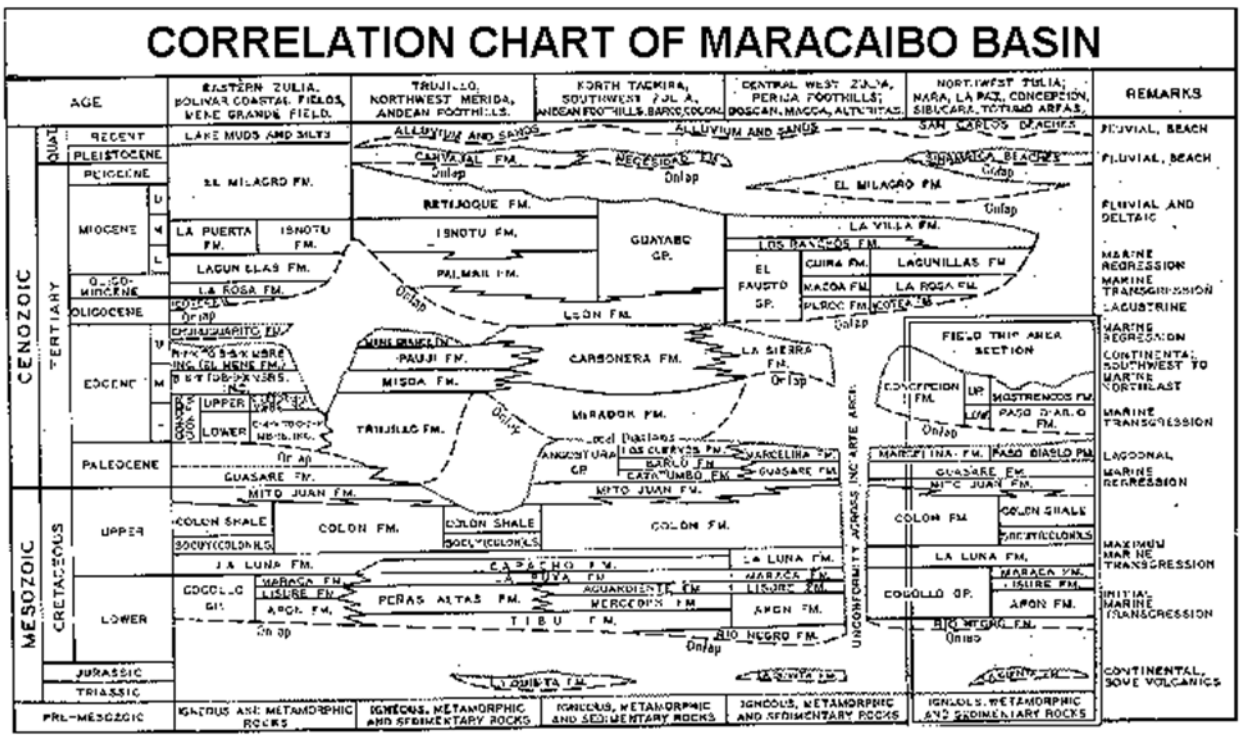
FIELD TRIP TO TOAS, SAN CARLOS AND ZAPARA ISLANDS [1]

April 3, 1960

by Rudolf Blaser, Cía. Shell de Venezuela, and Arthur N. Dusenbury, Jr., Creole Petroleum Corporation



Introduction

This guide book provides the plan and topical outline second field trip of the Sociedad Geológica de Venezuela Occidental. Toas Island is its principal destination and it is scheduled for Sunday, April 3, 1960. The most important sections and localities will be visited, although it should be realized that not everything of interest on this geologically complicated island can be seen in part of one day.

This book may serve in the future for individual or group excursions to Toas Island. If launches are not available, such excursions can proceed by automobile from Maracaibo north to the town of San Rafael de Moján, whence a launch ferry service carries passengers to and from the town of El Toro there are several taxis which can be hired for Bs. 10 per hour.

For the scheduled trip of the Sociedad Geológica de Venezuela Occidental, members and guests will assemble at the Mene Grande Oil Company's dock in Maracaibo in sufficient time to purchase guide books and embark at 7:00 A.M. on Sunday, April 3, 1960. Each participant should wear stout boots, as the limestone terrane is rugged and prickly pear cactus is quite common. It is also advisable to bring a hat along, since shade is very scarce on Toas Island. Geological hammers, pocket magnifying lenses, geological compasses and bottles containing hydrochloric acid should all prove to be of use.

Excursionists should bring their own lunches clearly labeled with their names. Beer and soft drinks will be provided through the courtesy of Schlumberger Surenco S.A. Launches and crews will be supplied by Creole Petroleum Corporation, Compañía Shell de Venezuela, Phillips Petroleum Company, Sun Oil Company and Superior Oil Company of Venezuela.

Access to the docks of the Mene Grande Oil Company, the Instituto Nacional de Canalizaciones and the Compañía Anónima Venezolana de Cementos was granted through the kindness of Mr. Robeert Baldwin, Dr. Bernardo Rodríguez d'Empaire and Sr. Eduardo Pantín Herrera respectively.

Because of the complications of Toas Island geology and the varying details of its interpretation, the authors decided to insert three different maps on the island's areal geology in this guide book. The Compañía Shell de Venezuela has contributed a hitherto unpublished map prepared by J. D. de Jong in January, 1949. The Creole Petroleum Corporation has supplied a hitherto unpublished map based on field work in 1942 and 1943 by A. N. Dusenburym Jr. and J. Más Vall, and revised after additional field work by A. N. Dusenbury, Jr. in October, 1959. It was also additional decided to reproduce the map of Toas published by Emile Rod of the Venezuela Atlantic Refining Company in 1956 (Bull. Amer. Assoc. Petrol. Geol., vol. 40, p. 461, fig. 3). This is a simplification and revision of a 1950 map by Rod and H. Feisted. In addition to the maps, cross sections interpreting the structure of the island were obtained from the last two sources. We thank the companies, individuals and association concerned for permission to publish these maps and cross sections.

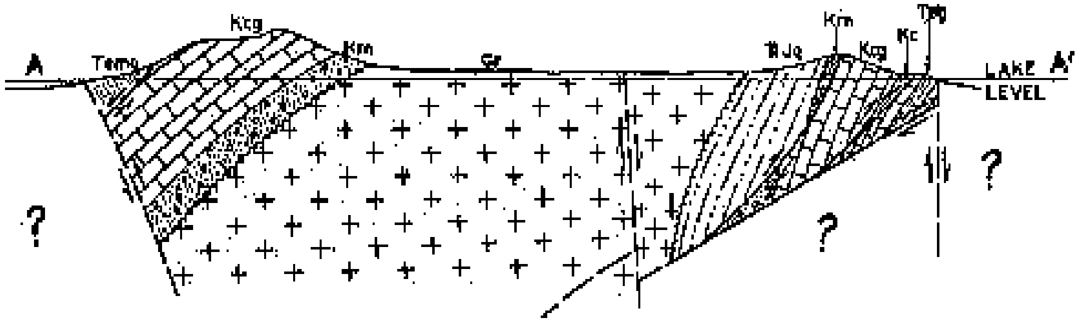
CREOLE PETROLEUM CORPORATION

TOAS ISLAND

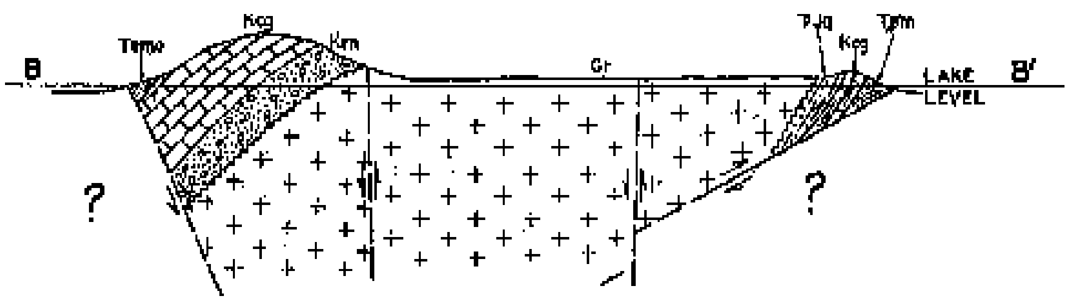
SCALE 1:10.000

0 100 200 300 400 500

METROS



SECTION A-A'



SECTION B-B'

LEGEND

EOCENE	MOSTRENCOS FM.	Temo
PALEOCENE	MARCELINA FM.	Tpm
	GUASARE FM.	Tpg
CRETACEOUS	COLON FM.	Kc
	COGOLLO GR.	Kcg
	RIO NEGRO FM.	Krn
TRIASSIC-JURASSIC	LA QUINTA FM.	TRJq
PRE-TRIASSIC	GRANITE	Gr

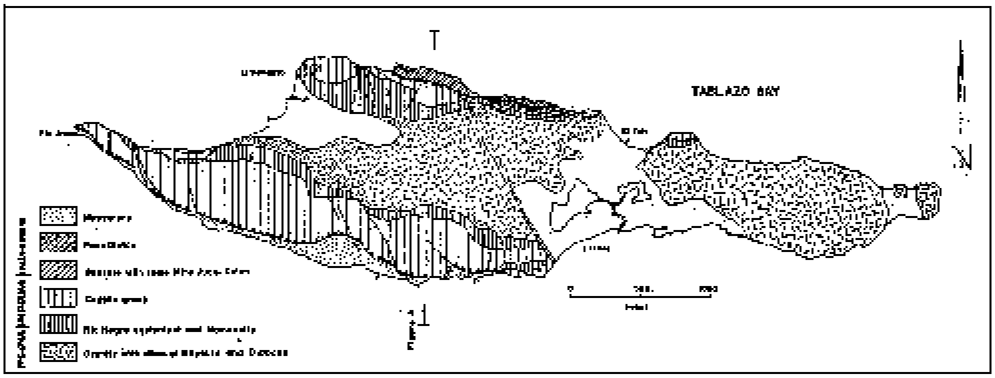


FIG. 3 TOAS ISLAND

FIG. 3 FROM EMILE ROD'S "STRIKE-SLIP FAULTS OF NORTHERN VENEZUELA" (1956, BULL. AMER. ASSOC. PETROL. GEOL., VOL. 40, N° 3, P. 461, FIG. 3).

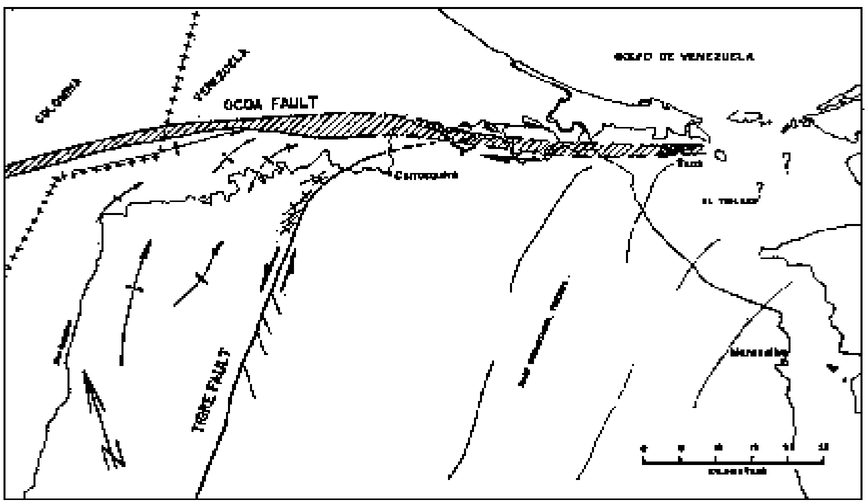


FIG. 2 OCCA FAULT AND RELATED STRUCTURES.

