray and the maximum thickness measured by us is about 20 m. They are almost identical in lithology with the fine-grained beds of the younger Peñalver formation, and would it not be for the occurrence of the characteristic basal loose calcirudites with conspicuous late Maastrichtian larger Foraminifera ("Lime Gravel" of PALMER), the Peñalver formation and these calcareous clastic intercalations of the Vía Blanca formation could not be distinguished in the field. Their main development is immediately south of the Regla-Guanabacoa uplift. The Bacuranao "limestone" occurs also farther to the east and perhaps could be regarded as a mappable unit. A single outcrop was found north of the Regla-Guanabacoa serpentinite mass near coordinates 368.13 N and 365.89 E, just southeast of the Esso Refinery Belot.

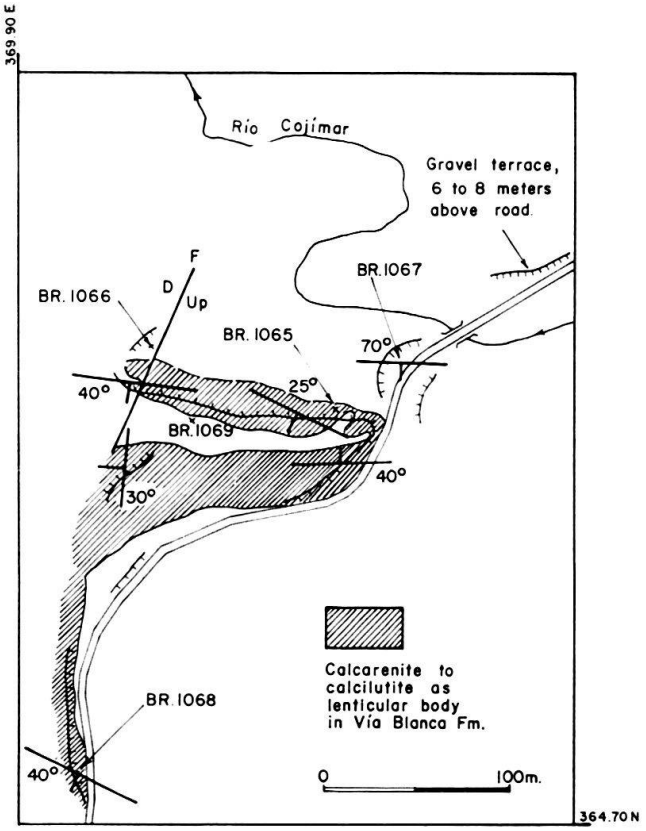


Fig. 4. Index map, Cantera San José.

The Bacuranao "limestone" seems to be enveloped in strongly contorted and squeezed Vía Blanca shales and graywackes. The intercalations are of Campanian age, and represent an earlier and apparently local development of Peñalver type lithology. In our area the intercalations appear to be lenticular as shown by the outcrops in the Cantera San José about 4 km east-southeast of Guanabacoa, coordinates 364.92 N and 370.00 E (see index map and cross sections figs. 4 and 5).

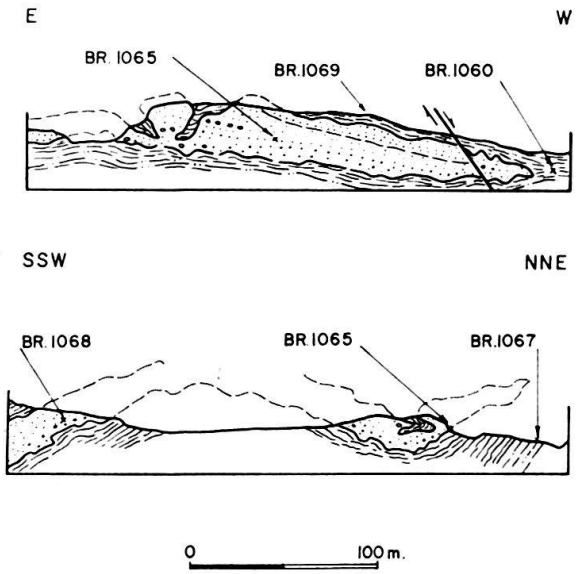


Fig. 5. Cross sections, Cantera San José.

Their lenticular nature is also reflected by the fact that they form discontinuous elliptical ridges, contrasting with the narrow, elongate and more continuous and more prominent crests of the younger Peñalver formation.

Good outcrops to study the calcarenaceous to calcilutaceous bodies are found in several quarries due east of Guanabacoa.

Cantera Río de Piedra

In the Cantera Río de Piedra, not to be confounded with the Cantera Río Piedras, at the continuation of the Avenida Monumental coordinates 366.16 N and 369.46 E, the attitude of the calcarenaceous intercalation cannot be seen, but

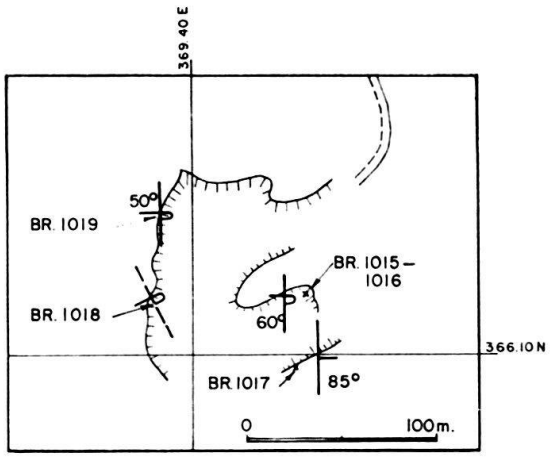


Fig. 6. Index map, Cantera Río de Piedra.

the Bacuranao lithologies are typically developed. The locations of the below described samples are explained in the index map (fig. 6):

BR stations 1015 and 1016

The samples from these stations are almost identical and therefore described together.

Lithology: Calcilutite, fine to coarse-grained, with minor igneous influence, yellowish gray.

Texture: Densely packed angular to rounded fragments derived from dark sediments, tuffs, and brownish to greenish igneous rocks. Also sponge spicules, Radiolaria, Foraminifera and algal fragments. Diameter of average grains from about 20 to 250 μ. Groundmass calcite.

Assemblage: *Globotruncana stuarti* (DE LAPPARENT) group
Heterohelix sp. or *Pseudoguembelina* sp. (striate forms)
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET
Pseudorbitoides sp. (fragment).

BR station 1017

Lithology: Calcilutite, fine-grained, with minor igneous influence, yellowish gray.

Texture: As in BR stations 1015 and 1016, but average grain size from about 5 to 60 μ. Groundmass clear microcrystalline calcite.

Assemblage: *Pithonella ovalis* (KAUFMANN)
Calcisphaerula innominata BONET

BR station 1018
Lithology: Chalk, soft, pale greenish yellow.
Washed residue with rare fragments of ostracodes.

BR station 1019
Lithology: Calcilutite, very fine-grained, with a few igneous grains, yellowish gray (coccolithite).

Texture: As in BR stations 1015 to 1017. Diameter of average grains from about 5 to 50 μ. Groundmass cryptocrystalline argillaceous calcite.

