LINKED EARTH SYSTEMS

Field Guide

Sedimentary Geology of Western Cuba

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THE 1ST SEPM CONGRESS ON SEDIMENTARY GEOLOGY
AUGUST 13-16, 1995
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USEFUL DATA

CLIMATE

Cuba has a humid and warm tropical climate, very much influenced by sea breezes. The mean temperature is 25°C (77°F). It has two well-differentiated seasons: a dry season, from November to April, and a rainy season, from May to October.

CLOTHING

Since Cuba is a tropical country, cotton, linen or light mixed materials are recommended. For the mid-Cuban winter, a sweater or light jacket is sufficient.

LANGUAGE

The national language is Spanish.

SANITARY REGULATIONS

Cuba has no special sanitary regulations applicable to foreign visitors, except to those coming from countries where yellow fever or cholera are endemic. In such cases, an International Vaccination Certificate will be demanded.

MONEY

The Cuban monetary unit is the peso. Direct payment, however, in the following foreign currencies are accepted and recommended: Canadian and US dollars; German Marks; French, Swiss or Belgian Francs, etc. Traveler's checks as well as credit cards not issued in the U.S.A. are accepted.

OTHER DATA

Official Cuban time is based on that of Greenwich Meridian. Daylight saving time is used during the summer months.

Traffic signals correspond to those of the International Code. Driving in Cuba is always on the right-hand side.

The standard electric power supply is 110 volts, 60 cycles AC.

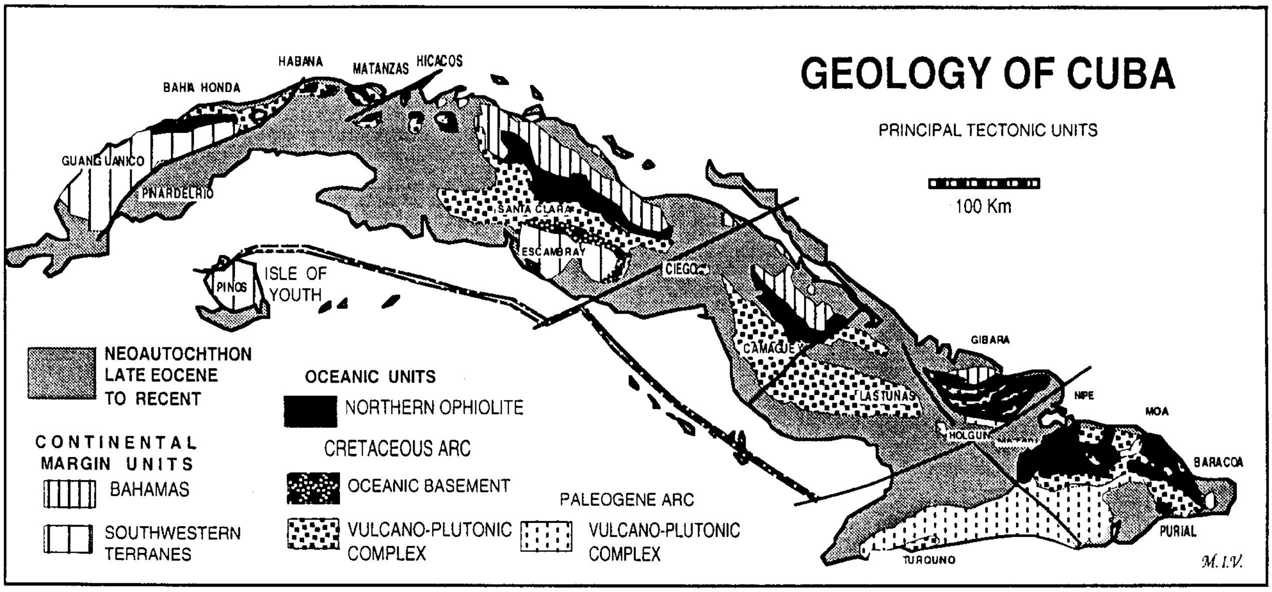
The International System of Units of Weight and Measures is used in the country.

Field Guide

Sedimentary Geology of Western Cuba

INTRODUCTION

The geological framework and deep structure of the Cuban archipelago are by far the most complex among the Caribbean islands. The great variety of rocks and landscapes that characterizes the territory has led to the formation of many different types of soils under the conditions of a tropical island climate. Under these conditions, zoned ecosystems evolved from marine shallow shelf, into small islands and keys, coastal areas, dissected plains, and mountain ranges whose highest peaks reach 2,000 m. Geologically speaking, the Cuban territory can be subdivided into two main geological entities (or structural levels): the *foldbelt* and the *neoautochthon* .



The ***foldbelt*** encompasses different suites of sedimentary, igneous and metamorphic rocks whose ages are as old as Neoproterozoic (1,000 Ma), but usually range from Early Jurassic (230-220 Ma) to early Late Eocene (42 Ma). They crop out mostly in mountain areas, but also in some dissected hilly and flattened terrains. These rocks originated within the old continental margins of the Bahamas and the Yucatan borderland, and within oceanic areas that represent ancient sea floors and chains of volcanic islands. These tectonic units originally were located far away from the present-day Cuba, and they reached their present position as a consequence of tectonic transport during early the Tertiary.

The ***neoautochthon*** represents sedimentary rocks of latest Eocene (42 Ma) to Recent ages, which have not been displaced from their original site of deposition. Study of the neoautochthon provides clues to the understanding of the evolution and consolidation of the present-day Cuban archipelago and shelf areas.

During the field trip the following subjects of Cuban sedimentary geology will be visited:

1. The Guaniguanico Mesozoic continental margin and its transition to a foreland basin (Stops 1-10),
2. The Tertiary synorogenic sediments of the allochthonous piggyback basins (Stops 11, 12),
3. The K/T boundary megaturbidite (an impact-derived deposit?) (Stop 13), and
4. The Miocene to Recent marine, deltaic and coastal sediments (Stops 14-18).

General Schedule

First Day: Arrival in Havana

Transfer to Viñales along Havana-Pinar Highway	Scenic view: The Guaniguanico mountain range. Along the highway from the south of Guaniguanico will be a panoramic view of the mountain area, and arriving in Viñales the general characteristics of the local geology will be visible.

Second Day: Sierra de Los Organos

Stop 1: Moncada section (Pons-Ancón-Manacas Fms)	Transition from continental margin into foreland sedimentation
Stop 2: Valle de Pons section (Pons Fm)	Cretaceous (Albian-Cenomanian-Turonian) basinal carbonate and chert facies
Lunch	
Stop 3: Valle de San Vicente section (Jagua-Guasasa Fm)	Late Jurassic (Oxfordian) -Early Cretaceous carbonate platform and transition to basinal carbonate and chert facies
Stop 4: Mogote la Mina section (San Cayetano Fm)	Lower-Middle Jurassic siliciclastics of alluvial coastal plain "Eagle Mills equivalents"
Stop 5: Hoyo del Palmar section (Jagua Fm)	Late Jurassic Oxfordian shales with fossiliferous concretions "Smackover equivalent "
Optional Stop 6: Pino Sola section (Ancón-La Guira Fm)	Early Paleocene sharpstones and hemipelagic limestones

Third Day: Sierra del Rosario

Stop 7: Carretera de Montaña (Polier-Sta. Teresa-Carmita Fm)	Early Cretaceous transition from deep-water carbonates to siliciclastic to cherts
Stop 8: Carretera de Montaña (Artemisa Fm)	Late Jurassic basinal section with interbedded clastics (calcarenites) derived from the Kimmeridgian platform
Lunch	
Stop 9: Carretera de Montaña (San Cayetano Fm)	Early-Middle Jurassic shallow marine siliciclastic deposits
Stop 10: Carretera de Montaña (El Sábalo Fm)	Late Oxfordian-early Kimmeridgian pillow basalts related to the early opening of the Caribbean seaway
Optional Stop 11: La Pastora section (Capdevila-Universidad Fms)	Paleocene-middle Eocene piggyback basin clastic to marly sediments
Optional Stop 12: Autopista section (Capdevila Fm)	Paleocene-lower Eocene syntectonic graywackes of the piggy back basins

Fourth Day: La Habana-Matanzas

Stop 13: Vía Monumental (Peñalver Fm)	Section of the late Maastrichtian megaturbidite with graded bedding and boulder weathering
Stop 14: Guanabo section (Guanabo Fm)	Pleistocene eolianites with interbedded paleosols on Miocene limestone paleohill
Stop 15: La Jíjira (Vedado-Jaimanitas Fms)	Pleistocene terraces and shallow marine carbonate deposits
Stop 16: Yumurí section (Cojímar-Guines-El Abra Fms)	Middle Miocene to Pliocene marls, limestones and clastics of a regressive section
Lunch	
Stop 17: Hicacos (beach sediments)	Recent beach complex and late Pleistocene eolianites
Stop 18: Playa Coral (coral growing)	Snorkel observation of coral reef recovery from recent destruction by burial