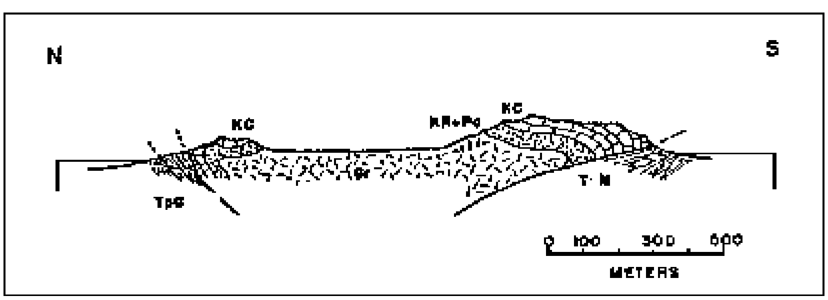
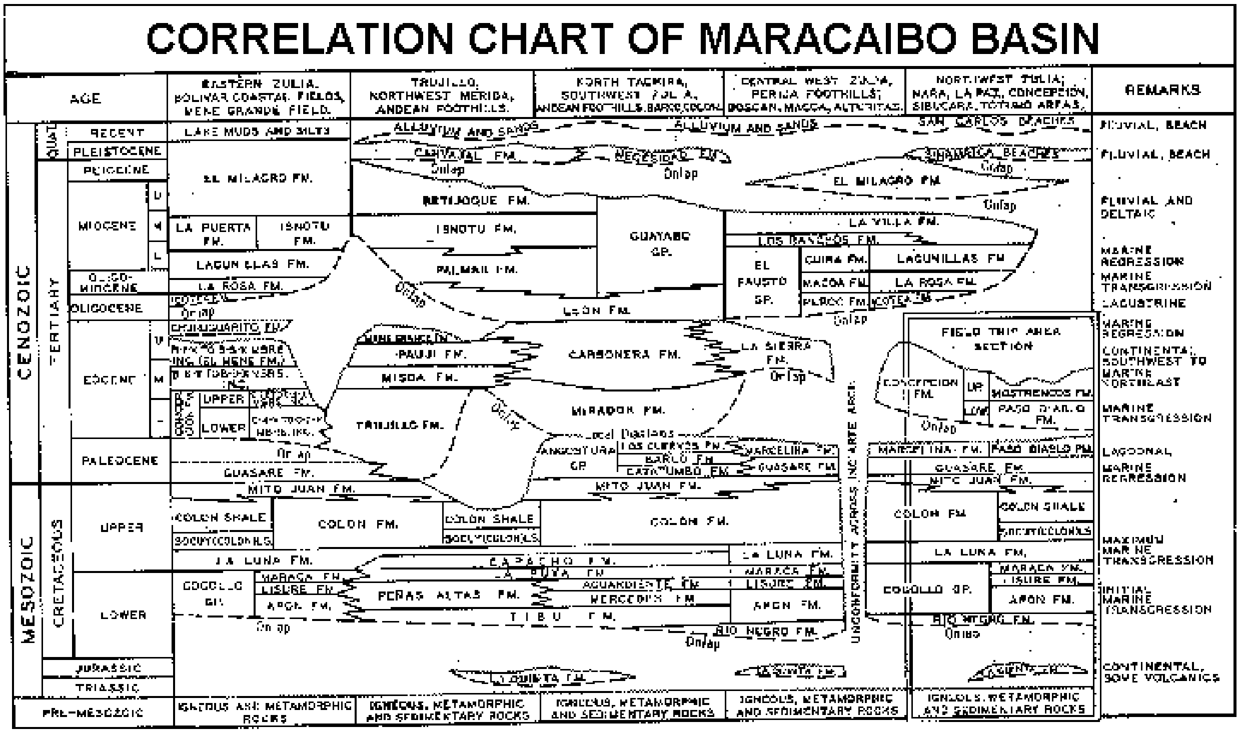


FIG. 4 CROSS SECTION THROUGH TOAS ISLAND. TM= MOSTRENCOS FORMATION. TpG= GUASARE FORMATION. KC= COGOLLO GROUP. KR+Pc= RIO NEGRO FORMATION AND PRE-CRETACEOUS SEDIMENTS. Gr= GRANITE

FIGS. 2 AND 4 FROM EMILE ROD'S "STRIKE-SLIP FAULTS OF NORTHERN VENEZUELA" (1956, BULL. AMER. ASSOC. PETROL. GEOL., VOL. 40, N° 3, P. 459, FIG. 2 AND P. 463, FIG. 4).



It will be noted that the stratigraphical nomenclature varies some what among the three maps referred to above. For the reader's convenience, a table comparing the three systems of nomenclature employed is here made available.

Shell	**Creole**	**Atlantic**
Eocene	Mostrencos	Mostrencos
*Eocene	Marcelina	Paso Diablo
Guasare	Guasare	Guasare
Colón	Colón	Mito Juan-Colón
Cogollo	Cogollo	Cogollo
Río Negro	Río Negro	Río Negro
La Quinta	La Quinta	Mamoncito

We also thank Dr. Alirio Bellizzia, Secretary of the Third Venezuelan Geological Congress, for permission to reproduce three figures from John B. Miller's paper on tectonics in the Sierra de Perijá and adjacent areas of Venezuela and Colombia. Mr. E. A. Doe of Creole has provided assistance in describing the islands, channels and currents of the Lake Maracaibo bar. The Instituto Nacional de Canalizaciones kindly allowed

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us to reproduce three photographs taken during the dredging of the ship channel and the building of the breakwater. Don David Bellosso Rossell and Mr. Jesse J. Howard have supplied historical data concerning the pirate attacks on Maracaibo.

EXCURSION PROGRAM

7:00 A.M. The launches will leave the Mene Grande Oil Company's dock at the Mene Grande de Camp on the store of Lake Maracaibo just north of the Hotel del Lago. Toas Island, some 6 kms. long and 1½ kms. wide, is situated in Tablazo Bay, the northern extension of Lake Maracaibo, about 35kms. to the north of the city of Maracaibo. As soon as the launches leave the dock and get out into the ship channel, the island may be seen on a clear day in rudged profile against the northern horizon. It constitutes the only high land in the islands or along the stores of Tablazo Bay. The Spanish word toas means tow ropes. Politically, Toas Island forms part of the District of Mara. The largest village on the island is El Toro, situated along the store of a small bay on the north coast. At the time of the 1950 census, its population was 688. The inhabitants of Toas Island are mostly fishermen and quarrymen. The economical importance of Toas lies in the fact that its Cretaceous limestone is the nearest source of easily exploitable raw material for the cement and construction industries of the State of Zulia. With the cement manufactured from the limestone of Toas the oil industry cement casing, plugs back and plugs for abandonment, manufactures the concrete piles and caissons that support the derricks that door the lake, and constructs the docks, offices, shops, schools, hospitals and homes for its workers. The housing and road construction industries of all of Zulia employ the limestone of Toas in the forms of both cement and gravel. The great jetty which helps to keep the 37-foot dredged channel across the Lake Maracaibo bar from filling up with sand transported by the longshore currents was built with blocks of limestone from Toas. The new bridge over the narrows connecting Lake Maracaibo with Tablazo Bay will require 206,000 cubic meters of concrete made of limestone from Toas, and the causeway at its eastern end in constructed of blocks of the same material. This large and ever-increasing consumption of Toas Island limestone threatens the gradual destruction of the most imposing part of a geogically unique natural monument. Large scale quarrying operations began only some twenty years ago, but already the topography of the southwest quarter of the island has been greatly altered, as reference to the maps of ten- or twenty-years age will readily demonstrate. As the launches approach the south coast of Toas Island, most of the large quarries will become visible. They are situated in an east west trending belt of light gray brownish gray, massive, thick-bedded limestone belonging to the Apón formation of the Cogollo Group. Identification of the following fossils indicates a Lower Cretaceous (upper Aptian) age and a shallow-water marine environment.

Foraminifera:

Orbitolina texana (Roemer), lower Aptian to middle Albian

Quinqueloculina sp.

Spiroloculina sp.

Triloculina sp.

Pelecypoda (or Lamellibranchia):

Amphitriscoelus waringi Harris and Hodson, Aptian

Exogyra boussingaultii d'Orbigny, Hauterivian to Aptian

Ostrea spp.

Requienia sp., fragment

Ammonoidea:

Cheloniceras sp., Aptian

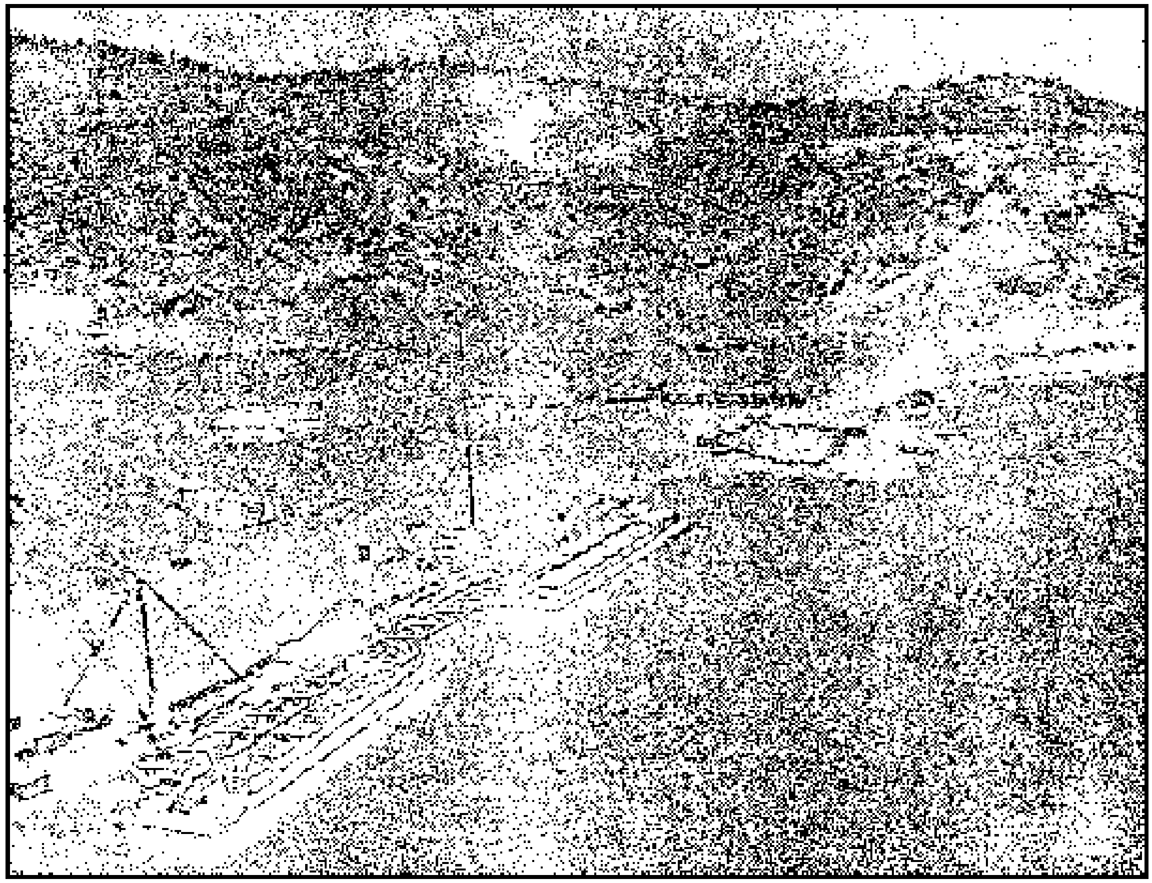
Parahoplites sp., upper Aptian

Most of the Albian portion of the Cogollo group appears to be missing at the fault contact with the Eocene, although Rod found a thin sliver of beds containing the microfauna of the Albian Lisure Formation north of that contact at the southeast end of Cerro Caribe. The zone of ***Choffatella decipiens*** Schlumberger, which occurs in the Tibú Member of the Apón Formation at the base of the Cogollo in the Sierra de Perijá, has not yet been encountered on Toas Island and may never have been deposited. The bulk of the Cogollo of Toas Island seems to be paleontologically correlative which the middle member of the Apón Formation of our previous field trip to the Río Negro section. At Punta Arena (Punta La Salinita) on the west end of the island is the quarry which used to belong to the Caribbean Petroleum Company, now Compañía Shell de Venezuela. In 1942-43, this was an excellent locality for collecting ***Orbitolina texana*** (Roemer), but subsequent excavation has completely eliminated these large foraminifera. The quarry is now owned and operated by the Martin Engineering Company. Half a kilometer to the east lies the quarry of the Raymond Concrete Pile Company. Seven hundred meters farther east is a second quarry of the Martin Engineering Company at Los Buchones. Another 1200 meters eastward the quarries of the Compañía Anónima Venezolana de Cementos may be observed at and east of Taparo. They formerly were the property of Juan E. París.