Assemblage: *Heterohelix* sp. or *Pseudoguembelina* sp. (striate forms)
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET
Coccoliths (abundant).

Abandoned quarry at coordinates 366.29 N and 369.40 E

The same lithologies can be seen in a nearby abandoned quarry at coordinates 366.29 N and 369. 40 E.

BR station 1020
Lithology: Calcilutite, coarse-grained, with a few igneous grains, yellowish gray.
Texture: As in BR stations 1015 to 1017, but diameter of average grains from about 60 to 250 μ. Groundmass clear microcrystalline calcite.

Assemblage: *Globotruncana lapparenti* BROTZEN group
Heterohelix sp. or *Pseudoguembelina* sp. (striate forms)
Sulcoperculina sp. (very small form with large umbilical plug)
Pseudorbitoides sp.
Cibicides sp.
Miliolids
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET.

BR station 1021
Lithology: Calcilutite, fine-grained, with a few igneous grains, yellowish gray.
Texture: As in BR stations 1015 to 1017 and 1020. Diameter of average grains from about 10 to 90 μ. Matrix microcrystalline to cryptocrystalline calcite.

Assemblage: *Sulcoperculina* sp.
Pseudorbitoides sp.
Heterohelix sp. or *Pseudoguembelina* sp. (striate forms)
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET

Washed residue with
Sulcoperculina sp. (very small form)
Calcisphaerula innominata BONET.

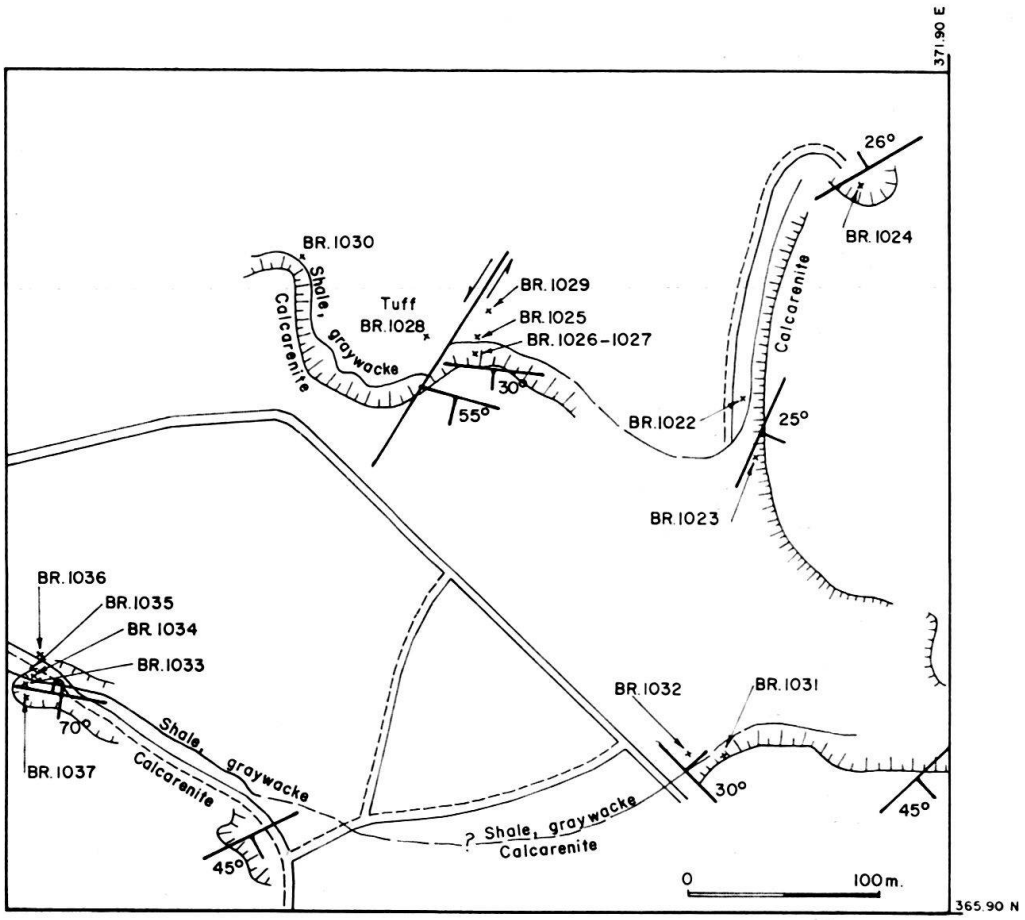


Fig.7. Index map, Cantera Santa María.

Cantera Santa María

In the Cantera Santa María, about 5 km east of Guanabacoa, two ridges of calcareous clastics are exposed (fig. 7). The ridge in the northern part of the quarry, north of grid latitude 366.05, is structurally normal and its contact toward the underlying Vía Blanca graywackes and shales shows submarine slumping. The other ridge in the southern part of the quarry is overturned and the contact toward the stratigraphically overlying graywacke shales and sandstones is well exposed.

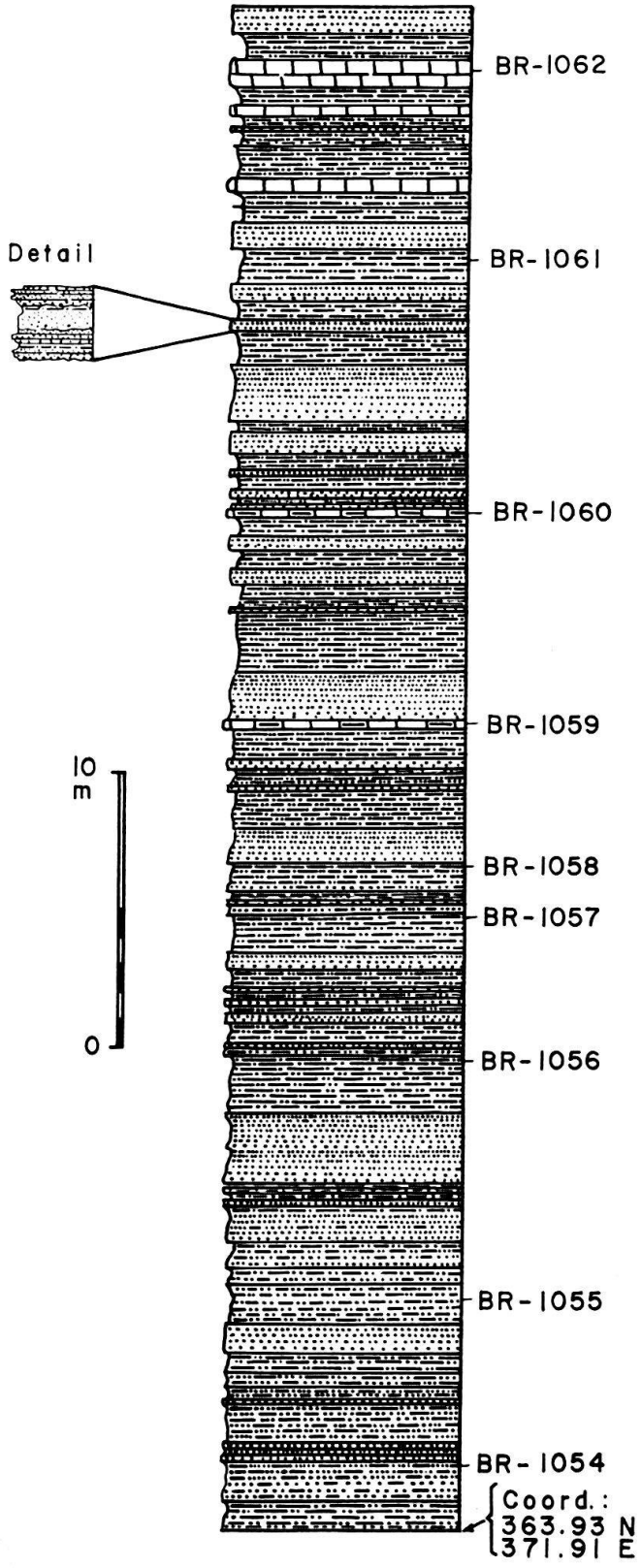
BR station 1022
Lithology: Calcilutite, very fine-grained, yellowish gray.
Washed residue with

