ARTICULO

PETROLEUM GEOLOGY OF THE TERRITORIO FEDERAL DELTA AMACURO, VENEZUELA (GEOLOGIA PETROLERA DEL TERRITORIO FEDERAL DELTA AMACURO, VENEZUELA)

by S. T. Pees[1], L. M. Banks[2] and A. Segovia[3]

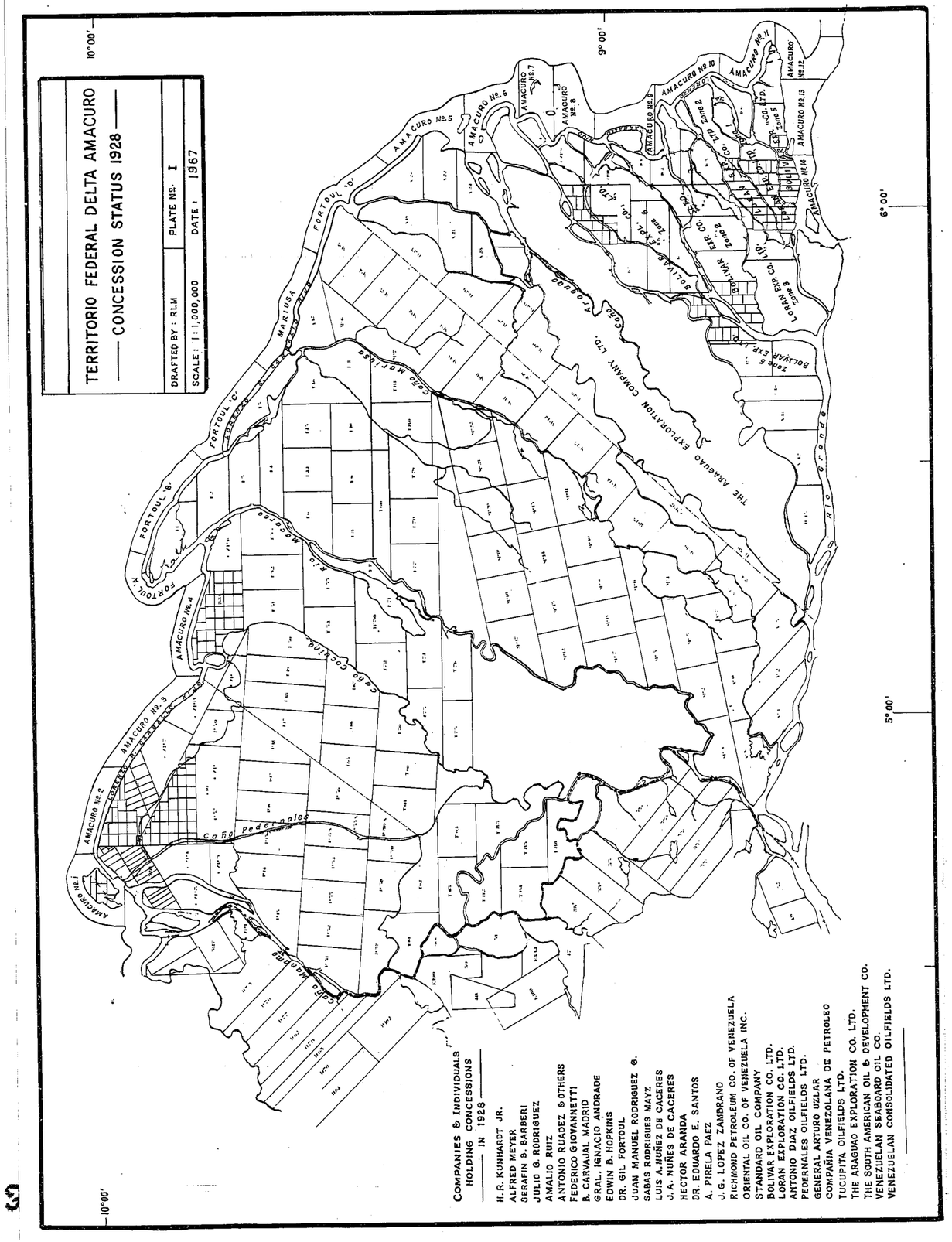
TABLE OF CONTENTS

PLATES

1. Skelly Oil Company, Tulsa, Oklahoma

2. Consultant, Buenos Aires, Argentina

3. Sinclair Research Laboratory, Tulsa, Oklahoma



ABSTRACT

More than 18,000 sq. km. of the Eastern Venezuelan Basin remain largely untested within Territorio Federal Delta Amacuro. The possibility of finding commercial oil accumulations in the area appears to be very good. Only 4 exploratory tests have been drilled outside of the area of the Pedernales and Tucupita structures. A very small fraction of the prospective area is under concession today. Offshore possibilities, which may be just as good as those of inland areas, are not discussed in this paper.

Exploration and exploitation of hydrocarbons began in Delta Amacuro in 1890, with production of asphalt and heavy oil from a pitch lake near Pedernales. By 1928 practically the entire Federal Territory was under concession, but most of the acreage was subsequently renounced without drilling. Sensational discoveries elsewhere in Eastern Venezuela deflected the main stream of exploration away from Delta Amacuro after 1928. However, two oil fields were discovered within the Territory, Pedernales (1933) and Tucupita (1945).

Surface seeps of oil and gas are scattered throughout the delta. Pitch and asphalt lakes occur on the north flank of the basin. The Bombal field, just west of the Delta Amacuro border, is on a regional producing trend which should remain prospective eastward into the delta. In Tucupita, most of the oil appears to be produced from the Oficina Formation (Lower Miocene). This formation becomes thinner, and it may even be absent, over part of the southern and southeastern sector of the delta. However, younger formations generally considered not prospective outside of the delta may present a more favorable development within the Territory. Cretaceous beds of the Temblador Group may also be reservoirs in the delta.

Most of the present day delta rests on the southern flank of the Eastern Venezuelan Basin. The thickest column of sedimentary rocks under the subaerial part of the delta should occur southeast of Pedernales, where 24,000-26,000 feet are inferred. Structural traps should exist in the south flank, along the Sabaneta anticlinal trend, a long, supratenuous fold, which extends offshore. Other structural traps could be provided by normal faults striking approximately N 60° E. Fault density in Delta Amacuro should be comparable to that found to the west, in Monagas State, where a large amount of oil is produced from such fault traps. A long, NW-trending lineament was observed on photomosaics covering the south flank of the basin. The lineament suggests the presence of a wrench fault similar to those found on the north flank of the basin, outside of the delta, in Venezuela and Trinidad.

Underlying structure influences the morphology of the subaerial delta. Surface elevation, drainage, deposition, erosion, and base level are in such a delicate balance that the response to a minute change caused by structure in one of these factors is almost instantaneously reflected in the others. Aerial photographs reveal local incision of gullies, deflections of streams, etc., which in some cases can be correlated directly with underlying structure. The The Tucupita faults, the Pedernales high, and the Macareo syncline have this type of surface expression. Additional geomorphic evidence suggests that the main area of infilling may have generally shifted toward the south during the period involved in the deposition of the present surface.

RESUMEN

Más de 18.000 Km.^{2} de la cuenca oriental de Venezuela se encuentran aún inexploradas en el Territorio Federal Delta Amacuro. Las posibilidades de encontrar acumulaciones comerciales de petróleo en el área son buenas. Solamente 4 pozos exploratorios se han perforado fuera de las áreas de las estructuras de Pedernales y Tucupita. Una parte muy pequeña del área favorable está asignada en concesiones hoy día. La posibilidad de encontrar yacimientos mar afuera puede ser tan buena como la del continente, pero no se analiza en este informe.

La exploración y explotación de hidrocarburos comenzó en Delta Amacuro en 1890 con la producción de asfalto y petróleo pesado del lago de brea cerca de Pedernales. Para 1928 prácticamente todo el Territorio Federal estaba distribuído en concesiones, pero la mayor parte del área fué luego renunciada sin haberla perforado. Descubrimientos sensacionales en otras partes del Oriente de Venezuela desviaron el curso de las exploraciones fuera de la región del Delta Amacuro, no obstante, dos campos petroleros fueron descubiertos en el Territorio, Pedernales (1933) y Tucupita (1945).

Menes de petróleo y gas se encuentran en varias partes del delta. Lagos de asfalto y brea existen en el flanco norte de la cuenca. El campo de Bombal, inmediatamente al oeste del límite del Delta Amacuro está en una faja productora regional, que hacia el este, en el delta, todavía debe ser promisora. En Tucupita, la mayor parte del petróleo parece provenir de la Formación Oficina (Mioceno inferior). Esta formación adelgaza e incluso puede no encontrarse en el sector sur y sureste del delta. No obstante, formaciones jóvenes, generalmente consideradas como no favorables fuera del delta, pueden presentar un desarrollo mas propicio en el Territorio. Las capas cretáceas del Grupo Temblador pueden también formar yacimientos en el delta.

La mayor parte del delta actual se encuentra en el flanco sur de la cuenca oriental de Venezuela. El espesor máximo de la columna sedimentaria del delta debe encontrarse al sureste de Pedernales y se estima en 24.000 a 26.000 pies. Trampas estructurales deben existir en el flanco sur, a lo largo de la faja anticlinal de Sabaneta, un pliegue largo, de muy poco relieve que se continúa mar afuera. Otras trampas estructurales pueden formarse por fallas normales que tienen un rumbo aproximado de N 60° E. La densidad de fallamiento en el Delta Amacuro debería ser comparable a la que se encuentra al oeste, en el Estado Monagas, donde una gran cantidad de petróleo se produce de este tipo de trampas. Un largo fotolineamiento con dirección NO. fué observado en fotomosaicos que cubren el flanco sur de la cuenca. Este lineamiento sugiere la presencia de una falla transcurrente, similar a las encontradas en el flanco norte de la cuenca, fuera del delta, en Venezuela y Trinidad.

La estructura del subsuelo controla la morfología del delta. La elevación de la superficie, el drenaje, sedimentación, erosión y el nivel de fondo están en equilibrio tan sensible, que el efecto del menor cambio originado estructuralmente en uno de estos factores se refleja casi instantáneamente en los otros. Las fotografías aéreas muestran encajamientos locales, cambios de cursos, etc. que en algunos casos pueden correlacionarse directamente con estructura infrayacente. La falla de Tucupita, el alto de Pedernales y el Sinclinal de Macareo, presentan este tipo de expresión superficial. Otras evidencias geomorfológicas indican que durante el período de formación de la superficie actual, el área principal de sedimentación se ha desplazado, generalmente, hacia el sur.