The hills formed by the Apón limestone in the southwest part of the island are the highest in all of Toas. From west to east, they are named Cerro Caribe (originally 50 m.), Cerro Guano (50 m.), Cerro Buchones (100 m.), Cerro Picacho (80 m.), Cerro Vigía (110 m.) and Cerro El Hato (50 m.). On the top of Cerro Vigía, the highest point on Toas Island, stand the twin towers of the station that relays television programs from Caracas to Maracaibo.

8:30 A.M. The launches will tie up to the dock of the Compañía Anónima Venezolana de Cementos at Taparo on the south coast of Toas Island and the party will go ashore. The taparo (***Crescentia cucurbitina***) is a tree with yellow flowers and fruit three inches long having hard brittle hulls used as containers. ***Crescentia cujete***, the calabash tree, is a near relative. Walk by the office building of the quarry on its eastern side and

Stop 1 Follow the small path which leads in a northwesterly direction to the quarry where the Eocene shales are exploited as one of the raw materials for the manufacture of cement. The Eocene section consists here mainly of gray blue and greenish shales with thin bands of intercalated sandstones. The shales often contain concretions of iron oxides, some carbonaceous matter and folia of selenite. Black shales are less abundant. The Eocene shales are in fault contact with limestones of the Cogollo Group. Looking eastward towards the opposite side of the quarry, one can see the fault surface on the Apón limestone. The striations on the fault surface are horizontal or subhorizontal and indicate the transcurrent character of this northwest-southeast trending fault. The northern limit of the Eocene complex is also bounded by a fault, one which trend approximately east and west. The Eocene shales dip steeply northward in contrast to more gently southward of southwestward dipping Cretaceous beds of the southern flank of the Toas structure. The Eocene sequence is not overturned, since the succession of microfloras is normal rather than reversed. Both Creole and Atlantic correlate this predominantly shale section with some part of the Eocene Mostrencos Formation. Before the Compañía de Cementos began its operations here, Taparo was the site of a local pottery and brickyard with several kilns and a small quarry in the Eocene shales east of Taparo. The shales in this area have been entirely stripped off and the underlying Cogollo limestones are now being quarried.



QUARRY AND LOADING DOCK OF THE INSTITUTO NACIONAL DE CANALIZACIONES ABOUT 300 METERS WEST OF CARRIZAL ON THE WEST END OF TOAS ISLAND. THE LIMESTONE QUARRIED HERE WAS USED TO BUILD THE BREAKWATER THAT PROTECTS THE SEAWARD END OF THE NAVEGATION CHANNEL.

9:00 A.M. Return to dock and board the launches, which will run westward along the south shore of the island past the other three previously mentioned quarries, and, rounding Punta Arenas, the western termination of Toas Island, will head for the dock of the quarry operated by the Instituto Nacional de Canalizaciones and situated only three hundred meters west of the little fishing village of Carrizal. Half way between Punta Arenas and the dock, on what was formerly the northeast slope of Cerro Caribe, is the locality from which the ammonites ***Cheloniceras*** and ***Parahoplites*** were obtained. This locality has also been destroyed by the encroachment of the quarries.

9:30 A.M. The launches will tie up to the dock of the Instituto Nacional de Canalizaciones and the party will land. Lunches will be left aboard. As soon as the party goes ashore, the launches will continue their way around the north side of the island to the public dock at El Toro. The field trip party will walk the 300 meters to Carrizal and another 300 meters beyond it along the road to El Toro. Here the road swings to the left and a good outcrop of basement granite can be seen just off the road on the right.

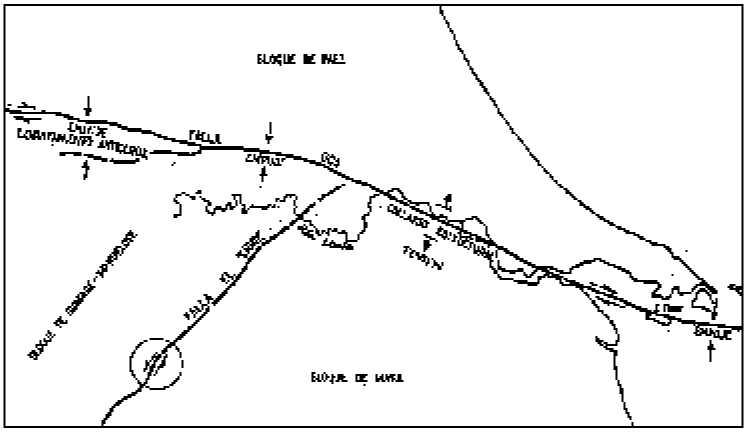
This walk will provide the first opportunity to observe the vegetation of Toas Island, which is typical of the arid areas along the Caribbean coast of Venezuela. The scanty xerophytic flora consists almost entirely of the prickly pear cactus or tuna (***Opuntia caracasana***), the organ cactus or cardón (***Lemaireocereus griseus***) and the thorn tree or cují (***Prosopis juliflora***). A few coconut palms (***Cocos nucifera***) grow along the shore. Along the Toas beaches the most abundant shell by far is that of the brackish-water pelecypod ***Cyrena arctata*** Deshayes, a species that was originally described from Lake Maracaibo and may perhaps be restricted to it. A few shells of the mangrove oyster ***Crassostrea rhizophorae*** (Guilding) and the green mussel ***Mytilus viridis*** Linné can occasionally be found, but the shells of the gastropods ***Purpura patula*** (Linné) and ***Thais (Thaisella) coronata*** (Lamarck) are quite rare. Barnacles are frequently seen attached to rocks at the shore line.

9:45 A.M. Stop at granite basement. The stratigraphically lowest and Stop 2 apparently the oldest formation on Toas Island is a massive, rather coarse-grained granite. When fresh, it looks pink because of the orthoclase, and it is dotted with dark crystals of biotite in the form of thick bundles of mica flakes. On weathering, which it does rather readily, the granite changes in color from pink to gray and the biotite becomes a golden brown. The rock becomes soft and crumbly and is easily eroded. For this reason, the granite core of the western half of Toas Island forms a topographically low flat valley between ridges of Apón limestone. In the smaller eastern part of the island, which is joined to the western part by Recent beach sands and lagoonal deposits at and south of El Toro, the granite has been intruded by dikes of rhyolite, which are generally more resistant to erosion and form the cores of low hills, the highest of which, Cerro La Cruz, rises about 50 meters above the level of the lake. Half way between El Toro and Cardón is an area where basic rocks have intruded the granite and have in turn been intruded by rhyolite dikes. The contact between the granite basement and the overlying La Quinta Formation is usually hidden by talus but is almost certainly an erosional one. No contact metamorphism and no apophyses of the granite in the La Quinta have ever been observed. Pebbles, cobbles and even small boulders of a biotite granite similar in composition to that of the basement occur in conglomerate bed of the La Quinta on the north side of the island in the saddle between Cerro Blanco and Cerro Corozal.

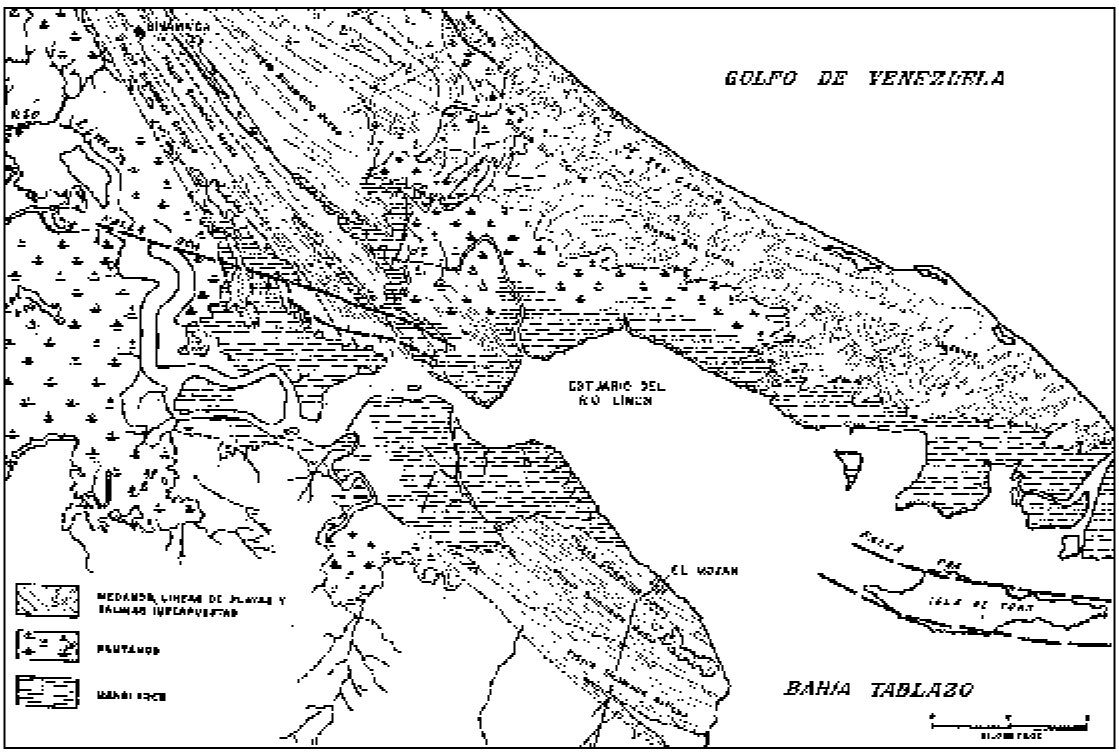
Stop 3 Return along the road to Carrizal, where a fairly good section of the La Quinta Formation can be studied in the gullies south of the village (see sketch). A mass of dark violet to brownish red, weathered rocks lies at the base of the La Quinta section in the gully above the masonry culvert and to the east of the gully. Thin sections of specimens collected from this locality indicate that at least part of this body consists of pyroclastic rocks. Tuffs of intermediate composition (probably dacitic to andesitic) have been determined by Shell petrographers. About 10 meters of whitish to greenish coarse arkosic sandstones interbedded with brownish red silty shales weathering to clays follow the pyroclastics after a short-covered interval. A second short covered interval separates this 10-meter sequence that is quite similar except that the sandstones are pink and may include a few small pebbles. A bed dark violet red rock about 40 centimeters thick, probably tuff like similar mass below, caps the second sandstone and shale sequence. This bed is overlain by 8 meters of brownish red shale that is weathered to clay, in interbedded with a few thin sandstones and is partly covered. Several feet of whitish to greenish siltstone and fine sandstone occur at the top of the formation. The La Quinta of Toas Island appears to be completely unfossiliferous and to consist probably of continental deposits. At its type locality in Táchira the La Quinta is considered to be Upper Triassic to Jurassic in age on the bases of stratigraphic position and fragmentary remains of a primitive species of the ganoid fish ***Lepidotus*** found in coprolites of some unknown predator. ***Lepidotus*** ranges from the Upper Triassic to the Lower Cretaceous and has been encountered in both fresh-water and marine sediments. The contact of the La Quinta with the overlying basal Cretaceous Río Negro formation is unconformable. Just to the west of El Hato on the south shore the Río Negro may be seen lying directly on the granite basement with the La Quinta missing. In fact, the only known La Quinta south of the granite is in the Carrizal area. Here the base of the Río Negro is probably marked by a stratum of course to conglomeratic sandstone with grains and pebbles reworked from the La Quinta red beds. This sandstone is exposed near the heads of the gullies. The rest of the formation is locally covered by soil and talus, but occasional blocks of a fairly clean, whitish to cream-colored arkosic sandstone are scattered about amid the more numerous and conspicuous blocks and boulders of the more resistant Apón limestone. Cross-bedding is not uncommon in the Río Negro. The formation is unfosiliferous on Toas Island, as it is in most of western Venezuela. It appears to cross time lines and to accompany the gradual transgression of the Cretaceous seas. It is believed that Toas Island was in a topographically high area at the beginning of the Cretaceous and that consequently the Río Negro is here not only much thinner but also considerably younger than at its type locality in the Machiques trough. The basal Cretaceous Río Negro sandstones are overlain conformably by the Apón limestones of the Cogollo group. At Carrizal these limestones form the scarp at the top of the hill south of the houses. The lowest limestones are platy and interbedded with sandstones and a few dolomitic layers. Shallow-water marine pelecypods, including the genera ***Ostrea*** and ***Exogyra,*** are visible in cross sections but are difficult to extract, and specimens well enough preserved for specific identification have not yet been found. This basal sequence is overlain by dense to microcrystalline, gray to brownish gray, thick-bedded limestone with sometimes a few thin intercalations of gray shale or yellowish-brown marl. Nowhere on Toas Island has a complete section of the Apón been discovered. The maximum thickness of the portion preserved is about 75 meters in the southern ridge and much less than that in the northern ridge, because faults have out so much of the normal section. The fossils previously listed indicate that at least part of the section is upper Aptian in age and correlative with the Middle Apón of the type section. However, between the locality where the diagnostic Upper Aptian ammonites were found and the conformable base of the formation there should be room for some Lower Aptian beds. At Carrizal and elsewhere along the north slope of the southern ridge the dips average about 25° and vary from south to southwest in the Mesozoic sedimentary section. On the south slope the dips range from a maximum of about 62° at the west end of the island to a minimum of 20° near Manzanillo. Most geologists now seem to agree that Toas Island should be regarded as an elongated upthrown fault block or wedge which, at least superficially, was compressed to from an anticlinal structure. The section at Carrizal in on south flank of the deeply eroded anticline. In addition to the east-west major faults that bound the Toas block to the north and south, there are many minor cross faults. On the southern limb of the anticline most of these cross faults trend northwest and southeast. In the subsidiary blocks thus formed, the dips may be south, south-southwest or southwest. In the block south of Carrizal the dip is to the southwest.