Heterohelix globulosa (EHRENBERG)
Pseudoguembelina cf. *striata* (EHRENBERG)
Bulimina reussi MORROW
Radiolaria.

BR station 1023
Lithology: Calcilutite, fine-grained, with a few igneous grains, yellowish gray.
Texture: As in BR station 1021.

Assemblage: *Pithonella ovalis* (KAUFMANN)
Calcisphaerula innominata BONET.

BR stations 1024 and 1025 (Vía Blanca shales)
Lithologies: Shale, calcareous, yellowish gray and yellowish brown.



Washed residue with well-preserved Radiolaria.

BR station 1026
Lithology: Calcarenite, with minor amounts of igneous material, yellowish gray.
Texture: As in BR stations 1015, 1016, but diameter of average grains from about 60 to 750 μ.
Assemblage:
Globotruncana stuarti (DE LAPPARENT) group
Globotruncana lapparenti BROTZEN group
Pseudorbitoides sp.
Sulcoperculina spp.
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET.

BR station 1027
Lithology: Calcarenite, fine-grained, yellowish gray, with large greenish "clay" inclusions. This sample is from the base of a clastic calcareous Bacuranao intercalation in the Vía Blanca formation.
Washed residue with
Globotruncana stuarti (DE LAPPARENT)
Sulcoperculina sp. (small form)
Pseudotextularia elegans (RZEHAK)
Radiolaria.

Fig. 8. Columnar section of the upper part of the Vía Blanca formation, *Rugotruncana gansseri* zone.

BR stations 1028 and 1029

The samples from these stations are practically identical, and therefore described together.

Lithologies: Tuff, very pale orange, laminated.

Textures: Glass shards and argillaceous components densely packed in siliceous groundmass.

Assemblage: Radiolaria
Pithonella ovalis (KAUFMANN).

BR station 1030

Lithology: Shale, non-calcareous, gray brown. Barren.

BR stations 1031, 1033 and 1037

These samples are lithologically and faunally practically identical, and therefore described together.

Lithologies: Calcilutite, very fine-grained, with faint igneous influence, yellowish gray (coccolithite).

Textures: Densely packed angular to subangular fragments derived from organic material and from dark brown and green igneous rocks. Diameter of average components from about 3 to 20 μ. Matrix calcareous, somewhat argillaceous.

Assemblages: Coccoliths (abundant)
Calcisphaerula innominata BONET
fragments of planktonic Foraminifera.

Washed residue with
Radiolaria.

BR station 1032

Lithology: Clay, calcareous, conchoidal breaking, grayish orange, chalk, soft, pale yellowish brown.

Washed residue with
Globotruncana fornicata PLUMMER
Globotruncana stuarti (DE LAPPARENT)
Globotruncana linneiana (D'ORBIGNY)
Globotruncana inornata BOLLI
Heterohelix globulosa (EHRENBERG)
Sulcoperculina sp.
Radiolaria.

Cantera San José

In the Cantera San José, about 4 km east-southeast of Guanabacoa, just north of a point of coordinates 364.70 N and 369.90 E, a lenticular calcarenite interbedded in reddish brownish graywacke silts and shales is exposed along a cliff. As in the Cantera Santa María, the base of the Bacuranao "limestones" exhibits typical submarine slumping while the top shows a disconformity. The geographic location of the below described samples is shown in the index map, and cross sections figs. 4 and 5.

BR stations 1065, 1066 and 1068

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

Lithologies: Calcarenite, fine-grained, with a few igneous grains, pale yellowish gray.

Texture: Densely packed angular to rounded components derived from mollusks, echinoderms, algae, larger Foraminifera, sedimentary and dark brown and green igneous rocks. Also planktonic microfossils. Diameter of average components ranges from about 10 to 300 μ. Groundmass microcrystalline calcite.

Assemblages: *Globotruncana lapparenti* BROTZEN
Sulcoperculina spp. (very small forms with strong umbilical plugs)
Pseudorbitoides sp. (with single set of vertical plates)
Rhabdorbitoides hedbergi BRÖNNIMANN
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET.

Sections from the typical lithology of the upper part of the Vía Blanca formation

Continuation of the Avenida Monumental

In the upper part of the Vía Blanca formation, a good section of Lower Maastrichtian age is exposed along the continuation of the Avenida Monumental from a point near coordinates 363.93 N and 371.91 E to about 200 m farther to the southeast. The lithology is of flysch type. Of particular interest is here the occurrence of a few thin beds of coccoliths-bearing very fine-grained white calcilutites which carry chondrites exhibiting an extraordinary range of dimensions. Lithology and stratigraphic position of the samples are explained in the columnar section, fig. 8, and in the cross section, fig. 9. Figure 10 is a photograph of a small part of this section described below in some detail.

A typical yellowish brown graywacke silt and sand bed from above outcrop is about 1.1 m thick, graded, with average grain size of about 150 to 1300 μ at the base and of about 100 to 600 μ at the top. The bottom is sharply defined against dark brown, finely laminated fissile shale and shows on the bottom surface well-defined markings or hieroglyphs, which are the infillings of depressions on the surface of the underlying mud layer at the time of the silt deposition. These depressions were made by organisms and by wave action. Reference is made to the excellent photographs published by WEYL (1953, pp. 88–91) of the tracks of the snail *Rhinocoryne humboldti* (VALENCIENNES), of unidentified worms and of hermite crabs with different gastropod tests on the mud surface of the tidal plains near Rio Lempa, El Salvador. The sharpness of the contact and of the markings suggest that the silt was rapidly laid down on the shale surface. The top contact toward somewhat lighter brown fissile shale is less sharp, and in places one has the impression that it is transitional, suggesting a gradual settling-out of the sediment. At the top surface no hieroglyphic markings but flow structures were observed. The coarse-grained portion of the bed contains many specimens of *Vaughanina cubensis* D. K. PALMER and *Sulcoperculina dickersoni* (D. K. PALMER). These