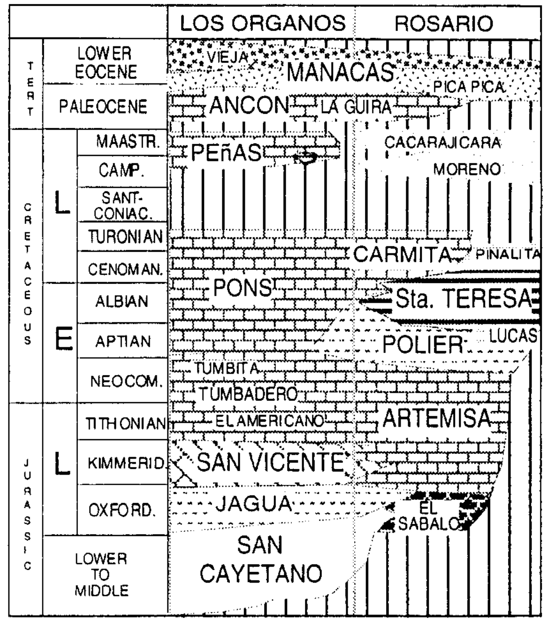
Fifth Day: Return

THEMATICS OF THE FIELD TRIP AND DESCRIPTION OF THE STOPS

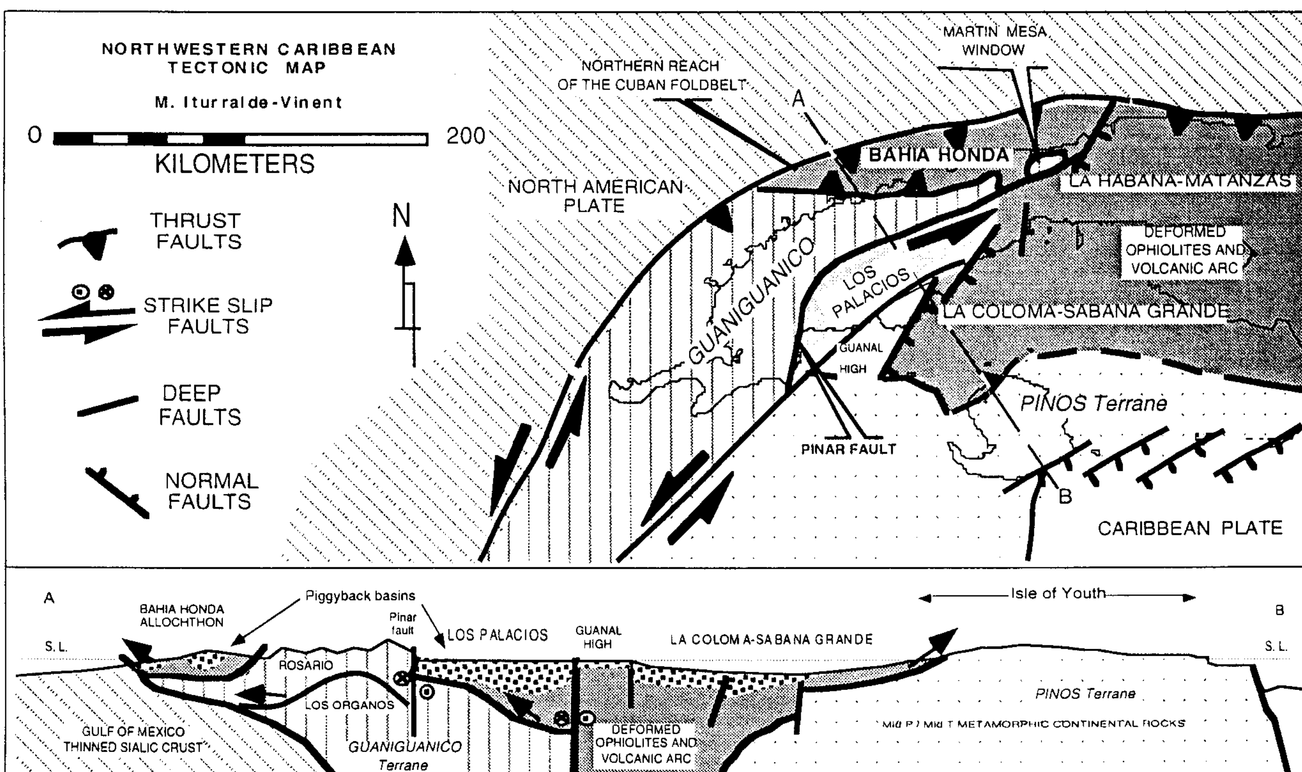
I. The Guaniguanico Mountains: Example of continental margin and foreland sedimentation

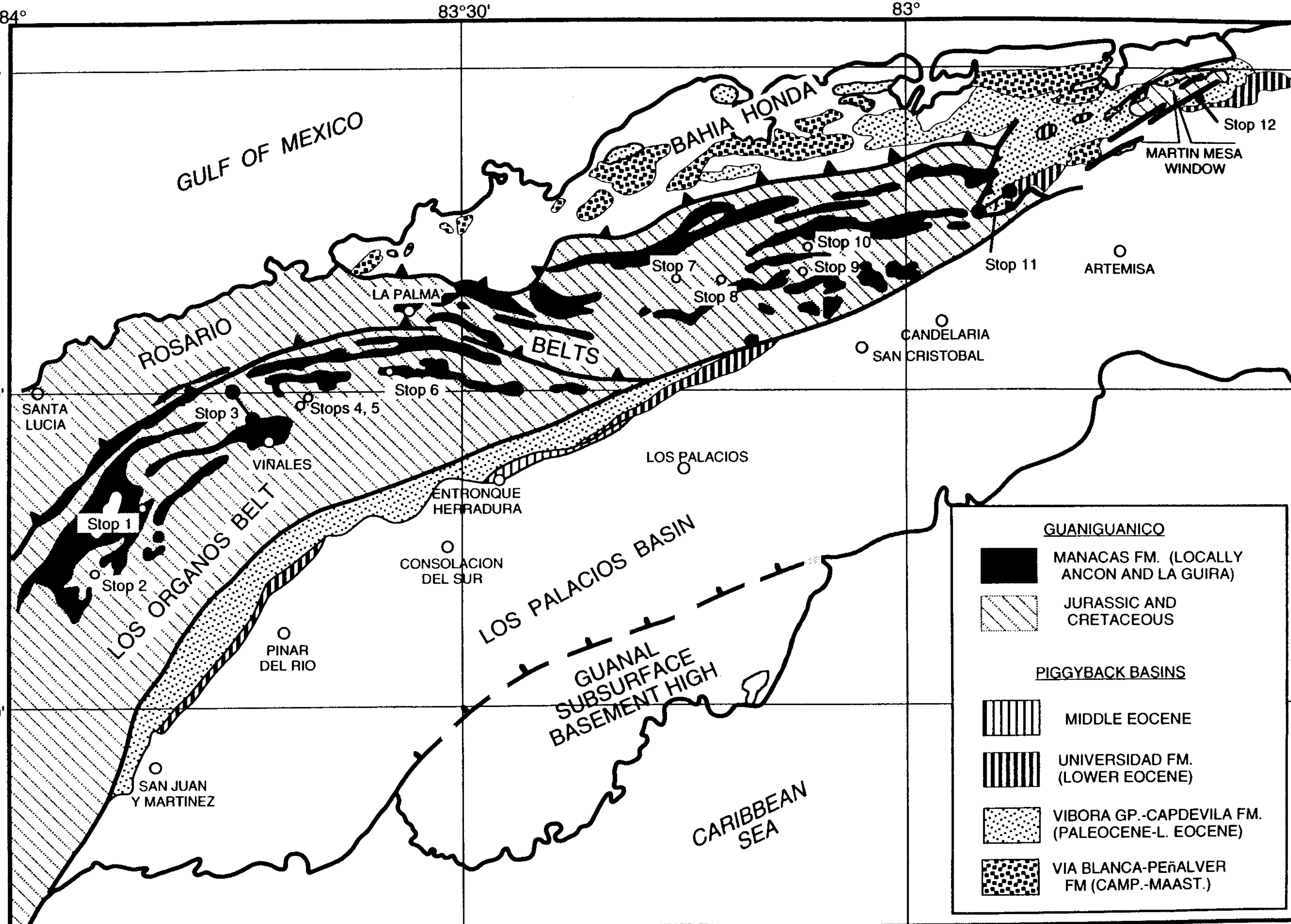
The Guaniguanico mountains have been defined as the Guaniguanico Terrane (Iturralde-Vinent 1994). They present a fold-thrust style of deformation, in which several thin-skinned thrust sheets were emplaced north- and northwestward, probably partially over autochthonous Mesozoic-Cenozoic southeastern Gulf of Mexico deposits. The internal structure of Guaniguanico shows that the thrust sheets of the Rosario area overlie those of the Los Organos area. Consequently, the continental margin represented by Guaniguanico was originally facing the Caribbean Sea (southeastward) before deformation took place.

The stratigraphy of Guaniguanico has been described by Pardo (1975) and Pszczolkowski (1978, 1994). The facies assemblage of the Los Organos units represent a landward basin, whereas those of the Rosario units are oceanic facies. In general, Mesozoic rocks exemplify the evolution of a continental passive margin from (?) Lower-Middle Jurassic up to the Lower Paleocene. The upper Paleocene to lower Eocene sections are less diversified laterally and represent foreland basin deposition.

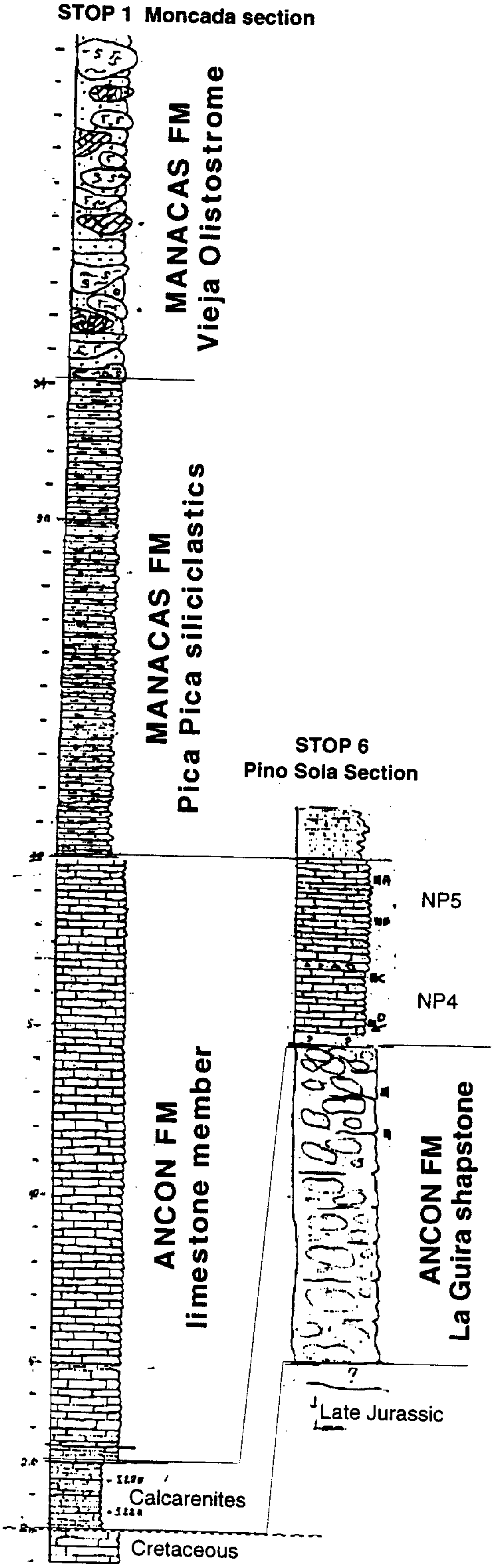


Simplified lithostratigraphy of Guaniguanico from Pszczolkowski (1978, 1994).





SCHEMATIC GEOLOGY OF WESTERN CUBA AND LOCATION OF STOPS



DESCRIPTION OF THE STOPS

Exposures in Sierra de los Organos

Stop 1 Moncada Section, Pons-Ancón-Manacas Fms.

From Viñales Town, drive 18 km to the west, just after the intersection to Moncada (southward).