10:30 A.M. Walk from Carrizal across the alluvial plain, which occupies the center of the valley eroded in the granite, to Cerro Blanco, a hill 50 meters high, which forms the west end of the northern ridge. Because of a read-bordered marshy inlet it is impossible to follow the shore by the most direct route. Incidentally, the name Carrizal is a Spanish word meaning an area where reeds grow. A short detour inland must be made, following at first the road from Carrizal to El Toro for almost a kilometer. Then cross the dry wash and turn black westward to the coast at the southwestern slope of Cerro Blanco. As you near the coast, you will see outcrops of the La Quinta red beds on your right.

11:00 A.M. The southern and eastern slopes of Cerro Blanco display. Stop 4: outcrops of the La quinta red beds. At the bottom of the southwest slope the dark red shales contain dikes of purple diabase basalt composed 50% of the feldspar labradorite, 35% of the pyroxene augite and 15% of magnetite, according to a petrographic study for Creole by José Más Vall. The term diabase basalt is used for rocks that look like basalt to the naked eye but reveal diabasic texture in thin section under the petrographic microscope. These dikes are cut by small veins if granite pegmatite composed of moderately large grains of white quartz and pink orthoclase. Still later, joints were formed and the fissures were filled by calcite or by clay, principally the latter. More diabase basalt dikes may be observed at the foot of the west slope of the hill behind the houses that occupy the narrow strip of shore. There the pegmatite veins are absent. On the west slope of Cerro Blanco, the Río Negro basal Cretaceous sandstone is found in contact with the intruded La Quinta red beds and with the Cogollo limestones. Dips in the Cogollo range from 25 to 55 degrees to the southwest and average about 45 degrees. It will be noted that Shell has mapped the Cretaceous at Cerro Blanco as a faulted normal sequence, while Creole has mapped the same beds as a faulted overturned sequence. Rod (1956, Bull. Amer. Assoc. Petrol. Geol., vol. 40, n° 3, p. 463, fig. 3) also has interpreted the section on Cerro Blanco as overturned but has located his faults quite differently. If the sequence on Cerro Blanco is normal, then the boundary between the Cretaceous and the La Quinta to the south is a fault contact, but, if the Cretaceous formations and overturned, the usual unconformable relationship between the La Quinta and overlying Río Negro should occur.



MILLER'S FIG. 13. "DIAGRAM TO RELATE THE MOVEMENTS ON THE EL TIGRE AND OCA FAULTS TO THE TECTONIC MODEL. THE SKETCH INDICATES HOW THE RIGHT LATERAL MOVEMENT ON THE OCA FAULT GIVES TO A STRUCTURAL COMPRESSION ALONG THE FAULT WHERE ITS COURSE IS NEARLY EAST AND PRODUCES A STRUCTURAL COLLAPSE LATERAL MOVEMENT ON THE EL TIGRE FAULT (AS IS INDICATED IN THE CIRCLE) DOES NOT HARMONIZE IN THIS MODEL. SUCH A MOVEMENT OUGHT NORMALLY TO MOVE THE MARA BLOCK TOWARD THE NORTHWEST WITH RESPECT TO THE GUASARE - MANUELOTE AND PAEZ BLOCKS, IN CONTRADICTION TO THE OBSERVED FACTS".



MILLER'S FIG. 14. "MAP THAT SOHWS THE ABANDONED COAST LINES IN THE NEIGHBORHOOD OF SINAMAICA, AND THEIR DISTURBANCE DUE TO THE OCA FAULT. SOME INDIVIDUAL BEACH LINES CAN BE FOLLOWED WITHOUT INTERRUPTION ACROSS THE LINES OF DISTURBANCE. THERE EXISTS A CLEAR VERTICAL DISPLACEMENT, BUT THERE IS NO HORIZONTAL MOVEMENT OF SIGNIFICANCE WITH THE POSSIBLE EXCEPTION IN THE OLDER SINAMAICA EPOCH".