forms occur also but less frequently in the fine-grained top portion of the bed associated with *Rugotruncana gansseri* (BOLLI), *Globotruncana arca* (CUSHMAN), *Globotruncana stuarti* (DE LAPPARENT), and *Globotruncanella havanensis* (VOORWIJK). The graded graywacke silt bed usually consists of friable material. Occasionally the silt is indurated or contains one or more indurated layers of elongate "nodules" of 15 to 40 cm length and about 8 cm thickness. The nodules are probably of concretionary origin. Other graded graywacke beds exhibit essentially the same features as described above. The thickness of the graded beds ranges from considerably less than a meter to about 2 m. In the thickest of these beds at the described road cut of the continuation of the Avenida Monumental occur 3 layers of "nodular" concretions. Apart from these thicker graded graywackes occur thinner also friable graywacke silt and sand beds, which do not exhibit grading, at least not detectable with the hand lens. A typical ungraded graywacke silt bed is about 4 to 8 cm thick, with sharply defined bottom and top contacts against 2 to 5 cm thick layers of fissile shale. The bottom contacts of some of the thin graywacke beds show concave ripple mark-like structures, which appear to be the infillings of regular depressions on the shale bottom possibly caused by wave action. Typical ripple marks were not seen at this road cut but elsewhere in the Vía Blanca area, and always at the top of sandy-silty layers. Thick pelitic beds are usually less thick than the thick

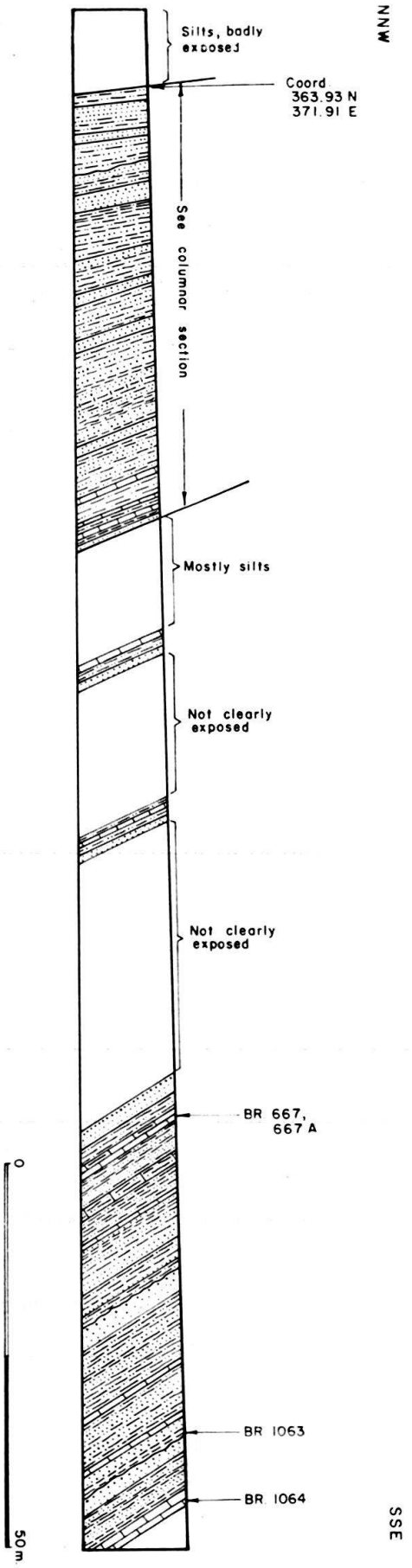


Fig. 9. Road cut at the continuation of the Avenida Monumental, across the upper part of the Vía Blanca formation, *Rugotruncana gansseri* zone.

Fig. 10. View of part of the Vía Blanca beds, *Rugotruncana gansseri* zone, Lower Maastrichtian. Road cut at the continuation of the Avenida Monumental south of a point of coordinates 363.93 N and 371.91 E.

psammitic beds. The thickness of the shale beds ranges from a few centimeters up to about 80 cm. A typical pale yellowish brown calcareous shale bed is about 30 cm thick, with well-defined bottom contact against a 4 cm thick bed of apparently ungraded lighter colored graywacke silt and equally sharp top contact against a 10 cm thick bed of whitish calcilutite (coccolithite), which is again overlain with well-defined contact by 10 cm of graywacke silt. The shales are normally finely laminated, fissile and occasionally they disintegrate into elongate nodular pieces. The calcilutites are whitish, and disintegrate either in form of nodular pieces or in form of very fine laminae. Calcilutites may contain chondrites and other ichnofossils. Some of the thinner beds of calcareous clastics exhibit grading from a fine calcarenite at the bottom with a grain size of about 20 to 180 μ to a calcilutite near the top, which is formed by a calcareous shale with a grain size of a few microns only. The calcilutaceous bed with the best chondrites seen at BR station 667 and 667A is about 1.2 m thick. Minor faults and typical slumping features were noted.

The planktonic assemblages are extremely rich and well preserved. *Rugotruncana gansseri* (BOLLI), the diagnostic form of the lower Maastrichtian, occurs in BR stations 1055, 1056, and 1061.

The samples are here listed from bottom to top:

BR station 1054
Lithology: Shale, calcareous, very pale yellowish brown.
Washed residue with

Globotruncanella havanensis (VOORWIJK)
Globotruncana mariei BANNER and BLOW
Globotruncana stuarti (DE LAPPARENT)
Globotruncana cf. *tricarinata* (QUEREAU)
} very small specimens

"Globigerinella" messinae messinae BRÖNNIMANN
"Globigerinella" messinae carinata BRÖNNIMANN
Pseudotextularia elegans (RZEHAK) (forms with and without additional chambers)
Pseudoguembelina excolata (CUSHMAN)
Pseudoguembelina striata (EHRENBERG)
Rugoglobigerina rugosa rugosa (PLUMMER)
Rugoglobigerina macrocephala macrocephala BRÖNNIMANN
Heterohelix carinata CUSHMAN
Heterohelix globulosa (EHRENBERG)
Heterohelix pulchra (BROTZEN)
Schackoina multispinata (CUSHMAN and WICKENDEN).