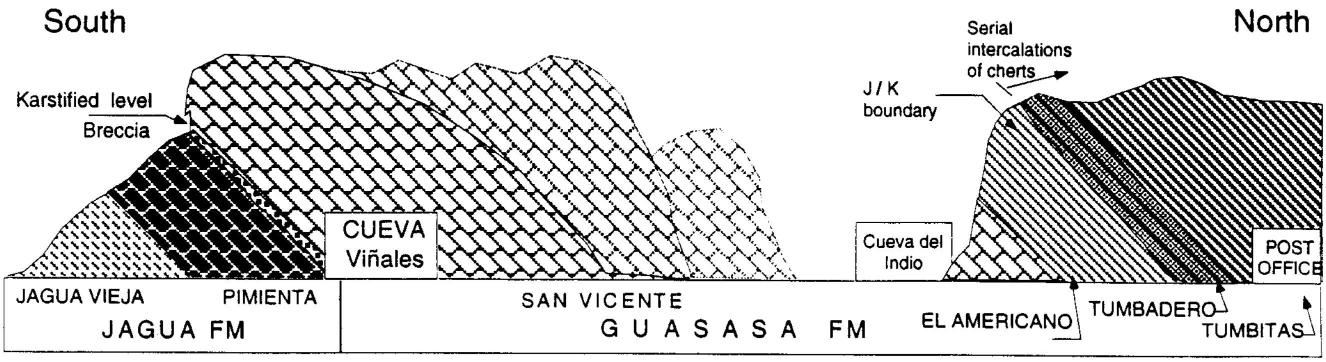
This section contains excellent examples of the Guaniguanico Tertiary deposits, with the transition from passive margin to foreland sedimentation. The continental passive margin deposits are represented by the Pons-La Guira-Ancón: The Pons Fm consists of well-bedded black micritic and biomicritic limestone and cherts. It is overlain by the La Güira Sharpstone represented by a 2 m thick layer of thin-bedded, fine-grained calcarenites located below the Ancón limestones. The Ancón limestone consists of about 18 m of well-bedded, light reddish-violet-green micritic, slaty to sub-lithographic limestone with interbedded calcarenite. The overlying foreland deposits are represented by the Manacas Fm which is subdivided into the Pica Pica siliciclastics and the Vieja Olistostrome. Pica Pica siliciclastics are represented by 15 m of thin-bedded claystone and fine- to medium-grained arkosic and lithoclastic sandstone. The section is capped by more than 30 m of olistostrome, composed of large blocks embedded in a strongly deformed sandy-claystone matrix. The blocks, which consist of limestone, chert, basalt, diabase, gabbro and serpentinite, are up to 3 or 4 m in diameter and coarsen toward the top of the outcrop. The age of the rocks and relationships with other outcrops are illustrated.

Stop 2. Outcrops at Río Piedras

From the previous stop, drive to Pons, but turn to the south in the intersection; the first small bridge.

The outcrop along the river, starting from the road bridge upstream includes the Pons (Albian-Cenomanian-Turonian?), Peñas (Campanian-Maastrichtian) and Ancón (Paleocene) Fms. The oldest unit is represented by micritic and biomicritic well-bedded black to dark gray limestones with interbedded cherts as nodules and layers. It contains planktonic foraminifera, radiolaria and calcispherulids. It is covered by limestones and cherts of the younger Peñas Fm, richer in chert intercalations. The contact is a non-evident parallel unconformity. The section is capped by the beige and pink limestones of the Ancón Fm and the Pica Pica siliciclastics. Peculiar to this section and typical of the Cretaceous in Sierra de Los Organos is the absence of siliciclastic intercalations, common to the isochronous units of the Rosario mountains.

The Pons-Peñas hiatus is probably isochronous to the so-called mid-Cretaceous unconformity.



STOP 3 SCHEMATIC CROSS SECTION OF VALLE DE SAN VICENTE

Stop 3. Observations along the walls of Valle de San Vicente. Jagua-Guasasa Fms.

This section is reached by driving southwestward from Viñales Town in the direction of Motel Rancho San Vicente. Just at the intersection to Laguna de Piedra, looking northward, begins the Abra del Ancón.

The first Jurassic fossils reported from Cuba were discovered last century by Manuel Fernández de Castro and shortly after by Carlos de la Torre y Huerta on the slopes of Abra del Ancón. At the gentle slope of the "mogote" hill on both sides of El Abra is found the Oxfordian Jagua Fm, represented by well-bedded shales with laminated fossiliferous limestone concretions (Jagua Vieja member), followed by well-bedded limestones (Pimienta member) exposed on the walls of the mogotes (Pszczolkowski 1978). At the top of the well-bedded limestones is located the base of the Guasasa Formation, containing well-developed kastic features.

The base of Guasasa Fm is a limestone breccia that can be observed on the wall just left of the Cueva de Viñales bar. Some geologists in the past saw in this breccia a tectonic unit, but most probably it is a sedimentary bed deposited during an onlap event.

Above the breccia, the massive limestones of the San Vicente Member (Guasasa Fm) are found. These limestones are latest Oxfordian to earliest Tithonian in age, and represent a carbonate platform known only in the Los Organos mountain area of western Cuba. The limestones are massive to thick-bedded, gray to black, totally or partially dolomitized. Micritic limestones dominate the lower section, whereas calcarenites are more common upward (Pszczolkowski 1978). These lithologies can be observed at the mogote wall on the right side of the Cueva de Viñales bar, and on the other side of the valley, near Cueva del Indio. Unfortunately combined recrystallization, karstification and weathering obscure details of the carbonate bank facies.

The San Vicente carbonate bank evolved upward into more open marine carbonates and cherts of the El Americano, Tumbadero and Tumbitas members, representing drowning and extinction of the carbonate platform.

The last three members are exposed at the mogote wall facing southeast, near the parking area of Cueva del Indio Cafeteria, walking toward the International Post Office (northward).

They are well stratified limestones with calpionellids, radiolaria and other nannofossils, occasionally ammonites. The lower part of the section above the San Vicente thick bedded limestones is El Americano's well-bedded, dark-gray to black limestones with some dolomites, up to 45 m thick. This unit is followed by thin-bedded to laminated limestones with black chert intercalations (Tumbadero mb), that reach 20 to 50 m thick. The Tumbitas mb consists of thick-bedded, compact, light-grey micritic limestones with some thin intercalations of darker limestones, ranging from 40 to 80 m thick (Pszczolkowski 1978). The Jurassic-Cretaceous boundary here is almost coincident with the El Americano-Tumbadero contact, which shows a minor unconformity.

Stop 4. Exposures just south of Mogote La Mina. (San Cayetano Fm)

This stop is reached by driving along the road to Laguna de Piedra from Viñales, and turning to the east, at the first intersection after the entrance to República de Chile. Drive 1.5 km from the intersection.

The San Cayetano Formation is exposed just after the intersection about 2 km. This unit is the oldest known in Guaniguanico mountains. It represents a siliciclastic shelf and coastal plain environment, with sedimentary features typical for these facies. Metamorphism is present from very low grade up to mid grade high-P locally. Terrestrial deposits occur in Sierra de los Organos with dry-land and brackish-water coastal plants (Areces 1990). Shallow marine incursions are also found as intercalations that yield bivalves. The age of the unit is identified as Lower? to Upper Jurassic (early Oxfordian) (Pszczolkowski 1978, 1994).

The San Cayetano Fm probably represents a sedimentary unit coeval with the breakup of Pangea in the

Mesoamerican area. Hence, it is locally cut by dikes and sills of basic igneous rocks.

In western Cuba, as in some sections of the Gulf coast, the siliciclastic deposits (Eagle Mills) are directly overlain by marine clays and limestones (Smackover), but the evaporites are not present. Only isolated gypsum veins have been recorded in some deep wells drilled in Guaniguanico.

Present in the outcrops are some of the sedimentary facies of San Cayetano, which consist here of well-bedded reddish and yellowish fine- to medium-grained sandstones with shales. The sandstones yield muscovite derived from Grenville and Pan African terranes.

Stop 5. Near Hoyo del Palmar. Jagua Vieja member (Jagua Fm).

From the intersection to Laguna de Piedra road, drive 2.3 km up to the first mogote located on the right side of the road. There is a rustic house (bohío) and a track along the SW face of the mogote. Walking from the road, turn left to a small track located behind the bohío and climb the hill slope.

The Jagua Vieja Member of the Jagua Formation represents a highly fossiliferous unit from which the only Jurassic vertebrates known from the Caribbean have been recovered. The carbonate concretions in this member yield fossil fishes, plesiosaurs, pliosaurs, metriorhynchus crocodiles, pterosaur and ammonites.

Uphill the Jagua Vieja member of the Jagua Fm crops out as dark shales and thin-bedded limestone, with embedded laminated calcareous concretions. The concretions are of different sizes and are named "jicoteas" or "quesos" in the local vernacular.

- **Outcrops of the Ancón-Manacas Fms occur to the next stop, on the north side of the road**

Stop 6. Side road exposure in Bella María. La Guira Sharpstone.

11.1 km from the intersection to the Laguna de Piedra road, near some houses, low outcrops on the north side of the road.

This section contains three lithologic units, from base to top: about 70 m of La Güira Sharpstone (composed of subrounded to subangular pebbles and blocks of Mesozoic limestone and chert, without matrix and cemented by sparry calcite), about 20 m of Ancón limestones (red very fine-bedded micritic limestone, with two 20 cm thick lenses of calcareous breccia) and about 5 m of lower Manacas Fm (poorly exposed siliciclastics). In this section the stratigraphic position of La Güira member below the Ancón limestones suggests an early Paleocene (Zone NP4 or earlier) age for the sharpstones (Iturralde-Vinent and Bralower in press).

These sharpstones are probably related to fault scarps active during deposition of Ancón Fm (Pszczolkowski 1978)

STOP 1: Partial view of Tertiary foreland sediments. Ancon limestones covered by Pica Pica siliciclastics of the Manacas Fm.