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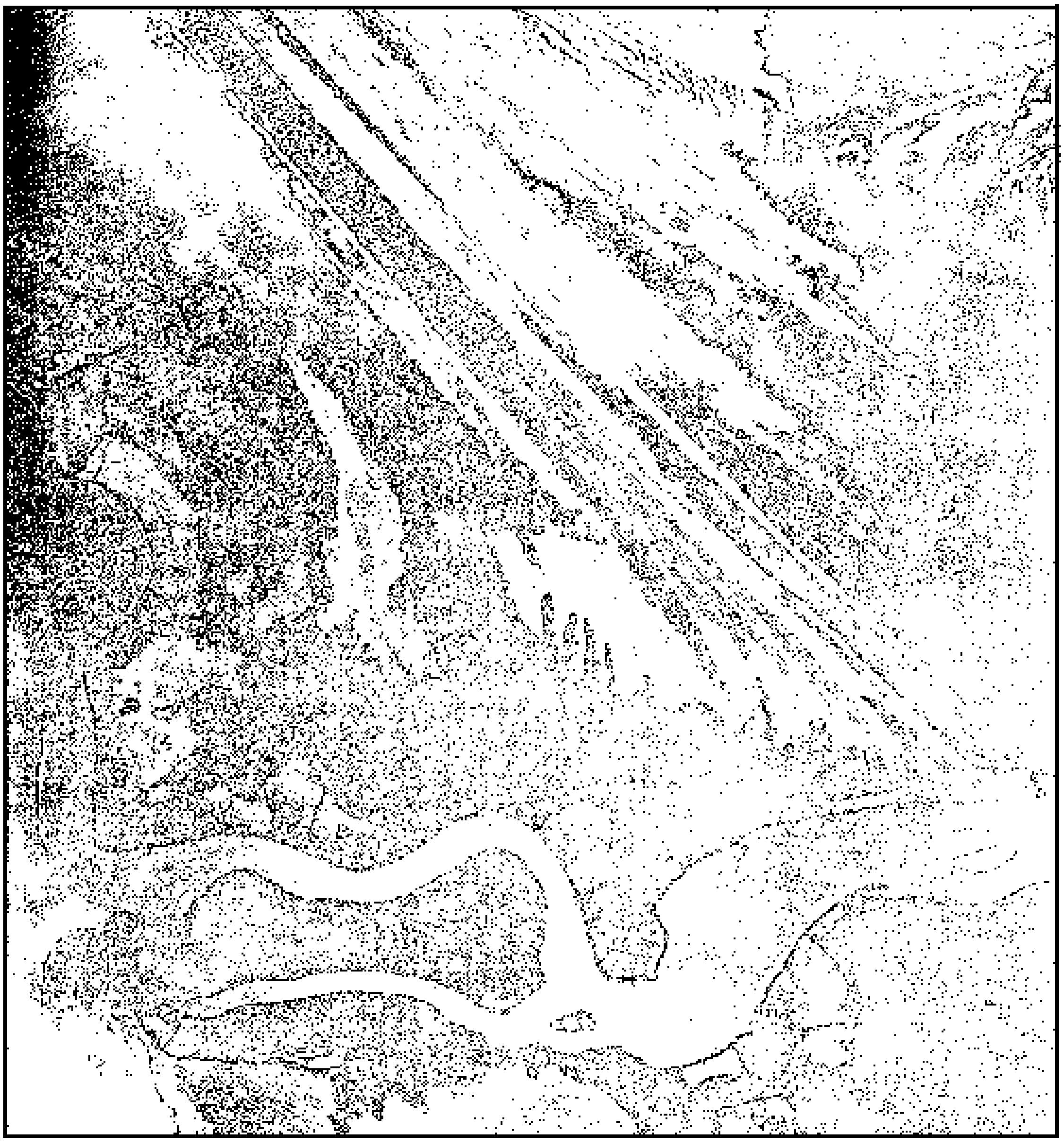
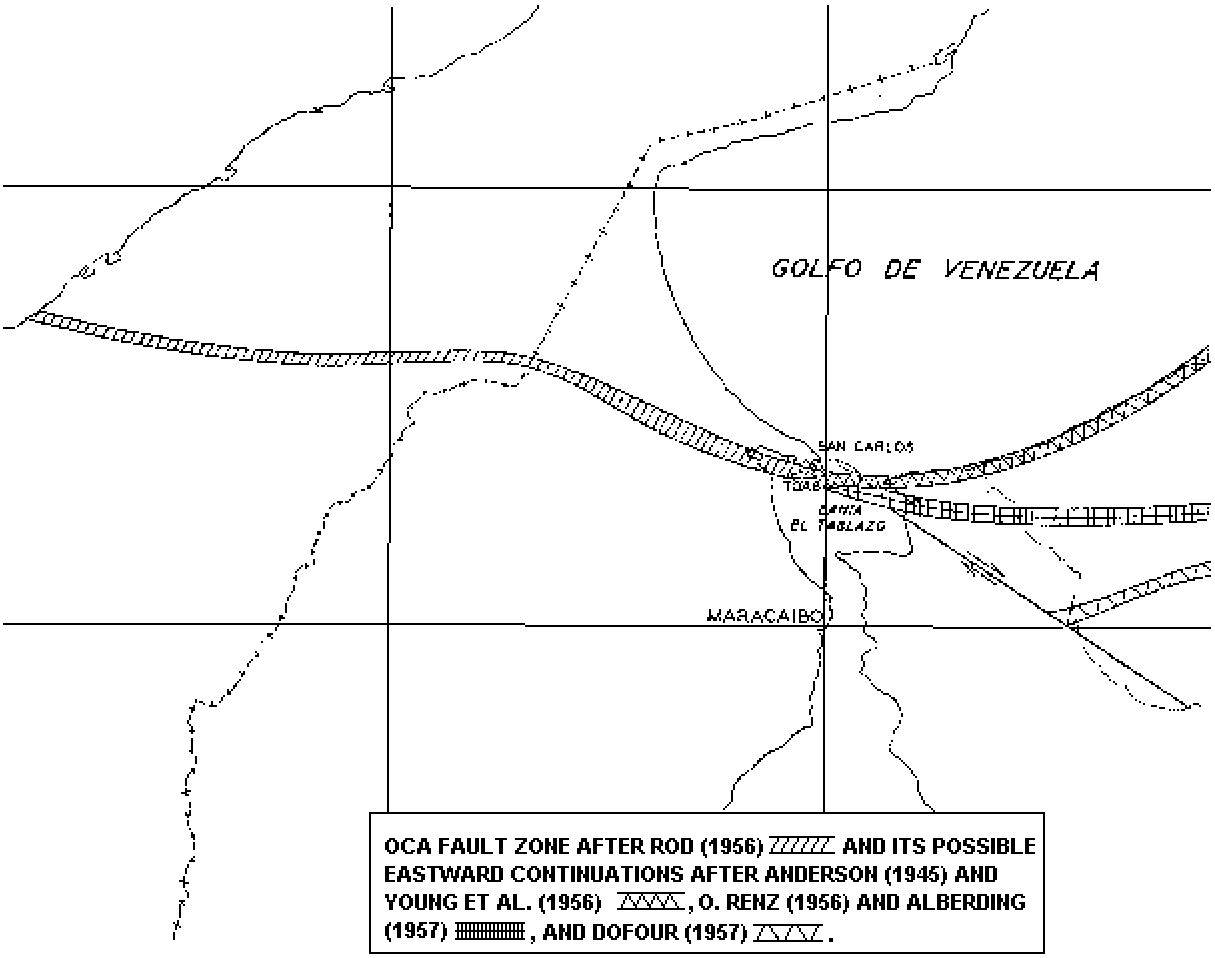
11:30 A.M. Proceed to the summit of Cerro Blanco for a view of an interesting panorama. To the west across the northwest angle of Tablazo Bay lie the houses of San Rafael del Moján, often called San Rafael or El Moján for short. This town of 3,347 people, according to the census of 1950, is the capital of the District of Mara. Moján is an Indian word meaning witch doctor or shaman and was probably the original name of the village before the Spaniards arrived. The Spaniards renamed it San Rafael and the two names have been combined according to custom in order to distinguish this particular San Rafael from others of the same name. As mentioned before, launches, running about once an hour during the daytime, ferry passengers back and forth between San Rafael del Moján and El Toro, the principal village of Toas Island. Punta Reina is the name of the headland 3 kilometers southeast of El Moján, and 4 kilometers northwest of El Moján Punta Cabecita can be seen at the mouth of the Río LImón. The Limón is a large river formed by the conjunction of the Río Socuy and the Río Guasare about two kilometers west of Carrasquero. It is the boundary between the District of Mara and the District of Páez throughout its length. From its mouth the boundary turns north up the Caño Paijana, which separates the island of San Carlos from the mainland. On the horizon behind El Moján, The Montes de Oca, which form the northern end of the Sierra de Perijá, are visible on a clear day. The Montes de Oca rise to an altitude of about 3,500 feet and continue the northeasterly trend of the somewhat higher Serranía de Valledupar, from which they are separated by a distinct saddle. They extend for a length of about 50 kms. to the northeast and then at a second saddle swing eastward for another 25 kms. The eastward swing, called the Fila de Majuyura, was explained by John B. Miller in a paper given last year before the Third Venezuelan Geological Congress (see his fig. 13) as an anticlinal horst whitin a fault zone, the main fault extending in an east-west direction and bounding the horst on the north. The similarity of this structure to the one at Toas Island seems apparent. Both the fault zone and the main fault are generally known as the Oca fault, misspelled "Ocoa" by the originator of the name, F. A. Sutton (1946, Bull. Amer. Assoc. Petrol. Geol., vol. 30, n° 10, p. 1718-1719), and by Rod (1956, loc. cit., p. 459-463), first correctly spelled by W. H. Bucher (1952, Geol. Soc. Amer., Mem. 49, p. 8). A synonym of the name Oca fault is the name Páez fault zone, first published by J. E. Smith (1951, Third World Petroleum Congress, Section 1, The Hague, p. 64, figs. 1, 2). Dufour (1957, Geol. Rundschau, vol. 45, n° 3, p. 765) called it "the Páez or Oca fault". In order to clarify the confusing terminology and render it more precise we propose that the junior synonyms Páez fault zone and Páez fault, and the erroneous spelling Ocoa fault be suppressed, that the name Oca fault be restricted to the major fault which runs along the northern foot of the Montes de Oca near the Venezuelan-Colombian boundary and that this name be retained only as far as the direct continuation of this specific fault can be ascertained. Faults which run parallel or subparallel to this fault should be given different names, but, together with the Oca fault, they may be grouped under the term Oca fault zone. This latter term should be restricted to only those faults not more than ten kilometers apart from the Oca fault on either side. From its type locality at the Montes de Oca fault zone extends westward across the based of the Guajira Península to the Caribbean coast of Colombia, along which it may continue westward, forming the northern boundary of the triangular Santa Marta massif. From the Montes de Oca the Oca fault zone extends east-southeast to the Río Limón about seven kilometers north of Carrasquero, according to Rod's Figure 2, and continues in this direction through the Laguna de Sinamaica to the mouth of the Río Limón. The river does not follow the fault zone but winds back and forth across it and then empties into Tablazo Bay. The published literature shows differences in opinion on the course of the Oca fault between the Laguna de Sinamaica and the mouth of the Río Limón. Smith (1951, loc. cit., figs. 1, 2) depicts his "Páez fault zone" as only about a kilometer in width and situated midway between El M has hisoján and the south bank of the Limón. Rod (1956, loc. cit., p. 459, fig. 2) has his "Ocoa fault" drawn as a fault zone about two kilometers wide with its north edge at the north bank of the mouth of the Limón and its south edge a kilometer south of the south bank. An air photograph of the area clearly indicates recent vertical movement along a fault running east-southeast across the Pleistocene Sinamaica beaches and disappearing in the mangrove swamps more than a kilometer north of the mouth of the Río Limón. It is this fault which Miller (Fig. 14) has termed the Oca fault, and he also shows a somewhat more dubious unnamed fault subparallel to the Oca fault about a kilometer to the south between the Oca fault and the north bank of the Limón. The current consensus of informed opinion is that Miller has correctly picked the true Oca fault and that Smith's "Páez fault zone" locally consists of a single subparallel fault distinct from the Oca fault itself but part of the Oca fault zone. The Shell geologists have renamed this fault the north Moján fault. The question that at once comes to mind is what relationship these mainland faults may have with those on Toas Island. It is interesting to note what happens when the traces of the mainland faults, as published in the literature, are prolonged eastward whit out deviation from their known courses. The true Oca fault prolongation would approximately follow the southern shore of San Carlos Island and the North Moján fault prolongation would tie into the east-west faults on the north side of Toas Island. It thus appears quite probable that, although the Toas Island block undoubtedly forms part of the Oca fault zone, the main Oca fault may pass well to the north of it. What becomes of the Oca fault zone east of Toas Island is a question that has elicited many diverse answers. J. L. Anderson (1945, Bull. Amer. Assoc. Petrol. Geol., vol. 29, n° 8, p. 1079, fig. 8) and Young, Bellizzia, H. Renz, F. Johnson, Robie and Más Vall (1956, Bol. Geol., Pub. Esp. 2, Ministerio de Minas e Hidrocarburos, Caracas, p. 21-28, figs. 6-12) agree in continuing the fault zone northeastward along the rather straight coast of Falcón. According to the latter publication, movement along the main Oca fault zone began in the Paleocene, but movement along its continuation on the shore of Falcón did not begin until the orogenesis at the end of the Eocene. No evidence is provided to substantiate these hypotheses. Sutton (1946, loc. cit., p. 1718, fig. 7) also continues the "Ocoa" fault zone eastward along the coast, but only for a short distance to the Zulia-Falcón boundary, where he ends it abruptly for no stated reason. Miller, Edwards, Wolcott, Anisgard, Martin and Anderegg (1958, Habitat of Oil, Amer. Assoc. Petrol. Geol., symposium, p. 613, 615) swing the eastward continuation of the Oca fault zone somewhat south of the coast line approximately in the vicinity of the village of Quisiro and, like Sutton, end it abruptly at the Zulia-Falcón boundary (Fig. 6). However, on page 615 they state: "Eastward, the fault belt probably merges with the north limb of the Falcón structural uplift". O. Renz (1956, "Cretaceous in western Venezuela and the Guajira (Colombia)", Proc. 20th Internat. Geol. Cong., Mexico City, fig. 3) and Alberding (1957, Bull. Geol. Soc. Amer., vol. 68, p. 790, pl. 1) both show an inferred continuation of the Oca fault zone extending almost due east half way across the State of Falcón. Rod (1956, loc. cit., p. 459, fig. 2) terminates the "Ocoa" fault zone abruptly with a pair of question marks immediately east of Toas Island. On p. 462-463 he asserts: "East of Toas Island the Ocoa fault loses its individuality and is resolved in several en échelon faults, the eastward continuation of which is not clear. A branch fault very likely crosses the folded mountains of Falcón and is again replaced farther east by the stike-slip fault system of the Caribbean Mountains". Dufour (1957, loc. cit., p. 761, fig. 1; p. 771, fig. 4) indicates a southeastward offset of the Oca fault zone by a single cross fault, with his fig. 4 showing a greater distance of offset than his fig. 1. Although he makes no mention of it the fault zone bounded by the El Mene de Mauroa fault on the south and the La Cumbre fault on the north falls within the range between his two figures, and he may have intended to propose the theory that the El Mene de Mauroa fault is the dislocated continuation of the Oca fault. On the other hand, Alberding and Young (1958, Asoc. Venezolana Geol. Min. Pet., Bol. Inform., Caracas, vol. 1, n° 1, p. 13, fig. 17) postulate a N. 30° W. dislocation which would offset the Oca fault an unspecified distance by means of two parallel cross faults and place its eastward continuation somewhere in the Gulf of Venezuela. It seems obvious that there has been both vertical and longitudinal displacement along the Oca fault zone. The upthrust of the Toas Island block is evident. At the north end of the Montes de Oca, it seems clear that the south side of the Oca fault is upthrown and the north side relatively downthrown. The eastward curvature of the Tigre fault and of the anticlinal axes in the eastern foothills of the Montes de Oca as they approach the Oca fault zone (Rod, 1956, fig. 2) can best be explained as drag resulting from right lateral displacement along the type of fault variously known as strike-slip, transcurrent or wrench. Dofour (1957, p. 765) suggests that this displacement may be of the order of 90 kilometers on the theory that the Central Cordillera, the Santa Marta block and the Guajira Península originally formed a single elongate massif. However, oven if this theory were correct, it is not necessary to assume that the entire displacement "of 90 kilometers" took place along the Oca} fault zone. The authors believe that the Oca fault zone includes only a few of the subparallel, potentially transcurrent, east-west faults in the region between the Guajira massif and the Maracaibo platform, and that the total theoretical lateral displacement should be shared among all or most of these many different faults. Miller has recently described the latest movement at true Oca fault between the Laguna de Sinamaica and the mouth of the Río Limón in southeastern Distrito Páez. Here the fault runs east-southeast, cutting through Quaternary beach deposits termed the older, middle and younger Sinamaica beaches. Still younger beach deposits called the San Carlos beaches lie to the northeast along the shore of the Gulf of Venezuela. The trace of the fault can be clearly seen in an air photograph, crossing the older and middle Sinamaica beaches, but the younger Sinamaica beaches mostly disappear beneath the mangrove swamps on the north bank of the Limón, and the fault trace is thus almost entirely concealed. The north side has been downthrown at least one meter where the fault crosses the middle Sinamaica beaches, with the result that the beach ridges increase both in width and height immediately south of the fault. Where the fault crosses the older Sinamaica beaches, a large area of sand flats south of the fault's contrasts with an area of mangrove swamp north of it. According to Miller, there is no lateral displacement visible, but it is unlikely that a small lateral displacement would show up distinctly on the air photograph, which is on the scale of 1:40.000. Looking from Cerro Blanco toward the northwest and north, one sees San Carlos Island across the waters of the northwestern part of Tablazo Bay. This island is separated from the mainland of the Sinamaica area by a narrow natural channel, the Caño Paijana, which, as previously mentioned, forms the boundary between Distrito Páez on the mainland and Distrito Mara on San Carlos. Because the Caño Paijana is so narrow, the island of San Carlos somewhat resembles a península extending to the southeast and separating the waters of the west half of Tablazo Bay from those of the Gulf of Venezuela. There are no roads or bridges across the swamp-bordered Caño Paijana and all transport to and from San Carlos Island is by boat. The Quaternary deposits which cover the flat terrane around the towns of El Moján and Sinamaica and on San Carlos Island consists mainly of a series of beach deposits. The older of these beaches have been called the Sinamaica beaches by Miller and are presumably Pleistocene in age. On aerial photographs a great number of parallel to subparallel, rather narrow, linear beach ridges can be observed in the vicinity of the town Sinamaica, all of them striking in an approximately northwest-southeast direction. The middle ridges are by far the most prominent, while the older island and younger seaward ridges are not so prominent and are separated by wide areas of sand flats. This has caused Miller to classify them as the older, middle and younger Sinamaica beaches. Some eight to ten kilometers southeast of Sinamaica these beach ridges are interrupted by the broad mangrove swamps that border both banks of the Río Limón near its mouth. Their southeasterly continuation is encountered in the vicinity of El Moján, which is situated amid the younger Sinamaica beaches. The Sinamaica beach ridges are the traces of former shore lines and were formed one after another by seaward accretion to the land area. They may have originated as barrier islands separated from the mainland to the southwest by lagoons, which were later almost completely filled up by the delta deposits of the Río Limón. The large quantities of sand which were deposited in all of these Quaternary beaches were transported by means of longshore currents flowing north-westward. The younger Quaternary beach deposits, probably Holocene in age, are quite well developed on San Carlos Island and cover the northern two-third of it. For this reason, they have been named the San Carlos beaches Miller. They continue in a slightly narrower belt along the mainland coast northwestward past Sinamaica. Strangely enough, the younger San Carlos beaches are not as well preserved as the older Sinamaica beaches. On the east end of San Carlos Island these younger beach ridges have been truncated by marine erosion. Everywhere on the island they are in the process of destruction by wind erosion and of obliteration by linear sand dunes, which are oriented parallel to the direction of the prevailing northeast trade winds. The Sinamaica beach ridges, partly covered by vegetation and located farther back from the exposed coast, are very much less affected by the trade winds, most of the erosion being recent and confined to the younger Sinamaica beaches, where is the least vegetation cover. One possible explanation might be that the trade-wind climatic zone lay farther to the south during the Pleistocene glaciation and the deposition of the Sinamaica beach ridges, and that it did not move north to its present position until post-glacial time and the period of the deposition of the San Carlos beach ridges. The southern third of San Carlos Island consists of dense mangrove swamps, plainly seen from Cerro Blanco. The Castillo and village of San Carlos lie together on the eastern tip of the island, hidden from the observer on Cerro Blanco by another much smaller mangrove-covered island variously known as the Isla del Diablo or the Isla de Pájaros. This smaller island is separated from San Carlos by a channel that is navigable to small boats, although quite narrow, and is called the Caño San Carlos. From Cerro Blanco to the east extends the strongly faulted northern flank of the Toas structure. On the eastern horizon the sand dunes of Zapara Island may be recognized. To the southeast and south lie the limestone hills of the south flank of Toas structure, topped at their highest point by the television relay station. The steep scarp slope is in full view across the deeply weathered granite of the axial topographic depression. With the exception of the Carrizal area, the rocks of the La Quinta formation are missing along the southern flank of the Toas Island structure, so that the Río Negro formation overlies unconformably the granitic core of the island.