BR station 1055
Lithology: Shale, calcareous, pale yellowish brown.
Washed residue with

Rugotruncana gansseri (BOLLI)
Globotruncana stuarti (DE LAPPARENT)
Globotruncana tricarinata (QUEREAU)
Globotruncana mariei BANNER and BLOW
Globotruncana arca (CUSHMAN)
Globotruncanella havanensis (VOORWIJK)
Intermediate forms between *Rugoglobigerina rugosa* (PLUMMER) and *Trinitella scotti* BRÖNNIMANN (last chamber slightly compressed, but not yet keeled)
Planoglobulina glabrata (CUSHMAN)
Rugoglobigerina rugosa rugosa (PLUMMER) group
Rugoglobigerina macrocephala macrocephala BRÖNNIMANN
Gublerina ornatissima (CUSHMAN and CHURCH)
Pseudotextularia elegans (RZEHAK) (forms with and without additional chambers)
Pseudoguembelina striata (EHRENBERG)
Pseudoguembelina excolata (CUSHMAN)
"Globigerinella" messinae messinae BRÖNNIMANN
"Globigerinella" messinae carinata BRÖNNIMANN
Heterohelix pulchra (BROTZEN)
Heterohelix globulosa (EHRENBERG)
Gublerina acuta robusta DE KLASZ
Heterohelix carinata CUSHMAN

BR station 1056
Lithology: Shale, calcareous, pale, yellowish brown.
Washed residue with

Rugotruncana gansseri (BOLLI)
Rugotruncana cf. *nothi* BRÖNNIMANN and BROWN
Globotruncana cf. *tricarinata* (QUEREAU)
Globotruncana stuarti (DE LAPPARENT)

Globotruncanella havanensis (VOORWIJK)
Globotruncana mariei BANNER and BLOW
Globotruncana arca (CUSHMAN)
Heterohelix globulosa (EHRENBERG)
"*Globigerinella*" *messinae messinae* BRÖNNIMANN
"*Globigerinella*" *messinae carinata* BRÖNNIMANN
Rugoglobigerina rugosa rugosa (PLUMMER) group
Heterohelix pulchra (BROTZEN)
Pseudotextularia elegans (RZEHAK) (forms with and without additional chambers)
Gublerina ornatissima (CUSHMAN and CHURCH)
Planoglobulina glabrata (CUSHMAN)
Pseudoguembelina striata (EHRENBERG)
Pseudoguembelina excolata (CUSHMAN)
Heterohelix carinata (CUSHMAN)
Intermediate forms between *Rugoglobigerina rugosa* (PLUMMER) and *Trinitella scotti* BRÖNNIMANN) (final chamber slightly compressed, but not yet keeled).

BR station 1057
Lithology: Shale, calcareous, nodular weathering, pale yellowish brown.
Washed residue with

Globotruncana mariei BANNER and BLOW
Globotruncanella havanensis (VOORWIJK)
Globotruncana stuarti (DE LAPPARENT)
Globotruncana tricarinata (QUEREAU)
Pseudoguembelina excolata (CUSHMAN)
Rugoglobigerina rugosa rugosa (PLUMMER)
"*Globigerinella*" *messinae messinae* BRÖNNIMANN
"*Globigerinella*" *messinae carinata* BRÖNNIMANN
Heterohelix carinata (CUSHMAN)
Heterohelix pulchra (BROTZEN)
Heterohelix globulosa (EHRENBERG)
Pseudoguembelina striata (EHRENBERG).

BR station 1058
Lithology: Marl, chalky, whitish.
Washed residue with

Pseudoguembelina striata (EHRENBERG)
Globotruncana cf. *mariei* BANNER and BLOW.

BR stations 1059, 1062 and 1064

These samples are lithologically and faunally practically identical and therefore reported together.

Lithologies: Calcilutite, dense, hard, manganese dendrites (1059); calcilutite, dense, hard, light yellowish gray (1062, 1064).
Textures: Cryptocrystalline groundmass with coccoliths in rock-forming quantities

and minute angular organic fragments and igneous grains. Similar as texture of Brönnimann stations 667 and 667 A.

Assemblages: "*Globigerina*" spp.
Heterohelix sp. or *Pseudoguembelina* sp. (with strong striae)
Pithonella ovalis (KAUFMANN)
Nannoconus steinmanni KAMPTNER } reworked
Nannoconus minutus BRÖNNIMANN }

BR station 1060
Lithology: Calcilutite, grayish orange.
Washed residue with
Pseudoguembelina striata (EHRENBERG)
Globotruncana cf. *arca* CUSHMAN
Globotruncana stuarti (DE LAPPARENT)
Globotruncana mariei BANNER and BLOW
Pseudotextularia elegans (RZEHAK)

BR station 1061
Lithology: Shale, calcareous, nodular weathering, pale yellowish brown.
Washed residue with
"*Globigerinella*" *messinae carinata* BRÖNNIMANN
Rugotruncana gansseri (BOLLI)

BR stations 667 and 667 A
Lithologies: Calcilutite, dense, hard, with chondrites, white to yellowish gray (coccolithite).
Textures: Cryptocrystalline groundmass with coccoliths in rock-forming quantities and minute, angular organic and igneous fragments. Limonitic spots. Diameter of average fragment ranges about 3 to 10 μ. With pockets of slightly coarser material.

Assemblage: *Heterohelix* sp. or *Pseudoguembelina* sp. (minute, striate forms)
Fragments of 2-keeled Globotruncanas
Globotruncanella havanensis (VOORWIJK)
Rugoglobigerina rugosa (PLUMMER)
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET

BR station 1063
Lithology: Shale, laminated, calcareous, pale yellowish brown.
Washed residue with
Pseudoguembelina striata (EHRENBERG)
Heterohelix globulosa (EHRENBERG)
"*Globigerina*" spp.

East of Casa Blanca

Another good section across the upper part of the Vía Blanca formation is exposed about 3 to 4 km east of Casa Blanca, in an area defined by grid longitudes 365.00 E and 367.00 E and by grid latitudes 369.00 N and 370.00 N. The geological

situation of this traverse is explained in the map of the rim-rock and core area between Casa Blanca and Cojímar (plate III). Vía Blanca and Peñalver formations are here in a tight syncline with west-northwest under the rim-rock plunging axis. The northern flank of this syncline is steeply dipping and overturned. The oldest Vía Blanca beds are to the northeast, where they are overlapped by Alkázar, Universidad and Cojímar beds, and the youngest Vía Blanca beds are at the contact with the late Maastrichtian Peñalver formation which forms the center of the syncline. Construction of the roads of the Reparto Vía Tunel and of the Vía Monumental furnished a series of good artificial outcrops in the Vía Blanca beds. The main lithologies are shales, graded-bedded graywackes and fine-grained calcareous clastics, tuffs and conglomerates. The overall color is light brown. The beds are thin, well-defined and often contorted, probably due to slumping. Small-scale faults are common. In spite of these minor local disturbances, the Vía Blanca section gives the impression to be more or less continuous from the older beds of Campanian age to the northeast to the younger Maastrichtian beds in the southwest. The Vía Tunel conglomerate is from the upper part of this section close to the contact with the Peñalver clastics (BR stations 1374, 1375, Baughman stations 1761, 1762, 1769, 1779). The following succession from older to younger beds is shown: tuffs, tuffaceous non-calcareous shales, graywackes and calcareous shales along the Vía Monumental, and calcareous and non-calcareous shales and calcareous clastics including the Vía Tunel conglomerate toward the Peñalver–Vía Blanca contact. The samples from these Vía Blanca outcrops are described below from bottom to top. The relative stratigraphic position of the stations are indicated in the above mentioned geological detail map of the area between Casa Blanca and Cojímar.

Baughman station 1488
Lithology: Tuff, yellowish gray to pale olive.
Texture: Glass shards and igneous grains in dark argillaceous groundmass.
Assemblage: Radiolaria.