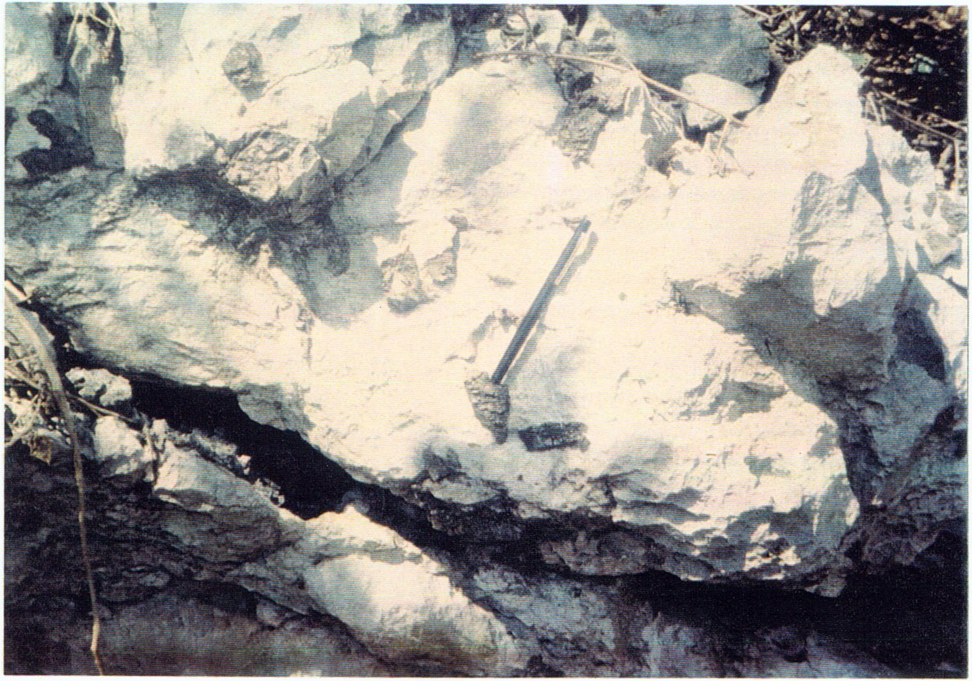
STOP 1: Partial view of the Vieja olistostrome with olistoliths of igneous (ultramafics, gabbroids, basalts) and sedimentary (older limestones and cherts) rocks.

STOP 2: Albian-Cenomanian well-bedded micritic limestones with cherts of the Pons Fm., along Rio Piedras .

STOP 3: El Americano-Tumbadero contact (the J/K boundary) at Valle de San Vicente. The thick bed in the lower third of the photo (El Americano) is covered by thin-bedded limestones and cherts that represent a northwestern Caribbean deepening event of the sea floor.

STOP 3: Abra del Ancon at Valle de San Vicente. General view of contact between the Jagua (mid slope) and San Vicente member of the Guasasa Fms. Jagua represents the Oxfordian marine transgression and San Vicente the Kimmeridgian-early Tithonian carbonate bank.

STOP 4: Mogote La Mina from stop 5. The limestones on the vertical wall are the San Vicente carbonate bank, whereas the lower slope is composed of the Jagua Fm. San Cayetano Fm crops out along the road side.



STOP 6: Close view of the Paleocene La Guira sharpstone with angular fragments of cherts and limestones.

Exposures at Sierra del Rosario

- **From intersection located 2 km SE of La Palma, driving east toward Mil Cumbres and Niceto Perez.**
- **Exposures of Manacas Fm from 2.5 to 5.2 km**
- **Exposures of San Cayetano Fm near 7.8 km**
- **Exposures of Manacas Fm from 9.7 to 11.5 km**
- **After 12 km, the contact between Guaniguanico and Bahía Honda allochthon**
- **Exposures of ophiolites (mainly serpentinites) of the Bahía Honda, from 14 to 20 km**
- **Scenic view of the Pan de Guajaibón, uphill from Mameyal, looking north, 24 km. (The Guajaibón Fm is an Albian to Cenomanian carbonate bank, which is part of a section located north in Sierra del Rosario)**
- **Albian Santa Teresa cherts thrust onto lower Eocene Vieja olistostrome from 32 to 33 km, 4 km before Niceto Perez.**
- **Niceto Perez. Turn in the intersection to the left; it is the road to Soroa and Las terrazas**
- **Scenic view looking north 7.4 km from Niceto Perez. The coastal plain north of the mountains is the Bahía Honda tectonic unit**
- **San Cayetano-Artemisa Fms contact 8.7 km after Niceto Perez**
- **Artemisa Fm from 9.4 to 10 km after Niceto Perez**

Stop 7. Cretaceous deep-water deposits in the Rosario mountains. Polier-Roble-Santa Teresa-Carmita.

Exposure on the left side of the road, 10.3 km after Niceto Perez

Four units are present in this exposure: the Polier Fm limestones and shales, the Roble sandstone member of the Polier, the Santa Teresa Fm cherts and the Carmita Fm limestones and cherts. They represent the Lower Cretaceous Hauterivian? to Turonian? basinal marine section, probably facing the Caribbean sea floor (Iturralde-Vinent 1994). A similar pattern of Lower Cretaceous facies development is found at the southern slope of the Bahamas platform (exposed in north-central Cuba). In contrast to the isochronous section in Sierra de los Organos (Stop 2 Valle de Pons), this section yields clastic sediments from a deeper water environment.

The outcrop is deformed, but still the units preserve the original superposition. From oldest to youngest are: The Polier Fm is composed of thin-bedded, gray, micritic limestones intercalated with sandstones and shales. The sandstones are yellow-brown, fine- to medium-grained, with some calcareous cement. They display flute casts, groove casts, cross and horizontal lamination and graded bedding. The clastic component is dominated by quartz with plagioclase and muscovite. The Roble member (of the Polier Fm) is composed of thick-bedded, medium-grained quartz sandstones, with few clayey shale intercalations. They display graded bedding, and abundant sole casts. The Santa Teresa Fm is composed of well-bedded turbiditic silicified sandstones, red to greenish-brown ribbon cherts and a few green shale intercalations. Sedimentary features typical of deep-water deposition are visible. The cherts are usually strongly folded. The Carmita Fm is light grey, well-bedded micritic limestone with interbedded radiolarian cherts and shales (Pszczolkowski 1978, 1994).

Stop 8. Exposures of Artemisa Formation

These limestones are exposed 13.5 to 14.5 km from Niceto Perez, 2.5 km before the intersection with the road to Soroa

Section of Late Jurassic (late Oxfordian) to Early Cretaceous well-bedded micritic, dark gray to black limestones and some black calcareous shales, with a few intercalations of coarse grained calcarenites. Sometimes aptychi are found in the limestones. The calcarenites in the lower (Kimmeridgian) part of the section are probably derived from the coeval carbonate platform in Los Organos (San Vicente mb of Guasasa Fm). Bioclastic limestones and coquinas composed of ammonite shells and aptychi are found near the top, as are some biomicritic limestones with radiolaria, calpionellids and other microfossils. In the late Tithonian part some cherts are found (Pszczolkowski 1978).

- **After this stop is exposed the San Cayetano Fm up to the intersection with the road to Bahía Honda. Drive across it and follow the road to Las Terrazas**

Stop 9. The Early to Late (early Oxfordian) Jurassic San Cayetano Fm in Rosario mountains

The formation crops out from 800 m to 1.5 km after the intersection with the Road to Bahía Honda

Exposures of the San Cayetano Fm in Sierra del Rosario are supposed to be oceanic (Haczewsky in Pszczolkowski et al. 1987). This outcrop has thin-bedded to slaty shales with bitumen, and thin to coarse-grained sandstones to conglomerates, often with small fragments of plant remains. The rocks are quartz and mica rich.

- **Manacas Fm 4.5 km after the intersection**

- **Exposures of Late Cretaceous units from 5 to 7.5 km**

Stop 10. Oxfordian-early Kimmeridgian El Sábalo basalts

These exposures are found 7.5 to 10.5 km after the intersection with the road to Bahía Honda

The El Sábalo Fm is a thick volcano-sedimentary unit deposited at the continental margin, during extension (and thinning) of the sialic crust. Because this continental margin was probably facing the Proto-Caribbean seaway, the thick basaltic extrusives suggest an active event of ocean spreading (drifting) in the basin (Iturralde-Vinent 1994).

The El Sábalo underlies the Artemisa Fm in this area as can be observed in several places where the limestones cap the elevations built up by basalts. The El Sábalo is composed of massive or pillow basalts and hialoclastites with thin intercalations of laminated limestones and shales. These intercalations contain microfossils (*Globochaete alpina, Colomisphaera* spp., and spicules of Didemnidae) (Pszczolkowski 1994). The basalts are geochemically very similar to those found in the ophiolitic sections of Cuba (Iturralde-Vinent 1989).

The unit is usually strongly brecciated but the character of the folding in the sedimentary intercalations shows that the deformation is not very strong.

- **After this stop is the road to Soroa. Turn left and about 1 km later turn right and drive toward Las Terrazas. Outcrops of the Manacas Fm tectonically covered by slivers of Polier Fm lead up to the following stop.**

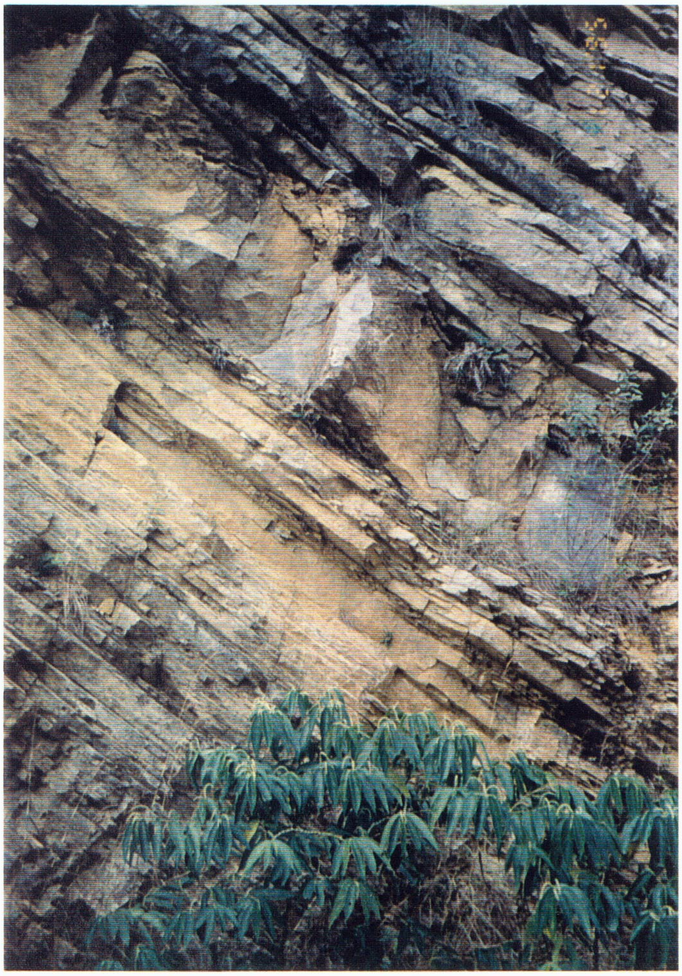
STOP 7: Partial view of a Cretaceous section typical of the Sierra del Rosario. Exposures of the Roble Sandstone (below) and the Santa Teresa cherts (above). The lady is pointing to the Carmita Limestone on top of the Santa Teresa.