ACKNOWLEDGEMENT

In the preparation of this paper the authors benefited from the work done by many previous authors and researchers. This broad reference base is greatly appreciated. It is also specifically desired to acknowledge the permission granted by Creole Petroleum Corporation for use of certain data from their wells and fields in the area of interest.

Skelly Oil Company provided the opportunity for the authors to visit the delta region. Drafting, reproduction, etc. was done by the Skelly staff in Venezuela and Tulsa.

GEOGRAPHIC AND PHYSIOGRAPHIC NOTES

Geography

Area of Territorio Federal Delta Amacuro is 40,200 sq. km. Capital: Tucupita (Pl. II).

Relief: The delta proper has very low relief. The highest elevation at the vertex of the delta is approximately 17 m above sea level, and the seaward slope is about 10 cm/km. Within Territorio Federal Delta Amacuro, however, elevations as high as 600 m above sea level may be reached in the Serrania de Imataca, in the Guiana Shield, south of Rio Grande (Pl. III).

Climate: Temperature extremes recorded at Pedernales (Pl. III) were 34.2°C (absolute maximum, 1954), and 16.7° C (absolute minimum, 1953). Annual mean temperatures oscillate between 25° C and 27° C (Vila, 1964). Relative humidity is high, but northeast trade winds and east-west winds make the area rather pleasant, as elsewhere in the Llanos Orientales (eastern plains). Wind velocities are low to moderate; seldom, if ever, of hurricane force. Annual mean rainfall oscillates between 1,300 mm and 2,000 mm. Tides every 12 hours cause a rise in water level of up to 2 m maximum, and a counter-current in the delta rivers and "caños" (Bayous).

Flora and Fauna: A tropophytic vegetation characterizes the jungle of the western part of the delta, where the "carapo" tree is typical, as well as two species of palm trees called "temiche" and "moriche". Coconut trees are common along the littoral part of the delta, and in the eastern area where the water is brackish.

Birds, monkeys, tapirs, jaguars, deer, ant eaters, sloths, wild pigs, iguanas, caymans and land and water snakes are plentiful. The rivers are thickly populated with many species of fish which provide the staple food of the Guarao Indians.

Population and Ethnic Groups: Delta Amacuro is very sparsely populated. According to the 1961 census, the territory's population, 40,200 (Vila, 1965), corresponds to a density of .81 inhabitants per sq. km. Principal population centers are Tucupita, 575 inhabitants, (probably closer to 10,000 in 1968), Pedernales, 691 inhabitants, down from 1,710 in 1950, and Curiapo, 314 inhabitants.

The Guarao or Guarauno Indians constitute the bulk of Delta Amacuro population. They are kind in nature and friendly. They live along the banks of the caños in palm-roofed huts built on stilts. Many small Indian villages are distributed throughout the delta, where the Guaraos lead an isolated and primitive life. Capuchino monks from Catalonia, Spain, run a mission in the Territory.

Venezuelans who moved from other parts of the country constitute the next important group, making about 20% of the Delta Amacuro population. They control the economic and industrial activities of the territory.

Communications: Pedernales may be reached by plane, small boats, and launches from Caripito, an oil port on Rio San Juan. There are no roads to Pedernales. Tucupita is serviced by a commercial airline via Maturin, capital of the Estado Monagas. A black-top road connects Maturin with Puerto Amador (Pl.III) and Barrancas (Pl. III). Tucupita can be reached by boat from these two rivers ports. A new road to Tucupita is under construction. In 1966, the road system within the territory totalled only 38.5 km and connected Tucupita with La Horqueta (Pl. III) and Coporito (Pl. III). The road system will undoubtedly improve rapidly when a water diversion project now in progress provides drained land, safe from annual floods, and suitable for agricultural development.

Surface communication within the delta is provided by small boats and launches. The Guarao Indians get around in canoes called "curiaras", many of which are equipped with out-board motors. The Rio Grande is navigated by sea-going tankers and iron-ore cargo boats. The iron mining companies at first used Caño Macareo (Pl. II) as their route to the sea, but it was abandoned because much dredging was needed to keep a navigable channel open. Caño Manamo (Pl. II) was also an important route to the sea up to 1965.

Economy

Outside of limited petroleum production and refining, commerce agriculture and industrial activities are still in an incipient stage. Tucupita is the main center of trade with the outside world. Traders from Tucupita travel the water routes with merchandise to supply the delta people with their basic needs, and they also buy the local products. Industrial activities include timber mills and rice drying plants, most of which are concentrated in Tucupita. A "palmito" (heart-of-palm) canning plant is now operating near Curiapo (Pl. II).

Fishing, farming and cattle raising constitute important activities in parts of the delta. Industrialization of fishing and agricultural products represents an untapped source of economic development with an important potential for the future. The economy of the Territory should experience a sharp rise as soon as a vast drainage project, now in progress, provides new lands for development. Corporación Venezolana de Guayana has initiated a project to divert water and drain roughly 970,000 hectares of periodically flooded lands in the Delta Amacuro. About one-third of this acreage should be suitable for agricultural and livestock enterprises. This drainage project will also render the area more accessible for petroleum exploration.

The isolated settler's homes are usually perched on natural levees, along the rivers. Lowlands behind the levees would remain covered with water received during the flood stage for long periods, drying out only shortly before the next year's floods are due to occur. Thus, a large part of the land area of the Delta Amacuro has heretofore been only intermittently avaiblable for cultivation or exploration.

Physiography

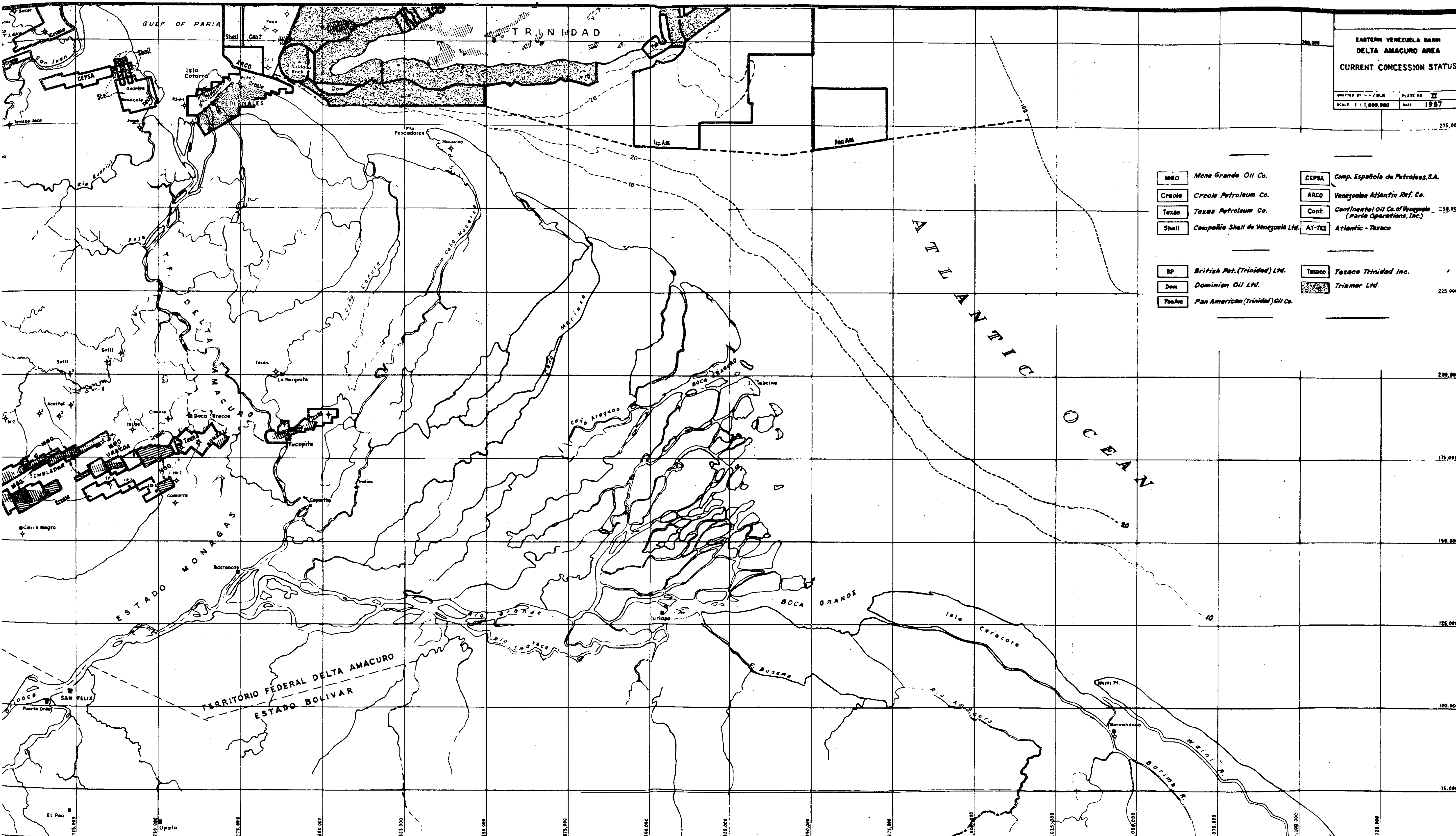
The influence of underlying structure on the morphology of the subaerial part of the delta is strong in some localities, and geomorphologic analysis of the region could facilitate exploration for oil. The seaward profile of the delta is controlled locally by underlying structure: the narrowing of the strait between Trinidad and the subaerial part of the delta at Boca de Serpiente (Pl. IV) reflects the structurally high trend which separates the Paria sub-