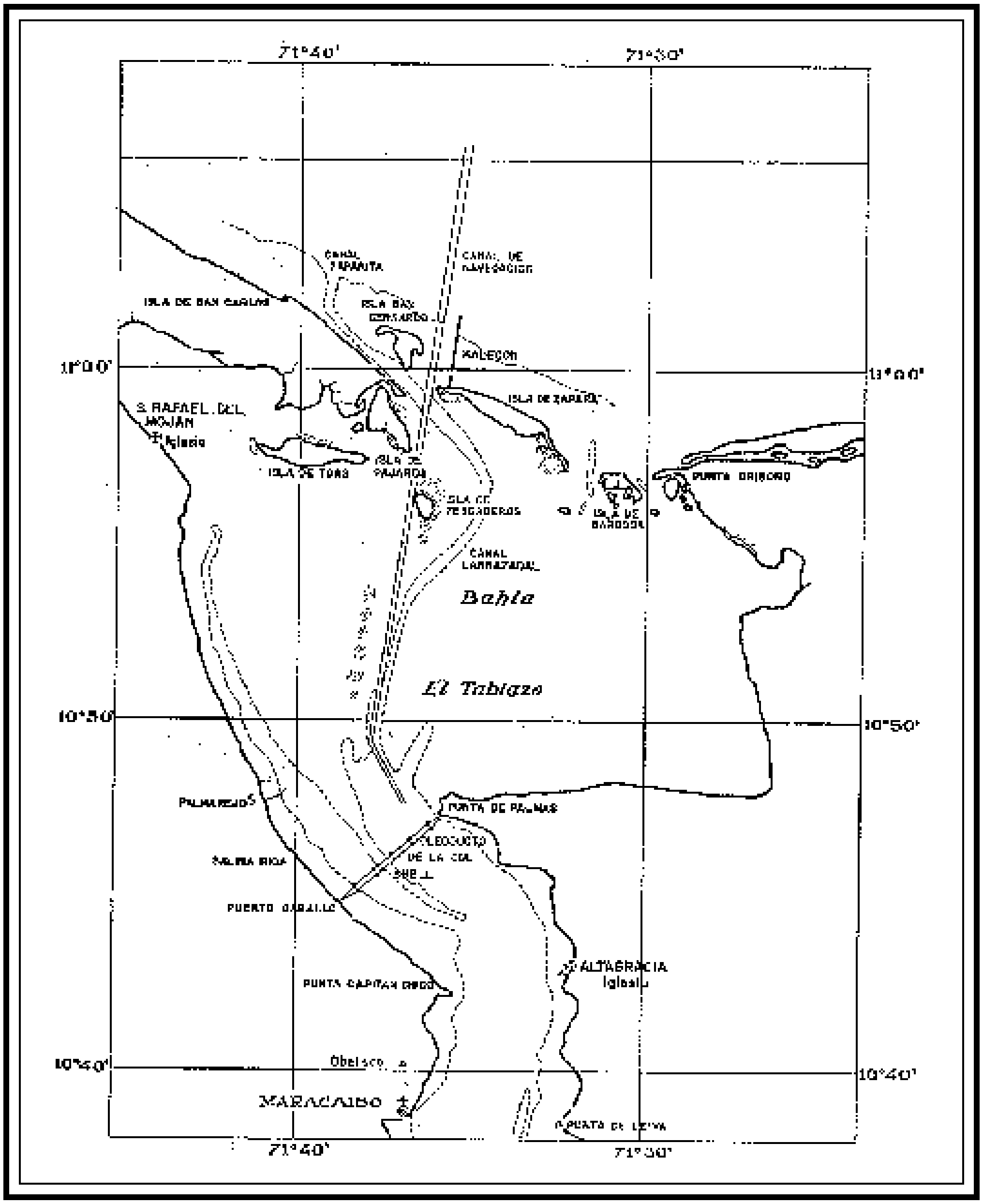


AERIAL PHOTOGRAPHY ON A SCALE OF 1:40.000 SHOWING RECENT VERTICAL MOVEMENT ON THE OCA FAULT NORTH OF THE RIO LIMON BETWEEN THE LAGUNA DE SINAMAICA AND THE NORTH ON THE RIVER. THE SOUTH SIDE OF THE FAULT IS UPTHROWN AND THE NORTH SIDE DOWNTHROWN WITH A DISPLACEMENT OF ABOUT ONE METER. THIS RESILTS IN THE ABRUPT INCREASE IN WIDTH AND HEIGHT OF THE MIDDLE SINAMAICA BEACH RIDGES SOUTH OF THE FAULT, AND IN A WITHE AREA OF BARREN SAND FLATS SOUTH OF THE FAULT IN CONTRAST WITH A DARK AREA OF MANGROVE SWAMPS NORTH OF THE FAULT WHERE IT CROSSES THE OLDER SINAMAICA BEACHES. NO APPRECIABLE LATERAL DISPLACEMENT IN VISIBLE ON THIS SCALE .

Field Trip to Toas, San Carlos and Zapara Islands



12:00 M. Proceed down the eastern slope of Cerro Blanco to the topographical saddle between Cerro Blanco and Cerro Corozal, the next hill to the east in the northern range. According to Shell's interpretation, a thin zone of Río Negro formation occurs between Cerro Blanco and the saddle. On Creole's map the Cogollo group is in fault contact with La Quinta formation. At the slope between the saddle and the lake shore to the north of it, an interesting section of La Quinta formation some 25-30 meters thick can be studied. As this locality the La Quinta section is composed mainly of olive green and rusty red, weathered, coarse and gritty arkosic sandstones, brown red silty clays and several intercalations of thick conglomerate beds. The pebbles of the conglomerates sometimes exceed 10 centimeters in diameter and consist of granites, porphyritic and/or pyroclastic rocks, quartzes and, occasionally, limestones. According to O. Renz (oral information), fusulinids have been found in a few of the limestone pebbles. This information indicates that the pebbles were probably produced by the erosion of limestones in the Permian Palmarito formation, which is not exposed on Toas Island. The stratigraphic position of this succession to the La Quinta formation is uncertain, since it was not found at Carrizal and because the section may be in fault contact with the Cretaceous.



12:30 P.M. Go eastward on path which follows the shore line. Between La Conserva and El Corozal the cliffs to the south of the path consist of strongly broken limestones of the Cogollo group. In this area the northern flank of the Toas structure appears to be overturned and local imbrication adds to its structural complexity. Impregnations of residual oil are reported to occur at some places in fractured limestones. At El Corozal the slope of the hill is composed of dark grey shales at least 15 meters in thickness. These shales contain assemblages of upper Senonian small foraminifera and are, therefore, considered to correspond with parts of the Colón or La Paz shales of the Mara-Maracaibo area.

Just before reaching the houses of Las Playitas, at the rocky point where the shoreline bends towards the southeast, these is a small outcrop of Guasare formation. This is the type locality of the Toas limestone, an obsolete junior synonym of the Guasare formation. From the shore to some ten meters higher up, alternating beds of impure, olive green, soft, glauconitic sandstones, of sandy shales and of thick-bedded, light brown and partly glauconitic Ostrea and *Venericardia* limestones occur. The Paleocene age of these rocks was mainly determined on the basis of the lamellibranch species Ostrea buski Woods and *Venericardia (Venericor) toasensis* Dusenbury. The first species occurs in the Paleocene Negritos formation of Perú. The second is characteristic of the basal limestone development of the Guasare formation in other parts of western Venezuela where undisturbed sections are present, e.g., in the Río Cachirí and the Caño Frío in western Mara or in the Monay Basin near Casa del Zinc in northeastern Trujillo. The Paleocene age of this interval is corroborated by the finding of diagnostic small foraminifera in some of the thin weathered layers at the surface of the sandy limestones. See Sutton, 1946, p. 19659, for the complete faunal list.

A narrow belt of black carbonaceous shales, which locally contain thin sandstones and coal layers, extends along the coast from Las Playitas towards the east in fault contact with the Cogollo limestones to the south. In earlier days coal was exploited from these beds and used to fire the local lime kilns. The Paleocene age of these coal layers was recently established on pollen evidence. Lithologically, the section can be compared with part of the Marcelina formation (an equivalent of the lower part of the Paso Diablo formation) of the Río Guasare area.