STOP 7: Folded radiolarian cherts of the Albian-Cenomanian Santa Teresa Fm.

STOP 8: Thin-bedded limestones with cherts of the late Tithonian-Early Cretaceous section of the Artemisa Fm.

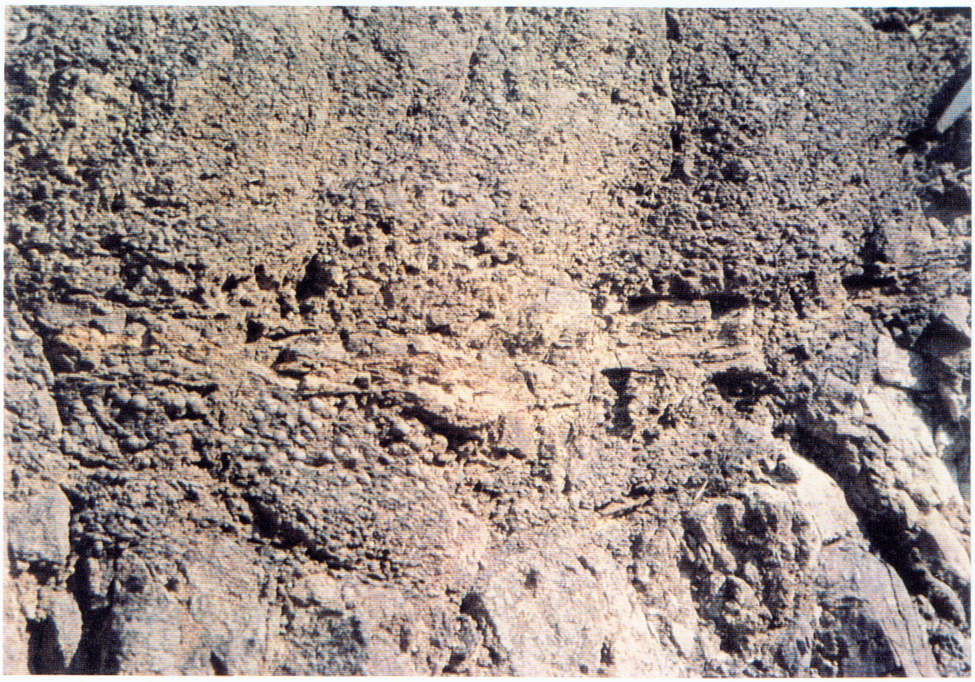
STOP 9: Folded section of sandstones and shales of the Early? to Late Jurassic (early Oxfordian) San Cayetano Fm.

STOP 8: Exposures of the late Oxfordian-Early Cretaceous deeper marine section partially isochronous with the San Vicente carbonate bank in Sierra de Los Organos.



STOP 8: Thick beds of bioclastic limestones (calcarenites) intercalated in the micritic limestones of the Artemisa Fm. They probably represent the detritus washed out from the San Vicente platform.

STOP 10: El Sabalo Fm. Oxfordian basalts and hialoclastites with intercalations of sedimentary rocks, mostly limestones (Light colored beds in the middle of the outcrop).



STOP 10: Interesting beds of siliceous spherulites within the basalt flows.

II. The Bahía Honda allochthon: Example of synorogenic sedimentation in piggyback basins

The geology of Bahía Honda has been discussed in several previous papers (Furrazola et al., 1964; Pszczolkowski and Albear, 1982). With few exceptions there is an agreement that Bahía Honda is an allochthon sheet thrust onto Guaniguanico by north-northwestward tectonic transport. The exotic character of Bahía Honda is also observed in the Martín Mesa window, NE of Guaniguanico, where deformed Guaniguanico rocks are surrounded and tectonically overlain by Bahía Honda units (see the western Caribbean tectonic map).

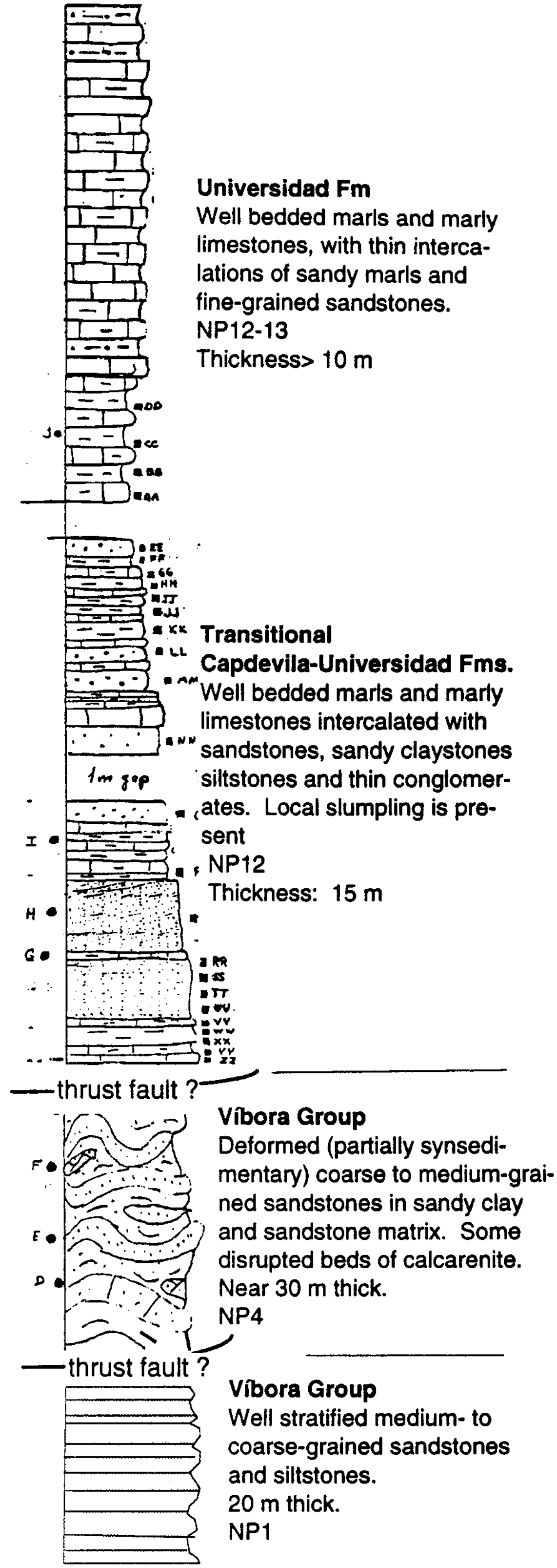
The Bahía Honda allochthon is represented by a lower deformed ophiolite sheet, overthrusted by Cretaceous volcano-sedimentary deposits of ?Albian to Campanian age. This volcanic arc section is unconformably overlain by upper Campanian-Lower Maastrichtian deep-water sandstone, claystone, and conglomerate of the Vía Blanca Fm. The clastics are mostly derived from the erosion of the extinct volcanic arc. Late Maastrichtian deposits include a calcareous megaturbidite (Peñalver Fm) (Albear et al. 1985, Puscharowski et al. 1989).

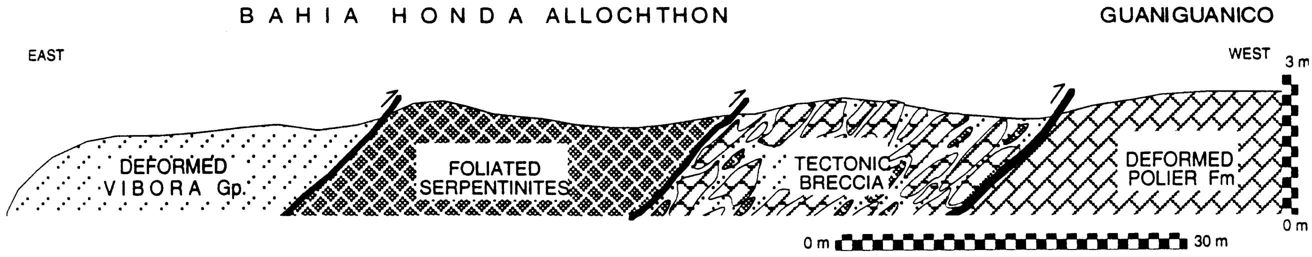
The lower Tertiary section was deposited in piggyback basins, partially during the tectonic emplacement of the Bahía Honda allochthon above Guaniguanico. Therefore, the Tertiary section of the piggyback basins is less deformed than the section of the foreland basin. In some localities (such as near Las Terrazas), the deposits of the piggyback basins directly overlie Guaniguanico, but the contact is tectonic (Iturralde-Vinent 1994, Iturralde-Vinent and Bralower in press).

The lower Tertiary section has been divided into the Vibora Group (well-stratified conglomerates, sandstones, siltstones and claystones, usually with slumping and olistostromic-like intercalations), the Capdevila Fm (well-bedded sandstone, claystone and siltstone, with minor intercalations of conglomerate), and the Universidad Fm (hemipelagic marls, marly limestone, and radiolarian marls, with rare intercalations of fine clastic rocks toward the base). These clastic rocks were deposited during the thrusting of Bahía Honda onto Guaniguanico, so abundant slumping and thick conglomerates developed. The transition between the clastics and the marls (Capdevila-Universidad) is coincidental with the end of the tectonic transport of Bahía Honda units above Guaniguanico (Iturralde-Vinent and Bralower in press).

During the field trip, some sections of the Tertiary piggyback deposits will be observed.

STOP 11
LA PASTORA SECTION





STOP 11. Outcrop on the south wall of the road near Las Terrazas, where the Bahía Honda Allochton contact with the Guaniguanico Terrane is located.

DESCRIPTION OF THE STOPS

Informative stop. Exposures of the Guaniguanico-Bahía Honda contact (after a long wet season, these exposures are covered by grass)

10 km from the road to Soroa, just after the intersection to Las Terrazas. Low exposures

In this locality the Bahía Honda sediments are exposed directly on the deformed Guaniguanico. From base to top: 1) strongly-deformed Lower Cretaceous Guaniguanico sedimentary rocks (Polier Fm); 2) a deformed contact, probably a thrust plane; 3) blocks and slivers of deformed Polier Fm mixed with deformed Paleocene sandstone; 4) foliated serpentinite dipping eastward probably along a thrust plane; 5) deformed Paleocene sandstone with inclusions of blocks of foliated serpentinite, chert and red tuff similar to those of the Cretaceous volcanic arc, and isolated small blocks of the Polier Fm.