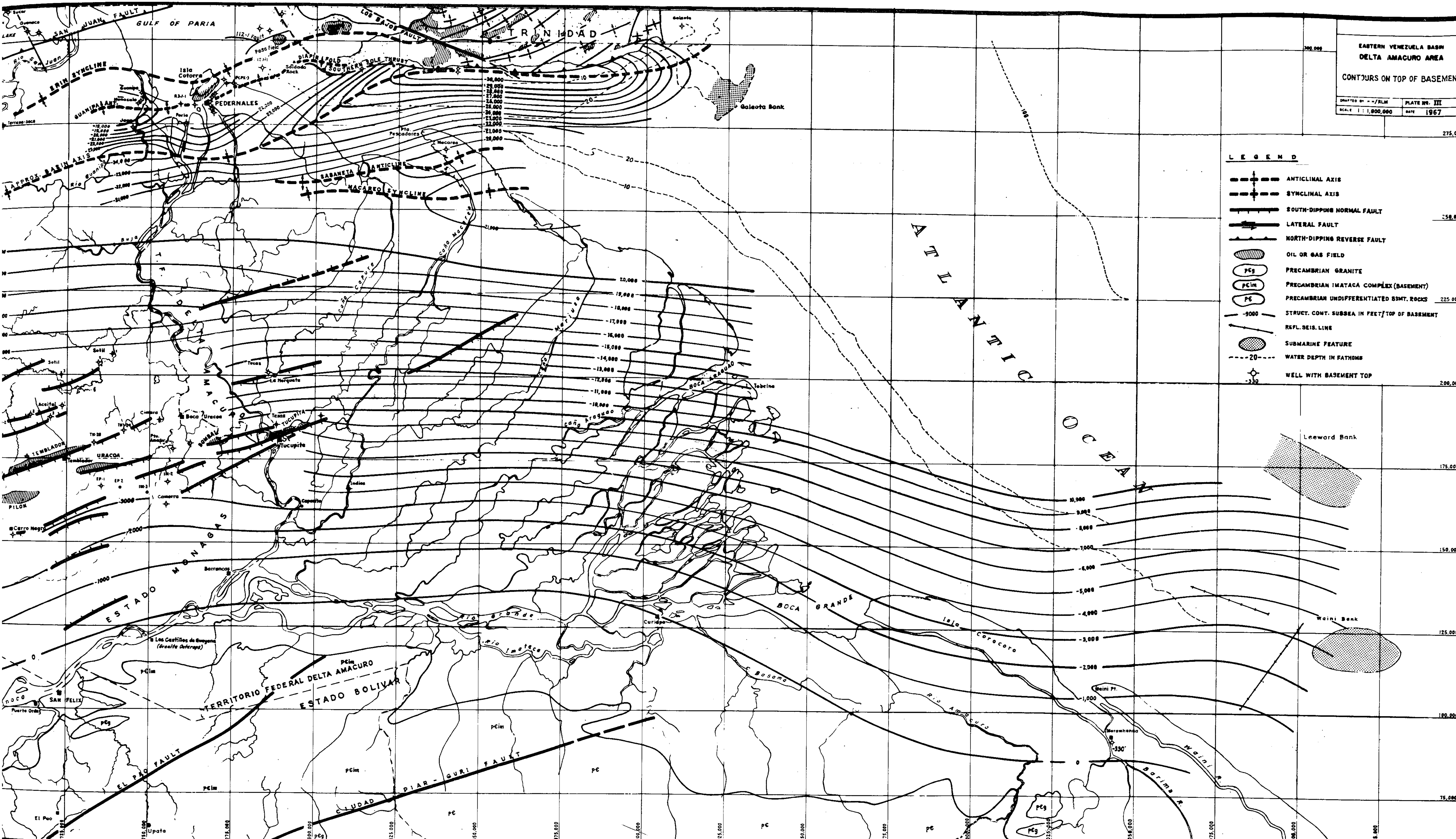
basin from the Orinoco subbasin (Pl. IV). This structural high extends southwestward from Trinidad to Pedernales and beyond (Pl. IV). Drilling and geophysical exploration have outlined parts of this structural high in detail. T. J. H. Van Andel (1967) indicates that the velocity of the northwest-flowing currents along the front of the delta increases at Boca de Serpiente. This increase in velocity would rule out simple sedimentary accretion as the cause for the formation of shoreline bulges at Punta Pescadores and Pedernales (Pl. III and IV). The bulges are probably the result of active structural uplift or differential compaction along the Trinidad-Pedernales high and the Sabaneta anticline. The high trends are also expressed by differential development of microdrainage in the subaerial part of the delta, as can be observed on air photos.

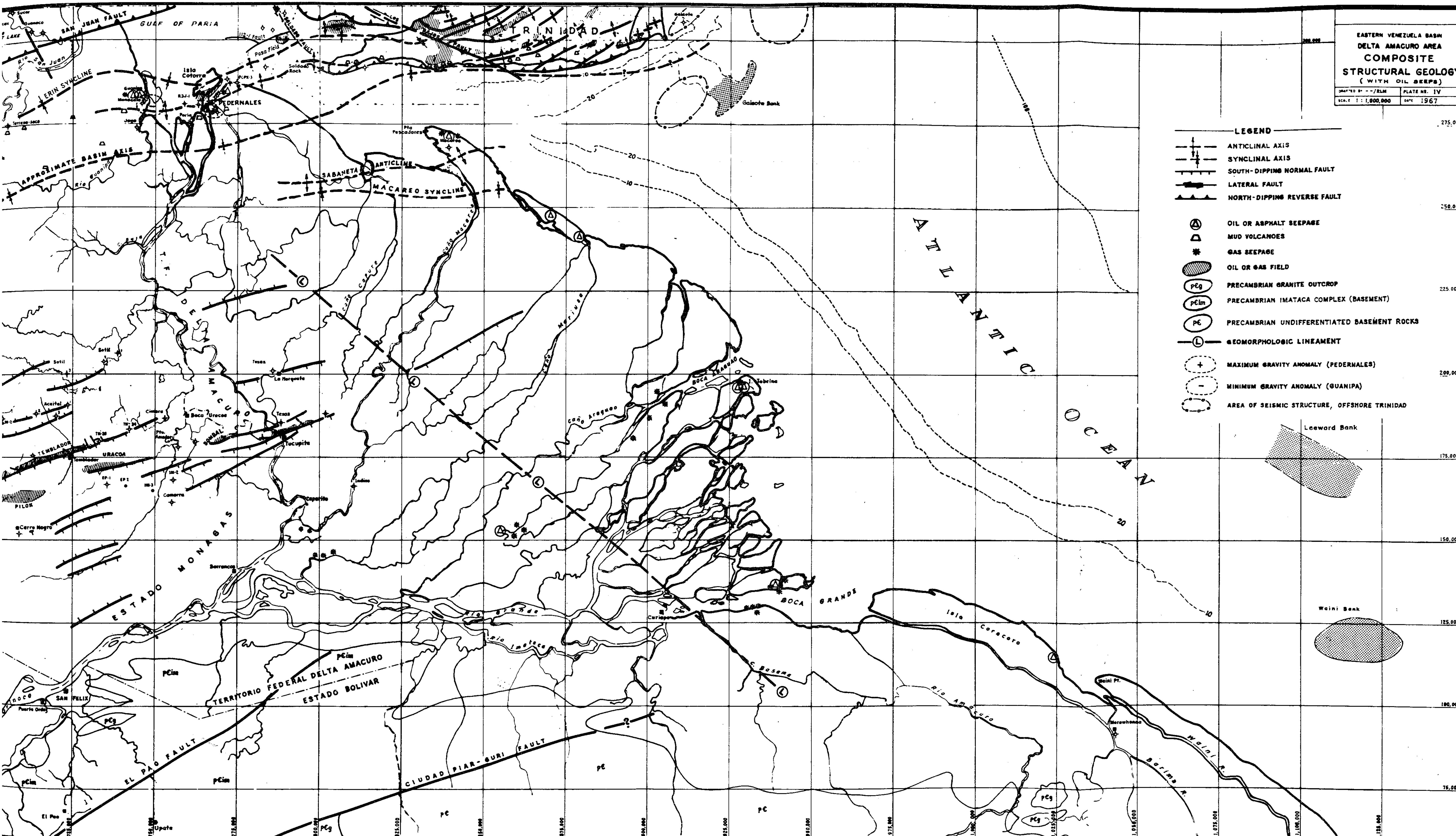
Other morphological features of the delta which are probably associated with underlying structure can be observed on photomosaics and even on physiographic maps. T. J. H. Van Andel (1967) has called attention to some of the most striking of these features, without indicating their probable structural implications. On the other hand, there are some geomorphic anomalies which cannot be attributed with certainty to the presence of underlying structure, because of insufficient subsurface data, and inadequate field check. An outstanding surface feature is a lineal trend of right-lateral deflections which cuts across many of the distributaries of the delta (Pl. IV). This lineament could be the expression of recently active, right-lateral wrench faulting. The Tucupita structural high is also expressed at the surface as a drainage anomaly.

It appears that in the Orinoco delta the extremely low relief favors the expression of even minor structural deformation. Surface elevation, drainage type, deposition, erosion and base level are in such delicate balance within the subaerial part of the delta, that the response to a change in one of them, caused by structural factors, is almost instantaneously reflected in the others.

The general development of surface drainage suggests that the northwestern part of the delta surface is older than the southern part. A tentative conclusion is that, if allowance is made for minor variations, the main area of infilling may have generally shifted toward the south during the period involved in the deposition of the present delta surface.


EASTERN VENEZUELA BASIN
DELTA AMACURO AREA
CURRENT CONCESSION STATUS
DRAFTED BY H.H./RLM
PLATE Nº II
SCALE 1 : 1,000,000
DATE 1967
MGO Mene Grande Oil Co.
Creole Creole Petroleum Co.
Texas Texas Petroleum Co.
Shell Compañia Shell de Venezuela Ltd.
CEPSA Comp. Española de Petroleos, S.A.
ARCO Venezuelan Atlantic Ref. Co.
Cont. Continental Oil Co. of Venezuela (Paria Operations, Inc.)
AT-TEX Atlantic - Texaco
BP British Pet. (Trinidad) Ltd.
Dom Dominion Oil Ltd.
PanAm Pan American (Trinidad) Oil Co.
Texaco Texaco Trinidad Inc.
Trinmar Ltd.
GULF OF PARIA
TRINIDAD
ATLANTIC OCEAN
Soldado Rock
Isla Cotorra
PEDERNALES
Pta. Pescadores
Macareo
Caño Macareo
Caño Capure
Rio Guanipa
Buja
T. F. DELTA AMACURO
San Juan
Guanipa
Jobo
Terrano-Seco
Sotil
Aceitel
Cimbra
Boco
Urecoa
TEMBLADOR
URACOA
Tamorra
Cerro Negro
Texas
La Morqueta
Tucupita
Indios
Caporito
Barrancas
ESTADO MONAGAS
Caño Mariusa
Caño Araguao
BOCA ARAGUAO
I. Tabeina
BOCA GRANDE
Isla Coracoro
Curiapo
Rio Grande
Rio Imataca
C. Busama
R. Amacuro
Waini Pt.
Morawhanna
Waini R.
Barima R.
Orinoco
SAN FELIX
Puerto Ordaz
El Pao
Upata
TERRITORIO FEDERAL DELTA AMACURO
ESTADO BOLIVAR
Pan Am
Dom
Shell
Cont
ARCO
Creole
CEPSA
20
10
100
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
725,000
750,000
775,000
800,000
825,000
850,000
875,000
900,000
925,000
950,000
975,000
1,000,000
1,025,000
1,050,000
1,075,000
1,100,000
1,125,000