Baughman station 1489
Lithology: Graywacke, slightly calcareous, with large clay inclusions, pale yellowish brown.
Texture: Mainly angular igneous derived fragments in argillaceous groundmass. Some Foraminifera and mollusks remains.

Washed residue with poorly preserved
Heterohelix sp. or *Pseudoguembelina* sp.
"*Globigerina*" spp.
Radiolaria.

Baughman station 1788
Lithology: Shale, non-calcareous, tuffaceous, laminated, light olive gray.
Texture: Argillaceous groundmass with abundant glass shards, angular igneous grains and Radiolaria arranged in microlaminae through sorting of the fragments.
Assemblage: Radiolaria

Baughman station 1789
Lithology: Tuff, porous, pale greenish yellow to grayish yellow.

Texture: Glass shards in argillaceous groundmass. Some dark brown inclusions, probably igneous grains.
Assemblage: Radiolaria (scarce).

Baughman station 1790
Lithology: Shale, tuffaceous, non-calcareous, grayish yellow.
Washed residue with well-preserved Radiolaria.

Baughman station 1791
Lithology: Shale, calcareous, moderate yellowish brown.
Washed residue with
Radiolaria
Sulcoperculina sp.
Pseudorbitoides sp. ?
Reussella szajnochae (GRZYBOWSKY).

Baughman station 1721
Lithology: Shale, non-calcareous, grayish yellow.
Washed residue with
Globotruncana linneiana (D'ORBIGNY)
Globotruncana stuarti (DE LAPPARENT)
Globotruncana fornicata PLUMMER
Radiolaria

Baughman station 1760
Lithology: Shale, tuffaceous, non-calcareous, pale greenish yellow, limonitic weathering.
Washed residue with well-preserved Radiolaria, similar to those of Baughman station 1790.

Baughman station 1723
The samples from this station are components from a conglomerate which may occur at the base of the Cojímar formation or which may be a local development of the Vía Tunel conglomerate.

(1) Lithology: Calcarenite, friable, pale yellowish brown (Campanian).
Washed residue with
Globotruncana fornicata PLUMMER
Globotruncana stuarti (DE LAPPARENT)
Globotruncana linneiana (D'ORBIGNY)
Globotruncana tricarinata (QUEREAU)
Globotruncana cretacea (D'ORBIGNY)
Rugoglobigerina rugosa rugosa (PLUMMER)
Pseudorbitoides israelskyi VAUGHAN and COLE
Pseudorbitoides sp.
Sulcoperculina sp.

(2) Lithology: Limestone, fragmental, very pale orange (Lower Maastrichtian).
Texture: Fragmental, poorly sorted. Fragments of mollusks, echinoderms algae, benthonic Foraminifera and sedimentary rocks in a microcrystalline re-

crystallized calcite groundmass. Diameter of average components ranges from about 50 to 900 μ.

Assemblage: *Orbitoides palmeri* GRAVELL
Vaughanina cubensis D. K. PALMER
Placopsilina ex gr. *cenomana* D'ORBIGNY-*longa* TAPPAN.

Baughman station 1768
Lithology: Calcilutite, with manganese dendrites, grayish orange.
Texture: Cryptocrystalline, minutely fragmental groundmass with planktonic microfossils.

Assemblage: *Heterohelix* sp. or *Pseudoguembelina* sp.
"*Globigerina*" sp.
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN)
Radiolaria.

Baughman station 1724 (Lower Maastrichtian)
Lithology: Calcarenite, with igneous fragments, graded-bedded. The following description is from the coarse part of the bed.
Texture: Fragmental, poorly sorted. Microcrystalline groundmass with angular to rounded fragments of sedimentary and igneous rocks, mollusks, echinoderms, algae and benthonic Foraminifera, in particular pseudorbitoids and orbitoids. Diameter of average fragments ranges from about 100 to 2000μ.

Assemblage: *Vaughanina cubensis* D. K. PALMER
Sulcoperculina cf. *dickersoni* (D. K. PALMER)
Sulcoperculina spp.
Orbitoides palmeri GRAVELL
Asterorbis sp.
Orbitocyclina sp.
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

Baughman station 1727
Lithology: Calcilutite, finely laminated, grayish orange.
Texture: Minutely fragmental. Groundmass argillaceous with angular organic fragments and pseudoöolitic elements probably derived from sedimentary rocks. Also igneous grains. Diameters of average components from about 10 to 60 μ.

Assemblage: *Heterohelix* sp. or *Pseudoguembelina* sp.
Pithonella ovalis (KAUFMANN)
Calcisphaerula innominata BONET
Nannoconus steinmanni KAMPTNER } reworked
Nannoconus globulus BRÖNNIMANN } reworked
Nannoconus wassalli BRÖNNIMANN } reworked
Coccoliths.

Baughman station 1726
Lithology: Calcilutite, grayish orange.
Texture: Fragmental, very fine-grained. Same suite of elements as listed in

Baughman station 1725(1). Diameter of average components ranges from about 10 to 100 μ.

Assemblage: *Calcisphaerula innominata* BONET
Pithonella ovalis (KAUFMANN)
Heterohelix sp. or *Pseudoguembelina* sp.

Baughman station 1725

The numbers in parentheses refer to different samples from graded bedded strata.

(1) Lithology: Calcarenite, fine-grained, with igneous grains, pale yellowish brown.

Texture: Fragmental, fine-grained. Groundmass microcrystalline calcite with angular to subrounded fragments of sedimentary and igneous rocks, mollusks, echinoderms, Foraminifera, and algae. Diameter of average fragments from about 30 to 300 μ.

Assemblage: *Vaughanina cubensis* D. K. PALMER
Heterohelix sp. or *Pseudoguembelina* spp.
Globotruncana lapparenti BROTZEN group
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

(2, 3, 4) Lithologies: Calcarenite to calcirudite, pale yellowish brown.

Textures: Fragmental, unsorted. Groundmass microcrystalline calcite, vacuolar, with angular to subrounded fragments of sedimentary rocks, mollusks, echinoderms, algae and benthonic Foraminifera. Discrete large mollusk fragments and larger Foraminifera. Diameter of average components ranges from about 30 to 600 μ. Large inclusions up to 2000 μ diameter.

Assemblages: *Orbitoides palmeri* GRAVELL
Sulcoperculina spp.
Vaughanina cubensis D. K. PALMER
Asterorbis sp. or *Orbitocyclina* sp.
Calcisphaerula innominata BONET.

The following samples of Campanian age appear to be of an intermediate stratigraphic position in respect to above traverse.

Baughman station 1781

Lithology: Limestone, fragmental, hard, pale yellowish brown.

Texture: Fragmental, laminated through sorting. Same suite of components as listed under Baughman station 1779, from about 20 to 60 μ in the fine-grained to about 90 to 450 μ in the coarse-grained portions. Groundmass recrystallized calcite.

Assemblage: "*Globigerina*" spp.
Globotruncana lapparenti BROTZEN group
Pseudorbitoides sp. (with single set of radial plates)
Pithonella ovalis (KAUFMANN)
Sulcoperculina sp.