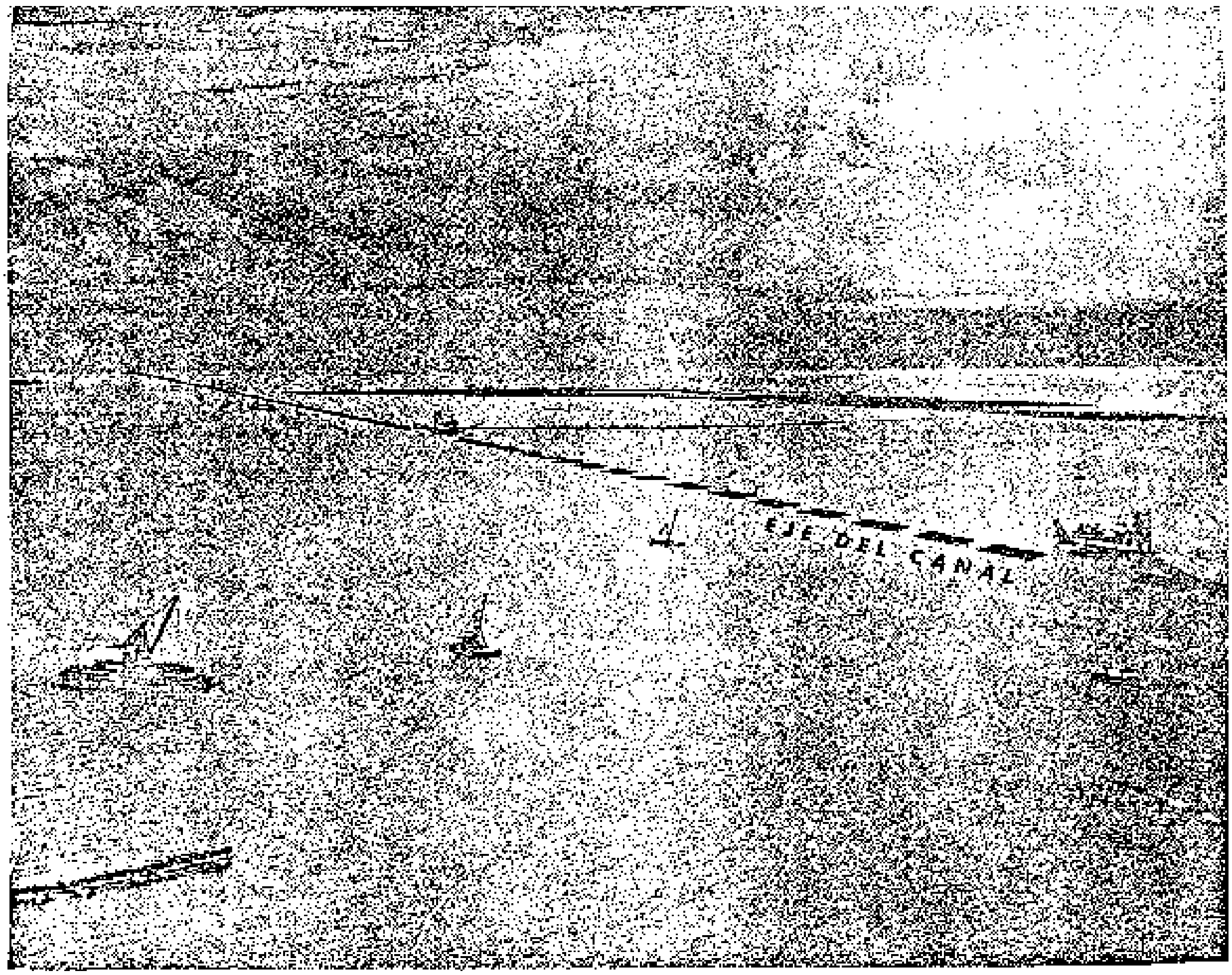
1:00 P.M. Arrive at Las Playitas. Lunch will be eaten in the shade of the palm trees. Lunches, beer and soft drinks will be brought from the launches at El Toro by taxi and distributed.

2:00 P.M. Proceed southeastward to the road which leads to El Toro, follow the road eastwards to El Toro to embark on launches.

2:30 P.M. The launches depart from El Toro, proceed directly northeast across Tablazo Bay to the Caño San Carlos and enter this narrow channel between the Isla de San Carlos on the left and the Isla de Pájaros on the right. The barges carrying the limestone blocks from the quarries on the west end of Toas Island for the construction of the breakwater to protect the channel across the Lake Maracaibo bar were towed to their destination through the Caño San Carlos. After navigating the length of the Caño, the launches arrive at the village and fort of San Carlos.

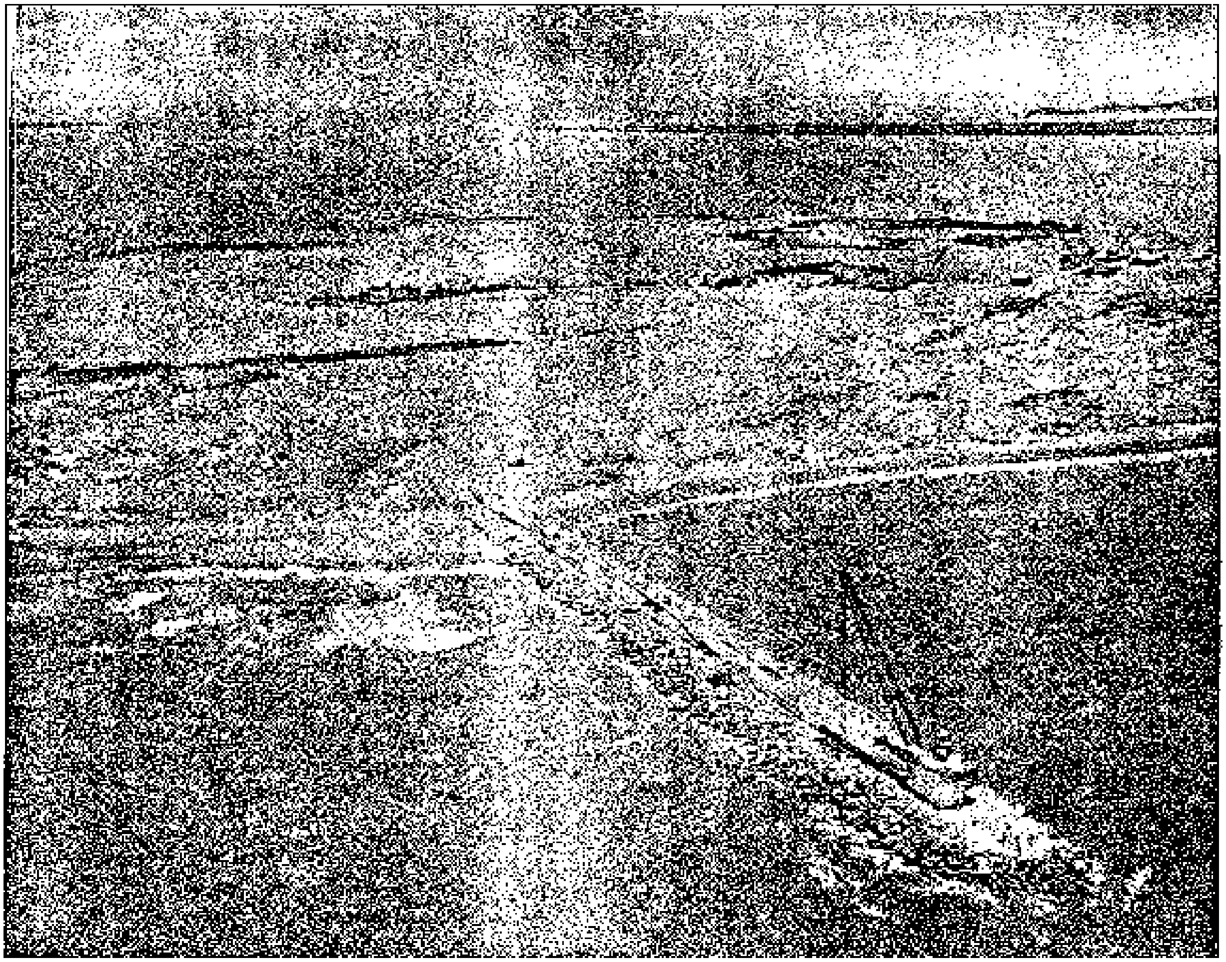
3:00 P.M. The party will go ashore at the Castillo de San Carlos. Permission to do this and the services of a guide were obtained through the courtesy of the Instituto Nacional de Canalizaciones. The village of San Carlos is inhabited principally by fishermen and had a population of 667 in 1950. The Castillo next to it was originally built to protect the entrance to Lake Maracaibo against pirate raids but has been used as a prison since colonial days. It was particularly infamous for the detention and torture od political prisoners under the dictatorship of Juan Vicente Gómez from 1908 to 1935. Eustóquio Gómez, the dictator's brother by adoption and a convicted murderer, was released from prison, when Juan Vicente Gómez seized power, and was placed in charge of the Castillo de San Carlos during 1909 and early 1910. In May, 1910, there was an uprising of the prison guards and employees against Eustóquio's greed and mismanagement. Warned in time, Eustóquio escaped in a fisherman's boat. Juan Vicente was quite amused by the affair and promoted Eustoquio to the governorship of the State of Táchira. When the General Gómez died and his regime came to an end in 1935, the prisoners were released and the Castillo was abandoned. In recent years it has been employed as a storage place for explosives. Across the entrance to Lake Maracaibo lies a string of shoals and barriers islands which, together with the shallow depths of Tablazo Bay, is known generally as "The Maracaibo Bar". The name "Outer Bar" has traditionally been applied to the section of shifting sand banks immediately north of the Isla de San Carlos which was crossed by the original ship channel, known as the Canal Zaparita. Sampling in the region of the Outer Bar has indicated that this formation consists almost entirely of fine sand, apparently of marine origin and probably transported westward from off the coast of Falcón by longshore currents. Clays and silts occur in significant proportions in the sediments of Tablazo Bay and also further offshore in the Gulf, but apparently have been selectively removed from the material accumulated in the Outer Bay by the action of waves and currents. San Carlos and Zapara Islands are characterized by spectacular sand dunes ranging in height up to 100 feet. Mangroves cover the low-lying shoreline along the south side of San Carlos, most of Pájaros, the east end of Zapara, Barbosa, and Punta Oribono. San Bernando is an artificial island formed of the material dredged from the new navigation channel. Zapara Island provides an interesting example of the migration of sand under the influence of prevailing winds. In the east central portion of the island there are two rows of cuspate dunes, technically known as barchans, that are oriented parallel to each other and normal to the mean direction of the wind. When the northeast trade wind is blowing, continual tiny sand slides can be seen on the leeward slopes. These start as a few grains, break away from the cusp and "flow" in a steadily widening stream of sand to the bottom of the dune. the ripples on the windward and upper surfaces present an endless variety of patterns apparently associated with the texture of the sand, its moisture content, and the local configuration of the dune. Between the two rows is a depression about 100-150 meters wide, which is lined with ridges running parallel to the rows of dunes. These ridges are of the order of a foot high and 15 feet apart, and seem to have been formed in the following way (hypothesis of J. H. Germeraad). During the rainy season this low-lying area holds rain water, which allows vegetation, mostly grasses, to become rooted along the bottom edges of the dunes. The windward edge of each dune then remains as a vegetation-anchored ridge when the rest od the sand migrates onward during the ensuing dry season. Thus, the distance between the ridges provides a convenient measure of the distance which the dune has migrated during any of the years represented. carrying this hypothesis a step further, one may infer the occurrence of a cycle of dune formation from the existence of the two rows and associated low areas. Starting from near the south shore of the island and walking northeast, one encounters in succession the first row of dunes, the first set of ridges, the second row of dunes, the second set of ridges, a finally, just above the beach of the Gulf shore, a row of very small dunes apparently in the earliest stage of formation. The total distance of about 3000 feet thus seems to correspond to slightly more than two full cycles of dune formation. At an average speed of migration of 15 feet per year, a cycle of the order of 100 years in suggested, in which dune formation passes from maximum through essentially zero activity to maximum again. The sands bars in the region of the Outer Bar have been of particular interest in the past because of the former navigation channel. This was the "natural" channel, scoured by the tidal currents as they ebbed and flooded between Tablazo Bay and the Gulf. Extending inward across the Outer Bar, it continues southeast along the north shore of San Carlos Island into Tablazo Bay and parallel to the south shore of San Zapara Island, then curves in an arc around the east side of Pescaderos Island until it is directly south of the entrance between San Carlos and Zapara. From here it follows a course approximately south across Tablazo Bay to a spot just west of Punta de Palmas, where it abruptly widens and deepens. The "natural" channel through the Outer Bar is called the Canal Zaparita, but its continuation through Tablazo Bay is termed the Canal Larrazábal. One of the most interesting features of the Outer Bar was the tendency for the Bar Channel to undergo a cyclic migration. With a period of about 20-25 years, the channel would break through in an easterly position, then move westward at a mean rate of about 600 feet a year until it reached a position of instability. At this point a new channel would break through, and the old one would fill up, starting the cycle again. The instability of the old channel may have been due to decreasing "efficiency" as the path lengthened, with consequent decrease of slope and hence of the average speed of flow. The following discussion of this process and the erosion of the Gulf shore appears in the publication "Model Study of Channel Improvements at Outer Bar, Lake of Maracaibo, Venezuela", (Technical Memorandum No. 106-1 of the U.S. Waterways Experiment Station, Vicksburg, Mississippi, December 1, 1938). "Characteristic hydrographic trends"40. By means of all the available maps, sailing directions, and oral and written descriptions, it is possible to trace the general trends which are characteristic of the Outer Bar area. These trends might be classified under two general headings; recession of the Gulf shore and cyclic extension of the Outer Bar. "41. The recession of the Gulf shore is first illustrated by the comparison of older maps. The survey of 1794 indicates a fort on the eastern end of Isla de Zapara, whereas the 1864 survey shows this fort as rock reef or shoal (Roca de Barbosa) some distance from shore. Present-day maps show this Roca de Barbosa. The reduction in size of the Isla de Barbosa from earlier maps also is to be noted. Hence regardless of the doubtful cartography of the earlier maps, it is evident that Isla de Zapara receded 1.6 miles during the period 1974 to date. Recent maps corroborate the fact that erosion is taking place. The Isla de Barbosa was surveyed in 1935 and again in 1937, and the recession of the northern shore of this island was clearly shown by a comparison of the two maps. Another fact which bears out this point is the recession of the northern shore of Isla de Zapara from 1925 to date.