EASTERN VENEZUELA BASIN
DELTA AMACURO AREA
CONTOURS ON TOP OF BASEMENT
PLATE NO. III
SCALE 1 : 1,000,000
DATE 1967
LEGEND
ANTICLINAL AXIS
SYNCLINAL AXIS
SOUTH-DIPPING NORMAL FAULT
LATERAL FAULT
NORTH-DIPPING REVERSE FAULT
OIL OR GAS FIELD
PRECAMBRIAN GRANITE
PRECAMBRIAN IMATACA COMPLEX (BASEMENT)
PRECAMBRIAN UNDIFFERENTIATED BSMT. ROCKS
STRUCT. CONT. SUBSEA IN FEET/TOP OF BASEMENT
REFL. SEIS. LINE
SUBMARINE FEATURE
WATER DEPTH IN FATHOMS
WELL WITH BASEMENT TOP
GULF OF PARIA
SAN JUAN FAULT
LOS BAJOS FAULT
TRINIDAD
Galeota Bank
PEDERNALES
Isla Cotorra
SOUTHERN SOLE THRUST
SABANETA ANTICLINE
MACAREO SYNCLINE
ATLANTIC OCEAN
Tucupita
TERRITORIO FEDERAL DELTA AMACURO
ESTADO MONAGAS
ESTADO BOLIVAR
EL PAO FAULT
CIUDAD PIAR - GURI FAULT
BOCA GRANDE
Isla Corocoro
Leeward Bank
Waini Bank
Barrancas
Curiapo
SAN FELIX
Puerto Ordaz
El Pao
Upata
Rio Grande
Rio Imataca
Rio Amacuro
Barima R.
Waini R.


EASTERN VENEZUELA BASIN
DELTA AMACURO AREA
COMPOSITE
STRUCTURAL GEOLOGY
(WITH OIL SEEPS)
DRAFTED BY – –/RLM
PLATE NR. IV
SCALE 1 : 1,000,000
DATE 1967
LEGEND
ANTICLINAL AXIS
SYNCLINAL AXIS
SOUTH-DIPPING NORMAL FAULT
LATERAL FAULT
NORTH-DIPPING REVERSE FAULT
OIL OR ASPHALT SEEPAGE
MUD VOLCANOES
GAS SEEPAGE
OIL OR GAS FIELD
PRECAMBRIAN GRANITE OUTCROP
PRECAMBRIAN IMATACA COMPLEX (BASEMENT)
PRECAMBRIAN UNDIFFERENTIATED BASEMENT ROCKS
GEOMORPHOLOGIC LINEAMENT
MAXIMUM GRAVITY ANOMALY (PEDERNALES)
MINIMUM GRAVITY ANOMALY (GUANIPA)
AREA OF SEISMIC STRUCTURE, OFFSHORE TRINIDAD
GULF OF PARIA
SAN JUAN FAULT
TRINIDAD
ERIN SYNCLINE
APPROXIMATE BASIN AXIS
PEDERNALES
Isla Cotorra
Galeota Bank
SABANETA ANTICLINE
MACAREO SYNCLINE
ATLANTIC OCEAN
Leeward Bank
Weini Bank
T. F. DELTA AMACURO
ESTADO MONAGAS
TERRITORIO FEDERAL DELTA AMACURO
ESTADO BOLIVAR
EL PAO FAULT
CIUDAD PIAR-GURI FAULT
BOCA GRANDE
Rio Grande
Isla Curacoro
Rio Amacuro
Tucupita
Barrancas
SAN FELIX
Puerto Ordaz
El Pao
Upata
TEMBLADOR
URACOA
PILON
Cerro Negro
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000

PAST EXPLORATION EFFORTS

The Delta Amacuro area has received attention on the part of oil companies since an early date for several reasons, among which mention should be made of the many surface manifestations of oil and gas in various forms, including pitch lakes such as Guanoco, and shows associated with mud volcanoes (Pl. IV).

In 1890, the Graham Co. of Trinidad began exploitation of asphalt and heavy oil from shallow wells located around a pitch lake near Pedernales. They even installed a small refinery. The Graham Co. operated only a short time, but a Venezuelan company took over the operations and later, in 1900, a German group tried their luck. Efforts were abandoned after a couple of years and no further exploration or production occurred anywhere in the Delta Amacuro until 1918.

The Caribbean Petroleum Co. began drilling in 1918 in the Guanipa area on the shore of the Gulf of Paria west of Pedernales on an anticlinal feature which was later realized to be an extension of the Pedernales diapir fold. Low gravity oil was encountered but no commercial production resulted.

All of the above efforts were located on the northern fringe of the delta in relatively accessible places. Practically nothing was done elsewhere until 1920.

Proximity of the delta to Trinidad made British Controlled Oil Fields the first company to become significantly active in this area. This company acquired concessions in the 20's, with exploratory titles to 1,202,000 hectares via various subsidiaries, and did field reconnaissance work and test drilling between 1920 and 1924. One well, Macareo-1, was drilled near Punta Pescadores but nothing is known about the results except that the T. D. was 1,612' and the well presumed abandoned for mechanical reasons. They also drilled on Isla Tobeina (Pl. IV) near oil seeps but not even the locations are known today. The Tobeina wells were shallow and some were drilled by manually operated rotary units.

For the purpose of historical interest, Plate I, shows the concession coverage in the Delta Amacuro as of May, 1928. British Controlled under names such as Tucupita Oil Fields, Pedernales Oil Fields, etc., as well as a few other companies, had nearly all of the delta under lease at that time. This map should be compared with the present day ownership map (Plate II).

British Controlled did not undertake any further work and most of the concessions were eventually farmed out to Standard Oil of Venezuela (now Creole), which company did the first reflection seismic work.

Standard Oil of Venezuela had acquired 1,000,000 hectares by 1932, but over the years, gradually renounced acreage until their holdings were reduced to 14,286 hectares in the Pedernales area, a concession which they still hold today.

SOV (Creole) spudded Paria-1, their first well in the National Territory, on December 9, 1931, and abandoned dry on February 27, 1932, at 5,066'. Activity was concentrated in the Pedernales area on the north fringe of the delta where a large anticlinal feature was detected. The first producer in the delta, Pedernales-2, was spudded on February 5, 1933 and

completed for 5,000 BOPD at 1,543' on April 5, 1933. Other exploratory wells drilled during that decade were Amacuro-1 to -6, Amacuro -9, Cotorra -1 to -5, all in the Pedernales Field, and Indios -1.

The Pedernales discovery in 1933 stirred renewed interest in the delta, and several companies eventually competed to pick up concessions which Creole (SOV) had renounced, as well as open acreage.

Those companies were as follows: Texas, Shell, Atlantic, Richmond (now Chevron) and Seaboard. Most of this acreage was subsequently renounced leaving only Texas and Atlantic as title holders of comparatively small patches. Exploration drilling was concentrated by these operators in the area around Pedernales except for the Texas Co. which discovered the Tucupita Field in 1945. Indios-1, a dry hole by Creole on the Caño Macareo, was the only other exception.

Apparently most companies were reluctant to embark upon major drilling campaigns because of high drilling costs in an isolated, swampy area. Also attention was shifted away from the delta by sensational discoveries and activity elsewhere in the Eastern Venezuelan basin (Quiriquire in 1928, Jusepin in 1938, Oficina in 1937, etc.).

STRUCTURE

The south flank of the basin (Pl. III and IV) is essentially a regional monocline dipping to the north, away from the Orinoco River and from the southern edge of the basin at low but variable rates ranging from 150' per mile to 450' per mile. This structure is modified by northdipping and south-dipping normal faults trending approximately N 60° E. Major fault trends studied at the surface in the Guayana Shield south of the Orinoco River maintain the same bearing. Our plates show only those faults currently in the literature (with the exception of a major feature, probably a fault, inferred from aerial photographs). It is probable, however, that fault density in the delta proper, where control is limited, should be comparable to that indicated for the area west of Caño Manamo. As in the Greater Oficina area, south-dipping faults are expected to trap most of the oil present in Territory Delta Amacuro.

A long lineament which trends NW and connects a series of parallel deflections of streams is shown on plate IV. The right-lateral displacement of streams is more apparent on the photomosaics than on the base map accompanying this paper. This lineament could be associated with an active fault which has a strong right-lateral component of slip. Wrench faults of this type are common on the north flank, and some have roughly the same strike as the lineament (Los Bajos, Soldado and San Francisco faults, Pl. IV). Wrench faults have not been reported on the south flank of the basin, to our knowledge.

Within the delta, aerial photos reveal incised gullies, parallel curvilinear deflection of streams, changes in regimes, rectangular drainage and other stream patterns which are believed to express local structural changes. Some of these areas are on, or near, known features such as the Tucupita faults, the Pedernales gravity high and the Macareo syncline.

Broad anticlinal and synclinal features of the supratenuous type have been found in the south flank of the basin. Two such features, the Sabaneta anticline and the Macareo syncline are in the northeastern part of the delta (Pl. IV).

In marked contrast with the south flank, the structure of the north flank of the basin is quite complicated. Compression folds, diapir folds, exotic blocks, thrust faults, and wrench faults are common (Pl. IV).

The Pedernales anticline is a long structure which extends eastward, across the Gulf of Paria, to Trinidad (Pl. III). The fold appears to bifurcate west of Pedernales with a northern branch extending at least as far as the Guanipa area (Pl. IV). This major fold can thus be traced for a distance of 70 kilometers and may extend beyond Guanipa. The north flank of the Pedernales field ends in the Erin syncline, the axis of which is believed to pass through Isla Cotorra (Pl. II).

The Pedernales anticline is characterized on the surface by mud volcanoes and exotic blocks such as Soldado Rock in the Gulf of Paria (Pl. IV). It is diapiric with a central core of intruded clay (Barnola, 1960). Because of clay piercement, structure of the crestal zone is complicated by displaced blocks and mixing of fauna. Slumping might be present on the upper part of the flanks.