This contact is tectonic, because: 1) Paleocene sediments at this locality are of the same age or older than those of the underlying Guaniguanico Tertiary rocks, so they cannot rest transgressively on Guaniguanico; 2) sedimentary rocks in these sites are more deformed than the Capdevila deposits elsewhere in the Bahía Honda Basin; and 3) slivers of allochthonous foliated serpentinite and blocks of Guaniguanico deposits are observed intercalated in the section, as in other locations along the same contact (Iturralde-Vinent and Bralower in press).

Stop 11. Deformed Víbora-Capdevila-Universidad Fm

Low exposures on the north side of the road, near the exit to Mirador and to Autopista (highway)

In this locality, known as La Pastora, a Paleocene to middle Eocene section of synorogenic piggyback deposits, of the so-called Bahía Honda allochthon is exposed.

The lowermost Paleocene (Víbora Group) is represented by about 20-25 m of well-stratified, medium- to coarse-grained sandstone and siltstone. This unit contains a lowermost Paleocene (Zone NP1) nannofossil assemblage. Above this unit are found, probably in tectonic contact, 30 m of folded medium- to coarse-grained sandstones mixed with calcarenite blocks in a matrix of sandy claystone and sandstone. These lithologies, partially produced by slumping, are also Paleocene. The lower Eocene Capdevila-Universidad transitional lithologies unconformably overlie the deformed deposits. This unit is represented by a 15 m thick well-stratified marlstone and marly limestone intercalated with sandstone, sandy claystone, siltstone and a few conglomeratic beds. The base of the Universidad Fm crops out on the other side of the road above the previous section and consists of marlstone and marly limestone. These formations were also described by Bronnimann and Rigassi (1963) and Albear et al. (1985) in the Havana area.

- **1 km toward Cayajabos lower Eocene marls and marly limestones (Universidad Fm) are exposed**

Stop 12. Folded Capdevila Fm

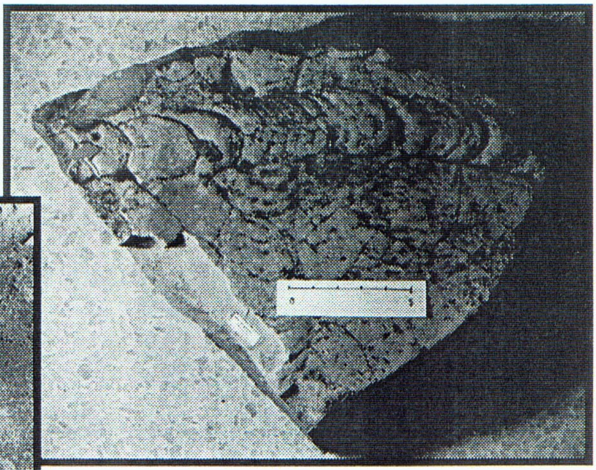
This exposure is at km 24 of A4 highway La Habana-Pinar del Río

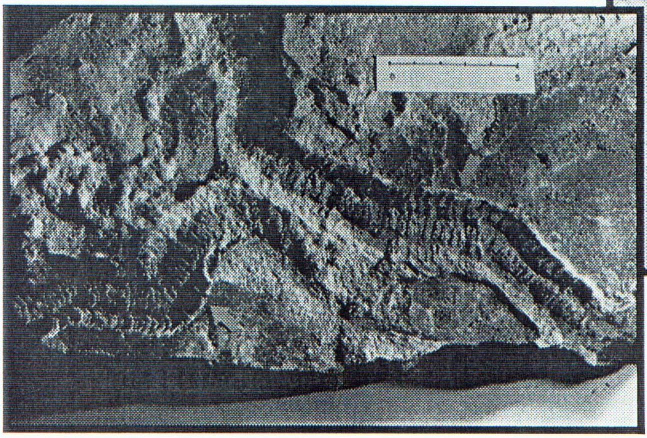
Exposures of deformed Paleocene-lower Eocene sandstones and claystones of the Capdevila Fm, a synorogenic flysch-type deposit of the piggyback basins, show graded bedding, cross and parallel lamination, and other sedimentary features, as well as ichnofossils. These sandstones, although coeval with those of the foreland basins, are lithologically very different. They are dominated by debris derived from the erosion of the Cretaceous volcanic arc terrane.

STOP 11: Upper Paleocene-lower Eocene well-bedded synorogenic graywackes (Capdevila Fm) of the piggyback basins.

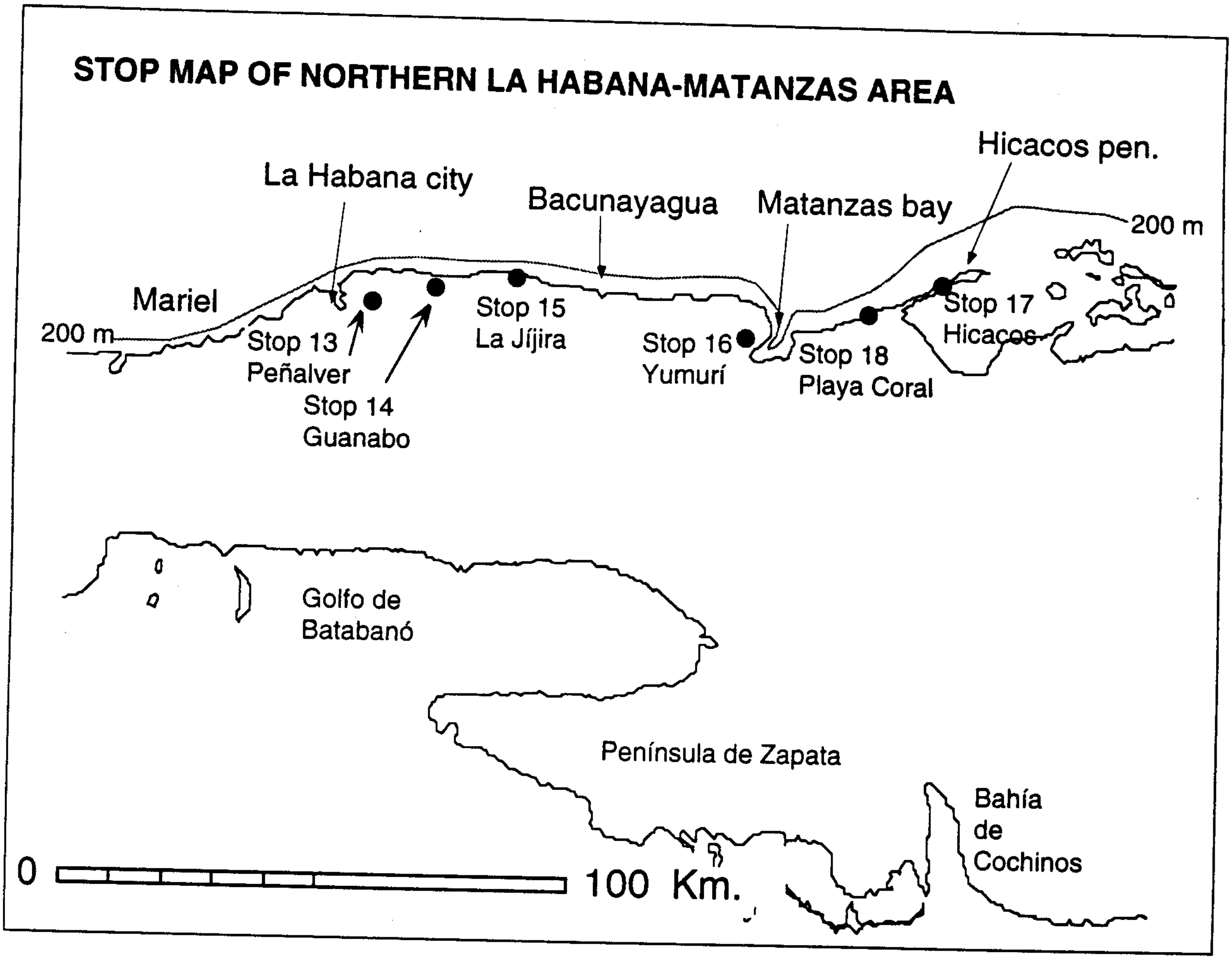
STOP 11: Lower to middle Eocene deep marine marls and marly limestones (Universidad Fm) deposited after the major overthrust event in western Cuba. This exposure is located 1 km east of stop 11.

STOP 12: Partial view of the folded graywackes of the upper Paleocene-lower Eocene (Capdevila Fm) synorogenic piggyback deposits. The folding here is probably related to the sinistral strike-slip stage of development of the Pinar Fault.





STOP 12: Ichnofossils (worm tracks) found in the upper Paleocene-lower Eocene Capdevila Formation.



III. The K/T Boundary Megaturbidite

In western and north-central Cuba are well developed Late Maastrichtian calcareous megaturbidites which have been discussed in relation to the suspected K/T boundary impact in the Caribbean (Pszczolkowski 1986, Iturralde-Vinent 1993). The megaturbidite crops out in several localities of Sierra del Rosario and La Habana, but the field trip will visit only one excellent outcrop. The following facts are relevant to the megaturbidite:

1. We do not know the exact age of the megaturbidite. It is probably mid-Late Maastrichtian, upper Late Maastrichtian, or Late Maastrichtian to early Paleocene. Additional sampling is needed.

2. No shocked quartz or true tektites have been found in these deposits. Tiny clay inclusions found in the calcarenites are to be studied in order to identify its origin.

3. Two features, single graded bedding and the great thickness of the deposit, suggest that it is an unusual sedimentary event. Its deposition has been related to an earthquake-derived tsunami or to a marine meteorite impact. But, did this event occur before or at the end of the Cretaceous?

DESCRIPTION OF THE STOP

Stop 13. Old quarry in Vía Monumental, near Peñalver, east of Havana

To reach this stop from Havana, you take highway I-3 (Vía Blanca) from the Tunel de la Bahía. Turn right toward Carretera Central, and after 3.6 km turn right again in the intersection with Primer Anillo. Follow Carretera Monumental to the bridge (Peñalver) and stop in the quarry (7.4 km).

Here is a good example of the Late Maastrichtian megaturbidite. The unit has been described as the Peñalver Fm, which rests on top of the Late Campanian-Early Maastrichtian flyschoid deposits of the Vía Blanca Fm (Bronnimann & Rigassi 1963). Southeast of the Peñalver Fm depocenter, in present-day central Cuba, an isochronous shallow-water carbonate bank is well developed, lying on top of the extinct Cretaceous volcanic arc (Iturralde-Vinent 1993).