Baughman stations 1782 and 1783

These samples are lithologically and faunally practically identical and therefore reported together.

Lithologies: Shale, calcareous, with clay inclusions, very pale orange (1782), and shale, calcareous, laminated, pale brown (1783).

Washed residue with

Globotruncana fornicata PLUMMER
Globotruncana stuarti (DE LAPPARENT)
Globotruncana linneiana (D'ORBIGNY)
Pseudoguembelina cf. *excolata* (CUSHMAN)
Planoglobulina glabrata (CUSHMAN)
Reussella szajnochae (GRZYBOWSKI).

The samples from the Vía Tunel conglomerate were described in the chapter on the conglomerates of the Vía Blanca formation.

The Peñalver beds forming the center of the syncline, are represented by the following random stations:

Baughman station 1772 (Peñalver)
Lithology: Calcarenite, fine-grained, light grayish yellow.
Texture: Fragmental. Groundmass microcrystalline calcite, very porous, with angular to rounded fragments of sedimentary rocks, mollusks, echinoderms and Foraminifera. Some igneous grains. Diameter of average components ranges from about 25 to 150 μ.

Assemblage:
Globotruncana lapparenti BROTZEN group
Heterohelix sp. or *Pseudoguembelina* sp.
Vaughanina cubensis D. K. PALMER (fragments)
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

Baughman station 1773 (Peñalver)
Lithology: Calcirudite, friable, moderate yellowish brown.
Washed residue with

Rugotruncana mayaroensis (BOLLI)
Globotruncana stuarti (DE LAPPARENT)
Globotruncana arca (CUSHMAN)
Rugoglobigerina rugosa rugosa (PLUMMER)
Vaughanina cubensis D. K. PALMER
Sulcoperculina spp.

Baughman station 1777 (Peñalver)
Lithology: Calcirudite, friable, grayish orange to pale yellowish brown.
Washed residue with

Vaughanina cubensis D. K. PALMER
Omphalocyclus macroporus (LAMARCK)
Cosinella sp.
Asterorbis cubensis D. K. PALMER
Sulcoperculina spp.
Radiolaria.

Baughman stations 1730, 1731 (Peñalver)
Lithologies: Calcarenite, pale yellowish brown.

Textures: Fragmental, medium-grained, poorly sorted. Groundmass microcrystalline to cryptocrystalline calcite, vacuolar, with angular to subrounded fragments of sedimentary rocks, mollusks, echinoderms, algae and benthonic microfossils. Some dark brown igneous grains. Diameter of average components ranges from about 60 to 750 μ.

Assemblages: *Vaughanina cubensis* D. K. PALMER
Sulcoperculina spp.
Asterorbis sp.
Asterorbis sp. or *Orbitocyclina* sp.
Orbitocyclina sp.
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

Baughman station 1733 (Peñalver)
Lithology: Calcarenite, fine-grained, grayish orange to pale yellowish brown.
Texture: Fragmental as Baughman stations 1730 and 1731, but finer grained. Diameter of average components ranges from about 30 to 250 μ.

Assemblage: *Vaughanina cubensis* D. K. PALMER
Sulcoperculina spp.
Asterorbis sp. or *Orbitocyclina* sp.
Asterorbis sp.
Calcisphaerula innominata BONET
Pithonella ovalis (KAUFMANN).

BR station 1136
Lithology: Calcirudite, friable, whitish to grayish yellow.
Washed residue with
Vaughanina cubensis D. K. PALMER
Asterorbis cubensis D. K. PALMER
Asterorbis macei D. K. PALMER
Omphalocyclus macroporus (LAMARCK)
Sulcoperculina cf. *dickersoni* (D. K. PALMER)
Sulcoperculina spp.
Cosinella sp.
Rugotruncana cf. *mayaroensis* (BOLLI)
Globotruncana arca (CUSHMAN)
Globotruncana stuarti (DE LAPPARENT)
Pseudoguembelina striata (EHRENBERG)
Trinitella scotti BRÖNNIMANN
Gublerina ornatissima (CUSHMAN and CHURCH)
Heterohelix globulosa (EHRENBERG)
Pseudotextularia elegans (RZEHAK).

BR station 1137
Lithology: Calcarenite, friable, whitish to yellowish gray.
Washed residue with
Globotruncana arca (CUSHMAN)
Globotruncana stuarti (DE LAPPARENT)

Globotruncana fornicata PLUMMER (reworked?)
Pseudotextularia elegans (RZEHAK) (forms with and without additional chambers)
Planoglobulina glabrata (CUSHMAN)
Pseudoguembelina excolata (CUSHMAN)
Pseudoguembelina striata (EHRENBERG)
Heterohelix globulosa (EHRENBERG)
Gublerina ornatissima (CUSHMAN and CHURCH)
Reussella szajnochae (GRZYBOWSKY)
Rugoglobigerina rugosa rugosa (PLUMMER).

Of special interest is the occurrence of *Rugotruncana mayaroensis* (BOLLI) with *Vaughanina cubensis* D. K. PALMER in the calcirudite of Baughman station 1773, which assigns the Peñalver beds to the late Maastrichtian *Rugotruncana mayaroensis* zone. *Omphalocyclus macroporus* (LAMARCK) was encountered in the nearby BR stations 1136 and 1137, both from the same calcirudite as Baughman station 1773.

Volcanic rocks

Elements of volcanic rocks are common in the conglomerates of the Vía Blanca formation. The following lithologic types were identified by H. H. HESS, Princeton:

Quartzdacite lava or very shallow intrusive
Feldspathic lava with marked flow texture
Flow breccia or agglomerate
Calcareous vitric tuff.

In a few isolated outcrops of the Vía Blanca formation andesitic rocks were found in situ. The most striking of these outcrops forms a geomorphologically prominent hill dominating to the northwest the town of Santa María del Rosario. Similar exposures of volcanic rocks as the one mentioned above are about 2.2 km west-northwest of Santa María del Rosario, coordinates 360.97 N and 369.18 E, and about 0.7 km southeast of Residencial Guanabacoa, coordinates 366.54 N and 371.25 E (BR station 1038). The igneous rocks are usually associated with brownish tuffs, but the relationship with other sediments can rarely be observed.

Environment and age

Representative of the overall lithology of the Vía Blanca formation is the series of graywacke silts and sands, calcareous and non-calcareous benthonitic shales, and finely clastic limestones from the continuation of the Avenida Monumental near coordinates 363.93 N and 371.91 E. Reference is made to the lithologic and faunal descriptions on page 247 to 249 of this paper and to the columnar section, fig.8. Similar lithologies can be found throughout the outcrop area of the Vía Blanca formation, but as a rule not as well-exposed and more disturbed. Bacuranao "limestone" intercalations, tuffs, flows and conglomerates are but local additions to this overall Vía Blanca lithology.

As mentioned before, this thick and monotonous series of sharply divided and relatively thin marine pelitic and psammitic layers reflects flysch sedimentation.