There are many strike-slip (wrench) faults in the northern area as shown on Pl. IV. Notable among these faults is the Soldado fault (Pl. IV) which displaces structures laterally by as much as 3 kilometers. The Los Bajos fault cuts diagonally across the southern part of Trinidad and displaces features laterally by approximately 34,000 ft. (Wilson, 1965). The Posa fault in the Gulf of Paria (Pl. IV) appears to be a complicated feature consisting of a rupture along the crestal portion of a diapiric fold and possibly having its predominant movement in a lateral direction, although it is usually shown as a down-to-the north fault in the immediate area of the Posa field (Renz, 1963).

STRATIGRAPHY

PRECAMBRIAN- The crystalline (igneous and metamorphic) basement has not been reached in wells in the north flank of the map area. In the geosynclinal trough, it is inferred as deep as 26,000' below sea level. Basement rocks have been encountered in several wells in the south flank and crop out south of the Rio Orinoco (Pl. III).

The border of the Guayana Shield, which rims the basin on the south, variously consists of gneisses, amphibolites, iron formation and migmatites of the Imataca Complex, as well as granites not belonging to that complex and other undifferentiated igneous rocks. (Kalliokoski, 1965, and G. C. McCandless, 1966).

CRETACEOUS- The Cretaceous rocks of the south flank are represented by the Temblador Group, deposited in a shallow sea and becoming progressively less marine southward toward the Orinoco River. The beds of this group range in age from the Lower Cretaceous to the Upper Cretaceous and perhaps even the Paleocene. The Temblador Group rests directly on basement and is overlain unconformably by the Oficina Formation of Lower Miocene age. In the Delta

Amacuro area, the group consists of a lower section (Canoa Formation) made up of non-marine, mottled sandstones, siltstones and shales and an upper section (Tigre Formation) of glauconitic sandstones, siltstones and shales deposited in a shallow marine environment. The marine character of this upper section appears to be best developed west of the Delta Amacuro in Anzoátegui State, where dolomitic limestones are also present. Many of the Temblador sands found in Anzoátegui are tight, but such may not be the case in the Delta Amacuro.

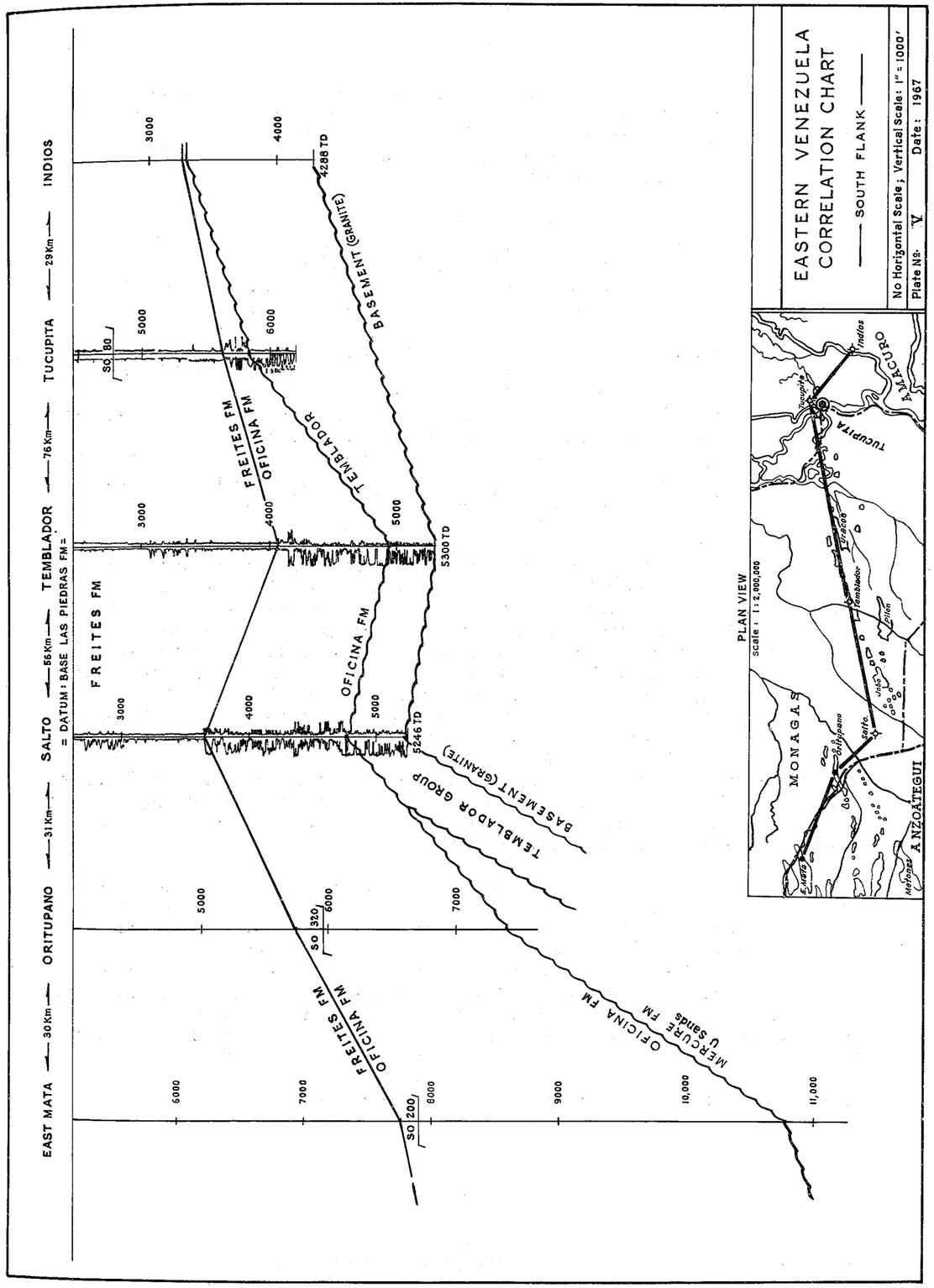
The Temblador Group is well known in the Tucupita and Temblador fields. On the basis of electric logs, it is sometimes difficult to pick the exact break between the Temblador and the Oficina Formation, both often consist of similar sands near the unconformity. This gives rise to the possibility that some of the oil being produced at Tucupita may come from Temblador sands lying immediately below the unconformity.

Plate V (cross section) shows the Temblador Group to increase in thickness eastward into the Delta Amacuro where it is estimated that in well Indios-1 it may attain a thickness of 1,000 feet. The development of the Temblador, farther to the east, in the deep delta, is still a matter of conjecture. It may prove to be a petroliferous unit.

In the north flank of the basin, the Cretaceous is well known in outcrops in the Serrania del Interior outside the map area. The limit of Cretaceous outcrops falls just outside the northwest corner of our base map (Pl. IV). Total thickness of the Cretaceous in the Serrania del Interior is at least 12,000 feet in outcrops, but the base is not exposed. Cretaceous stratigraphic units of the north flank differ considerably from the thin Temblador Group of the south flank. The north flank section is broken down into three groups, which are listed in Table I below.

TABLE I
CRETACEOUS UNITS, SERRANIA DEL INTERIOR

Age	Group, Formation	Lithology
Campanian to Paleocene	Santa Anita Group (San Juan, Vidoño and Caratas formations).	Over 2,300' in thickness. Hard massive sandstones (San Juan Fm.). Foraminiferal dark shales and subordinate sandstones (Vidoño Fm.), and glauconitic dolomites, dolomitic limestones, siltstones and subordinate sandstones (Caratas Fm.).
Cenomanian to Campanian (mainly Turonian)	Guayuta Group (Querecual and San Antonio formations).	Maximum thickness 3,700'. Querecual Fm. Black limestones and calcareous shales equivalent to La Luna Fm. in the Maracaibo Basin. The San Antonio Fm. also includes some sandstones, chert and cherty limestones.
Barremian to Cenomanian	Sucre Group (Barranquín, El Cantíl and Chimana formations).	Quartzitic sandstones (Barranquín Fm.), reefal limestones, shales and sandstones (El Cantíl Fm.), fissile shales, limestones and shales (Chimana Fm.). Maximum thickness about 7,800'.



In the area of the Guanoco Asphalt Lake, the limestones and shales of El Cantil-Chimana formations or other units of the Sucre Group, would probably be reached in moderate to deep wells but this area is outside the delta proper. Presumably only very deep wells would reach Cretaceous units in the north flank of the delta, south of Pedernales.

TERTIARY.- The Tertiary of the south flank in the base map area begins with the Oficina Formation of Lower Miocene age (Renz et al., 1963), which rests unconformably on the Cretaceous Temblador Group. The intermediate Merecure Formation (Eo-Oligocene), present west of the map area in Central Anzoátegui, is absent in the delta area (see cross section, Pl. V).

The Oficina Formation in the delta is much thinner than in the Greater Oficina area of Anzoátegui. At Tucupita it is only 200' thick. In the delta, it consists of a lower sandstone section, productive of oil in the Temblador-Tucupita trend, and an upper siltstone-shale section with subordinate sandstone. The eastward and southward thinning of the Oficina Formation is illustrated by Pl. V. Some geologists believe that the Oficina Formation should be altogether absent east of Tucupita, as it has supposedly not been found in the Coastal Plain of Guyana (Pl. III). North and northwest of Tucupita the formation should thicken.

Absence of the Oficina Formation east of Tucupita, if such is actually the case, may be due to non-deposition or removal by erosion. The first possibility could be explained as follows: During Oligocene time the Eastern Venezuelan Basin had a northeast-southwest depositional axis, regional dip was to the northwest, and the Greater Oficina area in Anzoátegui and Monagas marked the site of an ancestral Orinoco Delta. The southeast portion of the present-day delta and Guyana were probably high areas of non-deposition during this time. Tilting eastward during the late Tertiary caused a shift in the depositional axis towards its present east-west trend. The south flank of the Delta Amacuro area thus received sediments of Miocene to Pleistocene age, represented by the marine Freites Formation (Miocene shales mainly) and the Las Piedras Formation (Pliocene) made up of alternations of sands and shales of brackish and terrigenous, possibly deltaic, sedimentation. This was followed by Pleistocene and finally recent sediments which are still accumulating in the present-day delta.

Overlying the Oficina Formation in the south flank are the Freites, Las Piedras and Mesa formations in that order. The Freites Formation (Miocene) is essentially a shale unit with minor silt rhythms. The Las Piedras Formation (Pliocene) is well developed in Tucupita where it contains many sands, some of which are massive. These Las Piedras sands could be good reservoirs although they are non-productive in Tucupita. The Mesa Formation of Pleistocene to Recent age, may be replaced in the Delta Amacuro by the Paria Formation which is described at Pedernales (Hedberg, 1950) and is composed of clays and silts (Pl. VI). The Mesa and Paria formations rest unconformably on the Las Piedras Formation.