The megaturbidite is composed of clastic carbonate rocks (calcirudites to calcisiltites). The clastic components in the basal calcirudite are shallow-water and pelagic limestones, biodetritus including abundant rudist fragments, volcanic rocks and cherts. Some carbonaceous plant remains are present. Up section the calcarenites contain shallow-water limestone fragments. At the top of the section, planktonic microfossils are common, and the rocks are fine-grained calcarenites and calcisiltites.

Throughout the calcarenites are small grains of green clay, probably derived from weathered volcanic rocks. The amount of quartz is very small. The quartz does not display shocked structures.

The megabeds generally represent a massive single sedimentary cycle. The megaturbidites are dated as latest Maastrichtian, probably earlier than the end of the Cretaceous. Some blocks, isolated due to spherical weathering in the lower part of the unit, are sometimes confused with "a meteorite impact ejecta."

- **For the next stop you turn to the right before the bridge in Peñalver and follow the road to Campo Florido. You will reach Vía Blanca in Crucero de Guanabo and turn to the right again.**

STOP 13: General view of the old quarry, type locality of the late Maastrichtian Penalver megaturbidites.

STOP 13: Weathering creates huge spherical boulders in the medium-grained calcarenites of the Penalver Fm. Outcrop located after stop 12 on the west side of the road.

IV. Late Tertiary to Recent Deposits along La Habana and Matanzas coastal plain

The northern coastal plain of La Habana and Matanzas is underlain by Miocene to Recent deposits that dip gently toward the north. Miocene rocks are divided into two units, the marly Cojímar Fm and the carbonate Guines Fm. Late Miocene-Pliocene deposits are only locally developed at the Morro castle of La Habana (the Morro limestones) and surrounding Matanzas city (El Abra clastics). Pleistocene rocks include carbonate shelf and coastal deposits, subdivided into several formations and uplifted into as many as four marine terraces. Several levels of eolian sediments are quite well exposed (Bronnimann and Rigassi 1963, Albear et al. 1985). Coastal types include cumulative (beach-dune complex) and erosional (rocky shores with uplifted terraces). Near the shore are coral reefs and lagoonal basins. During the field trip all of these elements will be visited.

The Cojímar Fm is composed of fairly well-stratified marly limestones and marls, with locally abundant mollusks, echinoderms, corals, etc. The marls contain smaller benthonic and planktonic foraminifera. They represent a deep open shelf of early middle Miocene age. The marls unconformably overlain by the limestones of the Guines Fm. This unit is dominated by biohermal and biostromic facies with corals, mollusks, echinoderms and other reefal organisms; but calcarenites and biocalcarenites are also present, representing different environments in the calcareous shelf (Bronnimann and Rigassi 1963, Albear et al. 1985). These limestones represent a huge carbonate platform that covered nearly the entire Greater Antilles from the second half of the middle Miocene up to the late Miocene. The Pliocene El Abra Fm is a fluvio-marine unit represented by interbedded conglomerates with calcarenaceous matrix and poorly consolidated sands and gravel with well-preserved plant remains (Iturralde-Vinent 1969, 1978).

Quaternary carbonate rocks along the narrow coastal plain of La Habana and Matanzas are well exposed. Most of the rocky shores are built up by the late Pleistocene Jaimanitas Fm (coral reef limestones and calcarenites) (Albear et al. 1985).

In some areas west of the city of La Habana and in the Peninsula de Hicacos in Matanzas, young eolian calcarenites with cross lamination are well developed as small dune-like hills. Below the Jaimanitas Fm lies the Vedado Fm, a mid-Pleistocene reef and forereef limestone that crops out typically at the foot of the hill near the Hotel Nacional in La Habana, and along the northern coastal plain.

Near Guanabo village eolian calcarenites probably of Vedado age, are exposed on several hills. The centers of these hills are brecciated karsitifed Miocene limestones.

The topography of this coastal plain is characterized by several marine terraces. At the Matanzas Bay these terraces are well developed and have been given the following names (Ducloz 1963), from highest to lowest: Rayonera (25-51 m), Yucayo (15-33 m), Puerto (±16 m), Seboruco (±8 m), submerged (several submarine levels). The shores display the unconsolidated beach and dune deposits, characteristics of coastlines facing a well-developed sandy shelf.

DESCRIPTIONS OF THE STOPS

Stop 14: Exposures near Crucero de Guanabo, mid-Pleistocene eolianites

After Crucero de Guanabo in the direction of Matanzas are several outcrops of eolianites. Stop 2 km from Crucero.

At this locality there are several exposures of the Guanabo Fm eolianites. They are parallel and cross-laminated calcarenites, poorly to well consolidated. The clastic material is mostly marine organic detritus mixed with isolated terrestrial elements (land snails, etc.).

The eolianites consist of several superimposed beds separated by thin levels of paleosol (red clays rich in calcite) that can be missing. The beds show lamination in different directions, indicating the drift movement of the sand. These sands have accreted around small rounded hills, composed of strongly eroded and karstified carbonate brecciated Miocene limestones (Albear et al. 1985). Usually between the Miocene limestones and the eolianites there is a bed of carbonate breccia, up to 3 m thick, a slope weathering deposit composed of angular fragments of limestones embedded in red soil.

These eolianites probably formed during sea-level lowstands, when the wide sandy shelf was exposed and large quantities of marine shelf debris were transported landward.

Large dune deposits are common all along the northern shore of Cuba, including the archipelagos located on the northern shelf. This type of accumulation is also favored by the action of strong north winds every winter. At present, large active dunes are developing near the beach in Guanabo.

The deposition of eolianites in large quantities, as observed in Guanabo, represents an onlap event due to sea-level fall, an unexpected phenomena considering the normal method of interpreting coastal seismic sections.

- **Two marine terraces (Seboruco and del Puerto) are near the sea shore along the highway, 7 km after Crucero Guanabo**

Stop 15: <u>After Río Jaruco. Farallones de la Jíjira. Pleistocene terraces</u>

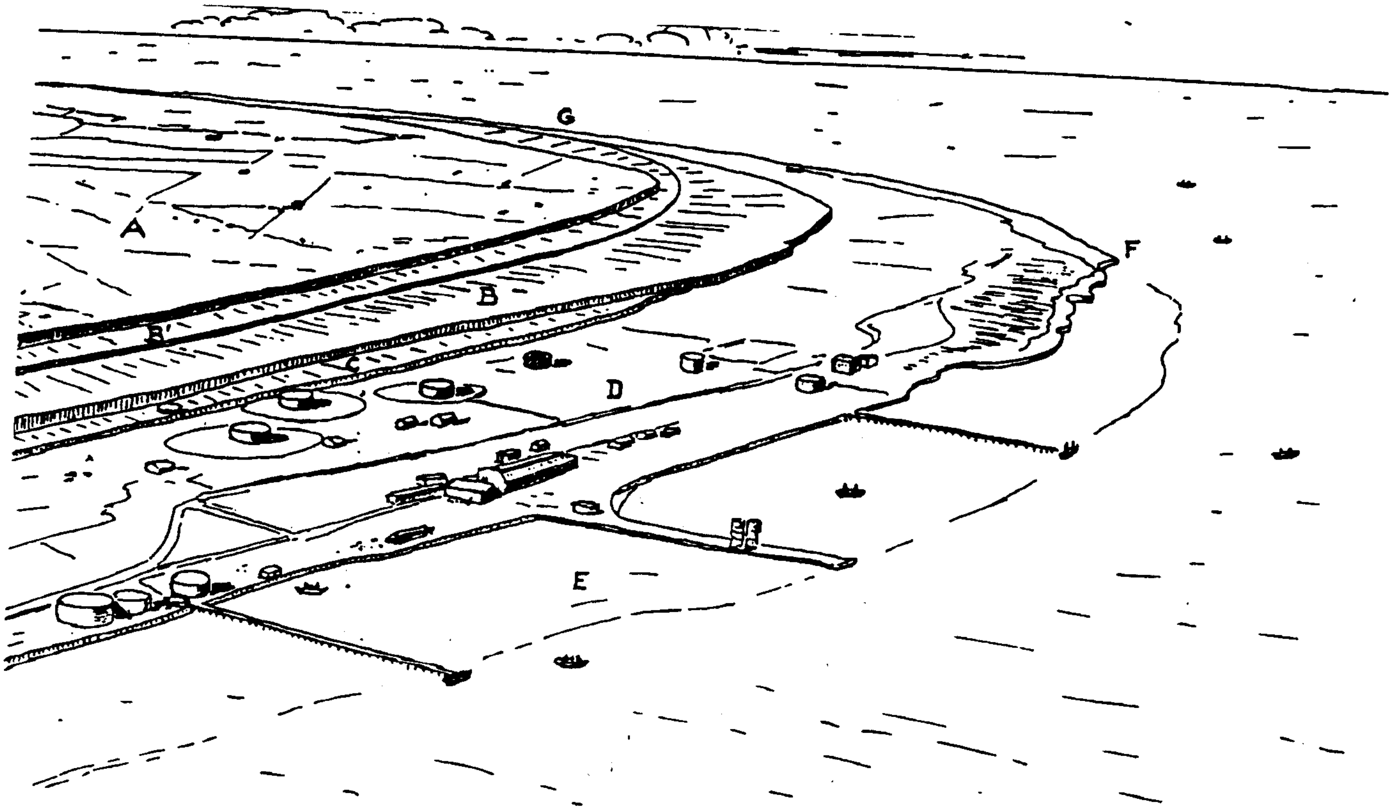
3.5 km after Río Jaruco bridge, looking to the west from near the sea shore.

Well exposed here is the late Pleistocene Jaimanitas Fm at the lower Terraza de Seboruco. The steep wall facing the sea is in the Terraza de Yucayo, composed of the limestones of the Vedado Fm. Looking southward, the "flat" surface on top of the hills was named Santoyo by Ducloz (1963) and is underlain by Miocene rocks. This surface is dissected by karst and fluvial erosion, and slope deposits are very common.