The second outstanding trends is the cyclic extension of the Outer Bar. This has its counterparts in the cyclic position and controlling depth of the Bar Channel, in the development of the incipient Eastern Channel, and in the movement of the bed material along the Outer Bar is unquestionably that not only the prevailing orientation of the Outer Bar is in a like direction, but present a measure of its rate of extension. As the Outer Bar is moved further to the westward, and the depths in the Bar Channel are decreased. As the Bar Channel moves westward, the slope at ebb tide through this channel becomes less. This decrease in slope results in a corresponding decrease in the velocity of flow, and channel shoaling ensues. As the main portion of the flood flow into the lake crosses the Bar between Isla de Zapara and the Eastern Channel, the changes at the outer end of the Outer Bar do not affect this flow, and hence the tidal prism, the ebb flow is not particularly affected. With a relatively constant tidal prism, the ebb flow is relatively constant; and, therefore, as the Bar Channel becomes less efficient, due to its decreased slope and cross section, more of the ebb flow is diverted across the Bar to the eastwards, thus developing any potential channel in that area. A point is finally reached where sufficient ebb flow is passing over the Bar to cause a breakout of a new channel, and the beginning of a new cycle. The former outer end of the Outer Bar is then relieved of the greater part of the pressure of the ebb flow on its southwest side, and, under the action of pressure of the waves, is moved shoreward and finally becomes a part of this shore.



DREDGING THE NAVIGATION CHANNEL IN TABLAZO BAY. SEAWARD THE SKETCHED-IN CENTER LINE OF THE CHANNEL PASSES BETWEEN THE ISLA DE SAN CARLOS ON THE LEFT AND THE ISLA DE ZAPARA ON THE RIGHT.

Field Trip to Toas, San Carlos and Zapara Islands



CONSTRUCTION OF THE BREAKWATER ON THE WEST END OF THE ISLA DE ZAPARA, SHOWING UNLOADING DOCK, RAILWAY AND GIANT MOBILE CRANE. PESCADORES, PAJAROS AND TOAS ISLANDS IN BACKGROUND.

These channels were tortuous, constantly shifting, and had limiting depths of the order of 12 feet. The consequent problems for navigation led first to the improvement and maintenance of the natural channel, which was dredged in stages to 22 feet, and finally to the dredging and maintenance of the new channel, which is one of the world's great canal projects. Responsibility for this work rests with the Instituto Nacional de Canalizaciones. The breakwater (malecón) which protects the landward end of the outer channel can be seen extending north from the west end of Zapara Island. It is 3.1 kilometers long, and contains 1.190.000 metric tons of rock which was obtained from the Cogollo limestone quarries at the west end of Toas Island. The outer channel extends 16 kilometers north from San Carlos. It is 305 meters wide and has been dredged to a depth of 37 feet. The inner channel extends 22 1/2 kilometers to the north, to reach the 43-foot contour line in the Gulf. It will also call for dredging to the same depth between Icotea Point (Cabimas) and Punta de Palmas del Sur. Since the opening of the new channel in 1955, considerable effort has been required to maintain the depth. In the outer channel this due presumably to the transport of sediments by transverse currents associated with the tides and the net longshore current. The breakwater affords partial protection in the region of maximum wave action where the problem would be expected to be more serious. In Tablazo bay the tidal currents tends to follow a curved path fairly well delineated by the old channel, which was presumably formed and maintained by the scouring action of the currents. A considerable amount of the water now follows the broad, deep, straight new channel, but nevertheless enough still follows the old route to cause considerable deposition of sediment where its path crosses or converges with the channel. One final point of interest in connection with the currents is associated with the existence of an antinode of the semidiurnal tidal component near the middle of Tablazo Bay. As a result of this, on a rising tide water flows into Tablazo from the Gulf and from the Lake simultaneously. (Superimposed upon this motion is the net discharge of the lake and also the diurnal tidal component, but nevertheless the effect is clearly noticeable). This antinode may have contributed to the accumulation of sediment and the shallow depths in Tablazo Bay. The guns of the Castillo de San Carlos have demanded for centuries the shifting natural channel which used to be the sole navigable entrance to Lake Maracaibo. before the present fort was erected in the latter part of the seventeenth century, Maracaibo was attacked no less than six times by the buccaneers. The Dutch freebooter, called by the Spaniards Enrique Gerar, made the first attack on Maracaibo in 1614. The second attack was made by the Englishman, Captain William Jackson, in 1642. Each time, the bar was apparently defenseless. In 1666 the terrible French buccaneer, Jean David Nau, better known as Francis l'Ollonais, captured both Maracaibo and Gibraltar, now a village of little importance at the south end of the lake but then a rich and thriving town from the export of sugar and cacao. By that time a fort sixteen cannon had been constructed in order to defend the entrance through the bar. When the pirates landed to assault the fort, its commander sent a platoon to ambush them, but the ambush was discovered and the platoon was completely wiped out. The pirates advanced to the Castillo and fought a three-hour battle without quarter, finally gaining possession, seizing everything of value including the cannon, and demolishing the walls to ensure their subsequent safe retreat. After two months of slaughter, torture, destruction and looting at Maracaibo and Gibralter, they again crossed the bar on their way back to Tortuga. Two renegade Spaniards accompanied l'Ollonais on this raid, Pedro el Picardo and Miguel El Vascongado. The next year, 1667, Miguel El Vascongado returned to take Maracaibo for the fourth time with a mere 40 men in three small boats. he knows that the soldiers killed, the weapons removed and the fort destroyed by the previous expedition had not yet been replaced by the slow-moving Spanish authorities and that he could easily compel the city of Maracaibo to pay a ransom without opposition. A small ransom was collected from the wealthier citizens and the pirates departed. Meanwhile, Pedro el Picardo, the other Spaniard who had been with l'Ollonais, and who not only knew the environs of Maracaibo but spoke good English as well, had contacted the notorious Englsih buccaneer, Sir Henry Morgan, in Jamaica. Morgan had wanted to take Cartagena, the biggest prize on the Spanish main, but this project was soon discarded as Cartagena was too heavily fortified. Perhaps Pedro el Picardo had a great influence in persuading Morgan to set sail for Maracaibo instead. They both realized that Maracaibo and Gibraltar would be easy to take due to the destruction by l'Ollonais a few years before. So, early in 1669, they set sail from Jamaica, landing for a short while on the island of Aruba, where they took on fresh water and goat meat, which they obtained from friendly Indians. Two days later they came upon the reconstructed Castillo at the entrance of Lake Maracaibo and cannonaded it all day. When the night fell, Morgan discovered that the Spanish troops had evacuated the fort, leaving behind a lighted fuse to blow it up. The pirates extinguished the fuse, carried-off the artillery, but foolishly neglected to destroy the walls. They then captured Maracaibo, seized about a hundred of the richest inhabitants, robbed, tortured and killed for three weeks, and then repeated the horrible routine at

Gibraltar, the principal port at the south of the lake. Finally, ransoms were obtained from 250 prisoners and from the two captured cities, but on preparing to depart for Jamaica, Morgan learned that the Spanish admiral, Don Alonso del Campo y Espinoza, had blocked the exit with a fleet of three large vessels of 36, 30 and 24 guns, each superior to any of Morgan's boat, and had reoccupied the Castillo. Caught in a trap, Morgan buried part of his loot, prepared a fire ship by equipping a merchant ship, captured at Gibraltar, with a dummy crew and guns and with the necessary combustibles, and, on April 30, 1969, sailed out in a desperate effort to break the blockade. The fire ship grappled with the admiral's flagship, was put to the torch and abandoned by its skeleton crew. The ruse was eminently successful and the 36-gun "Magdalena" was destroyed when the flames reached its powder magazine. The second Spanish ship fled, ran aground near the Castillo, and was burned and scuttled by its own crew, which then sought refuge in the fort. The third Spanish ship fought stoutly but was badly outnumbered and had to surrender. Don Alonso had escaped to the Castillo and there bravely beat off the assault of the pirates, who lost 60 men. Morgan retired and after nightfall succeeded in getting past the Castillo, whereupon he set sail for Jamaica with the remainder of his loot, amounting to 250.000 pieces of eight. In 1678, the French pirate, Francis de Grammont, headed the sixth and final raid of the buccaneers against Maracaibo, which had by the time recovered from the devastation wrought Morgan. The expedition began as an attack by the French from Haiti on the Dutch island of Curacao. The 18 French vessels under the command of the Comte d'Estrées through an error of the pilots ran aground on the reefs of Los Aves with the loss of 300 of the men and the destruction of many of the boats. Grammont collected the survivors of the shipwrecks, careened and repaired nine of the vessels, and set out with 700 men to re-supply the fleet at the expense of the towns of the Lake Maracaibo area. He anchored off San Carlos Island, landed most of his men and besieged the Castillo. The outnumbered garrison of only 70 men fought for two days but finally had to surrender and was allowed to depart unharmed. The artillery and small arms of the garrison were taken aboard, and a number of buccaneers stayed behind to hold the fort. Grammont and the rest of the pirates seized Maracaibo, Gibraltar and Trujillo one after another, the terrorized inhabitants fleeing before the pillagers and carrying their valuables with them. The pirates obtained so little that they left the lake and attacked Margarita, La Guaira and Puerto Cabello. The nomenclature of the islands and forts at the Maracaibo Lake bar has changed with time. In the preceding account, in order to avoid confusion, the present nomenclature has been employed. However, at the time of the pirate raids the present Isla de San Carlos was called the Isla de las Palomas and the Isla de Zapara was known as the Isla de las Virginias. The fort of the site of the present Castillo de San Carlos was termed El Castillo de la Barra. A high dune of Zapara was occupied by a watchhouse, hence the origin of the name Isla de las Vigilias. In the later part of the reign of Carlos II, after the last of the successful pirate raids, the royal command was given to strengthen the defenses of the Lake Maracaibo Bar. A much later fort was erected on the site of the former Castillo de la Barra and was named Castillo de San Carlos after the patron saint of the reigning monarch. At the same time the name of the island was changed from Isla de las Palomas to Isla San Carlos. Two more forts were constructed on the Isla de Zapara on the east end to guard the shallow channel between the Islands of Zapara and Barbosa. While the Castillo de San Carlos has been occupied almost continuously and kept in repair, the Castillo de Santa Rosa and the Castillo de Zapara were cut off from the Isla de Zapara by marine erosion, which has forced the abandonment of the forts and has leveled them to their foundations. This is the origin of the name Zapara, a Spanish word meaning an undermining of sapping process, and in the present case evidently referring to the marine erosion so characteristic of this island. At low tide the ruins of the Castillo de Santa Rosa may be observed about 100 yards off the west end of Zapara and those of the Castillo de Zapara on a shoal about 1.6 miles north of the Isla de Barbosa. The ruins of a more recent fort occur in the center of the Island of Zapara near the lighthouse.

3:30 P.M. The excursion group will board the launches, which will leave the Castillo and enter the ship channel. They will then turn north along the channel for a short distance in order to view the artificial island of San Bernando on the left and the breakwater, projecting from the west end of the island of Zapara, on the right. With luck the party may see in action one or more of the three dredges which the Venezuelan government keeps in constant operation to maintain the prescribed depth and width of the channel. the launches will then make a 180° turn end reverse their so as to follow the ship channel south all the way back to Maracaibo.

5:15 P.M. End of trip on arrival back at the dock of the Mene Grande Oil Company in Maracaibo.

[1] Por Rudolf Blaser, Cía. Shell de Venezuela, and Arthur N. Dusenbury, Jr., Creole Petroleum Corporation, Sociedad Geológica de Venezuela Occidental, Guidebook N° 2, 3 de Abril de 1960.

*** The outcrops along the north coast to the east of Las Playitas which are indicated as Eocene on Shell's map are now, in agreement with Creole's and Atlantic's interpretation, considered to be of Paleocene age.**