The stratigraphy of the Tucupita area is summed-up in Table 2.

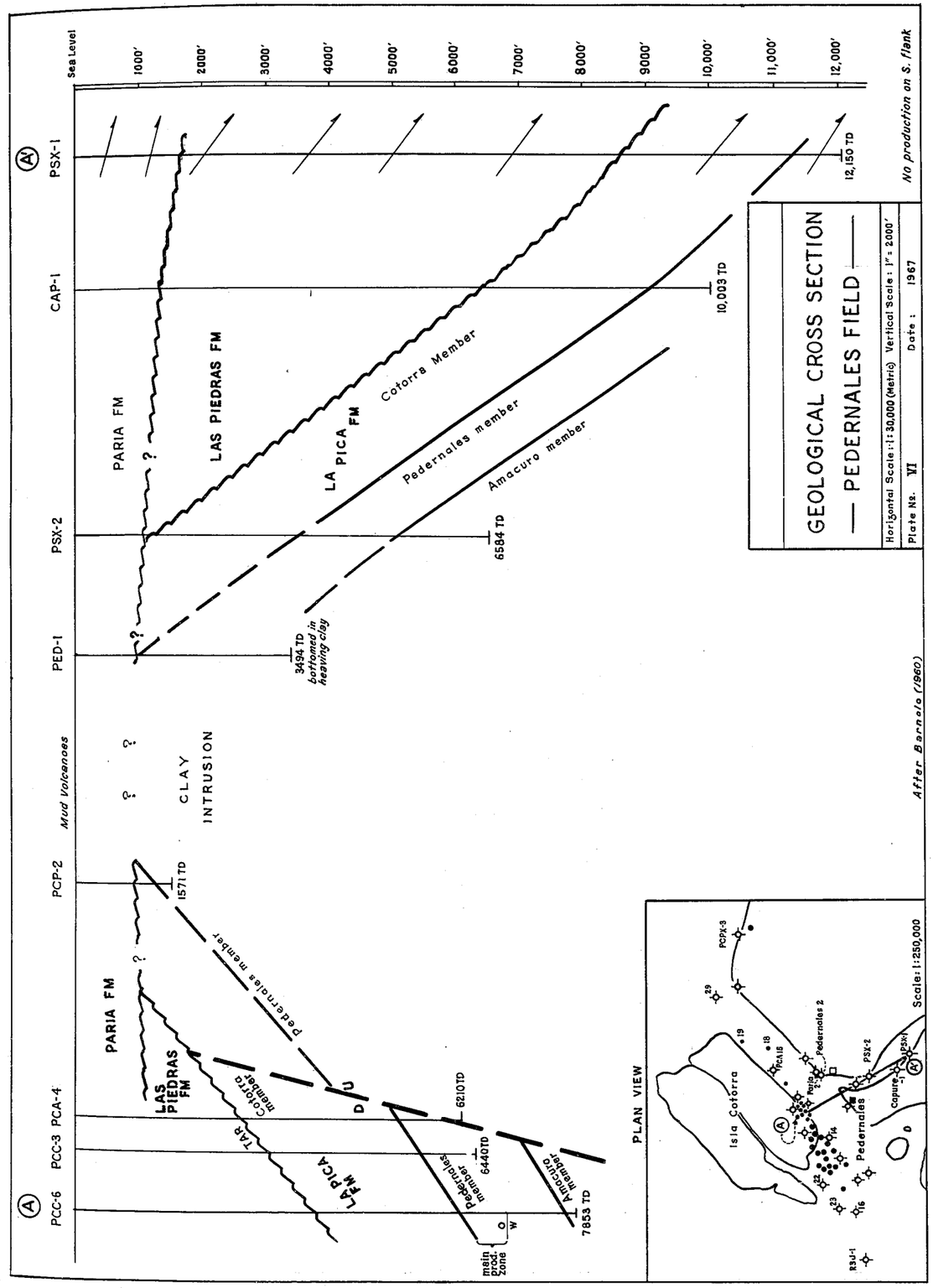


TABLE 3

TERTIARY UNITS, SOUTH-CENTRAL GULF OF PARIA AND PEDERNALES

	Southern Gulf Of Paria	Pedernales Area
Quaternary	Paria	
Pliocene	Las Piedras	
Miocene	Forest	La Pica
	Cruse	
	Lengua	Carapita
Oligocene	Cipero	
Eocene	Not Reached	Found in Well PCPX-3

TABLE 2

STRATIGRAPHY OF TUCUPITA AREA

Pleistocene-Recent	Mesa Formation or equivalent, thin veneer.
Pliocene	Las Piedras Formation, approximately 4,200' thick, consisting of gray shale, claystone and sand intercalations of brackish and continental origin.
Miocene	Freites Formation, approximately 1,000' of greenish gray marine shale.
Lower Miocene	Oficina Formation, about 200' thick. Top half is dark gray shale and lower part is mostly sandstone with shale intercalations. Total net sand up to 100' thick.
Cretaceous	Temblador Group, up to 2,300' thick, mostly sandstone of continental origin.
Precambrian	Basement made up of igneous (granite) and metamorphic rocks (Guiana Shield). Basement was reached in TUC-1, the Tucupita discovery well, at 6,873'.

The Tertiary of the north flank is better developed and more complete. Thicknesses on the order of 30,000'-40,000' have been attained in the Serrania del Interior.

In this paper, the description of the Tertiary of the north flank will be devoted mainly to the Pedernales-Gulf of Paria region (Pl. IV), on the north fringe of the delta, where well density has permitted a detailed analysis of the stratigraphy.

Pedernales - Gulf of Paria, Tertiary Formations

Table 3 is a simplified stratigraphic chart showing the broad relationship of Tertiary units in the south-central part of the Gulf of Paria with those of Pedernales. In this paper, the identification of formations in the Gulf of Paria follows the Trinidadian terminology.

The southern part of the Gulf of Paria is generally known as the Cruse Basin because of the presence of an oil-bearing Miocene formation of that name. The Cruse Basin, in the area between the 112-1 (Posa) fault and the seaward extension of the Pedernales fold, is characterized by southerly (also southeasterly) - derived marine sands of Middle and Upper Miocene age (Forest and Cruse formations) overlying a thick, generally monotonous, sequence of Lower Miocene (Lengua Fm.) and Mio-Oligocene (Cipero Fm.) sediments, the bulk of which are shales. Units older than the Oligocene have not been reached by the drill in this part of the gulf. However, the Upper Eocene is expected to be present in the Cruse Basin because it has been identified in the adjacent Pedernales Field area. Paleocene rocks should also be present in the subsurface. A rootless limestone block (Soldado Rock) which appears as a small island near the crest of the diapir fold in the Boca de Serpiente (Pl. IV), contains a rich molluscan and foraminiferal fauna of Paleocene age (Salvador and Stainforth, 1965; and Bolli, 1952). The Soldado exotic block may have traveled to the surface via the plastic clay-flow of the diapir.

The units in the Pedernales-Gulf of Paria area are discussed from youngest to oldest in the following paragraphs.

Paria Formation (Quaternary)

The Paria Formation consists of clay and silt. It lies unconformably on the Las Piedras Formation and is differentiated from it by lithology and dip. Average dips in the Paria Formation in the subject area are 15°. Dips in the underlying Las Piedras Formation are generally steeper, up to 40°. The Paria Formation is roughly 1,000-1,700 feet thick in the Pedernales Field.

Las Piedras Formation (Pliocene)

The Las Piedras Formation is predominantly sandy and contains plastic clays and silts with generally abundant macrofossils. It rests unconformably on the underlying Forest Formation (Upper La Pica) and is differentiated from it by a higher sand content. The Las Piedras Formation thickens rapidly down-dip on either flank of the Pedernales diapir fold (Pl. VI). It could increase in thickness from a range of 1,000' to 6,800' in the drilled portion of the south flank of the Pedernales structure, to possibly over 12,000' in the vicinity of the basin axis. It has been reduced by erosion and thinning over the crest of the Pedernales fold. Its age is Pliocene to Pleistocene.

Forest Formation (Upper Miocene)

This unit is ordinarily 900' to 1,000' thick in the Gulf of Paria, and consists of claystones and clayey sands. It is equivalent to the middle and upper part of the Cotorra Member of the La Pica Formation at Pedernales. It rests conformably on the Cruse Formation.

Cruse Formation (Middle and Upper Miocene)

This petroliferous formation consists of shallow marine shales and bar-type sand lenses deposited in a generally regressive environment. An erosional interval occurs approximately in the middle of the unit in the gulf. The shales and sand groups are correlatable with the help of paleontological studies and can be traced as sub-units throughout the Cruse Basin in the gulf. Four sand groups and five shaly intervals are usually differentiated.

The Cruse Formation is equivalent to all but the uppermost of the La Pica Formation. It embraces the Amacuro and Pedernales members as well as the basal part of the Cotorra Member of the La Pica Formation at Pedernales. It ranges from 3,500' to 4,500' in thickness.

Lengua Formation

This formation, as known in the Gulf of Paria, is essentially a shale formation with occasional thin sands. Spheroidinella dehiscens and Globorotalia menardii are common marker fossils. A tongue of the Lengua Formation appears to reach into at least the eastern part of the Pedernales Field but it is not recognized as a unit in Venezuelan nomenclature. It would be roughly equivalent to the upper part of the Carapita Formation (Venezuela). In well PCPX-3, it may be 2,600' thick.

Cipero and Carapita Formations (Miocene-Oligocene)

In the south-central Gulf of Paria the Cipero Formation contains a pelagic fauna and consists of a thick monotonous shale sequence underlain by chalky limestones, limy sandstones, silts and shales. The type section of the Cipero Formation is on the west coast of Trinidad, immediately north of the mouth of the Cipero River. The type section has been described in detail by Stainforth (1948). He states that the apparent thickness at that locality is 2,300 feet but that due to imbrication and internal thrusting the measurements are not exact.

In Pedernales, Barnola (1960) assigns 150M (493') to the Carapita Formation in well PCPX-3. The Carapita Formation is a shallower deposit equivalent in age to the Cipero, both being mainly Miocene but extending down into the Oligocene.

Navet Formation (Upper Eocene)

Approximately 1,127' of rocks of this age were drilled in well PCPX-3 in Pedernales. The base of the unit was not reached. It consists of calcareous and silty shales bearing the marker fossil Hantkenina alabamensis. This unit is generally referred to as the Navet Formation in Pedernales (H. H. Renz, 1963). Rocks of this age were not reached by the drill in the Posa Field of the south-central gulf.