The normal environment of the flysch facies is deep water as indicated by the pelitic layers which carry rich planktonic assemblages suggesting after GRIMSDALE and VAN MORKHOVEN (1955) a depth deeper than 600 m with more than 50 % of the fauna composed of planktonic Foraminifera. According to VON KUENEN (1959, pp. 1020–1021), depths in flysch troughs tend to exceed 200 m and in some cases even surpass 2000 m. The psammitic layers with reefal derived fragments and orbitoidal Foraminifera are regarded as interlopers in a strange environment (SUJKOWSKI, 1957, p. 550). They are interpreted as local accidents probably caused by turbidity currents which interrupted the normal pelitic sedimentation and brought clastic foreign material from an outside source. The monotonous alternation of pelitic and psammitic layers is caused by unstable conditions in the source region of the psammitic material. The great amount of igneous grains in the clastic beds and even in the shaley beds of the Vía Blanca formation suggests that the source region was made up essentially of igneous material. As the entire Cretaceous section to the north of Cuba consists of carbonates, the source of the pyroclastics must have been to the south of the area under description. This interpretation agrees with WOODRING's (1954, pp. 723–725, fig. 1 on p. 724) representation of volcano-bearing lands to the south of Cuba during late Cretaceous times. Along these lands reefs developed which furnished the rich mollusk, especially rudist, algal, orbitoidal and echinoderm assemblages found in the psammitic layers and in the elements of the conglomerates of the flysch sequence.

Volcanic activity was pronounced during early Campanian time as witnessed by tuffs, tuffaceous shales and volcanic flows in the lower part of the Vía Blanca formation. It subsided toward the end of the Vía Blanca sedimentation and may have come to an end already in early Maastrichtian time. Elements from the Bahía, Vía Tunel, Río Piedras and Schoolhouse conglomerates suggest initiating of reefal deposition in Campanian time. As a corollary to the decline of volcanic activity, these reefs became more important as a source for the Vía Blanca clastics in early Maastrichtian time. During the late Maastrichtian Peñalver deposition, shallow shelf material and reefs were the dominant source of the clastics. As will be explained in the description of the Peñalver formation, these late Maastrichtian clastics are in part nothing but a final psammitic bed of the Vía Blanca formation. It was given formation rank for its widespread occurrence, different lithological features and its disconformable contact with the Vía Blanca formation.

The age of the Vía Blanca formation ranges from the Campanian *Globotruncana linneiana* zone to the Lower Maastrichtian *Rugotruncana gansseri* zone. The age of the matrix samples of the Bahía conglomerate, apparently the oldest unit of the Vía Blanca formation as far as can be inferred from the field stratigraphic relationship with the pre-Vía Blanca beds, is inconclusive, and the youngest components are of Campanian age with *Pseudorbitoides israelskyi* VAUGHAN and COLE, and *Pseudorbitoides* cf. *rutteni* BRÖNNIMANN. The conglomerate is therefore of Campanian or slightly younger age. Planktonics of definitely Campanian age with *Globotruncana fornicata* PLUMMER, *Globotruncana linneiana* (D'ORBIGNY) and *Globotruncana stuarti* (DE LAPPARENT) were found in calcareous shales interbedded with tuffs and tuffaceous shales near the Martí monument; east of Casa Blanca, in the Bacuranao "limestone"; in the matrix of the Río Piedras conglomerate; and in

components of the Maastrichtian Vía Tunel and Schoolhouse conglomerates. *Rhabdorbitoides hedbergi* BRÖNNIMANN, a pseudorbitoid diagnostic of Campanian, was recorded in the basal calcirudaceous portion of the Bacuranao "limestone". *Pseudorbitoides israelskyi* VAUGHAN and COLE, another diagnostic form of Campanian age, was identified in a calcarenaceous boulder of the Bahía conglomerate associated with *Pseudorbitoides* cf. *rutteni* BRÖNNIMANN and sulcoperculinas; in a fragmental limestone component of the Schoolhouse conglomerate together with sulcoperculinas affin to *S. dickersoni* (D. K. PALMER), and with *Meandropsina rutteni* D. K. PALMER; and in a friable calcarenite from a conglomeratic outcrop east of Casa Blanca with the Campanian *Globotruncana fornicata* PLUMMER, *Globotruncana linneiana* (D'ORBIGNY), *Globotruncana stuarti* (DE LAPPARENT), *Globotruncana tricarinata* (QUEREAU), and *Globotruncana cretacea* (D'ORBIGNY). Other pseudorbitoids with a single set of vertical radial plates, such as *Pseudorbitoides rutteni* BRÖNNIMANN, apparently are also of Campanian age, because fragments of such forms were usually encountered with Campanian, or probable Campanian assemblages, or then reworked in Maastrichtian fragmental limestones. There is no reason at this time, to assume that the oldest Vía Blanca beds are of pre-Campanian age. That the Vía Blanca beds extend into the Lower Maastrichtian is proved by the occurrence of *Rugotruncana gansseri* (BOLLI) in the outcrops along the road cut of the continuation of the Avenida Monumental near coordinates 363.93 N and 371.91 E. This diagnostic form, however, was not found elsewhere in the Vía Blanca beds. But definitely Lower Maastrichtian Vía Blanca beds are also exposed east of Casa Blanca underlying the Peñalver formation with *Vaughanina cubensis* D. K. PALMER, *Omphalocyclus macroporus* (LAMARCK), *Asterorbis macei* D. K. PALMER, *Asterorbis cubensis* D. K. PALMER, *Orbitocyclina* sp., *Cosinella* sp. and a rich planktonic assemblage characterized by *Rugotruncana mayaroensis* (BOLLI), *Globotruncana arca* (CUSHMAN), *Trinitella scotti* BRÖNNIMANN. The underlying Lower Maastrichtian Vía Blanca beds contain *Vaughanina cubensis* D. K. PALMER, *Orbitoides palmeri* GRAVELL, and *Asterorbis* sp. In elements of the Vía Tunel conglomerate, which is from the upper part of the Lower Maastrichtian beds east of Casa Blanca, occur *Historbitoides kozaryi* BRÖNNIMANN, *Sulcoperculina angulata* BROWN and BRÖNNIMANN, *Orbitoides palmeri* GRAVELL and *Vaughanina cubensis* D. K. PALMER. Similar associations were encountered in elements of the likewise Lower Maastrichtian Schoolhouse conglomerate.

Discoasterids apparently do not occur or are extremely scarce in the Vía Blanca formation. Coccoliths, on the other hand, are the rock-forming elements of many of the calcilutites. Specimens of *Nannoconus* were occasionally seen in the very fine-grained lithologies, where they appear to be allochthonous. Megafossils, in particular rudists, were noted in the Vía Tunel and Schoolhouse conglomerates, but no collections have been made and described as yet from these localities or from any other locality of the Vía Blanca formation of the Habana area.

Peñalver Formation

The type locality of the Peñalver formation is situated on the continuation of the Avenida Monumental between the Vía Blanca and the Carretera Central, coordinates 362.85 N and 374.14 E (see location map, fig. 11). The name is derived