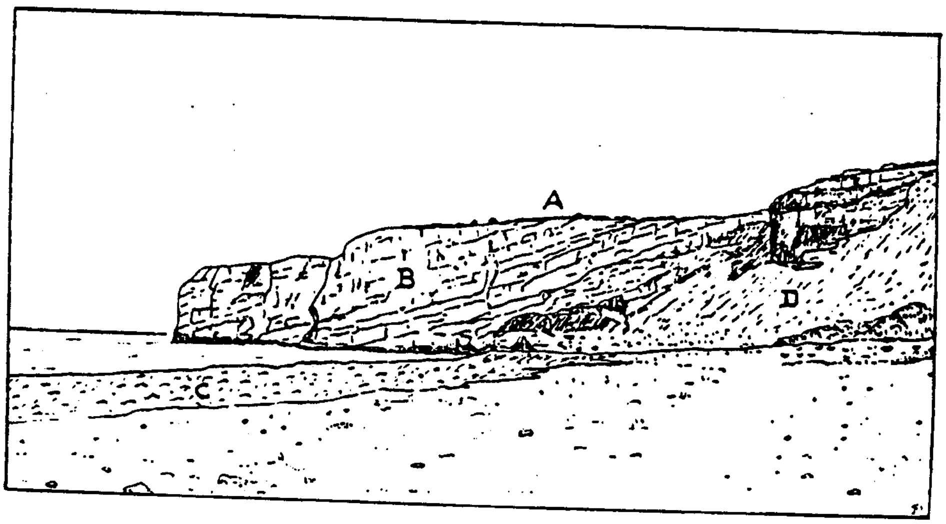
The erosional surface of the Jaimanitas Fm built by coral reefs and associated deposits, can be observed by walking on the Terraza de Seboruco .

- **After this stop, you find Santa Cruz del Norte and Playa Fraile. Between the road and the sea shore you will see a small limestone peak named "Peñon del Fraile", an erosional remain of the Rayonera or Yucayo terrace.**

Marine terraces on the west side of Matanzas bay, after Ducloz (1963).
Terraces: A. Rayonera, B and B'. Yucayo, C. del Puerto, D. Seboruco, E. submarines.
F- Punta Sabanilla and G- Punta Uvero Alto.



Rocky shore, 1.5 km west of Bacunayagua river, after Ducloz (1963)
Legend: A. Santoyo erosional surface buildup in Miocene rocks of the Guines and Cojímar Fms.
B. 30-40 m high wall, C. Terraza de Seboruco, D. slope deposits.



STOP 14: General view of outcrop. The core of the hill is composed of Miocene brecciated limestones that are overlain by a paleosol and the Pleistocene eolianites (Guanabo Fm).

STOP 14: Cross lamination in the Pleistocene eolianites (Guanabo Fm).

STOP 14: Detail of the contact between the eolianites (top), the paleosol (fragments of limestones in red matrix), and the underlying Miocene brecciated limestones.

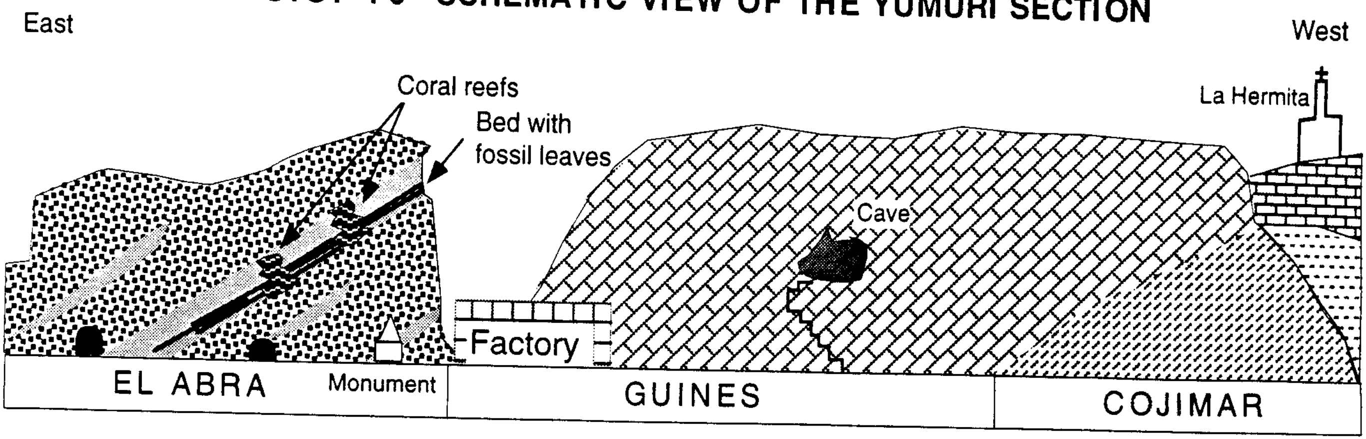
B

A

STOP 15: A) View of Punta Jijira from the east. The lower surface is Terraza de Seboruco, and the higher is Terraza de Yucayo.
B) Close-up view of the eroded surface of Terraza de Seboruco in the late Pleistocene Jaimanitas Fm.

Scenic View: Looking north from the interior of Valle de Yumuri in Matanzas; view of the Santoyo surface composed of Eocene and Miocene rocks and dissected by rivers that open beautiful "abras."

STOP 16 SCHEMATIC VIEW OF THE YUMURI SECTION



Stop 16: <u>Section at the Abra del Yumurí. Neogene sediments</u>

From the city of Matanzas, follow 79 street (also known as Contreras) and make a right turn at 292 street (two blocks after the central park). Drive downslope toward Parque Walking, and turn left to follow the road between the rock wall and the houses.

At the Abra del Yumurí there are good exposures of the Cojímar, Guines and El Abra Fms. Weathering and karstification have obliterated the limestones and marls, so some sedimentary features of the first two units are lost. Here Cojímar unconformably overlies lower Eocene rocks (Capdevila Fm).

The Cojímar Fm is composed of whitish to yellow massive marls. The contact with the Guines Fm is apparently an unconformity, but is obliterated due to the circulation of underground waters along this surface.

The Guines limestones are well stratified, and some mollusk coquinas with dissolved shells can be observed. A cave opens on the wall of the limestone outcrop.

The El Abra Fm overlies Guines Fm. Just at the contact a small fluvial valley opens, and a building covers the exposures, so it is not visible now (Iturralde-Vinent 1969a,b, 1971).

The El Abra begins with a well-consolidated marine conglomerate with calcarenitic matrix. Within this unit, near a small monument, there is a thin layer of alluvial sands, and another, a few meters above. The second sandy horizon clearly shows the characteristics of an alluvial channel deposit. The lower marine conglomeritic unit is overlain by a 3-4 m thick unit of fluvial sands and gravels. These are well-bedded to laminated and cross-laminated deposits, with some layers rich in red fossilized mangrove leaves. Within this unit are found the eroded and grounded remains of two coral reefs. These reefs are composed of *porites* and other fast growing corals, usually bioturbated, that were unable to survive the rapid influx of alluvial sands and gravel onto the marine shelf. On top of the alluvial beds is another thick level of marine conglomerates and calcarenites with two thin (up to 1.5 m) intercalations of alluvial sands and gravel.

These conglomerates are overlain by the biogenic limestones of the early Pleistocene Matanzas Fm, which crops out within Parque Walking.

This outcrop contains excellent evidence for Pliocene to early Pleistocene sea-level fluctuations.

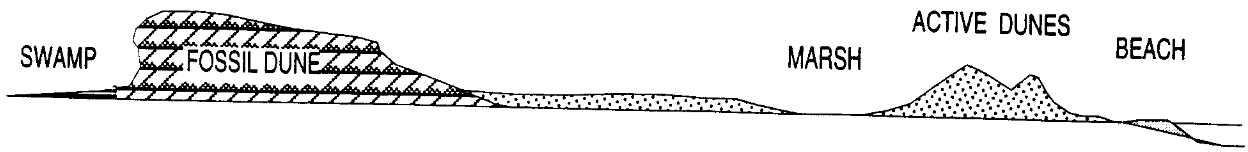
STOP 16: Outcrop of the Miocene Guines and Cojimar Fm at the Abra del Yumuri, Matanzas. The Guines is composed of well-bedded karstified limestones, whereas the Cojimar is composed of the light-colored marls at the right end of the outcrop.

STOP 16: Close-up view of the Pliocene coral reef that was progressively buried by alluvial deposits. Reef is overlain by the marine conglomerates with calcarenaceous matrix.

SOUTH

NORTH

STOP 17: RINCON FRANCES BEACH AND FOSSIL DUNE



Stop 17: Hicacos peninsula, near El Frances. Recent beach complex and late Pleistocene eolianites

To reach this locality you drive from Matanzas to Varadero, take the northern highway in Varadero toward Playa El Frances, and turn to the left to approach the beach from the sandy road.

The Varadero beach is a long, narrow strip of carbonate sands oriented SW-NE, roughly parallel with the direction of the Gulf Stream that impinges on the shores of northwestern Cuba up to the Peninsula of Hicacos. Seawinds are north and northeasterly. Parallel to the peninsula is a wide shallow-water shelf with a huge amount of submarine sands derived from erosion of the fringing coral reef at the edge of the shelf.

The sands are mainly skeletal, because the grains are dominated by particles and small fragments of mollusks shells, corals, fish bones, tests of foraminifera and other tiny animal detritus. The sands originated at the coral reef barrier and drifted coastward as submarine bars that eventually reached the beach.On the beach, the sands are differentiated by grain size due to the combined action of the wind and waves.

On a typical Hicacos peninsula beach, the coarse-grained sands are located at the shoreline, as a thin bar (2-3 m wide) parallel to the coast. These sands reach gravel size and include flat fragments (1-2 cm long) of mollusk shells. In the area just out of the reach of the medium-sized waves, the sands have a mixed grain size and are dominated by medium-sized grains, but layers of different grain size can occur. The mixed character of the grain size in this area of the beach bar is due to various factors. This part of the beach is reached by coarse-grained detritus only during storms. At other times, only the medium-grained detritus is deposited. When the sand is dry, the wind carrys the very fine-grained detritus landward, and as a result, medium size sands dominate the beach bar.

Active dunes are found landward. They are elongated roughly parallel to the seashore and are composed of fine-grained sands, usually well sorted. The more landward the dune, the finer and better sorted the grains are.

Beyond the dune is a marsh or lagoon. Laterally the dune sand can be found as far as the interior of the peninsula. Sand transport occurs during tornadoes, hurricanes and heavy winters (so-called north winds). The southern coast of the peninsula is covered by red and black mangroves.

In the center of the Peninsula de Hicacos are rocky hills, elongated along the axis of the peninsula, and composed of consolidated calcareous sands (fossil dunes). The inclination of the layers in the fossil dunes indicates that the wind at the time of formation of these deposits was from the same direction as it is today. The fossil dune hills reach 5-8 m high and are dissected by erosion and karst.

Stop 18: Coral growing at Playa Coral (Snorkeling)

Return along the road to Matanzas and make a right turn at the sign to Playa Coral.

At Playa Coral an interesting phenomenon can be observed. About 20 years ago sands were imported in order to transform a rocky shore into a beach. The allochthonous sands killed the corals, but the continuous action of the sea removed the sands and the shore recovered to its original state. During the last few years, new corals have begun growing on the dead colonies.

STOP 17: Small hill at Rincon Frances composed of very young eolianites.

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