OIL AND GAS OCCURRENCE AND PETROLEUM SOURCE ROCKS

Surface manifestations of oil and gas are plentiful, especially in the north flank of the delta where they are commonly associated with mud volcanoes (Pl. IV).

The oil and gas seepages reported by British Controlled Oilfields' geologists in the south flank, such as those on Caño Araguas and Isla Tobeina, are of special interest (Pl. IV). Some of these seepages have been discredited by other geologists who did later work there and who contended that these seeps were either float from ships or marsh gas rather than petroleum gas. While it is possible that some of these seepages may be of such a nature, it is believed that others are true oil seeps and heavier-than-methane gas seepages (J. Netick, personal communication). Oil has also been reported filling seismic shot holes during some of the surveys done in later years east of Tucupita.

Occurrences of pitch have also been verified south of the Orinoco Delta along the Guyana coast from the Waini River southward (Stockley, 1956). A well drilled near the Venezuelan border at Morawhanna had shows of heavy oil (Pl. III). Basement was encountered at a shallow depth (330') in the Morawhanna well (Simakov and Fedynsky, 1962).

Pitch or asphalt lakes of considerable size occur on the north flank of the basin, the best known being the Capure pitch lake near Pedernales and the larger Guanoco lake in the northwest corner of the map area (Plate IV). Attempts to produce oil and asphalt at Capure were unsuccessfully made in 1890. The Guanoco pitch lake yielded commercial production and is discussed later in this chapter.

As regards the stratigraphic distribution of oil in the Delta Amacuro area, the Temblador and Oficina formations contain oil reservoirs in the south flank (Tucupita, Bombal). There is actually a very tenuous lithologic break, if any, between the Temblador and Oficina formations at Tucupita, and the contact on electric logs is somewhat arbitrary. Thus, some oil reservoirs at Tucupita are assigned to the Upper Temblador in close proximity to Oficina reservoirs.

Post-Oficina formations are nonproductive so far in the delta, but this does not mean that they will be everywhere non-petroliferous. The Freites Formation, if of marine character and of the type found in the Greater Oficina area, may not be considered a source rock, if a La Pica-type facies is present within the Freites Formation, it should be considered a potential source of oil. The Las Piedras Formation is not very productive in Eastern Venezuela except in the north flank of the basin (Pirital, Quiriquire), where the largest single field in Eastern Venezuela produces oil from continental Las Piedras sands at Quiriquire.

Oil in the Pirital and Quiriquire fields is generally considered to be migrated oil from older formations (Carapita, Cretaceous, etc.) and reservoired in younger continental sands. While this may well be so, we wish to emphasize the possible in situ origin of this oil. There is strong evidence for a non-marine history of most of the commercial oil found in Eastern Venezuela (Banks, 1966). The deltaic environment, as an Oficina-type environment, where land-derived organic matter may accumulate and be preserved as petroleum and/or coal, is strongly favored as a potential petroleum source.

According to Kidwell and Hunt (1958), petroleum or petroleum-like hydrocarbons have been found in recent delta sediments. These geologists analyzed samples of the Paria Formation at Pedernales and reported that some of the petroleum found in the samples is not older than 10,000 years as per C-14 analysis. Samples analyzed were spread from the surface to a depth of 200' above the unconformable contact with the Las Piedras Formation. The quantity of organic matter decreases with depth, from which evidence Kidwell and Hunt conclude as follows: "Because the deeper Pedernales samples are more marine, this decrease may be a reflection of the lesser amounts of organic matter found in moving away from a near-shore environment".

Pedernales - Gulf Paria

The cumulative production of the Pedernales Field at the end of 1964 amounted to 57,409,468 barrels. The field is currently shut-in. All production comes from the north flank of the anticlinal structure.

Production at Pedernales is mostly confined to the Pedernales Member of the La Pica Formation. This section of the La Pica Formation is equivalent to the Cruse Formation (Trinidadian nomenclature in the Gulf of Paria).

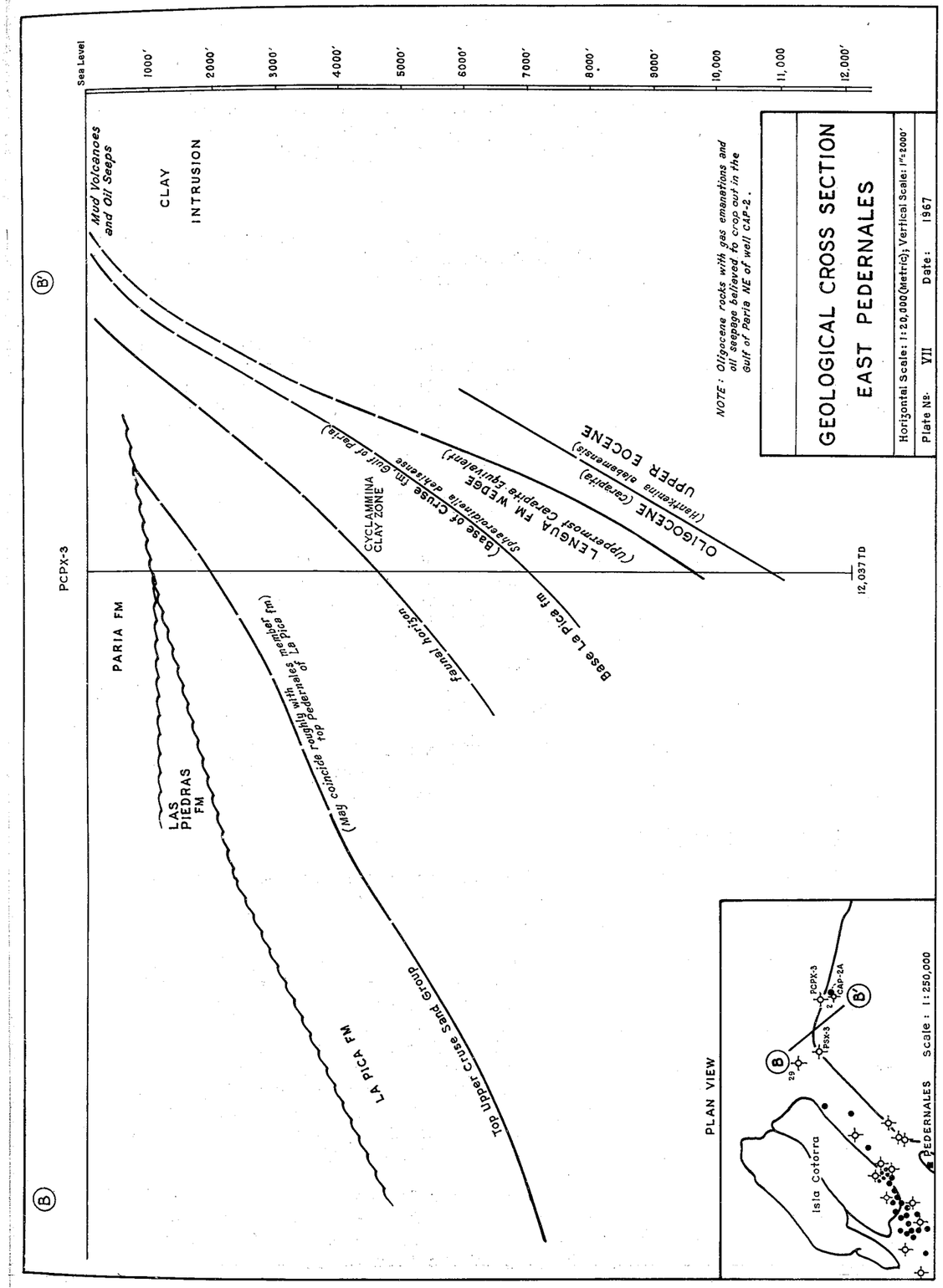
Pedernales crude oil ranges from 17.7° API to 27.2° API, the latter being found in the Amacuro Member of the La Pica Formation (H. H. Renz et al., 1963). The Pedernales Member produces crudes ranging from 17.7° to 21° API and with a high sulfur content (3 to 4%). Porosity of the main producing sands in the Pedernales Member averages 27% and the average permeability is 300 millidarcies (H. H. Renz et al., 1963).

Other formations have had shows at Pedernales. Non-commercial heavy oil and tar locally lie immediately above the unconformity at the base of the Las Piedras Formation. Some gas shows have been noted in the Amacuro Member on the south flank of the fold and some oil (possibly commercial) has been found in the Amacuro Member on the north flank. Shows have been observed in the Lengua Formation of well PCPX-3 and seeps are locally associated with the Oligocene at the surface. (Plate VII).

In the Gulf of Paria, the initial well, Posa 112-1 (Pl. V), drilled by Paria Operations Inc., was dually completed for over 2,000 B/D in sands of the Cruse Formation. Before ceasing operations in 1960, Paria Operations Inc. drilled 13 exploratory wells and 7 development wells, but oil was never again seen in the quantity of the discovery well. In fact, most subsequent wells were dry holes or abandoned as non-commercial wells.

Drilling was accomplished variously from single well tender platforms, over-the-side drilling barges, jack-up barges, and a multiwell platform designed to accommodate 26 directional holes radiating out from the site of the discovery well (112-1).

The cluster of directional wells (7 were drilled) in the Cruse Basin produced poorly. Poor permeability and lenticularity along with abnormally high viscosities in some wells made further development uneconomic. Workovers were also disappointing and it became evident that the wells would



have a very short flowing period at commercial rates. Paria Operations discontinued drilling on the basis of the above. The 112-1 field is reported to have a shut in capacity of only 950 B/D (Renz et al.,1963).

Tucupita

This field, operated by Texas Petroleum Co., produces from Oficina sands (and possible Temblador sands) on the upthrown side of an up-to-basin normal fault. Tucupita is probably the best indicator or what to expect deeper in the delta on the south flank.

The productive Oficina sands are treated as a single reservoir even though these sands have shale intercalations which may or may not be continous enough to establish complete reservoir separation. Porosities may be about 25% on the average and permeabilities are good, up to 5,000 md. Original BHP was 2,500 psi and original GOR's were low, between 150-200. The reservoir produces under a very strong water drive.

The Tucupita crude is sweet, asphaltic base, with an average gravity of 16.6° API. Sulfur content does not exceed 1%.

Tucupita was discovered in 1945. By the end of 1966 the field had produced 46,928,202 barrels of oil (Van Middlesworth, 1967). The peak of production, approximately 11,999 BOPD, was reached in 1952, but the field is still producing about 6,500 B/D (end of 1966).

The total productive area of Tucupita is about 2,000 - 2,100 acres (Van Middlesworth, 1967), but the field may be eventually extended southwestward or northeastward beyond current limits.

Original oil in place, based on 2,000 acres, 25% porosity, 90% oil saturation, 40' of net pay and 97% SF is estimated to be approximately 1691 bbl/acre foot of STOIIP and 135,280,000 bbl total STOIIP.

Guanoco Asphalt Lake

The Guanoco asphalt lake, said to be the largest in the world, is not actually located in the Delta Amacuro but appears on our plates II, III, and IV in the extreme northwest corner.

Efforts to extract pitch at Guanoco began in 1888 when A. H. Carner was guided to the site by Indians (Jimenez, 1913). In 1910, the New York and Bermudez Company was granted an exploitation concession of 11,000 acres covering the lake. This company actively mined the asphalt until 1934. Since that date there has been no additional production of asphalt. The New York and Bermudez Company built an asphalt plant, 17 kilometers of railroad, established a port on the Rio Guanoco (a tributary of the navigable Rio San Juan), and exported at least 1,250,000 metric tons of asphalt. They also drilled 40 shallow wells in the vicinity of the lake and produced about 2,000,000 barrels of 10-11° crude (El Farol, 1951).

It is interesting to note that the asphalt was well known in world markets and was referred to as Bermudez asphalt. Pennsylvania Avenue in Washington, D. C. was originally paved with this material. A deteriorating price situation caused the bankruptcy of the firm in 1934.

The Guanoco Lake covers approximately 1.85 sq. kms. We have no information as to the asphalt reserves. Important reserves of heavy oil may be associated with the Guanoco asphalt.

For comparison, Pitch Lake in Trinidad, a much smaller deposit, has a maximum depth of 285 feet and remaining proven reserves of about 6,000,000 long tons. The minable surface has been reduced to approximately 90 acres. The Trinidadian lake is non-reproducing (Mostofi, 1964). It represents a detached mass of asphalt that migrated vertically because of its low density and became emplaced in the axis of a fold 4,000' above its original postulated position (Kugler, 1965).

Little is known about the geologic mode of occurrence of Guanoco asphalt and heavy oil, but it is surmised that the oil escaped to the surface from Cretaceous rocks at depth along fault planes and fractures as in the case of the Orocual seeps farther to the west in the north flank of the basin. Tertiary sediments occur at the surface. It is said that the Guanoco Lake is an active seep continually replenished as evidenced by the filling up of pits produced by quarrying the asphalt. However, there seems to be no indication that the lake is expanding in surface area.

BIBLIOGRAPHY

ANDEL, Tj. van, 1955

Recent sedimentation on the Orinoco (Abstr.)
Jour. Sed. Pet., vol. 25, no. 2, p. 140

----------, 1967

The Orinoco Delta
Jour. Sed. Pet., vol. 37, no. 2, p. 297-310

----------, & POSTMA, H., 1954

Recent sediments of the Gulf of Paria. Reports on the Orinoco Shelf Expedition, vol. I.
Kon. Ned. Akad. Weten., Verh., vol. 20, no. 5, p. 1-245

BANKS, L. M., 1966

Geologic aspects of origin of petroleum
Amer. Assoc. Petrol. Geol., Bull., vol. 50, no. 2, p. 397-400

BARNOLA, A., 1960

Historia del Campo de Pedernales
III Congr. Geol. Ven., Mem., Tomo II, p. 552-573

BARR, K. W., WAITE, S. T. & WILSON, C. C., 1958

The mode of oil occurrence in the Miocene of Southern Trinidad in "Habitat of oil", AAPG Symposium, p. 533-550

BOLLI, H. M., 1962

Note on the Cretaceous-Tertiary boundary in Trinidad, B. W. I.
Jour. Paleont., vol. 26, no. 4, p. 669-675

CREOLE PETROLEUM CORPORATION, 1951

La región del lago de asfalto de Guanoco será escenario de nuevas actividades
Col. Ing. Ven., Revista, no. 178, p. 19

---------- , 1951

Volverá a producir el lago de Guanoco?
El Farol, p. 2-5

CUMMINGS, J., 1951

Delta del Orinoco: el campo Tucupita plantea diversos problemas
Petrol. Interam., vol. 9, no. 9, p. 84-89

DROOGER, C. W. & KAASSCHIETER, 1958

Foraminifera of the Orinoco-Trinidad-Paria shelf. Reports of the Orinoco Shelf Expedition, vol. IV
Kon. Ned. Akad. Weten., Verh., ser. 1, vol. 22, 108 pp.

HEDBERG, H. D., 1942

Mesozoic stratigraphy of northern South America
8th Amer. Sci. Congr., Proc., vol. 4, p. 195-227

_____, 1950

Geology of the Eastern Venezuela Basin
Geol. Soc. Am., Bull., vol. 61, no. 11, p. 1173-1215

_____ & PYRE, A., 1944

Stratigraphy of northeastern Anzoátegui, Venezuela
Amer. Assoc. Petrol. Geol., Bull., vol. 28, no. 1, p. 1-28

HERRERA-FIGUEREDO, L., 1938

Características del desarrollo de los campos petrolíferos en Venezuela
Rev. de Fomento (Venezuela), vol. 2, no. 8, p. 36-41

JIMENEZ, G., 1913

El lago de asfalto de Guanoco (Estado Sucre) perteneciente a la New York and Bermúdez Company
Rev. Tec. Min. Obras Publ., Caracas

KALLIOKOSKI, J., 1965

Geology of north-central Guayana Shield, Venezuela
Geol. Soc. Am., Bull., vol. 76, no. 9

KIDWELL, A. L. & HUNT, J. M., 1958

Migration of oil in Recent sediments of Pedernales, Venezuela
in "Habitat of Oil", AAPG Symposium, p. 790-817

KOLDEWIJN, B. W., 1958

Sediments of the Paria-Trinidad shelf. Reports of the Orinoco Shelf Expedition, Vol. III
Thesis, Univ. Amsterdam, 109 pp.

KUGLER, H. G., 1965

Sedimentary vulcanism
4th Carib. Geol. Conf. (Trinidad) (in press)

LIDDLE, R. A., 1946

The geology of Venezuela and Trinidad, 2nd. edn.
Paleont. Res. Inst., Ithaca, N. Y. (890 pp.)

MCCANDLESS, G. C., 1966

Geología general de la parte septentrional del Escudo de Guayana en Venezuela.
Bol. de Geol. (Venezuela), Vol. VIII, no. 15, p. 140-153

MOSTOFI, B., 1964

Report on the Commission of Enquiry into the Oil Industry of Trinidad and Tobago (1963-1964).
Government of Trinidad and Tobago, Port of Spain

MULLER, J., 1959

Palynology of Recent Orinoco Delta and Shelf sediments.
Reports of the Orinoco Shelf Expedition, vol. 5. Micropaleontology, vol. 5, no. 1, p. 1-32

MINISTERIO DE MINAS E HIDROCARBUROS, 1954: see under YOUNG, G. A. et al., 1956

NOTA, D. J. G., 1958

Sediments of the western Guiana Shelf. Reports of the Orinoco Shelf Expedition, vol. II.
Meded. Landbouwhogeschool te Wageningen, Nederland, 58 (2), p. 1-98

RENZ, H. H. et al., 1958

The Eastern Venezuela Basin.
in "Habitat of Oil", AAPG Symposium, p. 551-600

RENZ, H. H. et al., 1963

La cuenca oriental de Venezuela.
in "Aspectos de la industria petrolera en Venezuela", p. 100-189.
Primer Congr. Ven. de Petrol. (Soc. Ven. Ing. Petrol.)

SALVADOR, A., 1964

Proposed simplification of the stratigraphic nomenclature in Eastern Venezuela.
Asoc. Ven. Geol. Min. Petrol., Bol. Inf., vol. 7, no. 6, p. 153-202

----------, & STAINFORTH, R. M., 1965

Clues in Venezuela to the geology of Trinidad, and vice versa
4th Carib. Geol. Conf. (Trinidad) (in press)

SIMAKOV, S. N. & FEDYNSKY, V. V., 1965

Report on the prospecting for oil in British Guiana.
Geol. Surv. Br. Guiana, Bull. 36

STAINFORTH, R. M., 1948

Description, correlation and paleoecology of Tertiary Cipero Marl Formation, Trinidad, B.W.I.
Amer. Assoc. Petrol. Geol., Bull., vol. 32, no. 7, p. 1292-1330

VANMIDDLESWORTH, N., 1967

Drilling and production, all Venezuela, by operators and fields, year 1966 and cumulative.
Venezuelan Oil Scouting Association, Caracas

VILA, M. A., 1964

Aspectos geográficos del Territorio Federal Delta Amacuro.
Corp. Ven. Fomento, Caracas

----------, 1965

Aspectos geográficos del Estado Sucre.
Corp. Ven. Fomento, 267 pp. (see p. 226-227 on Guanoco)

WILSON, C. C., 1965

The Los Bajos Fault.
4th Carib. Geol. Conf. (Trinidad) (in press)

YOUNG, G. A. et al., 1956

Geología de las cuencas sedimentarias de Venezuela y de sus campos petrolíferos
Bol. de Geol. (Venezuela), Publ. Esp. no. 2.

NOTICIAS

El almuerzo mensual de abril se llevó a cabo el día 25. El Dr. Erimar von der Osten, de la Corporación Venezolana del Petróleo, habló sobre la geología de Lara, describiendo sus conceptos de la estratigrafía (véase Bol. Inf., vol. 10, no. 11) y la historia compleja de la región. La discusión que siguió fué dominada por el Dr. Alirio Bellizzia, quien se expresó con vehemencia al oponerse al punto de vista del Dr. von der Osten en lo que concierne al uso de los términos Formación Morán, que incluye depósitos de la plataforma y de la cuenca turbidítica, y Formación Villanueva, que incluye rocas metamórficas de varios grados y que por lo tanto debe ser dividida. Al terminar la altercación, el Presidente sugirió que la diferencia es sólo un problema de semántica ya que los proponentes están de acuerdo sobre los conceptos básicos de la geología.

NUEVOS MIEMBROS

En la reunión efectuada el 3 de abril de 1968, la Junta Directiva aceptó a las siguientes personas como miembros activos:

CAMPOS, Víctor, geólogo, Corporación Venezolana del Petróleo

CORDERO, Rafael, técnico, Ministerio de Obras Públicas

MASROUA, Luís, geólogo, Corporación Venezolana del Petróleo

SALAZAR, Amílcar, geólogo, Ministerio de Obras Públicas